Exemption request evaluation under Directive 2011/65/EU
Questionnaire Exemption Request No. 12
"Lead and cadmium in optical filter glass in monitoring and control instruments"

Contacts :

THALES ANGENIEUX
Bd Ravel de MALVAL
42570 Saint-Héand
France
Tel : +33-04-77-90-78-00

Joël Rollin: +33-04-77-90-78-22: joel.rollin@fr.thalesgroup.com

Copy: C.Germain B.Coumert C.Reboulet P.Gallais D.Galerne J.Durand P.Andurand.

Summary:

→ **1)** THALES ANGENIEUX sustains the applicant's motion to get an additional exemption delay on lead and cadmium glasses (up to 2011) for high standard optical devices.

→ **2)** THALES ANGENIEUX considers that an exemption up to 2018 will not be sufficient, since glass manufacturers have still many researches to undertake to fully replace cadmium and lead substrates.

→ **3)** The non availability or the non practicability of equivalent substitutes will appear later on, through the answers of the 14 questions.

→ **4)** The issue about the applicable refractive range is addressed also later on.

→ **5)** Same answer for the quality specifications.

→ **6)** Other aspects, such as the compatibility of the substitutes with moulding process are displayed hereafter.

Background:

THALES ANGENIEUX is a subsidiary of the THALES Group, specialized in the field of high standards for TV, Cine or Surveillance Zooms and addresses, also, the defence market through hand-free IR or Light Intensified goggles dedicated either for dismounted soldier or driving or piloting aids enhancement by night.

The Cinema and TV activities are backing on quite a demanding market with strong Japanese contenders (Fuji, Canon) that. excellently well placed on TV applications, are showing now a clear willingness of entering the Cinema market through large quantities requirements for zooms thanks to the digital sensors on comings.

Lead glasses still offer key advantages in term of aberrations corrections in zooms designs and their substitutes, despite the past decade efforts and their growth, cannot yet meet properties of lead glasses.

It is the reason why Thales Angenieux was deeply involved in 2003 with the French professional trades (FIM and AFOP) to obtain and exemption. It was by that time a crux matter not to allow to non E.U competitors a technical advantage.

Due to new revised RoHS regulation recast, the current expected expiry deadline had been postponed to June 2016. New RoHS rules are not yet published.

This questionnaire comes from a proposal to keep valid such an exemption up to year 2021.

After this short introductions, we will answer to the 14 questions of E.V Öko-Institut.

We will mainly focus on lead glasses for zooms or fixed focal length devices: many questions are ascribable to glass manufacturers themselves. As a consequence, we could not answer to all the items of the questionnary, enlightening an end user's standpoint, only.

Contents :

1-Question 1: Lead and Cadmium Filter Glasses.

Please provide test results/protocols that clearly indicate that optical filter glass containing lead and/or cadmium has significant technical advantages over lead- and cadmium-free substitutions.

Current status:
From the Öko-Institut report "Adaptation to scientific and technical progress under Directive 2002/95/EC" http://ec.europa.eu/environment/waste/weee/pdf/final_reportl_rohs1_en.pdf
Data and information provided by various stakeholders give evidence that there are some applications where the use of lead and/or cadmium in optical glass will be necessary, as there are no viable substitutes. (SECTION 4.19.3)

Answer:
Cadmium glass are used whenever smart filtering functions are requested.
Once an accurate colours balance dictates the device performances, notch or edge filters with precise transition slopes are required. If so, cadmium is used as the colouring agent in numerous deep red, orange and yellow filters. The steepness of the edges is unique for cadmium semiconductor crystals.
Many applications are needing such components (correction filters in general photography and photographic art, laser protection eye glass, UV and IR blocking windows for scanners, Filters for space or hyper-spectral applications….).
For the time being, manufacturers as Schott do not fully propose well suited substitutes to Cadmium glasses for long pass and band pass filters: it is the reason why Cadmium solutions are still present in Schott's catalogues.

- *GG*: green-yellow glass (example: *GG*395)
- *RG*: red-glass (example: *RG*715)
- *OG*: orange-glass (example: *OG*570).
- *VG*: green-glass (example: *VG*9).

Theoretically, a colour filtering could be achieved with multi-layers stack deposited on a clear glass substrate but such coating exhibit poorer transmissions, suffer from performances drifts against incoming ray angles, and do not always withstand hard environments unless expensive manufacturing process comes into play.
Dealing with neutral filters, it is worth mentioning that Schott has succeeded in promoting lead and arsenic free substrates (N-WG series).

2-Question 2: scope of the exemption request.

Please clarify the scope of the exemption request. Does it address solely lead and cadmium in optical filter glass? Or does it also cover mercury and hexavalent chromium?

Current status:
The Exemption request does not cover mercury or hexavalent chromium.

Answer:
This point is confirmed.

3-Question 3: presence of mercury and hexavalent chromium.

For the case the request also addresses mercury and hexavalent chromium, please provide a written and easy understandable justification for these substances, including information on the technical applications in optical filter glasses and substitutes.

Current status:
The Exemption request does not cover mercury or hexavalent chromium.

Answer:
This point is confirmed for optical glasses that do not contain such substances.

4-Question 4: composition of the substitutes.

Please specify which substances or combinations of substances are used in lead- and cadmium-free optical filter glasses (information on substitutes). Give information on the application range (e.g. product type, temperature range, range of refractive index) in which these substitutes are already applied. Please provide this information for each substance covered in this proposal for exemption.

