AfA ZF Friedrichshafen AG

Submission number: RU968687-80

Communication number: AFA-C-2114373404-51-01/F

Substance: Chromium trioxide, EC number: 215-607-8

Part 1 - Clarification on RAC comments & questions

The questions from the SEAC committee are provided in bold font. The response from the applicant, ZF Friedrichshafen AG, is provided in normal font under each respective comment or question.

Environmental Exposure assessment

1. Man via environment: Air and water monitoring data

Please further elaborate how the release factors for air and water emissions have been derived.

Regarding the measurements made, please include contextual information (number of samples, sampling method, duration, frequency and dates of sampling, analysis methodology, limit of detection/quantification).

ZF regularly monitors and reports Cr(VI) emissions as part of permit conditions. The measurements and analysis are conducted by accredited, certified external institutes.

Three samples of 30 minutes each are taken at the air emission sources according to DIN EN 15259. The maximum value of Cr(VI) of the three samples, as documented in g/h, was taken for risk assessment. The hourly emission values then were added by site, multiplied by the total emission time per year (6400h in Eitorf and 8760h in Schweinfurt), averaged in kg/day and then multiplied by a fixed value (2.78E-04 from ECHA Guidance R.16. Version 3.0, p.113) for the estimation of exposure at 100m distance from the point source. For Eitorf, measurement reports were available for each year since 2013. The estimated value for Eitorf in the CSR (7.36E-7 mg/m^3) is the mean value for the years 2013 to 2016. At Schweinfurt, the value of 4.68E-6 mg/m^3 is the mean value of the measurements conducted 2012 at all three emission sources and of the measurements 2013/2015, because not each of the point sources has been monitored in those years.

Wastewater monitoring is regulated by German Waste Water Regulation, Appendix 40. The maximum allowed value is 0.1 mgl/l Cr(VI) in wastewater. At the Schweinfurt site, Cr(VI) content in wastewater has to be determined and documented 2 times a week, at the Eitorf site 6 times/year. The analysis is conducted by accredited, certified external laboratories according to DIN 38405 D24 and with a detection limit for Cr(VI) of 0.01mg/l. Additionally, in Eitorf, each wastewater charge is monitored internally for Cr(VI) content. Hexavalent chromium emission to wastewater in Eitorf 2014-2016 and Schweinfurt in 2014 and 2015 were on average around 0.017 mg/L in Eitorf and 0.03 mg/L in Schweinfurt. These values were multiplied with the respective total yearly wastewater amount of the sites and set in relation to the yearly amount of Cr(VI) used at the sites to estimate the release fraction to wastewater.

Please also provide an annual summary of the available monitoring dataset (with range of values, max, min and mean for each year), as this would help RAC to conclude on the representativeness of the values used in the Chemical Safety Report (CSR).

The table below shows the available air emission monitoring data from Eitorf and Schweinfurt, including all three measured values (M1, M2, Mmax), see also description above. All results are expressed as g/h Cr(VI).

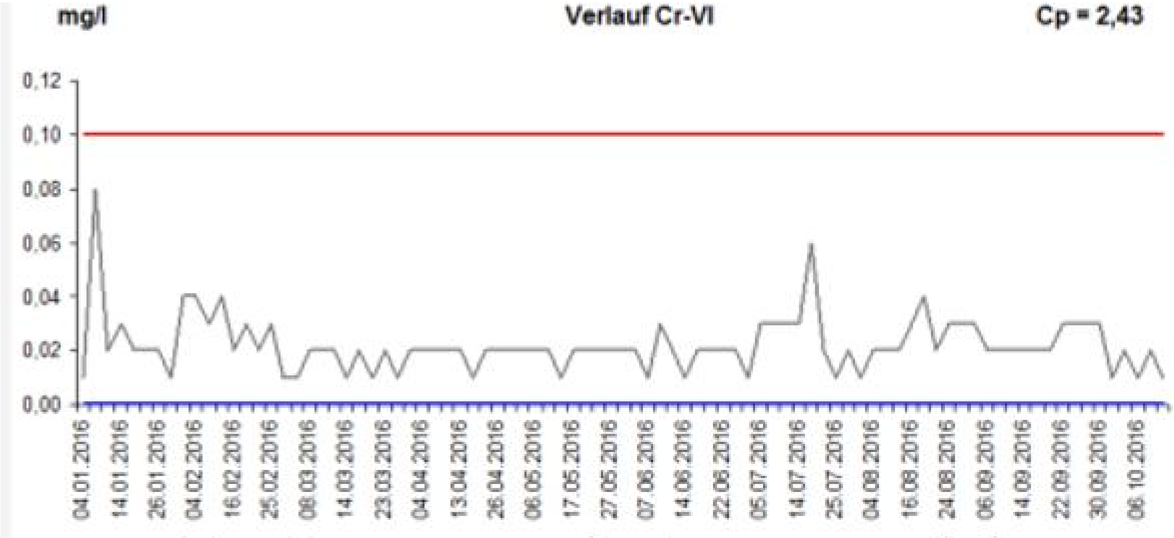
[redacted]									
	Chimney 1			Chimney 2					
Year	M1	M2	Mmax	M1	M2	Mmax			
2013	0.014	0.036	0.107	0.015	0.003	0.057			
2014	0.02	0.01	0.05	0.007	0.008	0.1			
2015	0.1	0.08	0.1	0.04	0.05	0.06			
2016	0.05	0.06	0.06	0.05	0.05	0.07			
[redacted]									
	Chimney 1			Chimney 2			Chimney 3		
Year	M1	M2	Mmax	M1	M2	Mmax	M1	M2	Mmax
2012	<0.015	<0.015	<0.016	0.105	0.064	0.133	0.184	0.132	0.2
2013	0.032	0.01	0.034				0.202	0.209	0.233
2015				0.381	0.121	0.793			

Examples of results of Cr(VI) in wastewater measurements are shown below (see also description above).

Eitorf (0.1 mg/l is the limit value) in 2015, 6 measurements conducted by a certified and accredited institute.

