Ref. Ares(2024)1356658 - 21/02/2024



# Application for derogations from PFAS REACH restriction for specific uses in railways

## Contents

# 1) Introduction

## The European rail sector

The following associations have jointly prepared this contribution: *Association of European Rail Rolling Stock Lessors* (AERRL), *Alliance of Passenger Rail New Entrants* (ALLRAIL), *Community of the European Railways and Infrastructure Companies* (CER), *European Rail Infrastructure Managers* (EIM), *European Rail Freight Association* (ERFA), *International Union of Wagon Keepers* (UIP), *International Union for Road-Rail Combined Transport* (UIRR), *International Association of Public Transport* (UITP) and *European Rail Supply Industry* (UNIFE), hereinafter "the European rail sector''.

Founded in 2021, the Association of European Rail Rolling Stock Lessors (AERRL) is a representative body from the railway sector acting at Union level. Our mission is to promote interoperable and safe European rail rolling stock (passenger trains and cargo/passenger locomotives) by addressing technical, operational, economic, legal and scientific issues and matters relating, directly or indirectly, to locomotives, passenger trains, (multiple-units and coaches) operated in the European Union and Switzerland.

ALLRAIL, the Alliance of Passenger Rail New Entrants in Europe, is a recognised association that represents independent passenger companies, including rail operators, ticket vendors and rolling stock lessors since 2017. We advocate for faster and effective market opening in passenger rail in Europe in order to accelerate modal shift to rail.

The Community of European Railway and Infrastructure Companies (CER) brings together railway undertakings, their national associations as well as infrastructure managers and vehicle leasing companies. The membership is made up of long-established bodies, new entrants and both private and public enterprises, representing 78% of the rail network length, 81% of the rail freight business and about 94% of rail passenger operations in EU, EFTA and EU accession countries. CER represents the interests of its members towards EU policy makers and transport stakeholders, advocating rail as the backbone of a competitive and sustainable transport system in Europe.

European Rail Infrastructure Managers EIM

EIM, the Association of European Rail Infrastructure Managers, was established in 2002 to promote the interests of the infrastructure managers in Europe. EIM's primary goal is to promote the growth of rail traffic and the development of an open, sustainable, efficient, customer-oriented rail network in Europe.

ERFA
European Rail Freight Association

ERFA, is the European Association representing European private and independent railway companies. ERFA members share a commitment to work towards a non-discriminatory, competitive and innovative Single European Railway Area.

UIP
INTERNATIONAL UNION OF WAGON KEEPERS

Founded in 1950, the UIP – International Union of Wagon Keepers - is the umbrella association of national associations from 14 European countries, thus representing more than 250 freight wagon keepers and Entities in Charge of Maintenance (ECMs). As the voice for more than 234,000 rail freight wagons which perform 50 % of the rail freight tons-kilometres throughout Europe, UIP represents half of the whole European wagon fleet and one of the most important resources for rail freight transportation in Europe.

UIRR
INTERNATIONAL UNION FOR ROAD-RAIL COMBINED TRANSPORT

Founded in 1970, the International Union for Road-Rail Combined Transport represents the interests of European road-rail Combined Transport Operators and Transhipment Terminal Managers. Road-Rail Combined Transport (CT) is a system of freight forwarding which is based on efficiently and economically inserting electric rail into long-distance (road) transport chains through the use of intermodal loading units (ILU).

UITP EUROPE

UITP is the international association representing public transport stakeholders. In the European Union, UITP brings together more than 450 urban, suburban and regional public transport operators and authorities from all Member States. We represent the perspective of short distance passenger transport services by all sustainable modes: bus, regional and suburban rail, metro, light rail, tram and waterborne. Visit our website: uitp.eu

unife THE EUROPEAN RAIL INDUSTRY

Operating in Brussels since 1992, UNIFE represents European train builders and rail equipment suppliers. The association advocates for more than 110 of Europe's leading rail supply companies – from SMEs to major industrial champions – active in designing, manufacturing, maintaining and refurbishing rail transport systems (trains, metros, trams, freight wagons), subsystems and related equipment. UNIFE also brings together national rail industry associations from 12 European countries. UNIFE members have an 84% market share in Europe and supply 46% of the worldwide rail production, representing more than 400,000 jobs in Europe.

## Preliminary statement and structure of the document

The European railway sector supports the European Commission's *Chemicals Strategy for Sustainability.* The sector supports efforts to restrict PFAS (Per and polyfluoroalkyl substances), which pose unacceptable risks to human health or the environment, such as perfluorooctanoic acid (PFOA). The rail sector is committed to continuously improving its products and services' environmental compatibility and safety.

However, the PFAS restriction proposal, submitted by the five dossier submitters to ECHA and aiming at amending the REACH Regulation, would significantly impact the European railway sector. Failure to grant exemptions or derogations would mean an immediate (18 months after entry into force) and total ban of PFAS for crucial rail applications. As these applications are critical for various essential rail components and are also required for spare parts and maintenance activities, the ban will trigger a cascade of far-reaching consequences. Without the use of some key PFAS, the rail sector would not be able to operate or be at least significantly less efficient. It can lead to serious adverse effects on the life of Europeans and the European economy. In addition, more expensive technologies would have to be used, drastically reducing competitiveness in non-EU markets and increasing the cost of transitioning to more sustainable transport within the EU.

The high cost due to a universal PFAS ban may negatively impact the deployment of rail solutions. Ultimately, this could hamper the crucial importance rail has to play in achieving the ambitious decarbonisation goals of the *Sustainable and Smart Mobility Strategy* and of the *EU Climate Law*.

For these reasons, the **European rail sector supports the following improvements to the PFAS restriction proposal**:

- The current list of derogations should be extended to consider the relevance of PFAS for a wide range of non-replaceable and indispensable applications in the railway industry.
- Risk-based and substance-based approaches should be preferred for banning the most harmful PFAS instead of a universal restriction, regardless of their toxicity and risk profile.
- The European rail sector supports the idea of introducing an information obligation for PFAS before the introduction of targeted restrictions. As PFAS are currently non-declarable substances, this legal requirement will include all relevant uses in the assessment and apply any necessary exemptions.
- A longer transition period should help to develop durable and safe PFAS-free alternatives and to verify and certify such options to fulfil all other applicable legislation.
- A clearly defined procedure for applying, reviewing, and extending derogations should be determined.
- The use of PFAS should remain possible as long as there is no full-scale availability of suitable and technically developed substitutes. There should be a long-term general derogation with review clauses before the expiration of the derogation for the use of risk-free PFAS.
- The "repair-as-produced" principle should be applied, with indefinite derogations for spare parts, refurbished parts, equipment, and products already placed on the market.
- Ensuring effective enforcement through the market surveillance system should be central to guarantee a level playing field between competitors, especially from third parties non-affected by the PFAS restriction.

The European rail sector's contribution provides feedback to the public consultation on the latest restriction proposal of 22 March 2023. It is essential to note that the specific usage of PFAS products in the railway industry may vary depending on regions' specific railway systems, regulations, and engineering requirements.

After this introduction (Section 1), the contribution details what types of PFAS are used in the railway sector and why they are essential, with illustrations (Section 2). Then, the European rail sector focuses on whether non-PFAS alternatives are available, but few are compatible with the safety standards of its products and services (Section 3).

In Section 4, the contribution provides a socio-economic impact assessment of the proposed PFAS restriction for the railway value chain. Three scenarios have been identified:

- Scenario 1: No derogation at all,
- Scenario 2: Proposed derogations are confirmed, but no other specific derogations,
- Scenario 3: No derogation for spare parts and maintenance activities.

In these three scenarios, the financial and social consequences would be catastrophic for the mobility of people and goods in Europe.[1]

The European rail sector could not continue to operate trains without some crucial PFAS listed in Section 5. The current PFAS restriction proposal lacks several derogations for essential PFAS applications. **The European rail sector requests derogations with review clauses for specific applications where PFAS are non-replaceable and indispensable in the railway industry.** These review clauses will provide sufficient time for the railway industry to identify and implement alternative non-PFAS solutions if such alternatives can be found. The list of derogations requested is summarised in Table 1 in section 5.8.

[1] More details on the economic impacts of the ban on PFAS could be provided on request – contact UNIFE.

## List of abbreviations and chemicals

| | |
|---|---|
| ETCS | European Train Control System |
| ETFE | Ethylene tetrafluoroethylene |
| FC-72 | 1,1,1,2,2,3,3,4,4,5,5,6,6,6-Tetradecafluorohexan |
| FC-3284 | Perfluor(N-methylmorpholin) |
| FEP | Tetrafluorethylen-Hexafluorpropylen-Copolymer |
| F-gases | Fluorinated greenhouse gases |
| FKM | Fluorocarbon-based elastomers / rubbers |
| FPM | Fluorocarbon-based elastomers / rubbers |
| HFO | Hydrofluoroolefin |
| HNBR | Hydrogenated nitrile butadiene rubber |
| HVAC | Heating, ventilation and air-conditioning |
| OEM | Original equipment manufacturer |
| PA | Polyamide |
| PEM | Proton exchange membrane |
| PFAS | Per- and polyfluoroalkyl substances |
| PFPE | Perfluoropolyether |
| PFSA | Perfluoro sulfonic acid |
| PFOA | Perfluorooctanoic acid |
| PI-FEP | Thermoplastic polyimide (PI) fluorinated ethylene propylene (FEP) |
| POM | Polyoxymethylene |
| PTFE | Polytetrafluoroethylene |
| PVDF | Polyvinylidene fluoride |
| NBR | Nitrile butadiene rubber |
| Novec 649 | 1,1,1,2,2,4,5,5,5-Nonafluor-4- (trifluormethyl)-3-pentanon |
| REACH | Regulation 1907/2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals |
| R-290 | Propane refrigerant number (ASHRAE number) |
| R-744 | $CO_2$ refrigerant number (ASHRAE number) |

## 2) Where are PFAS used in railways and why?

Different PFAS are used in the railway sector:

- For passenger rolling stock (see Figures 1 and 2)
- For freight rolling stock (see Figures 3 and 4)
- For the infrastructure and signalling (see Figures 5, 6 and 7)

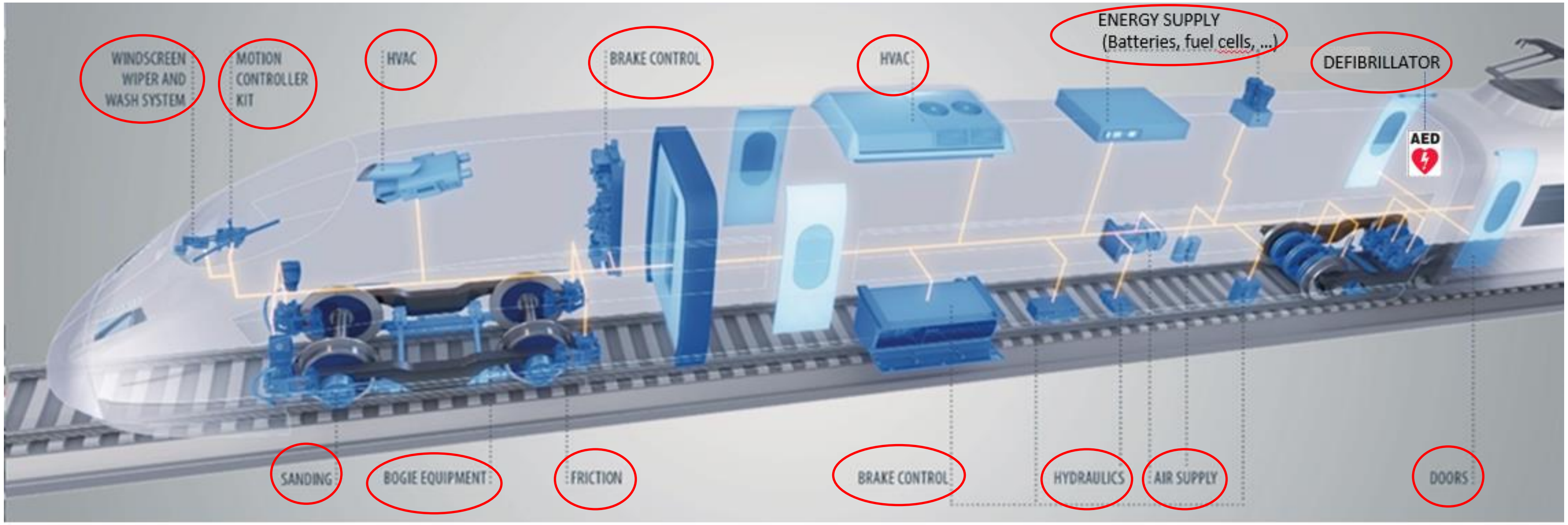



Image: © *Knorr-Bremse*

Figure 1: Schematic of a rolling stock with its main components – circled in red where PFAS are present.

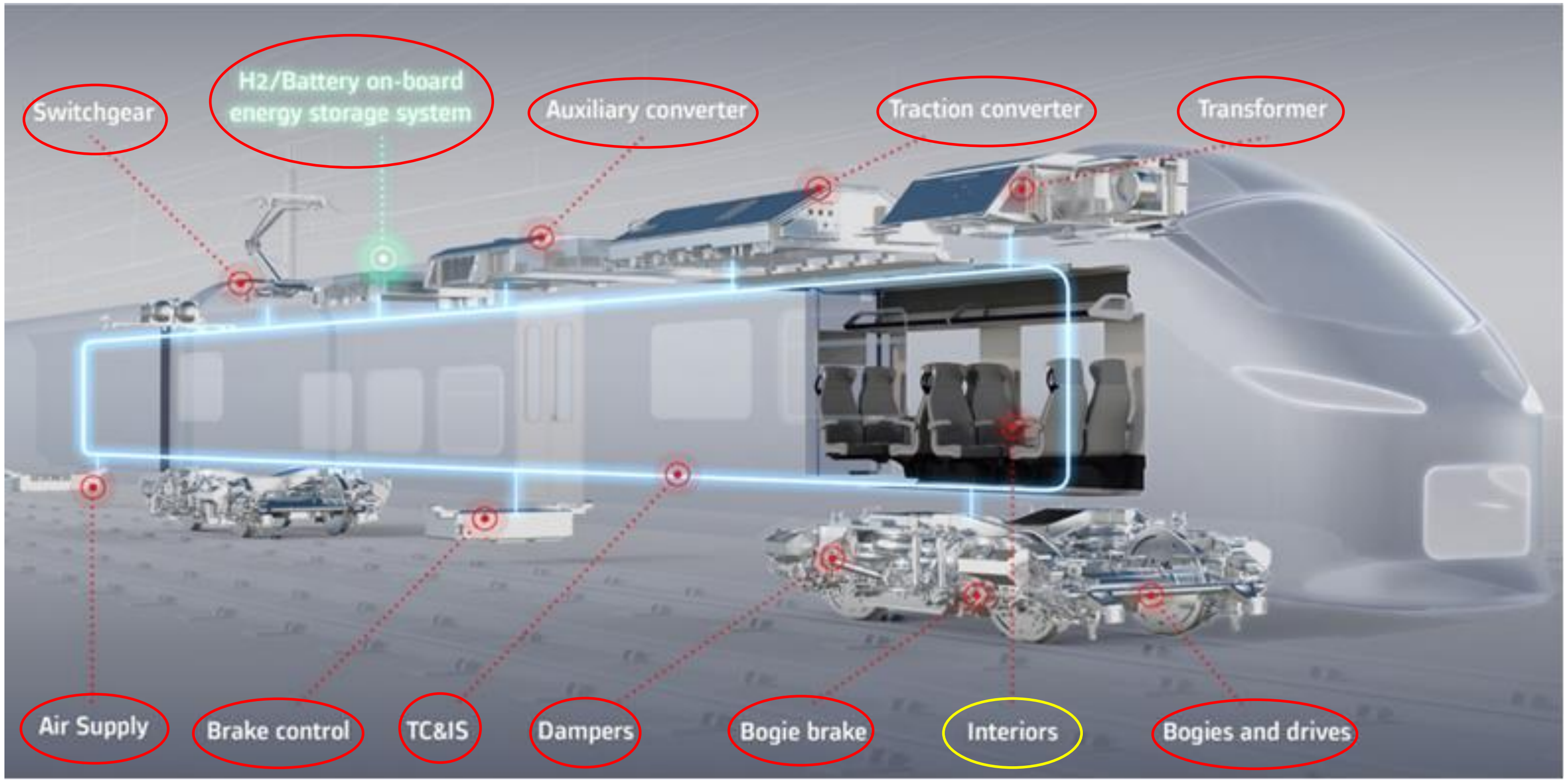



Image: © *Alstom*
Figure 2: Schematic of a rolling stock with its main components – circled in red where PFAS are present, in yellow potential presence.

