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Process Management

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(Sent by email to exemptions@oeko.de)

Dear Ms Zangl and Colleagues,

Subject: **Adaption to scientific and technical progress under directive 2002/95/EC**

Stakeholder comments made in support of continued Exemption 7(c) Lead in electronic ceramic parts (e.g. piezoelectronic devices)

Emerson Process Management owned companies including Mobrey Measurement, Daniel Measurement and Control, Rosemount and Micro Motions are engaged in the design, manufacture and supply of industrial sensors and industrial measuring instruments some of which use technology based on Lead Zirconate Titanate (PZT) piezo ceramic compounds (lead in ceramic).

When processed into fired ceramic parts, PZT is a highly stable piezo material used to generate and sense vibrations and ultrasonic signals passed through air and liquids. These signals are used in the measurement of liquids and bulk powders in the following applications:

- Tank storage level measurement and control
- Flow metering and control
- Density measurement and control
- Viscosity Measurement and control

The industries using these sensors and measuring instruments within the EU include amongst others:

- Water supply
- Sewage and waste treatment
- Power generation
- Chemical processing, storage and distribution
- Oil refining, fuel storage and distribution
- Pharmaceutical manufacturing
- Food and beverage production, storage and packaging.

Significantly, these sensors and measuring instruments are often required to operate in applications where; (1) explosive and ignitable liquids, powders and gasses limit the levels of current and voltage than can be supplied, and; (2) where the application temperatures involved require the use of the highest available temperature stable piezo electronic devices.

In addition, the lead used in PZT based piezos is lead oxide and when fired to produce ceramic parts, the structure is not easily broken down and hence poses minimal risk to the environment after the instrument is withdrawn from use. Further information and documents are enclosed for consideration by the Öko-Institute and Fraunhofer IZM.

Should the researchers, scientists and engineers from the Öko-Institute and Fraunhofer IZM wish to know more about the applications of PZT based piezoelectronic devices used by Emerson Process Management companies in their sensors and instruments, or to discuss these comments in support of continued exemption further, please contact David Aniszewski at Mobrey or Keith Groeschel at Daniel using the email addresses below.

Yours sincerely,

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Lead Free Reliability Review Project
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Enclosed

Answers to Specific Questions Section 7C.
Response document to General Questionaire
Review of alternative piezo materials
Report on the trial of Bismuth Titanate by Daniel Measurement and Control

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Adaptation to scientific and technical progress under Directive 2002/95/EC Stakeholder consultation

Specific Questions Section 7C.

1. **What are the different applications of Lead in electronic ceramic parts ?**

   Emerson Process Management companies are concerned only with lead as used in PZT based piezo ceramic components (piezoelectronic devices). PZT based piezoelectronic components are used to generate and detect vibrations or ultrasonic signals in the industrial sensors and measuring instruments they are used in.

2. **What is the amount of lead per application, the lead content in the homogeneous material, the annual production volume as well as the number of applications related to exemption 7(C) put on the market annually ?**

   A typical crystal weighs between 1 and 19 grams and contains between 50% and 70% of Lead in the form of Lead Oxide within any PZT compound. Emerson Process Management companies currently supply in the order of twenty thousand sensors and five thousand measurement instruments per year into EU based customers. A typical weight of a sensor is 1KG and the typical weight for the transducer, it's housing and fitments for liquid, density and flow measuring instruments is typically between 10 and 100 KG.

   The percentage weights do not exceed 0.01% in any product and are below .0000001% in the largest measuring instruments when shipped with largest permanently welded pipe flanges.

   The homogenous material weight of lead within Emerson Process Management sensors and measuring instruments to EU customers is 0.025 metric tons.

3. **Please explain whether and how lead can be substituted in the different applications in ceramics**

   Emerson Process Management companies frequently review the designs of their product to improve their safety and reliability and to improve performance. Whilst other piezo materials are known, none can be considered as suitable substitutes to PZT piezo ceramic compounds when fired to make piezoelectronic devices, in terms of overall performance in conversion efficiency and manufacturability.

4. **Please provide a roadmap or similar evidence with activities, milestones and timelines towards a replacement of lead in these applications.**

   Many commercially available lead free piezo ceramic compounds have been reviewed for current and future product designs. Currently none are suitable substitutes.