Current status:
The research into alternatives for applications covered by the old exemptions; testing and evaluation of available substitutes and defining of transition programmes; was not considered a priority as there was no apparent regulatory requirement since these applications were presumed to be available for the new categories brought into the RoHS scope. For further details see General comments Sections 1.1 and 2.

Answer:
This question is more applicable to the glass manufacturers than to glass end-user industries as us.
Complete ranges of lead and arsenic free glass have been developed: lead oxide has been replaced by titanium or niobium oxides, arsenic oxide, which served as a refining agent, has been discarded and thorium oxide or other radioactive substances are no longer used. For military purposes, the typical temperature domain ranges up to +70°C and down to –40°C: new Schott neutral filters comply with such a range.

5-Question 5: Research activities on substitutes (I).

Please give information on the research activities on substitutions for lead and cadmium in optical filter glass carried out by yourself and/or other sector players, including other companies in the supply chain.

Current status:
The research into alternatives for applications covered by the old exemptions; testing and evaluation of available substitutes and defining of transition programmes; was not considered a priority as there was no apparent regulatory requirement since these applications were presumed to be available for the new categories brought into the RoHS scope. For further details see General comments Sections 1.1 and 2.

Answer:
This question is more applicable to the glass manufacturers.
As an end-user, we make a point of choosing eco-compatible glasses on new designs, as far as possible.

6-Question 6: Research activities on substitutes (II).

Please give information on efforts carried out to evaluate research activities on substitutes (e.g. number of optical filter glass producers contacted in relation to the whole market).

Current status:
The research into alternatives for applications covered by the old exemptions; testing and evaluation of available substitutes and defining of transition programmes; was not considered a priority as there was no apparent

regulatory requirement since these applications were presumed to be available for the new categories brought into the RoHS scope. For further details see General comments Sections 1.1 and 2.

Answer:
This question is more applicable to the glass manufacturers.
Schott has promoted eco-type substrates (N glasses without lead). The main differences or deviations with their lead equivalents are recapped:

- Dispersion: The relative partial dispersions are unchanged only with glass types where only arsenic has been eliminated. Other glasses show some deviations in the partial dispersions.
- The temperature dependence of the dispersion is different.
- The dn/dT of N-type glasses is smaller than those of original substrates.
- Absorption: transmittances are decreased in the short wavelength and UV regions.
- Density: The lead free glasses have lower densities than their predecessors
- Chemical Resistance: N-Glasses are more resistant to chemical attacks partly very significantly.
- Knoop hardness: Part of the glasses have significantly higher hardness. They exhibit improved behaviour in processing and are less sensitive to scratches

7-Question 7: Substitutes impacts on the environment.

Please indicate if the negative environmental, health and/or consumer safety impacts caused by substitution are likely to outweigh the environmental, health and/or consumer safety benefits. If existing, please refer to relevant studies on negative impacts caused by substitution.

Current status:
The research into alternatives for applications covered by the old exemptions; testing and evaluation of available substitutes and defining of transition programmes; was not considered a priority as there was no apparent regulatory requirement since these applications were presumed to be available for the new categories brought into the RoHS scope. For further details see General comments Sections 1.1 and 2.

Answer:
This question is more applicable to the glass manufacturers.

8-Question 8: Research on substitutes in case of presence of mercury and hexavalent chromium.

If mercury and hexavalent chromium shall also be covered by the proposal forexemption, please also provide information on substitutes and research activities for these substances.

Current status:
The Exemption request does not cover mercury or hexavalent chromium.

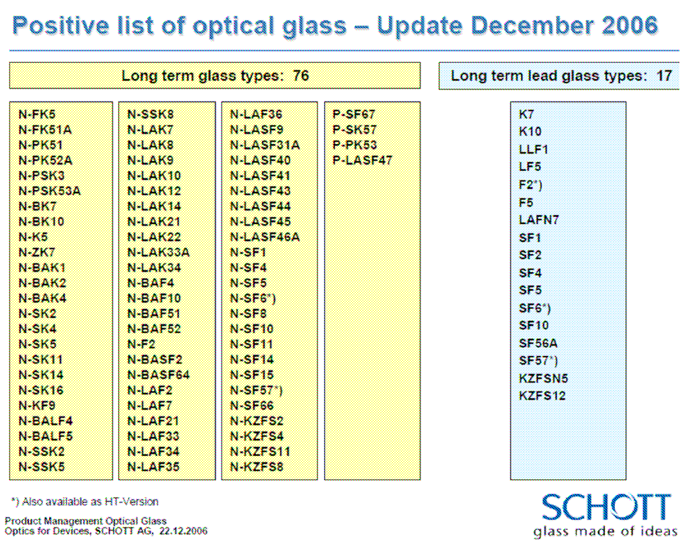
Answer:
Confirmed, there no mercury, nor hexavalent chromium in the optical glasses we are dealing with.

9-Question 9: Schott lead-free materials limitations and use in products.

The proposal for exemption states that the company Schott already offers lead-free alternatives. Please specify the range of use of these alternatives and their possible limitations. Please also provide this information for other lead- and cadmium-free products on the market.

Current status:
No additional information is available in advance of the public consultation.

Answer:
SCHOTT (but not only, for instance the Japanese glass supplier OHARA with the S substrates types) makes very best efforts to replace restlessly lead substrates by eco-compatible glasses.
As shown in the figure as follows, the number of positive glasses has been significantly increased over the past five years, but a great deal of current lead glasses have not yet found any equivalent.
They are still left in the catalogues.