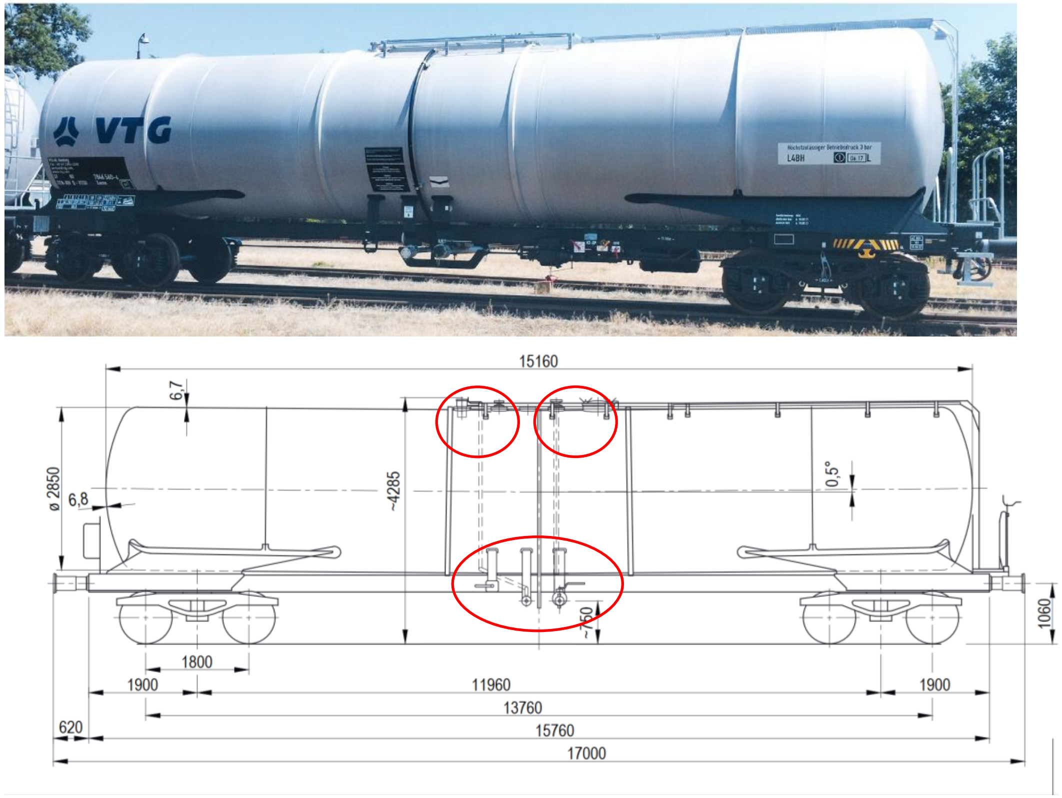



Image: *© VTG*

Figure 3: Example of a chemical tank wagon and its sealing assemblies with PFAS (circled in red).


Image: *© Ermewa*
Figure 4: Example of a gas tank wagon and its sealing assemblies with PFAS (circled in red).

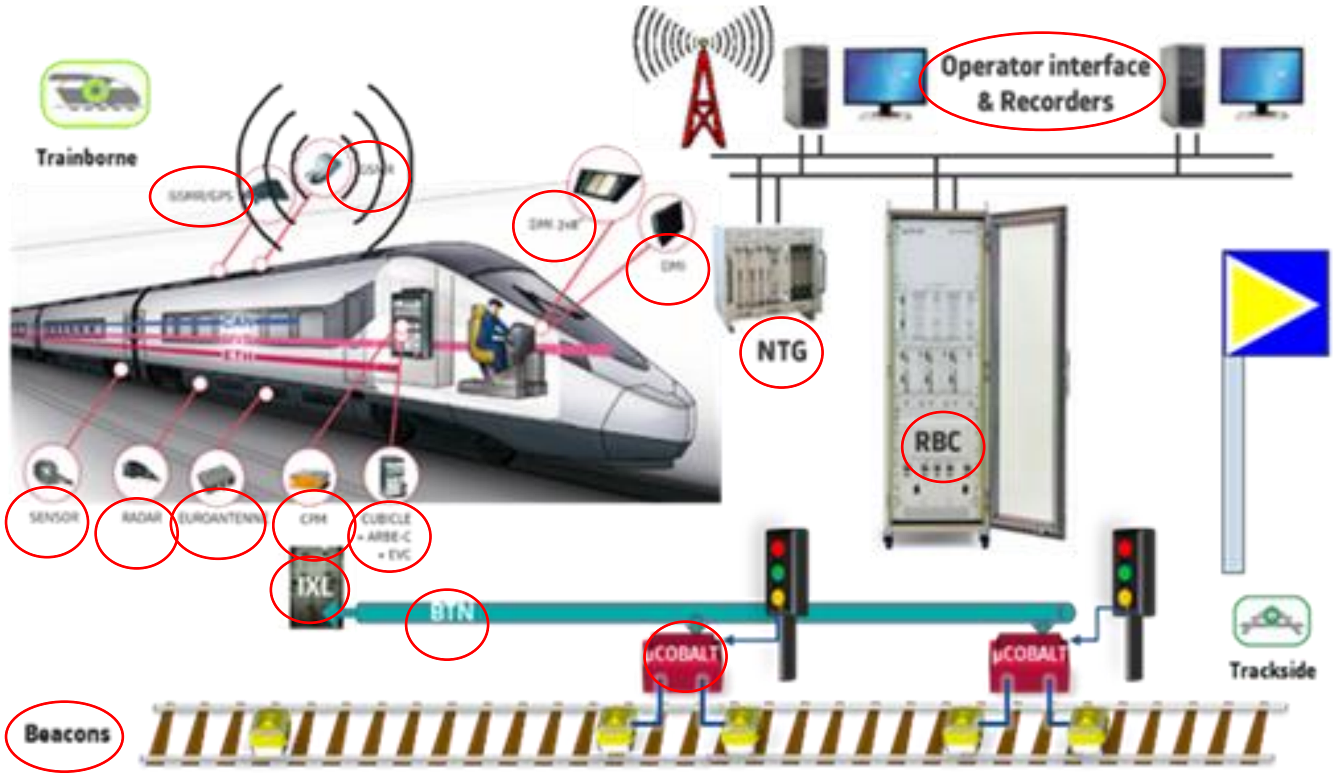



Image: © *Alstom*

Figure 5: Schematic of rolling stock with its on-board signalling components, wayside train monitoring system and the control centre – circled in red where PFAS are present.

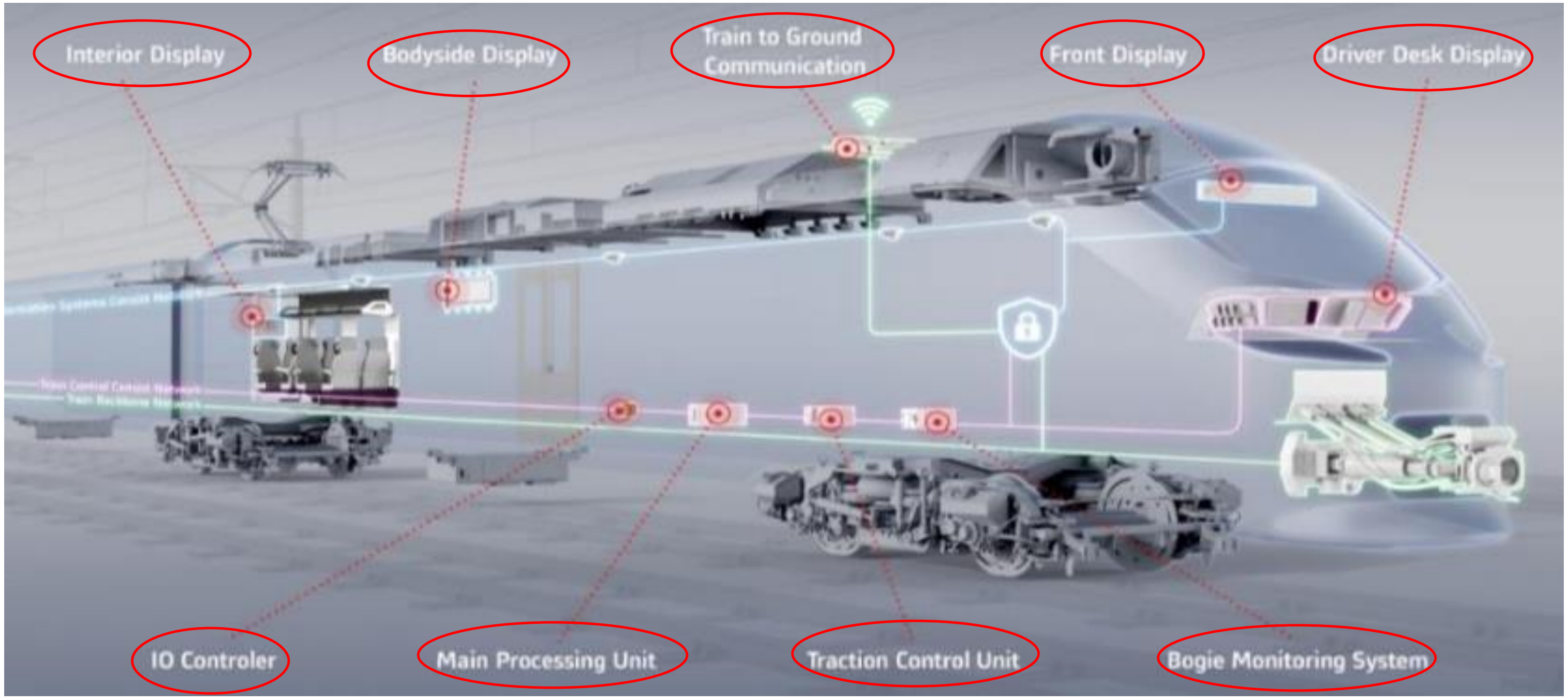



Image: © *Alstom*

Figure 6: Schematic of rolling stock with onboard electronic components – circled in red where PFAS are present.

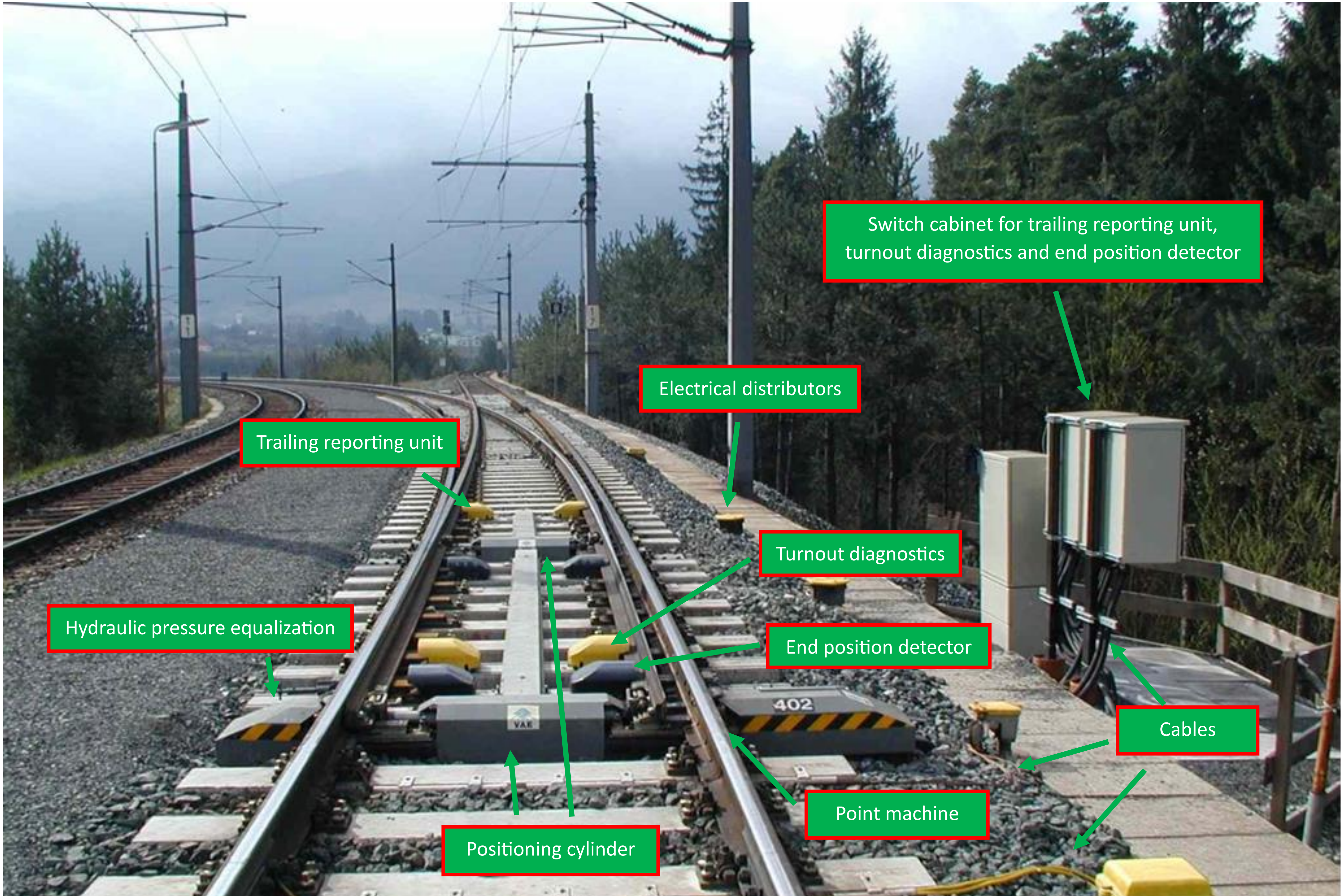

Switch cabinet for trailing reporting unit, turnout diagnostics and end position detector
Electrical distributors
Trailing reporting unit
Turnout diagnostics
Hydraulic pressure equalization
End position detector
402
VAE
Cables
Point machine
Positioning cylinder

Image: © *voestalpine Railway Systems GmbH*
Figure 7: Exemplary schematic of signalling and infrastructure – circled in red where PFAS are present.

Figure 7 shows components of an exemplary turnout system for which PFAS are necessary, including safety and performance-related monitoring. It should be noted that different signalling and monitoring systems may differ in look. In some cases, not all components and systems are directly visible in the track like in the exemplary picture. Nevertheless, the use of PFAS is the same and critical for the different included signalling components.

In the infrastructure, PFAS are associated with and vital for signalling components. This includes electronics like sensors, cables and point machines (also electrohydraulic systems), which are necessary for monitoring and operating turnouts. They operate the turnout system (point machine, positioning cylinder, hydraulic pressure equalisation), detect the correct positioning of the turnout and the train (end position detector, trailing reporting unit) and monitor the turnout (turnout diagnostics). Those safety and monitoring critical components are vital for a safe and efficient railway network. Failures could lead to safety-critical situations and heavy accidents.

Please refer to the later chapters where such uses are described together with similar uses in rolling stock and why PFAS are essential due to their sealing and gliding characteristics.

## 2.1) PFAS used in applications affecting the proper functioning related to the safety of transport

One of the main characteristics of the railway sector is that it is requested to comply with the highest safety and reliability standards. As a mass transport system for people and goods, the safe operation of the railway system under all environmental conditions must always be ensured. Certain essential elements used to guarantee the safety of the train are based on the use of materials containing PFAS due to their exceptional characteristics under extreme conditions.

In some PFAS applications listed below, there is no permanent exposure to the environment throughout their useful life, as the components mentioned above are contained within enclosures that are opened only during planned maintenance inspections and overhauls.

The generic applications are detailed in sections 2.1.1 to 2.1.4, and specific applications per main system are presented in section 2.1.5.

### 2.1.1) Sliding and guiding applications

#### 2.1.1.1) Sliding elements made from polytetrafluoroethylene (PTFE) for rubber sealing extrusions, technical gangway fabrics, and flexible tubes

Using this fluoropolymer allows several functions, such as the safe passage of passengers between vehicles during the operation of the trains guiding and protecting a rope or cable.

**Sliding parts such as flexible PTFE tubes**

They are used in several systems to guide and protect a rope or cable. Sliding plates inside bogies connect couplers, sliding steps, or sliding plates in air spring systems. They are used because of their low friction values. As an essential part of an air spring system, PTFE sliding plates ensure low friction values in deflated operation mode. This is necessary for safety against derailment of the train. Thus, PTFE sliding plates are crucial for all products equipped with air spring systems.

**Slide plates**

PTFE slide plates are commonly employed in railway infrastructure. These materials possess excellent self-lubricating properties and low friction coefficients, making them suitable for sliding applications. Slide plates are utilised in rail expansion joints, bridge bearings, and other components to facilitate smooth movement and reduce friction between surfaces.

#### 2.1.1.2) Guiding segments

They are used in the dampers at the rod guide level and around the piston. They ensure good guidance and, therefore, good alignment of moving parts. The guiding segment contains PTFE, which guarantees a good friction coefficient between the rod guide, the piston rod and the working tube/piston. Guiding segments in PTFE withstand severe constraints like the high-speed movement of the piston and the piston rod, the temperature in service from -50°C to + 70°C. Moreover, PTFE substance leads to an increase in the expected lifespan. Guiding segments work in the specific oil for dampers.

**Wear pads**

PTFE wear pads are employed in railway systems to reduce friction and wear between moving parts. These materials have high durability and low friction characteristics, making them suitable for applications such as bogie systems, couplers, and suspension components. Wear pads help prolong the lifespan of these parts and minimise maintenance requirements.