Chrom-VI	mg/l	0,1	<0,01	<0,01	0,05	0,010	<0,01	<0,01	<NWG	DIN 38405 D24[A]

Schweinfurt in 2016, measurements 2 times a week:



Finally, it is noted that you provided a single set of conditions of use (CSR/Table of section 9.1.1.1) for the assessment of the environmental releases for both sites. You indicated that since the majority of Cr(VI) consumption takes place at the Schweinfurt site, the corresponding results were used as worst case. In order to evaluate the representativeness of this scenario, please indicate: a) the licence discharge rate of the STP and, b) the receiving surface water flow rate (dilution capacity) for both sites.

The total wastewater discharge for the Schweinfurt site is between 36,000 m^3 and 43,000 m^3 per year between 2010 and 2016. The mean surface water flow rate of the river Main in Schweinfurt is around 9,200,000 m^3/day. The total wastewater discharge for the Eitorf site is between 6,000 m^3 and 8,500 m^3 per year between 2014 and 2016. The wastewater is discharged after reduction of Cr(VI) to Cr(III) to the municipal STP. The mean surface water flow rate of the river Sieg in Eitorf is around 2,400,000 m^3/day.

2. Risk Management Measures (RMM) & Operational Conditions (OC)

Please confirm RAC's understanding of the following RMM & OC's:

- *All liquid waste generated at both of the applicants sites, including any liquid waste from abatement systems (e.g. liquid waste from scrubbers) is treated on site before discharging to the local receiving surface waters.*
- *All solid waste and sludge from the on site waste water treatment system is disposed of as hazardous waste (i.e. Incineration with only ash disposal to landfill).*

The applicant confirms that both statements are correct.

If this interpretation is not correct, please provide details of how liquid and solid waste (including sludge that is not treated on site or disposed of by incineration), is disposed of.

Worker Exposure assessment

3. Biomonitoring

Historical data can be important to understand the trends in exposure over time, in particular to demonstrate to what extent the encapsulation of the automated lines reduced exposure. Please clarify in which year the encapsulation was installed and biomonitoring ceased in the corresponding site. Please provide a suitably anonymised summary of the biomonitoring data including the data before and after encapsulation (

For the analysis of the dataset, it will be very helpful if data is presented in the following way:

Site	*Year*	*Type of Worker (WCS)*	*Nature of tasks being completed*	*Worker location (encapsulated or semi-closed lines)*	*No of workers*	*Number and type of sample (blood/urine)*	*Spot/ Random/ moment of the shift/day of the week*	*Range of values and min and max.*	*Mean*	*90% ile*

We first want to clarify an obvious misunderstanding. The encapsulated systems are complete installations, not an encapsulation of already existing systems. In [redacted], the [redacted] replaced already existing lines in 1999, in [redacted] were installed in 2001, 2003 and 2011.

Biomonitoring of Cr in urine, as the usual non-invasive method, expresses individual exposure to Cr(VI) or Cr(III) through inhalation, dermal absorption or ingestion. No biomonitoring data are available for the time before the encapsulated systems were installed. As mentioned in the CSR, preventive medical examinations were ceased in [redacted] after installation of the encapsulated systems justified by the occupational physician due to the encapsulation of the automated plants and the resulting low exposure for the workers and only was restarted recently.

Aggregated blood and urine values are available in different graphical formats since 2009 (blood only until 2010) in Schweinfurt, and expressing total Cr. Comparable data for chrome in urine are shown below for the years 2012-2016:

[redacted]

Measurements were conducted at the end of the shift/exposure.

Please clarify and update the exposure assessments, where relevant, with respect to the following questions.

4. Please provide a spreadsheet with the calculations of the Excess Levels of Risk (ELRs) per Worker Contributing Scenario (WCS) and for Man via the Environment.

The Excel spreadsheet is attached as Annex CSR 1.[1]

5. Data used in the worker exposure assessment (WCS 2 and 3)

In its evaluation, RAC focusses very specifically on the measured exposure data provided and its context. From the information that you have provided it is not clear which values from the table in Annex 3 (workers exposure dataset) were used in the exposure assessment. Please clarify what measured exposure data from the plants was used in the modelling exposure assessments for WCS2 and WCS3. RAC notes 12 static samples for encapsulated charging/discharging are available but you have indicated that only 8 static samples were used. In addition, please provide the LOQ and LOD of the method used.

The following data were used for WCS 2 (for details please see AfA CSR Annex CSR 3). The values represent the LOD of the measurements.

[1] The value in the CSR erroneously shows the individual intestinal cancer risk for the general population, the correct risk estimate per 1000 persons is 4.55E-05. However, this does not change the assessment as negligible risk.

[redacted]	9/2/2017	< 0.0006	automatic / encapsulated
	8/2/2017	< 0.0008	automatic / encapsulated
	8/2/2017	< 0.0009	automatic / encapsulated
	9/2/2017	< 0.0009	automatic / encapsulated
	9/2/2017	< 0.0009	automatic / encapsulated
	8/2/2017	< 0.0008	automatic / encapsulated
	12/4/2016	< 0.000625	automatic / encapsulated
	12/4/2016	< 0.000625	automatic / encapsulated

The following data were used for WCS 3:

[redacted]	9/2/2017	< 0.0006	automatic / semi-closed
	8/2/2017	< 0.0007	automatic / semi-closed

6. Duration of exposure (WCS4 and 5)

In WCS4 you have provided a duration of <5 min and in WCS5 a duration of <10 min for the corresponding tasks. In WCS4 you have indicated that "one or more samples are drawn…". Please provide justification for the duration of activity selected for modelling, i.e. if several samples are drawn is the duration still estimated to be <5 min? In addition, we have noted that in other applications, sampling is sometimes done by other groups of workers (belonging to different cohorts of workers). Could you please clarify if the workers engaged in WCS 4, are process operators or laboratory technicians?

The duration shown in the WCSs are correct, < 5min for sampling (WCS 4) and < 10 min for concentration adjustment (WCS 5). Sampling is conducted at the Eitorf site by laboratory technicians, at the Schweinfurt site by plant operators. The latter is considered in the estimation of the combined exposure.

7. Regular Maintenance (WCS6)

RAC evaluates maintenance activities separately as these can lead to significant exposures often not experienced by other workers.