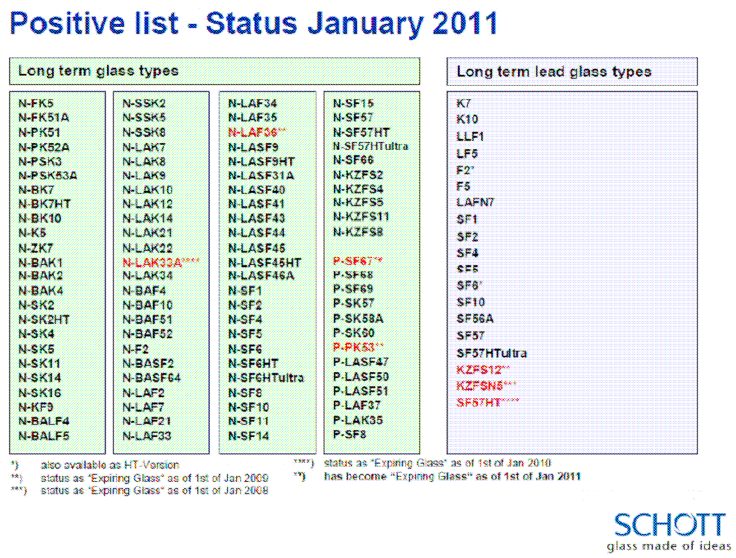


Figure: comparison of the Schott positive list 2006-2011.

Most of night vision goggles must be endowed with focus mechanisms, lying both in object space and image space: on the side of the observer, a diopter adjustment is necessary to compensate for vision ametropies, whilst in the object space a focus mechanism is devoted to look at different distances since highly sensitive night vision goggles are calling for high numerical apertures and therefore exhibit poor depths of focus.
To some extent, the presence of two mechanisms help relaxing the constraints on glass thermal behaviours (dn/dT, thermal expansion coefficients…).
However, even in such applications, high refractive indexes are yearned for in order to get moderate bent optical interfaces: such a configuration makes the optical designs less sensitive to geometrical aberrations. As a result, lead glasses use can largely open a wider choice.
The situation proves much more complex for TV or Cinema zooms. By nature these devices obey quite a multi-configuration scheme, with many moveable groups (for focussing at near objects, for allowing a large range of focal changes whilst maintaining a sharp image all over the full zooming span).
This means, that, individual groups of lenses must be chromatism free (longitudinal and lateral, primary and secondary), calling for many sequences of different glass types.

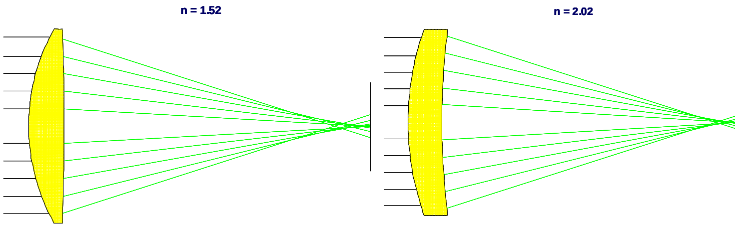
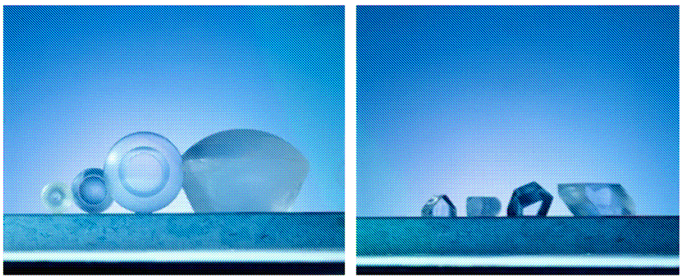


Figure: high refractive indexes ease the geometrical aberration correction.

Other characteristics than the pure refractive and colour dispersion glass properties must be borne in mind:

- The refractive index changes against temperature drifts.
- The transmission efficiency in the blue band: an exact colour balance must be reproduced through the lens and, besides, such a performance is remaining a key-differentiator among our customers and against our competitors. Most of lead glasses help to keep an advantage.
- The glass sensitivity to mechanical stresses that can lead to birefringence effects, with double images: in zooms, mechanical plays are reduced in order not to generate boresight drifts during zooming or focussing. This implies that the optical parts are tightly fastened inside mechanical barrels, and, as a consequence, might be subjected to stresses.
- The thermal glass behaviour abides by same rules: a based-lead glass from Schott, SF57 (23.9 % SiO_2, 74.8 % PbO), is currently used since its optical characteristics are not altered by mechanical stress as might occur due to temperature rises. For the time being, there is no eco stand-in. Such an situation is not rare in the world of wide cinema projection: enough light must illuminate screens over a large area, so that high power lamps are needed. As a consequence, the engineers have to cope with heat leakage through optics during tests.

Industrial and cost effectiveness considerations should prevail too, and can deter the glass end user from not singling out positive glasses. Lead glasses are still available in hot moulded supplies over larger sizes (Cinema zooms require lenses diameters up to 200 mm). Such pre-formed shapes enable a better raw material yield and comply with cost reduction budgets. Note also that precision moulding is a state-of-the-art technology for the volume production of complex aspherical lenses. In general used mould materials in the moulding process exhibit a thermal stability of up to 700°C for the Schott substrates.
Appear here indirect technical odds in favour of lead glasses: since they can be cast in larger dimensions, there are means of selecting the best fitted zones during the glass manufacturing process to guarantee the refractive index homogeneity levels, as might be required by the zooms optical performances.



