7th Adaptation to Scientific and Technical Progress of Exemptions 8(e), 8(f), 8(g), 8(h), 8(j) and 10(d) of Annex II to Directive 2000/53/EC (ELV)

Report for the European Commission DG Environment under Framework Contract Nº ENV.C.2/FRA/2011/0020

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8.0 Exemption 8(j) “Lead in solders for soldering in laminated glazing”

Abbreviations and Definitions

CTE	Coefficient of thermal expansion
OEM	Original equipment manufacturer, here: vehicle manufacturers
PVB	Polyvinyl butyral
R&D	Research and development
SOP	Start of production
SUV	Sport utility vehicle
Tonne	Metric tonne corresponding to 1,000 kg

Declaration

The phrasings and wordings of stakeholders’ explanations and arguments have been adopted from the documents provided by the stakeholders as far as possible. Formulations have been altered only in cases where it was necessary to maintain the readability and comprehensibility of the text.

8.1 Description of the Exemption

ACEA et al.[210] requests the continuation of Exemption 8(j) in Annex II of the ELV Directive:

Lead in solders for soldering in laminated glazing

ACEA et al.[211] suggests to review the exemption at the earliest in 2017.

8.1.1 History of the Exemption

The exemptions related to the use of lead in solders for soldering on or in automotive glazing have been reviewed several times since 2007. Until 2009, the use of lead in solders for soldering on glass and in laminated glazing fell under the scope of the

[210] ACEA et al. (2013a) ACEA, CLEPA, JAMA, KAMA stakeholder document “acea_clepa_jama_kama_contribution_Ex_8j_comprehensive_answers_20131104.pdf”, submitted during the online stakeholder consultation, retrieved from http://elv.exemptions.oeko.info/fileadmin/user_upload/Consultation_2013_1/Exemption_8_j_/acea_clepa_jama_kama_contribution_Ex_8j_comprehensive_answers_20131104.pdf; last accessed 10.01.2014

[211] Ibid.

former Exemption 8: “Lead in solder in electronic circuit boards and other applications” in Annex II of the ELV Directive[212], which was valid at that time. During the 2007/2008 review, a stakeholder, Antaya, claimed to have a solution for lead-free soldering on glass. In 2007, Antaya had applied for repealing the exemption as they claimed to have a viable solution to substitute the lead-containing solders. Glass makers and vehicle manufacturers opposed Antaya’s arguments and views. During the review process, the available stakeholder comments did not provide a basis for a clear recommendation to repeal the exemption. The general exemption for lead in solders was thus further specified, and soldering on glass incl. soldering in laminated glazing was covered by Exemption 8(b)[213]:

> *Lead in solder in electric applications on glasses*

The exemption was reviewed in 2009/2010 again[214], and the exemption was split into two parts:

> *8(i) Lead in solders in electrical glazing applications on glass except for soldering in laminated glazing in vehicles type approved before 1 January 2016;*

and

> *8(j) Lead in solders for soldering in laminated glazing; review in 2014;*

There was no evidence that the proposed indium-based lead-free solder may be viable for soldering in laminated glazing. Oeko-Institut[215] therefore recommended *“[...] to exclude soldering in laminated glass from the ban of lead until there is evidence that a solution is available. To promote the technical and scientific progress towards a lead-free solution, it is recommended to review this exemption in 2014. The stakeholders will then have to show that they have undertaken steps to achieve compliance with the material bans in the ELV Directive.*”

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[212] Cf. Directive 2000/53/EC (ELV Directive), Annex II, exemption 8: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2000:269:0034:0042:EN:PDF; last accessed 24.01.2014

[213] For details see page 45 ff of Oeko-Institut (2008) Stéphanie Zangl, Oeko-Institut e.V.; Otmar Deubzer, Fraunhofer IZM: Adaptation to Scientific and Technical Progress of Annex II Directive 2000/53/EC, final report from January 2008, Oeko-Institut e. V., Fraunhofer IZM; download from http://circa.europa.eu/Public/irc/env/elv/library?l=/stakeholder_consultation/evaluation_procedure/reports/final_report/report_revision/_EN_1.0_&a=d;

[214] For details see page 151 ff of Oeko-Institut (2010) Zangl, S.; Hendel, M.; Blepp, M.; Liu, R.; Gensch, c: (Oeko-Institut); Deubzer, O. (Fraunhofer Institute for Reliability and Microintegration IZM); Adaptation to scientific and technical progress of Annex II to Directive 2000/53/EC (ELV) and of the Annex to Directive 2002/95/EC (RoHS), revised version of the final report, Freiburg, 28 July 2010, retrievable rom https://circabc.europa.eu/sd/d/a4bca0a9-b6de-401d-beff-6d15bf423915/Corr_Final%20report_ELV_RoHS_28_07_2010.pdf; last accessed 24.01.2014

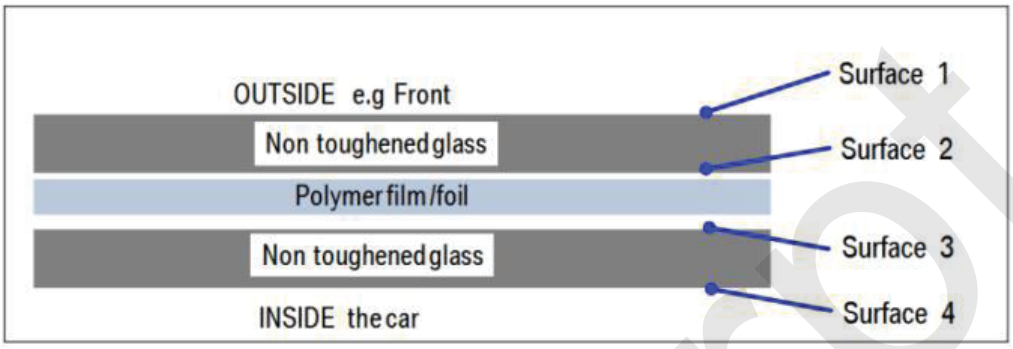
[215] Ibid.

The Commission followed the recommendation and set a review date for 2014 in Exemption 8(j) so that the exemption has become due for review. Exemption 8(i) was last reviewed in 2011/2012, and the wording of this Exemption was confirmed so that no changes became apparent regarding the wording of Exemption 8(j).[216]

8.1.2 Technical Background

ACEA et al.[217] explains that in laminated glazing structures, a polymer layer is embedded between two thinner panes of glass as illustrated in Figure 8-1.

Figure 8-1: Structure of Laminated Glazings



Source: BMW, quoted in ACEA et al.[218]

According to ACEA et al.[219], soldering of laminated glazing structures may be applied on a silver print on the non toughened glass, or on the silver print on top of the black lead-free enamel print of the glass, or to wires/films inside/on the foil. Wire materials are tungsten or copper.

[216] Oeko-Institut (2012) Deubzer, O. (Fraunhofer IZM); Zangl, S, (Oeko-Institut); Adaptation to Scientific and Technical Progress under Directive 2000/53/EC (ELV Directive) - Review of exemption 8 (i), Final Report, Freiburg, 10 March 2012; retrieved from http://elv.exemptions.oeko.info/fileadmin/user_upload/Exe_8_i_2011/ELV_Exemption_8i_final_report_March_2012.pdf; last accessed 10.01.2014

[217] Op. cit. ACEA et al. (2013a)

[218] Op. cit. ACEA et al. (2013a)

[219] Op. cit. ACEA et al. (2013a)

ACEA et al.[220] lists typical uses of lead containing solders within laminated glazing structures[221]:

1) Heating Applications

   a) Heated Wire Windshield or Backlight
   The technology is used to defrost/defog the entire windshield or backlight. Thin tungsten wires are embedded onto the interlayer materials (e.g.: polyvinyl butyral (PVB)) with solder connections to copper strip busbars. All is assembled between two plies of glass.

   b) Heated Coated Windshield
   The technology is used to defrost/defog the entire windshield. A metallic coating is heated by an electrical current. The electricity is applied through connectors soldered/ welded on busbars in contact with the coating. All is assembled between two plies of glass including an interlayer material (e.g. PVB).

   c) Heating pattern on backlight
   The technology is used to defrost/defog the laminated backlight. A silver print conductive pattern is printed on the occupant compartment side surface. Connections are soldered to the silver print busbar on glass.

   d) Heating Device Circuit on surface 4
   The technology is used to defrost the windshield on a local surface, for instance a heating pattern for camera area on windshield. A silver print conductive pattern is printed on the occupant compartment side surface. A connector is soldered to the silver print pattern on glass.

   e) Windshield Wiper De-icer Wire
   The technology is used to defrost the windshield wiper area in rest position. Thin tungsten wires are embedded onto the interlayer materials (e.g. PVB). Connectors are soldered to the busbar plate in a local area at the edge of the screen. Then connectors are covered by sealant.

   f) Windshield Wiper De-icer Printed
   The technology is used to defrost the windshield wiper area in rest position. Silver ceramic grid lines are printed on inner glass surface and heated up by an electrical current. Connectors are soldered to the silver ceramic busbar in a local area at the edge of the screen. Then connectors are covered by sealant.

[220] ACEA et al. (2013b) ACEA, CLEPA, JAMA, KAMA stakeholder document "acea_clepa_jama_kama_contribution_Ex_8j_further_Input_Public_20131104.pdf", submitted during the online stakeholder consultation, retrieved from http://elv.exemptions.oeko.info/fileadmin/user_upload/Consultation_2013_1/Exemption_8_j_/acea_clepa_jama_kama_contribution_Ex_8j_further_Input_Public_20131104.pdf; last accessed 10.01.2014

[221] The various applications were sorted and grouped by the consultants to improve the overview and comprehensibility of the information provided by ACEA et al. (2013b)

2) Antenna Applications:

   a) Wire Antenna
   The technology is used for radio/TV reception system on windshield. A metallic wire (usually made of copper) is embedded on the surface of the interlayer material (e.g. PVB) that is between the two plies of glass. A connector is soldered to the metallic wire.

   b) Antenna Printed
   The technology is used for radio/TV reception system on windshield, laminated sidelight or laminated backlight. A silver print conductive pattern is printed on the occupant compartment side surface. A connector is soldered to the antenna on glass.

3) Capacitive Coupling Connectors Soldered on Position 4
   This is a new development which is the final stage of development and intended to be introduced in a pilot application into the European market during the year 2014. A capacitive coupling connector is soldered on side 4 but not directly connected with used silver structure reception inside the glass pair. The connector therefore interacts like a capacitor.

ACEA et al.[222] claims that for laminated automotive glazing structures covered by Exemption entry 8(j), the technologies and demands are different from soldering on toughened glass, which is covered by Exemption 8(i). Besides some pilot applications, lead-free soldered solutions for laminated glazing structures are still at the screening stage. The challenges for contacting electrical joints in laminated glass structures are component and vehicle specific to a high degree.

ACEA et al.[223] say that as of today, the use of lead is still unavoidable for some applications for laminated glasses due to the facts that:

- Compared with toughened glasses, laminated glasses crack much easier when a certain stress is applied. The internal stress in laminated glass is not uniform and varies with the edge distance. Positive results with the same solder and connector can fail with the change of the position of the solder joint on the same glass.
- Compared with lead solders, lead-free solders give much higher stress to the glass to which the solders are attached.
- As a result, compared with toughened glasses, more advanced technologies are required to attach lead-free solders to laminated glazing structures - and to meet the specifications of the OEMs.