For all maintenance activities SOPs are available.

a. *Please provide a more detailed description of the task "…yearly cleaning and greasing works of components of the encapsulated plating lines" (WCS6/p40), including how workers carrying out this task are potentially exposed to Cr(VI).*

For cleaning & repair of the chromium baths, the chromium-plating frame is removed from the chromium bath. The slide bar for the chromium intake is shut off and the heating of the chromium bath switched off. Membrane pumps are used to pump the chromic acid from the chromium bath into the buffer tank. All anodes are removed from the anode frame. Anodes are stored in the washing area since the setscrews of the anodes are unscrewed. Anodes are cleaned and disposed in the provided container. The medium anode bar is then removed. Getting into the chromium tub is only allowed after instruction and with complete protective equipment (PPE) - protective clothing, chemical-resistant gloves, and goggles. The chromium tub is then cleaned and checked for possible damage. The chromium sludge is filled very carefully in a bucket and then transferred into a blue drum. The blue drum is then marked with a disposal certificate.

All contacts are checked and cleaned if necessary. New anodes are installed and the middle rail equipped with new anodes. Then the middle rail is installed, all anodes aligned, chromium is pumped back from the buffer tank, the heating switched on, and the bath inlet is turned on.

b. *Please provide a more detailed description of the "…cleaning of chromic acid from baths and edges" (WCS6/p41) including how workers carrying out this task are potentially exposed to Cr(VI). Please specify if during this task workers can be exposed to CrO_3 in solid form (e.g. from dried out material containing CrO_3), and if that is the case, how is this taken into account in the exposure assessment.*

Please see the illustration and description provided in Annex CSR 2.

8. Rare Maintenance (WCS7)

c. *You have provided two sub-scenarios: 1. "Rare maintenance when Local Exhaust Ventilation (LEV) is running" and 2. "Rare maintenance with entering the emptied plating baths". Please clearly specify which maintenance tasks fall under each of those scenarios, as this is not entirely clear from the information provided in your application. Please clarify if you plan to include the maintenance tasks in any future workplace measurement monitoring campaigns.*

The worst case scenario for unplanned, rare maintenance is the possible demolition of a motor when a jig has accidentally plunged. This kind of rare maintenance can take up to 4 hours and would include working under hot process conditions with running LEV.

In order for the anodes and cathodes to be checked, the baths are emptied twice a year. In addition, the demister is maintained every six months. This work is conducted without running LEV.

The applicant plans to include maintenance tasks in the future workplace measurement program.

d. *For the sub-scenario 2. "Rare maintenance with entering the emptied plating baths", you have indicated that the duration of the tasks is <7 hours. Could you please specify what is the maximum <u>continuous</u> duration of a task where the worker needs to wear RPE? In addition, you have mentioned an APF 30 for the RPE used (MOLDEX FFP3), whereas the manufacturers indicate an APF 20. This should be considered and corrected in the modelling performed for WCS7.*

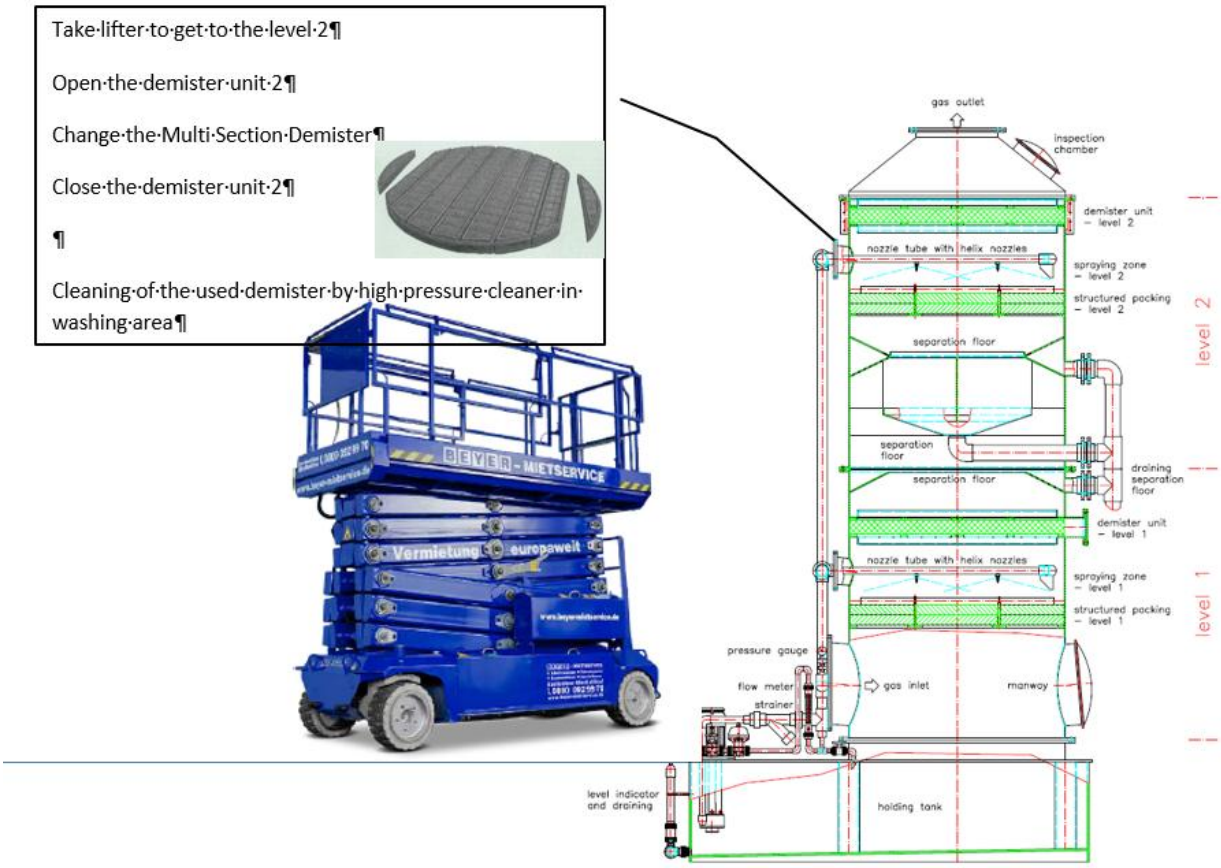
Based on national recommendations, wearing times of RPE are determined based on results of the workplace/task specific risk assessments and limited by company specific guidelines, as appropriate. The maximum continuous wearing time of RPE will not exceed 30-60 min until a break is made. However, this process might occur repeatedly during this task.