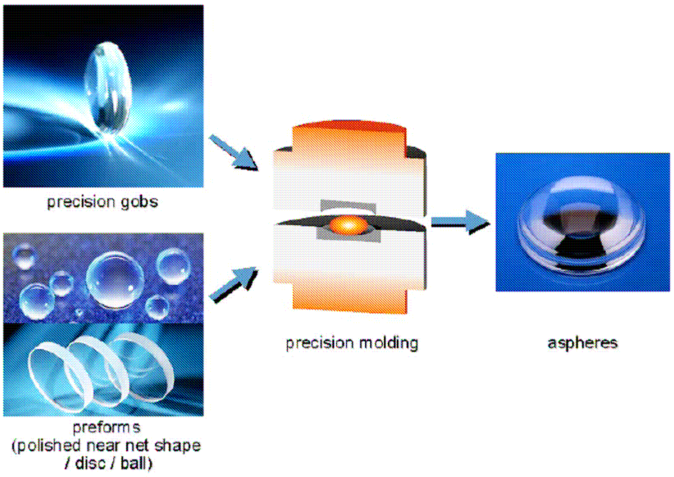


Figure: moulded optics. On right, moulded aspheres.

To fully answer to question 9, it is worth emphasizing that, besides the mere technical facts, industrial and logistic trades must be taken into account.
Reshuffling a zoom design, in order to comply with legislation rules in the current product life cycle, entails severe consequences for the manufacturer:

- Discrepancies between the performances of the earliest model and the updated one. Our demanding customers are very sensible to any performances changes, even slight. They may be disarrayed by small drifts, even in cosmetic.
- An upgraded product always call for a long qualification process (against environment conditions). Such tests require at least three full months of trials with significant extra-costs and work load.
- It becomes all the more difficult to simply maintain among customers two generations of products.

Legislation directives have a strong impact on our competitiveness in a worldwide market: we are facing similar difficulties with Reach on coming laws on paints and optical varnishes for instance.

10-Question 10: Refractive Index ranges (I).

The proposal for exemption states that lead-free alternatives are only available with low refractive index. Please further specify the range of the refractive index in which no lead-free alternatives of sufficient quality are on the market or in development.

Current status:
No additional information is available in advance of the public consultation.

Answer:
It is ordinary stated and conceded that most of the remaining lead glasses are mainly concentrated on the upper right side of the (n, υ) glass map. (n > 1.6)
When looking into the current Schott glass map, it becomes obvious that such a rule should not be taken for granted. Excluding lead glasses of lower refractive indexes may considerably jeopardize many dedicated optical designs. As displayed by the Schott map, this would mean that optical designers would not have any longer access to melts that can tailor their optical lens prescriptions.

