Test & Measurement Coalition

Impacts of potential inclusion of new RoHS substances on Category 9 industrial sector

15 June 2018

Introduction to the T&M Coalition

The Test & Measurement Coalition represents an ad-hoc group of companies active in producing Category 9 industrial type products. The Coalition includes leading companies in the sector including Agilent Technologies, Fluke Corporation, Keithley Instruments, Keysight Technologies, National Instruments, and Tektronix. We estimate the coalition membership represents roughly 60% of the global production of industrial test and measurement products and other Category 9 industrial equipment including chemical analysers.

The Test & Measurement Coalition has been actively participating in all consultations on RoHS substances organised by Öko-Institut, our first engagement dates back to 2008 contributing to the study on the RoHS substances in EEE in the context of the RoHS recast. We are pleased now to contribute with further input to the current study conducted by Öko-Institut assessing 7 substances for potential inclusion in the RoHS Directive.

Summary

As per our previous submissions, we would like to stress that:

- The initial six RoHS substance restrictions started applying to Category 9 industrial products very recently. Because of the specificity of the design process and the high reliability requirements, our products were given an extended transitional period until July 2017 for compliance with the initial RoHS restrictions. An extended transitional period until July 2021 was also granted for complying with the restriction of DEHP, DBP, BBP and DiBP for Category 9 industrial equipment.
- It took substantial effort to bring our portfolio of equipment into compliance with the six initial RoHS substances. Our member companies have been working continuously on their portfolio conversion since 2005 to ensure RoHS compliance by 2017.
- The substances currently being proposed for potential inclusion in RoHS are used in the majority of our products. While our initial investigations reveal that the cobalt and nickel substances are intermediary chemicals and do not

remain in the finished equipment, the potential restriction of all the other proposed substances all have broad application across multiple component commodities and would lead to forced redesign of the vast majority of our products after full evaluation. In particular beryllium, diantimony trioxide, tetrabromobisphenol A (TBBP-A), medium chain chlorinated paraffins (MCCPs) will each impact 100% of our portfolio.

- At this stage, there are no known alternatives to indium phosphide and beryllium for Category 9 industrial applications. Potential alternatives to diantimony trioxide, TBBP-A, and MCCPs, while available, need to be further evaluated to confirm they meet the performance and reliability specifications required for Category 9 industrial equipment. Moreover, potential alternatives to diantimony trioxide and TBBP-A have larger negative environmental impacts and therefore may not qualify as suitable alternatives.
- It must be considered that Category 9 portfolios are currently undergoing redesign to be compliant with the restriction of the phthalates by 22 July 2021.
- Test & Measurement products have a long product life up to 30 years and 10 years on average; and represent less than 0.25% by weight of the entire EU WEEE[1]. Given the longevity of the active use of this equipment, EHS processing controls for these substances will be required for the foreseeable future.
- Forcing redesign and withdrawal of these products is disproportionate and in contradiction with the objective of circular economy and resource efficiency and bring no benefits to environment.
- If the scope of the RoHS restriction is extended to these additional substances, the restriction should not apply to Category 9 industrial in order to limit negative impact of withdrawal of products on the economy and innovation. If inclusion of Category 9 industrial is considered in the future, an in depth analysis of the exemptions needs to be conducted, as previously done in preparation for RoHS II and socio-economic analysis of the impacts.

Specificity of Category 9 industrial equipment

Our products include a wide range of sophisticated electronic instruments such as signal generators, logic analysers, oscilloscopes, spectrum analysers, digital multimeters, chemical and biological analysers etc. The instruments are used by laboratories (for research and compliance evaluation), universities (for technical training, education, and research), manufacturers (for product development and manufacturing of their products), and governmental agencies (for conformance verification). They are essential to the good functioning of electronic communications

[1] Eurostat: WEEE data 2015

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 of all types.

Category 9 industrial EEE is very different from the consumer goods high volume products.

