1st Questionnaire Exemption No. 13a (renewal request)

Exemption for „ Lead in white glasses used for optical applications“

Abbreviations and Definitions

Cd	Cadmium
Cr VI	Hexavalent chromium
Pb	Lead

Background

The Oeko-Institut and Fraunhofer IZM have been appointed within a framework contract[1] for the evaluation of an application for granting an exemption to be included in or deleted from Annexes III and IV of the new RoHS Directive 2011/65/EU (RoHS 2) by the European Commission.

Spectaris e.V has submitted the above mentioned request for exemption which has been subject to a first evaluation. The information you have referred has been reviewed and as a result we have identified that there is some information missing and a few questions to clarify concerning your request.

Questions

1. The following information is specified on page 20:

   A European manufacturer of these types of optical equipment values the transmittance of a device as very high on the list of important features for our users and has filed patent applications (US 2013-0258161 A1, EP 2605055 A1) which strive for protection of the use of lead-containing glasses in binoculars as well as the new lead-free glasses using extremely pure ingredients (Schott's so-called HT glasses. The patent applications are still pending (as of Jan 2014). The types of glass that could be used are as follows:

   What is the purpose for which this patent is mentioned?

   The purpose is to show that there is an optical design for binoculars using Pb-containing glasses, for the reasons described in the application.
   An optical scope has at least one optical element which is used to image an object. An optical element is, for example, understood to mean a lens unit, a prism, or a prism system composed of multiple prisms. A lens unit is, for example, understood to mean one single lens or a unit which is composed of at least two lenses. It is now provided to make the optical element of glass, namely of at least one of the following glasses (glass types): N-BK7HT, N-SK2HT, F2HT, N-LASF45HT, SF6HT, N-SF6HTultra, N-SF6HT, SF57HTultra, N-SF57HTultra, N-SF57HT, as well as N-LASF9HT. The above-named glasses are glasses of the SCHOTT Corporation

[1] Contract is implemented through Framework Contract No. ENV.C.2/FRA/2011/0020 led by Eunomia

Ref:
https://www.google.de/patents/US20130258161?dq=US+2013-0258161&hl=de&sa=X&ei=jSvnVI7KIofJPJKggcgI&ved=0CCAQ6AEwAA
This patent shows that modern optical equipment needs to use many different types of glass to achieve the high performance required. In this case, the high performance relies on several lead-glasses as well as lead-free types. The high performance is achieved only if all of the listed glass types can be used.

2. In some of the figures and diagrams important information is missing – in some cases (e.g. figure 7, figure 11) the reference to what is presented on the x or y axis is not clear. In other cases leaded and non-leaded lenses are compared, however it is not always fully clear what is what (table on page 20) – please submit such images again to clarify these aspects, preferably within the original document (amended version).

Figure 7: x-Axis: simple enumeration; y-axis: lead content in weight-%; Figure 11: x-axis: wavelength in nm, y-axis: transmission in %. Explanation for table on page 20: nd: refractive index of the glass at Na-D-line (589 nm); vd: dispersion at 589 nm, τt: transmission (τt = 1: 100%), color code: can be omitted).

