Summary and commentary on the inclusion of metallic lead to the list of substances subject to authorization and the impacts of such a classification on the cultural heritage in Europe

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related material: lead (Pb)
EC Number: 231-100-4
CAS number: 7439-92-1
Application: pure metallic material and alloys with varying proportions of other metals in craft, artisanal, artistic and restoration work on and with objects of cultural and/or historic value.

1. The sectors affected

Craft, artisanal, artistic, and restoration work on and with objects of cultural and/or historic value does not include industrial applications.
The following trades would be affected in particular by a ban:

1.1. The traditional construction of pipe organs and the preservation and restoration of historic pipe organs and music automatons. Organ pipes of all types and sizes are at the heart of complex musical instruments. These only retain their full meaning and context if they can be preserved in working condition and played. At the same time keeping them in function is the basis for maintaining and passing on the knowledge about their operation and the interpretation of musical organ works.
The traditional expertise of organ builders, as well as the associated craft techniques, were recognized as Intangible Cultural Heritage of Humanity by UNESCO in 2017.
Organs as living cultural heritage, some of them centuries old, are still part of church liturgy and active music reception today. Because of this important function, it is not only important to preserve historic specimens, but it should also remain possible to commission and build new instruments of this kind.
Most of the historical pipe organs and related instruments built in the last decades have been equipped with electric wind generators today, but this does not mean that they can be regarded as "electric devices" from modern industrial production.

Their traditional manufacture and maintenance (as well as handing on the knowledge and techniques needed to do so) require a variety of different materials. Various tin-lead alloys are irreplaceable for metal pipes, reed nuts, and lead conductors for wind control.
Only this multitude of different tin-lead alloys, which are joined together with lead-containing soldering materials, have the necessary malleability, and produce the typical sound that cannot be achieved with any other material. Lead therefore is also a basic requirement for authentic musical reproduction of historical and contemporary organ works and the knowledge about how to play these highly complex instruments. When the instruments are operated, neither performers nor audience have direct contact with the components containing lead.

Organs and their pipes are characterized by an exceptionally long service life and functional period (usually well over 100 years).

Figure 1

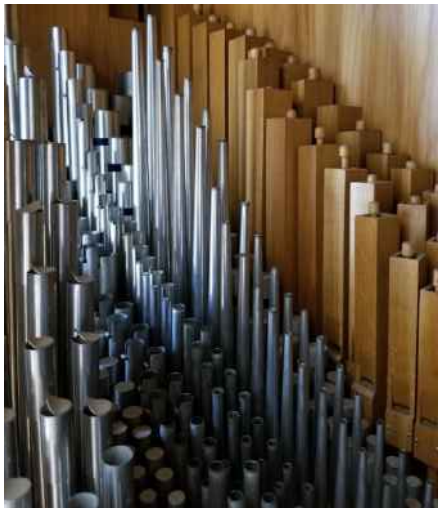

Figure 2

Figure 3

Figure 4

1.2. The traditional manufacture, repair, and restoration of brass instruments. Like for pipe organs, the joining of metal components with lead-containing soldering materials plays a decisive role in the craft manufacture of brass instruments, their repair and restoration. Solder materials made of lead-containing alloys are irreplaceable here too due to their specific technical and acoustic properties.

Figure 5

Figure 6

Figure 7

1.3. The traditional manufacture, repair, and restoration of various other musical instruments.
Metallic lead and lead-containing alloys are also found in other historical musical instruments. These are, for example, transverse flutes and other wind instruments of the 19th century, in fortepianos or the mechanism of glass harmonicas. Corresponding wind instruments are only presented in museums today, where visitors have no direct contact with it. The professionals in charge of the exhibitions are trained in handling lead-containing exhibits and comply with all prescribed safety measures. However, fortepianos are still regularly played in the context of historically informed performance of musical works, where neither musicians nor audience have direct contact with the components containing lead.
Metallic lead and lead-containing alloys are also found in other historic musical instruments. This includes, for example, the keypads of 19th century transverse flutes, lead weights in air bellow instruments or the flywheels of glass harmonicas, wind instruments made with lead or lead alloys, or various components in stringed keyboard instruments.

Figure 8

Figure 9

1.4. The artistic, craft and artisan design of sculptures and elements made of natural stone, as well as preservation and restoration of historic stonemasonry, buildings and structures made of natural stone. Metallic lead has been an important tool in artistic and craft work on objects made of natural stone since the Middle Ages. The caulking of joints with lead wool traditionally serves as an elastic, UV-, water- and frost-resistant joint seal. Liquid lead is also required for inserting and fixating metal elements such as steel anchors or decorative parts into natural stone components. Being very resistant to weather, lead ensures a secure hold and at the same time compensates the very different expansion of stone and metal elements in the event of temperature fluctuations. The historic techniques give stable, maintenance-free, and particularly durable connections that to this day cannot be achieved with any other material.

