BETZ CHROM
Ihr Partner für starke Bauteile

Betz-Chrom GmbH • Postfach 12 27 • D-82152 Gräfelfing

Subject: PFAS restriction proposal and the use of PFAS-based wetting agents in hard chrome plating (chromium trioxide-based functional chrome plating)

1. Introduction and Aims

This comment is submitted by BETZ-CHROM GmbH (BETZ-CHROM), a family-owned electroplating facility located in Gräfelfing, Germany. The company provides functional chrome plating (hard chrome plating) services across a wide range of industry sectors. These include, for example, machinery, textiles, plastics production, automotive, printing and medical technology. An important portion of BETZ-CHROM's activities is also dedicated to the refurbishment of worn-down components through the application of a new chrome coating. In their plating baths BETZ-CHROM uses two PFAS-based wetting agents to ensure low CrVI exposure to their workers and the environment.

BETZ-CHROM's vision is to become a green electroplating facility. This has been reflected in several projects aiming to substitute hazardous substances and to improve the overall safety of its processes. BETZ-CHROM is also committed to the safety of its employees and in creating a safe and adequate working environment free of work-related injuries. It also supports various ecological and social projects. Finally, BETZ-CHROM's occupational health and safety management as well as its measures for environmental protection and energy saving are audited and certified according to DIN standards. Together, these initiatives demonstrate the company's commitment to the safety of its employees and of the environment, supporting its vision of becoming a "green" plating facility. A summary of all efforts related to the substitution of hazardous substances is provided in the following:

- **Substitution of lead- and cadmium-free nickel electrolytes for nickel electroplating:** Lead and cadmium act as stabilizers in chemical nickel electrolytes. However, both are highly toxic substances strictly regulated in the EU. Due to the risks posed by cadmium, BETZ-CHROM completely discarded the use of cadmium-containing nickel electrolytes. Lead-based electrolytes were initially used instead. In 2009, however, an alternative stabilizer was sought due to the risks posed by lead. The substitution of the lead-containing electrolyte by a lead-free one took place the same year. The lead-free electrolyte has a lower stability, reacts more sensitively to foreign substances and is therefore more difficult to handle than lead-containing electrolytes. Nevertheless, BETZ-CHROM has decided to substitute it in order to reduce the risk for its employees. The lead- and cadmium-free electrolyte is RoHS-conform.
- **The use of bacteria instead of biocides in cooling water systems:** The cooling water must be kept free from bacteria (legionella), algae and fungi. The biocide used for this purpose was classified as having the hazard statements H314 (causes severe skin burns and severe eye damage), H317 (may cause allergic skin reactions) and being very toxic to aquatic organisms with long-term effects. A technically suitable alternative to this biocide showed equivalent effectiveness in the treatment of the cooling water against legionella and other bacteria. Therefore,

BETZ-CHROM decided to substituted the biocide by BamaGreen PB-HB in 2019. Unfortunately, long term testing showed that BamaGreen PB-HB was not effective enough against legionella. Consequently, BETZ-CHROM had to go back to the biocide.