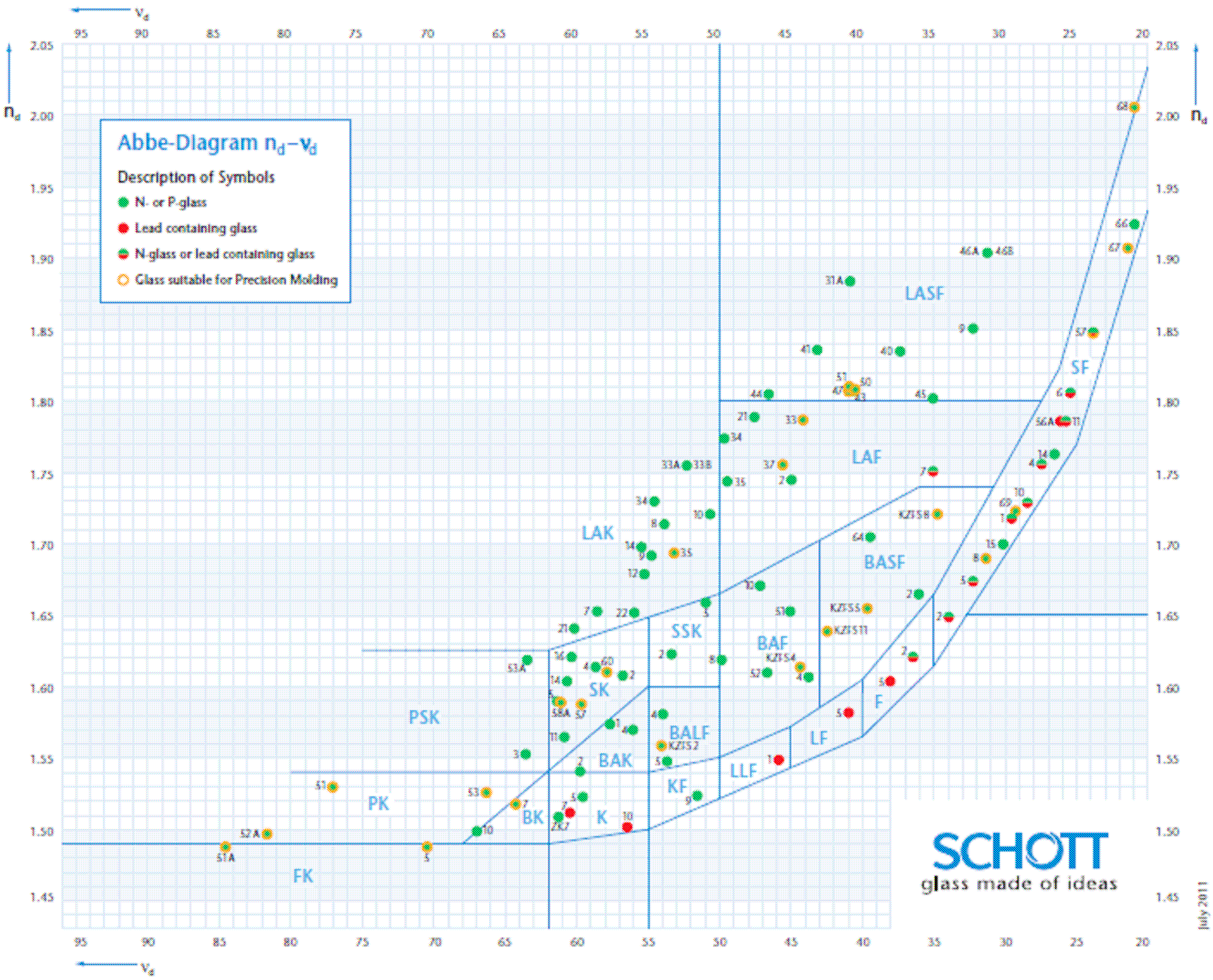


Figure: current Schott glass map.

Some glasses of low medium refractive indexes with intermediates Abbe Number would not be released (LLF, LF some K and F glasses) with no counterparts to be found at present.
The result would be to cut the necessary set of degrees of freedom at the design stage.
Noteworthy to point the fact that, contrary to an elder situation and an widespread feeling, highest refractive indexes might not be perhaps of the highest concerns.

Next Schott figure displays the partial dispersion curves. It will be observed that such a diagram exhibits on the upper edge of the ordinary glass line a lonely region where only lead glasses are available.

As will be underlined in the next chapter, and as earlier shown, other properties must also come into play to consider safely the problem in each of its aspects.

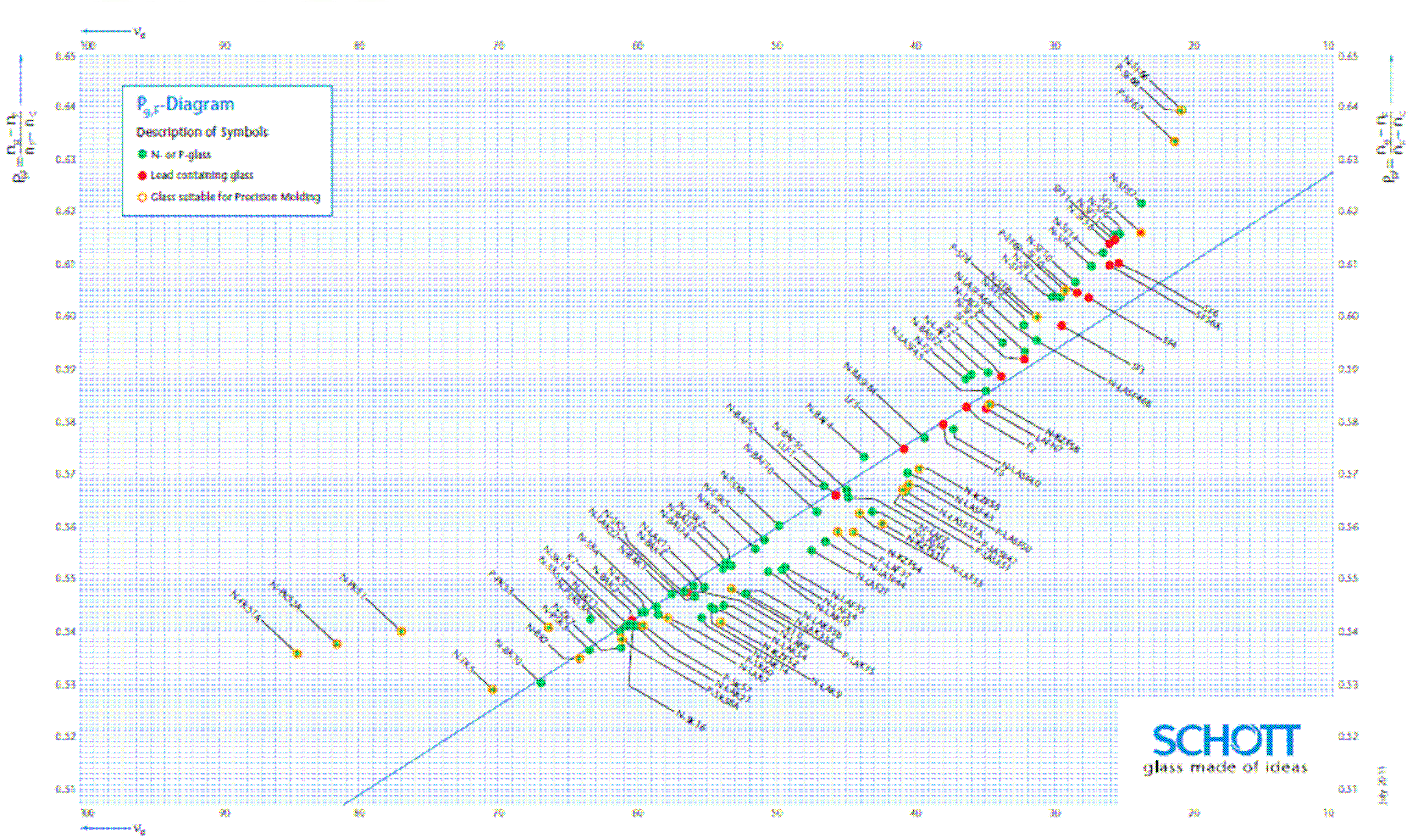


Figure: partial dispersions diagramme.