### 2.1.2) Sealing applications

#### 2.1.2.1) Applications in the bogie and transmission

Seals containing fluoroelastomers (particularly Fluorocarbon-based elastomers, FKM and FVMQ) have been used for years to guarantee the static and dynamic sealing of railway gearboxes fitted to bogies. These gearboxes ensure the transmission of the tractive effort of the bogie generated by the electric motor in both operation directions and are directly connected to the axle and wheels. Subject to high torques to be transmitted and high rotational speeds, as well as very severe reliability and availability constraints, these railway gearboxes use synthetic and semi-synthetic extreme-pressure oils with several additives to lubricate the gears and bearings and ensure the dissipation of calories. The operating temperature of these oils can vary from -50°C to +120°C for the most severe applications.

#### 2.1.2.2) Applications in the traction motors

Sealing gaskets made of FKM, FVMQ or FPM (fluoroelastomers) seal bearings have excellent chemical stability in contact with lubricating greases and oils, lasting ten years.

#### 2.1.2.3) Applications in the dampers

Seals containing PFAS (FKM or FPM) are used on dampers to ensure good sealing. Seals containing PFAS work under severe constraints like the high-speed movement of the piston and then the piston rod, with temperature in service from -50°C to + 70°C. They are in contact with specific oil for dampers. Dampers ensure good dynamic behaviour of the trainsets, the filtering of vibrations rising in the structure, and good comfort for the passengers. The dampers are designed to work for ten years before the first maintenance step. Until now, with PFAS substances included in the composition of the seal material, ten years or 3.6 million kilometres without any maintenance have been reached. Moreover, FKM materials are the only known materials that ensure compliance with legislation (e.g. Rolling Stock Noise: Directive 1304/2014/EU; Pressure Safety: Directive 2014/68/EU) and relevant specifications regarding e.g. withstanding low and high operating temperatures (> 260°C), resistance to aggressive fluids (e.g. oils, diesel, ethanol, etc.), vibration friction, and abrasion resistance.

#### 2.1.2.4) Applications in the traction transformer

The traction transformer is filled with dielectric-type mineral oil (according to EN 60296) or synthetic ester oil (according to EN 61099). Seals containing fluoroelastomers (FKM or FVMQ) have been used for many years to guarantee static sealing in the transformer. The seals have been tested and validated for their resistance and compatibility with the different types of oil used and to be suitable for a temperature range of -50°C to +150°C. The seals must maintain a perfect seal for 15-20 years and be replaced at the transformer's mid-life.

#### 2.1.2.5) Applications in the doors

Rubber-based sealings ensure the proper tightness of train coaches and driving cabs.

### 2.1.2.6) Applications in the cooling system

Cooling system for air conditioning system or climatic chamber, such as the materials of the functional and sealing components of the refrigerant circuit and the refrigerants.

### 2.1.2.7) Applications in rail tank wagons

PFAS is used in sealing elements within the metallic valves and equipment that are fitted to the tank operational openings and are crucial to the containment of the cargo of liquids and liquefied gases, most of which are regulated as dangerous goods (RID). Still, other substances, including food-grade and non-regulated, are transported in tank wagons.

The primary sealing materials are PTFE, FKM, FEP and PFA in solid form and PTFE/PFA envelope on an elastomer core. Seals and O-rings are of PTFE, FEP, and PFA and fitted within the body of the valve and access hatch. Sealing elements can be found in the airline assembly's bottom valve assembly and access hatch seals.

Sealing elements of tank wagons are made of PFAS because of their high thermal and chemical resistance and the fact that they have very low surface tension and are thus water and oil-repellent as well as abrasion and wear-resistant at the same time.

It is estimated that the materials used for tank wagons are an average of 82% non-PFAS and 18% PFAS. UIP estimates that up to 8,500 kg of PFAS material is used per annum for sealing elements on tanks of rail tank wagons in Europe.[2]

The solid form does not allow the materials to shred or degrade to particles, as with other industries, such as food packaging, clothing, and fire-fighting foams. Furthermore, the sealing element is incorporated into the tank and cannot enter the environment. During the mandatory RID maintenance check, sealings are replaced at least every eight years (complete check-up) or even earlier if needed during the intermediate check-up after four years.

As regards the end of the life-cycle phase, maintenance facilities dispose of the sealing materials as industrial waste since there is no recycling requirement. The percentage that is disposed of in landfills or municipal incineration is unknown. Given that sealing elements are solid materials and their persistence, they could be separated by our workshops for disposal of approved facilities if required.

For a more detailed presentation, please refer to the contribution of *UIP* (ECHA's consultation reference number 6213).

[2] Explanation of calculation: the European rail sector assumes that a tank wagon has around 0.5 kg of PFAS per wagon which needs to be replaced every 6 years (average of the mandatory periodic revision time of 4 and 8 years for tank wagons) of the current tank wagon fleet of 82,477, 0.5 kg x 82,477/ 6= 6,873 kg) + (sealings in new built per year: 3,000 new tank wagons x 0.5 kg= 1,500 kg.

#### 2.1.2.8) Applications in hose assemblies, joint heads, couplers, threads, and related applications

They depend on PTFE and PVDF as they are components that come in contact with aggressive media. Using per fluoropolymers reduces the risk of degradation or corrosion, thus cracking of materials or safety-relevant parts due to their inertness to aggressive fluids (e.g. hydraulic oils, gear oils, brake fluids, coolants, refrigerants) or because of their applicability in extremely low/high or changing temperature ranges.

### 2.1.3) Coatings, adhesives and finishing

#### 2.1.3.1) Applications in the liner on ball joints, rods and bearings

PTFE is a liner on ball joints, rods and bearings. The rod aims to transfer movement between two components, avoid system rupture by allowing more degrees of freedom, such as linear rotation and conical movement through ball joints and bearings, and carry the mechanical and angular load of the structure. The definition of the ball joints, rods and bearings considers the maintenance requirements, life cycle cost and passengers' comfort and security requirements: ten years of service life and no noise during the service time. To avoid rupture of the ball joint and rod, a lubrication of the surface between the inner ball and the outer ring/ball is required.

**Liners and seals**

PTFE liners and seals are utilised in railway equipment, such as valves and pumps, to provide chemical resistance and reduce friction. These materials have excellent resistance to abrasion, chemicals, and high temperatures. They help ensure the reliable and efficient operation of various fluid handling systems in railways.

#### 2.1.3.2) Applications in the painting and corrosion protection in the air supply unit

Different parts in the air supply unit require specific surface protections. PFAS are used to guarantee highly durable and weatherable surface treatments, antistick and anticorrosive coatings, the ability to form a second coat on a first coat and weather resistance paint.

#### 2.1.3.3) Applications in the surface treatments (zinc flake coating)

PFAS are used in different surface treatments. One necessary surface treatment for corrosion protection is the **zinc flake coating**. A topcoat containing PVDF is applied onto a base coat in this application. Compared to electroplating, hydrogen embrittlement is avoided, which would occur during the treatment. Furthermore, the PVDF in the topcoat ensures a defined friction coefficient of fasteners. It is essential to keep the installations fixed on the train, especially underframe-mounted devices, to avoid falling onto the tracks. This is a safety-critical point for which there is currently no alternative known.

#### 2.1.3.4) Applications in the plain bearings

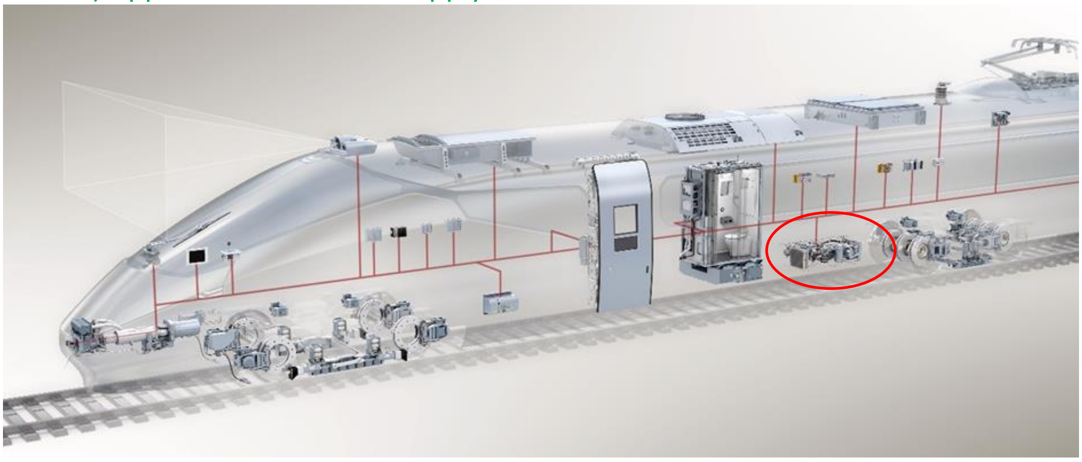
**Plain bearings** used in lubrication-free applications depend on PTFE and PVDF, e.g. to ensure emergency running properties because of their unique low friction values. Thus, the sliding properties of the lubrication-free bearings rely on the polymer materials themselves.

### 2.1.4) Noise dampening components

PTFE products are utilised to develop noise-dampening components for railways. Their low friction properties and ability to absorb vibrations and dampen noise make them suitable for rail pads, bushings, and vibration isolators. These components contribute to reducing noise pollution associated with train operations.

### 2.1.5) Detailed applications per main system

#### 2.1.5.1) Applications in the air supply unit



© Knorr-Bremse
Figure 8: location of the air supply unit in a train.

**Relief valve used in the air supply unit**
It supplies a train's brake system with compressed air, a functioning sanding system, suspension, etc. Within the compressor, as part of the air supply system, the function of the relief valve is to protect the compressor against impermissibly high pressure. The protective valve is screwed into the pressure chamber of the compressor. PFAS is present as FPM/FKM Seal on surfaces where high-temperature and ageing resistance are needed, e.g. NBR is unsuitable.

**Piston ring/piston**
They are used in the compressor within the oil-free air supply unit, which supplies the train with compressed air for brakes, a functioning sanding system, suspension, etc. The movement of the piston, including the piston ring within the cylinder of an oil-free compressor, provides the compressed air by suctioning and compressing the air. To ensure the system's function, the friction between the cylinder and piston/piston ring must be as low as possible. This is key to obtaining a reliable system with reduced waste by the high durability of the components and high energy efficiency provided by low friction within the system.

In conventional oil-lubricated compressors, oil is excreted into the environment. The idea of an oil-free compressor is to avoid this. Therefore, the oil lubrication of the friction pairing piston/cylinder must be replaced. In the environmentally friendly oil-free compressor, PTFE is present in piston rings and surfaces. The oil-free compressor technology is a milestone in environmental protection. PFAS, particularly PTFE, is the central key to replacing oil lubrication.

An extremely low friction coefficient in combination with high-temperature resistance and mechanical strength is needed. Simultaneously, the coating must not have an abrasive effect on the counterpart. Here, PTFE piston rings and PTFE-coated pistons are used.

© Knorr-Bremse
Figure 9: Left: Piston with piston ring in a cylinder of an oil-free compressor,
Right: Screws of an oil-lubricated screw-compressor.

© Knorr-Bremse
Figure 10: Oil free compressor.

© Knorr-Bremse
Figure 11: oil-lubricated screw compressor.

### Oil pipe, screw fittings in the air supply unit

PFAS is used as FPM/FKM Seal on surfaces where (high and low) temperature resistance, ageing resistance, oil, grease and water resistance are needed. The function of the oil pipe is to transport the oil with high temperature and pressure through the oil flow system. Screw fittings are required to ensure the system's tightness, i.e., to prevent leakages of oil/compressed air, as the case may be. One well-known fluoroelastomer, FKM or Viton™, is commonly used across all industries. These rubber compounds produce one of the best chemical and high-temperature resistance materials of all the rubber families.

### Casing in the air supply unit

FPM/FKM in the casings and wires and cables are explicitly used in the electromechanics installation of an air supply unit. The PFAS provides high-temperature resistance in some counter connectors on the sealing area.

### Needle bearings in the air supply unit

They are used in air supply units. For oil-free piston compressors, PFAS are present as PFPE/PTFE in the grease, which is used to lubricate the rolling bearings of the compressor. Without grease bearings, the compressor is not able to operate. As a long lifetime is claimed for railway equipment, aging-resistant greases are needed. Also, high temperatures can occur in the application, so high-temperature greases are required. PFPE grease fulfils requirements for ageing resistance and high-temperature usage.

### Shaft sealing Rings/O-rings in the air supply unit

Both items are used in air supply units. For the oil-free piston compressor, PFAS are present in the sealing rings used to seal the compressor's rolling bearings. Without shaft sealing rings, bearings/compressors are not able to operate. As a long lifetime is claimed for railway equipment, wear-resistant materials are needed. Also, high temperatures can occur in the application, so high-temperature materials are required. FPM/FKM fulfils requirements for wear resistance and high-temperature usage.
In the case of the O-rings, PFAS is present and used as an FPM/FKM seal on surfaces where high-temperature resistance and ageing resistance are needed, e.g., NBR is not applicable.

### Valve cones in the air supply unit

This is a check valve for air dryer units. The function is to restrict backflow from the system and from one reservoir to another during operation. Without this valve, the unit is not working. The valve is made from FKM/FPM to fulfil the following requirements: cold and high temperature (excellent thermal properties) stability, good resistance against chemicals and oils (due to oil-lubricated systems, the oil resistance is a must) and good impact and wear resistance (check valve shall endure at least one million cycles before overhaul).

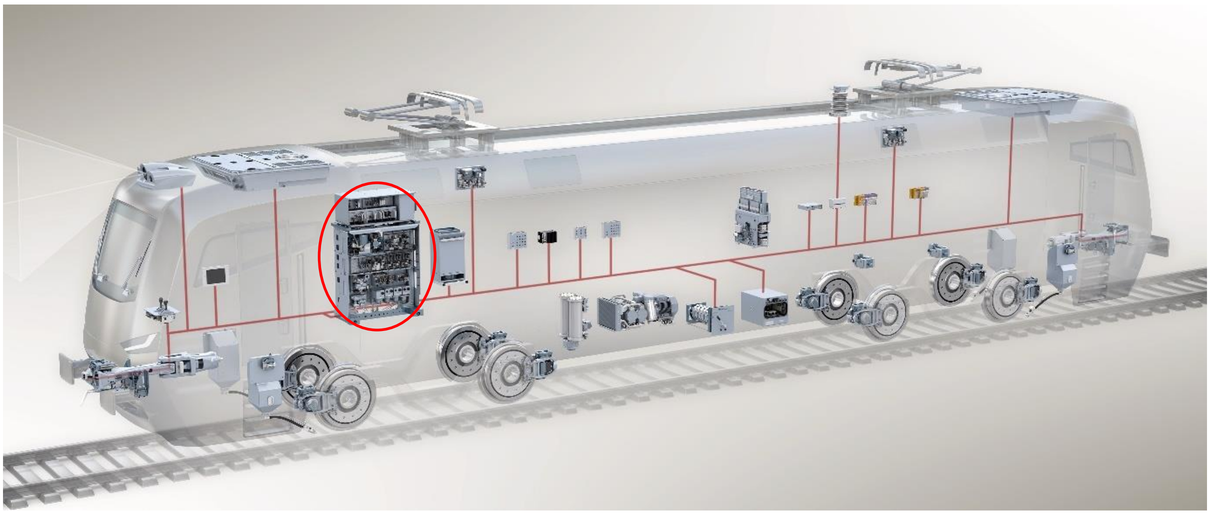
### Safety valve, minimum pressure valve in the air supply unit

The valve seat of the minimum pressure valve is made of FPM/FKM. Its function is to ensure that a system has a minimum operation pressure. The safety valve is a safety-relevant product and shall comply with regulations and laws such as 2014/68/EU (Pressure Equipment Directive). The valve seat is made of FKM (Vi 899), and an O-ring in the assembly is made of PTFE. These PFASs are used to comply with the following requirements:

- Cold and high temperatures (excellent thermal properties),

- Good resistance against chemicals and oils. Due to oil-lubricated systems, oil resistance is essential,
- Additionally, for the safety valve: good impact and wear resistance. The safety valve may open rapidly, which shall be endured by the valve seat.

### 2.1.5.2) Applications in the brake control



© Knorr-Bremse
Figure 12: location of the brake control in a train.

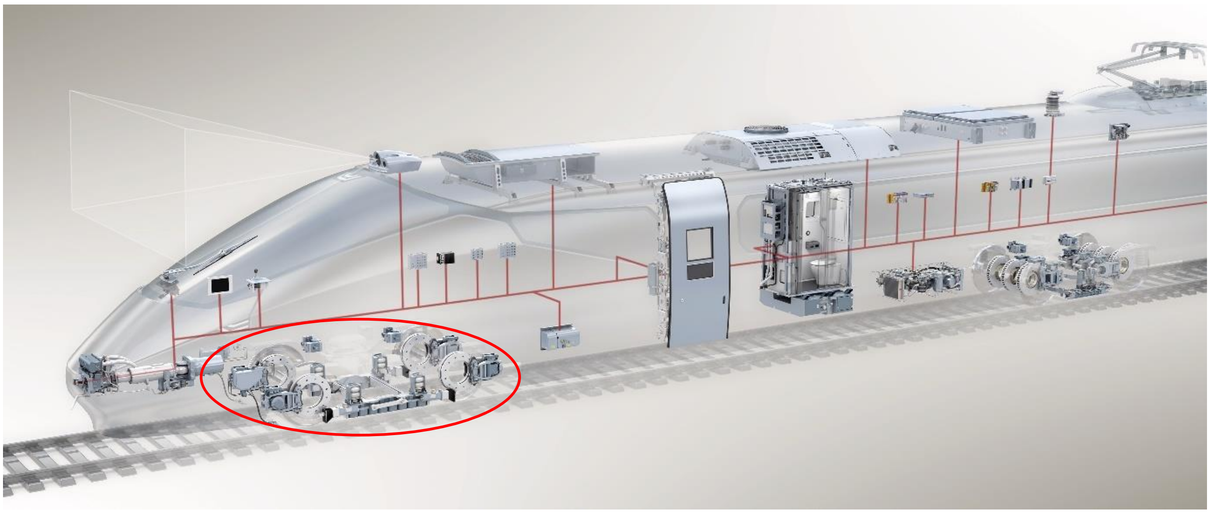
**O-rings in switching cylinders**

O-rings consisting of FPM/FKM are used in changing cylinders. The switching cylinder switches the shunting (reversing) modes for the locomotive (normal operation or locomotive is trailed). The O-ring is located inside the housing of the switching cylinder, and its function is to seal the equipment to avoid pressure loss.