- Test & Measurement products have a long product life up to 30 years and 10 years on average. Frequent redesign is not common for the sector, further emphasizing the need for extended transition periods to achieve compliance with existing resources.
- Test & Measurement products are extremely complex and there are a limited number of highly qualified engineers available to work on redesign. This will divert significant resources from the development of new, innovative products.
- Redesign often presents significant technical challenges that take time to resolve – it can be 1-5 years before a new product can be released and 0.5-2 years for an enhancement. A significant amount of the time is required for environmental and safety testing of new designs.
- 25 - 35% of the components used in Test & Measurement products are custom designed for our instruments. As many of our members use around 100,000 different parts today this means redesign and testing of several thousand custom parts for each company.
- Where RoHS compliant components are available, they require extensive testing to verify their long-term reliability when used in Test & Measurements products.
- Material substitutes meeting our customers' reliability criteria are limited in some instances. For example a domestic household product with expected life of five years has more material options for anti-corrosion coating than a Test & Measurement product for outdoor use which customers expect to work reliably for ten years or more.
- Historically, material or component substitutions have been validated through a number of tests under extreme conditions. Testing programmes can last one or two years.
- Given the specificity and complexity of our products, it is extremely challenging for our sector to adapt to frequent changes of the RoHS substance restriction scope. The redesign of our portfolio to comply with the initial six restricted substances took 12 years and we are currently redesigning our products to become compliant with the restriction of the phthalates by 22 July 2021.

The specific needs of Category 9 industrial taken into account in RoHS 1 and RoHS 2

Exclusion from the scope of RoHS 1

Category 9 was initially excluded from the scope of RoHS 1. At the time of the preparation of RoHS 1, the European Commission concluded that there was a lack of sufficient knowledge of the supply chain and waste flows of this category. In addition, it was noted from the very beginning that it would be difficult for this industry sector to comply with the directive's strict deadlines given the complexity of the products and the critical applications. This caution has been amply justified by the subsequent efforts required to identify and validate acceptable alternative materials suitable for long-lived, high reliability equipment and to transition large numbers of custom parts frequently sourced from SME suppliers – a task still in process of completion for RoHS 2.

Specific conditions foreseen for Category 9 industrial in RoHS 2

The Commission proposal brought Category 9 into scope and proposed a long transitional period for Category 9 industrial products, extending to mid-2017. The Commission impact assessment[2] recognised that Category 9 industrial products are "produced in low numbers or have critical applications and hence increased testing and reliability requirements". The Commission estimates that "the cost of RoHS compliance for some complex products could be as high as 7-10% of turnover (new product) or 1-10% (modification of existing product). A large part of this cost is attributable to the long development, testing and approval cycles of the more complex products. This is why a staged introduction for these products is proposed allowing the compliance conversion to take place in the framework of existing resources and product development cycles."

Numerous amendments to the Commission text were proposed by the Parliament and the Council during the RoHS recast. Even so, the date of compliance for Category 9 industrial and the specific exemptions have not been put in to question.
Moreover, the specificity of Category 9 was recognised by the Greens. In her report of December 2009, the rapporteur MEP Jill Evans, Greens, proposed an amendment[3] introducing new substance restrictions. Her amendment explicitly excluded Category 9 while foreseeing transitional periods for the other categories.

Compliance challenges with potential RoHS restriction of the seven substance

The Test & Measurement Coalition actively participated in the RoHS revision process, contributing to all studies and public consultations preparing the RoHS recast (ERA, Öko-Institut, and Bio Intelligence studies). In all our submissions we

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2 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=SEC:2008:2930:FIN:EN:PDF

3 Jill Evans report, Amendment 31: http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//NONSGML+COMPARL+PE-430.424+03+DOC+PDF+V0//EN&language=EN

made clear that the ability to transition to RoHS compliance products by 2017 was strictly linked to the assumption that no new substances would be added, Category 9 industrial specific exemptions will be granted and RoHS 1 exemptions will continue to be available.

Category 9 industrial companies have already faced the challenge of uncertainty about the availability of the old RoHS exemptions for which specific exemption applications had to be submitted right after the publication of the Directive and whose adoption took about 2 years.

In addition, new substances have been included in the scope of RoHS in 2015 - DEHP, DBP, BBP and DiBP. Our members have had to face a simultaneous challenge of surveying supply chains, adapting plans for RoHS compliance just two years before the deadline for compliance with the initial RoHS restrictions.

Category 9 industrial member companies of the Test & Measurement Coalition could begin to prepare for RoHS conversion of their portfolios as early as 2005 due to the consistency in the initial substance RoHS scope.

It took substantial effort and to bring our portfolio of equipment into compliance with the six initial RoHS substances. Even after establishing RoHS design and supply chain specifications to control product development processes during the extended transition period, 60% of the products in the pre-existing portfolio still had to be redesigned to meet the requirements of the RoHS Directive. Our member companies have been working continuously on their portfolio conversion efforts since 2005 to ensure RoHS compliance by 2017. However, 7.5% of the products had to be withdrawn from the EU market, affecting 7% of companies' turnover. Both the product withdrawals and the reduced pace of new product innovation necessitated by diverting resources to redesign activities have a negative impact on EU customers and their related industries.

