Adaptation to Scientific and Technical Progress under Directive 2002/95/EC – Evaluation of New Requests for Exemptions and/or Review of Existing Exemptions

Final report

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9.4 References

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10 Review of Exemption No. 32 "Lead Oxide in Seal Frit Used for Making Window Assemblies for Argon and Krypton Laser Tubes"

10.1 Background

In 2006, Coherent had applied for this exemption (Coherent 2006). Öko-Institut e.V. together with Fraunhofer IZM had recommended granting the exemption (Gensch et al. 2006). The exemption was then approved during the decision-making process and, in January 2008, came into force without, however, specifying the expiry date, with the following wording :

"Lead oxide in seal frit used for making window assemblies for Argon and Krypton laser tubes."

Following Article 5(1)(b) of the RoHS Directive (2002/95/EC), exemptions have to be reviewed at least every four years. Exemption 32 was therefore open to an online stakeholder consultation with a view to adapt it to scientific and technical progress.

Two stakeholders[12] have submitted feedback in the context of the online stakeholder consultation. They support the continuation of the existing exemption with the following wording:

"Lead oxide in seal frit used for making window assemblies for Argon and Krypton laser tubes."

[12] Coherent Inc. and JDS Uniphase (JDSU)

Details and contributions can be found under http://rohs.exemptions.oeko.info/index.php?id=87.

Further questions have been discussed with Coherent in several conference calls.

The outcome of this information gathering exercise and of the exchange with the above-mentioned stakeholders is reflected in the following paragraph.

10.2 Description of Application

As the majority of the ion lasers are components of large-scale stationary industrial tools, they are not subject to RoHS restrictions. Only in a small number of appliances, lead oxide is used in the seal frit as a vacuum seal in the manufacture of argon and krypton laser tube. The stakeholders request to maintain the exemption for the RoHS-relevant applications such as laser products, since such stable, coherent light sources find multiple uses in scientific applications (such as bioinstrumentation), in semiconductor industry (JDSU 2010), in light commercial applications (such as spectroscopy, microscopy, holography) as well as in the entertainment industry (Coherent 2010).

Frit sealing is a special technique used in high vacuum applications to bond the front and the rear glass. The glass (window) is the critical optical interface, where optical absorption and distortion eventually determine the performance of the laser. Special types of glass such as crystalline quartz are used because of their resistance to darkening caused by sub-200 nm deep ultraviolet (DUV), emanating from the electric arc discharge operating in the laser tube. Part geometries are adjusted within the particular constraints of the device in order to minimize the demands placed on the seal (Coherent 2010). These windows referred to as Brewster windows, need, for example, an acute angle at which the reflection losses for polarized light are at a minimum.

The typical quantity of lead per laser tube is about 10 to 20 mg (Gensch et al. 2006), while the current total annual amount of lead put on the EU-27 market by Coherent which is relevant for this exemption is less than 0,5 g (Coherent 2010).

10.3 Justification for Exemption

The stakeholder arguments to justify the continuation of the request can be summarised as follows:

- Lead oxide used in the seal frit is required for technical reasons:
  - the application requires a hermetic, thermo-mechanically stable, vacuum-tight seal (extremely low porosity) that will tolerate vacuum bake-out temperatures, however, lead oxide has a liquidus-solidus temperature that will not result in unacceptable mechanical strain at the operating temperature. The lead oxide in the seal frit is located in an optomechanical assembly that provides the mentioned vacuum-tight

seal and that is optically transparent to the laser radiation. Figure 4 below shows the location of the seal frit in the laser tube assembly.