ACEA et al. put forward that the five years development of lead-free solders for single sheet toughened glass (Exemption 8(i)), as communicated in previous consultations, is nearly completed. Now there is intensified development capacity on establishing

[222] Op. cit. ACEA et al. (2013a)

[223] Op. cit. ACEA et al. (2013a)

available lead-free solders applications for laminated glazing in laboratory and later full-scale. ACEA et al.[224] claims that this challenge will require five more years at least, possibly more, for complete industrialization.

Antaya[225] presents a different point of view concerning the scope of Exemption 8(j) in demarcation of Exemption 8(i). Antaya[226] considers soldering between – not on - surfaces 2 and 3 as soldering in laminated glazings, while any contacts to the glass on surface 1 – in principle, as no soldering joints are applied on this surface - and on surfaces 2, 3 and 4 are considered to be soldering on glass, and as such, to be in the scope of Exemption 8(i), and not of Exemption 8(j). Antaya's detailed arguments are described in Section 8.2.1.1 on page 74.

8.1.3 Amount of Lead Used under the Exemption

According to ACEA et al.[227], electrical contacts in laminated glazing structures today are applied in a limited quantity of vehicles. In the future, e-driven vehicles will need this application in general, because of missing heat emission from an internal combustion engine.

As a basis for calculation, ACEA et al.[228] use actual market development figures from the supply chain. For each application group min./max. values for the applied lead content have been used and then the numbers have been multiplied with the amount of vehicles on the EU market using this equipment. Table 8-1 shows the calculation for the EU in detail. Figures worldwide have not been investigated due to time constraints.

[224] Op. cit. ACEA et al. (2013a)

[225] Antaya (2014a) Antaya Technologies Corporation document "Antaya Response to Questionnaire-2 Exe 8j.pdf", sent via e-mail by William Booth, Antaya Technologies Corporation, to Otmar Deubzer, Fraunhofer IZM, on 14.02.2014

[226] Ibid.

[227] Op. cit. ACEA et al. (2013a)

[228] Op. cit. ACEA et al. (2013a)

Table 8-1: Calculation of Lead Use under Exemption 8(j) in the EU

	Lead per vehicle min; [g]	Lead per vehicle max; [g]	No of vehicles with application/y	Total min. [kg]	Total max. [kg]
Wired Heated	0,04	0,06	1200000	48	72
Wire Antenna	0,05	0,1	380000	19	38
Wire Heated Wiper Rest Area	0,63	1,5	84000	52,9	126
Printed Heated Wiper Rest Area	0,63	1,5	400000	252	600
Printed Heated Backlights	0,42	1,75	200000	84	350
Printed Camera Window	0,1	0,2	1000000	100	200
Printed Antenna	0,1	0,42	200000	20	84
			total [kg]	575,9	1426
			total [tons]rounded	*0,6*	*1,5*
density Lead 11,36 g/cm³			*Volume [m³]*	*0,05*	*0,13*

Source: ACEA et al.[229]

For the EU market, ACEA et al.[230] see a total quantity of lead used under Exemption 8(j) applications in the range of 0.6 to 1.5 metric tonnes per year.

8.2 Stakeholders' Justification for or against the Continuation of Exemption 8(j)

8.2.1 Scope of Exemption 8(j)

Antaya and ACEA et al. have opposing views on the scope of Exemption 8(j) concerning which applications are covered by this exemption in demarcation from Exemption 8(i).

8.2.1.1 Scope of Exemption 8(j) According to Antaya

Antaya[231] finds it important to fully understand the distinction between applications falling under Exemption 8(i) and those falling under Exemption 8(j):

[229] Op. cit. ACEA et al. (2013a)

[230] Op. cit. ACEA et al. (2013a)

[231] Op. cit. Antaya (2014a)

*8(i) Lead in solders in electrical glazing applications **on** glass except for soldering in laminated glazing in vehicles type approved before 1 January 2016*

and

*8(j) Lead in solders for soldering **in** laminated glazing; review in 2014*

Antaya[232] states that the critical distinction between Exemption 8(i) and 8(j) is the word "in" (laminated glazing).[233] Antaya claims that the numerous references contained in *"ACEA Submission of Joint Associations to Stakeholder Consultation on Entry 8(j) and Supplemental information"* in fact relate to applications covered by Exemption 8(i). Antaya[234] illustrates its point of view related to applications, which ACEA et al. see to be covered by Exemption 8(j).

In Table 8-2 below, Antaya[235] explains its view on, which application covers, which exemption. The green marked fields indicate cases of coincidence of Antaya's point of view with that of ACEA et al.

[232] Op. cit. Antaya (2014a)

[233] For further clarification please refer to pages 181 and 182 of the 2010 final report; http://elv.exemptions.oeko.info/fileadmin/user_upload/Consultation_2013_1/Exemption_8_j_/Exemption_8j_Excerpt_in_Final_report_ELV_RoHS_28_07_2010.pdf; reference as provided by Antaya

[234] Op. cit. Antaya (2014a)

[235] Op. cit. Antaya (2014a)

Table 8-2: Applications in and out of Scope of Exemption 8(j)[236]

Application as Listed by ACEA et al. to be in the Scope of Exemption 8j	According to Antaya Covered by Exemption No.
Wire heated windscreens with wires embedded into/on the foil between the two glass plies	8(j)
Printed heated device circuit on the inner surfaces of the windscreen (surface 2 or surface 3)	8(j) except when inner surface is exposed
Antenna or sensor wire products (wires embedded into/on the foil)	8(j)
Connection joints to electrically conductive films within the laminate	8(j)
Printed antenna device circuit on laminated glass surface 4	8(i)
Printed heated circuits on laminated glass surface 4	8(i)
Wire heated wiper rest area windscreens	8(i)
Capacitive coupling connectors soldered on position 4	8(i)

Source: Antaya[237]

Antaya[238] considers only the below two sub-categories as soldering "in" laminated glass applications:

- Wire heated applications, both for heated backlights and wiper rests where the soldered connection is made between the connector and a conductive foil, which is attached to a tungsten copper wire embedded in the polyvinyl butyral interlayer (PVB).
- Wire antenna applications, where a tungsten copper wire embedded in the PVB is soldered to the connector to provide signal reception.

[236] For the numbering of the surfaces see Figure 8-1 on page 59

[237] Op. cit. Antaya (2014a)

[238] Op. cit. Antaya (2014a)

8.2.1.2 Scope of Exemtion 8(j) According to ACEA et al.

ACEA et al.[239] bases its scope considerations on the report of Oeko-Institut[240]. On page 181, the first sentence is *"Soldering in laminated glazing was excluded from Joint Test Program"*, and further deductions are built on this statement. According to ACEA et al.[241], any soldering in laminated glazing applications was excluded from the Joint Test Program, "in" as well as "on". For ACEA et al. [242] this becomes even clearer with the next sentences, namely: *"Antaya had not tested its solder for this application. ... Antaya ... would need the glass makers' support for the supply of the laminated glass"*.

ACEA et al.[243] claims that the Test Program did not consider any kind of application of solder to laminated glazing. So the logical conclusion is that "in laminated glazing" has to be understood as "in laminated glazing applications". Differences between laminated and tempered products have been addressed in the previous reports (e.g. Oeko-Institut (2008) p. 60), but have not been detailed because there was common understanding at that time that laminated glass is out of scope for technical reasons.

ACEA et al.[244] highlights that in this instance the interpretation of the word "in" is critical. They explain that in the quoted reference[245] it seems that Antaya may have interpreted it as meaning wires inside laminated glass. The industry has interpreted it as meaning anything related to laminated glass and soldered connectors. It is obvious that there have been different interpretations of the wording in Exemption 8(j). To clarify the position for the automotive industry, ACEA et al.[246] suggests that this exemption could be redefined as part of the review. There are three distinct groups of automotive glass products:

- Printed toughened glass (covered by Exemption 8(i));
- Printed non-toughened laminated glass; and
- Laminated glass with foils or wires inside (covered by Exemption 8(j)).

[239] ACEA et al. (2014c) ACEA, CLEPA, JAMA, KAMA stakeholder document "ACEA, JAMA, KAMA Comments on ANTAYA statement on Exe-8(j)_20140507.pdf", sent via e-mail to Otmar Deubzer, Fraunhofer IZM, by Peter Kunze, ACEA, on 08.05.2014

[240] Op. cit. Oeko-Institut (2010)

[241] Op. cit. ACEA et al. (2014c)

[242] ACEA et al. (2014a) ACEA, CLEPA, JAMA, KAMA stakeholder document "ACEA, JAMA, KAMA Answers_Questionnaire-2_Exe-8j_20140404-rev.pdf", sent via e-mail to Otmar Deubzer, Fraunhofer IZM, by Peter Kunze, ACEA, on 24.04.2014

[243] Ibid.

[244] Op. cit. ACEA et al. (2014c)

[245] Op. cit. Oeko-Institut (2010)

[246] Op. cit. ACEA et al. (2014c)

ACEA et al.[247] states that all of the above glass products have differing technical challenges and require different solutions. Glass producers confirm the critical aspect of soldering on glass without lead and furthermore when glass is non-toughened in a laminated structure. There is therefore a paradox to consider that this most critical case (i.e. solder on non-toughened glass in a laminated structure) would have been included in the 8(i) Exemption with a termination date on Jan 1st 2016. ACEA et. al.[248] considers Exemption 8(j) applicable to a-non toughened laminated glass system (including solders in between the two sheets of glass or solders on the surface of non-toughened laminated glass).

8.2.2 Status of Substitution or Elimination of Lead According to ACEA et al.

ACEA et al.[249] states that, generally, lead is required to match the different coefficients of thermal expansion (CTE) of the materials used in laminated glazing structures (i.e. the mechanical stress-sensitive glass, the solder material and the connector) to avoid a glass failure by cracking. Since soldering is carried out at high temperature, the CTE mismatch, for example between the glass and the solder while cooling needs to be compensated by the ductility of the solder.

ACEA et al.[250] justify the continued use of lead as follows:

- Currently there is no sufficient, sustainable, lead-free solder available providing the high ductility of lead-containing solder (that fulfils the requirements of OEMs), especially since glass panes used for laminated glass are thinner and non-toughened resulting in higher glass crack sensitivity. In addition there are limitations in temperature process windows.
- No failure of the electric contacts in laminated glazing structures during vehicle lifetime is acceptable because this would directly affect vehicle safety aspects. Any potential substitute has to prove at least the same performance as the current solution.
- For some components, emerging solutions for the contacting inside the foil are on the way, but in general, and for the majority of applications, lead-free solders are still subjects of intensive R&D efforts. Testing has confirmed repeatedly that lead-free solders fail to fulfil the customer specifications. This is valid for in laminate soldering, where first solutions are available and complete industrialization needs sufficient implementation time. Particular challenges are faced when soldering laminated glass panes with structure contacts (e.g. silver prints) either directly on the glass or on top of a ceramic layer.

[247] Op. cit. ACEA et al. (2014c)

[248] Op. cit. ACEA et al. (2014c)

[249] Op. cit. ACEA et al. (2014a)

[250] Op. cit. ACEA et al. (2014a)

- The global supply chain cannot provide lead-free solutions for entry 8(j), which sufficiently fulfil the specifications of the OEMs. Due to efforts dedicated to tempered glass solutions, and the lack of validations by OEM's glass-makers, ACEA et al.[251] state in their contribution that they had no possibility of evaluating soldering on surface 2, 3 and 4 of laminated glazing structures at the time.
- Technical production situation is not capable / given that a technical solution has not yet been verified and therefore it is not feasible to identify investment requirements.
- The principal application of lead-based solders in laminated glazing structures is currently required to enable (reliable electrical contacting) production of:
    - Fine Wire Heating Grid (for de-icing of the entire windshield);
    - Local coating and printing on position 2 and 3 (for windshield de-icing frozen wipers);
    - Local printing on position 4 (for antenna on windshield for radio, TV systems or alarms and sensors);
    - In general silver prints on surface 2, surface 3 and surface 4;
    - Contacts on position 4 of laminated glazing structures for reliable contacts to antenna, heating, alarm or sensor circuits.