The incremental phthalate substance restriction timeline of July 2021 was initially considered acceptable as these substances are limited to use in plastics, and so it was presumed a limited number of suppliers and commodities would be impacted. However, in practice even this seemingly simple transition has presented unexpected complications due to the ubiquity of plastics in the supply chain (only about 10% of parts and assemblies are truly 'plastic-free') and also to the limited time between consumer and industrial implementation deadlines. During the lead up to RoHS 1 and the transitional period for RoHS 2, a major transformation occurred in the supply chain and most off-the-shelf parts had either transitioned to RoHS compliant or non-compliance was mostly well-understood where still present. Unfortunately this is not the case for the current transition as many suppliers of even off-the-shelf components are still not declaring parts to comply with the phthalate restrictions or providing roadmaps for part conversion despite the looming consumer deadline. Because of this the conversion of many sub-assemblies will be delayed, which further endangers the availability of the portfolio to EU customers in the 2021 timeframe, without even considering the impacts of seven new substance restrictions.

After Initial assessment, five of the proposed seven new substances can be present across even more component part types; forcing a full supply chain evaluation to

determine where they are currently present as well as assessment of the suitability of alternatives proposed for our applications. With our finite resources focused on the continued compliance with RoHS and adapting our portfolios with the Phthalate restrictions, assessing the impacts of additional substance restrictions before 2021 will be an insurmountable challenge. Such an assessment must be completed before work can begin to assess the suitability and reliability of alternatives for any new substance restrictions in our sector. Only once a design path is clear, the work to transition our portfolios could begin. This is clearly much more challenging than bringing Category 9 Industrial equipment into scope with the RoHS Recast or adopting to the additional Phthalate restrictions. At this stage, it is impossible to provide a timeline for any additional substance restrictions conformity.

In this context, potential restriction of additional proposed RoHS substances will essentially require our sector to restart our RoHS programs from the very beginning, undermining all the achievements of transforming our portfolios to be RoHS-compliant if these substance restrictions were to apply to Category 9 industrial.

Information about the presence of the priority substances in our products at the homogeneous material level is not yet available

It is anticipated that any attempt to add new substances to the scope for Category 9 products would require at a minimum a complete resurvey of the supply chain. Member companies of the Test and Measurement Coalition have supply chains that can exceed 100 000 suppliers for the quarter of a million parts used to produce our equipment. This scale makes the collection of data extremely difficult. Given the high complexity and specialized nature of instruments produced by our sector, there is a “long tail” of the number of component manufacturers fall into this category that provide many of the critical parts for Category 9 industrial equipment.

The quality of data relating to RoHS-compliance of purchased parts only rarely extends to full material composition. The majority of parts will require detailed supply chain engagement to even understand the presence of the proposed additional substances in the parts and the suppliers’ plans for substitution (if any) as a precursor to developing timelines for availability of material to establish suitability for our sector. It can be foreseen that more than one of the proposed substances will apply to many commodities of parts; adding to the complexity of data collection, analysis, and the need for any substitution throughout the supply chain.

In order to manage continuity of part supply, multiple part vendors are often approved to provide the equivalent parts. With multiple new substance impacts; there is a greater chance of diversity in the substitution approaches used across the supply chain and the equivalence must be re-established in each case for use in our equipment.

The transition for custom parts adds further complexity, requiring the state of the art for any substitutions to stabilize sufficiently in order to be brought into custom part production if they prove suitable for the more challenging performance requirements necessary for Category 9 industrial products.

The lack of sufficient information in the supply chain was sufficient reason to exclude Category 9 from the scope of RoHS 1 and to grant a special transitional period for compliance with the restriction of the phthalates. We believe it is a serious reason to exclude Category 9 from these proposed new substance restrictions.

Long term reliability of alternatives should be evaluated for Category 9 Industrial

The research into alternatives for the RoHS priority substances, testing and evaluation of available substitutes and defining of transition programmes is not a priority as our companies are focusing all efforts on the implementation and verification of substitutes for the existing substances. In the preparatory phase of the RoHS recast we submitted substantial amount of information to the Commission, including very detailed company specific confidential information about internal substitution programmes, status of research, results and prospects, costs and investments, and human resources dedicated to RoHS conversion activities.

Our products have long life time of 10 years on average with many remaining in service for up to 30 years. Substitutes need to be tested to meet customers' expectations of long term reliability of products capable of consistently meeting published specifications. These requirements go substantially beyond those of consumer goods applications. Accelerated life testing can only result in a compression factor of 7 – hence 30 year reliability requires at least 4 years of testing. Furthermore unlike consumer goods manufacturers Test and Measurement companies have thousands of products and yet relatively small but expert engineering staffs. This places human limitations on the ability to transition that are not felt by other companies. The design cycle in consumer goods is between 6 months to a year whereas in Test & Measurement it can be as long as 5 years, or even longer if specific regulatory regimes require additional verification testing.