For determining the efficiency of RPE, the German BG rule "BGR/GUV-R1902 was used because it provides a robust and consistent approach. The APF assigned in this rule for a half-face mask with P3 filter is 30. The APF assigned by the manufacturer of this mask is also 30, please see:
http://www.moldex-europe.com/produkte/ffp-masken/air-plus/

e. *Please describe in more detail how the filter is changed and the yearly cleaning of the demister undertaken. Please explain how is the cleaning performed (e.g. by using a vacuum, brush) and how is the exposure controlled.*

Please see the illustration and description provided in Annex CSR 3.

The cleaning of the demister is described in the figure below. Please note that the demister is hexavalent chromium free.



9. RMM & OC

The detailed description of operational conditions and risk management measures in place at each site is important to help RAC assess the appropriateness and effectiveness. Please clarify the differences in the LEV between the two sites and the type of testing undertaken.

For the encapsulated lines in [redacted], lip extraction is integrated in the installation and efficiency is checked weekly by volumetric flow measurements and tested externally one time per year. The semi-closed plating lines in [redacted] are also equipped with lip extraction and efficiency is checked weekly by volumetric flow measurements.

Part 2 - Clarification on SEAC comments & questions

The questions from the SEAC committee are provided in ***bold italicized*** font. The response from the applicant, ZF Friedrichshafen AG, is provided in normal font under each respective comment or question.

SEAC comments & question on the Analysis of Alternatives

Q1: ***What is the process time for the current Cr(VI) plating in hours/minutes per piece? In other words, how long does the plating process last for one piston rod? Process time is important to know when assessing suitability/preferability of alternatives as this may significantly affect productivity and process costs.***

ZF Friedrichshafen AG would like to point out that process time is a very critical economic factor and that potential alternative technologies must have processing times of at least the same magnitude as the current Cr(VI) plating process to be practical on an industrial scale.

Functional chrome plating offers the unique possibility to treat large numbers of piston rods in a short time period. At ZF, a state-of-the-art plating line has a production capacity of [redacted].

For the Cr(VI) plating process the piston rods are mounted on racks capable of carrying 40 pieces. The time required for the sheer Cr(VI) plating process of one rack of piston rods (measured from INPUT into the Cr(VI) plating bath to OUTPUT) is [redacted].

However, due to the sophisticated sequencing logic of INPUT and OUTPUT of different racks at different times combined with the availability of three Cr(VI) plating baths in a plating line, every [redacted] a rack of 40 piston rods exits the plating bath, meaning that every [redacted] a chromium plated piston rod is produced.

Please note that there is no difference between the processing time for [redacted]. In other words, if only one piston rod is mounted on the rack, the Cr(VI) plating process would require the same time as for [redacted] as this is the time needed to build up the chromium layer with sufficient thickness.

Therefore, it must be highlighted that the primary advantage of functional chrome plating compared to potential alternatives is that large numbers of piston rods can be treated at the same time in the same plating bath in short periods of time.

Q2: ***On page 52, you mention: "At this stage of the data analysis, some alternatives were screened out after bilateral discussions with the company, based on confirmation that technical and economic limitations clearly argue against their use as potential alternative to chromium trioxide". Could you please list these alternatives and briefly explain why these were not included in the AoA?***

This statement refers to the rejected alternatives No 5-13 mentioned in Chapter 3.2 “Identification of alternatives” in the AoA document on page 53. The technical limitations, which led to the early exclusion of these alternatives during bilateral discussions are presented in Table 13 on page 56 of the AoA document.

Q3: *On page 58, you mention: "Please note that for niche uses in racing applications (short-term use under circumstances with high loads) other piston rod base materials such as titanium and carbon fibre reinforced composite are applied but none of them is technical nor economical feasible on an industrial scale for the long-term use in vehicles." Could you please elaborate on this statement and explain why titanium and carbon fibre reinforced composites are not technically and economically feasible?*

The applicant would like to point out that titanium and carbon fibre reinforced composite are clearly not suitable alternative base materials for the high-volume production of piston rods used in automotive and rail vehicle applications due to the following reasons:

Titanium as piston rod base material

The usage of titanium as piston rod base material is clearly not suitable alternative neither technically nor economically. The prices for titanium raw material are approximately 30-50 times more expensive per kilogram compared to the currently used non- & low-alloyed steel materials.

Please note that the price indication per kilogram titanium only refers to the actual raw material costs. ZF additionally stated that the costs for processing of titanium are also higher than the costs for processing of the non- & low-alloyed steel materials, highlighting the economic infeasibility even more.

From a technical point of view, titanium would not be suitable as piston rod base material as the hardness is not sufficient. This shortcoming results in abrasion and insufficient wear resistance. Furthermore, many changes would have to be made to the current production process of piston rods.

Carbon fibre reinforced composite as piston rod base material

Carbon fibre reinforced composite as a piston rod base material is neither technically nor economically feasible.

From a technical perspective, piston rods made from carbon fibre reinforced composite are only suitable in applications where short-term performance is required (e.g. racing applications in which piston rods or more specifically damper units are exchanged more frequently, i.e. every couple of races). The material is not suitable for serial production of piston rods in automotive and rail applications due to the following limitations:

- Insufficient adhesion of the functional layer on surfaces made of pure carbon fibre reinforced composite.
- Longevity of piston rods made of carbon fibre reinforced composite not given.
- Tribological properties are not sufficient. This means that such piston rods are not capable of withstanding the mechanical stress, suspension strut loads and constant side loads resulting in insufficient wear resistance.
- The connection between the piston rod stem and the vehicle as well as between the stem and the piston valve inside the damper would need to be elaborated

Furthermore, carbon fibre reinforced composite as a base material for piston rods is not suitable from an economic point of view as the raw material is approximately 20-30 times more expensive than the currently used non- & low-alloyed steel materials.