**Guides (solenoid valves)**

Guides (solenoid valves) coated with PTFE are used in magnet valves and pistons. The PTFE coating allows low friction guidance.

### 2.1.5.3) Applications in the bogie equipment



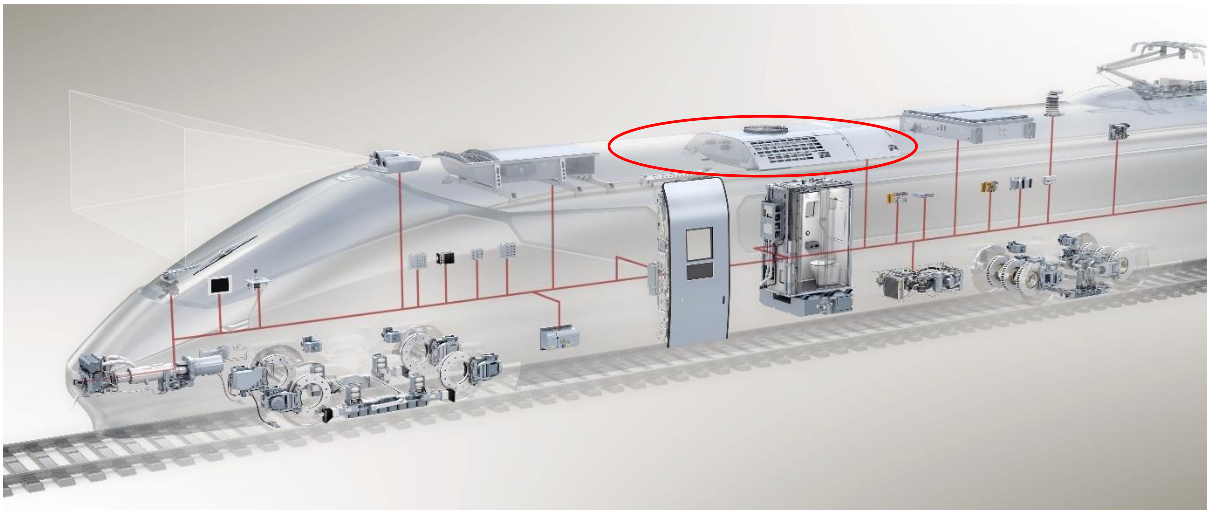
© Knorr-Bremse
Figure 13: location of the bogie equipment in a train.

**Slide bands, bushes, bandages, gaskets, swivel bearings, and different rings (spacing ring, thread seal ring, etc.) in the bogie equipment**

Slide bands, bushes, swivel bearings and rings are used in brake calliper units and tread brake units, and bandages in brake cylinders, gaskets, and track brake units. These items are made of PTFE in different variants (pure PTFE, PTFE with Carbon, PTFE with bronze, etc.), and some of them (e.g. O-rings in brake calliper units and tread brake units) are made of FPM/FKM to reduce friction and wear between internal components of brake mechanic products.

© Knorr-Bremse
Figure 14: brake calliper units.

## 2.1.5.4) Applications in the HVAC



© Knorr-Bremse
Figure 15: location of the HVAC system in a train.

**Washers, bushings, gaskets, and supporting plates in the HVAC**

These articles are used in different parts of air conditioning units. PTFE is the material used for these articles. Its molecular structure gives PTFE its characteristic properties, such as a high melting point, excellent chemical resistance and low surface tension, and allows for very low friction coefficients.

**Valves in the HVAC**

For HVAC systems, specific valves, such as closing valves for discharge, suction, tanks, pressure gauges, purge, etc., are needed to operate the system. These valves are used in the refrigerant circuit and serve essential purposes at different circuit points. To fulfil their function, PTFE is used within these valves and is needed to provide the following functions:

- **Sealing:** PTFE gaskets provide effective sealing properties in solenoid valves, ensuring a reliable and tight seal between the valve components. The PTFE material's excellent chemical resistance and low friction characteristics make it suitable for maintaining a leak-free connection, preventing refrigerant or fluid leakage in the system.
- **Compatibility:** PTFE is highly compatible with various refrigerants and fluids in refrigeration circuits. The material's resistance to chemical attack and non-reactive nature make PTFE gaskets suitable for maintaining integrity and performance in solenoid valves. They can withstand the harsh conditions and corrosive nature of refrigerants, ensuring long-lasting and reliable operation.
- **High-Temperature stability:** Solenoid valves in refrigeration circuits may be exposed to high temperatures, especially during compressor operation or in specific system components. PTFE gaskets offer exceptional thermal stability, enabling them to withstand elevated temperatures without compromising their sealing effectiveness. This characteristic ensures reliable performance and minimises the risk of leaks or system failures.

- **Low friction:** PTFE gaskets exhibit low friction properties, reducing the resistance to movement within the solenoid valve. This feature allows for smooth valve operation, minimising wear and extending the valve's lifespan. The low friction properties also contribute to energy efficiency by reducing energy losses associated with frictional resistance.
- **Longevity and reliability:** PTFE gaskets are known for their durability and long service life. They can withstand repeated compression and decompression cycles without losing their sealing capabilities or mechanical integrity. This reliability ensures consistent performance and minimises the need for frequent maintenance or replacement of gaskets in solenoid valves.

Its molecular structure gives PTFE its characteristic properties, such as a high melting point, excellent chemical resistance and low surface tension, and allows for very low friction coefficients.

### Fans in the HVAC

In an air conditioning unit, fan motors drive the fans that move air across the evaporator and condenser coils, enabling heat transfer between the refrigerant and the air. By drawing warm air from the room and blowing it over the cold evaporator coils, the fan motor aids in the cooling process. Similarly, during condensation, the motor helps reject the heat the refrigerant absorbs into the outside environment. PTFE seals in fan motors serve several vital purposes. Firstly, they provide an effective barrier between the moving and stationary parts, ensuring a tight seal and preventing the leakage of liquids or gases. This is crucial for maintaining the desired pressure within the motor. Secondly, PTFE's low friction properties reduce wear and heat generation between the motor shaft and housing, contributing to prolonged motor life. Additionally, PTFE is chemically inert and highly resistant to corrosion, protecting the motor's internal components from damage caused by corrosive substances. Lastly, PTFE's temperature resistance suits fan motors operating in high-temperature conditions. In summary, PTFE seals in fan motors offer effective sealing, wear protection, corrosion resistance, and stability in adverse conditions, contributing to reliable performance and extended motor life.

### Compressor in the HVAC

Compressors are used in the refrigerant circuit to circulate and compress the refrigerant gas in the system. It receives low-pressure, low-temperature refrigerant vapour from the evaporator coil and significantly raises its pressure and temperature before sending it to the condenser. PFAS are present in PTFE joints and bearings of both scroll and piston compressors and are needed to provide the following functions:

- **Sealing function:** PTFE joints are primarily utilised for sealing purposes in scroll compressors. These joints are designed to prevent leaks and maintain the integrity of the compression chamber. The PTFE material, known for its high chemical resistance, ensures a reliable seal even when exposed to various refrigerants and operating conditions.
- **Durability:** Scroll compressors undergo repeated compression cycles, subjecting the joints to significant mechanical stress. PTFE joints are known for their exceptional durability and resistance to wear, making them suitable for long-term use in scroll compressors. The material's low friction properties also reduce wear and tear, ensuring extended service life.

- **Chemical compatibility:** Refrigeration systems employ various refrigerants, some of which can be chemically aggressive or reactive. PTFE is highly resistant to chemical attack, making it an ideal choice for sealing joints in scroll compressors. The material's resistance to corrosive substances helps maintain the compressor's integrity and ensures efficient and reliable operation.
- **Temperature stability:** Scroll compressors operate under varying temperatures, including high discharge temperatures. PTFE joints exhibit excellent thermal stability, allowing them to withstand elevated temperatures without compromising their sealing properties. This characteristic ensures that the joints maintain their integrity and sealing effectiveness even during demanding operating conditions.
- **Low friction and efficiency:** PTFE's low coefficient of friction contributes to the overall efficiency of scroll compressors. The reduced friction between the moving parts, including the PTFE joints, minimises energy losses and enhances the compressor's performance. This feature allows for smooth operation and improved energy efficiency of the air conditioning equipment.

### 2.1.5.5) Applications in the hydraulics

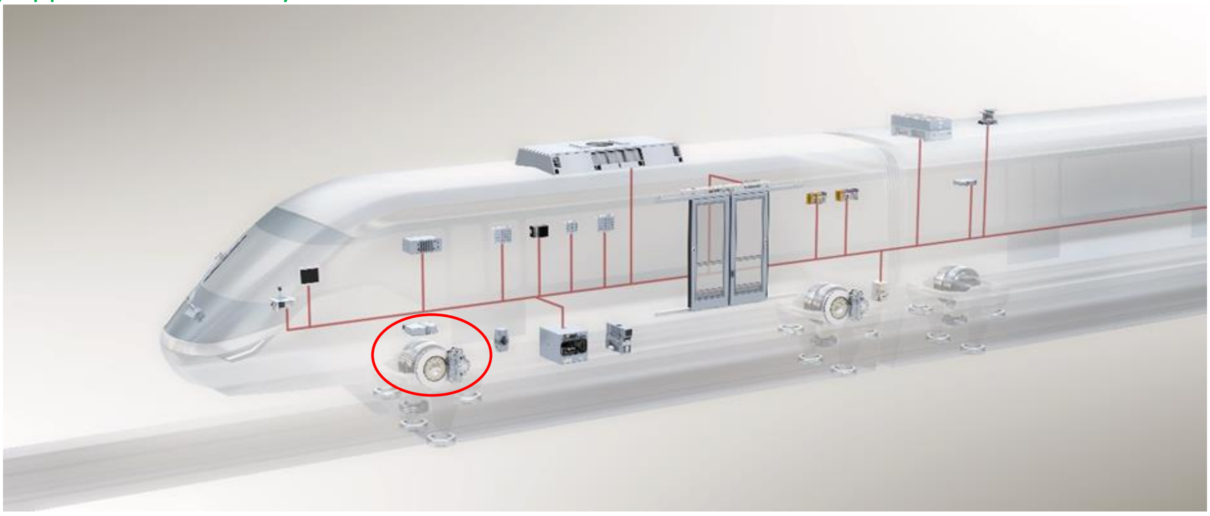


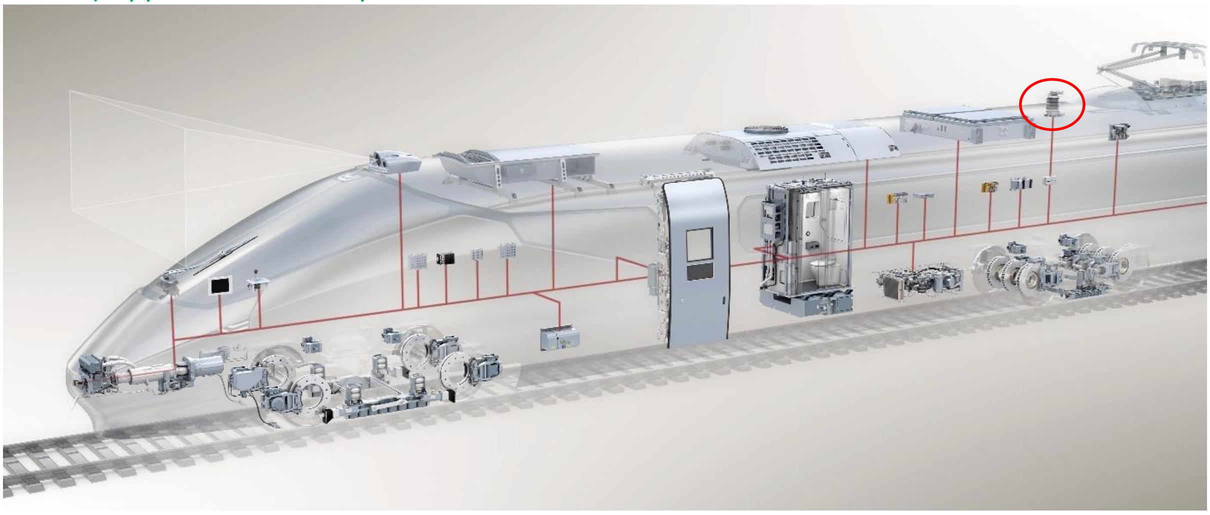

Figure 16: location of the hydraulic system in a train.

**Hydraulic Magnet and Proportional valves are used to control the hydraulic brake pressure.**
PFAS are used for sealing between coils and valve bodies in high-temperature areas, as other materials (e.g., NBR) cannot withstand the temperature generated due to magnetic coils' heat generation. Today, there are no known alternatives. Other materials (like NBR) cannot be used in high temperatures without losing their sealing functionality. The failure of sealing functionality will lead to loss of availability of the complete vehicle -> shortening of lifetime by 90% or more is expected to compensate for the reduced reliability.

**Sliding sealing rings in mechanical pressure switches or pressure limiting valves in the hydraulics**
PTFE is used in sliding sealings, which secure the main functionality of the assemblies. Sliding sealings in these applications need a high resistance against mechanical wear and pressures and need to resist hydraulic fluids. Using other improper materials may result in a loss of function of the part.

In the case of the pressure switch, it means that the use of unsuitable material may lead to a wrong pressure signal, which leads to dragging brake potential (fire incident on the train), whilst for pressure limiting valves, it may lead to wrong pressure adjustment, which leads to a train without enough braking force.

### 2.1.5.6) Applications in the power electrics

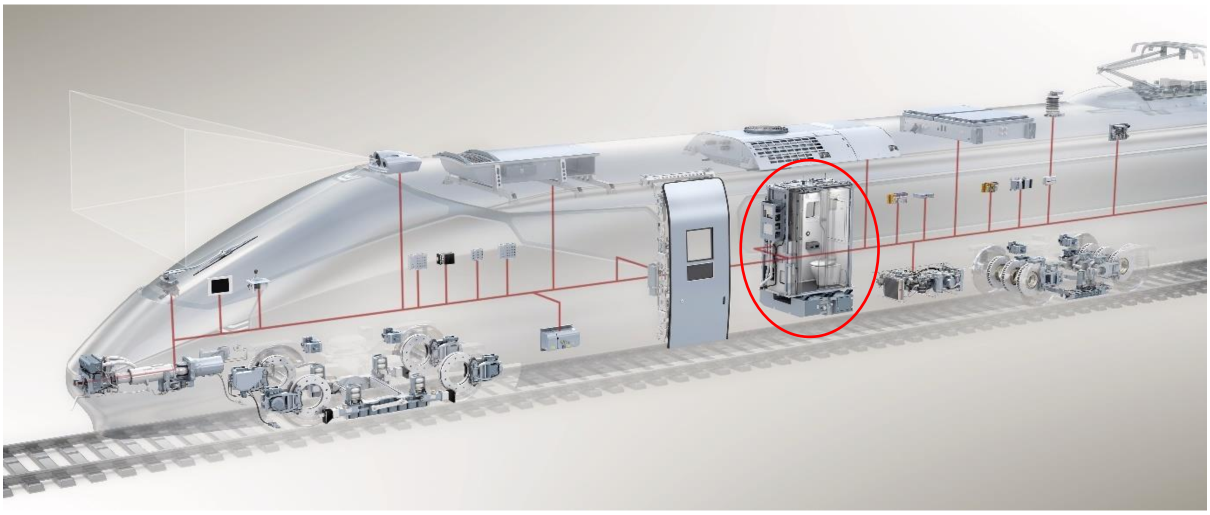


© Knorr-Bremse
Figure 17: location of the power electrics system in a train.

PFAS are used in the following parts for wear resistance at high temperatures:
- Contactor core,
- Bushing,
- Adhesive tape,
- Humidity valve,
- Insulating pipe,
- Insulator,
- And various mechanical parts.

PTFE is typically used, but ETFE in tubes and insulators is used for the same reason.

### 2.1.5.7) Applications in the sanitary systems



© Knorr-Bremse
Figure 18: location of the sanitary system in a train.

PTFE is used as a surface coating for the functional area in the following parts:

- Ball valves,
- Control boards and panels
- Gaskets,
- Line strainers,
- Hoses,
- Pipes,
- Sealing rings,
- Resolvable screw connections,
- And other parts of the sanitary systems.