ACEA et al.[252] claims that OEMs have been evaluating new solutions for toughened glass since 2008, with big failures during the first years, and they have been constantly in contact with their glass-makers. Because of the timing of the expiry of Exemption 8(i), the successful development of lead-free solders for that application has been the priority. This is still on-going. When the remaining challenges, e.g. of industrialization, have been met, the experiences can be used for development of entry 8(j), i.e. non-toughened glass issues.

ACEA et al. contend to have tested the following connectors/lead-free solders since 2008, which all failed to meet the requirements:

- Customer specified connectors with Pb-free solders:
    - 96.5Sn3.5Ag;
    - 42Sn57Bi1Ag;
    - 88Sn8In0.5Bi3.5Ag;
    - 92.5Sn4Bi3.5Ag).
- Flexible foil connectors with Pb-free solders:

[251] Op. cit. ACEA et al. (2014a)

[252] Op. cit. ACEA et al. (2014a)

- 98Sn2Ag;
- 55In2.5Ag42.5Sn.

➢ Stainless steel connectors with Pb-free solders:

- 96.5Sn3Ag0.5Cu;
- 42Sn57Bi1Ag;
- 98Sn2Ag.

➢ Directly soldered wires to the print with Pb-free solders:

- 98Sn2Ag;
- 57Bi42Sn1Ag;
- 55In2.5Ag42.5Sn;
- 90In10Ag;
- 65In30Sn4.5Ag0.5Cu;
- 90Sn7.5Bi2Ag0.5Cu.

➢ Alloys having a lower melting point than 96.5Sn3.5Ag for example, hence less stress to glass by soldering, and with a much less bismuth content than 42Sn57Bi1Ag, also understood as having bad thermodynamic effect on laminated glazing due to brittleness and CTE;

➢ In thermal cycle tests, ACEA et al.[253] found glass cracks with the following solders irrespective of connector type (copper, stainless steel, wires, foils):

- 96.5Sn3.5Ag;
- 42Sn57Bi1Ag;
- 88Sn8In0.5Bi3.5Ag;
- 98Sn2Ag;
- 96.5Sn3Ag0.5Cu;
- 90In10Ag.

According to ACEA et al.[254], the lead-free solders 55In2.5Ag42.5Sn and 65In30Sn4.5Ag0.5Cu do not produce glass cracks in thermal cycle tests, but they do not pass high temperature test requirements as specified in the German OEM test specification.

[253] Op. cit. ACEA et al. (2014a)

[254] Op. cit. ACEA et al. (2014a)

ACEA et al.[255] claim that positive R&D test results with lead-free solutions for some specific components will need further validation on vehicle level before a decision for volume production is feasible. The estimations vary between the end of 2016 and 2018, and depend on further positive component test results. As such, no concrete timing estimation is possible today.

Conductive gluing as a way to eliminate the use of lead is stated not to be an option for heating functions on surface S2 or S4 due to the current density they need; there is an inevitable compromise between mechanical resistance and conductivity. This presents technical barriers to developing applicable solutions that would even partially meet the OEM requirements, especially for durability. The technology is applied e.g. for embedded heated wires or heatable coated glass, but the conductivity is then stabilized by the pressure of glass panes assembled after auto-claving.

A technology screening has been made, to clarify if there are usable solutions in other industry sectors like photovoltaic cell production. Use of lead-based solder was found to be state of the art there as well, and a transferable and broadly applicable lead-free solution could not be identified.

8.2.3 Status of Substitution or Elimination of Lead According to Saint-Gobain Sekurit

8.2.3.1 Overview on Soldering on Laminated Glazings

Sekurit[256] presents the following applications of soldering on laminated glazings depending on the material that is to be connected[257]:

1) Connections to wire pattern:
   A) Wire heated windscreens (W wires embedded into/on the foil);
   B) Antenna or sensors wire products (Cu wires embedded into/on the foil);
   C) Wire heated wiper rest area windscreens (Cu wires embedded into/on the foil).
2) Connections to conductive layer:
   A) Connections to electrically conductive films within the laminate.
3) Connections to printed pattern:
   A) Printed heated device circuit on surface 2, 3 (inner surfaces of the windscreen);

[255] Op. cit. ACEA et al. (2014a)

[256] Sekurit (2014b) Saint- Gobain Sekurit document “2014-02-06_Saint Gobain_Lead-Free Soldering on laminated glass_external.pdf”, sent via e-mail by Volker Offermann, Sekurit Sekurit, to Otmar Deubzer, Fraunhofer IZM, on 06.02.2014

[257] For a list of functionally ordered applications see Section 8.1.2 on page 50

B) Printed heated circuits on surface 4;

C) Printed antenna device circuit on surface 4.

Sekurit[258] explains its strategy to enable lead-free soldering in the above applications.

- A lead-free solder has been developed;
- Flat connectors are especially developed to be applied on less robust non-tempered glass;
- Button and crimp connector properties have been adapted and optimized to reduce the mechanical impact on the glass as far as possible;

Sekurit[259] presents an overview of the lead-free solutions for the above applications.

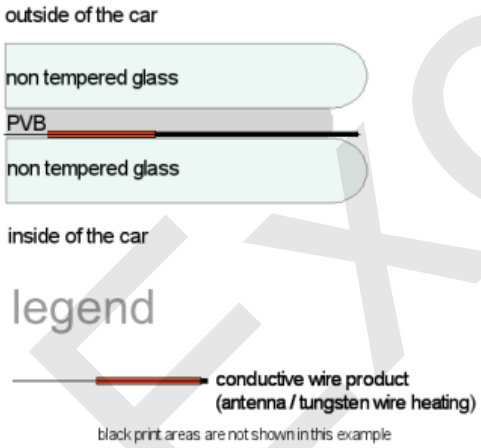
8.2.3.1.1 Lead-free Solutions for Connections to Wire Patterns

Applications based on connections to wire patterns according to St. Gobain (2014b) are:

1) antennae (copper wire)
2) camera defoggers (copper wire)
3) wiper park heaters (copper wire)
4) ice control wires (tungsten wire)

Figure 8-2 shows an outline of this technology.

Figure 8-2: Schematic View of Connections to Wired Patterns in Laminated Glazings



Source: Sekurit[260]

[258] Sekurit (2014a) Saint- Gobain Sekurit document "2014-02-03_Questionnaire-2_Exe-8j_St – Gobain.pdf", sent via e-mail by Volker Offermann, Sekurit Sekurit, to Otmar Deubzer, Fraunhofer IZM, on 03.02.2014

[259] Op. cit. Sekurit (2014b)

[260] Op. cit. Sekurit (2014b)

Sekurit[261] describes that the wires are stepped onto the PVB foil and are then contacted with lead-free solder via ribbon busbars/flat connectors (Figure 8-3) prior to the lamination process.

Figure 8-3: ICW Busbar (Ribbon Busbar/Flat Connector

Source: Sekurit (2014b)

According to Sekurit[262], this lead-free solution is lab-validated and validated at the industrial line, but there is no serial implementation yet due to higher costs of this technology compared to the lead-soldered solution.

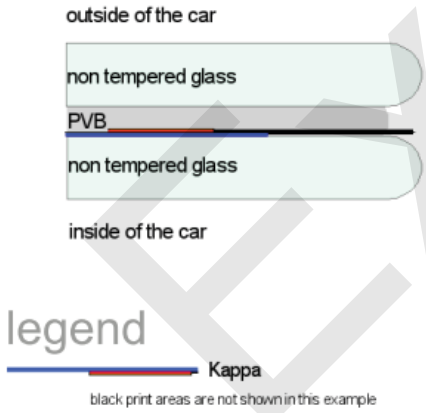
8.2.3.1.2 Lead-free Connections to Conductive Layers

Figure 8-4 shows an outline for soldering on conductive layers.

Applications requiring connections to conductive layers are antennae and heating "grids" (Figure 8-5), which Sekurit[263] manufactures using flat connectors.

According to Sekurit[264], this lead-free solution using flat connectors is already in serial production since 2013.

Figure 8-4: Lead-free Connections to Conductive Layers



[261] Op. cit. Sekurit (2014b)

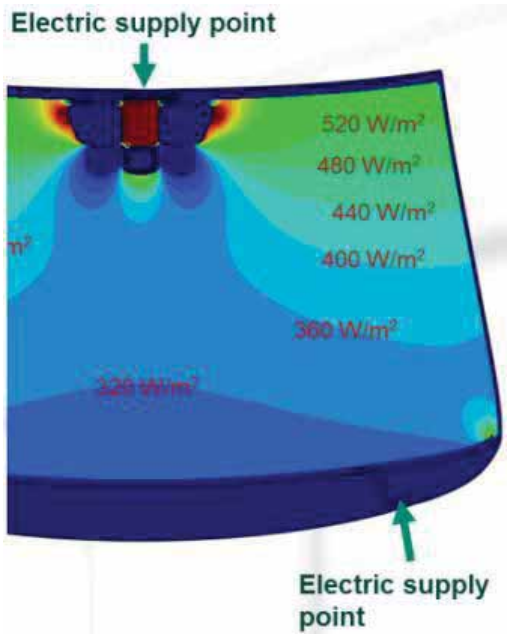
[262] Op. cit. Sekurit (2014b)

[263] Op. cit. Sekurit (2014b)

[264] Op. cit. Sekurit (2014b)

Source: Sekurit[265]

Figure 8-5: Contacted Heating Grid



Source: Sekurit[266]

Sekurit[267] specified examples, which are already applied in the field:

i. Mercedes VS20 (flat connector for antenna),

ii. Ford CD 391 (flat connector to contact ICW busbar, development 2010, delayed start of production (SOP) 2013).

iii. VW Passat 470 and Golf 370 (ICC) developed in completely lead-free.

Silver print on glass is contacted with a lead-free busbar. Finally, the flat connector for contacting this busbar has been taken over as identical part from former model (with Pb solder) to save costs.

8.2.3.1.3 Connections to Printed Patterns

8.2.3.1.3.1 Connections on and in Windscreens

Figure 8-6 shows the principle of connections to printed patterns on windscreens.

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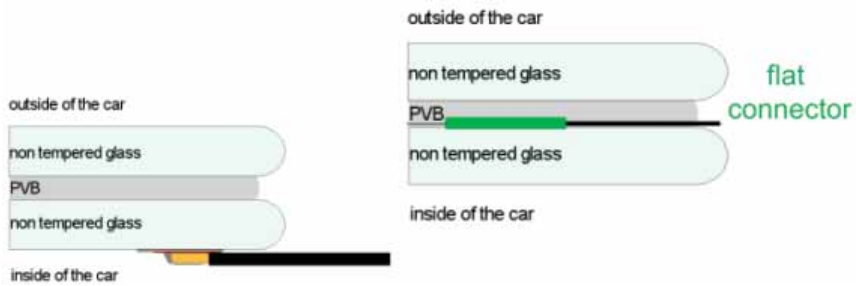
[265] Op. cit. Sekurit (2014b)

[266] Op. cit. Sekurit (2014b)

[267] Op. cit. Sekurit (2014b)

Figure 8-6: Outline of Connections to Printed Patterns on (left) and in Windscreens

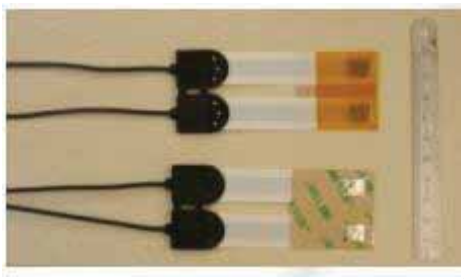


Source: Sekurit[268]

Sekurit[269] lists the following applications:

1) Antennae on windscreens
2) Camera defoggers
3) Wiper park heaters

Figure 8-7: Flat Connectors for Contacting Wiper Park Heaters



Source: Sekurit[270]

Sekurit[271] claims that this lead-free solution has been applied in series in laminates for two years already (since 2012 latest) using flat connectors for contacting printed silver busbars and ribbon busbars.