- **LEGOLAS project:** From 2019 to 2021, BETZ-CHROM participated as a project partner in the research project LEGOLAS, "Luftabsaugungstechnische Effizienzsteigerung in der Galvanik – Optimierte Luftführung mittels Abblas- und Saugvorrichtung" (in English, "increased air extraction efficiency in electroplating - optimized air flow using blow-off and suction devices"). The research project aimed to keep contaminated exhaust gas away from the factory's environment directly at the electroplating baths through a combination of blow-off and suction devices. This project was carried out in partnership with the electroplating equipment manufacturer Rauch Kunststoff- & Galvanotechnik GmbH (project coordination), the Chair of Manufacturing Automation and Production Systems at the Friedrich-Alexander University Erlangen-Nuremberg, the Chair of Environmentally Sound Production Technology at the University of Bayreuth and Zitt GmbH & Co. KG. Based on this project, BETZ-CHROM successfully updated nine plating baths with the developed technology until now.
- **Partial substitution of toxic nitro cleaner:** A specialized nitro cleaner is used to clean component surfaces before electroplating. This substance is suitable for cleaning due to its strong degreasing power. However, it is highly toxic, so Betz-Chrom has been investigating its substitution since 2012. Tests with FT100 failed due to a low cleaning performance. In 2015, FT400 was implemented partly as an alternative to the nitro cleaner. Nitro cleaner is still used for the cleaning of parts where it is absolutely required (e.g. removal of adhesive residues and waterproof markings). BETZ-CHROM is still striving to replace the nitro cleaner completely. Currently, it has been possible to reduce the annual consumption of the nitro cleaner (VOC) by half.
- **Others:** Betz-Chrom's vision is to become a green electroplating facility. This has been reflected, in addition to the projects and steps outlined above, in various certifications (certified environmental management ISO 14001, certified energy management ISO 50001 and certified occupational safety management ISO 45001) and sustainable energy management strategies (use of 100 % "green" electricity since 2008 and use of energy management software). In 2022, BETZ-CHROM installed a photovoltaic system on the roof of the Gräfelfing site which produces approx. 5 % of the company's electric energy demand. Additionally, Betz-Chrom is committed to the safety of its employees and in creating a safe and adequate working environment free of work-related injuries. Finally, Betz-Chrom supports various ecological and social projects. Some examples for 2022/2023 include:
    - Donation to Malteser Outpatient Hospice Service: 4k€ annually for 10 years.
    - Donation for emergency aid earthquake Syria and Turkey to Zeltschule e.V., Aktion Deutschland Hilft and UN Refugee Aid: total of 10k€ in 2023.

  - Annual donation for rhino sponsorship at Munich's Hellabrunn Zoo.
  - Annual donation to Gräfelfing Volunteer Fire Department.
  - Donation of 3k€ each to Lichtblick Seniorenhilfe e.V., the Gräfelfing Beekeepers' Association and the Malteser outpatient hospice service for children and young people in Munich.
  - Admission of a family of six in 2022 who had to flee from the war in Ukraine for several months.
  - Collected medical products from closed vaccination centers from Betz-Chrom in 2023. Following this, the truck including the driver was provided for three relief transports to the Ukrainian border.
- **Substitution of a PFOS-containing wetting agent:** In 2015 the use of PFOS was banned by the European Union for electroplating uses. PFOS was used as a component of wetting agents as it prevented their decomposition in chromium electrolytes. PFOS is both persistent and bioaccumulative and must therefore not be released into the environment. Even before the ban came into force, in 2014, BETZ-CHROM switched to the PFOS-free wetting agent Fumetrol 21 LF2 from Atotech. However, this substance causes severe skin irritation and eye damage and has some persistent transformation products. BETZ-CHROM therefore evaluated two alternatives to substitute Fumetrol 21 despite not being obliged from a regulatory perspective. The identity, results and other findings for both wetting agents are described in detailed in this document.
- Tests: Substitution of the previous degreasing process with a new product that uses bacteria to significantly extend service life and reduce operating temperature. This would have positive effects on energy consumption and reduce waste volumes. Tests with the new product will start in October 2023.

As stated per the last bullet point, BETZ-CHROM investigated two wetting agents (CrHG by KHW Galvanotechnik and Chromstop 450 by Conventya) as well as physical mist suppressants (plastic spheres) to substitute their currently used PFAS-based wetting agents. Notably, the company performed these efforts without any legal obligation. The three options, however, were found not suitable due to technical and hazard & risk related issues. The issues are further detailed below. Importantly, BETZ-CHROM is fully aware of the persistence of PFAS chemicals and the associated environmental pollution. Therefore, BETZ-CHROM plans to further investigate an alternative starting Q3 2023 to find a greener and technically suitable replacement (see chapter 4).

The aim of BETZ-CHROM's comment is to provide technical evidence that for their plating equipment and setup PFAS-based wetting agents are currently mandatory. Therefore, the company <u>fully supports the suggested time-limited derogation of 6.5 years for PFAS-based wetting agents as critical risk minimisation measure (RMM) for hard chrome plating</u> (see Column 2 on p. 6 of Annex XV report). This period guarantees safety of workers and the environment at BETZ-CHROM's hard chrome plating facility while allowing the company to find a technically suitable substitute.

