This initial feedback is submitted on behalf of participants in the Umbrella Project ("UP")´s Exemption #13(a) technical Working Group ("WG") (hereafter referred to as "UP Exemption #13(a) WG Participants")

Current wording of the exemption:

Lead in white glasses used for optical applications

Requested validity period: *Maximum (5 and 7 years respectively)*

1. Acronyms and Definitions

Cd	Cadmium
Pb	Lead
LCoS	Liquid Crystal on Silicon

2. Background

Bio Innovation Service, UNITAR and Fraunhofer IZM have been appointed[1] by the European Commission through for the evaluation of applications for the review of requests for new exemptions and the renewal of exemptions currently listed in Annexes III and IV of the RoHS Directive 2011/65/EU.

Spectaris e.V. submitted a request for the renewal of the above-mentioned exemption, which has been subject to a first review. As a result we have identified that there is some information missing. Against this background, the questions below are intended to clarify aspects concerning the request at hand.

We ask you to kindly answer the below questions until 5th February 2021 latest.

Remark

You request the renewal of exemption 13a for all EEE in category 8 and 9 while the exemption remains valid for in-vitro diagnostic devices until 2023 and until 2024 for industrial monitoring and control instruments. In line with the Commission approach, we would like to point out that, should the exemption be renewed for these subcategories of EEE, the new exemption validity periods would start with the official renewal date of the exemption, which forseeably would be before 2023 and 2024 respectively.

3. Questions

1. You mention that MOST clear and transparent polymers have low refractive indices and therefore are not suitable for use as lenses.

    a. Which clear and transparent polymers have higher refractive indices?

[1] It is implemented through the specific contract 070201/2020/832829/ENV.B.3 under the Framework contract ENV.B.3/FRA/2019/0017

A few types have been developed that are used to make spectacle lenses. Spectacle lenses can be thinner if they have high refractive index. Examples include allyl diglycol carbonate (ADC) and polymers manufactured by Mitsui[2].
High-refractive polymer (HRIP) based materials cover a range of refractive indices up to 1.74 with limited applications. Please refer to the Abbe-Diagram, fig. 34, page 47 of the renewal request for exemption 13a.