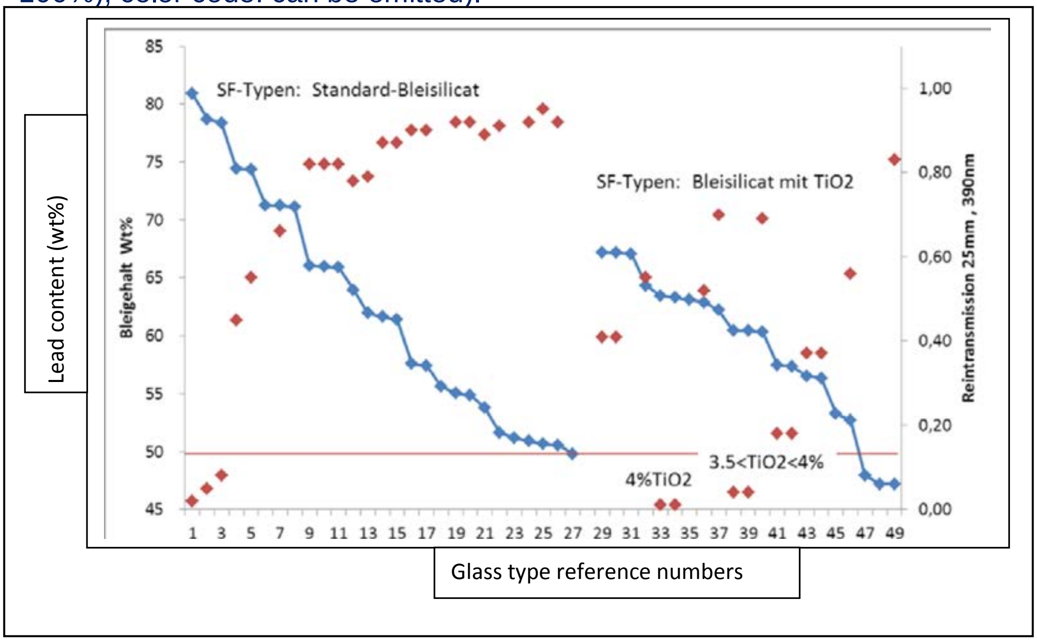
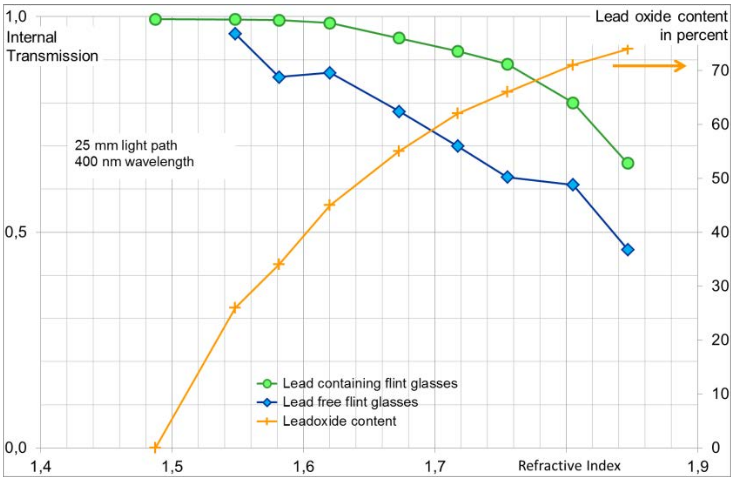
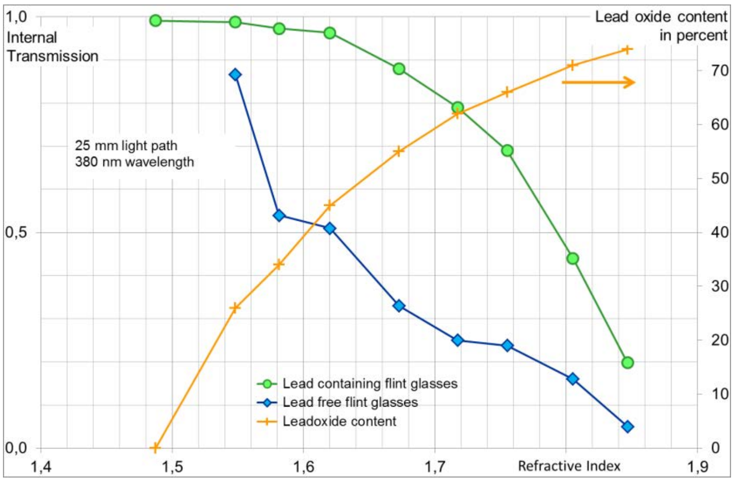


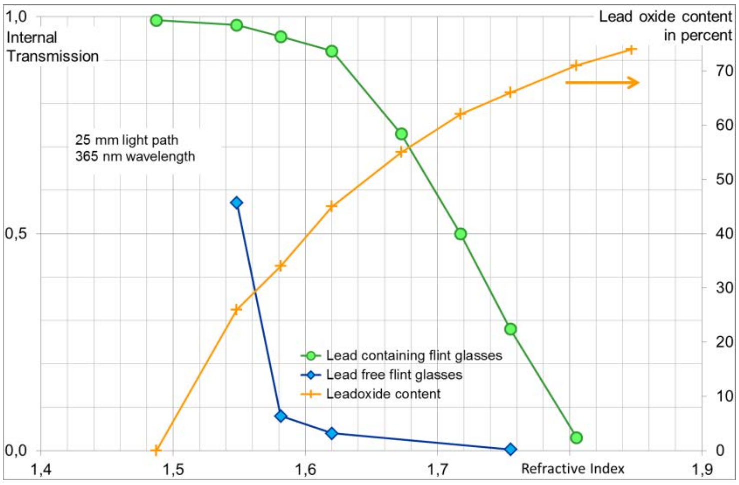
Figure 7. Relationship between lead and titania (TiO_2) content and internal transmission of light