5. **Do you consider thick film applications to be covered by the current wording of exemption 7(c)? This not applicable to the comments made in support of continued exemption for piezo devices**

   No. Thick film ceramic substrates are not the same as piezo ceramic materials and are not piezoelectronic components.

Adaptation to scientific and technical progress under Directive 2002/95/EC Stakeholder consultation

General questionnaire

- **For which substance(s) or compound(s) should the requested exemption be valid?**

  Lead in electronic ceramic parts (e.g. piezoelectronic devices)

- **What is the application in which the substance/compound is used for and what is its specific technical function?**

  Piezoelectronic devices are used to create and sense vibrations and ultrasonic signals. The measurement of these vibrations and signals allows for instrumentation to calculate and communicate static and changing levels, flow, density and viscosity of mainly liquids but in some cases powders as well.

- **What is the specific (technical) function of the substance/compound in this application?**

  Polarized piezo ceramic parts exhibit the characteristic of vibrating when a voltage is applied. Conversely when compressed by sound pressure they produce a voltage which can measured.

- **Please justify why this application falls under the scope of the RoHS Directive (e.g. is it a finished product? is it a fixed installation? What category of the WEEE Directive does it belong to?).**

  Piezoelectronic devices are electronic components. Components are not finished products and when placed on the market as individual items are outside the scope of the WEEE Regulations. When finished product containing components which include restricted chemicals are placed on the market, or when discarded as WEEE, the components will contribute to the reported weight of EEE or WEEE.

  One of the main elements of PZT based piezoelectronic devices is the restricted chemical lead (Pb) and as such the weight of lead might be reported under WEEE. However PZT based piezoelectronic devices are currently exempt under the classification of “Lead in ceramics” and need not be reported.

- **What is the amount (in absolute number and in percentage by weight) of the substance / compound in: i) the homogeneous material1, ii) the application and iii) total EU annually for RoHS relevant applications?**

  Answered in **Specific Questions Section 7C.**

- **Please check and justify why the application you request an exemption for does not overlap with already existing exemptions respectively does not overlap with exemption requests covered by previous consultations.**

  To the best of our knowledge there are no overlapping exemption requests for the category "Lead in electronic ceramic parts (e.g. piezoelectronic devices)."

  However, the sensors, measuring instruments and controls Emerson Process Management companies design, manufacture and supply are currently exempt under category 9 exemptions of WEEE as they are monitoring and control instruments; or, in many installations they can also be regarded as exempt under category 6 exemptions; large-scale stationary industrial tools.

  Progress in understanding the reliability issues surrounding lead free soldering in electronic assemblies might one day result in the removal of category 6 and 9 exemptions. In which case, it is important to make the **distinction** between a component which has had tin-lead plating on its soldered leads replaced with Pb free plating and Pb based piezoelectronic devices which are made largely of lead oxide.

  Hence, "Lead in ceramics (e.g. piezoelectronic devices)" must be reviewed as a separate category of parts to both electronic components and products currently exempt under category 9 of the WEEE Directive.

- **Please provide an unambiguous wording for the (requested) exemption. Documentation provided by stakeholders including replies to the questions above should take the following points into consideration:**

  Lead in electronic ceramic parts (e.g. piezoelectronic devices)

- **Please justify your contribution according to Article 5 (1) (b) RoHS Directive whereas:**

  - **Substitution of concerned hazardous substances via materials and components not containing these is technically or scientifically either practicable or impracticable;**

    Please see the review of commercially available substitutes by Mobrey Physicist Dr. Su. J. Zhang.

  - **Elimination or substitution of concerned hazardous substances via design changes is technically or scientifically either practicable or impracticable;**

    Daniel Measurement and Control has trialled the use of an alternative to PZT. The trial report J-01284 Rev B is enclosed for consideration by the researchers, scientists and engineers of the Öko-Institute and Fraunhofer IZM.

    "The results of the simulation show a reduction in signal output from the bismuth titanate piezo elements. A 5-6X reduction in signal pressure output will occur on the transmitting transducer and although not simulated a similar reduction in voltage output is expected to occur on the receiving transducer as well. This could be up to 30dB of signal loss in our application. This would have a significant negative impact on our measurement."

- **Negative environmental, health and/or consumer safety impacts caused by substitution are either likely or unlikely to outweigh environmental, health and/or consumer safety benefits thereof (If existing, please refer to relevant studies on negative or positive impacts caused by substitution).**

  Re: Negative environmental, health and or consumer safety impacts caused by substitution….

