SOCIO-ECONOMIC ANALYSIS

Of the impacts of non-renewal of Lead (Pb) exemption for test & measurement industrial type products (Category 9) Exemption 7(a) – Annex III

SUBSTANCE: Lead (Pb)

CAS: 7439-92-1

FROM: Test & Measurement Coalition (TMC)

INTENDED USE: in high melting temperature type solders (i.e., lead-based alloys containing 85 % by weight or more lead).

DATE: 20 January 2023

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Exemption 7(a) – Annex III

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CONTENTS

ABBREVIATIONS

B2B: Business-to-Business
CAR: Competent Authority Report
CAGR: Compound Annual Growth Rate
COTS: Commercial Off-The-Shelf
EEE: Electrical and Electronic Equipment
EBIT: Earnings Before Interest and Taxes
ECHA: European Chemicals Agency
EU: European Union
EUR: Euro (currency)
HMP: High Melting Point
NPV: Net Present Value
PCA: Printed Circuit Assembly
PCB: Printed Circuit Board
Pb: Lead
R&D: Research and Development
RoHS: Restriction of Hazardous Substances in Electrical and Electronic Equipment
SEA: Socio-Economic Analysis
SEAC: Committee for Socio-Economic Analysis
SME: Small and Medium Enterprise
T&M: Test & Measurement
TMC: Test & Measurement Coalition
WEEE: Waste from Electrical and Electronic Equipment

1. SUMMARY OF SOCIO-ECONOMIC ANALYSIS

Purpose and methodology

RoHS stands for Restriction of Hazardous Substances and impacts the entire electronics industry and many electrical products. The principal RoHS, also known as Directive 2002/95/EC,[1] originated in the European Union in 2002 and restricted the use of six harmful chemical substances in electric and electronic equipment (EEE), allowed in the EU market. Test & measurement instruments (current Category 9 - industrial) were initially excluded from the scope of RoHS 1. Moreover, **in 2011, the RoHS 1 was revoked and replaced with Directive 2011/65/EU,[2] which is known as RoHS-Recast or RoHS 2. It expanded the scope of products covered in RoHS 1 and imposed new obligations on EEE importers and manufacturers by adding Categories 8 (medical devices) and 9 (monitoring and control instruments).** RoHS 2 included a long transitional period for Category 9 industrial products, extending to mid-2017. On 4 June 2015, the European Commission Delegated Directive (EU) 2015/863[3] amended Annex II of EU RoHS 2 by adding four additional phthalates onto the original list of six restricted substances. Category 9 – Industrial equipment again required an extended transition period before these additional substance restrictions applied in July 2021.

Industrial test and measurement instruments are very different from low mix, high-volume consumer products which are frequently re-designed to follow consumer trends and are placed on the market for a limited duration. Industrial test & measurement (T&M) are high mix, low volume producers, managing portfolios of thousands of highly complex instruments. Each instrument is intentionally designed for high reliability and serviceability to support long useful lifespans and are made available on the market for at least a decade. In comparison with other categories of equipment in scope of RoHS 2, **Category 9 – Industrial equipment contributes a fraction of one percent of the total annual quantities of RoHS substances.**

[1] Directive 2002/95/EC of the European Parliament and of the Council of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32002L0095.

[2] 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) Text with EEA relevance. Available at: https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX:32011L0065.

[3] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32015L0863&from=EN.

In line with the **existing official guidance from ECHA on the preparation of the Socio-Economic Analysis,**[4] **this SEA aims to gather technical and economic information to describe ex-ante in both qualitative and (if feasible) quantitative terms the (orders of magnitude of) socio-economic impacts T&M Coalition members as well as the relevant EEA supply chain and society are expected to face from the non-renewal of the lead (Pb) in high melting temperature type solders (i.e., lead-based alloys containing 85 % by weight or more lead), which would otherwise expire on 21 July 2024.**

The SEA has been performed by EPPA[5] at the request of Test & Measurement Coalition (TMC), in view of providing regulators with strong evidence-based findings on the expected social and economic impacts that are expected to occur should the use of lead (Pb) be impacted by the non-renewal of the RoHS exemption.

This SEA is based on information and data gathered from the industrial and professional test and measurement equipment manufacturers. **A survey has been conducted**, by providing a detailed questionnaire to gather information and data from actors likely to be affected by a non-renewal of the RoHS exemption in the EU.

TMC manufacturers of industrial and professional test and measurement equipment have participated in the survey. The market share covered by this survey represents approximately 70% of the EEA market. The assessment is, therefore, highly representative and can serve as a basis for defining the anticipated socio-economic impacts resulting from the non-renewal of the RoHS exemption.

The participating companies indicated that the exemption 7(a), Annex III information reported in this SEA are relevant for the professional, scientific, laboratory, analytical, clinical, and industrial applications in numerous products groups. A full list of relevant product groupings and equipment types is provided in the Annex I of this SEA.

TMC members have been carefully instructed to base their statements and estimations as much closer to real data or perception of future changes as possible, so as to have conservative estimates, always putting the protection of the human health and environment upfront.

This SEA covers the safety use of test and measurement equipment, the technical difficulties associated with their substitution via alternatives, the social and economic impacts at different level of the supply chain, and the EU macroeconomic impacts.

Main findings

[4] The ECHA Guideline for the SEA preparation as a part of Application for Authorization is available at: https://echa.europa.eu/documents/10162/23036412/sea_authorisation_en.pdf/aadf96ec-fbfa-4bc7-9740-a3f6ceb68e6e ; The ECHA layout for an SEA to be used in Application for Authorization is available at: https://echa.europa.eu/documents/10162/13637/sea_format_with_instructions_v4_en.docx/0cbc5102-6ba2-2170-480a-0061d2798f55

[5] www.eppa.com

It is shown that there are currently no suitable lead-free alternatives that meet RoHS exemption criteria on the EU market for test & measurement industrial type products and that **re-designing of the test & measurement equipment could take four to six years per product line**. Hence, losing the ability to apply Annex III, exemption 7(a) when considering RoHS conformity for the associated test and measurement industrial products would entail the development of a fairly large number of new alternative compliant materials as well as the increased costs connected to the redesign, retesting, requalification, and replacement of the assembly process.

Overall, the **total impact of a non-renewal is monetized in the range of 2.9 billion EUR and 4.1 billion EUR** (conservative estimates in net losses; potential gains for suppliers of other components have been already taken into account), consisting of:

- **[CONF.]** EUR of economic impacts (EBIT loss) on test and measurement industrial type products' manufacturers;
- **[CONF.]** EUR of substitution costs for test and measurement industrial type products' manufacturers;
- **[CONF.]** EUR of social impacts (i.e., unemployment in the EU-27);

2. AIMS AND SCOPE OF THE SEA

2.1 Purpose, scope and methodology of SEA

RoHS stands for Restriction of Hazardous Substances, and impacts the entire electronics industry and many electrical products. The exemptions listed in Annexes III and IV must adapt to scientific and technical progress as defined in article 5 of Directive 2011/65/EU.[6] This application is specifically for the **renewal of Annex IIII exemption 7(a), Lead in high melting temperature type solders (i.e., lead-based alloys containing 85 % by weight or more lead)**, which would otherwise expire on 21 July 2024.