Please note that the price per kilogram of carbon fibre reinforced composite only refers to the actual raw material costs. ZF stated that, from experience with other projects, the costs for processing carbon fibre reinforced composite are higher than the processing costs of the non- & low-alloyed steel materials.

<u>Conclusion</u>

The usage of titanium or carbon fibre reinforced composite as piston rod base materials in racing applications is possible because the economic consideration of a complex market is incidental and only performance figures (e.g. weight) count. Additionally, in racing, the piston rods are only used for short periods of time and no long-term reliability is required.

Aside from the production costs of piston rods made of titanium or carbon fibre reinforced composite, these alternative base materials are not economically feasible because ZF's automotive and rail industry customers will clearly not accept these significant increases in price, considering the market is price sensitive. The production and material costs for a piston rod made of titanium or carbon fibre reinforced composite are already higher than a complete damper unit with a non- or low-alloyed steel piston rod.

Q4: *Please explain if the alternative technology extreme high-speed laser material deposition (EHLA) was considered in the analysis of alternatives. If relevant, please also provide details on the technical and economic feasibility of this technology.*

The applicant would like to point out that the technology *extreme high-speed laser material deposition (EHLA)* was not considered in the analysis of alternatives because it is currently not seen as a candidate alternative to functional chrome plating of piston rods for automotive and rail applications.

The proposed technology developed by Fraunhofer Institute for Laser Technology ILT is a refinement of the laser cladding process. The technology was indeed enhanced compared to laser cladding concerning process time, coating thickness and temperature. However, in this case, it does not set aside major technical shortcomings of laser technologies. From a technical and economic perspective, it is still considered not to be suitable for the use on piston rods for automotive and rail applications due to the following limitations:

- Piston rods for automotive and rail applications are subject to multidimensional forces. A key requirement is that they must withstand dynamic side loads. In this regard, the combination of bending properties and hardness is crucial to withstand these forces (e.g. to exclude crack formation) over the life-time of a vehicle as explained in the AoA.

  Coatings derived by laser technologies such as EHLA create a melt pool on the surface where the melted particles are deposited. Even though the thermal stress is reduced for EHLA compared to other laser technologies, this melting area reduces the critical surface hardening of the piston rod which consequently leads to an <u>insufficient combination of bending properties and hardness and therefore increases the risk of crack formation and abrasion.</u>

- A Dutch company is already using EHLA in production for its <u>off-shore piston rods for hydraulic cylinders, an application that is not comparable to the use described in this AfA.</u> Off-shore piston rods are different in dimension (up to 10 m vs. piston rods for ZF applications 30 cm) and are manufactured in small volumes. Such applications are typically subject to mostly one-dimensional mechanical stress, but not to static and dynamic side loads as it is the case for piston rods in scope of this AfA. Furthermore, EHLA was not used as an alternative to functional chrome plating but to HVOF.

- EHLA allows "piece by piece" laser treatment, compared to the current process allowing a throughput of [redacted] in one rack.

Coating time with EHLA for a typical piston rod was calculated by ZF experts to be more than 50 seconds for a typical piston rod. As described in the response to Q1, in the current functional chrome plating process, the time to plate one piston rod is calculated to be 4 seconds. Consequently, EHLA cannot be considered economically feasible as its performance of EHLA is [redacted] times slower than with the current process. Furthermore, post-machining is needed for parts treated with EHLA. Cost for material (tungsten-based powders) is 15 times higher than for chromium trioxide.

In this regard, these factors cannot be compensated by the reduced energy costs.

- Availability: According to available information, EHLA is a very new development currently not tested for automotive and rail applications, nor are automotive OEM approvals known. As described in the AoA, Chapter 2.6 (p.46), the development and approval process of a new technology for the coating of piston rods is complex has to be conducted with extraordinary care to meet the high quality and safety standards in order to avoid errors and regrettable substitutions. As of today, EHLA has not begun the early R&D phases for automotive applications, where the first step would be the advanced engineering process with the supplier. Considering this, the whole development and implementation process needs to be passed before this technology may be available to ZF Friedrichshafen AG and OEMs. As displayed in the AoA, R&D efforts and successful implementation at OEM level require a review period of at least 21 years.

In summary, the proposed technology is technically and economically not suitable and not available for applications in scope of this AfA. However, as the applicant is currently carrying out a project on the assessment of potential alternatives for the long-term replacement of functional chrome plating, the applicant is in contact with companies that test this technology to keep track on new surface coating technologies.

Q5a: *Please provide further explanation for the following statements related to the possibility of substitution of parts which are currently in production: P14 and 89 both state "design changes for running series are not possible, due to safety reasons". Please provide further explanation.*

The applicant would like to emphasize that it is not possible to change the design of the piston rod in a running series due to the necessary internal and external (OEM level) approval process. A piston rod or more specifically a damper unit is a safety relevant component of a vehicle chassis and crucial for its unrestricted road safety.

Therefore, a series of internal (ZF) and external (OEM) tests must be passed if changes (such as to the piston rod coating) are made. In the following, the contents of internal and external investigations are presented chronologically to give a better understanding of the complexity of the overall approval process necessary to guarantee safety of the emerging product.

Internal approval process at ZF:

- Laboratory testing (surface configuration, layering structure, layer thickness, roughness, etc.)
- Pre-tests (static tests, tear & bend tests, dynamic cold testing, corrosion testing, friction testing)
- Endurance testing (dynamic endurance oscillation testing under load, etc.)
- Additional testing (assembly testing, dirty water endurance testing, etc.)

Please refer also to Chapter 2.6.2 "Internal Development of Series Model" on page 47 of the AoA for detailed clarification on the internal approval process.

External approval process at OEM level

ZF stated that the customer inspection includes a similar test to the one that is necessary for the internal approval process. Additionally, the external approval process included extensive field testing of complete vehicles to evaluate the overall compatibility of all vehicle components. During this inspection and testing phase the vehicles equipped with the new damper model are tested under extreme conditions. For example, the OEMs conduct vehicle endurance runs in cold and / or hot conditions and additionally test the performance of the damper in obstacle courses.