  In relation to WEEE, Emerson companies have been unable to identify any studies detailing the effects from PZT and their alternatives once fired into ceramic.

  In the EINECS (European INventory of Existing Commercial chemical Substances) database, accessed through a web site operated by the Toxicology and Chemical Substances (TCS) Unit, known as European Chemicals Bureau (ECB), PZT is recognised by its CAS number. The collection of further data for CAS Number 12626-81-2 and under its EC Number 235-727-4 was placed by the bureau in its lowest priority category. For this chemical the web site stated "This substance is not listed in a priority list (as foreseen under Council Regulation (EEC) No 793/93 on the evaluation and control of the risks of existing substances.)."

  Council Regulation (EEC) No 793/93 has now been repealed to be replaced by Regulation (EC) No 1907/2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) and the work of ECB is now to be coordinated by the European Chemicals Agency (ECHA).

  Further information on any negative environmental and safety effects from PZT based ceramics and their alternatives should be available according to their CAS number or their EC Number in due course as the suppliers are required to register chemicals with an annual usage of 10 tonnes or more with the ECHA. However, the Material Safety Data Sheets (MSDS) for PZT and some of the alternatives are enclosed for consideration by the consultants and engineers of the Öko-Institute and Fraunhofer IZM.

  Re: Benefits of retaining PZT based piezo ceramic compounds as the basis of preferred fired ceramic piezoelectronic devices where used in industrial sensors and measuring instruments…..

  There have been numerous examples of industrial accidents where the consequences to the environment and human safety have been negative. With the release of the final report on the explosion at the Buncefield fuel storage depot (Hemel Hempstead, England), an increased focus by the oil, gas, chemical and other process industries can be expected on high integrity systems for safety warning and automated control.

  Emerson Process Management companies manufacture for and supply industrial sensors and measuring instruments into hazardous environments where safety and reliability are a fundamental part of product design. Where these designs include ultrasonic transducers based on piezoelectronic devices, then where used, fired PZT compounds will have specific benefits over alternative fired piezo compounds. Additionally, because they are not reliant on moving parts, ultrasonic sensors and measuring instruments can be amongst the safest in their respective applications. The use of PZT as one of the most efficient piezo compounds also serves to reduce to a minimum the amounts of voltage and current required by equipment in their respective applications in general and more specifically in explosive environments.

  Since 2003, equipment intended for use on sites such as Buncefield are required to meet EU Directive 95/9/EC Equipment and Protective Systems intended for use in Potentially Explosive Atmospheres (ATEX).

Should the exemption for "Lead in Ceramics (e.g. piezoelectronic devices)" not be continued then it is likely that replacement ATEX approved ultrasonic sensors and measuring instruments using lead-free piezo electro ceramic devices would not be available for several years.

Included is a table of some of the ATEX approved Emerson Process Management vibration and ultrasonic sensors, measuring instruments and controls based on PZT compounds fired into piezo ceramic devices.

Emerson Process Management company and product	Current ATEX approvals held
Rosemount 8800D Series Vortex Flow Meter	ATEX II 1 G EEx ia IIC T4
Daniel 3804 Liquid Ultrasonic Flow Meter	ATEX II 2 G EEx d ia IIB T4
Mobrey Squitch Gap Sensors	ATEX II 1 G EEx ia T5
Mobrey 433 Tank Mount Gap Sensors	ATEX II 1 G EEx ia T5
Mobrey Electrosensor	ATEX II 1 G EEx ia C T4
Mobrey Electropulse	ATEX II 2 G EEx d II C T4
Micro Motion 7826 Insertion Density Transmitter	ATEX II 2 G EEx d II C T4
Micro Motion 7829 Viscomaster	ATEX II 2 G EEx d II C T4
Mobrey MSM448 Sludge Gap Sensor	ATEX II 1 G EEx ia II C T5
Mobrey MSP900SH Ultrasonic Transmitter	ATEX II 1 G EEx ia IIC T6
Rosemount 3105 Ultrasonic Transmitter	ATEX II 1 G EEx ia IIC T6
Squing 2 Vibrating Fork Level Switch	ATEX II 1 G D EEx ia, IIC T5 EExd IIC T6
Rosemount 2120 Fork Level Switch	ATEX II 1 G D EEx ia, IIC T5 EExd IIC T6

The use of Emerson Process Management's ultrasonic sensors and measuring instruments is of course not restricted only to ATEX applications. This is given as only one example. Other industries achieve significant benefits due to overall cost and reliability where these products use PZT based piezoelectronic devices.