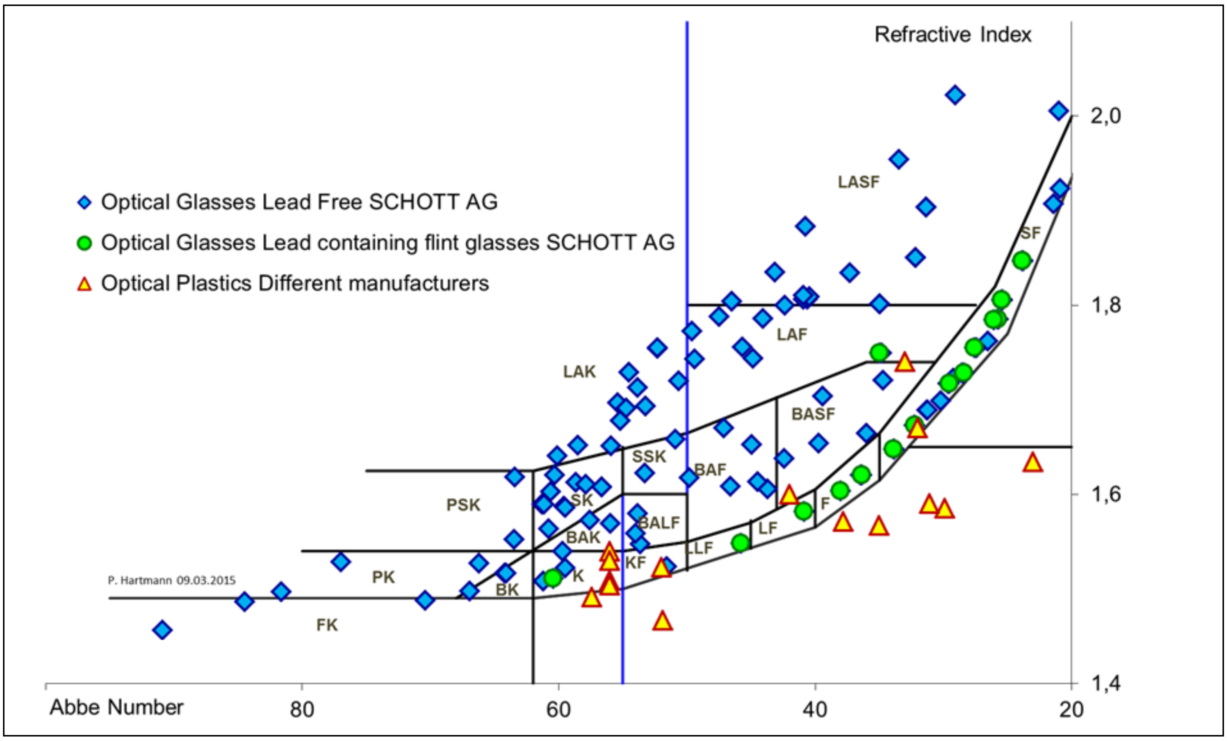

Fig. 1: Abbe-Diagram of optical plastics and optical glass

However, such HRIPs do still have a low dispersion behavior. For this reason, optical corrections cannot be made by using HRIPs. Especially the following optical corrections are not possible with polymer glasses:

- Reduction of the chromatic aberration,
- Reduction of Petzval field curvatures,
- Achromatization,
- Reduction of spherical aberrations,
- Correction of apochromates and colour correction.

For the correction of theses parameters optical glasses are necessary which have not only a high refractive index but also a high dispersion, which is fulfilled by optical lead glasses.

Additionally, polymer glasses have severe disadvantages as compared to inorganic glasses, pls refer to table 8, p. 46 of the report for the renewal of exemption 13a.

Polymer lenses have very different optical and physical properties to lead-based glass. One of their limitations for many applications is their inferior heat stability when compared to glass; for example, the temperature inside projectors can reach well over 100˚C and many polymers will distort or melt at these use temperatures. High refractive index (R.I.) spectacle lenses are stable <120˚C and the plastic lens material with the highest refractive index is MR174 (made by Mitsui) with R.I. of 1.74 which has a heat distortion temperature of 78˚C.

[2] https://eu.mitsuichemicals.com/sites/default/files/media/document/2018/mr_brochure_en.pdf

Polymers also have much higher coefficients of thermal expansion (CTE) than glass so that temperature changes can cause dimensional changes which alter the optical characteristics.

Most clear transparent polymers such as polycarbonate and acrylics have relatively low refractive indices (<1.6) making them even more unsuitable for high performance magnification applications.

Property	Glass	Plastics
Refractive index	1.44 to 2.1 achievable (highest for lead is 2.1)	1.49 to 1.74
Tolerance (i.e. variation in characteristics of commercial lenses)	Low (±0.0001) can be achieved, so variation is very small	Estimated at ±0.001
Abbe number	Broader range (20 to >80) especially to low dispersion values	23 – 58 is possible
Transmittance (through 3mm)	>99% achievable	85 – 91% typically
Birefringence	2 to 10 nm/cm	2 to >40 nm/cm
Density	Lead-based are ca. 5 g/cm^3. This offers advantages and disadvantages	1 – 1.2
Water absorption	Zero (so moisture has no effect on performance)	All plastics absorb water causing changes to optical properties (as they swell) and also potentially degradation can occur. From 0.01% to 0.3%
Thermal expansion	SF57HT Ultra is 9.2 x 10^{-6}/K, all glass 4.5 to 13 x 10^{-6}/K.	Range is 47 to 80 x 10^{-6}/K. This causes optical changes with temperature and thermal degradation
Refractive index thermal dependence	Smaller range of - 0.7 to + 1.2 10^{-5}/°C	-8 to -14 10^{-5}/°C
Resistance to damage	Relatively hard so not easily damaged.	Soft so easily scratched
Exposure to UV light	No effect	Discolours and degraded
Heat resistance	Resistant to temperatures created by lamps and laser light sources	Lamps and lasers can easily cause deformation or even make holes
Medical sterilisation	Completely resistant	May be damaged at sterilisation temperature. Viruses and bacteria can survive within scratches which plastics are more prone to than glass
Thermal conductivity	Lead-glass is relatively high so equilibrates faster than lead-free glass and plastics	Slow to equilibrate so can distort due to uneven heating