## 2.2) Fluorinated gases used

In the rail sector, and in particular in rolling stock manufacturing, the use of fluorinated greenhouse gases (F-gases) is present in different applications:

**Fire suppressants**
In automatic fire systems, fluorinated gases (hydrofluorocarbons) are common.

**Air conditioning and heat pumps**
All current HVAC systems rely on fluorinated gases (hydrofluorocarbons), except in a few cases where natural gases have been used since 2022. The transformation from fluorinated gases to natural gases (R-290 – Propane, R-744 – $CO_2$) has been started and is accelerating. Train projects using only natural refrigerants in HVAC systems are in place. This will also allow the rail sector to align with the future revised F-Gases regulation.

**Refrigeration**
Fluorinated gases (hydrofluorocarbons) are used to refrigerate the catering equipment in the restaurant vehicle and refrigerate the traction battery using lithium technology. During the manufacturing and testing, fluorinated gases are used for the burn-in test of the electronic board and the validation of the rolling stock in a climatic chamber. Also, natural refrigerants can be used for this application and are in first serial applications.

**Electrical switchgear**
The voltage switchgear uses fluorinated gases (perfluorinated compounds) in the power station.

The use of fluorinated gases is already regulated by the EU regulation 517/2014. This regulation imposes quota reduction, prohibiting the placing on the market for several applications. This regulation is ongoing and revised, and the new regulation will be published in 2023 with additional quotas reduction to achieve the 2016 *Kigali Amendment to the Montreal Protocol* and new prohibitions on the placing on the market. The leak checks will be applicable for rolling stock to prevent environmental leakage. The restriction proposal on PFAS generates double restrictions for the same application with different deadlines.

HVAC units are also part of the rolling stock used by rail operators and used in control-command and signalling devices. Due to the long lifetime of rolling stock, the particularities of the rail sector have to be taken into account, and the HVAC units are designed for a long operation duration, averaging 30 years. Replacing all these existing units would cause high costs of several billion euros and huge amounts of waste for rail operators and significantly weaken their competitiveness as the most sustainable mode of transport. These costs for operators must be weighted with the continuously reduced and already small amount of f-gas for maintenance. In addition, the HVAC industry, just like EVU, is affected by the shortage of skilled workers and thus does not have the engineering and manufacturing capacity for a complete replacement within the given timeframe of PFAS restrictions.

## 2.3) PFAS used in electronics and semiconductors

In the rail sector, the use of PFAS in electronics and semiconductors is present in different applications:

**Wires and cables**

For railway traction motors, PFAS are present in the wires' insulation used to manufacture the winding.

The rectangular copper wire used in traction motors is insulated with a Polyimide tape (PI) with one side coated with fluorinated ethylene propylene (FEP). The layer of FEP is necessary to ensure good adhesion of the Polyimide film on the copper during the wrapping operation. There is no alternative to allow good adhesion of the Polyimide film on the copper wire. With this insulated copper wire, with excellent sealing of the Polyimide film on the copper wire, it is possible to form traction motors' coils to the final geometry (form-wound winding) in deforming the copper wire in all directions without damaging the insulation. The coil-forming process is very stressful for the insulated copper wire. Without a good adhesion of the Polyimide film/FEP on the copper, obtaining the coils for form-wound winding is impossible. Lastly, form-wound winding (using PI-FEP film on copper wire) is the only way to make traction motors winding able to support high temperature (240°C), high voltage (between 900 V to 5000 V), harsh environmental conditions (pollution and humidity), mechanical stresses due to vibrations during a very long lifetime (40 years).

This use is generalised to all railway traction motors and for all train applications combined (tram, metros, regional, high speed and locomotives). Moreover, after manufacturing the traction motor, the PI-FEP is included and maintained inside the insulation system with no possible emissions outside the motor and a limited environmental pollution risk. A failure in the insulation system may lead, in combination with an unlikely malfunction of the used shut-off device, to fire and can therefore be considered safety-relevant. Other materials such as sheath and heat shrinkable tubes are also made with a fluoropolymer (polyvinylidene fluoride (PVDF), or polytetrafluoroethylene) and used in form-wound winding of a traction motor to meet the same technical constraints.

**Cable insulation**

Signalling equipment installed along the wayside (balise, encoder, field device control) is developed to work in a harsh environment in an extensive temperature range. Cables using PTFE tapes have been selected for their ability to support high temperature, high voltage, extreme environmental conditions (pollution and humidity), and mechanical stresses due to vibrations during a very long lifetime (40 years).

**Cables for magnetic coil, used in valves for pressure control of the hydraulic brake**

PTFE is used in cable insulation to fulfil fire protection requirements set by European norms (e.g., EN 45545). Electric functions without proper insulation will lead to an immobilisation of the complete train. In case of unsuitable alternative material usage, there is a risk to human health due to releasing toxic substances in case of fire.

**Electronic components, semiconductors and coatings**

All railway products (rolling stocks, signalling equipment, infrastructure) need circuit boards with components to ensure operation and safety. Most components used on these circuit boards use PFAS and fluoropolymers.

**Two-phase cooling for power semiconductors**

PFAS-based heat transfer and semiconductor cooling substances such as FC-3284, FC-72, or Novec 649 are non-conductive, thermally, and chemically stable fluids with low boiling points and high latent heat, which are ideal for use in single- and two-phase heat transfer fluid applications, such as semiconductor package testing, power electronics and computer cooling. While there is no longer a need for those substances in state-of-the-art rail products and components, existing, e.g., metros that are well established in many European cities, still rely on these substances for maintenance purposes, e.g., two-phase cooling systems for power semiconductor modules in power converters. The main reason for regular re-filling or replacement is contamination of the substances, which thus requires cleaning or filtering.

**Power semiconductors**

They are also an essential element of electric trains, as these devices control the electric power used for the traction system. PFAS substances are extensively used in the fabrication process of semiconductors because of their unique properties. For a more detailed presentation, please refer to the contributions of *Orgalim*, *SEMI* (ECHA's consultation reference number 4304) and *ESIA* (ECHA's consultation reference number 4449).

**RF (Radio Frequency) connectors**

They are used in PFAS fabrication and as insulator PTFE because of low power loss. For instance, they are used in Tag Reader to connect radio frequency antenna to ETCS.

**Cooling systems**

These systems need specific components to ensure operation and resistance, which is only possible using PFAS materials, allowing energy efficiency as a compressor, control valve or sensors.

**Various electronic assemblies in the Brake Control (capacitors, plugs, transducers…)**

These items are used in the electronics of the brake control systems and indoor control systems. Commonly used is FPM/FKM, e. g. in plugs for specific cabling. Furthermore, various fluoropolymers are used in capacitors as dielectric films and occasionally as liquid impregnates. They are used for their high dielectric strength, heat resistance, and ability to be produced into thin films.

**Insulation materials or cable insulation in power converters of trains**

PTFE and PVDF are ideal materials as they show the highest possible tracking resistance (i.e. the resistance against the formation of conductive paths on the surface of an insulator) and, at the same time, withstand extreme working temperatures and high electric fields, which is both a safety and a functional requirement. The materials provide a unique mixture of properties to ensure safe operations of the converters over a typical 30-year lifetime.

## 2.4) PFAS used in the energy sector

### 2.4.1) Batteries

In the rail sector, batteries containing PFAS are used for rolling stock, signalling equipment or infrastructure. Their functions are mainly onboard backup, engine starting, regenerative traction, and trackside applications. Batteries are also found in defibrillators present today in many trains.

For instance, the on-board battery systems provide backup power to support vital safety and control functions, including:

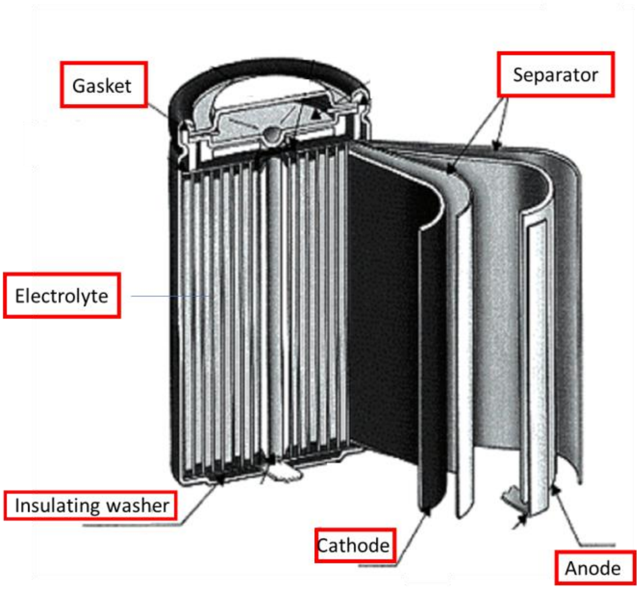
- braking,
- smoke detection,
- emergency lighting,
- door opening.

Traction batteries are already used onboard tramways to provide traction energy when catenaries or third rail are to be avoided (e.g. historical centres, tunnels, bridges). Also, they will allow replacing Diesel propulsion to reach the *European Green Deal*'s targets. The goal is to replace Diesel propulsion on lines where electrification is not done, typically lines with lower traffic that did not satisfy the economic equation to amortise catenary infrastructure investment costs.

Examples of batteries for trackside applications are uninterruptible power supply for station or traffic control, to allow passengers to leave the station in case of grid power loss, or trackside signalisation to continue to issue orders to train drivers (e.g. Diesel operated, thus not impacted by grid loss) when main power has collapsed. They also support railway crossings to ensure the safety of citizens when they want to cross a rail track or switch to continue to let trains follow their intended route.

As chemical resistance and tolerance to a high range of working temperatures are crucial for batteries, PFAS, mainly fluoropolymers, are critical components for all high-performance and lithium battery technologies. As depicted in Figure 19, PFAS are used in essential components of:

- Cathode,
- Anode,
- Separator,
- Gasket,
- Electrolyte,
- Insulating washer.




© SAFT
Figure 19: where PFAS are used in a battery.

At the battery system level, some critical components like connectors, contactors, relays, self-welder sleeves, LHD (Linear Heat Detection) cables, cable ties and vents use PFAS (mainly PTFE, PVDF, ETFE and fluorosilicone).

For a more detailed presentation, please refer to the second contribution of *RECHARGE*.

### 2.4.2) Proton exchange membrane (PEM) fuel cells

Hydrogen fuel cells are electrochemical devices fitted in modules and deployed for heavy-duty transportation applications. In the rail sector, hydrogen fuel cells are well suited to replace heavy diesel engines (no tailpipe emissions) wherever catenary infrastructure or battery storage is inappropriate. In short, fuel cells are the device that generate electricity from on-board hydrogen.

Fuel cells consist of individual cells piled up in series, also called a "stack". The voltage of all the cells adds up to provide the required tension in the system. Breaking down the individual cell further reveals three significant components for the operation: The hydrogen compartment, a proton exchange membrane (or solid electrolyte) and its catalyst layers, and the air compartment. The proton exchange membrane (PEM) is used as the electrolyte. The PEM is vital to the operation and works optimally based on perfluoro sulfonic acid (PFSA) fluoropolymer.

The cells operate at relatively low temperatures and can quickly vary their output to meet shifting power demands. Whilst protons flow through the membrane, electrons follow the external circuit pathway to generate electric power. When the loop is completed, water and electric current are generated, and heat is dissipated.

For a more detailed presentation, please refer to the contribution of *Hydrogen Europe* (ECHA's consultation reference number 4144).

## 2.5) PFAS used in lubricants

**Traction motors**

Lubricating grease using PTFE is used for lubrication of the bearings of the traction motors for high-temperature applications. PTFE has excellent thermal resistance, which gives the perfect stability of the lubricating grease without performance losses and does not need to be replaced regularly.

Very high-performance greases based on PFPE oils are used in railway vehicles because of their excellent lubrication properties at a wide temperature range and the high protection corrosion level they provide for a long time. The traction motor bearings use these greases due to the outstanding characteristics for oil retention at high permanent temperatures and good corrosion protection and water resistance, offering an extremely long service life.

For turnout systems in the railway infrastructure, some slide chairs for switching the switch rails to the desired direction must be regularly lubricated with PFAS lubricants.

For a more detailed presentation, please refer to the contribution of *ATIEL* (ECHA's consultation reference number 4423).

## 2.6) PFAS used in TULAC (Textile, upholstery, leather, apparel and carpets)

In the rail sector, technical textiles such as membranes/filters in valves/venting are widely used in different applications for transport, the energy sector (battery), electronics and semiconductors.

**Energy sector (battery)**
A fragile permeable membrane of PTFE is used in venting valves for cell, module or battery system casing. The purpose of these venting valves is to evacuate pressure and gases associated with the potential thermal runaway of a single cell or module. At the same time, due to the unique properties of PTFE, these valves prevent the ingress of moisture, water, dirt and dust into the batteries, which is particularly important for batteries that operate outdoors in harsh environmental conditions.

**Electronics and semiconductors**
The infrastructure systems use electronic products deployed along the tracks. In this configuration, electronic devices must be maintained in a water-free environment. The product is placed in a waterproof envelope with an IP68 sealing protection level, i.e., a device can survive against dust and up to 1.5 metres of water for 30 minutes. This solution is sensitive to the phenomenon called "pumping": temperature variations of the environment or the product changes the air enclosed in the product pressure. These changes make the seals work excessively and do not guarantee the water tightness of the product over a long period. The solution to the pumping effect is to use a protective vent, which uses a membrane made with PTFE. The microporous structure of the membrane allows the free passage of gases while at the same time preventing water, dust and salt crystals from entering the enclosure.

# 3) Analysis of alternatives

## 3.1) Alternatives to PFAS used in applications affecting the proper functioning related to the safety of transport

As fluoropolymers or fluoroelastomers are widely used in the rail sector to ensure products' safety, the maturity and availability of alternatives depend on the application.

### 3.1.1) Sliding and guiding applications

#### 3.1.1.1) Sliding elements and parts

The rope will have poor guiding performances without a flexible PTFE tube. This can cause operational issues, leading to train downtime. New solutions must be qualified to check their compatibility with the subframe environment.

Alternatives covering the full range of applications of PTFE and PVDF in sliding and emergency running applications are not yet on the market. Other options, if available, would require extensive testing, re-certification, and, in many cases, re-design of equipment or products. In applications such as flexible PTFE tubes to guide and protect a rope or cable., the PTFE ban will result in poor guiding performances in non-PTFE tubes. This can cause operational issues, leading to train downtime. New solutions must be qualified to check their compatibility with the subframe environment. For sliding element applications made from PTFE, the non-PFAS alternative material ultra-high molecular weight polyethylene (UHMW-PE), as proposed in the restriction dossier (Annex E.2.10), is not applicable for rolling stock product sliding applications as they need to comply with special requirements regarding tolerance values, service temperature, lifetime, or chemical resistance, etc. according to the respective homologation.

**PTFE-made friction and compression rings**

Used in oil-free compressors, they are a crucial component in operating motor compressors with this technology. They required years of fine-tuning to ensure the durability and reliability of previous technologies based on lubricating oil, which is much more polluting and dangerous. There are currently no known alternative materials with comparable durability and reliability.

#### 3.1.1.2) Guiding segments

The PTFE used for guiding segments leads to a good friction coefficient and lifespan and withstand the severe conditions met during running service. Currently, PTFE is used and fully compliant with safety requirements. Today, no alternative is known to replace PTFE material. Alternative materials must be validated in every detail to fulfil the requirements. An extensive validation requires many engineering hours, substantial financial resources for validation tests (on the test bench and track tests), and customer support. It will take several months, and it is uncertain whether to reach the expected results with the first mixture.

#### 3.1.1.3) Pneumatic valves of brake control devices

PTFE is used for both static and dynamic functions when subject to friction. Other commercially available materials can more easily replace these applications in the case of low-duty cycle functions.

It should be noted that these materials are generally present in small quantities, tens of grams at most, remain on the train for even ten years or more and do not release particles directly into the environment.

Teflon-based lubricants are widely used for these functions. These very high-performance products have been introduced in the design for at least a couple of decades by significantly improving the sliding of the moving parts, ensuring more excellent durability and reliability, which can remain in operation for very long before being disposed of. Currently, no known alternatives can guarantee the benefits obtained with these products. In this case, a few grams of PFAS per valve are generally enclosed within the device and almost negligible release into the environment.

#### 3.1.1.4) Plain bearings

For emergency running properties of lubrication-free bearings, the alternatives proposed in the restriction dossier (such as PA, PBT, PEEK, PP and Silicones; Annex E.2.10) are mechanically unsuitable for the applications, except for polyamide (PA). However, PA is only suitable if the temperature range is suitable and if environmental influences or aggressive media are kept within certain limits. Without emergency running properties of specific plain bearing applications, it would be necessary to revert to conventional technology with roller bearings and lubricants, thereby abandoning the low maintenance and environmentally friendly oil-free design. In some plain bearing applications, no real alternatives would last typical 30 years of safe operation.

#### 3.1.1.5) Hose assemblies, joint heads, couplers, threads, and related applications

They require protection or resistance to aggressive media and extreme operating temperatures, or both, highly depending on the availability of PTFE and PVDF. Thus, even the restriction dossier does not propose alternative materials. This is because such materials do not exist at present. The relevant suppliers of these materials also confirm and warn that suitable substitutes will not be available soon.