This ex-ante Socio-Economic Analysis (SEA) aims to identify and to assess in both qualitative and quantitative terms the socio-economic impacts that are expected to occur should this exemption not be renewed (i.e., the likely impacts in the non-exemption scenario as compared to the baseline business-as-usual scenario).

A survey has been conducted, by providing a detailed questionnaire to gather information and data from industrial and professional test and measurement equipment manufacturers likely to be affected by a non-renewal of the RoHS exemption in the EU.

[6] 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) Text with EEA relevance. Available at: https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX:32011L0065.

The participating companies have provided socio-economic data in view of extrapolating (based on a large total market share) the impacts for the whole market in a conservative approach, as further detailed below. Based on the weight of RoHS substances used in their products, the market share covered by this survey represents approximately 70% of the EEA market. **The estimates reported in this socio-economic analysis should be considered as a minimum (lower bound) of the expected impacts of a non-renewal of Annex III, exemption 7(a).**

From a geographical perspective, this analysis focuses on the European Economic Area (EEA) territory, comprising the European Union (EU-27), Iceland, Liechtenstein, and Norway. One has followed "SEAC's approach to assessing changes in producer surplus".[7] As there is no alternative available in general (SAGA)[8] to lead (Pb), one has considered a **4-year time horizon for this assessment**, starting from the year 2024, (year of the expiry of the current exemption). In other terms, the SEA accounts for the costs and benefits to the EEA society in the event of RoHS substance is not granted the renewal of the RoHS exemption in test and measurement industrial type products.

Future monetary values (when data were available) have been estimated by using the concept of net present value (NPV), adopting a 4% annual discount rate, which is the standard discount rate, adopted by the European Commission and European agencies (e.g., ECHA) in impacts assessments. All monetized values have been adjusted to a base year, assumed to be 2024. Information and data have been aggregated and anonymized. Statements and estimations from the participating companies are as close to real data or perception of future changes as possible.

2.2 Overview of industrial test and measurement instruments and their value chain

General overview

Industrial test and measurement instruments (category 9 – Industrial under the RoHS Directive) are very different from low mix, high-volume consumer products which are frequently re-designed to follow consumer trends and are placed on the market for a limited duration. Industrial test and measurement are high mix, low volume producers, managing portfolios of thousands of highly complex instruments. Each instrument is intentionally designed for high reliability and serviceability to support long useful lifespans and are made available on the market for at least a decade. These instruments are designed: exclusively for professional and industrial use; to meet high performance requirements in critical applications; and last up to 40 years. Redesign is not frequent and happens every seven years on average (as compared to every 1.5 years or less for consumer products). Once test and measurement instruments are placed onto the market, they are typically accompanied with a long-term customer support arrangement to maintain reliability and calibration.

Product portfolios are widely diversified, with T&M Coalition members each having typically 2,000 to 3,000 products currently made available on the market. These are highly complex, sophisticated

[7] https://echa.europa.eu/documents/10162/0/afa_seac_surplus-loss_seac-52_en.pdf/5e24c796-d6fa-d8cc-882c-df887c6cf6be?t=1633422139138

[8] https://echa.europa.eu/documents/10162/13637/ec_note_suitable_alternative_in_general.pdf/5d0f551b-92b5-3157-8fdf-f2507cf071c1

electronic instruments such as signal generators, power analysers, oscilloscopes, spectrum analysers, digital multi-meters, electron microscopes, chemical and biological analysers, complex chromatography systems and their detectors, each having many necessary options and accessories. Each instrument can have a minimum of 2,000 and up to 40,000 parts; requiring a vast supply chain involving tens of thousands of suppliers and hundreds of thousands of unique components.

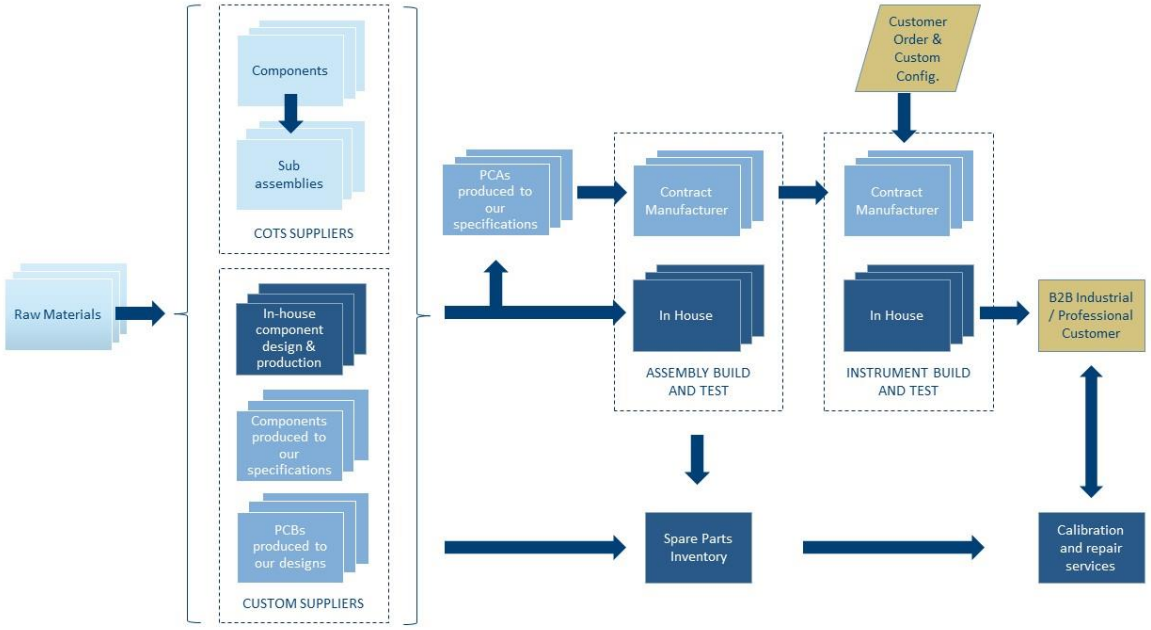
Considering the EU added-value, test and measurement equipment is manufactured and sold in relatively small volumes (per instrument design) and placed on the global market. There is an added value in community level action, which guarantees more coherent and consistent rules across Europe. But with the expansion of RoHS-like requirements beyond the EU, this creates a risk of discrepancies in RoHS-like national laws adopted in third countries.

The professional test and measurement products provide the tools for engineers to develop new solutions and businesses to bring them to market. These instruments are used in Research, Quality Control and Testing laboratories (including field testing) in Universities, Manufacturing, and clinical facilities and by Governmental Agencies for conformance verification and environmental testing. They are essential to the good functioning of electronic communications networks, heavy industrial processes such as steel manufacturing, the testing of vehicles for compliance with emissions standards, and the monitoring of complex and critical systems. The nature of the tests and measurements made by industrial equipment necessitates that the equipment performing those tests are itself is highly complex; with upwards of 40,000 components necessary to produce a single instrument. Even a relatively simple hand-held instrument incorporates significantly more components that a typical consumer product.

Historically, between 25 - 35% of the components used in test & measurement products are custom designed. The features of the T&M Coalition's equipment necessitate the development and production of unique components that are not commercially made available on the open market and are typically made by sole, boutique suppliers. These components have their own development lifecycle and take years to bring into production. When these suppliers are unable to deliver compliant parts that meet current RoHS regulations, the product would be stopped from being sold into the EU.