Tab. 1: Comparison of properties of glass and plastic lenses

Specially relating to medical sterilization, the use of polymers is unsuitable. The following provides further detail than provided in the exemption request as an indicative example of the challenges this type of application faces. Medical endoscopes are required to be autoclaved at a temperature of 134°C for sterilization. At these temperatures polymers tend to deform, having a strong negative impact on both the color fastness and image brightness. Being exposed to such temperatures also introduces significant stress due to different coefficients of thermal expansion for the plastic and the coating, causing the coating to flake off after a few cycles of being exposed to such temperatures. These are both in addition to the consideration that the transmission of such polymers is much lower than leaded optical glasses, which would greatly reduce the image brightness. For the specific application in question the newer high-conductivity polymers from Zeonex and Topas, were compared to the Schott's F2HT, where the transmission was still found to be inadequate.

Additionally, it has to be considered that some of the polymer materials are based on compositions and production processes involving chemical substances regulated by the REACH Regulation 1907/2006. For certain chemical substances restrictions apply according to Annex XVII of REACH Regulation 1907/2006. Although, the use of polymer materials currently is not technically practical, how such substances will be regulated in the future is noteworthy as it may impose future restrictions.

The plastics strategy from the EC outlined targets towards tighter control of (single use) plastic material and the associated impacts on the environment, especially the pollution of our maritime environment. We have to assume that this plastic strategy will have effects also on other polymer materials besides single-use plastics making optical applications with polymer materials unattractive.

2. You describe the example of LCoS projectors as ONE example for which alternative designs have been developed and are widely used even though LCoS designs give the best optical performance.

    a. Are there other examples of such alternative designs which give acceptable performance compared to designs depending on lead-containing glass?

In the 1990s all large optical manufacturers globally introduced lead free glass types with optical properties as close as possible to those of the preceding lead glass types. The lead-free glass types were required by the consumer optics market, which asked for eco-friendly cameras. By the end of the 1990s there was hardly any lead glass used for consumer optics, which has the largest share of glass usage by far. Companies, which could not afford developing the lead-free glasses went out of business. Nowadays lead glasses are used only for cases, where there are no alternatives to achieve the required optical performance. (please refer also to: 150311_Ex_13a_Clarification-Questions_Answers.doc (exemption review under Directive 2011/65/EU, 1st Questionnaire Exemption No. 13a (renewal request) from 2015)).

Substitutions had been driven by customers of consumer optics in the last 30 years. The applications provide already implemented substitutions and with a stable production tonnage over the last years, the application refers to existing applications accordingly. It is assumed, that feasible substitutions have been fully implemented.

All consumer optics from pocket cameras to DSLRs (digital single lens reflex) use only lead-free glasses. Industrial optical systems without special performance requirements also use lead-free glasses. A large if not the most part of pocket cameras has been replaced by smartphone cameras using mainly plastic optics.
Since substitutions were made in the 1990s, we are not aware of new examples of types of products that have replaced lead-glass with lead-free glass types.

3. We understand, that high-quality lead-containing lenses are needed for high-quality cameras, projectors, camcorders and similar products and that chromatic aberration should be minimized. You mention software compensating performance deficits of lead-free glass/lead-free lenses.

    a. Is this software compensation applied especially in the consumer sector for photo and video equipment? If other areas are relevant, please name them and let us know product examples.

Substitutions have been driven by customers producing consumer optics. It is assumed that this did not only reduce the total amount of optical lead glass which has been produced over the last years but also includes substitutions in combination with software assisted compensations.

However, such software compensation can be done only to convert poor or medium optical quality to acceptable limits for amateur users. High end optics, such as diffractive limited microscope objectives, or professional applications such as film shooting, require the best direct optical imaging techniques. If an image is distorted due to the properties of the optical system not being adequate, digital processing software will not make the image better – it will only retouch unwanted effects for the untrained eye.

    b. What is the technical status here for professional applications such as film shooting? Are there new software solutions available since the last exemption request?

Please see answer to question 3a.

4. On page 48 you state: "In the last 25 years not one single lead-containing glass type had been developed. Lead-containing glass types had been reduced by 88 % by number within this time-frame and now have a share of 12% on the melted tonnage of all optical glass types."

    a. We understand that this statement is not related to glasses used in the scope of exemption 13(a) only, but also other types of filter glass (ex. 13(b)-I)). Is this correct?

Yes, this is correct.

    b. If yes, could you please let us know the share of lead-free glass produced and used for applications in the scope of exemption 13(a)?

