Assistance to the Commission on Technological Socio-Economic and Cost-Benefit Assessment Related to Exemptions from the Substance Restrictions in Electrical and Electronic Equipment (RoHS Directive)

Pack 2 – Final Report

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

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Disclaimer

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8.0 Exemption Request 14: "Lead in Solder for Ignition Modules"

The "Andreas STIHL AG & Co KG" (STIHL) applied for an exemption of:

> *"Lead in solders for the ignition module and other electronic engine controls mounted directly on or close to the cylinder of hand-held engines (classes SH: 1, SH: 2, SH: 3 of 2002/88/EC)."*

STIHL[138] requests an expiry date in mid 2025.

8.1 Description of Requested Exemption

Sections 8.1 and 8.2 are heavily based on information provided by the applicant and other stakeholders and do not necessarily reflect the view of the consultants.

8.1.1 Technical Background

STIHL[139] explains that regulation 2002/88/EC regulates emissions and type-approval procedures for non-road mobile machinery. The classification in the classes SH: 1, SH: 2, SH: 3 in this regulation is based on the displacement of the engine as illustrated in Table 8-1.

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[138] STIHL (2012a), Andreas STIHL AG & Co KG original exemption request no. 14, document "RoHS_Ex_request_14_lead_solder_ignition_modules_2012_09_18.pdf", retrieved from http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_VII/Request_14/RoHS_Ex_request_14_lead_solder_ignition_modules_2012_09_18.pdf, last accessed 8 February 2013

Table 8-1: *Classification of small engines according to Directive 2002/88/EC*

Main class S: small engines with a net power ≤ 19 kW

The main class S shall be divided into two categories:

H: engines for hand-held machinery

N: engines for non-hand-held machinery

Class/category	Displacement (cubic cm)
Hand-held engines Class SH:1	< 20
Class SH:2	≥ 20 < 50
Class SH:3	≥ 50
Non-hand-held engines Class SN:1	< 66
Class SN:2	≥ 66 < 100
Class SN:3	≥ 100 < 225
Class SN:4	≥ 225

Source: Directive 2002/88/EC[140] *referenced in (STIHL 2012b)*

According to STIHL[141], classes SH:1, SH:2 and SH:3 are all hand-held products with spark-ignition engines. As typical product examples for the classes, STIHL[142] indicates:

- SH 1
  - Very small hedge trimmers
- SH 2
  - Small chain saws
  - Hedge trimmers
  - Lawn trimmers
  - Blowers

[140] Directive 2002/88/EC, retrieved from *http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2003:035:0028:0081:en:PDF*; last accessed 8 February 2013

[141] STIHL (2012b), Andreas STIHL AG & Co KG document "20121029_RoHS_Request_No_3_Clarification Answers_GEHealth.pdf" submitted for the online stakeholder consultation, retrieved from http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_VII/Request_14/20121029_RoHS_Request_No_3_Clarification__Answers_GEHealth.pdf; last accessed 8 February 2013

[142] Op. cit. STIHL (2012b)

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- SH 3
  - Large chain saws
  - Brush cutters
  - Cut-quicks
  - Backpack blowers

STIHL[143] indicates the average life spans of hand-held combustion-powered garden, forest and construction equipment with 5 - 9 years in professional and up to 20 years in private use The typical use and life time of such equipment used in rental business and in professional use is around 300 h over 5 - 9 years.

The ignition modules for small spark ignition engines have a compact design and are located in direct proximity to the engine and must operate reliably under harsh conditions, as detailed in section 8.2.1 - Technical Constraints.[144, 145]

According to STIHL,[146] to withstand these harsh conditions, materials and design have had to be optimized and thoroughly tested. For additional mechanical stability and protection against water, fuel and oil, the electronic circuits are sealed with epoxy resin.

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[143] STIHL (2013a), Andreas STIHL AG & Co KG, document "2nd-Questionnaire-Exe-req 14_Answers_2013_02_25.docx" submitted via e-mail by Mrs. Christina Wedel per Email, on 25 February 2013

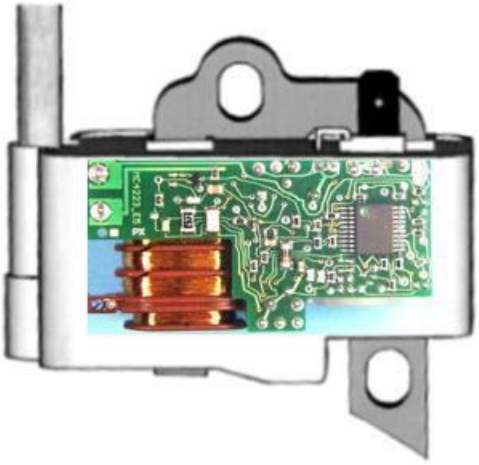
[144] Op. cit. STIHL (2012a)

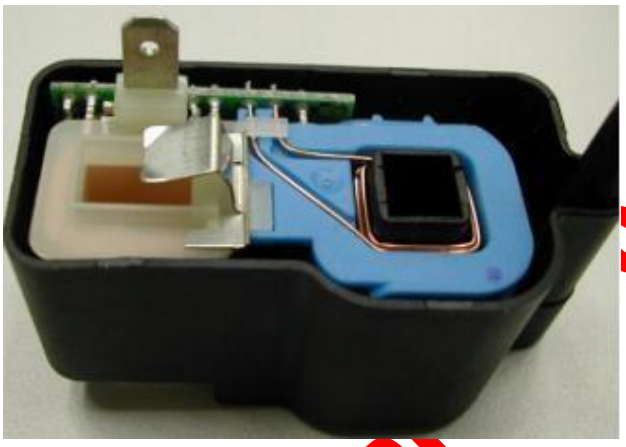
[145] Op. cit. STIHL (2012b)

[146] Op. cit. STIHL (2012a)

*Sections 8.1 through 8.2 are heavily based on information provided by the applicant and other stakeholders. Alterations have been made mainly to ensure comprehension and to avoid repetition.