Typical supply chain

The typical supply chain for test and measurement industrial type products is as follows:



- Raw materials are globally sourced for component production.
- Components, sub-assemblies, and printed circuit boards (PCBs) are manufactured and sourced globally. These are either produced as commercial off-the-shelf (COTS) products or custom made according to in-house Test & Measurement producers' designs and specifications.
- Printed circuit assemblies (PCAs) are produced and tested to Test & Measurement producers' designs and specifications.
- Assemblies are built and tested, either in-house or by contract manufacturers.
- In response to customer orders or for inventory, finished equipment is configured, built, and tested for global distribution.
- Equipment is supplied into the EU market either directly or through distributors to industrial and professional customers (B2B market).
- Spare parts are made available from the supply chain and utilised in the ongoing support (including servicing, calibration, repair, and refurbishment services) typically provided in-house by Test & Measurement producers.

3. ANALYSIS OF ALTERNATIVES

3.1 Function and technical performance of Lead (Pb) and Pb-based industrial type 9 products

Lead is a significant ingredient of the solder alloys used to electrically or physically join two elements. High Melting Point (HMP) solders are used for a wide variety of applications. Based on the application type, a lead amount of >85% in HMP solder is required to achieve the necessary melting temperature and to obtain other material properties. Examples of critical components currently available on the market that utilise this exemption and for which there are no alternative lead-free components that satisfy the required performance characteristics, include:

- Industrial voltage regulators used in source-measure units and semiconductor characterisation systems.
- High performance network synchronizer clocks for industrial applications, used in oscilloscopes.
- High frequency resistors used in signal sources.

The use of lead in high melting temperature type solders provide superior properties and reliability compared to lead-free alternatives. Some of these properties and reasons for these required characteristics include:

- **high melting point** (>260°C) that is higher than standard eutectic solders. This prevents melting during secondary installations and the deterioration of the functionality of electrical parts;
- **thermal conductivity** ensures the reliability of electronic components due to heat dissipation;
- **ductility** is essential to join materials that have different coefficients of thermal expansion together in order to guarantee mechanical reliability;
- **electrical conductivity** is essential for electrical functionality;
- **electrical resistivity**;
- **corrosion resistivity** ensures reliability;
- **resistance to thermal oxidation**;
- **appropriate oxidation nature** prevents oxidation at the secondary mounting and guarantees reliability;
- **wettability**;
- **manufacturability**;
- **reliability in a harsh environment**.

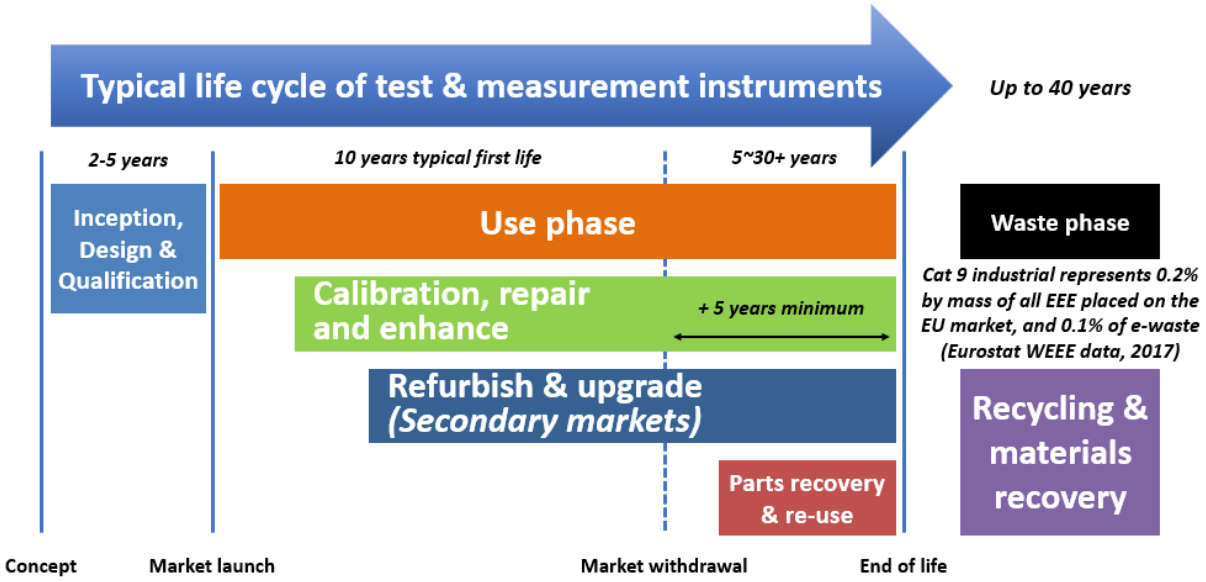
Lead, as stated in the application of the RoHS Umbrella Industry from January 2020, is the only known element which satisfies all these properties.[9] It is the **combination of physical and chemical properties of the leaded alloys that is important**. It is therefore not possible to pick a single property as a criterion of distinction under RoHS.

[9] Previous applications for RoHS exemptions or their renewals can be downloaded from the European Commission webpage available at: https://environment.ec.europa.eu/topics/waste-and-recycling/rohs-directive/implementation-rohs-directive_en.

Lead in HMP solders is also necessary to prevent solders within a component from melting during subsequent soldering operations. Solders that melt within the components can lead to open and unreliable joints and the shifting of features. Such failures at the component level will impact overall product reliability and the technical performance of products. This can, in turn, lead to intermittent failures that result in invalid measurement results from the finalised equipment. Lead in high melting temperature type solders allows for a higher standoff, improving processability and reliability, robust from higher Pb-free PCBA reflow temperatures.

3.2 Typical Industrial Test and Measurement End-to-End Life Cycle

The market sectors addressed by industrial test and measurement equipment can in some cases require that the instruments can be maintained in use for decades. The end-to-end lifecycle model below helps to illustrate how the members contribute to the circular economy by assuring the materials they consume to produce the equipment are kept in use for as long as possible.



The nature of industrial test and measurement instrument applications demand highly accurate and reproducible results throughout their life. With a typical first use of 10 years and a total life of up to 40 years, great care is taken during the design and qualification phases to ensure that the stringent performance and reliability requirements are met and must incorporate design for serviceability. This provides a continuous supply chain of equipment for refurbishment with extended life through resale providing great economic and environmental benefit. Whilst the instruments are designed for long-term reliability, failures do occur during such an extended period of use requiring ability to service and replace parts. After market withdrawal, equipment is normally supported for a minimum of five years. Moreover, refurbishing and reselling on the secondary market are crucial in this sector and often account for 4–5% of producer turnover for test and measurement manufacturers.

Due to the cost, reliability, and unique applications of T&M equipment, many customers do not dispose of the equipment, but instead keep it for use at a later date or place it on the secondary market. Therefore, Category 9 Industrial equipment's contribution to the Waste Electrical and Electronic Equipment stream is very small (0.2% by weight of EU WEEE) with industrial WEEE being collected through B2B systems. Consequently, the environmental impact of industrial test and measurement products is negligible. Nevertheless, test and measurement equipment does enter the waste stream, typically many decades after it is placed on the EU market.