### 3.1.2) Sealing applications

#### 3.1.2.1) Bogie and transmission

In the past, many tests on the bench and in commercial service have been carried out to validate the materials capable of guaranteeing these performance requirements. From using NBR (nitrile butadiene rubber) materials, the experts were initially led to use more technical materials to meet the stricter performance requirements. To date, only FKM materials are validated for sealing solutions. In some applications, using HNBR could be an alternative to FKM seals, but this substitution will involve design modifications and requalification tests. The current seals with FKM cannot be replaced directly in the actual design and the existing fleets of trains in operation. Requalification tests would require many engineering hours, extensive financial resources, customer support, and delays of several months. All this on a large number of references and projects. Prohibiting the use of this type of material would lead to two significant constraints:

- The need to review the validation of the static and dynamic seals of the gearboxes via the development of alternative materials for the delivery of new equipment.
- The impossibility for the customers to obtain spare parts to carry out maintenance operations (as a reminder, the trains are defined for a contractual life of 30 to 40 years).

### 3.1.2.2) Traction motors

Alternative materials to fluoroelastomers (FKM and FPM) for sealing gaskets do not have the same chemical resistance, meaning lower performances and shorter lifetimes. No known alternative is available for this application.

### 3.1.2.3) Dampers

The seal material's composition is a critical parameter for good tightness. Suppose something is modified in the tightness function (seal shape, seal material, rod condition surface, rod surface treatment). In that case, extensive validation must be done to be sure that the new conditions of the tightness function will give an equivalent behaviour. Seals are in contact with the oil of the dampers. It could be possible to use seals in NBR as it was done 20 years ago, but a redesign is mandatory, and the performances have to be validated. HNBR could be a possible alternative for seals under the condition to succeed in performance and fatigue tests. Anti-yaw dampers that use these seals are safety-relevant, and any modification must be validated in every detail. An extensive validation requires many engineering hours, substantial financial resources for validation tests (on the test bench and track tests), and customer support. It will take several years, knowing it is not sure to reach the expected results with the first mixture. The polymer market currently does not provide material comparable to FKM for sealings and dampers used under harsh conditions in rail vehicles. Alternative elastomers mentioned in the restriction dossier (Appendix E.2.10), such as rubbers, polyurethanes or silicones, do not meet the requirements regarding extreme temperature ranges or aggressive media. For FKM substitution research applications, testing and implementation until market maturity level would take more than ten years.

### 3.1.2.4) Traction transformer

In some past projects, the use of NBR and HNBR seals has been realised, but it depends on the temperature ranges and especially on the compatibility of the seals with the oil used. While switching to NBR or HNBR seals, the OEMs must requalify the seals with the oils used and guarantee a hold on the temperature ranges. Oil manufacturers perform qualifications. Few alternatives can be used from -50°C to +150°C.

### 3.1.2.5) Tank wagons for the transport of dangerous goods

To the European rail sector's best knowledge and supported by the European Sealing Manufacturers and ITCO, no alternative materials would perform as well as existing solid PFAS sealings required for chemical thermal, plasma and radioactive resistance for seals.

Less-performing alternatives would significantly increase the risk of leakages and threaten the environment and human health due to the more frequent replacements of sealings and the risk of contamination and leaks.
For a more detailed presentation, please refer to the contribution of *UIP* (ECHA's consultation reference number 6213).

### 3.1.2.6) Cooling system components with PTFE or FKM sealing

They cannot be changed without the proof of their suitability. Alternative PFAS-free materials are unavailable due to the exceptionally severe operating requirements.

### 3.1.3) Coatings, adhesives and finishing

**Liner on ball joints and rods**

Lubrication can be done using liquid grease. However, in the railway industry, finding a grease that can do lubrication and shock and vibration suppression has been proven impossible while guaranteeing the required load, angular capacity and lifetime (10 years at least).

Regarding the use of lined bearings in railway vehicles, there are no alternatives available in the market without PTFE that can achieve the performances of the current solutions. Using this bearing in safety-related elements of the trains makes it difficult to substitute them with products with less reliability or worse performances under extreme conditions where the trains are used.

**Painting and corrosion protection in the air supply unit**

Alternatives are not available soon.

**Zinc flake coating**

This is a safety-critical point for which there is currently no alternative known.

### 3.1.4) Detailed application per main system

### 3.1.4.1) Air supply unit

**Relief valve used in the air supply unit**

Alternatives are possible. However, homologation and qualification of the proposed solutions will take several years. Developing and qualifying alternative material is without guaranteeing success. These potential alternatives are not available soon.

**Piston ring and piston in the air supply unit**

There is no alternative known. Based on the experience of developing the current system, a PFAS-free alternative is hardly imaginable. As outlined above, alternative materials must provide an extremely low friction coefficient, high-temperature resistance, and mechanical strength. Simultaneously, the coating must not have an abrasive effect on the counterpart. The research and development of alternatives without PFAS will take several years, and the homologation and qualification of the proposed solutions will also take several years.

**Oil pipe, screw fittings in the air supply unit**

One theoretical alternative could be NBR rubber. However, NBR is unsuitable due to insufficient resistance to high and low temperatures. Additionally, NBR does not have sufficient resistance to elements such as oil, grease and water. These elements could be found inside the compressed air, causing damage to the whole system.

**Casing in the air supply unit**

There is an alternative available, but not enough information about it. It is required to test and validate these alternatives before using them.

**Needle bearings in the air supply unit**

Suitable alternatives for PFPE-based grease in this specific application are currently unknown. However, it would be possible. Homologation and qualification of the proposed solutions will also take several years.

**Shaft sealing rings and O-rings in the air supply unit**

Alternatives are possible, however, depending on the concrete use-case unknown. Homologation and qualification of the proposed solutions will also take several years.

**Valve cones in the air supply unit**

Currently, there is no known alternative.

**Safety valve, minimum pressure valve in the air supply unit**

Currently, no alternatives are known. General rubber materials may not endure the described requirements.

#### 3.1.4.2) Brake control

**O- Rings in switching cylinders in the brake control**

As an alternative, low-temperature nitrile rubbers could be tested, and other possibilities have to be checked. However, current limitations are high-temperature properties, chemical resistance, dynamic impact properties, questions about cost, certification and homologation, which require several years without guarantee of success. Alternatives are not available soon.

**Guides (solenoid valves) in the brake control**

Alternatives could be TECASINT 2021 (Polyimide) or POM. However, availability, price and function must be checked and validated before replacement.

#### 3.1.4.3) Bogie equipment

**Slide bands, bushes, bandages, gaskets, swivel bearings, and different rings (spacing ring, thread seal ring, etc.) in the bogie equipment**

Compliance with Standards of alternative material cannot be guaranteed. Some standards require, e.g. efficiency and sensitivity for brake mechanics products, which must also be met in different environmental conditions (e.g. low-temperature performances). Currently, alternatives are in development for some of these use cases. However, no information on other options is available for most use cases. The development and validation of alternative solutions take time.

#### 3.1.4.4) HVAC

**Washers, bushings, gaskets, and supporting plates in the HVAC**

Suitable alternatives for PTFE-based joints in this specific application are currently unavailable. However, they are in development.

**Valves in the HVAC**

Suitable alternatives for PTFE-based joints in this specific application are currently unavailable. However, they are in development.

**Fans in the HVAC**

Suitable alternatives for PTFE-based joints in this specific application are currently unavailable. However, they are in development.

**Compressor in the HVAC**

Suitable alternatives for PTFE-based joints in this specific application are currently unavailable. However, they are in development.

### 3.1.4.5) Hydraulic

**Hydraulic Magnet and proportional valves used for pressure control of the hydraulic brake**

Alternatives are not available soon.

**Sliding sealing rings in mechanical pressure switches or pressure limiting valves in the hydraulics**

Alternatives are not available soon.

### 3.1.4.6) Powe electric and sanitary systems

**Contactor core, bushing, adhesive tape, humidity valve, insulating pipe, insulator, and various mechanical parts in the power electric**

Alternatives are not available soon.

**Ball valves, control boards/ panels, gaskets, line strainers, hoses, pipes, sealing rings, resolvable screw connections and other parts in the sanitary systems**

Alternatives are not available soon.

## 3.2) Alternatives to fluorinated gases

As far as the use of fluorinated greenhouse gases in the rail sector is concerned, **the development of alternatives is gradually starting to be mature enough for large-scale deployment on some applications,** as evidenced by the first projects:

**R-744 ($CO_2$)**
The use of R-744 ($CO_2$) as a natural refrigerant in eco-friendly HVAC units has been simulated, developed and tested in real operation in the *Shift2Rail* research projects *PIVOT2* and *PINTA3*, to be finalised in 2023. These solutions are less efficient regarding weight/volume due to higher working pressure and less performant in higher ambient operational temperatures. Therefore, state-of-the-art HVAC equipment with alternative fluids does not yet follow the railway market requirements, such as weight reduction (significant for battery trains) and good performance in extremely high temperatures (more common due to the climate change adaptation needs).

**R-290 (Propane)**
Refrigerant R-290 (Propane) was also deeply investigated by two major HVAC railway suppliers and a railway operator in 2019-2021, with a prototype in a field test on a regional train. The first projects with R-290 HVAC in serial production are under development and will start operation in 2023. With R-290, these solutions have similar weight/volume/energy consumption performance, but the safety concerns related to the gas flammability need to be respected. The first projects have demonstrated technical feasibility for operation in the opened field of trains with roof-mounted HVAC, typical application of mainlines or regional trains.

Safety studies require a strong collaboration between HVAC suppliers, car builders, rail operators, and assessors (Independent Safety Assessors and Designated Bodies (DeBo) in case of specific *National Safety Rules*) to check all the use cases in the life cycle of the product (manufacturing, transport, assembly, operation, maintenance and end of life). So far, only a few stakeholders in specific markets have reached maturity. In conclusion, R-290 is a potential alternative, but its suitability for all railway applications has not yet been validated and proven in the field.

### 3.2.1) Air conditioning and heat pumps

#### 3.2.1.1) On technical feasibility

So far, the development of solutions with natural refrigerants has started only for a few product applications, i.e. for mainlines and regional and only in a few countries; for the rest of the European market, no solution has been realised. However, it is likely that the number of projects using HVAC units with R-290 will quickly increase in the coming years. Still, a full implementation of these solutions will take up to ten years due to product development time in the railway industry.

Refrigerant R-744 ($CO_2$) is not an acceptable alternative for all applications due to environmental reasons. It has a higher weight (leading to an increase in energy consumption for traction) and higher cooling power consumption, especially in conditions of external temperature higher than 40°C, where most trains in the EU must operate.

Extensive test campaigns are ongoing to prove the use of R-290 is safe in other applications such as metro/underground operation, roof-embedded HVAC units, or both.

### 3.2.1.2) On project execution

As far as R-290 is concerned, no international nor European railway standard is available yet for using flammable refrigerants for HVAC, as it is for other domains (for instance, IEC 60335- 2-40[1] for household appliances). Nevertheless, a draft of the German standard (DIN 27165), which has been elaborated and is currently in the discussion phase, may be the starting point for creating a European-wide or even international standard.

Therefore, any project relying on R-290 will suffer during a transition period from a longer time to deliver trains, as the safety study hypothesis and methodology must be discussed case by case for each project with the HVAC supplier, rolling stock manufacturer, operator, maintainer, Independent Safety Assessor, Notified Body (NoBo) and Designated Body (DeBo), that is providing the third party assessment as required in Interoperability Directive 2016/797.

### 3.2.1.3) On economic feasibility

The initial cost of a refrigerant R-290 HVAC unit or R-744 ($CO_2$) unit is still higher than that of a unit equipped with existing refrigerant R-134a (HFC) or R-513A (a blend of HCF/HFO). For instance, in the case of R-290, the maintainer would have to adapt their infrastructure and process to the characteristics of R-290 proof (sufficient ventilation, new procedures, particular storage area, etc.).

### 3.2.2) Refrigeration

To this day, alternatives to fluorinated gases for burn-in tests and climatic chambers, based on R-290 refrigerant, exist in the operating range between -20°C and +60°C and for the test of medium and small-scale equipment. No alternative exists for applications outside this temperature range to test big-scale equipment, such as a complete car body or train.

Recent installations using natural gas like R-744 ($CO_2$) are not considered adequate alternatives, as they use hydrofluorocarbons in addition to $CO_2$.

### 3.2.3) Fire suppressants

Alternatives to PFAS exist on the market but not for every applications.

### 3.2.4) Electrical switchgear

Alternatives to PFAS exist on the market.

## 3.3) Alternatives to PFAS used in electronics and semiconductors

Detailed alternatives per application

### 3.3.1) Wires and cables

Today, regarding the high performance of traction motors, no known alternative exists to using Polyimide (PI) and Fluorinated ethylene-propylene (FEP) tape. The use of this tape is common in all industries manufacturing traction motors. The development of alternatives by the suppliers of copper insulation without PFAS will take several years, and the homologation and qualification of the proposed solutions will also take many years. The development and qualification of new materials risk failure in the end. Developing an alternative material to Polyimide/FEP is very challenging. It includes several technological barriers to overcome to find an equivalent solution with the same technical performance.

On the one hand, products used in the automotive industry for electrical motors, such as enamelled copper wire or fibre-insulated wire using Polyamide-imide varnish, cannot be used for railway industry traction motors because this insulation is not able to support the coil-forming process of a form-wound winding without cracking. The temperature and voltage resistances are too low compared to Polyimide/FEP film. The electrical motors in the automotive industry use completely different winding processes (random wire technology or hairpin technology) compared to the traction motors manufactured for the railway industry (form-wound winding), and the technical constraints are different. In the automotive industry, the voltage levels are lower (400V compared to 900V minimum), the temperature conditions are lower (not 240°C as in railway), and the lifetime of an automotive vehicle is also significantly shorter, 12 years compared to the 40 years of a train lifetime.

On the other hand, the technologies of high-power electrical motors manufactured for heavy industries (steelmaking industry, for example) or nuclear power plants cannot be used because the design constraints are entirely different. Voltage levels (6 600V) are higher than in railway, with lower temperature resistance materials (155°C vs 240°C), and for a different lifetime.

In conclusion, materials used in other fields cannot be used for the traction motors in the railway industry.

**Highly resistant adhesive layer in wire insulation used in electric motor coils**
Drop-in alternatives of FEP in electric insulation applications, such as motor coil insulation systems, are not yet on the market. FEP alternatives for motor coil insulation systems that are in research are, e.g. polyimide (PI) materials. However, market readiness will take at least five years. The PI solution will increase the product prices significantly. Expected is more than a doubling of costs per subpart. Another PFAS-free insulation system is already under development, which does not need any thermoplastic adhesives. This new technology is not expected to be available before 2030.

**Insulation materials or cable insulation in power converters of trains**
It must ensure the highest tracking resistance. Thus, PTFE and PVDF are the ideal materials. Without a drop-in replacement, a considerable engineering effort would be required, focusing on, e.g. drastic changes to the mechanical design.

### 3.3.2) Electronic components, semiconductors and coatings

The semiconductor production industry uses PFAS widely in chemical formulation, components of manufacturing process tools, facilities and packaging. The current semiconductor state of the art is critically reliant on PFAS chemistry. Nowadays, there are no alternatives in the market for producing non-PFAS semiconductors.

Parallel to the application in rolling stocks, this also applies to the railway infrastructure. Signalling equipment and point machines for turnout systems are essential for operating a modern railway system.

PFAS can also be used in electrohydraulic point machine systems as sealings in the railway infrastructure due to their water-repellent properties. Point machines are essentially for the safety and functionality of the railway network, and correct functioning avoids failures and accidents.

Alternatives for PFAS in the two-phase cooling technology for power semiconductors in power converters are unavailable. As the technology and the related products are mainly outdated, there is currently no attempt or business case for suppliers of the substances to research alternative non-PFAS substitutes.

Drop-in alternatives for PFAS used as insulation material in power converters are unavailable. While there are indeed PFAS-free materials that will be used in new designs, to substitute PFAS in established power converter technology, the mechanical design of the converter would need to be changed. Apart from the immense effort of developing this altered design, maintenance and supply of spare parts pose a significant problem.

For a more detailed presentation, please refer to the contributions of *Orgalim*, *SEMI* (ECHA's consultation reference number 4304) and *ESIA* (ECHA's consultation reference number 4449).

### 3.3.3) Various electronic assemblies (capacitors, plugs, transducers…) in the brake control

Alternative polymers for use as dielectric films are theoretically available. However, it can be assumed that, at least not for all use cases, alternatives are available or in development today. A complete analysis of > 1,000 capacitors would be required to get the complete picture.

### 3.3.4) Cables for magnetic coil, used in valves for pressure control of the hydraulic brake

Today, there are no known alternatives. The development of other materials for insulation without PFAS that can fulfil the fire protection requirements will take several years, and the homologation and qualification of the proposed solutions will also take several years. Of course, the development and qualification are without guarantee of success. Alternatives are not available soon.

## 3.4) Alternatives to PFAS used in the energy sector

### 3.4.1) Alternatives to PFAS used in batteries

Contrary to what is stated in Annex E of the PFAS restriction proposal (page 416), solid-state and lead-acid batteries are **not potential** non-PFAS alternatives to Lithium-ion batteries. This is because:

- Solid-state batteries use PFAS, specifically PVDF and PTFE:
    - In the binder within the active material,
    - In solid electrolytes and,
    - In gel polymer electrolytes.
- Although lead acid batteries do not use PFAS, they have a low energy density. They cannot be used in applications which require high energy, high power, very long life, superior reliability, and the ability to withstand extreme temperatures.