Figure 8-1: PCB and coil of the ignition module (left), and an ignition module before sealing





Source: STIHL (2012c), Andreas STIHL AG & Co KG, document "RoHS_II_exemption_request_ignition_modules_for_publication_2012_10_30.pdf" submitted for the online stakeholder consultation, retrieved from http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_VII/Request_14/RoHS_II_exemption_request_ignition_modules_for_publication_2012_10_30.pdf; last accessed 8 February 2013

Figure 8-2 illustrates the position of the ignition module in a chain saw.

Figure 8-2: Position of the ignition module in a chain saw

Source: STIHL (2013a)

STIHL[147] presents images of typical failure modes observed in ignition modules as a result of the harsh environmental conditions.

[147] STIHL (2012c), Andreas STIHL AG & Co KG, document "RoHS_II_exemption_request_ignition_modules_for_publication_2012_10_30.pdf" submitted for the online stakeholder consultation, retrieved from

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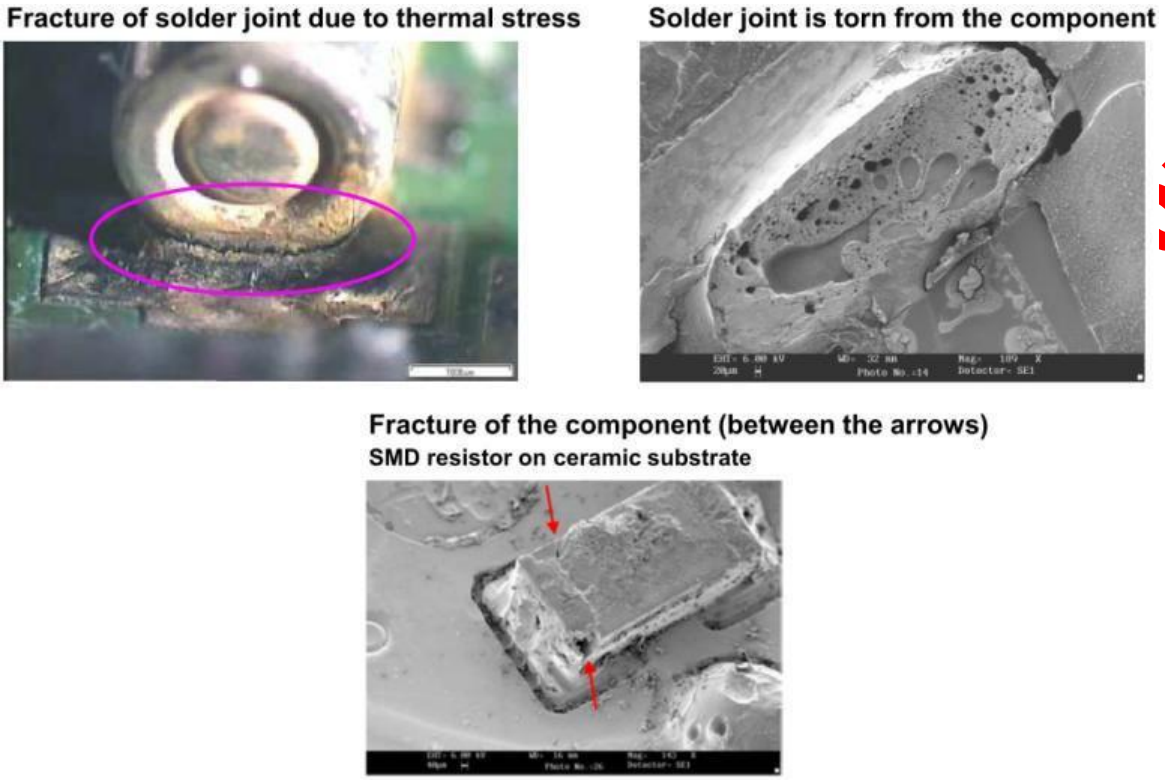
Figure 8-3: Typical failures observed in ignition modules



Source: (STIHL 2012c)

Over the last years, STIHL[148] considerably invested in R&D efforts to include new electronic functions for the reduction of exhaust emissions in the ignition module and minimize the failure rate at the same time. STIHL has now reached a failure rate that allows the ignition module to have the same life-time as the product. These effects currently can only be achieved using lead solder in the ignition modules.

STIHL[149] categorizes all of the products as category 11 (other EEE, not covered by categories 1-10,[150], or alternatively as newly included in category 6 (electrical and

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http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_VII/Request_14/RoHS_II_exemption_request_ignition_modules_for_publication_2012_10_30.pdf; last accessed 8 February 2013

[148] Op. cit. STIHL (2012a)

[149] Op. cit. STIHL (2012c)

[150] According to Annex I of Directive 2011/65/EU (RoHS 2) RoHS Directive (2011) Directive 2011/65/EU of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (recast), http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32011L0065:EN:

*Sections 8.1 through 8.2 are heavily based on information provided by the applicant and other stakeholders. Alterations have been made mainly to ensure comprehension and to avoid repetition.

electronic tools[151]) through the changed scope of the RoHS Directive. STIHL[152] states that in any case the products would have to fulfil the substance restrictions from July 2019 on.

8.1.2 Amount of Lead Used under the Requested Exemption

STIHL[153] does not have data for the worldwide sales of hand-held garden equipment, but claims that the amount of lead put on the market outside of the EU is not likely to be affected by the requested exemption. According to (STIHL 2012 a), an ignition module contains around 0.75 g of lead.

Based on BIOIS,[154] STIHL[155] estimates the amount of lead put on the EU market as follows:

- Annual sales in EU 15 in 2005 for non-professional hand-held domestic combustion-engine powered garden equipment (without lawn mowers and riding mowers):
  2,101,230 units

  Correction for market share and EU 27 (with the same factor used in (BIOIS 2012 a)):
  2,101,230 units * 1.53 = 3,209,000 units
- Estimated total of lead in ignition modules:
  3,209,000 units * 0.75 g/unit = 2.4 t

The total annual amount of lead put on the European market due to this exemption would thus be around 2.4 t.