3.3 Assessment of potential alternatives to lead (Pb)

To the best knowledge of the Test & Measurement Coalition, there is no single substitute available that would be suitable for all the applications identified and match the technical performance of lead. Currently, substitutes for even the major uses have rarely been found. Evaluating alternatives for each of the niche uses would take an enormous amount of time and resources, with little probability of success.

HMP solders, as noted above, are used for a wide variety of applications. There are potential substitutes for several applications; however, when the chemical and physical properties of substitutes are compared with HMP solder bonds, it becomes clear why these **substitutes are not broadly suitable**.

Alternatives must melt **above the temperature for Pb-free solder reflow**. Potential alternatives, and the main reason why these are not suitable for substitution, are listed here:

- **Standard lead-free solders** have a lower melting point than HMP lead solders but are also used for reflow soldering of PCBs. These would melt during reflow and therefore cause bond failure when used for sealing components and for making bonds inside components or in modules.
- **Welding and brazing** are alternative bonding methods but require much higher temperatures. Brazing alloys typically melt at >400°C and welds are formed at >1,000°C. The silicon chip and the polymers used in electronic components will be destroyed at these temperatures.
- **Crimp connections** are often used in electrical equipment but suffer from a multitude of disadvantages. They cannot be used for sealing and their size precludes them from use inside small electronic components. Their main limitation is unreliability; repeated temperature cycles and vibrations cause very small movements between crimp and terminal that expose the underlying base metals that re-oxidise after their natural air-formed oxide is disrupted. The increase in the oxide amount can increase contact resistance to a value where the equipment no longer functions. The increased resistance in power circuits, for example, will cause heating that can ultimately lead to fires.

The following alternatives are also deemed unsuitable for substitution and replacement: [10]

[10] Next generation transition liquid phase sintering pastes for Z-Axis interconnection in sub-400-micron pitch high density interconnect. Available at: https://ieeexplore.ieee.org/document/6510400

- **Mixed alloy pastes** that combine when melted to a new high temperature alloy. These are new to the market. Manufacturability and reliability of the resultant high temperature alloys has not been fully tested. These pastes could, in due time, achieve 70% efficacy.
- **Gold-tin braze** requires a particularly high melting temperature that can damage the components. This alternative has a limited 10% efficacy.
- **Sintered silver** is currently being tested but has not yet proven to be manufacturable and reliable. This alternative has a limited efficacy at 30%.

These alternatives are, for the reasons listed above, not suitable for substitution or replacement. They do not fulfil the same functions and do not have the same unique combinations of advantageous characteristics as lead.

3.3.1 Challenges with substitution with alternatives

As outlined in the previous section, the companies have indicated that there are currently no suitable alternatives that meet the performance expectations of their customers.

Members of the Test & Measurement Coalition have pointed out that they principally rely on their component suppliers to find alternatives to the use of restricted substances since most of the components utilizing exemption 7(a) incorporated into T&M equipment are COTS parts (and so forth, potentially many levels down). Implementation of change necessitated by regulatory pressures typically starts with raw material manufacturers and the end-product manufacturers (e.g., Test and Measurement suppliers) who have the largest economic stake. Intermediate manufacturers are geographically and jurisdictionally diverse and are often SMEs. As such, this part of the supply chain is slower and more inconsistently able to adapt. Assuring full adaption in the supply chain and validating the alternatives in the final product application can and often does require up to 4 years. The general process involves communicating with the supply chain, evaluating samples, conducting design impact studies, reconfiguring the instrument and its software where necessary and testing in manufacture and validating the final assembly.

The companies reported that the validation period alone would take a minimum of 6 months and up to a year after the delivery of suitable alternatives per product. It is significant to note that this validation period would only apply if the component were a fit, form, and function drop-in replacement. If any design changes to the exemption-free part of the product would be required to accommodate for the alternative, a validation period would be required for each redesigned product that used to utilize the component that relied on the exemption. Moreover, the validation would lead to the organizations incurring additional expenses. These include labour costs and costs arising from potential product resubmission requirements for testing to various notified bodies to ensure that substitution does not create any electrical and functional safety concerns.

If a new lead-free part is available, this part must be qualified for use by performing a variety of tasks, as described above. Due to the complexity and diversity of the applications, this must be done individually by each company for each product group. This process would divert resources from other projects and increase the cost to ensure continued availability of these products. This validation and testing process varies according to part complexity and impact to the final product design; which can be categorised as low, medium, and high:

- **Low complexity** parts are the off-the-shelf components or hardware parts that do not have a substantial performance impact. Replacement can be done based on supplier information, assuming a form/fit/function compliance, with standard manufacturing, testing, and validation processes. Based on process timescales reported by a T&M coalition company, the average time that it can take for these parts to be replaced ranges from **3 to 6 months**.
- **Medium complexity** parts are more complex sub-assembly electronic parts, such as small motors, which need additional validation for their performance. These parts are often commercial assemblies that are generally available to the electronic industry, and are utilised by the Test & Measurement coalition companies. Replacement of these assemblies, like-for-like, requires testing and validation prior to being integrated into the manufacturing process. The average time to find an alternative for medium complexity parts for production is reported to range from **6 to 12 months**.
- **High complexity** parts are complex sub-assembly parts and have a significant impact on the performance of the companies' products. These also have a critical role in the overall safety of the products. These parts need to go through extensive validation for performance and/or compliances, according to varying regulations, before the appropriate files can be updated and the proper competent authorities or regulatory bodies can be notified prior to the purchase of parts for validation. The average time that it would take to find an alternative for high complexity parts for production is up to 1 year of additional testing. Where the exemption directly impacts the performance of that component (e.g., a centrifuge rotor) the evaluation of the replacement could take **3 to 5 years**.

3.4 Overall conclusion on suitability and availability of alternatives

Some combinations of substitutes will meet some criteria, but the significance of lead in HMP solders is its **unique ability to satisfy a unique combination of essential properties**. It is therefore not possible to pick a single property as a criterion of distinction under RoHS. Substitution is therefore not possible due to the numerous properties required from substitutes. Alternative technologies that match the ductility and strength of lead whilst retaining reliability during one or several reflow processes (melting of solder), which would otherwise weaken the bond, are not yet available.

The unavailability of alternatives for replacement and substitution asserted above echoes the findings of the RoHS exemption pack 22 conducted by the Öko-Institut published in February 2022.[11] The information made available accordingly suggests that the substitution and elimination of lead in high melting temperature type solders is still technically and scientifically impracticable. The granting of exemption 7(a) should therefore be justified by Art. 5(1).

4. ANALYSIS OF IMPACTS

4.1 Human health and environmental impacts

Annex II of the Directive 2011/65/EU (RoHS) specifies the restricted substances referred to in Article 4(1) and maximum concentration values tolerated by weight in homogeneous materials. The maximum concentration value for lead (Pb) tolerated by weight in homogenous materials is 0.1% unless there is an application listed in Annex III or IV available to the product category of EEE.

TMC members emphasized that the quantity of lead utilized in their homogeneous materials can contain between 85% and 95% lead by weight, with the annual amount of approximately 25.5 kg of Pb entering the EU market annually through the application for which the exemption is requested.

Lead is considered to be a reproductive toxin. Given its hazardous properties, lead is on the REACH candidate list of SVHCs.

4.1.1 Reduction in the quantity of lead (Pb) placed on the EEA market

The participating companies have reported that no change in releases of lead to the environment are likely during equipment production or use phases of the concerned products over the next seven years as a consequence of the revocation of the RoHS exemption. During test and measurement equipment production, the solder is internal to the component and does not create an exposure during assembly. At component manufacturers, waste and exposure to lead is considered controlled through good OSH management practices.