[268] Op. cit. Sekurit (2014b)

[269] Op. cit. Sekurit (2014b)

[270] Op. cit. Sekurit (2014b)

[271] Op. cit. Sekurit (2014b)

Figure 8-8: ICW Ribbon Busbar/Flat Connector (left) and Crimp (right) and Button (left) Connectors

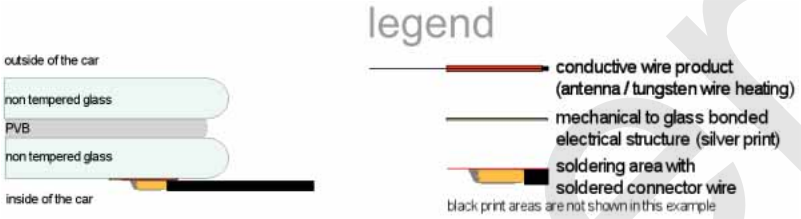
Source: Sekurit[272]

For soldering on laminates, the lead-free solutions are lab-validated using flat connectors and crimp and button connectors, which exert less mechanical forces to the glass.

8.2.3.1.3.2 Connections on Backlights

Figure 8-9 illustrates connections to printed patterns on backlights.

Figure 8-9: Outline of Connections to Printed Patterns on Backlights



Source: Sekurit[273]

Such connections are used for heating grids and antennae on backlights, according to Sekurit[274]. Sekurit[275] uses flat connectors like those for contacting wiper park heaters (Figure 8-7) to produce such connections.

Sekurit[276] claims that the lead-free flat connector and the lead-free button solutions on laminates are both lab-tested.

Sekurit[277] says that bridge connectors are sometimes used to contact printed patterns on laminated glass. Sekurit[278] has banned such connectors from use on

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[272] Op. cit. Sekurit (2014b)

[273] Op. cit. Sekurit (2014b)

[274] Op. cit. Sekurit (2014b)

[275] Op. cit. Sekurit (2014b)

[276] Op. cit. Sekurit (2014b)

[277] Op. cit. Sekurit (2014b)

[278] Op. cit. Sekurit (2014b)

laminated glass irrespective of whether the connections are soldered with lead-containing or lead-free solders, because the bridge connectors exert too strong a mechanical stress to the glass.

8.2.3.2 Detailled Status and Applications of Lead-free Soldering

Sekurit[279] describes the status of its lead-free soldering programs for the various laminated glazing applications in more detail. The surface numbering is taken from Figure 8-1 on page 70.

1) Electrical Connections on Surface (2) and 3
   - ➢ Electrical Connections in Laminated Glazings to Silver Printed Busbars by Flat Connectors
     - Applications:
       Connection to coatings via printed busbar or complete silver printed structures (antenna, heating,...). Sekurit[280] states that, as a general rule, the manufacturer does not solder on surface 2. According to Sekurit[281], in terms of connection technology there is no difference between connections to side 2 and 3.
     - Status:
       - o Development finished and ready for series, i.e. every car manufacturer sending a request for quotation will obtain an offer for serial application.
       - o Lab-validated and industrially developed for laminated glasses heated by coating in the frame of industrial car projects (VW Passat 470 and Golf 370).
       - o Other applications are fully analogue.
     - Reference:
       - o Up to now no serial reference.
       - o Mentioned models equipped with Pb-containing take-over parts to save costs for initial connector development.
2) Electrical Connections Between Surfaces 2 and 3 to Structures on or in the PVB Foil
   - ➢ Electrical Connections in Laminated Glazings to Single Wires or Ribbons on PVB Foil by Flat Connectors:

[279] Sekurit (2014c) Saint- Gobain Sekurit document “2014-05-23_Questionnaire-4_Meeting-Follow-up_Sekurit_final.docx”, sent via e-mail by Klaus Schmalbuch, Sekurit Sekurit, to Otmar Deubzer, Fraunhofer IZM, on 23.05.2014

[280] Op. cit. Sekurit (2014b)

[281] Op. cit. Sekurit (2014c)

- Application:
  Contact to wire antenna or to ribbon busbar (e.g. laminated glass heated by several wires – heating application for windshield, compare the below connections to several wires on PVB foil by ribbon busbars).
- Status:
  Development finished and ready for series, i.e. every car manufacturer sending a request for quotation will obtain an offer for serial application.
- Reference:
  Serial references and serial developments:
  - Mercedes VS20;
    Flat connector to contact antenna;
  - Ford CD 391;
    Flat connector to contact ribbon busbar of a windshield heated by several wires. Busbar itself is today still with Pb for economic reasons. Substitute without lead is developed at industrial level;
  - Volvo;
    Flat connector to contact ribbon busbar of windshields heated by several wires in serial development;
    - Volvo V526 with SOP CW (calendar week) 05/2015;
    - Volvo V541 with SOP CW 17/2016;
    - Volvo V542 with SOP CW 20/2016;
    - Volvo V543 with SOP CW 46/2016.

➢ Electrical Connections in Laminated Glazings to Several Wires on PVB Foil by Ribbon Busbar:

- Application:

  Contact of ribbon busbar to heating wires for laminated glasses heated by several wires – heating application for windshield.
- Status:
  Lab and industrially validated.
- Reference:

  Serial developments:
  - Volvo in serial development (busbar to contact several wires of a wire heated windshield);
  - Volvo V526 with SOP CW 05/2015;
  - Volvo V541 with SOP CW 17/2016;
  - Volvo V542 with SOP CW 20/2016;
  - Volvo V543 with SOP CW 46/2016.

3) Electrical Connections on Surface 4:

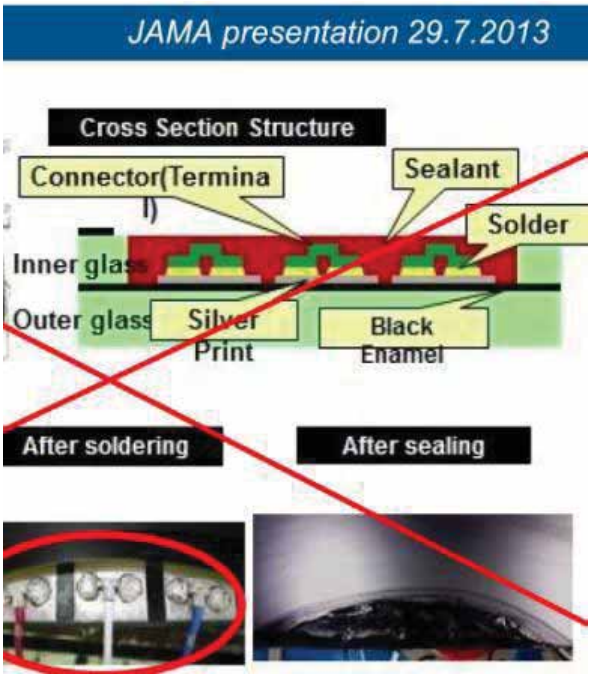
- Electrical Connections on Laminated Glazings to Heating Applications by Flat Connectors:
  - Applications:
    - Wiper park heater on windscreen;
    - Heating grid on backlight.
  - Status:
    Lab-validated, see Appendix A.3.0.
  - Reference:
    Up to now no serial reference.
- Electrical Connections on Laminated Glazings to Low Power Applications:
  - Applications:
    - Antenna;
    - Camera window defogger, etc.
  - Status:
    - Flat connector;
    - Crimp or button connector.
  - Reference:
    - All versions lab-validated;
    - Some versions validated at industrial level;
    - Crimp solution on first industrial car project:
      - Volvo V526 with SOP CW5/2015 in development;
      - 3 further models follow 2016.

8.2.3.3 Explanations for the Exclusion of Soldering on Surface 2

Sekurit[282] identifies a chain of non-preferable technical solutions in the special case of connections to silver printed busbars on side 2 as presented in Figure 8-10.

[282] Op. cit. Sekurit (2014c)

Figure 8-10: Soldering on Surface 2



Source: Sekurit[283]

Sekurit[284] recommends more robust alternatives like using flat connectors. If the customer cannot agree on these alternatives, Sekurit (2014b) states that Sekurit itself will provide the imposed layout. The flat connector technology used by Sekurit to connect side 3 is also feasible for connections to side 2.

Sekurit[285] explains that stone impacts affect the inner glass much less than the outer since both outer glass and PVB foil act like buffer layers. Sekurit therefore avoids soldering to surface 2 as well as silver prints on side 2, which both weakens the outer glazing and, as a consequence, reduces the resistance against stone impacts. Sekurit avoids such a configuration when developing new products for its customers.

Sekurit[286] states that the manufacturer is fully aware that today many references in the market do have printing on side 2, mainly for heating purposes. Sekurit[287] claims that the same functionality can be reached also with a minor design change that moves the heating grid from side 2 to side 4. If, however, this design change is impossible for reasons related to the overall vehicle architecture, and the affected car

[283] Op. cit. Sekurit (2014b)

[284] Op. cit. Sekurit (2014c)

[285] Op. cit. Sekurit (2014c)

[286] Op. cit. Sekurit (2014c)

[287] Op. cit. Sekurit (2014a)

makers are ready to accept the lower stone impact resistance, then Sekurit will make available also a lead-free connection to printed structures on side 2.

8.2.3.4 Saint-Gobain Sekurit's Conclusions

Sekurit[288] concludes that lead-free solutions are available for all applications around laminates, and that for Sekurit laminated products the continuation of Exemption 8(j) is not required.

Sekurit[289] underlines that for Sekurit, as a glass manufacturer, a SOP date in 2014 is possible without any problem. Regarding the car manufacturers' validation process, Sekurit[290] points out that it can provide lead-free prototypes immediately to any car manufacturer, so that the car manufacturer validation time can be kept to a minimum.

According to Sekurit[291], the industrialization will be planned as soon as the EU has decided when Exemption 8(j) will end. Sekurit[292] says that today, there is no benefit for OEMs to switch to lead-free soldering on laminates. The introduction of a new technique always coincides with risks, and cost for some of the mentioned technologies may be higher than those related to conventional systems containing lead. Sekurit[293] concludes that without a clear visibility of a lead-free need, the OEMs are not willing to pay for this. Sekurit[294] underpins this conclusion with the experiences related to Exemption 8(i)[295]. When it was unclear whether the exemption would be continued after 2012, the number of requests for lead-free connectors on tempered glasses increased enormously during the first half of 2013[296], whereas the request for lead-free connectors on laminated glass remained at a low level.

[288] Op. cit. Sekurit (2014b)

[289] Op. cit. Sekurit (2014a)

[290] Op. cit. Sekurit (2014a)

[291] Op. cit. Sekurit (2014a)

[292] Op. cit. Sekurit (2014a)

[293] Op. cit. Sekurit (2014a)

[294] Op. cit. Sekurit (2014a)

[295] Lead in solders in electrical glazing applications on glass except for soldering in laminated glazing

8.2.4 Status of Substitution and Elimination of Lead According to Antaya Technologies

8.2.4.1 Removal of Exemption 8(j)

Antaya[297] calls for the immediate removal of Exemption 8(j). Antaya[298] claims to have developed, tested, and to supply lead free solder alloys for use on and in automotive glass.