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[151] According to Annex I of Directive 2011/65/EU (RoHS 2) RoHS Directive (2011) Directive 2011/65/EU of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (recast), http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32011L0065:EN:

[152] Op. cit. STIHL (2012c)

[153] Op. cit. STIHL (2013a)

[154] BIO (2012), Bio Intelligence Service, Document submitted via e-mail by Mrs. Christina Wedel, STIHL, to Otmar Deubzer on 25 February 2013; section from the report "Measures to be implemented and additional impact assessment with regard to scope changes, pursuant to the new RoHS Directive" prepared by BIO Intelligence Service for the European Commission, DG ENV, published on 6 July 2012, retrieved from

[155] Op. cit. STIHL (2013a)

8.2 Applicant's Justification of the Exemption

8.2.1 Substitution of Lead

8.2.1.1 Technical Constraints

According to STIHL,[156] solutions for lead-free soldering exist on the market, but today not all electronic components used in the ignition module are available in a version that is suitable for lead-free soldering. In addition to that, extensive field testing and optimization cycles are needed before the alternative can be used in the market.

STIHL[157] explains that the ignition module for small spark ignition engines has to withstand high vibrations (> 80 g) and must operate reliably in the temperature range of cold weather conditions up to the operating temperature of the engine (-30 °C to +110 °C). The solder joints have to be suited for a high number of temperature cycles between ambient temperature and operating temperature. Research on the ignition module allowed reducing exhaust emissions and failure rates using lead-solders. The ignition module now has the same life-time as the product.

STIHL[158] has no reliable data on the use of lead-free solder in ignition modules for small engines. As the products have an average life-time of over 10 years on the market, this poses a high risk for a decrease of durability. Lead-free solders differ from the solder used today in process temperature (20 °C higher), porosity and adhesion on the component. The overall effect poses a high risk for a decrease of durability.

STIHL[159] needs a comprehensive study and field testing to minimize this risk. STIHL[160] puts forward that some components appropriate for lead-free soldering are only available in sizes different from those used nowadays in the lead-soldered ignition modules. Therefore, the switch to lead-free soldered ignition modules requires a complete redesign of the printed circuit board, which requires additional time. Only if lead-free modules prove to have a comparable life-time as today's lead-containing modules, is a change for all modules feasible. Failing modules would have to be replaced more often during the life time of the product. Therefore, more waste is produced, which is difficult to recycle because of the necessary sealing with epoxy resin.

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[156] Op. cit. STIHL (2012a)

[157] Op. cit. STIHL (2012a)

[158] Op. cit. STIHL (2012a)

[159] Op. cit. STIHL (2012a)

[160] Op. cit. STIHL (2013a)

*Sections 8.1 through 8.2 are heavily based on information provided by the applicant and other stakeholders. Alterations have been made mainly to ensure comprehension and to avoid repetition.

8.2.1.2 Supply Chain Constraints

STIHL[161,162,163] argues that its suppliers of ignition modules have little experience and no equipment for lead-free solders. Most other customers of these suppliers do not demand lead-free soldered parts. Considerable investment in production facilities is hence needed since a lot of equipment would have to be doubled, so that the suppliers can offer production lines for lead containing and for lead-free soldered products. A switch between lead-containing and lead-free solder on the same machine is economically not feasible.

STIHL[164] explains that, even though there are many other assembly service providers that have a lot of experience with lead-free soldering, a change of suppliers would create a lot of new problems. STIHL's suppliers are experts for ignition systems, and they are not only the manufacturers of the ignition modules, but also development partners for new technologies. Besides ignition modules for forest and garden equipment, they manufacture ignition modules and control electronics for products like snow mobiles, outboard engines for boats and auxiliary heating systems for cars, for which there is no legislation demanding lead-free solder for these products today.

8.2.2 Elimination of Lead

The applicant did not submit any information with its exemption request on possibilities to eliminate lead in this application.

8.2.3 Environmental and Socioeconomic Arguments

STIHL[165] says that lead-free ignition modules must prove to have a comparable life-time as today's lead-containing modules, as failing modules would have to be replaced more often during the life time of the product. Therefore, more waste is produced, which is difficult to recycle because of the necessary sealing with epoxy resin.

As mentioned in section 8.2.1 - Supply Chain Constraints, STIHL[166] argues that considerable investment shall be needed in production facilities, before suppliers of the ignition modules can provide lead free alternatives.

STIHL[167] assumes that most of the other manufacturers are not yet able or willing to invest time and money into the research of lead-free soldering for ignition modules, since they still see a chance of being taken out of scope in the 2014 review of the

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[161] Op. cit. STIHL (2012c)

[162] Op. cit. STIHL (2012a)

[163] Op. cit. STIHL (2013a)

[164] Op. cit. STIHL (2013a)

[165] Op. cit. STIHL (2012a)

[166] Op. cit. STIHL (2012c)

[167] Op. cit. STIHL (2013a)

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scope of the RoHS Directive.[168] STIHL[169] puts forward that the smaller manufacturers most likely do not have the manpower to start working on the question right now. The clarification of the situation in the company and supply chain alone is a significant administrative burden. Manufacturers will probably start their research and application for exemptions after the review of the RoHS Directive.

8.2.4 Roadmap to Substitution or Elimination of Lead

8.2.4.1 Timing of the Exemption Request

STIHL[170] says that the equipment in the scope of the requested exemption would only come under the RoHS Directive in 2019. STIHL[171] explains that the RoHS Directive applies to "making available on the market" from July 2019 on. That means the complete supply chain would have to be changed to lead-free products. Since this definition includes also products in the rental business, these products would have to be replaced well before 2019, in order to serve their normal life time in rental business. This means that the products would have to comply with RoHS at least three years before July 2019.