Lead-free glass types were introduced to the market by SCHOTT in the 1990s, but the majority of substitutions was not documented by applications. With SCHOTT being a special glass producer in the EU, 12% is the proportion of optical lead glass manufactured in the EU and the share of 12% of all optical glass types can be assumed as being slightly higher than the global share, which we believe is nearer to 5%; please refer to question 5a. Since SCHOTT is only providing the materials, no more specific ratios on applications within the downstream user supply chains are on hand.

Data from glass-specific tonnage and their reference to applications are not available in either public available statistics and reports, nor industry reports and statistics. Accordingly, the share of globally produced lead-free and lead-containing glasses - partly also imported to the EU market - is not available to provide shares of higher exactness as in the application document.

Although we are able to provide the above data on the proportion of optical glass that contains lead and which is lead-free that is manufactured in the EU and globally, it is not possible to determine the proportion that is used in equipment placed on the EU market. This is because the destination of optical glass components made in the EU can be anywhere in the world and is not separately reported and the amount of leaded optical glass in equipment imported into the EU is not separately reported either.

5. On page 51 you state: “For the world-wide production SCHOTT estimate the present ratio between lead-free to lead containing optical glass is about 20:1.”

    a. Does this ratio of 20:1 refer to the mass or the numbers of optical glass?

Please refer to the answer given for question 4b. The 20:1 ratio is derived from mass of the production of optical glass globally and is an educated estimation, since no glass type specific statistics are available on a global scale.

6. You mention commercial shares of lead-free glasses in several contexts (c.f. above questions). You also state that none of the publications since 2014 are applicable for the combination of high index, low refraction and high transmission at short wavelengths, so no content explains new approaches of lead-free optical glass types.

    a. We assume that there are less challenging applications where lead-free glass types are used also for applications in the scope of exemption 13(a). Can you confirm this, or explain why this assumption is misleading given the above statements?

In preparation of the latest renewal request for exemption 13a, publications have been screened. Based on this exercise and a stable market demand in recent decades, we have to assume that all substitutions from lead-containing to lead-free glasses were made in the past (mostly in the 1990s) whenever this was technically feasible.

    b. If applicable, please also let us know applications using lead-free glass as alternatives to the glass in the scope of exemption 13(a).

Please refer to the answer given for question 2.

    c. Are there applications as well that use polymers instead of inorganic optical glass? Which ones?

Yes, there are applications using polymer lenses instead of inorganic optical glass. Applications making use of polymer lenses are for instance camera modules in smartphones, ophthalmological spectacle lenses (the latter are not in the scope of the RoHS directive, since they do not rely on electrical functions). They may also be used in applications that we are unaware, possibly in children’s toys.

7. You marked every category (from 1 to 11) as relevant. However, the list of illustrative examples beginning on page 8 of the exemption request form does not provide examples for all categories.

a. Please provide examples for each category

From our point of view, it cannot be excluded that for special applications in categories 1 and 2 (large household appliances, small household appliances) optical lead glass is used in optical elements like sensors and others.

Optical production is a highly fragmented business. There are some big companies but also a lot of small and medium sized companies in this market. It is very likely that such small and medium sized optical manufacturers, which are often very specialized and application driven companies, make use of exemption 13a for the categories 1, 2, 5, 7 and 10 and buy leaded optical glass components from distributors and so were not able to provide examples of uses in all RoHS categories. The correct RoHS category for some types of electrical products is not clear and may depend on their end use application. More information has been provided since writing the exemption renewal request and video and television cameras, camcorders and projectors specifically designed for sporting applications are indicative examples of category 7 applications.

b. Can you give an overview of the most important categories in terms of quantities for the use of optical glass?

Based on the examples provided in our request for the renewal of RoHS exemption 13a we are aware of, these would be the categories 3, 4, 6, 8, 9 and 11. However leaded optical glass may be also used in other categories. However, the technical function of leaded optical glass – as outlined in detail in our renewal request for exemption 13a – are applicable to all RoHS categories and therefore the use of the exemption may be significant in other categories as well.

Please note that answers to these questions will be published as part of the evaluation of this request. If your answers contain confidential information, please provide a version that can be made public along with a confidential version, in which proprietary information is clearly marked.

It would be helpful if you could kindly provide the information in formats that allow copying text, figures and tables to be included into the review report.