Antaya[299] highlights that:

- The indium alloy works in the lamination, whether soldering occurs adjacent to the inside surface of glass or the PVB;
- There are lead free high tin / bismuth "in lamination" programs in production that work well when the soldering occurs not adjacent to the inside surface of the glass (which is most of the time);
- Sekurit has a third solution that is publicly promoted.

Antaya[300] says that the author's lead free alloys are in use on millions of production OEM vehicles, and Antaya has tested its alloys for use in laminated glass successfully with its automotive glass customers. Antaya's lead-free solder has several demonstrated benefits over lead based solders for use in laminated glass, especially in regards to melting point and resistance to cracking. It submits that Exemption 8(j) should therefore be repealed.

8.2.4.2 Detailed Status of Lead-free Soldering According to Antaya

Antaya[301] claims that both for soldering on glass as well as for soldering in laminated glazing, lead-free solutions are available. Antaya was asked to explain in more detail the status of its various lead-free programs related to this exemption to allow the consultants to obtain a clearer picture of the current situation.

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[297] Antaya (2013a) Antaya Technologies Corporation stakeholder document "20131101c_Antaya_Tech_Corp_Ex_8j_Stakeholder_Contribution_Cover_Letter.doc.pdf", retrieved from http://elv.exemptions.oeko.info/fileadmin/user_upload/Consultation_2013_1/Exemption_8_j_/20131101c_Antaya_Tech_Corp_Ex_8j_Stakeholder_Contribution_Cover_Letter.doc.pdf; last accessed 10.01.2014

[298] Antaya (2013b) Antaya Technologies Corporation document "20131101q_Antaya_Tech_Corp_Ex_8j_Stakeholder_Contribution_Questionaire.pdf", retrieved from http://elv.exemptions.oeko.info/fileadmin/user_upload/Consultation_2013_1/Exemption_8_j_/20131101q_Antaya_Tech_Corp_Ex_8j_Stakeholder_Contribution_Questionaire.pdfhttp://elv.exemptions.oeko.info/fileadmin/user_upload/Consultation_2013_1/Exemption_8_j_/20131101c_Antaya_Tech_Corp_Ex_8j_Stakeholder_Contribution_Cover_Letter.doc.pdf; last accessed 10.01.2014

[299] Op. cit. Antaya (2014a)

[300] Op. cit. Antaya (2013a)

[301] Op. cit. Antaya (2013b)

In the below listing, the uses of Antaya lead-free alloys are differentiated by the surface on or in between which the solder alloys are applied, regardless of the interpretation whether this is considered in or outside of the scope of Exemption 8(i). Antaya's scope interpretation for the below listed applications is added in footnotes.

1) Soldering applications on surface 4[302]:
    - Ford Thunderbird (North America);
        - Pre-soldered copper terminal;
        - Lead free 65% Indium solder released for volume production;
        - In production from 2000-2005, no warranty claims related to the solder;
        - Lead free solder was specifically requested to solve cracking issues that were occurring with lead based solder.
    - GM U Vans (North America (Chevrolet Venture, Oldsmobile Silhouette, Pontiac Trans Sport) and Europe (Opel/Vauxhall Sinatra));
        - Pre-soldered copper terminal;
        - Lead free 65% Indium solder released for volume production to fix cracking problems with lead solder connectors;
        - In production 2000-2008, no warranty claims related to the solder.
    - Global vehicles:
        - Pre-soldered copper terminal;
        - Asian SUV (sports utility vehicle);
        - Start of production February 2016;
        - Validated with 65% indium solder to comply with the ELV Exemption 8(i) which is due to expire December 2015.
    - Global vehicles:
        - Windshield camera heater and heated wiper rest connectors;
        - European large SUV;
        - Start of production spring of 2016;
        - Validated with 65% indium solder to comply with the ELV Exemption 8(i) which is due to expire December 2015.

[302] According to Antaya (2014b) Antaya Technologies Corporation document "Antaya_Response_Meeting-2014-05-09.pdf", sent via e-mail by William Booth, Antaya Technologies Corporation, to Otmar Deubzer, Fraunhofer IZM, on 19.05.2014; covered by Exemption 8(i)

2) Surface applications on surface 2[303]:
    - Global vehicle:
        - Pre-soldered copper terminals for heated wiper rest;
        - Lead free 65% Indium solder released for volume production;
        - Has been running in high volume production beginning in March 2013.
    - Global Vehicle:
        - Pre-soldered copper terminal;
        - Asian small SUV;
        - Start of production August 2016;
        - Validated with 65% Indium solder to comply with the ELV Exemption 8(i) which is due to expire December of 2015.
    - Global vehicle:
        - Windshield heated wiper area;
        - European small SUV;
        - Will be lead free using 65% Indium solder;
        - Start of production July 2016.
    - Global Vehicle:
        - Windshield antenna;
        - Asian Sedan;
        - Will use lead free 65% solder for 3 lead antenna;
        - Start of production September 2016.

3) Soldering applications between surfaces 2 and 3[304]:
    - Global Vehicle:
        - Windshield antenna;
        - European SUV;
        - Part has gone through validation testing, production part approval process (PPAP) has been issued, production orders pending;

[303] According to Antaya (2014b), covered by Exemption 8(i)

[304] According to Antaya (2014b) this is the only application covered by Exemption 8(j)

        - Part uses 65% Indium solder;
        - Lead free was selected because of superior soldering performance in the plant, especially in respect to its lower melting point, which did not damage the PVB material.
    - Global vehicle:
        - Windshield antenna;
        - European SUV;
        - Part is transitioning from lead solder to lead free solder (65%) for demonstrated performance and yield improvements in the plant.
    - Global vehicle:
        - Windshield antenna;
        - European Sedan;
        - Part is transitioning from lead solder to lead free solder (65%) for demonstrated performance and yield improvements in the plant.

Antaya[305] claims that, as a result of the political nature of the ELV exemption review process, Antaya has been required to execute non-disclosure agreements with several glass manufacturers which precludes sharing successful test results, program information, and field data.

Antaya[306] says that the OEM and glass suppliers were purposely left anonymous for current programs, as, given Antaya's previous experience with ACEA, it feels that disclosing these details would jeopardize the continued production, as well as the planned use of lead free solder for these awarded programs. Antaya (2014b) claims that lead free programs were successfully launched and in production at VW Mexico on well over 500,000 vehicles without production problems or warranty claims, until members of ACEA became aware of the use of lead free solder, and forced the change back to lead for purely political reasons. Representatives of the glass suppliers and OEMs, under the umbrella of ACEA, are currently in opposition to the repeal of Exemption 8(j), while independently, these same OEMs and glass suppliers (as evidenced above) have launched, and continue to launch programs for both Exemption 8(i) and 8(j) in order to comply with the repeal of 8(i) and 8(j). According to Antaya[307], indium based solder is used both to solve technical problems as well as to comply with legislation.

[305] Op. cit. Antaya (2014a)

[306] Op. cit. Antaya (2014b)

[307] Op. cit. Antaya (2014b)

8.2.5 Roadmap to Substitution or Elimination of Lead

8.2.5.1 Roadmap of ACEA et al.

ACEA et al.[308] says that the generic roadmap towards ELV compliance is not different from the timeline requested for entry 8(i) in the last review[309]. The reason for that is that industry is more or less in a similar position as during the stakeholder consultation on entry 8(i) and the implementation time of an identified, valid solution - which is an ongoing issue- mainly depends on the positive test results needed on vehicle level.

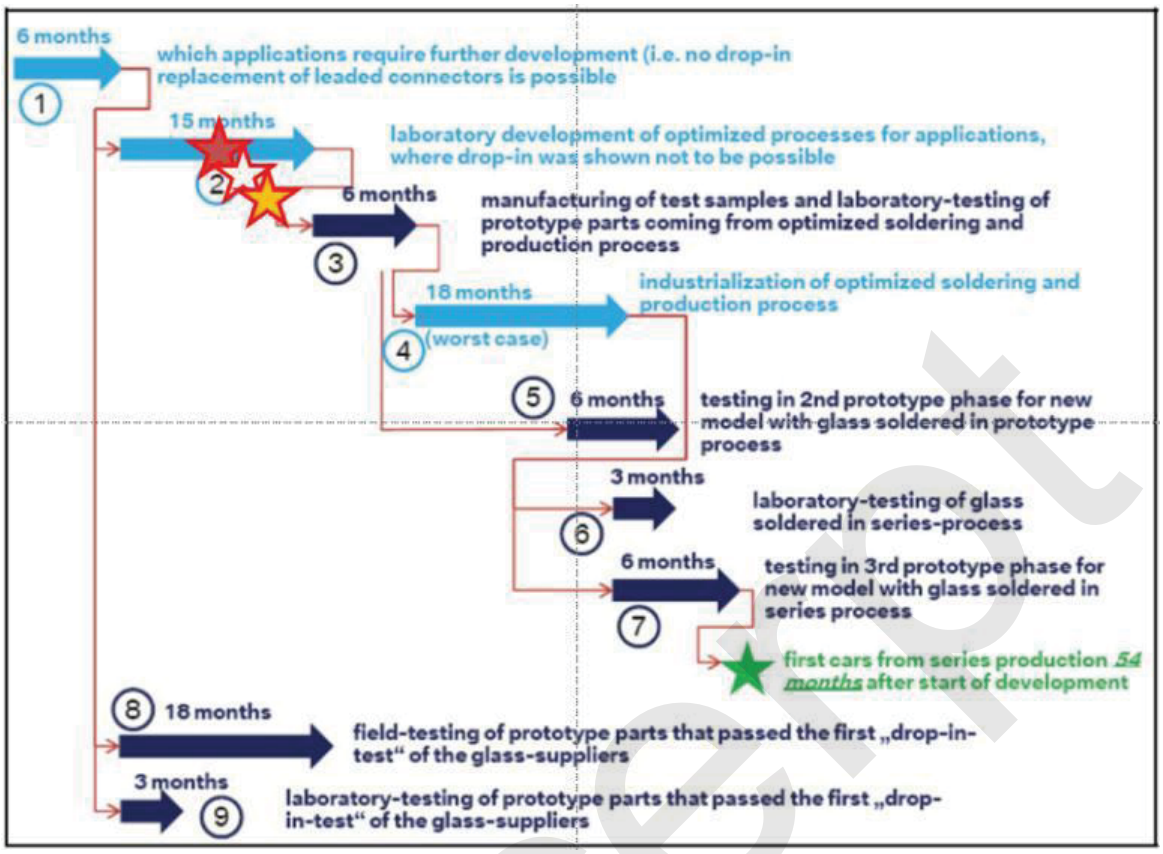
ACEA et al.[310] states that, when the remaining challenges e.g. of industrialization have been met in the supply chain, the experiences can be used for development of entry 8(j) i.e. non-toughened glass issues, which is in their opinion even more challenging.

[308] Op. cit. ACEA et al. (2013a)

[309] For details see Oeko-Institut (2012)

[310] Op. cit. ACEA et al. (2013a)

Figure 8-11: Timeline for Soldering of Laminated Glass Structures and Soldering on Non-toughened Glass



Source: ACEA et al.[311]

ACEA et al.[312] contends that, based on solution availability on component level 48 to 60 months are necessary for validation on vehicle level and ramp up of production processes. ACEA et al.[313] states that the generic timeline given during the Entry 8(i) revision[314] is still valid and not repeated here again.

More practical experience with pilot applications is necessary to collect knowledge on long-term reliability as a prerequisite for volume production. A limited access to recently patented potential solutions may influence further progress speed as negotiations may be challenging.