8.2.4.2 Schedule to RoHS Compliance

In order for STIHL[172] to research proper alternatives that fulfil the customer expectations for product durability and prevent the unnecessary waste produced through premature product failure, at least one exemption period until 2025 is needed. For the investments needed in R&D and production, STIHL[173] needs the legal certainty of this exemption. Without the exemption, STIHL would need an immediate emergency plan to keep being able to deliver its products after July 2019. With the exemption STIHL[174] claims to be most likely able to manage a proper changeover until 2025.

Table 8-2 details STIHL's steps towards RoHS compliance.

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[168] Art. 24 of the RoHS Directive 2011/65/EU stipulates that "No later than 22 July 2014 [...] the Commission shall examine the need to amend the scope of the Directive [...] with respect to any additional exclusions [...]" from the scope of the RoHS Directive.

[169] STIHL 2013b STIHL (2013b), Andreas STIHL AG & Co KG, document "3rd-Questionnaire-Exe-req 14_2013_03_08.docx" submitted via e-mail by Mrs. Christina Wedel per Email, on 8 March 2013

[170] STIHL 2012b STIHL (2012b), Andreas STIHL AG & Co KG document "20121029_RoHS_Request_No_3_Clarification Answers_GEHealth.pdf" submitted for the online stakeholder consultation, retrieved from http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_VII/Request_14/20121029_RoHS_Request_No_3_Clarification__Answers_GEHealth.pdf; last accessed 8 February 2013

[171] Op. cit. STIHL (2012c)

[172] Op. cit. STIHL (2012c)

[173] Op. cit. STIHL (2012c)

[174] Op. cit. STIHL (2012c)

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Table 8-2: Steps and timelines towards RoHS compliance

Task	Activity	Required Time
Step 1: Redesign	Selection of alternative components for lead-free solder and redesign	2 – 3 months
Step 2: Qualification and optimization based on lab tests	Production of samples, lab tests (temperature shock testing, up to 4 months), and optimization of design based on test results	1.5 years
Step 3: Supplier invests in new equipment	If tests from step 2 were successful: supplier invests in additional production equipment (planning, invest, construction and startup)	1 - 2 years
Step 4: Change to lead-free solder for one product	A worst-case product is identified and changed to lead-free solder	2 months
Step 5: Field testing	The performance of the lead-free products is observed in the field. Customer claims are evaluated and analyzed, if the failure is related to the new solder.	2 years
Step 6: Investment and changeover phase to lead-free	• Supplier invests in new equipment for a change to lead-free solder for all STIHL ignition systems • Change all 85 types (ca. 15 families) of ignition systems for STIHL products to lead-free soldering	2 years
Total time		~ 7 to 8 years

Source: STIHL (2013c)

STIHL[175] explains that if it starts right away and if there are no major technical complications, STIHL could change the whole product range to lead-free solders in 8 years. To account for reaction time and time for design changes, if failures occur in the field tests, an exemption until 2025 is needed. Until then the change to lead-free solder can be completed, if no major technical barriers are encountered. If the tests prove that major technical barriers exist, STIHL[176] predicts that an extension of the exemption will be necessary.

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[175] Op. cit. STIHL (2013a)

[176] Op. cit. STIHL (2013a)

8.3 Critical Review

8.3.1 REACH Compliance - Relation to the REACH Regulation

This exemption request concerns lead in solders used in handheld equipment with combustion engines.

Entries 10, 11, and 12 of Annex XIV (for further details see Section 5.0 above) concern lead chromate, lead sulfochromate yellow and lead chromate molybdate sulphate red, respectively. These compounds can only be further used once a request for Authorization has been applied for and granted, concerning the application in which it should be allowed for use. As from the consultants' knowledge, these compounds are not in use as solder alloys, these entries have no further implications for this request.

Entries 16 and 17 in Annex XVII concern lead compounds applied in specific articles which are irrelevant in the context of this request for exemption (for further details see Section 5.0 above).

Entry 30 in Annex XVII of the REACH Regulation, stipulates that lead and its compounds shall not be placed on the market, or used, as substances, constituents of other substances, or in mixtures for supply to the general public. A prerequisite to granting the requested exemption would therefore be to establish whether the intended use of lead in this exemption request might weaken the environmental and health protection afforded by the REACH Regulation.

In the consultants' understanding, the restriction for substances under entry 30 of Annex XVII does not apply to the use of lead in this application. The application of lead in the ignition modules of handheld equipment placed on the market, in the consultants' point of view is not a supply of lead and its compounds as a substance, mixture or constituent of other mixtures to the general public. Lead is part of an article and as such, entry 30 of Annex XVII would not apply.

No other entries, relevant for the use of lead in the requested exemption, were identified in Annex XIV and Annex XVII (status June 2013).

Various processes that may result in future restrictions of the use of lead are detailed in Section 5.0 above. In all these cases, it cannot yet be assumed if the processes shall result in a new restriction or in the addition of lead in certain compounds to the list of substances requiring an authorization. Therefore, at present these processes could not be assumed to have implications for this request for exemption in terms of ensuring the protection afforded by REACH.

As the intended restriction for lead and its compounds in consumer articles currently is not yet enacted, based on the current status of Annexes XIV and XVII of the REACH Regulation, the requested exemption would not weaken the environmental and health protection afforded by the REACH Regulation. An exemption could therefore be granted if other criteria of Art. 5(1)(a) apply.

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8.3.2 Situation of RoHS Compliance in the Sector

No contributions were made from stakeholders during the online stakeholder consultations and therefore it has not been possible to identify whether this request for exemption is supported by other stakeholders. The applicant was therefore asked if the requested exemption was needed solely for STIHL products or if it is relevant for other manufacturers of hand-held machinery addressed in this request for exemption. STIHL[177] says that using lead-containing solder for ignition modules is the state of the art technology in this industry. STIHL claims Husqvarna, a competitor of STIHL, to face the same difficulties. Husqvarna[178] confirmed this information and supports STIHL's exemption request. According to STIHL,[179] STIHL and Husqvarna together have a market share of over 60% for chain saws in Europe.