11-Question 11: Refractive Index ranges (II).

Would it be possible to limit an exemption for optical glasses for a certain refractive index range?

Current status:

No, since refractive index is not the only factor involved, as noted in the original submission. Detailed technical information is not available at this stage. The reason is that this exemption was presumed to be available for category 9 and therefore no detail assessment and investigation has been performed so far. Our supply chains are very complex as our products are made of thousands of parts and we deal with a substantial number of suppliers. For further details see General comments Sections 1 and 2.2. 8.

Answer:

This fact is confirmed.

Industrial issues such as the ability of lead glasses to be moulded over large sizes have been already addressed at the question 9.

The transmissions in the blue slot and the dn/dT differences have been alluded, too.

To better capture these issues, let us compare some properties of Schott substrates of N types (lead free) with their former equivalents (containing lead).

The following table sketches out some characteristics for lead glasses and their positive equivalents (N type substrates):

- The refractive index for the d ray (d: λ = 587.56 nm)
- The Abbe number $u_d = (n_d - 1)/(n_F - n_C)$ with F: λ = 486.13 nm, C: : λ = 656.27 nm.
- The dispersion $n_F - n_C$.
- The relative dn/dT in the +20°C/+40°C temperature range at λ = 546.07 nm.

- The bulk transmission of a plate of 25 mm thickness at λ = 400 nm.

Glass	n_d	υd	n_F-n_C	Transmittance 400 nm e = 25 mm	dn/dT (10^{-6}/K) +20℃/+40℃ Ray e
F2	1.62004	36.37	0.01705	0.985	4.4
N-F2	1.62005	36.43	0.01702	0.87	3.5
SF2	1.64769	33.85	0.019135	0.954	4.6
N-SF2	1.64769	33.82	0.019151	0.83	4
SF5	1.6727	32.21	0.020885	0.95	5.8
N-SF5	1.67271	32.25	0.020858	0.78	3.4
SF1	1.71736	29.51	0.024307	0.92	7.9
N-SF1	1.71736	29.62	0.024219	0.7	1.8
SF10	1.72825	28.41	0.025633	0.69	8.1
N-SF10	1.72828	28.53	0.025524	0.64	1.5
LaFN7	1.7495	34.95	0.021455	0.85	8.3
N-LaF7	1.7495	34.82	0.021525	0.49	4.3
SF4	1.7522	27.58	0.027383	0.89	9.2
N-SF4	1.75513	27.38	0.027583	0.628	1.4
SF11	1.78472	25.76	0.030467	0.2	12.9
N-SF11	1.78472	25.68	0.030558	0.6	2.4
SF6	1.80518	25.43	0.03166	0.8	11.1
N-SF6	1.80518	25.36	0.03175	0.61	1.5
SF57	1.84666	23.83	0.035536	0.66	12.5
N-SF57	1.84666	23.78	0.035604	0.46	2.2

Table: comparison of the lead and lead free glasses properties.

It should be pointed out that:

- The indexes and the dispersion are remaining close to each others.
- There are significant changes in bulk transmittances at 400 nm. As often as not, lead glasses are better, with nevertheless one noticeable exception, the pair SF11/ N-SF11.
- The dn/dT prove much smaller for lead-free glasses.

Not displayed in this table, there are some minor differences, too, in the expansion coefficients data.

SF11
785258.474

Internal Transmittance τ_i		
λ [nm]	τ_i (10mm)	τ_i (25mm)
2500	0.821	0.610
2325	0.867	0.700
1970	0.971	0.930
1530	0.993	0.982
1060	0.999	0.997
700	0.997	0.993
660	0.996	0.991
620	0.996	0.991
580	0.996	0.991
546	0.996	0.989
500	0.990	0.976
460	0.976	0.940
436	0.941	0.860
420	0.867	0.700
405	0.650	0.340
400	0.525	0.200

N-SF11
785257.322

Internal Transmittance τ_i		
λ [nm]	τ_i (10mm)	τ_i (25mm)
2500	0.826	0.620
2325	0.867	0.700
1970	0.965	0.915
1530	0.994	0.985
1060	0.999	0.998
700	0.994	0.985
660	0.992	0.981
620	0.992	0.981
580	0.994	0.984
546	0.991	0.978
500	0.981	0.953
460	0.967	0.920
436	0.946	0.870
420	0.919	0.810
405	0.852	0.670
400	0.815	0.600

Figure: the SF11 exception.

It has been also earlier on depicted the outstanding mechanical resistance of the SF57 glass against stress (see figure): its equivalent N-SF57 does not offer the same level of performances.