Please note that the OEM approval process is specific for a damper / vehicle combination. In other words, if a new damper model is developed, direct introduction into a running vehicle series is not possible due to the mentioned OEM approval process. This would also be the case for newly developed damper systems using well-established chromium coated piston rods.

Please refer also to Chapter 2.6.4 “Customer inspection and Testing” on page 48 of the AoA for detailed clarification on the external approval process.

<u>Conclusion</u>

Due to the complex and time consuming internal and external (OEM level) approval process, it is not possible to change the design of a running piston rod series with direct introduction into a running vehicle series.

Therefore, Cr(VI) will still be required for those vehicle series which have been tested and approved with damper units using chromium coated piston rods. This is important, because a change of the damper technology in a running vehicle series is not possible and not accepted by the OEM as it would entail a complete re-construction of the vehicle chassis accompanied with all necessary safety assessment procedures. Usually, in the automotive sector a vehicle is produced in a series (from start of production (SOP) to EOP) for 7 years. Furthermore, ZF produces a piston rod model in series over the whole lifetime of a vehicle, which includes aftermarket supply of spare parts for 10 - 15 years dependent on customer requirements.

Q5b: *Similarly, the comment on p 36 (italics added) “The contractual obligations include 7 years of serial production and that the supply with spare parts has to be guaranteed by the company at least for 10 years after End of Production (EOP) for every series produced now and in the future. Changing the technology is explicitly not allowed to not impair the function and the safety of the damper system”) <u>Please clarify these comments- do they mean that even if an alternative to Cr VI were to become available, it would not be used in existing damper systems, but would only be introduced in future new designs?</u> (Subject to the approval of the OEMs)*

Yes, this assumption is correct.

An alternative coating technology would only be applied on piston rods used in newly developed damper units as it is not possible nor allowed by the OEM to change the design of a damper, for example by changing the piston rod coating. As described in detail in Q5a this is due to the complex internal (ZF) and external (OEM) approval process necessary to guarantee safety.

Even if an alternative to Cr(VI) was to become available in the future this does not mean that a fully mature damper model with an alternatively coated piston rod would be accessible. First, the ZF internal development and approval process must be passed, meaning that all damper components are tested for their compatibility (please refer to Q5a for further clarification).

The next step in substituting the Cr(VI) based piston rod or more specifically damper is the external approval process at OEM level. During this phase a damper / vehicle combination is tested to be functional without restrictions to guarantee safety. This specific combination of a damper model and a vehicle chassis is then, after passing the OEM approval process, certified.

Therefore, changing the design of the damper by changing the piston rod coating would immediately lead to the loss of this certification because safety cannot be guaranteed as performance data on the new coating is missing.

For further clarification and a detailed description of the internal (ZF) and external (OEM) approval process concerning alternative piston rod coatings and the resulting newly developed damper units please refer to Q5a. Please also refer to Chapter 2.6.2 "Internal Development of Series Model" on page 47 and Chapter 2.6.4 "Customer inspection and Testing" on page 48 of the AoA. For a detailed description of the overall development process of an alternative to a fully mature damper model please refer to Chapter 2.6 beginning on page 45 of the AoA.

Q5c: *Similarly, comment on P15 and figure 25 (p49) "As a result, a review period of at least 21 years was selected because it coincides with best case scenario estimated by ZF for the schedule required to industrialize an alternative for the substance chromium trioxide and the corresponding processes (including pre-treatment) for refining piston rods for ZF's applications". <u>Would any new process, once developed, only be used in new applications, not to replace existing uses?</u>*

Yes, this assumption is correct.

If a suitable alternative process for the refinement of piston rods was to become available in the future, it would not replace the currently used Cr(VI) plating process for piston rods used in running damper series. As described in detail in Q5a this is due to the complex internal (ZF) and external (OEM) approval process necessary to guarantee safety.

For further clarification and a detailed description of the internal and external approval process concerning alternative piston rod coatings and the resulting newly developed damper units please refer to Q5a. Please also refer to Chapter 2.6.2 on page 47 and Chapter 2.6.4 on page 48 of the AoA document. For a detailed description of the overall development process of an alternative to a fully mature damper model please refer to Chapter 2.6 beginning on page 45 of the AoA document.

Q6: *To better understand the effect of the review period on the use applied for, please explain the impacts on you and your customers that would be the consequence of a normal (7 years), or long (12 years) review period. Specifically, describe what would be the possible positive or negative impacts of different review periods:*

a. on your business security/predictability:

ZF Friedrichshafen AG is a major player in the production of piston rods and covers around [redacted] % of the EEA-market for passenger car applications ([redacted] % worldwide) and [redacted] % of the EEA-market for truck and rail applications ([redacted] % worldwide). In general, [redacted]. ZF and its position in this competitive and price sensitive market is highly dependent on the continuous use of functional chrome plating using chromium trioxide as development, validation and implementation of an alternative method, which is, however, not foreseen yet, is time-consuming and cost-intensive.

The applicant would like to point out that the impacts on business security / predictability as consequence of a normal (7 years), or long (12 years) review period are immense. Regarding both, the highly complex nature of supply chains (see chapter 2.5.9 “Supply Chain” on page 43 of the AoA) in the automotive and rail vehicle industry and the different lifetime of vehicles, planning reliability is crucial for operating successfully. Planning security for future series is mandatory.

Therefore, ZF accepts and signs contracts for Cr(VI) based series production damper models at least 3 years before the production of a series starts which lasts 7 years. As of 2017, contractual supply obligations for more than [redacted] projects exist for the applicants (End of Production (EOP) not before 2024). Additionally, contractual obligations include supply with spare parts that must be guaranteed by ZF for 10-15 years after EOP for every series produced now and in the future.

a) A review period of 7 years would have the following consequences:

- Existing contracts for running series with supply obligations beyond 2024 could not be fulfilled any more if non-EEA capacities were not set up.
- New contracts cannot be signed with immediate effect when taking the typical lead time (3 years before SOP) and production cycles (7 years) into account.
- Non-EEA competitors could increase their production capacities based on Cr(VI) and initiate intensive promotion campaigns to profit from the insecure supply situation from the applicant.
- Sending a review-report 18 months before the end of the first review period of 7 years is clearly not sufficient to satisfy the mandatory planning security in the automotive industry. Customers will not rely on this possibility and will certainly plan to source their parts from non-EEA countries.