7.1a)



7.1b)



7.1c)

Figures 7.1 a-c shows the internal transmittance of optical glasses at the three different wavelengths 400 nm (a), 380 nm (b) and 365 nm (c). At these wavelengths close to the border line between visible light and near UV light most glasses lose transmittance sharply (this phenomena is called UV-edge). The diagrams depict the internal transmittance as a function of the refractive index, which in the case of lead flint glasses is closely related to the lead oxide content (given in a separate curve with the scale on the right side). The lead free glasses lie clearly below the lead containing glasses. The difference between lead containing and lead free (barium, niobium and titanium containing) glasses rises with increasing refractive index except for very high indices where internal transmittance is already very low. It gets also higher with shorter wavelengths.

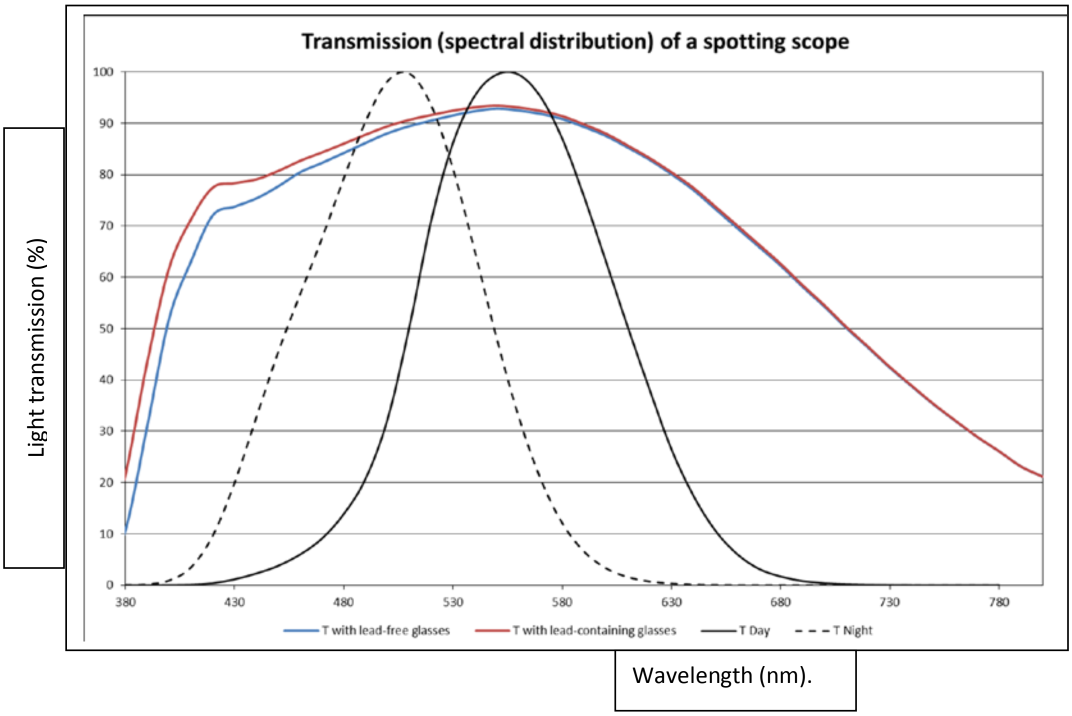


Figure 11. Light transmission with lead and lead-free glass compared with day and night human vision behaviour

3. In a number of places you refer to “batches”. This term is usually referred to in production when a process is operated “batch-wise” as opposed to “continuously”. What is meant in the use of this word in this case? Manufacturing / melting batches of a certain lens? The group of lenses used within a certain application?

The word “batch” can have two different meanings – please see explanation below:

Page 5: Replace “batch” by “set”. This means a set of objectives which are matched to each other and thus form a contiguous set, where one part cannot be replace by another one easily, but requires matching again.