Furthermore, according to STIHL[180], the products in the scope of this exemption request have at least 20 manufacturers, including the following main manufacturers: STIHL, Husqvarna, Honda, Makita/Dolmar, Solo, Shindaiwa, Eco/Kioritz, Ryobi, Komatsu/Zenoah, Hilti and Wacker Neuson.

STIHL was asked why only STIHL and Husqvarna support this exemption request. STIHL[181] assumes that most of the other manufacturers are not yet able or willing to invest time and money into the research of lead-free soldering for ignition modules, since they still see a chance of being taken out of scope in the 2014 review of the scope of the RoHS Directive.[182] According to STIHL,[183] these hopes are based on the ongoing discussion about which products are and will actually remain in the scope of the RoHS Directive. Article 2(4)(g) of the RoHS Directives excludes "non-road mobile machinery made available exclusively for professional use" from the scope of the RoHS Directive. Since STIHL[184] finds it difficult to draw a clear line between professional and non-professional products, STIHL[185] believes that manufacturers probably hope for a new wording in the review, which will exclude their own products from the scope.

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[177] Op. cit. STIHL (2013a)

[178] Husqvarna (2013a), Husqvarna Group, document „Husqvarna 2013 a.pdf" submitted by Dan Ericsson per Email on 20 February 2013

[179] Op. cit. STIHL (2013a)

[180] Op. cit. STIHL (2013b)

[181] Op. cit. STIHL (2013a)

[182] Art. 24 of the Directive 2011/65/EU (RoHS Directive) stipulates that "No later than 22 July 2014 [...] the Commission shall examine the need to amend the scope of the Directive [...] with respect to any additional exclusions [...]" from the scope of the RoHS Directive.

[183] Op. cit. STIHL (2013b)

[184] Op. cit. STIHL (2013b)

[185] Op. cit. STIHL (2013b)

Additionally, STIHL[186] puts forward that the smaller manufactures most likely do not have the manpower to start working on RoHS compliance. The clarification of the situation in the company and supply chain alone is a significant administrative burden. Manufacturers will probably start their research and application for exemptions after the review of the RoHS Directive.

STIHL was asked why it follows a different approach and applies for this exemption. STIHL[187] stated that it is possible for most parts in the STIHL product range – except the ignition module – to comply with the RoHS substance bans without significant trade-off to the technical performance. Therefore, an exemption for the remaining technical barrier (the lead-containing solder in the ignition module) seems to be a more realistic option than to hope for an exclusion from the scope and start too late with the testing of alternatives.

8.3.3 Technical Practicability of Lead Substitution and Elimination

Technically, it is plausible that ignition modules are exposed to harsh conditions, which require the ignition modules to be carefully designed in order to achieve sufficient reliability. STIHL claims that its ignition modules' lifetime in has been extended in recent years to match the lifetimes of the combustion engine handheld products they are built in.

Lead-free soldered ignition modules are expected to achieve a comparable lifetime and reliability as the lead-soldered ones, in order to be considered sufficiently reliable, as otherwise the combustion engine products' lifetime either becomes shorter or they must be repaired, exchanging the ignition modules for new ones which may lead to greater waste.

STIHL does not claim that the substitution of lead in ignition modules is in principle scientifically and technically impracticable, but it claims that it would require seven to eight years to achieve a sufficiently reliable lead-free soldering solution for the ignition modules. As until 2011, combustion engines with ignition modules were not in the scope of the RoHS Directive, lead-free soldered ignition modules have not been state of the art, and like any other part of an EEE, it is plausible that a changeover to lead-free soldering requires research and technical development.

STIHL was also asked whether alternative interconnection technologies like conductive adhesives or others may facilitate eliminating the use of lead in ignition modules. STIHL[188] answered that no alternative interconnection technology could be identified besides soldering, which is able to withstand the vibrations (> 80 g) and temperature changes (-30 °C ... + 110 °C) in the ignition modules over the life time of the products.

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[186] Op. cit. STIHL (2013b)

[187] Op. cit. STIHL (2013b)

[188] STIHL (2013c), Andreas STIHL AG & Co KG, document "4th-Questionnaire_Exe-req-14_2013_03_14.docx", submitted by Mrs. Christina Wedel per e-mail, on 18 March 2013

Article 5(1)(a) justifies an exemption if "the reliability of substitutes is not ensured". Given the evidence presented in this case, an exemption granting time to ensure a reliable RoHS-compliant solution would therefore be justified under this criterion, but the duration of the exemption needs to be assessed.

8.3.4 Clarification of the Exemption Scope

8.3.4.1 Inclusion of "*Other Electronic Engine Controls*" into the Scope

The scope of STIHL's wording proposal includes, besides the ignition modules, other electronic engine controls as well, mounted directly on or close to the cylinder of engines:

"Lead in solders for the ignition module and other electronic engine controls mounted directly on or close to the cylinder of hand-held engines"

In its justification, STIHL argues, however, only concerning ignition modules. It is therefore necessary to clarify what "other electronic engine controls" would be and why they should be included in the exemption as well.

According to STIHL[189], the ignition module also contains the engine management system controlling the fuel quantity for engines with the "STIHL M-Tronic" system. The M-Tronic technology uses an additional electronically controlled valve to regulate the fuel flow into the carburetor. STIHL[190] says that a conventional carburetor has to be adjusted manually by the user, the M-Tronic system and the low pressure injection both control automatically the air/fuel mixture ratio for the combustion. The advantage is that the machine always runs with the optimum air/fuel ratio. The machine is never in a too rich setting and therefore it uses less fuel and causes less exhaust emissions than a conventional carburetor. The M-Tronic system is not a standard technology, but nevertheless some other competitors use this or similar technologies as well, but under different names, e.g. AutoTune for Husqvarna.