<u>Clearly, risk of supply shortages is not acceptable for OEMs in the automotive sector.</u>

b) A review period of 12 years would have the following consequences:

- Planning reliability can be maintained, therefore existing contracts can be fulfilled with EOP until 2030.
- The applicant will be in a position to establish new contracts with SOP after 2017 for at least some years.
- The applicant will not lose its position in the market to non-EEA competitors.

<u>Therefore, the difference between granting a normal (7 years) or a long (12 years) review period is very critical for ZF’s internal business strategy.</u>

Indeed, as indicated in the AoA, a review period of 12 years will not be sufficient for full substitution of Cr(VI) for piston rod applications. ZF Friedrichshafen AG applied for a review period of 21 years as by consideration of all necessary steps, this is the time required for development and successful implementation at OEM level. Nevertheless, as a review period of 12 years is the currently achievable maximum, ZF Friedrichshafen AG would be recognized as a reliable partner in the market.

b. on the affected supply chains:

Important considerations on the impact of a normal (7 years) or a long (12 years) review period on ZF’s supply chains are described in the response to Q6a.

a) A review period of 7 years would have the following consequences:

- As stated above, a review period of 7 years will disable ZF to fulfil most of their contractual arrangement with its current EEA capacities and supply chains.
- Consequently, as no alternative will be available within 7 years and OEMs can get Cr(VI) plated piston rods from non-EEA suppliers, the applicant is forced to outsource the production of piston rods.
- Customers will rearrange their supply chains to non-EEA suppliers that can guarantee supply until EOP;

In summary, a review period of 7 years will increase the pressure on the applicant only, while it might not have a major impact on the OEMs that can rearrange their supply chains that already operate on a global level.

b) A review period of 12 years would have the following consequences:

- It would enable ZF to keep its position in the market as a reliable partner within their supply chains that can fulfil its contractual arrangements with Cr(V)-plated piston rods.
- It will also enable ZF to sign new contracts for productions with SOP after 2018.
- From a European economic perspective, the whole value chain will remain in Europe.

c. on substitution activities within your company:

The applicant would like to highlight that a review period of 7 years would make the chances to succeed with the overall goal - to develop and substitute Cr(VI) for functional chrome plating of piston rods – impossible. As described above, planning reliability is crucial for the OEMs, supply shortages are not acceptable. In consequence, to mitigate this risk the OEMs will move to suppliers in non-EEA countries. In this case, all investments to find a substitute for functional chrome plating of piston rods within the EEA are ineffectual.

It was described in the AoA that there is no suitable alternative available on the market and that R&D activities with candidate alternatives are in preliminary stages. The development process is complex and lengthy and also depends on the acceptance of a new development at the OEM level. If the applicant does not have the time to develop, implement and industrialise new technologies, investments in outsourcing to non-EEA countries are more attractive compared to investments in R&D which finally cannot be industrialized because of lacking time. A review period of 7 years will consequently not trigger quicker substitution of Cr(VI), but will impede effective competition with non-EEA companies.

This is not in line with Article 55 of the REACH Regulation stating that *"The aim of this Title is to ensure the good functioning of the internal market while assuring that the risks from substances of very high concern are properly controlled and that these substances are progressively replaced by suitable alternative substances or technologies where these are economically and technically viable."*

Again, if a shorter review period than at least 12 years is granted, ZF will immediately start to re-orientate its piston rod supply strategy to non-EEA suppliers.

A review period of 12 years will result in the following consequences:

- ZF is highly involved in the R&D process for finding suitable candidates for the current Cr(VI) based process together with different partners from industry (please refer to Chapter 3.1 on page 52 and Chapter 3.5 on page 74 of the AoA). However, R&D is in early stages. A review period of 12 years will enable ZF with its partners to further develop technologies and reach industrialization/market acceptance for first applications out of its [redacted] different parts.
- Sufficient time for the development of new technologies will increased business for alternative suppliers and potential acceptance by other industry sectors if first applications can be implemented successfully in the automotive industry.
- Allowing sufficient time for substitution activities, Cr(VI) plating from non-EEA countries will be less competitive and industry can profit from better reputation.

In conclusion, the applicant would like to recall that the business relevance and factual dimension regarding the replacement of functional chrome plating for piston rods is immense for ZF Friedrichshafen AG. It needs to be pointed out that <u>even within a long review period of 12 years only minor effects can be achieved</u> and functional chrome plating will still be required to a large extent after the 12-year review period. ZF applied for a review period of at least 21 years as this is the time required to fully substitute functional chrome plating using chromium trioxide and comply with the contractual arrangements set in the contracts between them and their customers.

"R&D is a time-consuming process and exact time schedules are hard to predict as scientific breakthroughs and positive results cannot be enforced but come with experience, time and patience."

Q7: Please explain the "unacceptable corrosion risk" that is referred to for Scenario 3/P79: (Outsourcing of the chrome plating process to a non-EEA company).

The production of piston rods is an integrated, fully automated process. The process steps where the piston rods are chrome plated takes place in the middle of the process chain. This means that the chrome plating step alone cannot be outsourced without changing the entire piston rod production process. This would involve huge efforts for changing the process and would also negatively affect cycle times.

Furthermore, if only the chrome plating step would be outsourced to a non-EEA company, the ´raw´ piston rods would have to be shipped to a distant location before the corrosion protection (chrome plating) is applied. These ´raw´ piston rods must be regarded as bare-metal goods which, by nature, are prone to corrosion even within hours of manufacturing and only minimal exposure to moisture and oxygen. During shipping, the piston rods are exposed to such adverse conditions (i.e. oxygen, humidity and/or slight salt spray for days or weeks in case of overseas shipping), causing corrosion and possibly scratches on the surface. There are temporary corrosion protective materials on the market, which are supposed to protect bare-metal goods against corrosion between production steps or during transportation. Such protection materials, however, are most often not easy to handle and/or inefficient so that the risk of corrosion remains. Moreover, the temporary corrosion protection needs to be removed in additional degreasing and cleaning steps before the actual chrome plating process chain can commence. It is important to add that the corrosion risk is just one of the disadvantages of this scenario. Besides that, there is also the logistic risk, since any delays in shipments affect the whole production process of dampers putting at risk the just-in-time delivery of the dampers.