Figure 10

Figure 11

In addition, lead pads are used for leveling, such as when setting up sculptures. In outdoor use, they are significantly more durable than plastic pads or other materials. This plays an important role especially in areas that are difficult to access, like for example church facades.

1.5. The craftsmanship of preserving, repairing, and restoring historic roofing with rolled lead sheets. Plates of rolled lead, or iron sheets coated with lead, have been used for roofing since the Middle Ages. Prominent examples include the cathedral Saint Denis near Paris, the dome of Cologne, and the Doge's Palace in Venice. Due to the special flexibility of the material, it was also used to create very complex ornamental components and shapes that could not obtained with other materials.
The faithful preservation of these historic roofs as well as a preservation of the knowledge and craft techniques necessary for this is impossible without the corresponding materials.

Figure 12

Figure 13

1.6. The design, conservation, and restoration of works of art and craft objects made of lead alloys. Since Roman antiquity, metallic lead and lead alloys have been used to make craft objects, pieces of jewelry, pilgrim badges or figurines. Today, such objects are important parts of museums and collections, but they are also part of historic buildings and monuments, or they are exhibited in other ways in public spaces.

Figure 14

Figure 15

Figure 16

Because of its corrosion resistance and easy formability, but also because of the immanent “material statement”, lead has been used by artists again and again. Thus, especially in the 18th century, but also up to the present day, large figures cast or chased from lead and other artistic ensembles were created.

Figure 17

Figure 18

Figure 19

Figure 20

Even today, the material properties of lead inspire the creativity of artists such as Anselm Kiefer, Antony Gormley or Inge Andler-Laurenz to create unique works.

Medals, ornaments and elaborately painted small figures (e.g., “tin soldiers”) cast from different lead-tin alloys were particularly widespread between the 18th and early 20th century. Some of these were contemporary arranged into impressive dioramas, which are owned by museums today. In all epochs, also elaborate sarcophagi were made of lead-tin alloys.

Figure 21

Figure 22

1.7. The design, conservation, and restoration of stained-glass windows. In this technique, which has been used since the Middle Ages, flat pieces of glass are framed using U- and H-shaped lead rods, which then are joint by soldering. Since the Middle Ages, stained glass windows of this kind have been impressive elements for both sacred and secular interiors. They not just serve as decoration or to illustrate religious beliefs, but the colorful illumination created is integral part of the overall design of the interior.

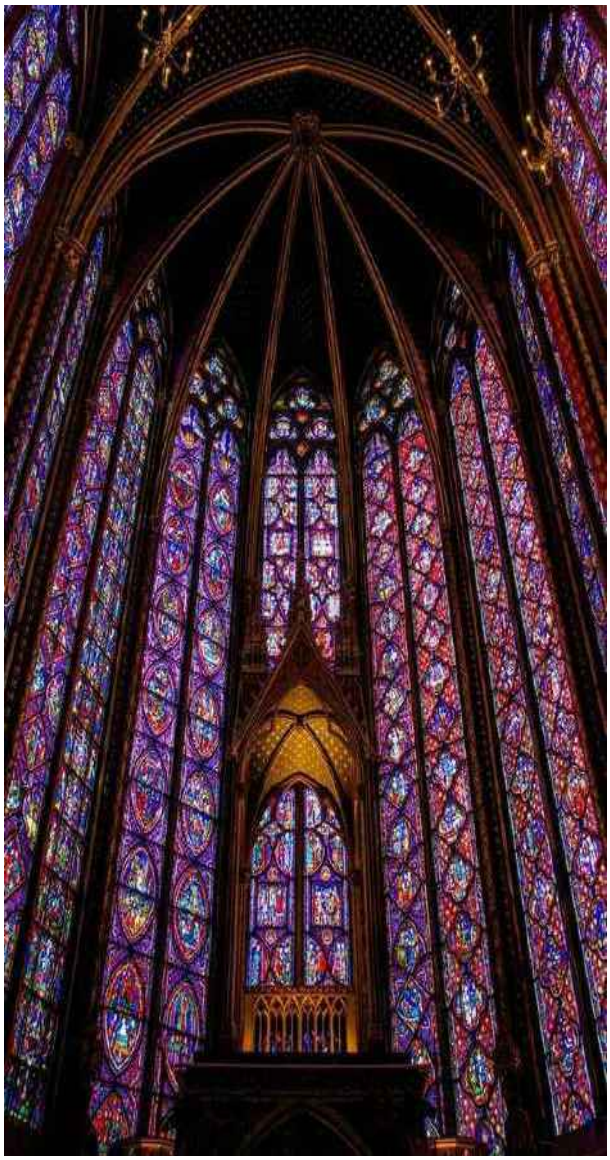

Figure 23

Figure 24

Figure 26

Figure 27

Today, the technique of joining glass elements with lead rods is predominantly used for the restoration of historic glass windows, but also in the artistic and craft design of new glazing. For example, important contemporary artists such as Neo Rauch, Thomas Kuzio or Markus Lüpertz have designed glass windows in the last years, which have been manufactured using this historic technique.