Besides the M-Tronic engine management system and ignition module, STIHL[191] has a new product with a low pressure fuel injection system that uses additional components. STIHL[192] says that the low pressure injection is a STIHL technology, which optimizes the starting behavior and engine performance. STIHL[193] explains that a P/T sensor and an injection valve with a small circuit board are placed in the crankcase (see Figure 8-8 on page 88). This system has no carburettor because the fuel is injected into the crankcase. STIHL[194] explains that the P/T sensor measures

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[189] STIHL (2013e), Andreas STIHL AG & Co KG, document "6th-Questionnaire_Exe-req-14_2013_04_15.docx", submitted via e-mail by Mrs. Christina Wedel per Email, on 25 April 2013

[190] STIHL (2013f), Andreas STIHL AG & Co KG, document "7th-Questionnaire_Exe-req-14_2013-05-08.docx", submitted via e-mail by Mrs. Christina Wedel per Email, on 8 May 2013

[191] Op. cit. STIHL (2013e)

[192] Op. cit. STIHL (2013f)

[193] Op. cit. STIHL (2013e)

[194] Op. cit. STIHL (2013f)

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pressure and temperature of the air in the crankcase. Here the fuel is injected and the mixture is then transferred into the combustion chamber. According to STIHL[195], the sensor is needed to determine the air efficiency at the engine operating point. As both the sensor and the injection valve need to operate in the crankcase, no other position more distant from the crankcase is possible.

Figure 8-4: Injection valve (left) and P/T sensor (STIHL 2013e)

With the term "*other electronic engine controls" in the proposed* exemption wording, STIHL[196] wants to make sure the exemption comprises the components for the M-Tronic system as well as the above injection valve and P/T sensor for the low pressure fuel injection system.

8.3.4.2 Proximity of Systems to the Cylinder

STIHL justifies the exemption request with the harsh environmental conditions – in particular temperature and vibrations - the ignition modules and other electronic engine controls are exposed to. The root cause for these harsh conditions is the components' proximity to the cylinder.

STIHL's proposed exemption wording only allows the use of lead in ignition modules and other electronic engine controls if they are *"mounted directly on or close to the cylinder"* of hand-held engines. This wording raises three questions:

1. Why must the ignition modules and other electronic engine control systems be mounted directly on or close to the cylinder?
2. If the mounting of these components on or close to the cylinder is indispensable, why can vibrations and high temperatures not be mitigated with damping elements and insulators?
3. How exactly should "*close to*" the cylinder be interpreted in terms of distance from the cylinder?

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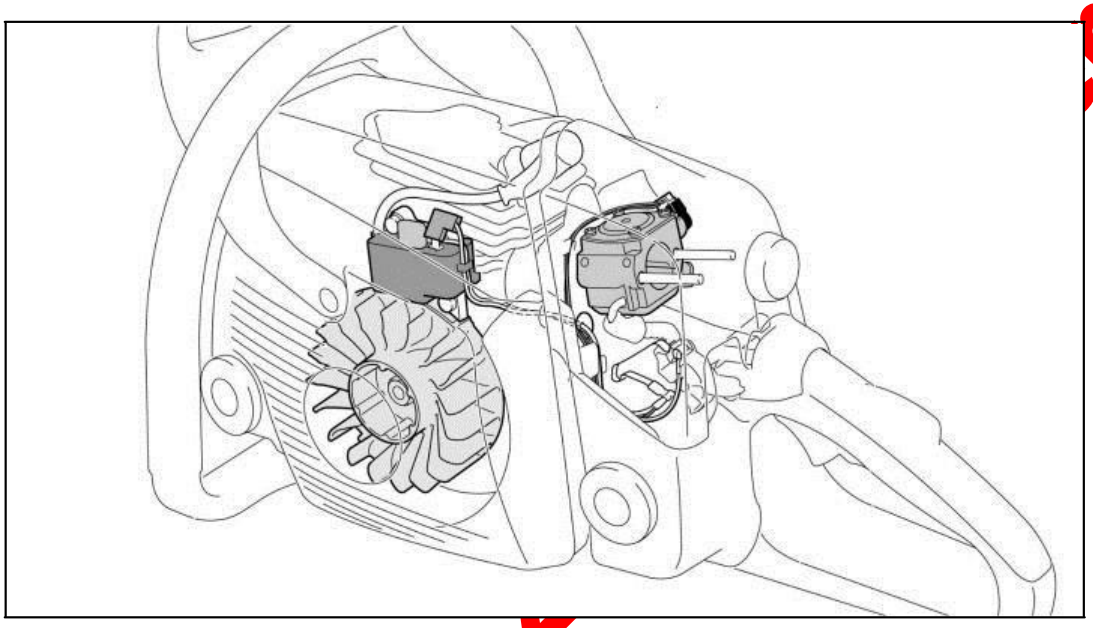
[195] Op. cit. STIHL (2013e)

[196] Op. cit. STIHL (2013e)

STIHL provided the drawing in Figure 8-5 showing the position of the ignition module in a chain saw in order to make the subsequent explanations more comprehensible.

Figure 8-5: Position of the Ignition Module (dark grey left) and the Carburettor (grey right) in a Chain Saw



Source: (STIHL 2013e,f)

STIHL[197] explained that the electric current for the engine management system and the spark ignition is generated by induction from permanent magnets integrated in the flywheel as shown in Figure 8-6.