#### 3.4.1.1) Use of PVDF and PTFE as electrode binders

PVDF is the binder material in the active masses for electrodes for the Li-ion wet process (except for the graphite anode), Na-ion, Lithium metal rechargeable, and solid-state batteries. All attempts to replace PVDF binder materials with other polymers for the positive electrode have caused cell performance and manufacturability issues. The degradation of alternative binder systems in the electrolyte has been demonstrated for the positive electrode. The European Commission has recently funded the GIGAGREEN research project on dry alternatives and water-based binder systems for the positive electrode, which propose to utilise a range of polymers including CMC/SBR, poly(acrylic acid), sodium alginate, polyurethanes and catechol-bearing polymers.[3.] Whilst these initial research studies have indicated that these aqueous binder systems may have good adhesion properties, further research and development are required to investigate whether these alternatives have adequate chemical, mechanical, and electrical properties[4]. Significant concerns exist about whether water-based CMC/SBR technology will have the necessary rheology and stability to match today's positive electrode active materials such as LCO, NMC, NCA, LNMO, and LFP. There are specific concerns about water use in the slurry production and the electrode coating, drying and calendaring processes, mainly if the water is not completely removed before the battery is assembled.

PTFE is used as the binder material in the active masses for electrodes for Li-ion dry process and semi-dry process, Li primary, Ni-Cd, Ni-MH, Zinc oxide, metal-air, Silver oxide, Zinc-ion rechargeable, Lithium metal rechargeable and solid-state batteries.

There are currently no alternatives to PTFE due to its unique combination of properties that are essential for the performance and durability of these batteries, especially for the following:

[3] Funding & tenders, Towards the sustainable giga-factory: developing green cell manufacturing processes (GIGAGREEN). (n.d.) https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/how-to-participate/org-details/999999999/project/101069707/program/43108390/details

[4] Cholewinski, A., Si, P., Uceda, M., Pope, M., & Zhao, B. (2021). Polymer Binders: Characterization and Development toward Aqueous Electrode Fabrication for Sustainability. *Polymers*, *13*(4), 631– https://doi.org/10.3390/polym13040631

- Fibrillation properties, which produce an excellent mechanical electrode surface without covering the surface of the active material,
- Chemical properties, including chemical stability in very aggressive environments,
- hydrophobic properties.

Alternative non-PFAS materials such as Polyvinyl alcohol (PVA, CAS 9002-89-5) and Poly(acrylic acid) (PAA, CAS 9003-01-4) have been tested as potential binder materials for the positive electrode and have been found to fail due to performance and manufacturability issues. The degradation of these alternative binder systems in the electrolyte has been demonstrated.

### 3.4.1.2) Use of PFAS in electrolytes

Various PFAS substances are used in electrolytes for established and new battery technologies under development in areas such as Lithium-ion rechargeable, Lithium primary, secondary Lithium metal, and Sodium-ion rechargeable batteries. PFAS substances are utilised as salts (a significant component or an additive), electrolyte solvents or electrolyte additives. These substances improve a battery's performance, efficiency, safety and lifetime[5].

### 3.4.1.3) Use of PTFE & FEP in gaskets and washers (and in battery equipment) in chemically aggressive environments

There are no alternatives to using PTFE and FEP in gaskets and washers used in chemically aggressive environments, such as the SO2 and SOCl2 substances used in electrolytes in primary Lithium batteries. SO2 and SOCl2 are powerful oxidising agents that degrade almost all polymer types except PFAS materials. Degradation of the gasket and washer would result in loss of battery component properties and release of the electrolyte.

### 3.4.1.4) Use of PFA, VDF-HFP, and FKM in gaskets in high-performance batteries

There are no alternatives to the use of PFA, VDF-HFP, and FKM in gaskets in high-performance Lithium-ion rechargeable and Lithium metal rechargeable batteries (e.g., high-power batteries for automotive, industrial applications and power tools), which require very thin and thermally robust gaskets for safety reasons. These gaskets are critical to the functioning of current interrupt devices, which are essential to use high-performance batteries safely. Attempting to use non-PFAS materials available today to manufacture these gaskets will result in the battery failing safety testing standards and risking the battery catching fire or exploding during use.
For a more detailed presentation, please refer to the second contribution of *RECHARGE*.

[5] Xu, N., Shi, J., Liu, G., Yang, X., Zheng, J., Zhang, Z., & Yang, Y. (2021). Research progress of fluorine-containing electrolyte additives for lithium ion batteries. *Journal of Power Sources Advances*, *7*, 100043 https://doi.org/10.1016/j.powera.2020.100043

### 3.4.2) Proton exchange membrane (PEM) fuel cells

Fluorine-free ionomers and membrane materials have been around in science for decades. However, making them meet the requirements for hydrogen applications was impossible all this time. Research has been ongoing for developing hydrocarbon membranes such as sulphonated polyetheretherketone (PEEK). The durability is often poor, as oxidation by oxygen radicals, which are inevitably generated at the cathode electrode, occurs. The non-fluorinated membrane concepts are mainly unproven at the laboratory or pilot scale on industrial scales. They are still highly immature, lasting only dozens of hours against lifetime requirements of >25,000 hours for fuel cell applications. In the 1990s, there was great interest in substituting Nafion and other fluoropolymer-based membranes since those were more expensive and released HF, which can attack the steel bipolar plates. Still, all of these programmes failed to produce viable alternatives. In the 2010s, there was another surge of hydrocarbon membrane interest, as companies have tried non- and partially fluorinated chemistries.

In PEM fuel cell applications, hydrocarbon alternatives are poor in situational performance, particularly under reduced RH (relative humidity) of <50% and thus operationally relevant conditions: we experience a strong dependence of electrochemical performance on material hydration, and more excellent material swelling and dimensional instability. PFSA ionomers are used in the catalyst layer as they provide ion conductivity and hydrophobic properties to the electrode catalyst layer. The hydrophobicity is a function of the fluorinated PFSA backbone and is, therefore, very difficult to replace, as hydrocarbon polymers are inherently not as hydrophobic as fluorocarbons.

There are additional issues with implementation in a manufacturing setting, as the new materials’ mechanical properties in a membrane electrode assembly cause poor adhesion between the catalyst layer and the membrane. Solutions to this problem are unclear and unproven. The timescale to resolve these performance and manufacturing issues would go far beyond the time provided by any time-limited derogations.

Research activities to replace conventional perfluorinated ionomers with fluorine-free materials have been ongoing for 25 years. Still, no commercial product has been released due to poor oxidation stability. Fuel cell manufacturers are in close contact with the manufacturers of the components to test the materials at a relatively early stage and thus identify and qualify promising materials, promote their industrialisation and replace the current perfluorinated compounds as early as possible. However, building on experience and knowing when a validated alternative material may be available in volume is impossible.

For a more detailed presentation, please refer to the contribution of *Hydrogen Europe* (ECHA’s consultation reference number 4144).

## 3.5) Alternatives to PFAS used in lubricants

**Traction motors.**

Without PTFE, the lubricating grease will have poor performance in terms of thermal resistance. This means lower reliability of the traction motors and the need to regularly replace the lubricating grease for high-temperature applications to avoid traction motor failures. Today, there is no known lubricating grease with the same performance.

**PTFE-free micronised polyethylene wax**

It is an additive for aqueous, solvent-borne, solventless and UV coating systems to improve scratch and abrasion resistance and increase surface slip, comparable to typical PE/PTFE wax additives.

**PTFE-free silicone oil**

They are usually linear molecules of different chain lengths made up of dimethylsiloxane units. For this reason, silicone oils are also called polydimethylsiloxanes (PDMS). Compared to mineral oils, silicone oils have high thermal and oxidative resistance. They can be functionalised with different groups to specifically influence the properties of the pure silicone oils.

**PTFE-free ceramic lubricating greases**

They are resource-saving, wear-reducing and sustainable. The ceramic particles smooth metal surfaces and thus reduce the need for lubrication. The efficiency gains are reflected in lower operating temperatures and longer component life. Significantly lower amounts of lubricant reduce the logistics effort.

**PTFE-free medical grade white oil**

This component serves as a lubricant and anti-corrosion agent. The alcohol components have a disinfecting and preserving effect. So that the two can be mixed, alkali salts of oleic acid are present as detergents. Together with the alcohols, they enable a water-displacing and dirt-dissolving effect, making the oil film washable. Ballistol forms a milky emulsion with water and, according to the manufacturer, has a pH of 8 to 8.5 (alkaline). Ballistol is biodegradable, not hazardous to water and harmless in terms of the food law.

For a more detailed presentation, please refer to the contribution of *ATIEL* (ECHA's consultation reference number 4423).

## 3.6) Alternatives to PFAS used in TULAC (Textile, upholstery, leather, apparel and carpets)

An alternative solution to the waterproof envelope could be filling the product with resin. However, this solution is unsuitable because it prohibits product maintenance, which becomes disposable and is incompatible with electronic devices like contactors, insulation switches, etc. Today, no solution has been identified to replace the protective vent made with PTFE.

# 4) Possible consequences: socio-economic impact assessment of the proposed PFAS restriction for railways value chain

## Scenario 1: No derogation at all

In an unlikely scenario, all the derogations in the current PFAS restriction proposal are not granted. In this case, this means the end of the rail sector in Europe and the loss of hundreds of thousands of jobs. Without some essential PFAS, operators will not fulfil safety standards, disrupting railway traffic. The impact of this decision on climate change will be an increase in current $CO_2$ emissions due to a negative modal shift from rail to other more polluted modes of transport.

A ban on PFAS for sealings used in tank wagons approved for transporting dangerous goods would severely disrupt the global chemical and liquefied gas transportation supply chain. Some products could not be transported any longer, implying a possible shortage of basic needs products. Given that around 212 million tons/km of dangerous goods are transported by rail yearly, the effects would be catastrophic for the chemical industry, all related industries that depend on chemical supplies, and the European economy. In addition, around 82,477 tank wagons and hence, the assets of SMEs will be affected.
For a more detailed presentation, please refer to the contribution of *UIP* (ECHA's consultation reference number 6213).

## Scenario 2: Proposed derogations are confirmed, but no other specific derogations

The current PFAS restriction proposal lacks several derogations for PFAS applications, which are essential for the European rail industry. These missing use applications comprise the following:

- Refrigerant of air conditioning and heat pumps - new HVAC,
- Refrigeration - catering battery monitoring systems,
- Coating, solvents & cleaning,
- Electronic components,
- Wires, cables, motor sheath - heat shrinkable,
- Batteries.

In a scenario where only the derogations of the current PFAS restriction proposal are granted, the impact on the European rail sector would be immense, with significant consequences for the European economy, citizens, workers, and public transport, as well as the shift towards more sustainable transport. Failure to grant derogations (or exemptions for fluorinated gases) would mean an immediate (18 months after entry into force) and total ban of PFAS for the above applications. As these applications are critical for various essential rail components and are also required for spare parts and maintenance activities, the ban will trigger a cascade of far-reaching consequences. These include a complete stop and loss of established technologies and products, the need for rapid re-design or short-term development of new solutions, or loss of certification, homologation, and safety approval. This, in turn, would have significant economic, social, and environmental impacts.

Economic impacts will include increased design, manufacturing, operating, maintenance and repair costs and longer service intervals leading to higher prices and expenses for the product owners (e.g. companies, public transport operators, cities and communities) and passengers.

Social and environmental impacts will include, e.g. reduced reliability of rail products and, thus, increased safety and health risks and reduced durability of rail products. Reduced durability means materials must be replaced more frequently, leading to an increase in waste and loss of resources.

The instant ban (18 months after entry into force) of PFAS for electronic components, wires, cables, electric motors, and batteries without the availability of drop-in alternatives will endanger the entire railway industry and, thus, all related stakeholders.

## Scenario 3: No derogation for spare parts and maintenance activities

Although the PFAS restrictions and bans will not apply retroactively on products already placed on the market before the ban date, they will affect the aftermarket, spare part and maintenance business as far as it will not be possible after the ban date to replace products in use with spare or equivalent products that contain PFAS or refill/exchange operating substances.

Following the "*Repair as Produced*" principle, PFAS applications will be required for spare parts and maintenance activities. Many exemptions will be required for PFAS applications. Many PFAS applications will still need to be used on components that have been type-approved. This also applies to spare parts and operating substances relating to type-approved components.

As this scenario is currently not sufficiently addressed within the Restriction Proposal, the railways sector is highly concerned that this may generate multiple liability and contractual disputes between OEMs and train operators as to which entity is responsible for bearing the efforts (hence, the costs) for re-designing spare parts to comply with the PFAS restrictions. In the case of maintenance activities that require the refill or exchange of operating substances of PFAS consumables or substances, customers or product owners would be immediately and unexpectedly faced with a situation where their rail products would need to be redesigned, retrofitted or replaced. This will affect many European rail and public transport companies and many European cities currently planning for a multi-decade lifetime of their transport systems.

A theoretical workaround to this conflicting scenario could be that, shortly before the entry into force of the PFAS restriction, the train operators refill the spare stock to cover the remaining useful life of PFAS-based products in use. Nevertheless, this is not considered a viable solution as it implies significant economic and logistic impacts for operators and OEMs and does not address the need for replacing products in use because of obsolescence. Furthermore, stockpiling large quantities of PFAS spares or operating substances would counteract the intention of the proposed restriction and even increase the risk of increased release of PFAS into the environment.

As a consequence of the above, the railway's sector requires that either the PFAS restrictions are not applied to spare parts of products in use as well as maintenance activities at the date of the ban and throughout their useful life or that specific provisions are provided in the PFAS restriction proposal as to how to handle this potentially very critical scenario from a contractual, legal and technical standpoint, splitting the responsibilities between OEMs and final users (i.e. railways operators).

## Possible consequences: environmental and human health consequences

As regards the tank wagons, a ban on PFAS and the fact that there are no real alternatives to PFAS for sealing applications would mean a significantly higher risk of leakages of dangerous goods into the environment. It would also mean higher emissions of toxic and hazardous products because before sealing can be replaced, the tank needs to be cleaned from the product. Less-performing alternatives would also bring a much higher risk to human health, especially those working in workshops that would need to work with possible contaminated sealings. It means a higher exposure to dangerous goods while replacing the sealings.

# 5) Requests for derogations and for a review clause

## 5.1) Applications affecting the proper functioning related to the safety of transport

### 5.1.1) Sliding and guiding elements

The Annex XV report proposes a derogation under reconsideration :

- 6.o [applications affecting the proper functioning related to the safety of transport vehicles and affecting the safety of operators, passengers or goods until 13.5 years after EiF]

Fluoropolymers ensure the operability and guidance of the rail equipment. Without these polymers, there is a risk of equipment failure and a risk to the safety of operators, passengers or goods.

Drop-in replacements for PTFE and PVDF are currently not available. This results in the safe operation of products containing, e.g. air spring systems, which would not be able to be ensured in case of an instant ban of PTFE with a transition period of only 18 months. This holds for more than 90% of all rolling stock products. Moreover, even if alternative materials were available, this would not guarantee a drop-in exchange of PTFE in this application, as a change of fabric in ongoing projects would affect the homologation of the whole train, including extensive dynamic tests in finished vehicles. Altered friction and stiffness values will change the reaction moments when driving through curves. According to EN 14363, only a minimal % tolerance range of 10% is allowed. Repeating all affected products' homologations and test runs would take several years and an enormous investment. As the PTFE ban would also affect spare parts for the air spring systems of trains already put on the market, this would result in a gradual loss of more and more trains if the air spring system is subject to maintenance.

Also, in other safety-related applications mentioned in Section 2.1, such as resistance to aggressive media, emergency running properties, high tracking resistance or high-temperature range applications, PTFE and PVDF are essential materials (i.e. sliding parts, lubrication-free plain bearings, hose assemblies, joint heads, couplers, threads, and insulation material or cable insulation for power converters). Total turnover only with products depending on PTFE materials to ensure high tracking resistance under high-temperature conditions is estimated to be immense. However, the economic impact will be even higher as almost all train products depend on the mentioned subparts. Thus, an instant ban on perfluorinated polymers with a transition period of only 18 months would cause a significant threat to the safety of rail transport applications in general and a setback to well-established and needed safety-relevant and competitive technologies. This would highly affect the whole rail industry, thus significantly impacting employees, public transport, and the shift toward more sustainable transportation. In addition, since in most of the above applications, emissions of Fluoropolymers to the environment can be excluded entirely (e.g. because of use in closed assemblies or sealed and leak-proof containers with no direct contact with the environment), there is no environmental concern with the help of these materials in the safety-related applications.

Without an alternative solution, the rail sector faces a situation that justifies **the derogation for 13.5 years after entry into force** to retain the possibility of supplying these materials.

As laid down, alternatives for PTFE and PVDF materials in rail applications are unavailable soon. Therefore, a derogation of at least 13.5 years after entry into force is required, e.g. via the "*PFAS used in applications affecting the proper functioning related to the safety of transport*" derogation or a general derogation for perfluoro polymers.