Under normal conditions of equipment use, the lead content associated with the application of Exemption 7(a) is encapsulated within the equipment enclosure and will neither be touched nor released to the environment.[12] As this equipment is sold B2B for professional/industrial use only, equipment that finally reaches end-of-life will be appropriately processed by professional recyclers who are obligated to have suitable controls to avoid any environmental releases and are notified of the presence of the substance under the producers' obligation to provide a SCIP notification.

11 Available at: https://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_22/RoHS_Pack-22_final_report_amended_February_2022.pdf

12 All substance is captured in sealed electrical enclosures and chemically or metallurgically bound in alloys, glasses, or ceramics.

As a result of the participating companies' relatively low consumption of parts, in comparison to the product Categories 1-7 and 10, renewing this exemption for Category 9 will have a minimal impact on the environment. As previously indicated, Category 9 industrial producers are only responsible for 0.2% of annual WEEE production. The number of components relying on this exemption that are specialized for test and measurement applications combined with their collective use provide a strong rationale to keep the specialized components, that rely on this exemption, in production. The manufacturing of specialized components represents a minute fraction of the total exemption usage referenced in this report. The majority of the components that utilize this exemption, that constitute Category 9 industrial usage, are common to all product categories. The component manufacturers therefore rely on volume use of the other categories to justify their continued production. Renewing this exemption only for Category 9 for the full 7 years will not extend the production life of these higher volume components beyond the exemption renewal period assigned to Categories 1-7 and 10. It will, however, enable the Test & Measurement coalition members to buy sufficient (relatively small) quantities to update the design and continue to use the relevant components for an extended period. As a result, a renewal of this exemption will have a minimal environmental impact and has a positive socio-economic impact by enabling the continued production of Category 9 products critical to the health and welfare of the EU (and global) society whilst the multi-year redesign process is executed.

4.1.2 Additional waste in case of a non-compliant stock

The expected additional waste before the end of the regular lifetime (non-compliant stock) reported by the T&M equipment manufacturers varies. Whereas one company expects no additional waste, another has reported a relatively larger amount of additional waste as a consequence of a high number of low-value components that cannot be consumed completely. Another company stressed that the finished goods' inventory is expected to be minimal due to production of the products being based on short-term demand, therefore any remaining stock in distribution would be consumed (by selling to the non-EEA markets).

One company has reported that no recycling concerns for of equipment that is currently placed on the market nor of any future product replacements are to be expected. Another company has, however, reported that scrap rates are anticipated to increase in case of RoHS restriction for non-leaded alloys as the increased waste due to scrap and tool wear will result in increased consumption of metals and alloys that have a very large carbon footprint. This would result in many scrapped materials from all companies entering the waste stream.

Material costs and waste, due to scrapping the materials that could not be RoHS compliant, would also have to be addressed. However, due to the large and poorly predictable volume of parts impacted by the loss of the exemptions it is impossible to quantify the costs. The parts may be withheld for use in models that might be sold to other nations that would permit the ongoing use of materials with RoHS substance levels above the EU RoHS 2011/65/EU set values.

No negative environmental impacts are expected if the parts that are used in T&M products are RoHS compliant as it would reduce the amount of RoHS substances potentially released into the waste stream. However, adverse effects on customers that undertake environmental analyses are to be anticipated given that they would require the company's equipment to carry out tasks and to maintain the existing equipment.

4.2 Economic impacts

The sections below provide a general overview of the social and economic impacts, considering business impacts (i.e., at different stages of the value chain), market impacts (i.e., on the product market), substitution costs, and broader macroeconomic consequences resulting from a potential non-renewal of the exemption 7(a), Annex III.

4.2.1 Business impacts on manufacturers

A survey was utilized in the preparation of this report. **Data from TMC members have been received and aggregated**. These companies are among the biggest producers in the EEA test and measurement equipment market. The market share covered by this survey is more than 70% of the whole EEA test and measurement equipment market. The assessment is, therefore, highly representative. This market share can be used to obtain reliable estimates for the EEA market via extrapolation, as detailed below for the assessment of the economic impacts.

Products manufactured by these companies are typically made available on the market for a period of 10 years from market launch until discontinuance. A further five to seven years of guaranteed support life follows discontinuance to assure availability of spare parts. The lifetime of any given unit can often be extended through regular maintenance and servicing. Under normal conditions of use and availability of spare parts, products can remain in use by customers for more than 25 years, supported by repair and calibration services. Even though the information varies across different products and businesses within the participating companies, the products recently placed on the market are expected to be present on the market for at least the next 15 years.

Due to the very specialized nature of the industrial test and measurement equipment, sales volumes are in many orders of magnitude lower than those of consumer products. Industrial test and measurement equipment are not subject to fast-paced changes in market patterns. The specialized nature reflects in the prices. The prices of these products vary greatly, depending on factors such as cost, size, and complexity.

The T&M Coalition member companies have declared that more than **[CONF.]** product lines that apply this exemption would be impacted. During 2021, > **[CONF.]** units of these products were placed on the EEA market. These data were taken from a typical sales year and the volumes are considered representative for annual volumes.

The remaining stock reported by the companies that risk not to be sold as a consequence of the restriction varies. Whereas some of the companies reported that given enough transition time. no major negative impact is expected for the stock of the test and measurement equipment products as the production site stock will be consumed (e.g., by selling to other non-EEA markets) before phase-out, the others emphasized that component inventory affected by the exemption is significant. One of the participating companies emphasized that **[CONF.]** EUR of component inventory would be remaining after 2-year transition of all products not utilizing these components, mostly due to last-time-buy inventory. The disposal of unsold or unusable inventory would have a negative environmental impact (even if negligible), which is exacerbated by the major supply issues that have affected the electronics sector and led to historically high last-time-buy volumes.

Depending on the part complexity, different compliance costs are also to be expected. The companies emphasized that switching to RoHS compliant products without using the exemption would require a disruptive amount of work and investments. The companies have provided different ranges of products that would have to be redesigned in case of a non-renewal. Companies reported that the exemption is used in a range of 66% to 78% of all equipment families marketed by Category 9 OEMs. This would have to occur with limited availability of resources and specialized engineers, a high proportion of custom parts, extensive testing, and re-qualification requirements before products could be marketed. Increased capacity of test facilities would also be required to verify in parallel a larger than normal range of products – many of which are already taxed beyond capabilities to accommodate unrelated changes to the EU IVDR/MDR and created by Brexit.

Given the fact that new products drive long-term company growth, the time spent sustaining existing products directly impacts the company's growth, resulting in a large opportunity cost. Further, significant testing must be done to ensure that alterations will not affect the safety, quality and performance of the final product since T&M equipment is particularly sensitive to component, material, and manufacturing changes. Therefore, **considering the number of products affected by this restriction, the expected investments to comply with the restriction would be more than [CONF.] EUR**. Additional costs due to loss of efficiencies and additional R&D spending at companies' suppliers are to be expected.

Therefore, the non-renewal of the Annex III exemption 7(a) exemption would have significant impacts on their business and customers. The companies reported that due to the specificity of the equipment, there are no known methods to produce compliant equipment (cf. Annex I to this report for details on product groups) meeting the specific performance specifications of production today. Should the exemption not be renewed, this equipment would have to be withdrawn from the EEA market.