2. Overview of the use of PFAS-based wetting agent by BETZ-CHROM GmbH

Background on use and advantages of PFAS-based wetting agents

Chromium trioxide-based electrolytes have reduced current efficiency. In the hard chrome plating baths of BETZ-CHROM the current yield is approx. 20 %. The remaining current is consumed for the electrolysis of H_2O. While hydrogen is produced at the cathode, oxygen is formed at the anode. Due to this gas formation a toxic aerosol develops around the working area due to presence of CrVI in the aqueous solution. It is highly important to protect BETZ-CHROM's employees and the environment from this toxic aerosol. Please note that hydrogen formation also presents a significant danger since spark induced oxyhydrogen explosion can cause severe damage to employees and the plating facility itself. More details on the relevancy of hydrogen formation in regard to PFAS-free wetting agents is provided below. The key component to achieve the required level of protection is the application of mist suppressants (or wetting agents) in chromium trioxide-based electrolytes. Currently, BETZ-CHROM uses two PFAS-based wetting agents, namely [redacted] and [redacted]

Both wetting agents contain [redacted] – a substance that falls under the PFAS definition (= at least one CF_2 or CF_3 group). The key advantages of the PFAS-based wetting agents in use are:

- Highly effective in suppression of CrVI-containing aerosols by lowering the surface tension of the aqueous electrolyte without foaming → guarantees minimal CrVI exposure to workers & environment, prevents oxyhydrogen explosion, low drag-out (by removal of components from plating bath) and thus low consumption as well as cleanliness of equipment.
- High chemical stability → PFAS-based wetting agents decompose (oxidise) only slowly even in strongly oxidising acids like chromic acid → also ensures low consumption since less redosing is required. Besides, no degradation products of the wetting agent can influence the quality of the plating process.
- Both wetting agents are compliant with the Stockholm Agreement on the global ban of the production and use of perfluoro octane sulfonic acid (PFOS) and perfluorooctanoic acid (PFOA).

Dealing with wastewater at BETZ-CHROM – CrVI and PFAS-based wetting agents

The wastewater (containing chromium trioxide and PFAS-based wetting agents) from the chrome plating baths is first pumped into a batch unit tank. The pH value and rH value (redox potential) are regulated to guarantee an optimal reduction from Cr(VI) to Cr(III) in the batch unit tank and the values are regularly monitored. After that, Cr(III) containing wastewater is pumped in the settling tank for sedimentation of Cr(III) and heavy metal containing sludge. Either the clear water phase or the sludge phase is pumped through a chamber filter press to get filtered clear water. Remaining condensed sludge pellets are collected and drained. The dry sludge pellets are disposed of by an external service provider. After the filter press, the filtered clear water is pumped through a gravel filter to remove remaining undissolved particles and a selective exchanger for removing heavy metals. Prior to discharging the water is analyzed for Cr and the pH of the water is checked.

To reduce the PFAS content in the wastewater a *Selective Exchanger* (ion exchanger/resins) is in place since 2014. It contains resins to which the PFAS molecules adhere to. The resins of the ion exchanger are replaced every six months to ensure proper reduction of the PFAS concentration in the wastewater. The cartridges of the ion exchanger are sent for off-site special waste incineration since these substances can only be destroyed if they are treated with high temperature (>1000°C).

From July 2023, measurements are conducted twice a year for perfluorinated carbonic and sulfonic acids in the wastewater after the Selective Exchanger. The measurements are already included in BETZ-CHROM's maintenance software. The samples are taken by BETZ-CHROM employees, and the analysis is carried out by an independent institute ([redacted]). A schematic drawing of the main wastewater treatment steps is provided in Figure 1 below.