### 5.1.2) Sealing applications

The Annex XV report proposes a derogation under reconsideration :

- 6.o [applications affecting the proper functioning related to the safety of transport vehicles and affecting the safety of operators, passengers or goods until 13.5 years after EiF]

FKM materials ensure the safety of the rolling stock during operation. This includes the safety-relevant applications mentioned in section 2.1, such as sealings (safety relief) valves, sealing gaskets in traction motors, dampers, sealing of traction transformers, sealing of casings, etc. A failure in the effectiveness of the static and dynamic seals generates, e.g., a lubricant leak and, thus, rapid destruction of gears and bearings, which can go as far as an axle blockage in commercial service. This risk is one of the most severe in terms of criticality, involving a potential derailment of the train or a fire and the loss of the lives of passengers. Other sealing failures could, e.g. lead to safety-relevant loss of operating pressure or liquid, corrosion, or environmental pollution. Thus, sealing failure may lead to diverse risks to the safety of operators, passengers or goods.

Also, the materials of static and dynamic seals must withstand the thermal stresses and chemically resist the aggressiveness of oils and lubricants used for up to 10 years (potentially 15 years in the future) between two maintenance steps.

As laid down, alternatives for FKM materials in rail applications are unavailable soon. Therefore, a derogation of at least 13.5 years after entry into force is required, e.g. via the "PFAS used in applications affecting the proper functioning related to the safety of transport" derogation or a general derogation for perfluoro polymers.

The European rail sector supports the requests for derogations **for 13.5 years after entry into force**. As of today, no alternatives exist.

### 5.1.3) Coating, adhesives and finishings

The Annex XV report proposes a derogation under reconsideration:

- 6.o [applications affecting the proper functioning related to the safety of transport vehicles and affecting the safety of operators, passengers or goods until 13.5 years after EiF]

PTFE liner ensures the operability and the auto-lubrication of the ball joints and rods used in bogies. Without this liner, there is a risk of equipment failure and generating risk to the safety of operators, passengers or goods.

Without an alternative solution, the rail sector faces a situation that justifies **the derogation for 13.5 years after entry into force** to retain the possibility of supplying these materials.

### 5.1.4) Noise dampening components

FKM materials are the only materials that can effectively reduce ambient noise levels of rail vehicles by reducing rolling and squealing noise. So far, no alternative materials have been known that combine the best noise-absorbing properties and meet thermal, mechanical, and chemical specifications. The FKM noise-absorbing wheel damping technology is incorporated in various rolling stock products, from metros and trams to high-speed trains. According to WHO[6], reducing noise exposure could also reduce accidents, injuries and other potential safety risks. Several organisations have established regulations for protecting workers from hazards to their health and safety arising from noise exposure, particularly hearing threats. The target of protecting human health from noise pollution from various sources, including rail transport, will be in danger due to the ban on PFAS.

A ban on FKM materials in the rail industry would thus set back well-established and needed safety and noise-reduction related technologies, would highly affect the whole industry, and thus lead to a significant impact on employees, citizens, product users, and the transportation shift toward more sustainable transportation.

As laid down, alternatives for FKM materials in rail applications are unavailable soon. Therefore, a **derogation of at least 13.5 years after entry into force** is required, e.g. via the "PFAS used in applications affecting the proper functioning related to the safety of transport" derogation or a general derogation for perfluoro polymers.

### 5.1.5) Detailed application per main system

The main systems and specific uses described in section 2.1.5 ensure that the railway system is a reliable and safe means of transport. Systems such as the brake and air supply allow the train to be stopped safely when required, with the highest safety integration levels in the transport sector. A failure in the effectiveness of the brake elements can go as far as a train collision and the lives of passengers. As many components rely on using elements containing PFAS, a ban will cause extensive redesign, homologation and testing campaigns taking several years and great investment.

Without an alternative solution, the rail sector faces a situation that justifies **the derogation for 13.5 years after entry into force** to retain the possibility of supplying these systems.

### 5.1.6) Electrical engineering & information technology

The Annex XV report proposes a derogation under reconsideration :

- 6.o [applications affecting the proper functioning related to the safety of transport vehicles and affecting the safety of operators, passengers or goods until 13.5 years after EiF]

Without an alternative solution, the rail sector faces a situation that justifies **the derogation for 13.5 years after entry into force** to retain the possibility of supplying these materials.

[6] https://www.who.int/europe/publications/i/item/9789289053563

### 5.1.7) Safety equipment (including fire prevention and protection)

The Annex XV report proposes a derogation under reconsideration :
- 6.o [applications affecting the proper functioning related to the safety of transport vehicles and affecting the safety of operators, passengers or goods until 13.5 years after EiF]

Without an alternative solution, the rail sector faces a situation that justifies **the derogation for 13.5 years after entry into force** to retain the possibility of supplying these materials.

**Ball valves, control boards/panels, gaskets, line strainers, hoses, pipes, sealing rings, resolvable screw connections and other parts in the sanitary systems**
A derogation of **13.5 years after entry into force** is required.

**Sealing elements in tank wagons approved for the transport of dangerous goods**
Since there are no equal performant alternatives to PFAS sealings in tank wagons and given the significant impact it would have in terms of environmental and human health as well as on the economy due to the disruption of the global chemical and liquefied gas transportation supply chain and all related industries, a derogation of **13.5 years after entry into force as a minimum** is required.

For a more detailed presentation, please refer to the contribution of *UIP* (ECHA's consultation reference number 6213).

## 5.2) Application of fluorinated gases

Several derogations are proposed in the Annex XV report concerning the use of fluorinated gases impacting the rail sector:

- 5.f refrigerants in low-temperature refrigeration below -50 °C until 6.5 years after EiF;
- 5.g. refrigerants in laboratory test and measurement equipment until 13.5 years after EiF;
- 5.i. maintenance and refilling of existing HVACR equipment put on the market before [18 months after EiF] and for which no drop-in alternative exists until 13.5 years after EiF;
- 5.p. refrigerants in mobile air conditioning systems in combustion engine vehicles with mechanical compressors until 6.5 years after EiF;
- 5.r. insulating gases in high-voltage switchgear (above 145 kV) until 6.5 years after EIF.

For some uses, particularly for HVAC and refrigeration, the proposed duration is incompatible with developing new solutions without F-Gases and PFAS. Rolling stocks have a long life duration (40 years), and it is impossible to replace refrigerant with HFC with natural gas without an essential design modification. Concerning the reduction of $CO_2$ emissions, the remaining service life of the vehicles must also be considered as a function of the ban on use in order not to cause a higher burden due to any new production of HVAC systems, which are then in use for a remaining service life of the vehicles of a few months.

The risks of emissions and prohibition of fluorinated gases are adequately controlled through existing EU legislation, in particular the F-Gases Regulation (517/2014), **by consequent rail sector proposed an exemption for fluorinated gases under the scope of this regulation** as some regulations are already exempted in the proposed restrictions in the point 4. Having the inclusion of fluorinated gases in the restriction list will generate several prohibitions on the placing on the market with different timelines and rules.

## 5.3) Electronics and semiconductors

### 5.3.1) Coating, solvents and cleaning

The Annex XV report does not propose any derogation on coating, solvents, and cleaning.

Without an alternative solution, the rail sector faces a situation that justifies **the derogation for 13.5 years after entry into force** to retain the possibility of supplying these materials.

The European rail sector supports the requests for derogations **for 13.5 years after entry into force** made by *FIEEC* and by *Orgalim*.

### 5.3.2) Electronic components

The Annex XV report does not propose any derogation regarding the use of fluoropolymers for technically functional elements within the electrical or electronic equipment in the rail industry.

Without an alternative solution, the rail sector faces a situation that justifies **the derogation for 13.5 years after entry into force** to retain the possibility of supplying these materials.

The European rail sector supports the requests for derogations **for 13.5 years after entry into force** made by *FIEEC* and by *Orgalim*.

### 5.3.3) Semiconductors

Semiconductors are essential for operating the railway system. The rail industry is a downstream user of PFAS-containing products and is not responsible for selecting the material used for the semiconductors.

As drop-in PFAS substitutes for established technologies, such as two-phase semiconductor cooling in metros, are not available, an instant ban with a transition period of only 18 months would result in the affected product owners (European cities) no longer being able to maintain their metros and thus gradually (maintenance typically necessary every 5-6 years) must take them out of service. Well-established and running metro lines of big European cities currently planned with a projected remaining lifetime of around 20 years would be affected. Per city which will be affected, this concerns at minimum around 80 metro trains, each containing several power converters that depend on these substances. This would also mean that if one of those converters would need maintenance, the whole train would instantly fall out. In addition, even if retrofitting is technically feasible, cities would have to pay for redesign and implementation, extensive testing, and re-certification. Costs that cannot be estimated now would certainly and unexpectedly challenge or even overwhelm the cities' budgets. The need to completely replace an existing metro train/line would be even more challenging. If retrofitting or replacement would not be an option for a city, the worst-case scenario of banning PFAS would be the gradual loss of its public transport system.

As laid down, drop-in alternatives for PFAS-based heat transfer and semiconductor cooling substances such as FC-3284, FC-72, or Novec 649 in existing rail applications, e.g. metros are not available, and their ban would significantly impact the owners of the products (e.g. European cities). Therefore, a derogation of at least 12 years + 18 months after entry into force is required. The best option would be the complete exemption of those substances or PFAS from applications for rolling stock maintenance activities.

The Annex XV report proposes a derogation under reconsideration :

- 5.ee [[the semiconductor manufacturing process until 13.5 year after EiF]

The European rail sector supports the requests for derogations **for 13.5 years after entry into force** made by *SEMI Europe* (ECHA's consultation reference number 4304) by *ESIA* (ECHA's consultation reference number 4449) and by *FIEEC* and by *Orgalim*.

### 5.3.4) Wires and cables

For wires and cables in the proposed restriction, there is no derogation covering the use of motor winding. **The rail sector needs at least 13.5 years after entry into force** to find alternative solutions. Without this derogation, an immediate ban of PFAS with a transition period of only 18 months for use in electric motors for rail applications would result in a total prohibition on electric train motors, including new and existing motors, when they require maintenance. The total turnover of new motors that a PFAS ban would impact is estimated to be immense. The economic impact on business with electric trains or trains depending on electric motors is expected to be even higher. This would highly affect and threaten the whole rail industry, thus significantly impacting employees, public transport, and the shift toward more sustainable transportation.

### 5.3.5) Various electronic assemblies (capacitors, plugs, transducers…) in the brake control

It can be assumed that, at least not for all use cases, alternatives are available or in development today. A complete analysis of > 1,000 capacitors would be required to get the complete picture.

### 5.3.6) Cables for magnetic coil, used in valves for pressure control of the hydraulic brake

A **derogation for 13.5 years after entry into force** is required.

## 5.4) Energy sector

### 5.4.1) Batteries

Batteries are essential for operating the railway system. The rail industry is a downstream user of PFAS-containing products and is not responsible for selecting the substances used for the battery composition.

The European rail sector supports the requests for derogations **for 13.5 years after entry into force** made by *RECHARGE* (the second contribution).

### 5.4.2) Proton exchange membrane (PEM) fuel cells

For the PEM fuel cell, the restriction proposal includes a derogation:

- 6.e proton-exchange membrane (PEM) fuel cells until 6.5 years after EiF;

Fluoropolymers used in fuel cells are a distinct category of PFAS, recognised by OCDE as "of low concern". Still, the target of decreasing all emissions could be envisaged through a "binding monitoring, reporting and verification (MRV) system", ideally harmonised across industry and Member States. For more information, read the contribution of *Hydrogen Europe* (ECHA's consultation reference number 4144).

The European rail sector supports the requests for derogations **for 13.5 years after entry into force as a minimum** for fluoropolymers used in fuel cells. This appropriate set-up would guarantee strict emissions control whilst securing adequate regulation for a crucial sector in the energy transition, as hydrogen is essential in supporting the *European Green Deal* and *REPowerEU* schemes.

## 5.5) Lubricants

### 5.5.1) Greases

Greases are essential for operating the railway system. The rail industry is a downstream user of PFAS-containing products and is not responsible for selecting the substances used for the grease composition.

The Annex XV report proposes a derogation under reconsideration :

- 5.s [lubricants where the use takes place under harsh conditions, or the use is needed for safe functioning and safety of equipment until 13.5 years after EIF;]

The European rail sector supports the requests for derogations **for 13.5 years after entry into force** made by *ATIEL* (ECHA's consultation reference number 4423).

### 5.5.2) Low-viscosity lubricants

Lubricants are essential for operating the railway system. The rail industry is a downstream user of PFAS-containing products and is not responsible for selecting the substances used for the lubricant composition.

The Annex XV report proposes a derogation under reconsideration :

- 5.s [lubricants where the use takes place under harsh conditions, or the use is needed for safe functioning and safety of equipment until 13.5 years after EIF;]

The European rail sector supports the requests for derogations **for 13.5 years after entry into force** made by *ATIEL* (ECHA's consultation reference number 4423).

## 5.6) TULAC (Textile, upholstery, leather, apparel and carpets)

The Annex XV report proposes a derogation :

- 5.e textiles for the use in filtration and separation media used in high-performance air and liquid applications in industrial or professional settings that require a combination of water- and oil repellence until 6.5 years after EiF.

As a downstream user of PFAS-containing products and not responsible for selecting the material used for the filtration, **the rail industry supports the derogation for 6.5 years after entry into force**.

## 5.7) Request for a review clause and summary of derogation requests

The assessment of railways ideally requires an exemption for all spare parts of products and for maintenance/servicing of equipment and vehicles already placed on the market at the time of the ban. If necessary, a unique railway regulation with transitional arrangements could be applicable until the end of the useful life of the equipment commonly used for the safe operation of the railway system. The European rail sector is applying for 13.5 years derogation periods for the uses where alternatives are unavailable today. At the end of this derogation period, some uses could be identified for which options will still not be available or where the choices would be regrettable substitutions. In these cases, a mechanism to renew the derogation would be essential to avoid the substantial socio-economic impacts of the European Green Deal. However, such a renewal mechanism is currently missing from the proposed PFAS restriction.

Therefore**, a review clause should be included in the final restriction to provide three years to evaluate derogations before their expiry to assess whether alternatives are now available or whether a further renewal of the derogation is needed**. In addition, achieving a coherent policy without duplicating the future revised regulations on F-gases will also be necessary.

**Table 1 - The following table summarises the derogation requests :**

**Exemption*:** as already covered by the revision of the F-gases regulation

| Main application as defined in Annex XV report proposal | Sub-uses as described in Annex XV report proposal | Examples of use | Request for confirmation of the proposed derogation as in the Annex XV report proposal (plus a review clause) | Request for derogations for missing uses and/or no possibility of modifying the existing application (plus a review clause) |
|---|---|---|---|---|
| **Applications of fluorinated gases (F-gas)** | Air conditioning and heat pumps | **New HVAC** | **Missing use** | **Exemption*** |
| | | Existing HVAC | 5.i (13.5 years after EiF) | **Exemption*** |
| | | Existing HVAC with mechanical and hydraulic compressors | 5.p (6.5 years after EiF) | **Exemption*** |
| | Fire suppressants | Automatic fire system | 5.m (13.5 years after EiF) | **Exemption*** |

| | | | | |
|---|---|---|---|---|
| | **Refrigeration** | **Catering Battery Monitoring Systems** | **Missing use** | **Exemption*** |
| | | Climatic chamber | 5.g (13.5 years after EiF) | **Exemption*** |
| **Electronics & semiconductors** | **Coating, solvents, cleaning** | | **Missing use** | **13.5 years after EiF** |
| | **Electronic components** | | **Missing use** | **13.5 years after EiF** |
| | Semiconductors | | 5.ee (**13.5 years after EiF**) | - |
| | **Wires & cables** | **Motor Sheath - Heat shrinkable** | **Missing use** | **13.5 years after EiF** |
| **Energy sector** | **Batteries** | **Batteries** | **Missing use** | **13.5 years after EiF** |
| | Proton exchange membrane (PEM) fuel cells | Fuel cells | 6.e (6.5 years after EiF) | **13.5 years after EiF as a minimum** |
| **Lubricants** | Greases | Grease | 5.s (**13.5 years after EiF**) | - |
| | Low viscosity lubricants | Oil | 5.s (**13.5 years after EiF**) | - |
| **Transport** | Coating and finishings | Balljoint | 6.o (**13.5 years after EiF**) | - |
| | Electrical engineering and information technology | | 6.o (**13.5 years after EiF**) | - |
| | Sliding and guiding elements | Sliding part - segment - guide - bearing | 5.a (6.5 years after EiF)<br>6.o (**13.5 years after EiF**) | **13.5 years after EiF** |
| | Safety equipment (incl. fire prevention & protection) | | 6.o (**13.5 years after EiF**) | - |
| | Sealing applications | Transformer - bogie - motor - brake | 6.o (**13.5 years after EiF**) | - |
| | | Valves of tank wagons | **Missing use** | **13.5 years after EiF as a minimum** |
| **TULAC (Textile, upholstery, leather, apparel and carpets)** | Technical textiles | Valves, venting, membrane | 5.e (**6.5 years after EiF**) | - |

## 6) Annex

A tentative list of mapping PFAS used by the rail industry, particularly by a rolling stock manufacturer, is an example of how many and where PFAS are used in its products.

**Cf. 2023-09 UNIFE contribution to PFAS restriction proposal - non-exhaustive list**