The Test and Measurement sector has invested hundreds of millions of Euros in systems and data to support the development of RoHS compliant products with a view to meeting the intended compliance dates. Many products have already been introduced which have been designed to meet the substance restrictions. The investment in these product developments, the material compliance systems and supporting component data is all thrown into question if the new substance restrictions are to be added. 25-35% of parts used in T&M products are of non-generic design – this compares to less than 1% in consumer products – and not infrequently the substitution of one new RoHS compliant part can force additional substitutions and redesigns when a sub-component is not a true 'drop-in' replacement for the non-RoHS version. The exclusion from any further substance restrictions are therefore essential to maintain the path to transition to RoHS compliance which can otherwise not be achieved or will result in product withdrawal.

The consequence of not excluding Category 9 industrial from the proposed substance restrictions will cause massive disruptions to the complete electrical and electronics industry who use T&M equipment for design, development and production across all industry segments.

Comments on the priority substances listed by Öko-Institut

Diantimony trioxide

1. Number of products and quantity of substance in T&M equipment

At this stage, it is difficult to evaluate the exact number of products impacted as well as the precise content of the substance in our products.

Diantimony trioxide may have limited use in custom components of T&M equipment producers. From our research, it is understood this substance is widely used as flame retardant in component encapsulation by our upstream supply chain. The reporting of diantimony trioxide presence is not mandatory. This information is not readily available due to the lack of full materials composition information in the vast majority of parts RoHS conformity declarations.

Each producer will need to run in-depth supply chain surveys to get confirmation and to quantify impacted parts across our portfolios.

In the absence of this information and the broad use of this substance, T&M Coalition members anticipate that the entire portfolio of products will be impacted. To our current knowledge, the substance would typically represent a very insignificant part of the total product weight.

2. Function

Diantimony trioxide is generally known as flame retardant suitable to being used for polyethylene, polystyrene, polyvinyl chloride, polyester, epoxy resin, polyurethane and other plastics.
In our products, it additionally has a specific known use as flame retardant in packaged integrated circuit chips including semiconductors.
Other uses are yet to be discovered through supply chain survey, but presence of antimony detected in various plastics is suggestive of widespread application.

3. Possible Alternatives

Potential alternatives for the flame retardant function could exist, such as some halogenated flame retardants, excluding PBBs and PBDEs. However, these alternatives may prove to have larger negative environmental impact, especially in the waste phase. Therefore they may not qualify as suitable alternatives.

4. Cost implications resulting from potential restriction

We anticipate that complete product redesign will be needed wherever no substance free equivalents are available from component manufacturers. The available

alternatives have to be validated to meet Category 9 industrial performance and reliability requirements.

Forced redesign of entire portfolios to eliminate antimony based flame retardants would lead to reduction in innovation in new products, withdrawals from EU market, and potentially premature end-of-life for existing products.

In addition, substantial costs will result from the update and validation of product safety third-party certifications required for any changes to safety critical parts.
Given the critical applications of our products and the very long lifetime, the component certifications are critical to ensure product safety.

Restricting Diantimony trioxide will lead to:

- Forced redesign and requalification testing of entire portfolio;
- Lost opportunity for introduction of new, cutting edge products;
- Withdrawal of products from EU market.
- Impacts on innovation of users unable to access withdrawn products.

5. Time needed for compliance with potential RoHS restriction

Substantial research and testing of the performance of alternatives and reliability of substitution in the supply chain is required to be in a position to estimate the timing for compliance with potential restriction. This effort is similar to the experience the member companies had with RoHS I, and we anticipate that at least 12 years will be needed for category 9 industrial products to comply with the restriction in order to minimize consequent premature withdrawal of portfolio products from the market and the consequent impact on customer innovation and critical downstream industries. A review period of 12 years has become the standard in the context of REACH authorisation decisions for industrial uses[4].

6. Need for exemptions

If diantimony trioxide is restricted under RoHS, this restriction should not immediately apply to Category 9 industrial producers. Further research by Commission services will be required to define what exemptions will be necessary should this restriction apply to our sector.

Tetrabromobisphenol A (TBBP-A)

1. Number of products and quantity of substance in T&M equipment

TBBP-A is used in large number of products, we anticipate that our entire portfolio of products will be impacted. As with diantimony trioxide, each producer will need to run in-depth supply chain surveys to get confirmation of the presence or absence of the substance and to quantify the extent of impacted parts across our portfolios.