As a consequence of these technical and practical challenges, the TMC manufacturers anticipate loss of business in the EEA. The direct cost of a non-renewal of the exemption is represented by the loss of the contribution to the EEA economy of the EBIT generated by manufacturers using lead (Pb) in HMP solders. The relevant economic measure to quantify this economic impact is given by EBIT. The monetization (net present value, NPV, with 4% discount rate) of this economic impact (lost EBIT) is reported below.

Therefore, if Annex III, exemption 7(a) would not be renewed,[13] it is estimated that **manufacturers of test and measurement equipment using lead (Pb) in high melting temperature type solders (i.e., lead-based alloys containing 85% by weight or more lead) would face a net EBIT loss of approximately [CONF.] EUR/year. Over four years**, the total impact is expected to be approximately **[CONF.] EUR** (NPV, 4% d.r.)[14] for the **manufacturers**.

We can use the market share of the test and measurement equipment manufactured by the participating companies to extrapolate **the total economic impact in the EEA across all manufacturers.** The market share covered by this survey represents more than 70% of the whole EEA test and measurement equipment market. This market share is used for the extrapolation of the impacts for the whole EEA market in a conservative approach. **The total impact for the EEA market (manufacturers of test and measurement equipment) would therefore be in the range of [CONF.] EUR (derived above) and [CONF.] EUR** (**[CONF.]** EUR x 1/0.70).

Other companies may benefit from a negative regulatory outcome for lead, especially, competitors based outside the EEA. Because the RoHS restrictions would affect equally the whole EEA T&M industry, the corresponding loss in value added (i.e., loss in EBIT) can be considered an EEA industry-wide impact.

It must be noted that what occurs in Europe also has repercussions on other markets, such as the Asian market. This is because the CE mark is used by T&M equipment manufacturer as evidence that their products are suitable for the EU and therefore are considered of acceptable quality in a non-EEA location. Consequently, the economic consequences of a non-renewal for Annex III, exemption 7(a) would result in much larger impacts for the industry than those reported above.

Given the specificity and complexity of industrial test and measurement instruments, it is extremely challenging for the test and measurement sector to adapt to frequent changes of the lead restriction in scope. The main challenge that has been raised by the companies is the fact that deadlines provided by authorities are considered too tight for business adaptability and to develop alternative products. The existing maximum renewal duration of up to 7 years is considerably shorter that product development lifecycles. This renewal request is therefore made to cover the full seven-year maximum duration.

Substitution costs for test and measurement equipment manufacturers

Most of the components utilizing exemption 7(a) incorporated into T&M equipment are COTS parts. Consequently, T&M manufacturers are heavily reliant on their suppliers to identify alternatives.

[13] Company was asked to consider how the revenues (and EBIT) for year 2022 were impacted under the assumption that a RoHS restriction on lead in test and measurement industrial products types were to be fully adopted with immediate effect (i.e., in 2023).

[14] Using the Excel function =PV(4%,4, -[CONF.],0,0).

For the other parts, it is estimated that at least 4 years are needed to evaluate the suitability of potential alternatives given the wide variety of uses. A further three to five years are however, to be anticipated for implementing the substitution or concentration reduction of RoHS restricted substances. Overall, it is anticipated that four to six years are needed for re-designing (i.e., implementing the substitution, or concentration reduction of lead) in a full product.[15] This timeline applies only if a usable substitution candidate can be identified. Moreover, this is highly dependent on the complexity and the impact of change upon the final product.

As the companies do not manufacture the majority of parts incorporated into test and measurement equipment and purchase the most parts from the respective suppliers, **implementing a re-design requires longer timelines to convert the entire portfolio and significant cost increases**. The change would involve researching an alternate component, assembling it into a test product, and evaluating the new product for functionality, hardware and software performance, reliability, EMC, safety, manufacturability, etc.

Therefore, **the T&M Coalition member companies have indicated that the implementation of substitution or concentration reduction of lead would cost approximately [CONF.] EUR** (rounded),[16] including validation and testing, engineering, quality and administrative costs. This also includes incremental investment necessary to characterize potential substitutes, and where practicable, tailor production processes to assure existing product's published specifications can be maintained.

In reality, the switching costs are likely to be much larger than the estimate above. By making use of the market share of about 70% covered in this SEA, we can extrapolate a **total switching cost of [CONF.] EUR** (= **[CONF.]** EUR * 1/70%) for all manufacturers of test and measurement equipment industrial products.

4.3 Wider economic impacts

It is also important to consider the wider macroeconomic impacts and consequences on the EU society at large, by focusing on the expected consequences for the EEA market. In particular, there are concerns on the overall EU trade balance (increase of imported test and measurement industrial product types) and on the competitiveness of EEA market.

Impacts on the market – Quality and costs

If **Annex III, exemption 7(a)** would no longer be available for use in test and measurement equipment, sectors relying on these products would be particularly affected. Manufacturers of chips and electric and electronical equipment may experience a decreased availability for test and measurement industrial equipment.

[15] Average of the estimated timelines provided by TMC manufacturers.

[16] ECB exchange rate on 11 October 2022 (1 EUR = 0.9723). Available at: https://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/eurofxref-graph-usd.en.html.

For the majority of the products that utilize the exemption 7(a), Annex III it is likely not feasible to remove the exempt components without risk to product. safety, quality, reliability, or performance or an increase in cost.

For those products that are possible to convert, they would be prioritized by EEA revenue as it likely would not be worth the investment to re-design all products to be free of the exemption. Even if there were suitable alternatives on the market today, it is expected to take several years or more to convert the entire companies' portfolio. This would likely result in withdrawal of products from the market until products are converted. On the other hand, low revenue products that require significant re-design, or those products that are within a few years of obsolescence, are likely be withdrawn from the EEA market.

The impact of reduced volumes manufactured will also have a **significant impact on the fixed costs of various supply chain actors**. Participating companies would also be strained by increased costs associated with addressing new product development and resourcing components for manufacturing. As a result, prices of final products would increase accordingly.

Impacts on suppliers

The participating companies maintain a large supply chain: a vast majority of actors supply components, materials, and performs contract manufacturing operations. This supply chain is global and not limited to businesses located in the EEA. There are a number of actors in the production of the impacted equipment produced by the Applicant: component and sub assembly suppliers, contract manufacturers for printed circuit assembly production, and contract manufacturers for selected products' assembly. Most of these suppliers leverage RoHS exemptions in their supply chain, especially for electrical components.

If **Annex III, exemption 7(a)** would not be renewed, **there would be a decrease in demand for the services of each actor in the supply chain**. These suppliers are at a risk of losing these sales and the need to develop new technologies to replace their existing products. Depending on the speed of R&D, they could permanently lose sales if a competitor brings a replacement to market faster.

The greatest direct impact would be on the component and subassembly contract manufacturers whose core business is to provide such items to the electronics market. Reduced product volumes from equipment producers would also affect profitability (reduced volumes vs. fixed costs) of contract manufacturers. **The supply chains of the participating companies would require a lengthy transition period in case of non-renewal** as they would need to resource alternative materials, validate the production of components with new materials, and build the critical sub-components that are used to assemble and manufacture equipment on behalf of the TMC manufacturers.