- **Please provide sound data/evidence on why substitution / elimination is either practicable or impracticable (e.g. what research has been done, what was the outcome, is there a timeline for possible substitutes, why is the substance and its function in the application indispensable or not, is there available economic data on the possible substitutes, where relevant, etc.).**

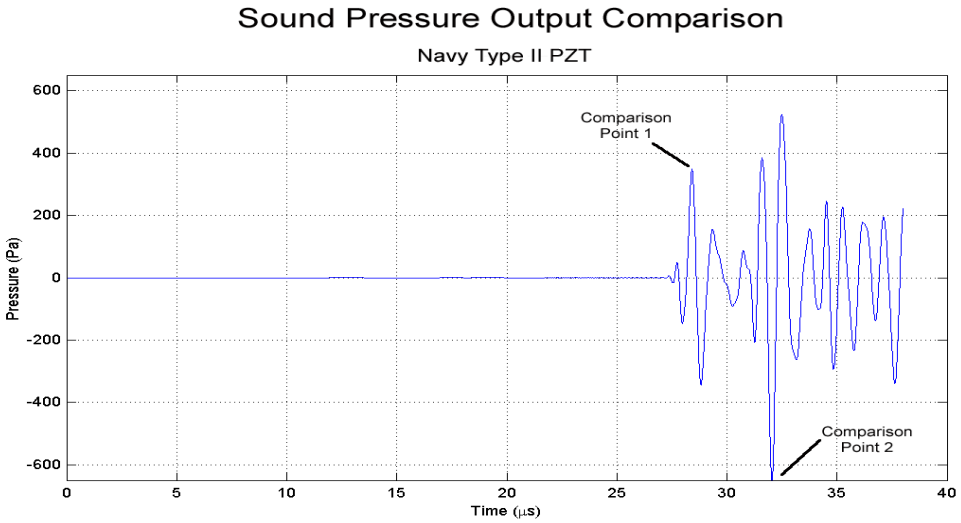
  Lead Zirconate Titanate (PZT) has the highest piezoelectric constant of the commercially available piezo compounds. This property makes PZT the most efficient at converting electrical energy to acoustic sound pressure

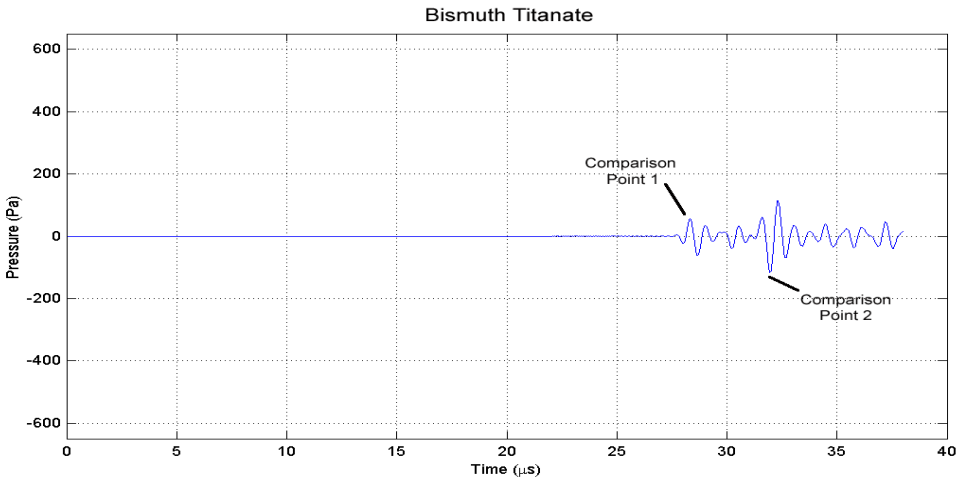
  Daniel Measurement and Control have trialled the most promising of the substitute materials and offer the following results:

Summary of simulation results for sound Pressure Output Comparison between PZT and lead free alternate bismuth titanate. Results shows approx 5-6x (15dB) reduction is pressure output.