[4] https://echa.europa.eu/applications-for-authorisation-explained;
https://echa.europa.eu/documents/10162/13637/tecch_report_socioeconomic_impact_reach_authorisations_en.pdf

On the presumption that the application of TBBP-A as an intermediate in the production of fire-retardant PCB laminates is not applicable for RoHS, T&M Coalition members anticipate that the entire portfolio of products will still be impacted and a focused data collection on parts with the potential to contain polycarbonates will be required to establish impacted commodities. To our current knowledge, the substance would typically represent a very insignificant part of the total product weight.

2. Function

TBBP-A is known to be used as plasticiser and flame retardant. The presence of the substance in the electronics supply chain is most broadly known to be used in two very different applications – as a reactive component used to formulate printed circuit board laminates and as a component in certain polymers.

- *Use of TBBP-A as flame retardant in PCB laminate materials*

TBBP-A is the most widely-used flame retardant in PCB laminate materials. In use, it is reacted into the epoxy polymer where it is not separable back into TBBP-A and is not biologically available.

> During this process it becomes an integral element that defines the electrical performance properties of the printed circuit board material which are a critical design element for the specifications of industrial monitoring and control equipment. "TBBP-A is employed as a starting material that fully reacts to form the epoxy resins of laminates for printed circuit boards. This full integration into the epoxy resin ensures that the final product, flame retarded printed circuit boards, no longer contains TBBP-A, leaving the user free from any possible exposure."[5]

Consequently, TBBP-A is not detectable in finished printed circuit boards and so this application is not applicable for RoHS. In order to avoid costly and unnecessary testing this inapplicability should be clearly indicated should any restriction on the use of the material in finished EEE be established.

- *Use of TBBPA-A as a component in certain polymers*

The other main known use of TBBP-A in the electronics supply chain is as a component of polymers, meaning that it is incorporated into the polymer backbone. It is specifically used as a substitute for Bisphenol A to produce fire-resistant polycarbonates, including ABS.

In category 9 industrial products, our use of TBBP-A in polycarbonate materials will require further investigation to establish the full breadth of supply chain use.

[5] http://www.isola-group.com/wp-content/uploads/Fire-Retardancy-What-Why-and-How.pdf

3. Possible Alternatives

No drop-in replacements are available for all applications. Previous studies[6] failed to identify adequate substitutes that did not have potentially similar or greater risks for environment and health.

Substitution of TBBP-A would require revision of nearly every product in our member companies' portfolio for both of the applications discussed above. It is anticipated that it will be extremely difficult to find alternatives that meet all performance and safety requirements, especially for PCB laminate materials.

Monitoring and control instrumentation relies on parameters inherent to the printed circuit board materials and trace layout to enable products to meet performance demands exceeding those of the products under test. Change to the board material would require a minimum board re-layout and product requalification (EMC, safety, reliability, environmental) presuming performance could be duplicated with a new material. Forced substitution would require premature design cycling of the entire portfolio and would risk market withdrawal of products which could not meet specifications with new materials.

While Halogen-free PCB laminate materials are available today, they do not exist for all applications, especially in high-frequency circuitry. Those that do exist do not have all necessary safety approvals.

4. Cost implications resulting from potential restriction

A full supply chain survey will be needed to be able to confirm and quantify impacted parts in finished EEE products. At this stage, our assessment is that potential restriction would impact the entire product portfolio.

In addition, substantial costs will result from the update and validation of product safety third-party certifications required for any changes to safety critical parts.
Given the critical applications of our products and the very long lifetime, the component certifications are critical to ensure product safety.

Restricting TBBP-A will lead to:

- Forced redesign and requalification testing of entire portfolio;
- Lost opportunity for introduction of new, cutting edge products;
- Withdrawal of products from EU market.
- Impacts on innovation of users unable to access withdrawn products.

5. Time needed

[6] https://echa.europa.eu/documents/10162/17c7379e-f47b-4a76-aa43-060da5830c07

Substantial research and testing of the performance of alternatives and reliability of substitution in the supply chain is required to be in a position to estimate the timing for compliance with potential restriction. This effort is similar to the experience we had with RoHS I, and we anticipate that at least 12 years will be needed for category 9 industrial products to comply with the restriction in polycarbonates. A review period of 12 years has become the standard in the context of REACH authorisation decisions for industrial uses[7]. A restriction on the reactive use of TBBP-A in the formulation of PCB laminates would be considered catastrophic as it would likely lead to a much higher percentage of product market withdrawal due to cost, effort and extent of required redesign even if suitable substitutes could be identified for some products.