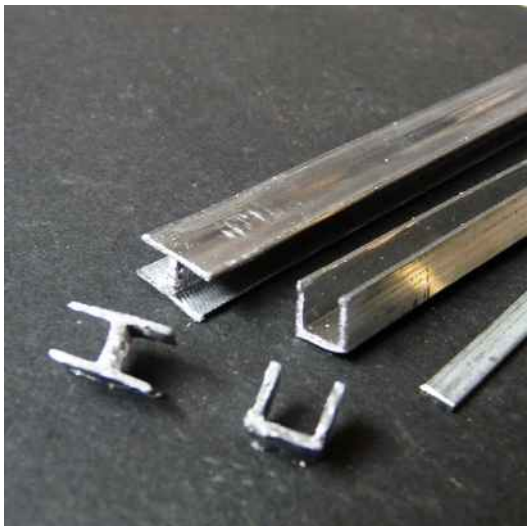

Figure 27

Figure 28

1.8. The preservation and restoration of technical heritage. Technical heritage comprises objects, that give material evidence of the history and development of technology and their impact on society and culture. This area includes, to name just a few examples:

- historic industrial plants, machines, and tools (like water or electricity plants, production facilities as well as related equipment, etc.)
- historic railroad material (like locomotives, railroad carriages, as well as facilities, production plants and equipment related to rail transport, etc.)
- historic land vehicles of all kinds (like commercial vehicles, passenger cars, motorcycles, but also equipment, facilities and production plants related to land transport, etc.)
- historic watercrafts (like passenger ships, cargo ships, military watercrafts, but also facilities, production plants and equipment related to air transport, etc.)
- historic aircraft (like airplanes, zeppelins, but also facilities, production plants and equipment related to water transport, etc.)
- a wide range of other historic objects such as Roman water pipes or devices and equipment used in medicine, research, and education

Figure 29

Figure 30

Figure 31

Figure 32

Lead-containing soldering materials, alluvial tin for the “tinning” of surfaces, leaded sheet metal, or other components made with metallic lead are often original components of central parts of such objects.

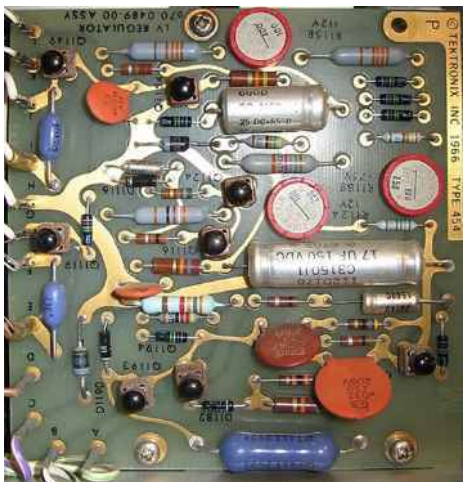

Figure 33

Figure 34

Since the functionality of technical cultural heritage is usually an important part of the original historic context, they are often kept in working condition and presented in working order. In this way, the historic context remains intact and the sometimes-complex historic skills about their maintenance and operation can be preserved for future generations.

Figure 35

Figure 36

For the true-to-the-original maintenance, repair and restoration of technical cultural assets, lead-containing soldering materials of various compositions are required (e.g. electrical solders, solders for radiators, so-called alluvial tin for the restoration of car bodies) as well as leaded sheets and alloys for cast and rolled lead. In the field of historic rail and land vehicles, metallic lead is also a component of plain bearings and other components.

1.9. **Traditional lead type printing processes.** These are historical letterpress processes with types cast from lead-tin-antimony ("letter metal") alloys

Figure 37

Figure 38

In so-called "manual typesetting" or when using typesetting machines, individual types are put together to form the complete shape of a page. After printing, the form can be disassembled into individual types again. In the case of machine typesetting using cast lines, such as those supplied by Linotype or Ludlow casting machines, these are melted down again and recast after use. Corresponding methods of duplicating written material revolutionized the reproduction and dissemination of knowledge on a scale never seen before. The techniques of printing in lead typesetting, along with other printing techniques, have been recognized and protected as intangible cultural heritage in Germany since 2018. Today, corresponding methods are still used for particularly high-quality as well as aesthetically and artistically sophisticated printed works.