Page 35 replace “batch” by “melting tank run”, Glass production needs minimum production amounts in order to achieve the very high quality required. The first part of the melting run, when essential properties are still varied to reach the tolerance ranges, cannot be used. The last part while emptying the melting tank cannot be used also because refining, stirring and casting require a minimum glass level in the system. Only the glass molten in between, when all properties remain in tolerance and sufficiently stable, is usable. Depending on the glass type the melting tanks and pots need a minimum size to achieve the required glass quality. For lead flint glasses the minimum production amount is 2 tons. That means even if only 100 kg would be required, two tons would have to be produced thus being absolutely uneconomic and also non-ecologic.

4. You mention the manufacturers Carl Zeiss and Schott, apparently as manufacturers of lenses.

a. Please specify additional names of manufacturers of optical lenses;

Many of the companies listed below have factories in several countries:

Company and country

- Swarovski Optik KG Austria
- Raytheon ELCAN Optical Technologies Canada
- CASIX, Inc. China
- Meopta - optika, s.r.o. Czech Republic
- Angenieux France
- Sagem France
- Thales France
- JENOPTIK AG Germany
- Berliner Glas KGaA Herbert Kubatz GmbH & Co. Germany
- Carl Zeiss AG Germany
- Jenoptik AG Germany
- Jos. Schneider Optische Werke GmbH Germany
- Leica Camera AG Germany
- Leica Microsystems GmbH Germany
- POG Precision Optics Gera Germany
- Qioptiq Photonics GmbH & Co. KG Germany
- Sill Optics GmbH & Co. KG Germany
- Schneider Kreuznach Germany
- Canon Corp. Japan
- Hoya Group Japan
- Nikon Corp. Japan
- Panasonic Corp. Japan
- Fisba Optik AG Switzerland
- Mikrop AG Switzerland
- SwissOptic AG Switzerland
- Cooke Optics UK
- ULO Optics UK
- CVI Melles Griot USA
- Edmund Optics USA
- Lambda Research Optics, Inc. USA
- Rocky Mountain Instrument Co. (RMI) USA

Comprehensive lists of lens manufacturers can be found here:

http://optics.org/buyers/category/55 and at;

http://www.photonics.com/CategoryGroup.aspx?CatGroupID=71

b. In the Additional Facts document you refer to possible competitive disadvantages on page 30. RoHS applies to all manufacturers who place applications on the EU market evenly, assuming that they have a similar product portfolio (manufacturing both lead based and lead free optical glasses). Please specify if all manufacturers produce both leaded and non-leaded optical lenses and explain on what grounds disadvantages are expected. No, only some manufacturers produce lead based glass as well as lead-free glass. Several glass manufacturers stopped making lead-based glass due to the declining market size resulting restrictions on lead by RoHS and to some extent due to consumer demand. Also, as stated on page 29 (not 30) of the supporting document, using optical designs without Pb-containing glasses will require more lens elements which increases lens size and reduces light transmission; both are unacceptable to users, although this may also increase costs.

We think the argument of the Öko Institute holds within the EU. There is no real disadvantage since all manufacturers have to follow RoHS in EU. However, EU companies may be at a disadvantage when competing outside of the EU with competitors that do not operate within the EU. This would not only be applicable to lead-glass manufacturers, but also users of products made with glass if the EU-versions have inferior performance. On page 27 you mention that glass manufacturers are subject to the IED Directive, and therefore that emissions are controlled, however this Directive is only relevant in the EU[2]. Please clarify if production of leaded optical lenses is done both within and without the EU. In the EU there is only one glass manufacturer left over. Emissions from lead containing glass types are very small and controlled. In Japan almost all glass manufacturers have stopped production of lead containing glasses since consumer optics, which is their by far largest market, does not require the special performance of these glasses. Only one manufacturer produces glass for microlithography, of which some glasses must be lead containing ones. They do not disclose much about their production. Due to cost reasons Japanese glass manufacturers shifted a high amount of glass production to China. China is the only country with a comparable production of lead glasses but on a lower quality level. Details about these productions are not known. However, just as with the European production emissions should be very low.

5. On page 23 an estimation is provided as to the amount of Pb expected to be placed on the market annually through this application. The estimation assumes an average of 55% Pb in leaded optical lenses. On page 23 a range of Pb content is provided of 37-60%.
    a. Is 55% Pb assumed to be the average ratio of Pb in optical glasses? Yes, as a weighted average (i.e. taking into account the quantities of each type)
    b. Can you provide an estimated distribution as to how may leaded lenses are manufactured with the lower concentrations and how many with the higher ones?