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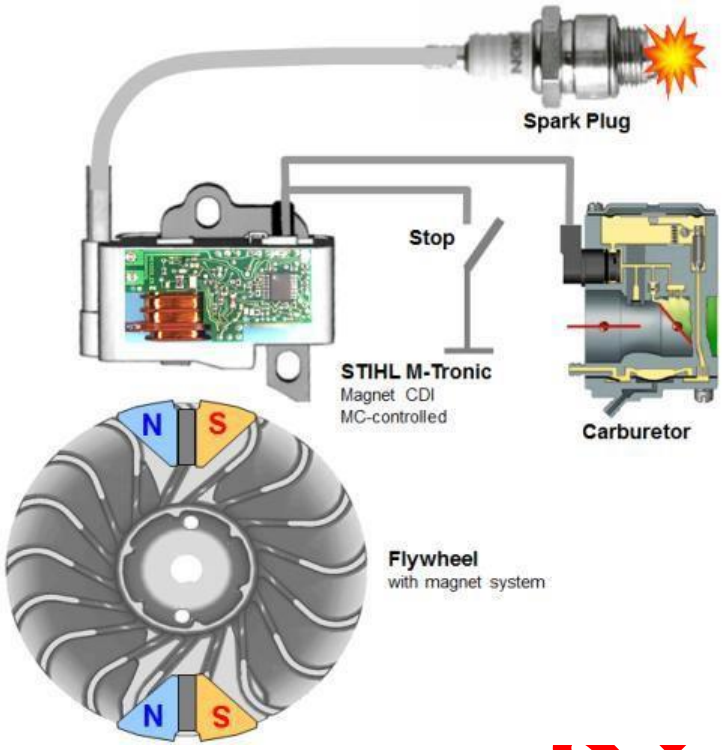
[197] Op. cit. STIHL (2013e)

Figure 8-6: Schematic drawing of the magnetic powered STIHL M-Tronic engine management system



Source: (STIHL 2013e)

STIHL[198] puts forward that the size of the air gap between the permanent magnet and the ignition module is 0.15 to 0.45 mm depending on the model. Figure 8-7 illustrates the overall situation.

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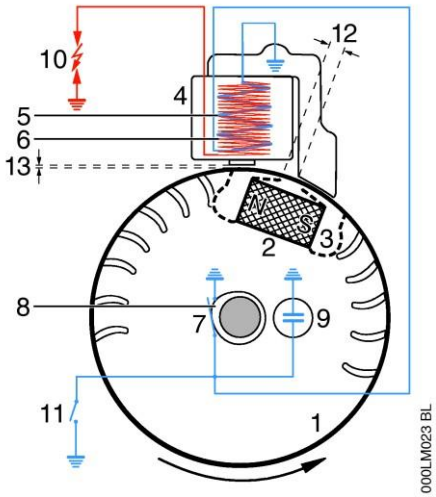
[198] Op. cit. STIHL (2013e)

Figure 8-7: Schematic drawing of an ignition system

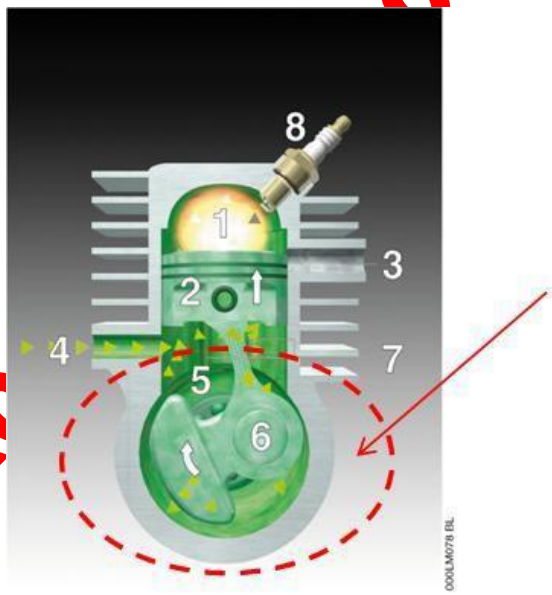


1 = Flywheel
2 = Permanent magnet
3 = Pole shoe
4 = Ignition coil
5 = Primary winding
6 = Secondary winding
7 = Breaker point
8 = Cam
9 = Condenser
10 = Spark plug
11 = Ignition switch
12 = Magneto edge gap
13 = Air gap

Source: (STIHL 2013e)

STIHL[199] says that this gap width is critical for the correct function of the ignition system. The ignition module therefore needs a stable, low distance fixation at the diameter of the flywheel. This is only achievable if mounted on the cylinder and the crankcase. The crankcase is part of the core engine block. It is the lower part of the engine block which houses the crankshaft as displayed in Figure 8-8.

Figure 8-8: Crankcase and cylinder



1: Combustion chamber
2: Piston
3: Exhaust port
4: Inlet port
5: Crankcase
6: Crankshaft
7: Transfer ports
8: Spark plug

Source: (STIHL 2013e)

[199] Op. cit. STIHL (2013e)

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As STIHL[200] plausibly explained, the ignition module needs the proximity to the flywheel to function properly. According to STIHL (2013f), this technology is the standard technology in this industry.

STIHL[201] states that the other electronic engine control systems need the proximity to the cylinder or the crankcase as well, because the electricity for their control and operation comes from the ignition unit, and/or these control systems can only provide their functions at the cylinder or the crankcase. On account of this, the electronic modules have to be connected directly to the engine block (crankcase and/or cylinder) to ensure a defined size of the air gap. According to STIHL,[202] vibration damping hence is not possible since it would enable relative movements of the module. Insulation rings are, however, used to reduce the temperature of the electronic module by about 15 °C, but the screws have to be fixed directly to the engine block.

8.3.4.3 Rewording of the Proposed Exemption

STIHL could show that the exemption is required for ignition modules and for other electronic engine control systems. In the proposed exemption wording, STIHL proposed to restrict the exemption to engine control systems *"mounted directly on or close to the cylinder"* of hand-held engines. The term "close to the cylinder" is too vague and hence needs to be clearly defined.