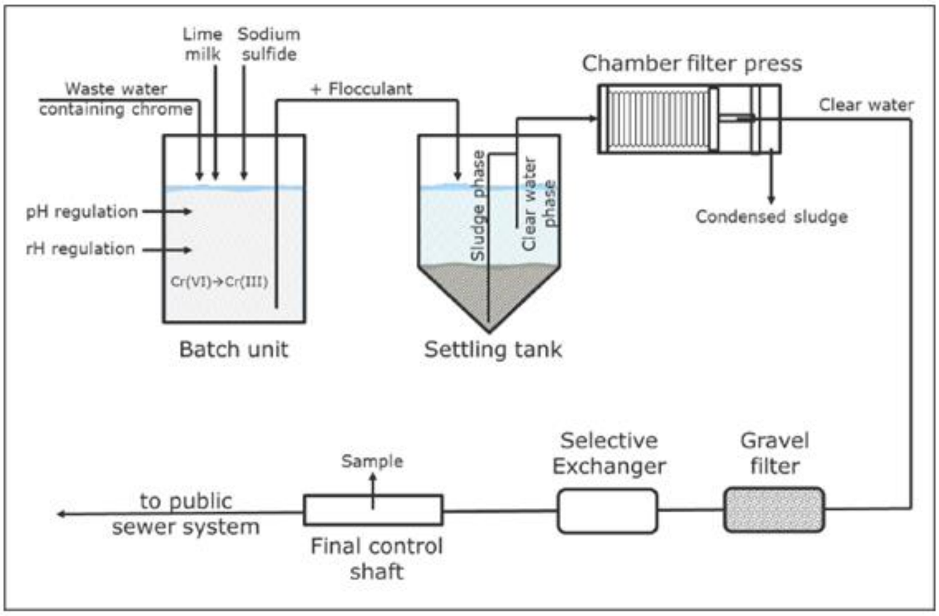

Figure 1: Schematic drawing of the main wastewater treatment steps at BETZ-CHROM

However, up to this point, no monitoring of the wastewater or limit values about PFAS have been prescribed by authorities. The implementation of ion exchangers/resins and the examination of the wastewater for perfluorinated carbonic and sulfonic acids was initiated based on BETZ-CHROM's own motivation to reduce the company's environmental impact. The current problem is that BETZ-CHROM does not know how to interpret the measured values since there are no limit values for guidance.

Beginning of 2023 BETZ-CHROM established a working group dealing with PFAS substitution and wastewater treatment. Members of the working group are:

- Management, Miriam Betz

- Production Manager, Mohammad Farahani
- Manager Strategy & Innovation, Hannah Betz
- Application Engineer Surface Technology, Rania Hasan
- Management Systems Officer, Michael Nirschl

Further considerations of alternative/additional wastewater treatments are currently being carried out intensively:

- Membrane technologies such as reverse osmosis
- Ultrafiltration
- Retention processes: combination of ultrafiltration and reverse osmosis
- Degradation processes: PFAS destruction (>99.999 %) at [redacted] °C
- Functional precipitants ([redacted]).

3. R&D activities for substitution of PFAS-based wetting agents including results

Upon enquiry with the suppliers, BETZ-CHROM was informed of two alternative wetting agents. The experimental results with the alternative [redacted] are described in detail below. For the second wetting agent [redacted] the screening of the corresponding Safety Data Sheet (SDS) showed that the mixture contains [redacted] a substance that clearly falls under the PFAS definition. Thus, it is not an alternative to the wetting agents currently in use at BETZ-CHROM. Consequently, the tests were cancelled. Additionally, in the past, spheres (plastic balls) were used in electroplating to act as a physical barrier to reduce the generation of spray mist and aerosols. However, the main disadvantages occurring during the application of spheres are:

- Spheres do not enclose the entire bath surface and aerosols still occur → the protective effect is lower than with wetting agents.
- Accumulation of grease and oil on the outside of the spheres → issues with coating quality since oil/grease adheres to cleaned components during immersion into electroplating bath. Logically, issues with the cleaning of the components after removal from electroplating bath also occur.

Experimental investigation of wetting agent [redacted]

The wetting agent [redacted] does not contain any PFAS but [redacted] and [redacted]. The manufacturer states that the mixture does not contain any persistent and bio-accumulative components classified as PBT[1] or vPvB[2]. In addition, there are independent studies on the degradation of [redacted]. For example, [redacted] confirms the biodegradability of [redacted]

[1] Persistant, bioaccumulative and toxic
[2] Very persistent, very bioaccumulative

[redacted] is an [redacted] derivative of [redacted] produced by the reaction of [redacted] with [redacted] itself is an [redacted] compound.

BETZ-CHROM started the production scale trials with the wetting agent [redacted] on 12 October 2021. The wetting agent was tested in a plant containing the following baths:

- Bath 8.1: 1500 l volume, 1.36 m² surface, approx. 2000 Ampere applied rectifier power.
- Bath 8.2: 580 l volume, 0.52 m² surface, approx. 300 Ampere applied rectifier power.
- Bath 8.3: 2080 l volume, 1.89 m² surface, approx. 1000 Ampere applied rectifier power.
- Bath 9/10/11: 5680 l volume, 3.98 m² surface, approx. 12000 Ampere applied rectifier power.