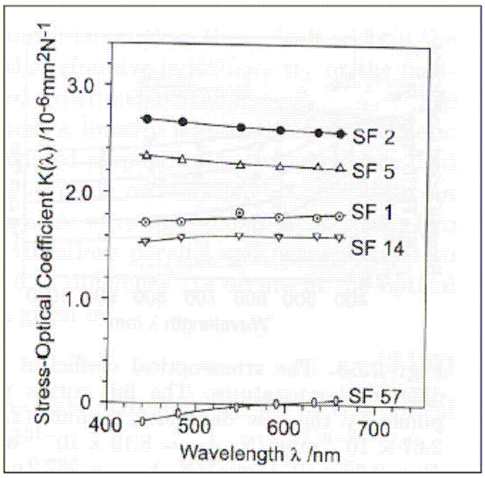


Figure: comparison of the stress birefringence coefficient.

12-Question 12: specifications for the substitutes.

The proposal for exemption states that substitutes have lower quality than lead- or cadmium-containing optical filter glasses. Please provide an objective definition of quality aspects of optical filter glasses, including quality aspect (e.g. thermal stability), indicators (e.g. maximum variation over a certain temperature range) and threshold values for the applications included in this proposal for exemption.

Current status:
This request is inconsistent with scope of Exemptions 13a and 13b of Annex III. No additional information is available in advance of the public consultation. For further details see General comments Section 2.

Answer:

→ Theoretical characteristics: it is of the utmost importance to keep on covering the full glass chart:

- Access to high refractive indexes (up to 2) with a wide range of dispersion.
- Access to equivalent glasses to LLF, KF, K series in term of Abbe number and refractive indexes (see glass chart).
- A large range of dn/dT is advisable, too, since sometimes, such pair of different glasses may be used to compensate for mechanical mounts expansions against thermal changes: the aim is to design passively athermalised solutions. If we come back to the previous example SF6-N-SF6 of the previous chapter, we note that these materials have thermal constringences opposite in sign. It tells that a lens can be split in two positive contributors of smaller optical powers whose thermal changes counterbalance. This leads to reduced defocuses against temperature shifts. Values of dn/dT comprised between almost 2.10^{-7}/°K (example Zerodur) and 13.10^{-6}/°K should answer most of the requirements.
- High resistances to stresses: at least one or two glasses of very low birefringence coefficient K are required. K is defined as follows: $\Delta = K.d.\sigma.$, where d is the optical thickness, σ the stress and Δ the optical path difference due to the refractive index differences between their values for light parallel and light perpendicular to the direction of stress. SF57 exhibits quite unusual good properties. It is the reason why, a reasonable requirement would be cornered to: $K < 0.4\times10^{-6}$ mm^2/N^{-1}.

→ Dispersion, homogeneity.

- It is important to warrant the values of the refractive indexes and, even more, the spectral dispersions from one manufactured batch to an other one. Index average scattering is not a too troublesome question , since deviations can be corrected by refocusing. The tougher requirements deal with our Cinema Zooms activities. Keep aware that such requests very much depend upon the location of the optical part within the lens prescription.
  - Average refractive indexes: ± 0.0003 to ± 0.0004
  - Abbe numbers: ± 0.2 % to ± 0.5 %
- Index radial or in-depth homogeneity over large sizes (> 200 mm) must be obtained. Otherwise wave-front defects are likely to debase the lens performances. At least, the existing grades must be maintained, in order not to diverge from the current state of art. This should apply both to bars and moulded supplies. Homogeneity of at least H4 class is required ($\Delta n < 2\times10^{-6}$) and H5 class is wished ($\Delta n < 1\times10^{-6}$).
- Certificate must still backtrace, as today, the glass manufacturer commitments.

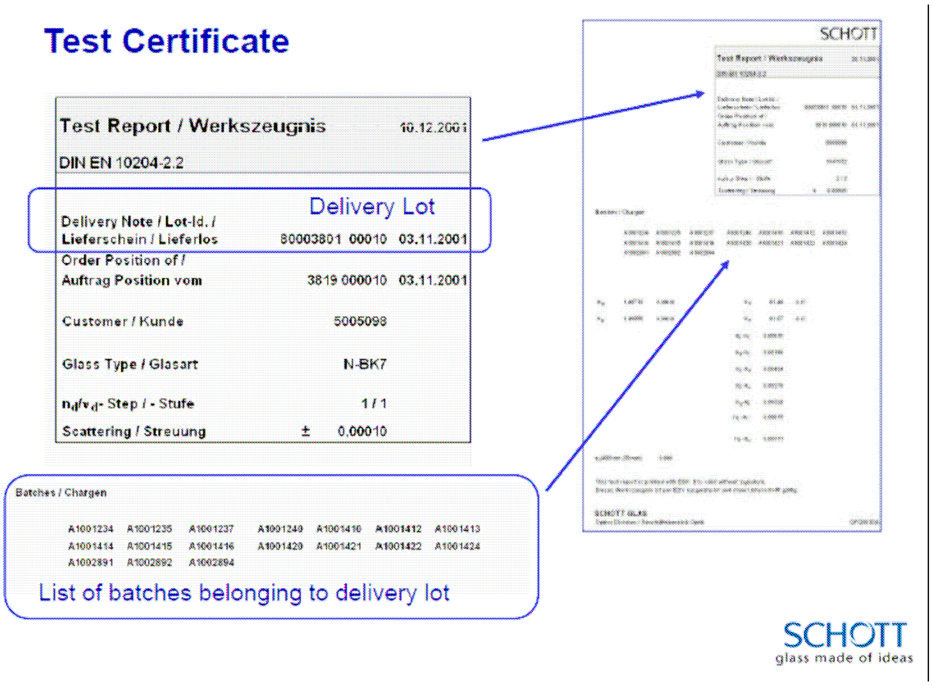


Figure: test certificates.