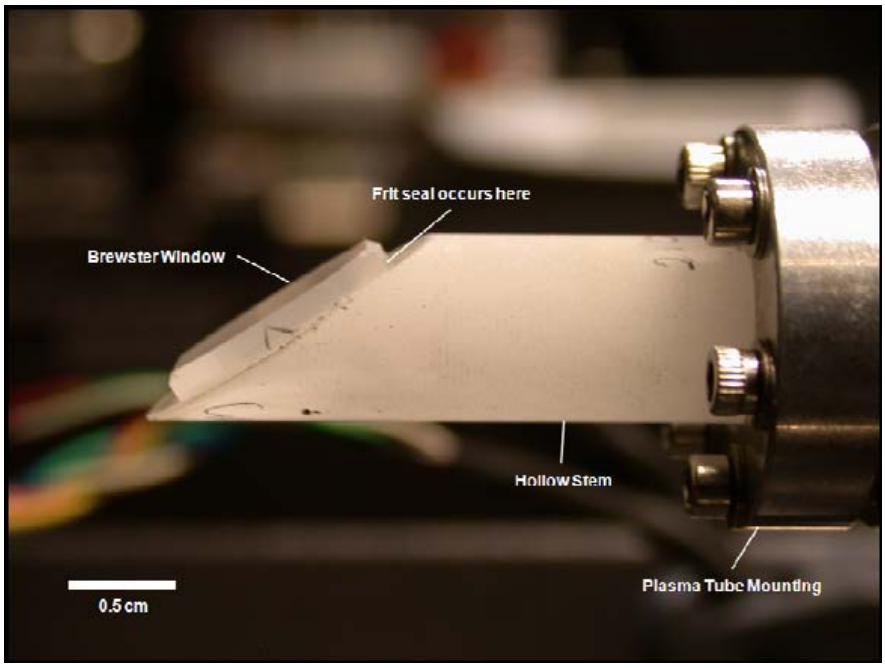

Figure 4 Lead oxide located in the seal frits *(Source: Coherent 2010)*

– The lead lowers the melting point of the seal frit which is necessary for the vital coefficient of thermal expansion. At approximately 420°C, the window temperature does not promote damage to fragile components (JDSU 2010). Other materials with lead-free fritted windows require a higher melting point. The higher temperature (up to 120°C) results in major optical losses (absorption problems) and a degradation of the transverse emission mode between 20-25%. This decreased reliability of the seal will cause the lasers to fail and thus result in an unacceptable risk to the end users. In addition, the higher melting point and the ensuing cooling down phase contribute to the fact that the window does not come to the correct angle (Coherent 2010).
– In contrast to the flat panel industry, the requirements for the window assemblies for krypton and argon tubes are very high. The windows play a role in determining the transverse mode quality and the divergence of the laser beams. These qualities ensure that the laser beam can be delivered and focused to an extremely small spot, thus determining its usefulness as a radiation source.
– The yield related to these laser tubes adds to more than 90%, and could only be achieved through the use of lead frits.

- Lead oxide in the seal frit currently cannot be substituted:
  - Despite years of ongoing development on the use of substitutes such as bismuth-based or phosphorus-based frits, the stakeholders to date have no technically viable substitute for the use of lead oxide in such laser tubes (JDSU 2010). Lead-free substitutes result in a poor yield, significantly higher melting temperatures. Moreover, they have different coefficients of thermal expansions than the present frit.
  - Other technologies such as thermal combination or optical contacting rely on the atomic forces which come into play when atoms in the quartz can be brought close enough as to hold them together[13]. This could only be achieved by the use of components that are enormously thin. Otherwise, a weak attraction of these components and a leakage could result. Moreover, the highly specialized requirements for flatness increased the process costs, resulted in a lower yield (it was not possible to achieve a yield of more than 50%) and uncertain lifetime (Coherent).
- Both stakeholders also argued that there were significantly smaller environmental, health and safety impacts in the case of continuation of the exemption than with the use of other sealing technologies and substitutes. The elimination of lead, for example, would require more frequent replacements and would cause increased waste streams.

10.4 Critical Review

The stakeholders provided comprehensive data and well-structured responses to the consultation questions, especially on the issue of substitutes and other technologies for sealing the argon and krypton laser tubes. Therefore, a critical review of the documents that was made available and an evaluation of the stakeholders' contribution led to the following observations:

Since the original exemption application was handed in by Coherent, additional testing has been completed using lead-free materials. Recently, for example, lead oxide, which had been used in glass frit as a sealing process, has been eliminated for some devices such as flat panel displays. However, it seems that the stakeholders are not aware of any currently available technical and scientific substitutes for their purpose-built appliances. The requirements for glass in a flat panel display are different from those applicable to the window assembly for the argon and krypton laser tubes. According to the stakeholders, lead-free frit materials and other technologies are no alternative for these special window assemblies, as they fail to meet the higher requirements set for this product group, such as the transverse mode quality, the impermeable vacuum seal and divergence of the laser beam.

[13] Because of Van der Waal´s forces.

Furthermore, Coherent argues that other technologies (e.g. optical contacting) are technically and scientifically impracticable as it was not possible to achieve sufficient yield results. This statement was already indicated in the previous evaluation (Gensch et al. 2006).

10.5 Recommendation

Concluding on the basis of all available information and technical justification, it is unavoidable to use lead oxide in seal frit used for making window assemblies for argon and krypton laser tubes. In accordance with the requirements of Article 5(1)(b) and with regard to the abovementioned arguments, it is recommended to grant a continuation of this exemption. From the consultant's point of view, the present wording seems to be appropriate for the time being:

„*Lead oxide in seal frit used for making window assemblies for Argon and Krypton laser tubes*."

10.6 References

Coherent 2006 — Stakeholder document submitted by Coherent within the online stakeholder consultation on Adaptation to scientific and technical progress under Directive 2002/95/EC for the purpose of a possible amendment of the annex; http://circa.europa.eu/Public/irc/env/dir_2002_95/library?l=/requests_exempions/electrical_transducers&vm=detailed&sb=Title

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