Baths 8.1, 8.2 and 8.3 are always run individually. The baths are designed for chrome plating of small surfaces. Accordingly, the rectifier power at these baths is smaller. Larger components can also be introduced into the baths where only partial surfaces are to be chrome-plated.

Baths 9, 10, 11 are always run together. Here, components (mainly rods and tubes) are chrome-plated horizontally. The surfaces to be chromium-plated are relatively large, which is why a much greater rectifier power is required than in the baths of the 8 series.

The baths of the 8 series and the bath series 9, 10, 11 consist of two tanks, each with an inflow on the right side and an outflow on the left side. Both baths share a storage tank and thus the same electrolyte. There is continuous circulation of the electrolyte. The wetting agent [redacted] was added continuously to bath 8.3 via a metering pump. The continuous circulation resulted in distribution to the other baths and the storage tank. The following figure illustrates the plant.

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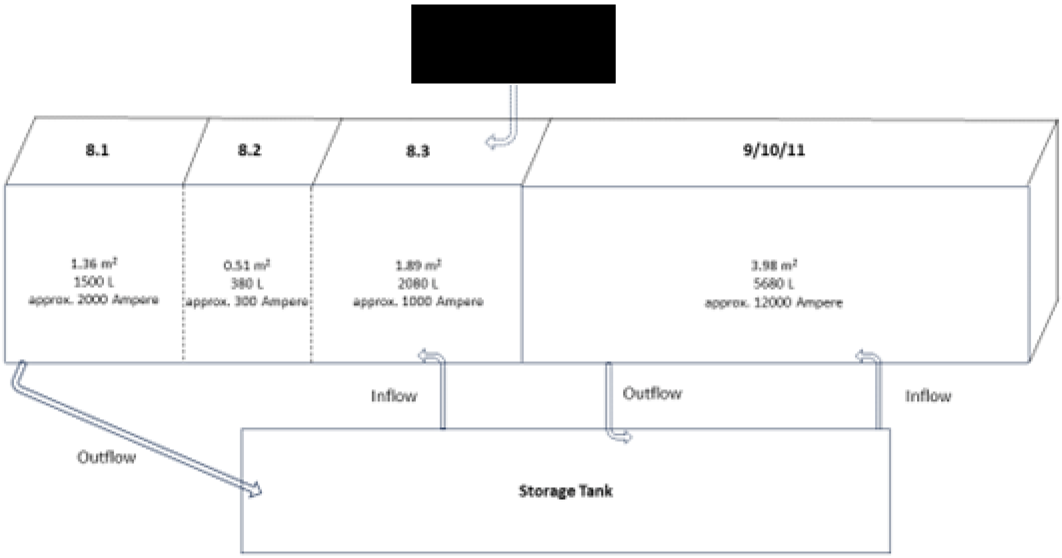

Figure 2: Schematic drawing of bath setup

Due to negative and dangerous observations (= risk of explosion) the trials were stopped on 08 November 2021.

In these experimental investigations BETZ-CHROM realized that their system design is not suitable for wetting agents that use “foaming” for suppressing mist/aerosol formation.

In BETZ-CHROM’s electroplating systems, several baths share the same storage tank and thus the same electrolyte. The baths have different volumes, bath surfaces and rectifier powers. BETZ-CHROM observed that in baths with comparably large volume but small surface and high rectifier power too much foam develops. Consequently, the concentration of the wetting agent would have to be reduced for these baths. However, low wetting agent concentration causes insufficient foam formation and thus mist/aerosol development in baths with comparably smaller volume (and rectifier power) but a comparatively larger bath surface that are feed from the same storage tank (= same electrolyte). Logically, individual adjustment of the wetting agent concentrations per bath is not possible in BETZ-CHROM’s systems since ultimately both baths end up in the same storage tank. Importantly, a protective foam layer must be between 2-4 cm thickness and cover the entire bath surface.

The tests were finally stopped because in the bath series 9/10/11, where the ratio of bath surface area to rectifier power is low, the foam development was too strong and the risk for spark induced oxyhydrogen explosion became significant (caused by short-circuit between cathode and anode in case conductive connection would have been created by foam). Additionally, it was not possible to create a consistent protective foam layer effect in baths 8.1, 8.2, 8.3 with a larger surface area compared to the lower rectifier power.