Summing up, this scenario would involve (i) prohibitively high efforts/costs for re-arrangement of the piston rod production process as well as for additional steps for corrosion protection (application and removal of temporary corrosion protection, additional degreasing/cleaning step) and (ii) prohibitively high logistical risks putting the whole damper production and supply chain at risk. Finally, additional transport costs need to be considered. For these reasons, this scenario cannot be considered as a realistic non-use scenario.

Q8a: Is the requalification cost figure (confidential) a "worst case scenario", assuming multiple retesting by both ZF and OEMs? What is the most likely range of costs?

No, the requalification costs reported in the SEA are not a worst-case scenario. They have been calculated using realistic assumptions based on experience from previous projects. See confidential Annex SEA 1 for further details on requalification costs.

Q8b: P79 Scenario 4: Outsourcing to non-EEA based company – the outlined scenario appears to suggest the work would be carried out outside the EU by an external third party, without considering the option of using or expanding an overseas ZF facility. Would it not be possible/preferable to undertake the process in an overseas subsidiary? P80 refers to the costs of building a new facility, but does ZF have chromium VI facilities elsewhere that could be expanded or considered as an alternative option? (An alternative to Scenario 2, greenfield relocation). What would be the requalification costs in a scenario, where ZF overseas subsidiary continues/takes over production? What would be the requalification costs in a scenario, where a third party (overseas company) continues/takes over production?

Regarding the first part of the question, if possible it would be clearly preferable to relocate production to an existing facility instead of relocating to greenfield. It is important to note, however, that this is a matter of having available capacity at one of the existing facilities overseas. After assessing the current situation in its (chrome plating) facilities outside the EEA, the applicant concluded that none of them have idle capacity or buildings/space appropriate for expansion and/or relocation of the German piston rod production lines. Therefore, the only viable scenario is greenfield relocation.

Concerning the requalification costs in a scenario of relocation to an overseas subsidiary, a separation between internal and customer requalification costs must be done. While customer requalification costs are expected to be the same (subsidiary vs. third party scenarios), internal requalification costs in case of relocation to an overseas subsidiary are expected to be slightly lower if it is possible to move the complete process (equipment, machines) and to use the same chemical materials. It is not possible for the applicant to exactly quantify the potential reduction in requalification costs because in the end it is the customer´s decision how many and which approvals need to be renewed. If the machines and equipment cannot be moved/used and totally different ones must be used, then the original requalification costs of approx. EUR [redacted] must be expected.

However, as previously stated, relocation to a ZF overseas subsidiary is not an option!

Q8c: Please provide further explanation of the requalification process and duration. Why is it estimated to take between 7-14 years? (Table 21 p82). Does this mean that even if ZF moved existing production overseas (scenario 2), it would also take up to 14 years before OEMs would be ready to accept this alternative source of supply? Or in such a case, would the internal requalification process take less time, since the supplier would not be a third party company? Would the same qualification period always be required?

As stated on page 82 of the combined AoA+SEA document, the period of 7 to 14 years is composed of a period of 3 to 6 years for internal qualification (design verification process) and 4 to 8 years for the qualification at all customers. Since it is not possible to proceed with requalification of all clients at the same time, such a long period of up to 14 years is explained by the fact that customer requalification would happen in groups of customers, progressing until requalification has been achieved for all of them and for all the concerned sizes of piston rods.

Similarly to what would happen with the costs of requalification, the relocation to an existing ZF facility overseas (and not outsourcing to a third party), could potentially lead to a slightly shorter internal requalification period.

However, as previously stated, relocation to a ZF overseas subsidiary is not an option!

Q9: Decommissioning expenses: Could the existing facilities be used for another purpose after ceasing the current production? Please explain how the value per square meter of decommissioning costs (claimed confidential) was estimated.

The ZF production areas are rented. Therefore, when ZF leaves the area, the buildings, the land (and its soil) must be repaired and brought to the original state before the facilities/land can potentially be used for another purpose. ZF has performed many reconstructions and plant modifications in the past years and for this reason has gained significant experience in estimating decommissioning costs.

Based on previous ZF works in Schweinfurt, the cost of [redacted] EUR/sq. meter has been estimated by combining the following items:

- Basic cleaning, soil remediation (for example, pits and shafts close, rough work on the land): [redacted] EUR/m^2
- Coating of the surface (2K Epoxy industrial floor): approx. [redacted] EUR / m^2
- Various dismantling works (electric, pneumatic etc.): [redacted] EUR / m^2
- Painter and painting work: approx. [redacted] EUR / m^2

Q10: You mention in the application that there are approximately 10 competitors in the EEA and 30 worldwide. Please specify if, to your knowledge, any of the competitors is using an alternative substance (other than CrO3) in similar uses like the use applied for (treatment of piston rods). If that is the case, please specify the identity of these substances.

As stated on page 20 of the combined AoA+SEA document: "ZF Friedrichshafen AG regularly conducts worldwide bench mark investigations to stay well informed about the current R&D status at competitors concerning chromium trioxide alternatives. However, no alternative to state-of-the-art chromium trioxide based functional chrome plating is available on the market or used at any of ZF's competitors up to date."

Since the time when the combined AoA+SEA document has been submitted until today, no new information about alternative substances or processes has been received or collected by ZF.

Q11: Could you further justify the fairly high number of workers that would be dismissed in the non-use scenario (a total of [redacted] + [redacted] = [redacted] workers for both sites).

As stated on page 39 of the of the combined AoA+SEA document, [redacted] and [redacted] workers are currently employed in the production of piston rods in Schweinfurt and Eitorf respectively. It is natural that, if the production of piston rods is outsourced to another company, the job positions which currently perform this task at ZF become redundant and employees are dismissed. Since an entire production step would be outsourced in the non-use scenario and the high number of workers that would be released, those workers cannot be absorbed by the remaining company divisions.