6. Need for exemptions

If TBBP-A in non-PCB applications is restricted under RoHS, this restriction should not immediately apply to Category 9 industrial producers. Further research by Commission services will be required to define what exemptions will be necessary should this restriction apply to our sector.

TBBP-A as used in the formulation of PCB laminates should by definition not be considered for restriction under RoHS since it will not be present in homogeneous materials, but if such a restriction is contemplated it must not apply to Category 9 industrial products.

Indium phosphide

1. Number of products and quantity of substance in T&M equipment

At this stage, it is difficult to evaluate the exact number of products impacted as well as the precise content of the substance in our products.

To our knowledge, Indium phosphide is used in laser diodes, photodetectors, fiber optic transceivers, specialized LEDs, heterojunction bipolar transistors (HBTs, building blocks for semiconductors and high-end integrated circuits); all commonly used in industrial monitoring and control instruments. The actual quantity of InP is not readily available due to the lack of full materials composition information in the vast majority of parts RoHS conformity declarations.

We estimate that custom components developed and produced by T&M Coalition members will not exceed 2kg of InP in finished equipment sold into the EU market annually.

[7] https://echa.europa.eu/applications-for-authorisation-explained;

https://echa.europa.eu/documents/10162/13637/tecch_report_socioeconomic_impact_reach_authorisations_en.pdf

Each producer will need to run in-depth supply chain surveys to get confirmation and to quantify purchased parts across our portfolios. In the absence of this information and the broad use of this substance, T&M Coalition members anticipate that the entire portfolio of products will be impacted.

To our current knowledge, the substance would typically represent a very insignificant part of the total product weight.

2. Function

Indium phosphide uniquely enables high power and/or high frequency performance components and various functionalities of opto-electronic devices.

Indium phosphide wafer is an important semiconductor material which has superior electrical and thermal properties , compared to silicon wafer and GaAs wafer , Indium phosphide wafer has higher electron mobility, higher frequency , low power consumption , higher thermal conductivity and low noise performance.[8]

Indium phosphide has been a focus of development since the early 1980s, and today the material is being used as a platform for a wide variety of unique applications including RF & microwave components, fiber communications components, including lasers, specialized LEDs, semiconductor optical amplifiers, modulators and photo-detectors.

The Heterojunction bipolar transistor (HBT) is a type of bipolar junction transistor (BJT) which uses differing semiconductor materials for the emitter and base regions, creating a heterojunction. The HBT improves on the BJT is that it can handle signals of very high frequencies, up to THz. HBTs provide very high gain and have very broad functionality; commonly used in modern ultrafast circuits, mostly radio-frequency (RF) systems, and in applications requiring a high power efficiency, such as RF power amplifiers. HBTs are the workhorse device for such high-performance circuit designs; and are used to enhance gain-bandwidth product and output power, harmonic injection to improve linearity, and active load termination to extend the overall bandwidth.

The use of Indium phosphide is vital to Category 9 industrial high frequency components in addition to the high power applications. This has been already acknowledged by Öko-Institut in its report from 2014[9].

3. Possible Alternatives

At this stage, there are no known alternatives that meet equivalent performance specifications or can assure the reliability of substitution required for of Category 9 industrial equipment.

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[8] http://semiwafer.com/inp%20wafer.html

[9] http://ec.europa.eu/environment/waste/rohs_eee/pdf/2.%20Oeko%20Study%20on%20the%20review%20of%20the%20RoHS%20scope%20review.pdf

Indium phosphide devices outperform other semiconductor materials such as Complementary metal–oxide–semiconductor (CMOS), Silicon-germanium (SiGe), Gallium Nitride (GaN) and Gallium arsenide (GaAs). These cannot match the transistor performance of Indium phosphide for high-frequency applications. Indium phosphide is superior to GaAs in its electron peak velocity, negative differential resistivity, immunity to side gating, radiation hardness and thermal conductivity[10].

Indium phosphide is only used to produce components where its performance benefits are necessary. Raw material cost premiums coupled to lower efficiency production processes naturally restrict the use of this substance.

Category 9 industrial equipment's potential performance will be severely degraded by reverting to lower-performance materials in affected high power, high frequency and opto-electronic devices.

4. Cost implications resulting from potential restriction

Suitable alternatives do not exist for any application utilizing Indium phosphide. Restriction of the substance will lead to forced massive market withdrawal impacting a vast array of industry sectors; including Aerospace & Defence; all high-speed communications; as well as the whole of the electronics industry.

Considering the specific aspects related to Category 9 industrial sector, the costs associated with assessing substitutes for potential replacement of Indium phosphide are substantial with no guaranteed result.