The generic timeline for transition to replacement of lead-containing solder, provided by JAMA concerning laminated glass de-icer and antenna terminals as well, gives a

[311] Op. cit. ACEA et al. (2013a)

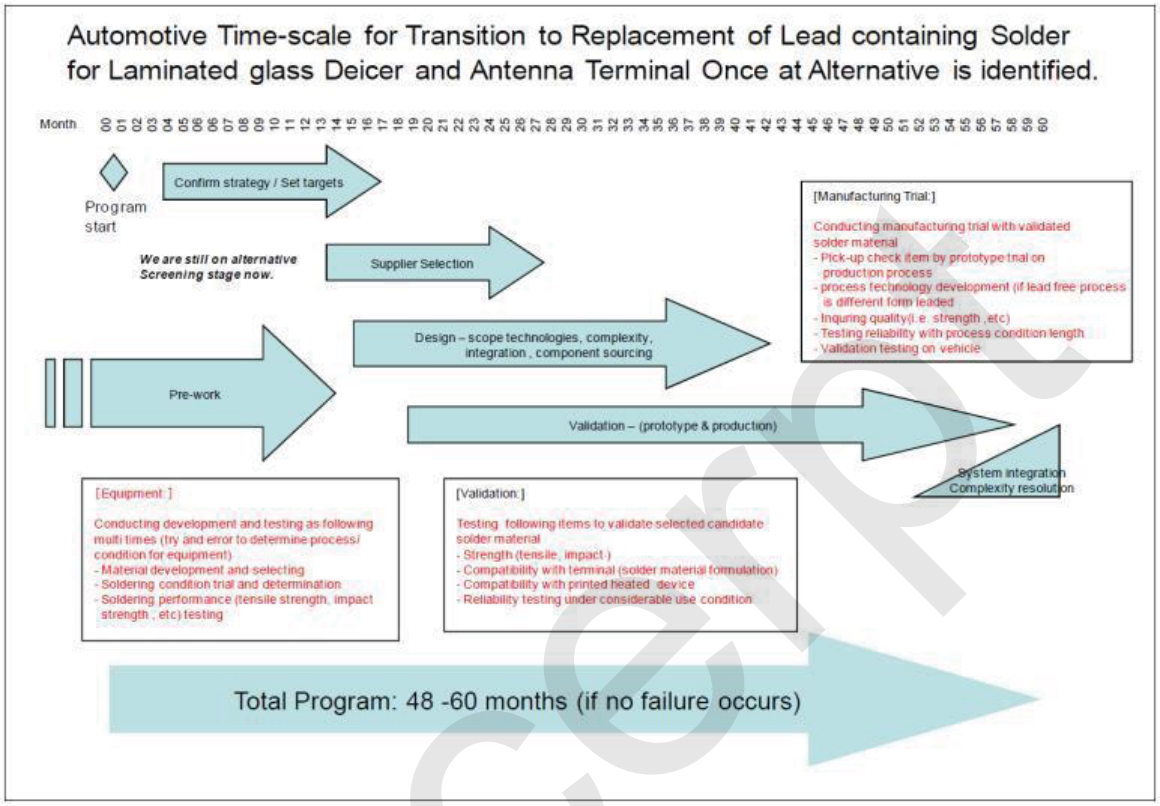
[312] Op. cit. ACEA et al. (2013a)

[313] Op. cit. ACEA et al. (2013a)

[314] For details see Oeko-Institut (2012), page 25 ff; source as referenced in ACEA et al. (2012a)

total program period of 48 to 60 months if no failures occur. It reconfirms that the overall timing in general is similar with the timeline shown in the above Figure 8-11 with the difference that the procedure of supplier selection requires more effort, resulting in an earliest implementation period of 48 months.

Figure 8-12: Timeline for Laminated Glass De-icer and Antenna Terminal



Source: JAMA, referenced in ACEA et al.[315]

ACEA et al.[316] states that today, numerous component and vehicle specific challenges still need to be tackled before a general volume production of lead-free soldered laminated glazing structures may be possible. Therefore ACEA et al.[317] suggests to continue the currently unlimited exemption and to have a review on the progress in 2017 at the earliest.

[315] ACEA et al. (2013a)

[316] ACEA et al. (2013a)

[317] ACEA et al. (2013a)

8.2.5.2 Saint-Gobain Sekurit

Sekurit[318] claims to have already developed technologies for lead-free soldering in/on laminated glass, and consequently a continuation of Exemption 8(j) is not required. Regarding soldering in laminated glass, the first serial solution has been brought to the market already in 2013, and today Sekurit[319] is developing various models with lead-free solutions. Sekurit[320] claims that all lead-free solutions are at least lab-tested. Further technical solutions have been validated already on industrial scale. Sekurit[321] will plan the industrialization as soon as the EU has decided when Exemption 8(j) will end.

8.2.5.3 Antaya Technologies

Antaya[322] takes issue with the claim of ACEA et al. asking for 5 years of development time justified by the suggestion that ACEA has spent 5 years developing the "Lead free solder for single sheet toughened glass". According to Antaya[323], its lead-free solution is in use in over 7 million instances, and it is the very same alloy and system that has been in use since 1998, in the United States. Antaya[324] blames ACEA for not having developed anything while Antaya[325] states that Antaya completed its development work in the 90's.

Antaya[326] states that between 1998 and 2014, the composition of the Indium alloy in wide use has not changed by even 0.1% of any element. The application / installation technology has not changed and the dimensions and functionality have not changed. Antaya[327] claims that the so called "development time" for lead free soldering has already consumed 16 years beyond the date it was in commercial use.

According to Antaya [328], its alloys have been fully industrialized and are in wide commercial use on all connector types for several high volume production vehicles.

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[318] Sekurit (2013b) Sekurit document "20131029s_Sekurit-Sekurit_contribution_ELV_Ex-8j_-Statement_FINAL.pdf", submitted during the online consultation, retrieved from http://elv.exemptions.oeko.info/fileadmin/user_upload/Consultation_2013_1/Exemption_8_j_/20131029s_Sekurit-Sekurit_contribution_ELV_Ex-8j_-Statement_FINAL.pdf; last accessed 10.01.2014

[319] Ibid.

[320] Op. cit. Sekurit (2014a)

[321] Op. cit. Sekurit (2013b)

[322] Op. cit. Antaya (2014a)

[323] Op. cit. Antaya (2014a)

[324] Op. cit. Antaya (2014a)

[325] Op. cit. Antaya (2014a)

[326] Op. cit. Antaya (2014a)

[327] Op. cit. Antaya (2014a)

[328] Op. cit. Antaya (2014b)

Antaya[329] claims that the time for lead free validation for new OEM programs is 90 days or less, therefore no additional time is required for production readiness to justify continuing or delaying the removal of Exemption 8(j).

8.3 Critical Review

The conflicting views of ACEA et al., Antaya and Saint-Gobain Sekurit were discussed during the stakeholder meeting on 9 May 2014 at Fraunhofer IZM in Berlin. It became obvious that the current status of lead-free soldering in the various applications needs to be assessed in more detail. Statements of ACEA et al. that no reliable solutions are available do not adequately reflect the situation. It is also necessary to clarify the scope of the two Exemptions 8(i) and 8(j).

8.3.1 The Indium LCA Study by PE International

8.3.1.1 Compliance with ISO 14040 and ISO 14044

ACEA submitted the report "Indium Production - Life Cycle Assessment of the Indium Production Process" to this exemption review process. This LCA study was commissioned by ACEA and conducted by PE International, and is referenced here as PE (2012)[330]. The following is cited from the executive summary of the study[331]:

> "*The goal of this study is to show the environmental aspects of the production of indium... In summary, the results show that indium has a substantial environmental impact associated with its production... Based on this environmental profile of indium, Supplement B puts the impact of the production of indium into perspective through comparison with some other selected metals... The critical review confirmed the compliance of the methodology and report with ISO 14040/44. The verification of individual datasets and the comparison with other materials as shown in Supplement B were outside the scope of the review*".

PE[332] further states in the report that *"The study is prepared in accordance with ISO 14040/44. It is not intended to be used for comparative assertions intended to be disclosed to the public."*

[329] Op. cit. Antaya (2013b)

[330] PE International (2012), "Indium Production - Life Cycle Assessment of the Indium Production Process", commissioned by ACEA (European Automobile Manufacturers Association), stakeholder document "ISO report indium production 2012-05-22", sent via e-mail to Otmar Deubzer, Fraunhofer IZM, on 25.04.2014, by Peter Kunze, ACEA

[331] Ibid.

[332] Ibid.

In item 5 of ISO 14044[333] a critical review is one of the aspects to be included in an LCA report, when the results of the analysis are to be communicated to any third party, i.e. an interested party other than the commissioner or the practitioner of the study. In case the study is a comparative assertion to be disclosed to the public, the aim of the critical review process is explained in item 6.1, also requiring that "*In order to decrease the likelihood of misunderstandings or negative effects on external interested parties, a panel of interested parties shall conduct critical reviews on LCA studies where the results are intended to be used to support a comparative assertion intended to be disclosed to the public*." The standard defines a 'comparative assertion' as an *"environmental claim regarding the superiority or equivalence of one product versus a competing product that performs the same function"*.

The PE LCA study was submitted by ACEA et. al, in the course of the ELV evaluation of Ex. 8(j), in which indium based solders are a potential substitute for lead based solders. The report was reviewed by an external expert. This expert[334] confirms the compliance of the study with ISO 14040 and ISO 14044. However, in this regard, the review report states[335] that "*The review was performed according to paragraph 6.2. of ISO 14040 and ISO 14044, because the study is not intended to be used for comparative assertions intended to be disclosed to the public. This review statement is only valid for this specific report received on 11.05.2012 with the exception of Supplement B, which provides information which goes beyond the cradle-to-gate study of Indium.*" The reviewer thus took into account the limitations under which the report was prepared, excluding its use for public comparative assertions. As a consequence, the review statements on the ISO compliance of the study are correct.

ACEA et al., however, submitted the report to this public exemption review process in order to support the continued use of lead in laminated glazings according to the current exemption 8(j). In the consultants' point of view, as the study is publicly available, it could be used to inform about environmental burdens and impacts of indium mining and refining, and about environmental impacts of lead versus indium solders mentioned in supplement B of the report. However, it cannot be used to draw conclusions about the environmental superiority of lead solders compared to indium solders, as this implies that it is used as a public comparative assertion about the performance of lead solders and indium solders. Such use is contrary to the reviewed intended application given the study. In cases where results of an LCA are to be used to support comparative assertions intended to be disclosed to the public, paragraph

[333] ISO (2006), The International Organization for Standardization, ISO 14044-2006: Environmental management — Life Cycle Assessment — Requirements and Guidelines, published 2006, reviewed 2010.

[334] Finkbeiner (2014) Finkbeiner, M. (TU Berlin); Critical Review of the Study "Life Cycle Assessment of Indium Production", commissioned by ACEA (European Automobile Manufacturers Association), stakeholder document "ISO report indium production 2012-05-22_Summary+CR.pdf", sent via e-mail to Otmar Deubzer, Fraunhofer IZM, on 25.04.2014, by Peter Kunze, ACEA

[335] Ibid.

6.1 of ISO 14044 requires among others: *"a panel of interested parties shall conduct critical reviews"*[336] *on the LCA study.*

Thus, in the consultants' opinion, using the views expressed in the study as comparative assertions, for concluding as to the environmental superiority of lead solders over indium solders, would be different from the studies intended and reviewed type of application. Such use would require that *"a panel of interested parties shall conduct critical reviews"* of the study. The reviewed study is thus understood not to be appropriate for such use in this public exemption review process.