Please note that foaming is caused by hydrogen formation. The basic rule of thumb is: the higher the rectifier power the higher the hydrogen formation and thus more foam is developed. However, with high rectifier powers the problem is that excessive hydrogen formation caused too much foam development which in turn is highly problematic for many

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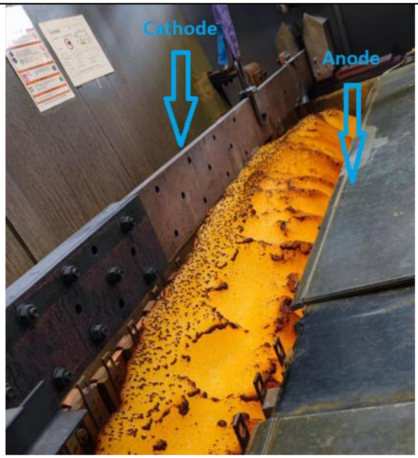
reasons (see *'Technical issues/disadvantages and risks of foam layers of high thickness'* below Table 1). Consequently, when the rectifier power is lower also the hydrogen formation is lower, and thus no/little foam development occurs. This mean that the protective foam layer does not develop sufficiently.

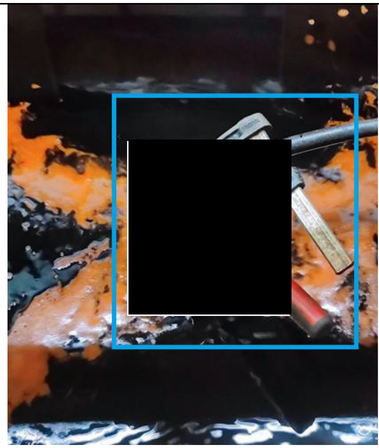
Concluding, BETZ-CHROM is not able to apply [redacted] in a concentration that suits the different bath variants that are feed from the same storage tank. These experimental findings are documented in a series of pictures that are provided in Table 1 below. Importantly, for suitability evaluation always both bath versions need to be compared in Table 1.

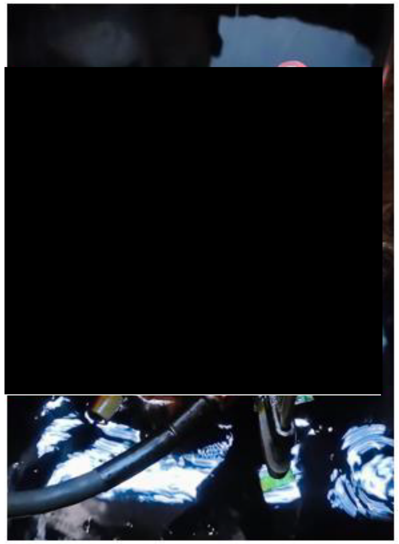
Table 1: Pictures of plating baths per day during testing of [redacted]

Da y	Bath series 9/10/11 with high rectifier power and comparatively smaller bath surface	Bath series 8.1, 8.2 and 8.3 with lower rectifier power and comparatively larger bath surface
1	 → way too much foaming: concentration of hydrogen gas in foam → risk of explosion	 → foaming not sufficient to effectively reduce mist/aerosol formation
2	 → foaming not sufficient to effectively reduce mist/aerosol formation	**n/a**

3	 → way too much foaming: concentration of hydrogen gas in foam → risk of explosion	**n/a**
8	 → correct and sufficient foaming	 → foaming not sufficient to effectively reduce mist/aerosol formation

9	 → correct and sufficient foaming	 → foaming not sufficient to effectively reduce mist/aerosol formation
11	 → correct and sufficient foaming	 → foaming not sufficient to effectively reduce mist/aerosol formation

19	**n/a**	 → foaming not sufficient to effectively reduce mist/aerosol formation
20	**n/a**	 Bath 8.2  Bath 8.3 Note: Bath 8.2 and 8.3 (and 8.1) are one single bath → there is no physical separation of the electrolyte.