5. Time needed

As there are no known alternatives to Indium phosphide in the above critical applications, it is clearly impossible to provide any timeline.

6. Need for exemptions

If Indium phosphide is restricted under RoHS, this restriction must not apply to Category 9 industrial equipment. Considerable research will be required by the Commission services to document all current applications of Indium phosphide, which will each require an appropriate exemption to be made available.

Medium chain chlorinated paraffins (MCCPs)

1. Number of products and quantity of substance in T&M equipment

[10]Technology and Application of Indium Phosphide and Related Semiconductors. http://www.dtic.mil/dtic/tr/fulltext/u2/a208251.pdf

At this stage, it is difficult to evaluate the exact number of products impacted as well as the precise content of the substance in our products. This information is not readily available due to the lack of full materials composition information in the vast majority of parts RoHS conformity declarations.

Each producer will need to run in-depth supply chain surveys to get confirmation and to quantify impacted parts using MCCPs across our portfolios.

In the absence of this information and the potential broad use of this substance, T&M Coalition members anticipate that the entire portfolio of products will be impacted. To our current knowledge, the substance would typically represent a very insignificant part of the total product weight.

2. Function

MCCPs are known to be used both as a plasticiser and a flame retardant. Currently, over a very large number of formulations are in use for a wide range of industrial applications, as described in the Öko-Institut Consultation notes..

3. Possible Alternatives

To date, no known suitable alternative exists which can perform all functions of MCCPs.

It is anticipated that no direct substitution that can be consistently applied, different solutions will need to be specifically tailored in each applicable use. This will extend the time needed to determine if the reliability of substitutes is assured for our sector's applications.

In addition, for each potential alternative to flame retardant applications, updates to the product safety third-party certifications will be needed. The assurance of component certification continuity by the supply chain critical to our maintenance of product safety.

4. Cost implications resulting from potential restriction

Further insight into performance of alternatives and reliability of substitution in the supply chain is required to be able to assess the total impact of potential restriction. It is anticipated that raw component costs will directly increase.

In absence of suitable alternatives, producers will be forced to redesign, test and requalify the entire portfolio. This will have severe negative impact on the product availability and innovation not only on Category 9 industrial producers but also on our customers.

5. Time needed

Substantial research and testing of the performance of alternatives and reliability of substitution in the supply chain is required to be in a position to estimate the timing for compliance with potential restriction. This effort is similar to the experience we had with RoHS I, and we anticipate than 12 years will be needed for category 9 industrial products to comply with the restriction.

6. Need for exemptions

Substantial research and testing of the performance of alternatives and reliability of substitution in the supply chain is required to be in a position to estimate the timing for compliance with potential restriction. This effort is similar to the experience we had with RoHS I, and we anticipate that 12 years will be needed for category 9 industrial products to comply with the restriction. A review period of 12 years has become the standard in the context of REACH authorisation decisions for industrial uses[11].

Beryllium and its compounds

1. Number of products and quantity of substance in T&M equipment

At this stage, it is difficult to evaluate the exact number of products impacted as well as the precise content of the substance in our products.

The actual quantity of Beryllium and its compounds is not readily available due to the lack of full materials composition information in the vast majority of parts RoHS conformity declarations. Each producer will need to run in-depth supply chain surveys to get confirmation and to quantify purchased parts across our portfolios. In the absence of this information and the broad use of this substance, T&M Coalition members anticipate that the entire portfolio of products will be impacted.

To our current knowledge, the substance would typically represent a very insignificant part of the total product weight.

2. Function

Beryllium and its compounds are critical elements of connectors; and components in switches and attenuators; probe tips and contacts, HRF connectors, and springs and gaskets to ensure EMC compliance. It is used to assure long life, reliability and consistent electrical performance in moving/mating parts over the extended lifetime of Category 9 industrial equipment. Beryllium oxide is specifically used in the ceramic encapsulation of high-power semiconductors to provide efficient thermal

[11] https://echa.europa.eu/applications-for-authorisation-explained;
https://echa.europa.eu/documents/10162/13637/tecch_report_socioeconomic_impact_reach_authorisations_en.pdf

management and effective heat dissipation. General uses common to other sectors are outlined in the Öko-Institut consultation document.

Beryllium Copper (BeCu) distinguishes itself by high fatigue strength, outstanding relaxation resistance at elevated temperatures and a unique combination of high strength and excellent electrical conductivity. In addition, this material is heat treatable, which means that it can be formed in a soft state, then hardened by exposure to a designated temperature for a prescribed period of time. Heat treating improves the wear and spring characteristics of the material, allowing it to be used to make electrical contacts and components. This makes is ideal for machined parts used in high performing electronic measurement equipment. BeCu is plated after machining which eliminates exposure to contact.