    This is not possible due to the highly fragmented lens market. Hundreds of companies would have to assemble detailed data, which they might not have at hand in an easy way. From an application point of view one can deduce that glasses with higher lead content are expected to be used more than those with lower content. The superior performance of these glass types gets more pronounced for higher refractive indices, where high light refraction is combined with still high transmission. At low refractive

[2] Certain countries may have legislation similar to the IED Directive in place

indices other non-lead containing glasses might be used instead. The refractive index is proportional to the lead content.

c. What does the amount of Pb depend on?

It depends on the required refractive index.

6. On page 24, both Cd and Cr are mentioned as further substances sometimes added to the glass of optical lenses.
   a. Is the Cr added as Cr VI compound? If so, what are the average concentrations? Cr is added only as CrIII (CrVI is not permitted by RoHS in the EU)
   b. Would applications in which Cd is added covered by a different exemption? Please detail by what exemption or how Cd can be used in such applications without a valid exemption. Yes, exemption 13b
7. On page 2 of the Additional Information document you mention thorite and barium along with Pb as heavy atoms that increase the refractive index.
   a. Please explain why thorite and barium do not provide substance alternatives (or why their application is not relevant for a larger range of applications)?

   Thorium oxide is banned because of its radioactivity and also gives inferior light transmission in the blue – near ultra-violet spectrum. Barium also does not provide the required combination of properties needed for many applications that can be achieved only with lead.

   b. What are the properties of Pb that are important for establishing the various technical performances required of optical lenses? i.e., what are the substance properties which prevent the use of substance alternatives? Please see discussion in section 4A.3, from page 9 which describes the function of lead in optical glass. Research has shown that lead-free optical glasses do not have all of the essential characteristics that can be obtained with lead-glass.
8. In your reference to possible alternative technologies, information is provided regarding plastic lenses.
   a. It is mentioned that plastic lenses scratch more easily than glass ones, however at the beginning of the dossier, it is mentioned that leaded glass is softer than regular glass and also more sensitive to scratching. Please comment as to the scratching sensitivity of these two types of lenses in comparison to each other (i.e. plastic glasses and leaded optical glasses). Lead based glass is much harder than the types of plastic that can be used for lenses. Although lead-based glass is softer than lead-free glass, it is much harder than plastic and is not easily scratched except by very hard materials whereas plastic lenses are scratched by much softer materials. The methods used to measure the hardness of glass and plastic are not the same and so comparative data is not published. However Spectaris has arranged for three plastics that are used for lenses to be measured for “Knoop hardness” (0.1kg weight and 20 sec indentation, 5 measurements per sample), which is the standard method used for brittle materials such as optical glass. These measured values are compared with the values for glass published by Schott as follows:

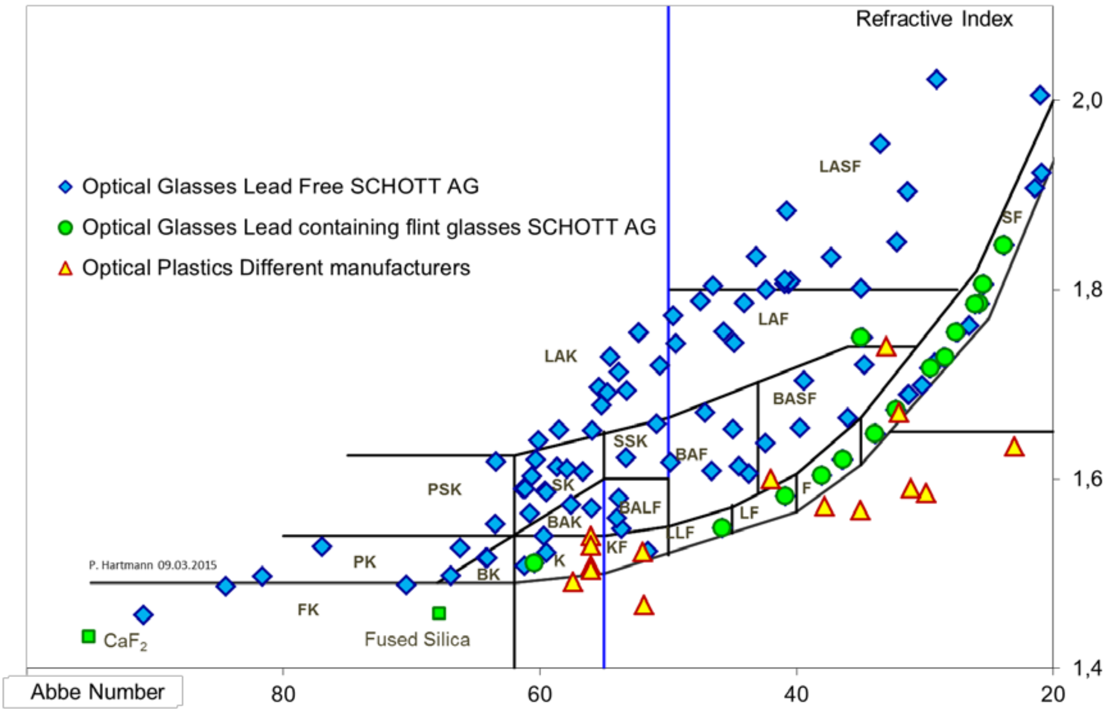
Material	**Knoop hardness (Pascals)**

Polycarbonate	Measured at 13.2 ± 0.2
PMMA	Measured at 22.4 ± 0.1
Polydithiourethane (used for spectacle lenses)	Measured at 14.0 ± 0.1
Lead-based glass SF57	350
Lead-based glass SF11	450
Lead-free N-SF57	520
Lead-free N-SF11	615

The larger the Knoop hardness value, the harder the material. Lead-based glass is more than 10 times harder than the hardest plastics.

b. Please also provide a comparison of figures 3 and 23 to allow seeing how plastic lenses compare in comparison to leaded ones and not to glass lenses in general.

Please see alternative version of Figure 23 below:



9. Page 33 discusses research into alternatives.
   a. On what basis do you assume that where alternatives are available, that they are applied instead of leaded optical lenses (page 35, answer to C) availability of substitutes)? In the 1990s all large optical manufacturers introduced lead free glass

types with optical properties as close as possible to those of the preceding lead containing 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 containing 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 containing glasses are used only for cases, where there are no alternatives to achieve the optical performance. This restricts their use to special high end applications. The production of lead free glasses since then is larger than that of lead containing glasses by far.

b. Please detail what efforts are being performed in this regard.

Since more than 15 years all newly developed glass types are lead free glass types Can you estimate how successful such efforts have been since the first Directive (RoHS 1) came into force? For example, can you provide an estimation as to the ratio between optical glasses manufactured with Pb and without, and how this ratio has developed since RoHS 1?

Before 1998 the Schott glass program had a share of 35% of lead containing glasses. Now it is 15%. However, the total number of glass types is only half since then. Related to the original number before 1998 (202 glasses) the present number means a share of 8%. For the world-wide production we estimate the present ratio between lead free to lead containing glasses to about 20:1. RoHS 1 has not contributed much since most replacement had been done much earlier. There is a contribution to the reduction to be expected, since optical companies tried to remove lead glasses wherever possible form their designs. However, this contribution can hardly be separated from the yearly fluctuations in total volume and in ratio between lead free to lead containing glasses.

c. Please provide some examples concerning applications in which these efforts have allowed the substitution of lead. You may refer both to substance substitution within the glass as well as technology developments that have allowed the elimination of the need for lead.

All consumer optics from pocket cameras to DSLRs (digital single lens reflex) uses only lead free glasses.
Industrial optical systems without special performance requirements also use lead free glasses.
A large part of pocket cameras has been replaced by smartphone cameras using mainly plastics optics. However, this has nothing to do with lead since this had been replaced already before.

d. For example, have the developments in digital technologies allowed eliminating the need for lead in certain devices through the use of digital compensation software? No, this 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 need best direct optical imaging. 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.

10. In consumer products, is it correct to understand that leaded lenses are used only in high-end products? On what basis is it assumed that such products are sold mainly to professionals (reference to B2B on page 28)? To achieve the higher performance required by professionals, the price of the equipment is ten times higher and can be even much more. Lead also adds weight to the optical systems, which amateur users try to avoid.

Please note that answers to these questions are to be published as part of the available information relevant for the stakeholder consultation to be carried out 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.