Impacts on the market – Competitiveness

As the RoHS regulation applies to all producers equally when placing equipment on the EEA market and since the majority of the production is based outside of the EEA (mainly in the US), **a non-renewal of the Annex III, exemption 7(a) for test and measurement industrial product types in the EEA would disadvantage the EEA markets in their competition with the rest of the world.**

Indeed, as other regions have RoHS-equal regulations which are not market restricting but rather mainly notification based, if the exemption 7(a), Annex III is removed, the risk is that test and measurement equipment manufacturers will be forced to look at other growth areas, such as, for example, the Asia-Pacific region. T&M equipment manufacturers' supply chain is global and not limited to businesses located in the EEA. Their portfolio is highly specialized and so equipment is built for global distribution. Therefore, manufacturers cannot afford to regionalise the production. **The manufacturing of a specific variant of a product for distribution only within the EEA is not an economically viable option.** This would negatively impact the competitiveness of EEA market players compared to those that have access to a wider portfolio of test and measurement instruments in other areas of the world.

Furthermore, non-EEA competitors would not be subject to restriction and would be able to supply and place on the international market a wider range of products, without bearing any redesign costs. Thus, non-EEA competitors are likely to gain market share if the restrictions are applied in the EEA market. In particular, the Asia-Pacific region could greatly benefit in terms of possibility of increasing their market share by taking advantage of the opportunity of additional production.

On the one hand, expiring exemptions, particularly related to use of lead (Pb), will prevent the rest of the world from doing business with EEA. Lead is widely used in free machining brass, steel, and aluminium for small parts with very precise features. These materials are widely used in electrical pin, contacts, connectors, etc and the industry has not yet been able to replace these types of components with Pb-free versions. This would effectively prohibit the electrical components and microelectronics business from doing business in the EAA, as well as have significant impact on EU based businesses that also relying on lead components to make precision micro machining technically feasible. Furthermore, many semiconductor components utilize lead that do not yet have an economically or technically feasible replacement. **This gap in availability of products to the EEA will again impact the ability of many to perform the necessary functions to compete with non-EEA markets.**

Impacts on the market – Innovation and R&D

The revocation of Annex III, exemption 7(a) is expected to have wider impacts on innovation in Europe. One of the major uses of the Category 9 products is in essential research and development processes, both within private companies and for state sponsored research. The limited access to test and measurement equipment in the EEA will constrict investment in both innovation and commercialization of new technologies in a wide variety of sectors, from life science to chemical and from engineering to material science. The limited access to test and measurement equipment in the EEA will be the main driver for investment in both the development and production of all electronic equipment to other non-EEA regions. This will have a market impact on the innovation and the know-how in the EEA. The removal of products from the market due to the non-renewal of exemption 7(a), will therefore have a **direct negative impact on the research and innovation output within the EEA.**

A possible non-renewal will, as noted before, influence the EEA market's competitiveness and significantly affect the sales of the companies. The significant reduction in sales as a result of a possible non-renewal of **Annex III, exemption 7(a)** will have an inevitable negative impact on R&D investments. Therefore, based on the assumption that the percentage of revenue spent remains the same, the loss of sales to the EEA market will result in a decrease in R&D spending. Moreover, the manufacturers have further noted that the current geopolitical situation, supply chain disruptions and the inflated cost of materials have already resulted in a cut in R&D investments. The non-renewal of the exemption would exacerbate the lack of and decrease in R&D funding.

The current R&D efforts and resource would inevitably be redirected towards redesigning legacy products to accommodate alternate component and will only exacerbate the lack of and decrease in funding R&D for additional T&M equipment products. The non-renewal of Annex III, exemption 7(a) would **adversely affect the resources available for new product design and innovation, as the limited R&D resources available would be spent on responding to a non-renewal instead**.

It is further anticipated that chip producers would be particularly impacted due to the non-availability of test equipment exclusively needed for these sectors. the electronics industry has increasingly emphasized the importance of increasing investment and lowering supply chain dependence on manufacturing in other regions (i.e., the recently proposed EU Chips Act). Within this context, **a non-renewal of Annex III, exemption 7(a) would be a significant step back for innovation in the semiconductor industry.**

Impacts on the market – Trade

When assessing this aspect, it is important to consider the trade balance of the EU. **A non-renewal of this exemption in the EEA would disadvantage European companies in their trade with the rest of the world.**

A non-renewal of **Annex III, exemption 7(a)** would effectively prohibit the electrical components and microelectronics industry from doing business in the EEA. It would also have a significant impact on EU-based businesses that also rely on lead-based materials to make precision micro machining technically feasible. A non-renewal will hamper the EU's relative importance as an exporter and trading partner for the goods and industries mentioned above.

The exports from the EEA would be particularly hard hit by a potential restriction (non-renewal of the exemption). As a result, the **overall EU trade balance would be adversely impacted**.

4.4 Social impacts: unemployment

The restriction of lead will not have a direct impact on the headcount of the manufacturer companies. The headcount is dynamically changing based on different factors, including customer relationships, opportunities and market dynamics.

In general, it is difficult to estimate the unemployment because this depends on whether the end user market can be addressed in the future with products that do not rely on Annex III, exemption 7(a) and if that transition is capable of retaining the same precise product specifications and reliability performance.

However, the TMC manufacturers declared that a non-renewal would very likely lead to unemployment within the companies. With the loss of business, action would be deemed necessary to reduce workforce, especially high-skilled (e.g., scientists, engineers, microbiologists, and quality experts. It is estimated that, assuming a RoHS restriction is implemented, approximately **[CONF.]**[17] highly skilled workers in the companies participating in the survey will face layoff in the EEA. Here we report the monetization of the likely social costs of unemployment for these workers.

For the purpose of this SEA, it is assumed that the average annual salary across these European workers (including the employer's social security contributions) is **[CONF.]** EUR.

A well-known guideline in monetizing the social impact of unemployment has been developed by the European Chemicals Agency (ECHA) for evaluating such impact in different regulatory processes.

Estimates have been made in accordance with the ECHA document on the evaluation of unemployment (SEAC/32/2016/04)[18] and the paper of Dubourg (2016)[19] endorsed by ECHA. Therefore:

- Using Table A7 (column G, considering the gross wages including the employer's social security contributions) in Dubourg's paper, the total social cost of unemployment in EU is equal to 2.16 times the annual gross salary.[20]
- Table 1 presents the statistics from Eurostat (data for 2021-Q3) on the average duration of unemployment for both men and women in the age of 15-64 years in EU-27.[21]
- Only 75% of the average duration of employment is considered, to reflect the fact that some affected workers are highly skilled and could find employment sooner.

Table 1: Duration of unemployment in EU-27

Duration Grouping	Thousand units	Proportion (A)	Assumed duration (B)	Weighted average (A*B)
Less than 1 month	1328.5	0.096128799	0.5	0.048064399

[17] Due to the lack of sufficient data from several of the participating companies, we adopt the conservative estimate of at least 20 workers being laid off in the EEA for per company.

[18] ECHA (2016). The Social Cost of Unemployment. Available at: https://echa.europa.eu/documents/10162/13555/seac_unemployment_evaluation_en.pdf/af3a487e-65e5-49bb-84a3-2c1bcbc35d25

[19] Richard Dubourg, 2016. Valuing the Social Costs of Job Losses in Applications for Authorization. The Economics Interface Limited.