→ Mouldable glass.

- N-type mouldable glasses are already available over a large span of refractive indexes and dispersions (1.49 < n < 2, 20 < υ < 85). Schott mouldable material of highest refractive index is the LaSF68 (n > 2).
- If possible, the future lead free equivalents must remain mouldable.

13-Question 13: domains of application of the exemption.

Please provide a common definition of the applications that shall be covered by a possible exemption. The definition should specify functions and typical application ranges (e.g. optical precision measurement instruments for laboratory use with a refractive index larger than…). In addition, product lists can be added.

Current status.
This request is inconsistent with scope of Exemptions 13a and 13b of Annex III.
From the Öko-Institut report "Adaptation to scientific and technical progress under Directive 2002/95/EC" http://ec.europa.eu/environment/waste/weee/pdf/final_reportl_rohs1_en.pdf "Although stakeholder could provide an enumeration and list of application examples, this list would be by no means fully exhaustive, because applications which make use of these glasses would be possibly several hundreds in number." (Section 4.18.3)
No additional information is available in advance of the public consultation.

Answer.

It is indeed difficult to be exhaustive. For instance long focal length devices would be legitimately subjected to an exemption and they address many applications areas: Recce airborne PODs, Space products, Cine Zooms……

There is no point coming back on the difficulties that might arise in the zoom design, with a high level of multi-configuration nature, without the availability of lead glasses, according to the current manufacturers glass offer.

As to Thales Angenieux the fields where the exemption should apply is consequently as follows:

- Civil applications: TV, Cinema-Film or digital-Cinema zooms.
- Dual use: Surveillance or Security zooms or dual field of view or long focal length refractive devices (F > 100 mm).
- Dual use: Refractive optical sub assemblies of long focal length (F > 100 mm) or lenses of large diameters as those required by fish-eye applications.
- Dual use: Optical test benches (example: MTF assessment benches) with waveband filtering functions. (cadmium filters).
- Defence applications: dedicated function in night vision goggles such as smart filters (class C filters for instance). Cadmium filters.
- Civil applications: Medical devices (endoscopes, fiberscopes, cameras) where transmissions over the blue and UV wavebands are searched for.

Of course, the ranges of applications expands much beyond these scopes:

Cadmium filters: Many applications are needing such components (correction filters in general photography and photographic art, laser protection eye glass, UV and IR blocking windows for scanners, ….). They come with image processing units when spectral information is to be detected and monitored afterwards: aerial photography for environmental damages assessments, road toll systems, automatic reading or sorting devices…..

For space applications, for instance, the ELT telescope requires large filters whose sizes range up to 750 mm.

Medical X-ray diagnosis equipment's are currently using image intensifiers with digital devices, that must be shielded against x-rays radiations; equipments of same nature hold for electron microscopes.
For the present time, such applications cannot do otherwise than using lead glass lenses.

14-Question 14: substitution forecasts.

You are proposing an exemption valid until 2021 and claim that in many products, substitution is impractical as the design and qualification effort required is equivalent to that for a wholly new product introduction. How are the forecasts for substitutions over the next ten years? Will research and market penetration of alternatives, as well as innovation cycle in optical measurement instruments allow a complete substitution after 2021? (It is clear that you cannot give perfect forecast for the technical and market developments for the next ten years. Nevertheless, a sound and justified outlook could help in the evaluation and stakeholder process).

Current status.
The research into alternatives for applications covered by the old exemptions; testing and evaluation of available substitutes and defining of transition programmes; was not considered a priority as there was no apparent regulatory requirement since these applications were presumed to be available for the new categories brought into the RoHS scope. The European Commission and ERA confirmed the need of continuation of the exemptions for category. 9. For more details see General comments, Section 1.1 The path to finding a proven reliable alternative is unknown at this time and we cannot predict if such a substitute can be found far less widely available in ten years.
It is important to stress that many products have been already transitioned to RoHS compliant products, with the assumption that existing RoHS exemptions continue to apply. Test and Measurement producers do not rely on

continued availability of material on the market that utilize the exemptions requested. Our supply chain management is extremely complex. For more details see General comments Section 2.2.10. There are a large number of contributing factors why complete substitution in the timeframes proposed is impractical; see General comments Section 2.

Answer.

The impracticalness of the substitutes, when they exist, under some circumstances and the qualification costs of eventual upgrades have been already outlined in the answer to the question 9 (chapter 9 of this document).

As mere end-users, it is problematic to predict the glass manufacturers policy, such forecast will be always doubtful, they are not at our command although many pieces of information are regularly swapped through Schott Newsletter for instance.
These cares are firmly anchored in our Purchase Department.

What is sure is that our new designs integrate now the substitutes whenever possible. Sometimes, it might be at the expense of the zooms performances (we are thinking about the colour balance, among others).

As a rule of thumb, at least in the TV and Zoom cinema, perhaps 40 % of our product lines in sales are still beneficiating by this exemption. With our present knowledge and feelings on the researches that are carried out in this field by the glass manufacturers, and once relying on our self experience of the past ten years, a 20% rates would sound achievable over the next decade.

Cadmium glasses replacement is not so easy; For the time being, we do not see any proper alternative at short notice.