In consultation with the applicant, the following wording was elaborated and finally agreed upon with STIHL.[203]

> *Lead in solders and termination finishes of electrical and electronic components and finishes of printed circuit boards used in ignition modules and other electrical and electronic engine control systems, which for technical reasons must be mounted directly on or in the crankcase or cylinder of hand-held combustion engines (classes SH: 1, SH: 2, SH: 3 of 2002/88/EC)*

The reference to the direct mounting on the cylinder or crankcase clearly defines the location of the exempted engine control systems. The addition "which must be mounted" excludes that alternatives to the direct mounting on the cylinder or crankcase, the root cause of the harsh conditions hampering the shift to lead-free soldering. Though technical reasons are not specified for the enforcement of market surveillance, mentioning this term in the wording requires manufacturers to detail such reasons in technical specifications and data sheets of relevant products. In case

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[200] Op. cit. STIHL (2013e)

[201] Op. cit. STIHL (2013e)

[202] Op. cit. STIHL (2013e)

[203] STIHL (2013g), Andreas STIHL AG & Co KG, document", submitted via e-mail by Mrs. Christina Wedel per Email, on 15 May 2013

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of a control by competent authorities, this data is to prove that an alternative installation with less harsh environmental conditions is technically not viable.

8.3.5 Applicant's Roadmap to RoHS Compliance

8.3.5.1 Total Time Required to Achieve RoHS Compliance

STIHL claims seven to eight years' time to achieve the RoHS compliance of the ignition modules and presented the roadmap as detailed in Table 8-2 above. The applicant was asked how long it took STIHL to approximate the lead-soldered ignition module's life time to the product life time. STIHL[204] puts forward the example of a certain ignition module, for which it took five years and three improvement packages to lower the failure rate from 22% down to 0.1%.

The applicant was asked whether some of the supplier-related steps could not be shortened, or be conducted parallel to other steps in the roadmap. Even though suppliers of ignition modules are development partners as well, the pure assembly of the designed ignition module could be contracted to an assembly service provider which is experienced in working with lead-free solders and has a separate assembly line available for lead-free soldering. The roadmap indicates that it takes suppliers up to two years to invest and startup new equipment just for the production of a worst case product. It can be concluded from this that the investment as well as the time and related cost for this step must be considerable, and then the equipment would not be used for many months until the equipment can be used again in step 6 of the roadmap. In the consultant's understanding, such a procedure is economically questionable and supports the contracting of the lead-free assembly to an assembly service provider, at least in this early phase. Step 3 could thus be reduced to a few weeks.

STIHL[205] replied that this is not possible. The ignition modules have a compact and specialized design and integrate special coils onto the circuit board. Only for step 2, the production of samples for laboratory testing, it would be possible to use lead-free PCBs manufactured elsewhere (e.g. assembly service providers), which are then completed with prototype technologies. After that, STIHL would need to qualify the series processes and therefore needs to invest in the lead-free production equipment for the existing suppliers.

The consultants also proposed that step 6 can at least partially be done in parallel to step 5. Even though final results from step 5 might not yet be available, at least the planning of the new production line or facility can be prepared already. As the supplier has spent up to two years already in step 3, respective production equipment should at least in parts already be available. The consultants hence asked STIHL whether step 6 could not be reduced to around 6 months. STIHL (2013d) admitted that the planning could be done in parallel with step 5, but that it would have no large effect

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[204] STIHL (2013d), Andreas STIHL AG & Co KG, document "5th-Questionnaire_Exe-req-14_2013_03_21.docx", submitted via e-mail by Mrs. Christina Wedel to per Email, on 25 March 2013

[205] Op. cit. STIHL (2013d)

on the total time line. The long time needed in step 6 is due to the change-over phase for all products. To minimize the risk of premature failure of a wide range of products, STIHL claims to need this time to minimize this risk.

STIHL[206] therefore is confident to manage the change-over to lead-free soldering in the estimated time frame of 8 years. STIHL[207] says that it may be possible to reduce this time, but STIHL would need time to work out a detailed action plan together with its suppliers, that is shorter, but still limits the technical risk to an acceptable level.

The consultants assume that some time may be saved through the parallelization of some of the required activities. However, in any case, the maximum duration of an exemption from the RoHS Directive for categories 1-7, 10 and 11 is 5 years. As it can be followed that parallelization of activities would not shorten the time frame to a degree relevant for establishing the duration of a possible exemption, this aspect is not further discussed.

8.3.6 Starting Date of the Exemption Validity Period and Setting of the Expiry Date for the Exemption

STIHL requests the exemption until 2025. According to the Commission, the validity periods of exemptions related to equipment addressed by RoHS Art. 2(2) start running on 2 January 2013 at the earliest, or at the latest with their publication in the Official Journal of the European Union. The maximum validity period for exemptions used by EEE, other than categories 8 and 9 of RoHS Annex I, is five years. Even though it can be followed that up to eight years may be needed to guarantee RoHS compliance, the exemption can only be granted for a maximum of five years.

8.4 Recommendation Exemption Request 14

Based on the information submitted, the consultants recommend granting the requested exemption. Ignition modules and other electrical and electronic combustion engine control systems which have to be mounted close to the cylinder or crankcase are exposed to harsh environmental conditions. Possible alternatives need additional time to overcome reliability issues and to be worked in to design before RoHS compliant products can be made available on the market. It can thus be followed that achieving RoHS compliance of the products in the scope of this exemption request, with a degree of reliability comparable to the current status, justifies granting an exemption for five years in line with Art. 5(1)(a).

The consultants and the applicant agreed upon the following wording for the exemption to be added to Annex III of the RoHS Directive:

Lead in solders and termination finishes of electrical and electronic components and finishes of printed circuit boards used in ignition modules and other electrical

[206] Op. cit. STIHL (2013d)

[207] Op. cit. STIHL (2013d)

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and electronic engine control systems, which for technical reasons must be mounted directly on or in the crankcase or cylinder of hand-held combustion engines (classes SH: 1, SH: 2, SH: 3 of 2002/88/EC)

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