[20] This value is greater than one (1) because it takes into account the following components: lost wage, costs of job searching, recruitment costs, the impact of unemployment status on future wages (scarring effect) and employment possibilities, and leisure time (which is a benefit and therefore subtracted from the previous components).

[21] Data extracted from http://appsso.eurostat.ec.europa.eu/nui/show.do?wai=true&dataset=lfsq_ugad

From 1 to 2 months	2585.5	0.187083936	1.5	0.280625904
From 3 to 5 months	2175.0	0.157380608	4.5	0.708212735
From 6 to 11 months	1953.3	0.14133864	8.5	1.201378437
From 12 to 17 months	1637.8	0.118509407	14.5	1.718386397
From 18 to 23 months	640.3	0.046331404	20.5	0.949793777
From 24 to 47 months	1651.0	0.119464544	35.5	4.240991317
48 months or over	1848.6	0.133762663	48	6.420607815
Total	13820.0	1		**15.56806078**

The social costs of unemployment would therefore be equal to:

[CONF.] EUR x **[CONF.]** people x 2.16 x 15.56806078/12 x 75% = **[CONF.]** EUR.

Although companies along the supply chain would face a reduction in sales over the years, we assume for simplicity that the entire workforce will continue working for other three years. Therefore, we discount the monetized impact derived above by three years due to the assumed delay in the layoff, using discount rate of 4% per year, as follows: **[CONF.]** EUR x $(1 + 0.04)^{-3}$ = **[CONF.]** EUR.

As reported above, the test and measurement industrial type products' manufacturers (participating in the survey) use in total 25.5 kg per year of lead related to the application of Annex III, exemption 7(a). One can use the tonnage (proxy for market share) of test and measurement industrial products to extrapolate the total social impact of the unemployment in the EU across all T&M manufacturers: **[CONF.]** EUR x 1/0.70 = **[CONF.] EUR (rounded).**

Other (low-skilled) workers would be impacted, even though the TMC manufacturers are not in a position today to quantify the unemployment effect.

Moreover, as a progressive result and due to the expected reduction in sales, job creation is also expected to be negatively affected. Manufacturers anticipated that eventually they would inevitably reduce new recruitment.

We can affirm with a high likelihood that the total social impact of a restriction of lead in high melting temperature type solders (i.e., lead-based alloys containing 85 % by weight or more lead) *along the whole supply chain* would be much larger than [CONF.] EUR, once one considers all other economic operators having business linked to test and measurement industrial equipment products.

5. CONCLUSION

This SEA identifies the main potential negative consequences that the EU society at large would face in the framework of the potential restriction of lead in high melting point temperature type solders (i.e., lead-based alloys containing 85 % by weight or more lead). It has been performed in line with existing ECHA guidance for the preparation of the Socio-Economic Analysis. The results are based on a survey focused on the EU test and measurement equipment industry, with market share coverage of approximately 70% of the EU market. It therefore provided sufficiently reliable data for a representative extrapolation of the EU market.

Overall, the results of the SEA demonstrate the safe use of lead (Pb) in high melting point temperature type solders (i.e., lead-based alloys containing 85 % by weight or more lead) and can reasonably justify the renewal of this exemption, on the grounds that a broad restriction would have disproportionate negative impacts on society when compared with the risk to human health, animal health or the environment.

The **total monetized impact** of a non-renewal is estimated in the range of **2.9 billion EUR to 4.1 billion EUR**, including: **[CONF.]** EUR of economic impacts (EBIT loss) on test and measurement industrial type products' manufacturers; **[CONF.]** EUR of substitution costs; **[CONF.]** EUR of social impacts deriving from unemployment. This is a conservative estimate (lower bound), on the understanding this is not the sole injury likely to be suffered in the EU.

In terms of **business and market impacts**, a non-renewal would constraint most of the companies currently supplying RoHS-based test and measurement industrial products to cease production and business activities of all products that include lead.

In addition, and pursuant to Article 5 of the RoHS Directive a continuation of exemption 7(a) Annex III is warranted as **no suitable alternatives to the RoHS restricted substance are available.**

ANNEX I

Product groupings and equipment types relevant to Annex III, exemption 7(a)

Product Grouping	Equipment Types
Oscilloscopes, Analyzers & Meters	Oscilloscopes
	Spectrum Analyzers (Signal Analyzers)
	Network Analyzers
	Logic Analyzers
	Protocol Analyzers and Exercisers
	Bit Error Ratio Testers
	Noise Figure Analyzers and Noise Sources
	High-Speed Digitizers and Multichannel DAQ Solutions
	AC Power Analyzers
	DC Power Analyser's
	Materials Test Equipment
	Device Current Waveform Analyzers
	Parameter and Device Analyzers, Curve Tracers
	(Digital) Multimeters
	Phase Noise Measurement
	Power Meters and Power Sensors
	Counters
	LCR Meters and Impedance Measurement Products
	Picoammeters & Electrometers
	Oscilloscope Upgrades and Accessories
Generators, Sources and Power	Signal Generators (Signal Sources)
	Waveform and Function Generators
	Arbitrary Waveform Generators
	Pulse Generator Products
	HEV/EV/Grid Emulators and Test Systems
	DC Power Supplies
	Source Measure Units
	DC Electronic Load
	AC Power Sources
	Sourcemeter
	Sensitive Meter/Source
Wireless	Wireless Network Emulators
	Channel Emulation Solutions
	Nemo Wireless Network Solutions
	5G OTA Chambers
	Wireless Analyzers
	IoT Regulatory Compliance Solutions
Modular Instruments	PXI Products
	AXIe Products
	Data Acquisition – DAQ
	USB Products
	VXI Products
	Reference Solutions
Network Test, Security & Network Visability	GPIB
	Embedded Networks Hardware
	Industrial Communications Hardware
	Vision
Application-Specific Test Systems and Components	

Product Grouping	Equipment Types
Photonic Test & Measurement Products	
Laser Interferometers and Calibration Systems	Monolithic Laser Combiners & Precision Optics
In-Circuit Test Systems	
Used Equipment	
Bioprocessing Equipment Automation	Large Chambers
	Mixers for Processing Drug Intermediaries
Laboratory Products	Autoclave Sterilizers
	Baths and Circulators
	Biological Safety Cabinets
	Blood Culturing Devices
	Centrifuges
	Chillers
	Electrophoresis
	Environmental Chambers
	Freeze Dryers
	Furnaces
	Heat Controllers/Exchangers
	Ovens
	Refrigerators
	Freezers
	Mixers
	Water Purification
Chemical Analysis	Handheld XRF Analyzers
	Dosimetry Personnel Contamination Monitors
	(Laser) Spectroscopy
Genetic Sciences	Gold Standard Products for COVID-19
	PCR Testing Modules
Other	Test and Measurement Upgrades and Accessories
	Probe
	Semiconductor Characterization System
	Chromatography
	Mass Spectrometry
	Gas Chromatography
	Smart Docking Solutions
	Electron Microscopes
	Series Controllers
	Value Controllers
	Distributed Nodes
	Embedded Networks Hardware
	Ethernet Hardware
	Industrial Communications Hardware
	Industrial Controllers
	Motion Control Hardware
	Multifunction Instruments
	Programmable Power Supplies
	Embedded Controllers
	Remote Controllers
	Astronomical Equipment

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