> "Beryllium is a scarce and expensive metal and so is essentially used only where no suitable substitutes exist. Therefore, it is very probable that most manufacturers will have already looked for alternatives and switched wherever possible. In consequence the remaining uses are those where the high performance of beryllium cannot be equalled which implies that and all current uses would require exemptions if this were restricted"[12].

The commercial grades of beryllium copper contain 0.4 to 2.0 percent beryllium. The small ratio of beryllium to copper creates a family of high copper alloys with strength as high as alloy steel. The first of the two families, C17200 and C17300, includes high strength with moderate conductivity, while the second family, C17500 and C17510, offers high conductivity with moderate strength[13]. The principle characteristics of these alloys are their excellent response to precipitation-hardening treatments, excellent thermal conductivity, and resistance to stress relaxation.

Beryllium and its compounds are only used to produce components where performance benefits are necessary. Raw material cost premiums coupled to stringent EHS controls for the production processes naturally restrict the use of this substance.

3. Possible Alternatives

At this stage, there are no known alternatives that meet equivalent performance specifications or can assure the reliability of substitution required for of Category 9 industrial equipment.

We have become aware of a single-source supplier for a beryllium-free alloy being marketed for use in high-reliability connectors, but this does not provide either assurance of supply chain availability nor has the substitute been evaluated for use in all our Category 9 industrial applications.

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[12] Compliance & Risks subscription service update: RoHS additional substances proposals consultation assessment from RINA – (Dr Paul Goodman)

[13] https://www.avivametals.com/collections/beryllium-copper

Product performance, reliability and longevity will be degraded by reverting to lower-performance materials in affected measurement devices and probing solutions. As a result, compliance to EMC Directive may not be possible for some applications.

4. Cost implications resulting from potential restriction

Suitable alternatives do not exist for all applications utilizing Beryllium and its compounds in Category 9 industrial equipment.

BeCu use is ubiquitous in the connector business and many if not all of our products would have to be redesigned. BeCu could be substituted only if our suppliers were to redesign their component product. Unfortunately due to the low volumes in our industry, it is likely that suppliers will discontinue the production of subparts and this will lead to forced obsolescence of our products.

Restriction of the substance will lead to forced massive market withdrawal impacting a vast array of industry sectors; including Aerospace & Defence; Communications; Research as well as the whole of the electronics industry.

5. Time needed

Substantial research and testing of the performance of alternatives and reliability of substitution in the supply chain is required to be in a position to estimate the timing for compliance with potential restriction. This effort is similar to the experience we had with RoHS I, and we anticipate that 12 years will be needed for category 9 industrial products to comply with the restriction. A review period of 12 years has become the standard in the context of REACH authorisation decisions for industrial uses[14].

6. Need for exemptions

If Beryllium and compounds are restricted under RoHS, this restriction should not immediately apply to Category 9 industrial producers. Further research by Commission services will be required to define what exemptions will be necessary should this restriction apply to our sector.

Nickel sulphate and nickel sulfamate

1. Number of products and quantity of substance in T&M equipment

It is our understanding that these substances are only used as intermediate chemicals in processes such as electroplating of nickel metal. These substances will

[14] https://echa.europa.eu/applications-for-authorisation-explained;
https://echa.europa.eu/documents/10162/13637/tecch_report_socioeconomic_impact_reach_authorisations_en.pdf

not occur in electrical equipment so a restriction would give no health or environmental benefits as they are not present.

2. Function

No known presence of these substances in homogeneous material of components or in finished electrical and electronic equipment.

3. Possible Alternatives

As there is no known presence of these substances in homogeneous material of components or in finished electrical and electronic equipment; alternatives are irrelevant.

4. Cost implications resulting from potential restriction

Not applicable

5. Time needed

Not applicable.

6. Need for exemptions

Not applicable.

Cobalt dichloride and cobalt sulfate

1. Number of products and quantity of substance in T&M equipment

It is our understanding that these substances are only used as intermediate chemicals in processes. These substances will not occur in electrical equipment so a restriction would give no health or environmental benefits as they are not present.

2. Function

No known presence of these substances in homogeneous material of components or in finished electrical and electronic equipment.

3. Possible Alternatives

As there is no known presence of these substances in homogeneous material of components or in finished electrical and electronic equipment; alternatives are irrelevant.

4. Cost implications resulting from potential restriction

Not applicable.

5. Time needed

Not applicable.

6. Need for exemptions

Not applicable.