Adding to this, *supplement B of the study was not subjected to the review process.*[337] Supplement B of the report compares environmental impacts of one kilogram of indium and lead, and volume equivalent amounts of indium and lead solder. Neither the conclusions of this part of the study, nor the underlying datasets for lead were subject to the review, nor is it mentioned that they had been subject to any other review process.

The consultants have thus not taken into account the PE[338] LCA study submitted by ACEA. Arguments of Teck[339] and of Indium Corporation[340] and Indium Corporation[341] related to the PE[342] LCA study were therefore not reviewed.

8.3.1.2 Remarks on Requirements for LCA Studies in Exemption Review Processes

Based on the current and past experiences with LCA studies in the adaptation processes of ELV and RoHS exemptions to the scientific and technical progress, the consultants would like to recommend that the Commission sets clear requirements for LCA studies used in these exemption adaptation processes. Beyond the compliance with the requirements of the ISO 14000 series, other aspects should be taken into account as well, especially:

- The life cycle scope of the LCA study:

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[336] ISO 14044-2006: Environmental management — Life cycle assessment — Requirements and guidelines

[338] Ibid.

[339] Teck (2014) Teck Metals Ltd. stakeholder document "Teck letter for Oeko Review of indium.pdf", sent via e-mail to Otmar Deubzer, Fraunhofer IZM, on 4 June 2014 by William Booth, Antaya

[340] Indium Corp. (2014a) Indium Corporation stakeholder document "Auby Analyst Visit 20092012 FINAL.pdf", sent via e-mail to Otmar Deubzer, Fraunhofer IZM, on 06.06.2014, by Claire Mikolajczak, Indium Corporation

[341] Indium Corp. (2014b) Indium Corporation stakeholder document "E-Mail_Indium-Corporation_LCA-Indium.pdf", sent via e-mail to Otmar Deubzer, Fraunhofer IZM, on 06.06.2014, by Claire Mikolajczak, Indium Corporation

[342] Op. cit. PE (2014)

The PE[343] report is a cradle to gate LCA. It does not cover the solder manufacturing phase, the application of the solder, and the end-of-life (EoL) phase.
In the consultants' opinion, LCA studies should cover all aspects of the life cycle unless there is clear and undisputed evidence that certain phases of the life cycle are irrelevant.

- Consideration of the whole product system:

  An LCA should comprise the full product system, unless there is clear and undisputed evidence that alternative approaches are comparable in a certain phase. It can be assumed that it would not affect the main results in this case, but the PE[344] report only comprises a comparison of lead vs. indium, while the product systems concern the soldering alloys, consisting of several other elements used for soldering on or in automotive glazings.

- Review of all relevant aspects of an LCA study:

  The PE[345] report provides the comparative assertions that are of highest relevance for this review process in supplement B "Indium in relation to other metals". In this supplement, the environmental impacts arising from the mining and refining of indium are compared with those from lead. Finkbeiner[346] states in his review report that supplement B was not part of his review task. Within supplement B itself, there is no information whether the LCA or other studies behind the environmental impacts of lead, silver and the other metals in the comparison have been subject to any kind of review.

- Inclusion of datasets into the review:

  Finkbeiner[347] states that the individual datasets were not part of his review. The consultants recommend that datasets should be included into the review as far as possible.

- Weighting of environmental impacts:

  ISO 14044 excludes the weighting of environmental impacts in LCA studies for public comparative assertions. In comparative studies of different product systems, e.g. two different soldering alloys, the consultants cannot decide which of the assessed product systems has an overall lower impact, as such a weighting of different environmental aspects is beyond their mandate. [348] The

[343] Op. cit. PE (2014)

[344] Op. cit. PE (2014)

[345] Op. cit. PE (2014)

[346] Op. cit. Finkbeiner (2014)

[347] Op. cit. Finkbeiner (2014)

[348] As example see the report of Oeko-Institut 2006, Adaptation to scientific and technical progress under directive 2002/95/EC, final report, page 13

Commission may therefore consider developing a weighting system to be applied in such public assertions.

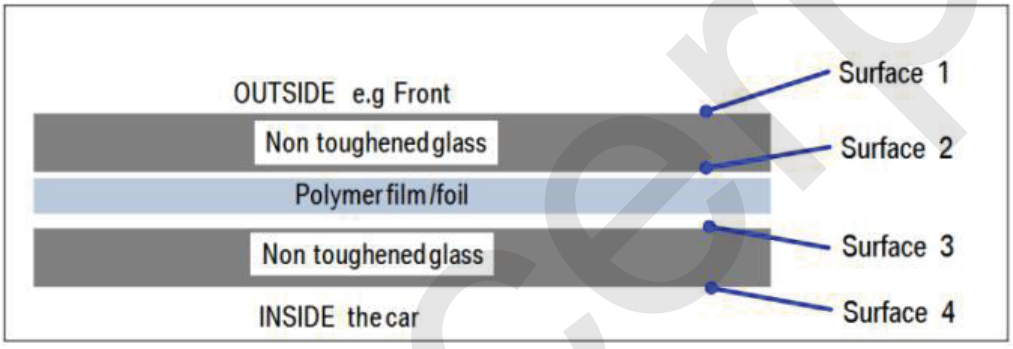
The above list of considerations is not exhaustive. It reflects aspects which have become apparent from the consultants' experience with exemption reviews in the past and at present, regarding LCA studies and environmental arguments.

8.3.2 Scope of Exemption 8(j)

8.3.2.1 Summary of the Diverging Views of ACEA et al. and Antaya

Antaya challenges the view of ACEA et al. concerning the applications, which ACEA et al. contend to be covered by Exemption 8(j). ACEA et al. interpret Exemption 8(j) to cover all applications where the lead solder is applied on non-toughened glass on surfaces 1, 2, 3 or 4, or where contacts are established in or on the polymer film or foil between the surfaces 3 and 4 of the non-toughened glass plies as indicated in Figure 8-13. From this point of view, the use of non-toughened or toughened glass is the main differentiating criterion between the scope of Exemption 8(i) and 8(j).

Figure 8-13: Structure of Laminated Glazings



Source: BMW, quoted in ACEA et al.[349]

Antaya highlights that the word "in" in Exemption 8(j), *"Lead in solders for soldering **in** laminated glazing*", demarcates the scopes of Exemptions 8(j) and 8(i), as Exemption 8(i), *"Lead in solders in electrical glazing applications **on glass** except for soldering **in** laminated glazing",* allows the use of lead "on glass", regardless of whether this glass is toughened or non-toughened glass. From Antaya's point of view, Exemption 8(j) covers only soldering in between – not on - surfaces 2 and 3 when contacting structures embedded into the foil, while soldering on surfaces 1, 2, 3 and 4 is soldering on glass and as such covered by Exemption 8(i), not Exemption 8(j).

Antaya is, however, not consistent with this argumentation. In Table 8-2 on page 76, Antaya considers a "Printed heated device circuit on the inner surfaces of the windscreen (surface 2 or surface 3)" as an application covered by Exemption 8(j).

[349] Op. cit. ACEA et al. (2013a)

Antaya in this case considers soldering **on** surfaces 2 or 3 an application within the scope of Exemption 8(j).

8.3.2.2 Background of the Exemption Wordings

Exemptions 8(i) and 8(j) were introduced in the 2009/2010 review of Annex II of the ELV Directive.[350] Prior to that review, a joint test programme had been designed and agreed between ACEA et al. on the one hand and Antaya on the other hand, to test the performance of Antaya's lead-free solder alloy. The report of Oeko-Institut[351] lists results from these tests from page 157 on. As a matter of fact, soldering on laminated glazing (non-toughened glass) was part of the test program. Table 8-3 shows one of the test results, a comparative performance of the lead and the Antaya lead-free alloy on laminated and toughened glass.

Table 8-3: Results of Pull-off Tests by Type of Glass

Glass Type	Laminated glass		Tempered glass	
Solder	Pb-free solder	Pb-solder	Pb-free solder	Pb-solder
No. of joints	84	84	297	296
Passed	71	66	287	296
Failed	13	18	10	0
% of failures	15%	21%	3%	0%

Source: Oeko-Institut[352], page 159

The laminated glazing solder joints were applied and tested on surfaces 4 of the non-toughened glasses. No solder joints had been applied and tested on surfaces 2 or 3, or between surfaces 2 and 3 to structures in or on the polymer foil.

The background of this situation is explained in the 2009/2010 review report:[353]

> "*Soldering in laminated glazings was excluded from the Joint Test Program. Antaya had not tested its solders for this application. At a meeting of the Joint Testing Group, Antaya suggested integrating soldering in laminated glass into the testing program, but would need the glass makers' support for the supply of the laminated glass. The glass makers opposed this plan stating that soldering in laminated glass would be product and technology development and that the Joint Testing Program focuses on testing solutions which Antaya had claimed to have, not those that have to be developed. Antaya admits that none of its test results submitted to the review process proves that the lead free solution works in the "in lamination" application*."

[350] For details see Oeko-Institut (2010), page 151 ff

[351] Op. Cit. Oeko-Institut (2010)

[352] Op. Cit. Oeko-Institut (2010)

[353] See Oeko-Institut (2010), page 181

The wording of Exemptions 8(i) and 8(j), a result of the 2009/2010 review, reflects the above background concerning the wordings of Exemption 8(i) and 8(j). The wordings of both exemptions were discussed with all stakeholders during the 2009/2010 review, and all stakeholders besides Antaya had agreed to this wording. The wording of both exemptions was continued, unchanged, with the agreement of all stakeholders, following the 2011/2012 review.

The technical background and the details in the 2010 review report[350] as well as the wording of Exemptions 8(i) and 8(j) show that the type of glass – toughened (tempered) or non-toughened – was not a differentiating criterion for the scope of these exemptions.

Based on the conditions and results of those prior reviews, soldering to structures on or in the polymer foil between surfaces 2 or 3 are therefore in the scope of Exemption 8(j). Soldered contacts on surface 2 and 3 are contacts applied on glass, but they may also be considered as solder joints in the laminated glazing. The wording of the exemptions in the consultants' opinion allows both interpretations. In the joint test program, which was the basis for the introduction of Exemptions 8(i) and 8(j), solder joints on surface 2 or 3 were not implemented and not tested, which gives reason to include them into the scope of Exemption 8(j).[354]

8.3.3 Comments of ACEA et al. on the Presented Lead-free Soldering Applications

ACEA et al. were asked to comment the applications and claims of Sekurit. ACEA et al.[355] put Sekurit's product references in a different perspective. The Mercedes VS20, introduced into market in 2014, the new VW Passat 470 and the Golf 370 references according to ACEA et al.[356] are on or in the PVB foil, but not soldering on non-toughened glass in laminated glazing structures. The Ford CD 391 lead-free solution according to ACEA et al.[357] is not on the EU market yet, and the solution is not yet validated by Ford Europe.

ACEA et al.[358] admits that there are some technical solutions for some laminated products within the normal portfolio for the automotive glass industry, like for the contacting inside the foil, but in general and for the majority of applications lead-free solders are still subjects of intensive research and development efforts. The pilot applications show that the automotive industry works on achieving further progress and probably not only Sekurit has the knowledge. ACEA et al.[359] claims that all suppliers are active in the development of lead-free solutions, even if they are not

[354] See Oeko-Institut 2010, page 181

[355] Op. cit. ACEA et al. (2014a)

[356] Op. cit. ACEA et al. (2014a)

[357] Op. cit. ACEA et al. (2014a)

[358] Op. cit. ACEA et al. (2014a)

[359] Op. cit. ACEA et al. (2014a)

giving presentations on their developments. ACEA et al.[360] demands that this joint approach of suppliers and OEMs should be acknowledged. For connections to wire patterns in the laminate, as mentioned before, some lead-free applications are on the market even today, even though there is an unlimited exemption for that.