Sound Pressure Output Comparison

Piezo Material	Comparison Point 1 (Pa)	Comparison Point 2 (Pa)	Comparison Point 1 (dB - SPL)	Comparison Point 2 (dB - SPL)
Navy Type II PZT	355	650	145.0	150.2
Bismuth Titanate	60	120	129.5	135.5
Pressure Output Reduction Factor	5.9	5.4		
Pressure Output Reduction (dB)	15.4	15		





There are numerous academic papers reviewing the possibilities of alternative lead-free compounds. However, piezo electro ceramic part manufactures need to drive the adoption and substitution of lead free alternates. For Emerson's manufacturing companies which already use the highest performance piezo materials, it is highly impractical to plan for using any substitutes until they are recognised as commercially available and meet the performance specifications and cost of PZT.

- **Please also indicate if feasible substitutes currently exist in an industrial and/or commercial scale for similar use.**

  For some commercial and possibly industrial applications other compounds are known to have piezo properties, These include but are not limited to Barium Titanate, Bismuth Titanate, Copolymers and Electromechanical film.

- **Please indicate the possibilities and/or the status for the development of substitutes and indicate if these substitutes were available by 1 July 2006 or at a later stage.**

  Today there continues to be no suitable substitutes commercially available for PZT based piezo electro ceramic parts that Emerson Process Management have not already considered or trialled in the development and manufacture of their sensors and measurement instruments where PZT based piezo electro ceramic parts are used.

- **Please indicate if any current restrictions apply to such substitutes. If yes, please quote the exact title of the appropriate legislation/regulation.**

  Emerson Process Management companies are not aware of legislative restriction on the use of alternative piezo compounds to PZT.

- **Please indicate benefits / advantages and disadvantages of such substitutes**.

  - Barium Titanate, Available but not efficient in electro-mechanical conversion and would not tolerate the operational temperatures of industrial applications.
  - Bismuth Titanate, Available and would operate at required temperatures but not efficient in electro-mechanical conversion.
  - Copolymers Available but not efficient in electro-mechanical conversion and would not tolerate the operational temperatures of industrial applications.

- **Please state whether there are overlapping issues with other relevant legislation such as e.g. the ELV Directive that should be taken into account.**

  The End of Life Vehicles Directive Annex II Materials and components exempt from Article 4 (2)(a), includes "Electrical components which contain lead in a glass or ceramic matrix compound except glass in bulbs and glaze of spark plugs".

  The directive advises the "dismantling" (taken to mean extraction of lead) of the piezo parts if the weight of lead exceeds 60 grams.

The Öko-Institute is possibly the best placed authority to know whether this exemption will be retained as they hold the assignment for the "Adaption to scientific and technical progress of Annex II Directive 2000/53/EC". The evaluation task is presented as "Proposal for removing existing exemption. It is to be checked whether the use of lead is avoidable due to the availability of substitutes."

If a transition period between the publication of an amended Annex is needed or seems appropriate, please state how long this period should be for the specific application concerned

It is obviously difficult to answer a hypothetical question with specific time scales but Daniel Measurement and Control's evaluation that it would take two years to produce a working model using a possible substitute material is probably correct. The time taken to tool such a product would take another year and the time to achieve all of the necessary approvals would take a further year. However, there is no certainty that ATEX and other approvals would be granted.

The numbers of sensors and measuring instruments and the numbers of variant types offered by Emerson Process Management companies also far exceed the numbers of available design engineers to simultaneously work on replacement products.

Were the exemption for "Lead in Ceramics (e.g. piezoelectronic devices)" not be continued then the replacements designs using inferior (for the applications) substitute piezo materials would be several years.

The equipment manufacturers using PZT based piezoelectronic devices in their ultrasonic sensors and measuring instruments might take the least satisfactory approach (to EU industry) of withdrawing product from sale within the EU whilst continuing to produce the same products for the remaining world markets.

Internet links to the same examples of some of Emerson Process Management companies' ATEX approved ultrasonic products previously listed, are provided as additional information for consideration by the researchers, scientists and engineers of the Öko-Institute and Fraunhofer IZM

http://www.emersonprocess.com/Rosemount/document/pds/00813-0105-4004.pdf
http://www.emersonprocess.com/daniel/products/gas/usonic/seniorsonic/Ds_Sheets/DAN_USM_B_FAMILY_0405.pdf
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