		→ In bath 8.3, a sufficient foam layer was created during chrome plating. Due to the absence of a physical separation the foam was sufficiently distributed to bath 8.2 → protective foam layer achieved in bath 8.2. However, for the component in bath 8.2, a higher chrome layer thickness needed to be achieved and thus chrome plating lasted significantly longer (24 h) than for the component in bath 8.3. The issue was that the rectifier power required for the plating of the component in bath 8.2 was too low to create any foaming (see picture below). Consequently, no exposure minimization could be achieved during plating. The picture below also illustrates the contamination of the component area outside the electrolyte which occurs due to aerosol formation (exploding bubbles).  **Bath 8.2; 24 h chrome plating**

24	 → too much foaming: concentration of hydrogen gas in foam → risk of explosion	 → correct and sufficient foaming
27	 → little too much foaming	**n/a**

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Technical issues/disadvantages and risks of foam layers of high thickness:

- During chromium plating, hydrogen is produced by the electrolysis of H_2O. The hydrogen atoms accumulate in the foam layer. If the foam comes into contact with warm rails, there is a danger of oxyhydrogen explosion. There is also the risk of a short circuit if the foam creates a conductive connection between the cathode and the anode (see picture for Day 3 and small bath surface in Table 1). This may also cause a spark induced oxyhydrogen explosion.
- Issues with coating quality due to foaming: oils and greases accumulate in the foam layer (source: oils/greases from uncleaned areas of a component to be plated (e.g. boreholes)). When the components with the cleaned surfaces to be plated are immersed into the plating bath through the foam layer, the component surface is contaminated, and the subsequent plating process deteriorated → no proper coating deposition. This leads to inacceptable quality issues.
- Foam can be sucked into the extraction system, possibly overloading the air scrubber and extraction system. Additionally, the extraction system suffers from higher wear.
- In contact with the foam, the system technology above the plating bath is attacked (corroded) because Cr(VI) concentrate is present in the foam.
- Rapid consumption of wetting agent due to oxidation at the anode → high frequency of re-dosing → high costs. Besides, there is a risk that the long term accumulation of the wetting agent's oxidation products (degradation products) in the electrolyte deteriorate the quality of the plating process. This assumption was raised during discussions with partners from industry. However, BETZ-CHROM's experimental investigations did not last long enough to see an impact on coating quality.
- In the literature [redacted], there are also studies that show that when switching to the PFAS-free wetting agent [redacted], more anode sludge is produced in the electrolyte. This leads to more maintenance which in turn increases exposure risk for workers. Lead anodes also seem to corrode more strongly and have a shorter service life. However, this phenomenon could not be observed at BETZ-CHROM since testing was not performed long enough (only 27 days).

4. Outlook

An experimental test with the PFAS-free wetting agent [redacted] is planned for Q3 2023. The protective effect of the wetting agent also works via a foam layer. However, the mixture contains an additional component, a defoamer, to control the height of the foam layer. The tests are planned for the same bath / storage tank combination to enable a direct comparison with the wetting agents [redacted] and [redacted]. The initial test phase is three months and if successful the investigations will be extended to other baths. Importantly, the bath concentrations must be adjusted to:

- Bath geometry: surface/volume ratio.
- Bath design: electrode configuration, drag-out.
- Coating conditions (temperature, current density per area (A/m²)).
- Bath age.

According to the supplier, a smooth changeover from [redacted] to [redacted] should be no problem. The same applies to the changeover from [redacted] back to [redacted] [redacted]. At the beginning of the changeover from [redacted] [redacted] to [redacted], however, the supplementary quantities of [redacted] and [redacted] must be adjusted (=higher concentration) and may differ from the later values. According to the experience of the [redacted] supplier, slightly more [redacted] [redacted] is needed at the beginning compared to regular operation at later stage.

Importantly, all supplier statements must be proven by BETZ-CHROM's own observations gathered from long-term testing.

During testing of the wetting agent, extensive monitoring of the following parameters needs to be conducted:

- Surface tension: surface tension is used to monitor the concentration of the wetting agent. This ensures uniform and objective addition.
- Foam layer: correct coverage of bath to ensure effectiveness of aerosol formation suppression, monitoring of height of foam layer to counteract potential for oxyhydrogen explosion, short circuit and damage of bath equipment (by CrVI-based corrosion)
- Concentration and wastewater: the consumption of [redacted] depends on: temperature, electrolysis and extraction. Regarding the degradation products of [redacted], the wastewater must be analyzed. [redacted] is completely degraded to [redacted]. An analysis in wastewater or clear water is therefore difficult. According to the supplier [redacted] is stable in the chromic acid environment. However, this statement is counter indicated by the necessity to re-dose [redacted] constantly – especially in the beginning. Thus, BETZ-CHROM assumes that [redacted] degrades at least to some degree and therefore needs to gather their own long-term experiences with this wetting agent.