ACEA et al.[361] explains, however, that the experiences on some model specific pilot applications are not sufficient to derive general decisions or to resume global sourcing possibilities for all. A ramp up step-by-step is necessary. Pilot applications are always necessary to get experience for volume production and model specific pilot application results do not guarantee that a solution is feasible in every vehicle.

ACEA et al.[362] states that there are different approaches and technologies today on the market for producing laminated glass structures and electrical contacts therein, and that different companies have developed their own specific solutions. In addition, specific patent issues may have to be considered in developments. They may hinder the application of similar approaches, but on the other hand may trigger the way to new approaches.

ACEA et al.[363] states that validations in the laboratories of the OEMs and in test vehicles will show, which solutions can fulfil the demands for future vehicle models. They claim that today, there is no statement possible, if the promising Sekurit developments can solve all technical issues and in most of the vehicle models. As illustrated in the stakeholder contribution, the implementation of a solution here is a very model specific sensitive issue and a specific evaluation for each model is necessary. It is the experience of ACEA et al.[364], in their submission, that in this field the way from first promising lab-test results to the successful implementation in series cars is long and covered with failures forcing to go back to the start.

ACEA et al.[365] says they provided their statements to address Exemption 8(j) in its entirety. As it is written, Exemption 8(j) covers all laminated glass products within the automotive industry. Validated lead-free solutions are not available for all laminated products, which is also stated in Sekurit's recent communication, e.g. Sekurit excludes soldering on side 2. ACEA et al.[366] deems Sekurit's solutions suitable for "simple" in laminate soldering cases, e.g. contacting of wires and circuits within the laminate without direct contact to the glass surfaces. They can be applied in specific

[360] Op. cit. ACEA et al. (2014a)

[361] Op. cit. ACEA et al. (2014a)

[362] Op. cit. ACEA et al. (2014a)

[363] Op. cit. ACEA et al. (2014a)

[364] Op. cit. ACEA et al. (2014a)

[365] Op. cit. ACEA et al. (2014a)

[366] Op. cit. ACEA et al. (2014a)

models. There is, however, a difference if connecting structures are for antenna function or heating functions, as ACEA et al.[367] explains:

- Printed heated device circuit on surface 2, 3 (inner surfaces of the windscreen):

  St. Gobain states that soldering to surface 2 is forbidden. But, surface 2 printed products are in large volume production. Therefore, exemptions have to be maintained (existing production). There is no further information why it is forbidden, or if there is an interference with black enamel prints.

- Printed antenna device circuit on surface 4:

  If soldering to a printed circuit on surface 2 is forbidden (for technical difficulties) then soldering to a printed circuit on surface 4 has the same technical difficulties. This is especially true since in many products the inner glass (with print on surface 3 or surface 4 for example) is thinner than the outer glass. Consequently, this increases the technical difficulty for lead-free soldering.

- Printed heated circuits on surface 4:

  The lead-free application on surface 4 (non-toughened glass) is new. When Sekurit claims lead free application on surface 4 of laminated glass, it mentions it is only lab validated. Furthermore, Sekurit excludes some designs and it is thus unclear if the Sekurit solution is applicable to all existing designs or to Sekurit product portfolio only. So today, it is impossible to cover the global production.

  Connections to printed patterns on surface 3 or 4 can be necessary for certain applications, e.g. antennas, and some applications of defrosting of camera area. For these types of connection (connection to glass directly), every glass-maker complains about difficulties, only Sekurit has announced to have lab-validated solutions. ACEA et al.[368] request publication details of the solution and validation.

ACEA et al.[369] claims that lead-free soldering of non-toughened glass (incl. structures on the glass) fulfilling the specifications of the customers is not available. From Sekurit's above lead-free applications, no evidence can be resumed for what glass combinations the proposed solution can be applied (e.g. thin glass) or what surfaces are possible e.g. soldering on surface 4 and 2. There are also car specific areas, where for design or functional reasons no contact can be made; this means that the choice to design the right position for a contact is limited. ACEA et al.[370] therefore

[367] Op. cit. ACEA et al. (2014a)

[368] Op. cit. ACEA et al. (2014a)

[369] Op. cit. ACEA et al. (2014a)

[370] Op. cit. ACEA et al. (2014a)

requests that Exemption 8(j) be maintained until the entire portfolio can be successfully converted to lead-free solder.

Additionally, ACEA et al.[371] claims that the availability of glass experts is limited and several companies have to concentrate their development activities in solving the issues for toughened glass (Exemption 8(i)), which expires end of December 2015 for new type-approved vehicles.

8.3.4 Conclusions

8.3.4.1 Antaya's Lead-free Soldering Solutions

Antaya claims applications of its lead-free 65% indium alloy on surface 4 in the Ford Thunderbird (North America) and several GM U Van models for the North American and European market. These applications and the 65% indium alloy were subject to an intensive review in the 2011/2012 review[372]. The above applications were confirmed during the review. For the other applications of its lead-free alloy, described in Section 8.2.4.2 on page 92, Antaya did not disclose the car models and vehicle manufacturers, so that these applications cannot be reviewed and commented.

In the 2011/2012 review, the consultants concluded that the 65% indium alloy from the technical point of view is not an optimum substitute mainly due to its low melting point, but that it can be used at least in specific applications. Antaya claims that its other lead-free alloy, the B6 alloy, has a higher melting point, but the application examples Antaya provided in Section 8.2.4.2 on page 92 do not contain any examples for the application of this alloy. The evaluation of all arguments raised during the 2009/2010 and the 2011/2012 review are still valid in the consultants' point of view, even though the evaluation at that time was for Exemption 8(i). The consultants therefore see no reason to re-evaluate Antaya's lead-free alloys.

8.3.4.2 Lead-free Solutions Provided by Saint-Gobain Sekurit and Others

Sekurit has lead-free solutions ready for the market or at least lab tested[373] for soldering on surfaces (2), 3 and 4, and in between surfaces 2 and 3 to structures on or in the polymer foil. The lead-free solutions are based on the development of a lead-free solder and new or adaptations of existing connector designs for lead-free soldering requirements, and more specifically for soldering on and in laminated glazings.

ACEA et al. confirm that all suppliers are active in the development of lead-free solutions, even if they do not provide presentations on their developments. For connections to wire patterns in the laminate, as mentioned before, some lead-free applications are on the market even today, despite the availability of an unlimited exemption allowing the continued use of lead in such applications.

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[371] Op. cit. ACEA et al. (2014a)

[372] For details see Oeko-Institut 2012

[373] For details see Appendix A.3.0.

The above statement of ACEA et al. is an indication that besides the solutions presented by Antaya and Sekurit, more solutions for applications covered by Exemption 8(j) are probably available on the market.

8.3.4.3 Consequences for the Continuation of Exemption 8(j)

Based on the available information, the consultants conclude that lead-free solutions for soldering applications covered by Exemption 8(j) are available in different development stages. ACEA et al. confirm that for contacts to wire patterns in the polymer foil between surfaces 2 and 3 lead-free applications are even on the market already. The unlimited continuation of Exemption 8(j) is therefore not justified.

The consultants are aware that lead-free solutions need to be adapted to the specific requirements of individual vehicles, and that this requires time and effort, and possibly further research and development work. Vehicle manufacturers, with support of their suppliers are, however, expected to adapt their designs as well, in order to avoid the use of substances restricted in legislation such as the ELV Directive. Article 4(1)(a) of the ELV Directive requires "*[…] vehicle manufacturers, in liaison with material and equipment manufacturers, to limit the use of hazardous substances in vehicles and to reduce them as far as possible from the conception of the vehicle onwards […]", among others to make sure "[…] that materials and components of vehicles put on the market after 1 July 2003 do not contain lead, mercury, cadmium or hexavalent chromium […]*" as stipulated in Article 4(2)(a).

Exemptions can therefore not be continued until 1:1 drop-in solutions are available for all the various designs on the market. The consultants are aware that vehicle designs are the result of more than one requirement, but ACEA et al. are expected to move towards new lead-free solders and connector designs as far as possible.

ACEA et al. confirm that *"all suppliers are active in the development of lead-free solutions, even if they are not giving presentations on their developments."* These suppliers and their customers, the vehicle manufacturers, are, however, part of the ACEA et al. worldwide consortium consisting of vehicle manufacturers and their suppliers. Even more, ACEA et al. confirm that for connections to wire patterns in the laminate, as mentioned before, some lead-free applications are on the market even today. The question arises why ACEA et al. then did not inform the consultants in detail about the status of these lead-free solutions but instead ask for the continuation of Exemption 8(j) in its current broad scope and without an expiry date.

Applicants requesting the continuation of exemptions are obliged to prove that the exemption is still required and justifiable in accordance with Art. 4(2)(b)(ii). The only detailed information received was from suppliers outside the ACEA et al. consortium. Neither the vehicle manufacturers nor their suppliers in the consortium contributed detailed information about their lead-free programs, despite requesting the continuation of Exemption 8(j) without scope limitation and without an expiry date.

Based on this situation, the consultants conclude that there is no evidence proving that the unlimited continuation of Exemption 8(j) as requested by ACEA et al. is justified by Art. 4(2)(b)(ii). The Antaya and Sekurit lead-free soldering programs show that lead-free solutions can be achieved already, and ACEA et al. confirmed that other suppliers are working on lead-free solutions as well, and that lead-free solutions are even on the market already.

It is thus recommended to introduce an expiry date for Exemption 8(j) at the end of 2019 for new type-approved vehicles. ACEA et al.[374] request 36 to 60 months-time, once solutions are available. Antaya's claim that generally only 90 days would be required for the transition to lead-free soldering was refuted in the past reviews of Exemption 8(i). The more than 60 months until the expiry of the exemption leaves sufficient time to adapt and implement lead-free solutions to the individual vehicle manufacturers' needs. In case no solutions can be found for specific applications, or more time is required in specific cases, there would still be sufficient time until the end of 2019 to apply for a specific exemption in due time, prior to the recommended expiry of Exemption 8(j).

ACEA et al. claim that the availability of glass experts is limited and that they are busy with the implementation of lead-free soldering on applications on toughened glass related to Exemption 8(i), which expires at the end of 2015. ACEA et al. did not provide further information substantiating this claim of limited capacities to a degree that would justify the unlimited continuation of Exemption 8(j) in line with Art. 4(2)(b)(ii).

8.4 Recommendation

Based on the information submitted, the use of lead in applications covered by Exemption 8(j) is no longer unavoidable, and the unlimited continuation of Exemption 8(j) is no longer justified in line with Art. 4(2)(b)(ii). Lead-free solutions are on the market already, or are in a status that allows their implementation, even though they may have to be adapted for the individual vehicles and technologies on the one hand, or they may require vehicle design and technology adaptations on the other hand. A transition period until the end of 2019 is therefore justified in the consultants' opinion. In case specific applications require the continued use of lead after 2019, the transition period until the end of 2019 is long enough to apply for specific exemptions in due time. ACEA et al. would, however, have to prove that the use of lead is still unavoidable in these cases in spite of efforts to adapt the design to the requirements of lead-free soldering, and that the continuation of the exemption is hence justified beyond 2019 for such specific applications.

The consultants recommend the following wording and expiry date for the exemption:

Materials and components	Scope and expiry date of the exemption
Lead in solders for soldering in laminated glazing	*Vehicles type approved before 1 January 2020 and spare parts for these vehicles*

[374] Op. cit. ACEA et al. (2013a)

8.5 References Exemption 8(j)

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