The criteria for termination of testing are:

- Foaming cannot be controlled → danger of oxyhydrogen explosion or short circuit due to too high foam layer.
- No foam layer is repeatedly formed over the entire bath surface → protective function against aerosols is not guaranteed.
- Foam formation in the storage tank cannot be controlled → foam overflows in the feed tank.

- Wetting agent and its potential degradation products cause constant quality problems in the coating.

Please note that the supplier has informed BETZ-CHROM that [redacted] is not yet in use at any electroplating shop in Germany and that the internal R&D solely took place in the US. BETZ-CHROM's contact persons therefore have no experience with the product themselves. All statements/predictions made by the supplier about the product must therefore first be verified by BETZ-CHROM in practice. So far, there are no long-term tests that allow statements about by-products or anode wear, etc. Only after successful long-term tests BETZ-CHROM would use the wetting agent in electroplating baths that are used for treatment of components for the aerospace industry. Since the use of a new wetting agent presents a process change, customers from the aerospace industry must approve it before series production is allowed.

Finally, BETZ-CHROM would like to point out that [redacted] is significantly more expensive compared to the currently used [redacted] In Table 2, BETZ-CHROM displays the consumption and cost comparison calculated for their test bath with a volume of 12.840 L for three-shift work. Importantly, the calculation is based on the information given by the supplier. Once experimental data is available, the consumption and cost comparison calculation need to be re-done. If the trials are successful, an overall calculation will be made for all baths.

Table 2: Consumption and cost comparison for test bath

Item	[redacted]		[redacted]
	[redacted]	[redacted]	
Dosing [L/week]	[redacted]	[redacted]	[redacted]
Costs [€/L]	[redacted]	[redacted]	[redacted]
Costs per week [€/week]	[redacted]	[redacted]	[redacted]
	[redacted]		

Consumption and cost comparison shows that [redacted] is approx. 6.5 times more expensive compared to [redacted]

In addition, there are one-off costs for the peripherals required for the use of [redacted]. The cost of the peripherals for the intended test is approximately 7.000 EUR. The costs consist of the following equipment: Mixing tanks, dosing pumps, suction lances, control cables, connection sets, pressure maintenance valves, overflow valves, dosing monitors, agitators. Should the use of [redacted] be extended to the other plants, these would also have to be equipped with the appropriate equipment.

However, based on the current cost comparison and given technical suitability BETZ-CHROM would consider [redacted] an economically viable alternative.

5. Conclusion

Despite BETZ-CHROM's efforts no suitable replacement for the currently used PFAS-based wetting agents was found. [redacted] showed insufficient exposure minimisation (= too little foam formation in baths with comparable large surfaces) and dangerous foam formation in baths with comparably small surface (see results/pictures in chapter 3). Other wetting agents based on the same functional principle as [redacted] have therefore not been tested by BETZ-CHROM. [redacted] was chosen for future R&D because the mixture was designed with a specific defoamer. However, this mixture is not used by any electroplating shop in Germany and no long-term experience on the behaviour of the mixture (e.g., exposure reduction, coating quality, anode wear, etc.) is available (not even for the German contact persons of the supplier). Therefore, BETZ-CHROM needs to carefully evaluate the performance of [redacted] - especially for its electroplating baths used for the aerospace industry.

Concluding, BETZ-CHROM, its workers and the environment are currently dependent on the use of PFAS-based wetting agents in the electroplating baths. Without this important process additive, the plating process would not be safe (= higher CrVI exposure to workers and environment) and additional hazards & risks like oxyhydrogen explosion occur.

For the reasons outlined in this comment, BETZ-CHROM fully supports the suggested time-limited derogation of 6.5 years for PFAS-based wetting agents as critical risk minimisation measure (RMM) for hard chrome plating (see Column 2 on p. 6 of Annex XV report). This period guarantees safety of workers and the environment at BETZ-CHROM's hard chrome plating facility while allowing the company to find a technically suitable substitute.

References

[redacted]