2. Traditional working techniques & skills and good professional practices in the conservation of cultural heritage and substitute materials for lead alloys.

The specialists working in these fields mostly are solo self-employed or small businesses. Due to their limited personnel capacities and financial resources, they would not be able to undergo lengthy and expensive certification procedures to obtain individual exemptions for the use of lead materials. This would severely limit them in practicing their profession or make it impossible altogether, and the preservation of a lot of objects representing the cultural heritage of the EU could no longer be ensured. This would also affect the possibilities of producing, storing, and selling the required materials, as well as storing and publicly exhibiting corresponding historic objects containing lead.

To give some examples, about 50 tons of lead-containing materials are needed in pipe organ restoration and building throughout the EU each year[1], and about 5 tons of lead wool were processed between 2010 and 2012 for restoration work on the facade of the medieval cathedral in Magdeburg alone[2]. Nevertheless, the amount needed for cultural assets is only a per mille share of the total lead annually used in the EU.

The special properties of lead (malleability, acoustic properties, processing parameters, long-term outdoor durability) make this material indispensable for many historic objects of cultural importance. However, tests carried out by the International Scientific Committee for the Conservation of Stained Glass (ISCCSG) of ICOMOS and CVMA have shown it is not possible to carry out repairs with lead-free substitute materials within joints already containing historic (lead-alloy) solder. In such a case, no viable adhesion will be achieved between the different materials[3]. As far as possible, lead-free substitutes are already used today in the preservation of cultural assets as well as in arts and crafts and in the field of fine arts. Thus, it would make no sense to try to restore modern components already made with lead-free soldering materials with leaded solder. Reliable and durable adhesion between the different alloys could not be guaranteed even in this (reverse) case.

Lead-free substitute materials also cannot be used in other fields of heritage preservation, so for example

2.1. in the manufacture and restoration of pipe organs (see section 1.1.). Cast pipe metal sheets made from alloys with varying proportions of lead and tin as well as the historically used lead-containing soldering materials with low melting points are crucial for the typical sound of the instruments and thus ultimately also for an unadulterated musical interpretation of organ music of all epochs. At the same time, the reliable and durable bonding of lead-free repair materials to existing joints soldered with lead materials cannot be achieved during a restoration (see above). The knowledge and working techniques handed down in traditional pipe organ building, which is recognized by UNESCO as Intangible Cultural Heritage of Mankind since 2017, can only be preserved along with the traditional working materials.
Metallic lead is also indispensable for the function of so-called "regals" or “Reed Organs”. In the mechanics of these portable small pipe organs, lead pieces are used as counterweights in the bellows. The particularly small size of these instruments and the very limited space inside do not allow other (lighter) materials to be used here.

2.2. in the traditional manufacture and restoration of brass instruments (see section 1.2.). From a technical and acoustic point of view, lead-free substitute materials for soldering joints can be used only in very few cases here. In the restoration of historic instruments, a reliable and durable bonding of lead-free repair materials to lead-containing solder joints cannot be ensured. Materials containing lead therefore are important for the survival of the skills and possibilities to build and restore handcrafted brass-instruments in the EU.

[1] Information from the Bund Deutscher Orgelbaumeister e. V. from April 2022

[2] https://www.bauhandwerk.de/artikel/bhw_Fugenverschluss_mit_Blei_Magdeburger_Dom_Sandstein_Restaurierung_Spaetgotik_1959345.html, session of 12. 12. 2022.

[3] Results of a test series with lead-free soldering materials, reported by Prof. Dr. Ivo Rauch, professional referee ECHA / lead at the International Scientific Committee for the Conservation of Stained Glass (ISCCSG), reported in April 2022.

2.3. **in the traditional manufacture, repair, and restoration of various other musical instruments** (see section 1.3.). Today, historic wind instruments made with leaded alloys or with leaded keys today are presented and conserved only in museums. Here the focus is always on preserving the historic substance, so that replacing original components made of lead with other materials would mean damaging the originality and historical testimony of the object.
However, historic keyboard instruments and their accurate copies built today are an important element in the research and historically informed performance of musical works. They must therefore be preserved in accordance with the original method of construction and, in some cases, with the use of materials containing lead, to maintain their typical sound and authentic functioning.

2.4. **in the authentic preservation and restoration of historic roofing with lead panels** (see section 1.4.). Both the historic appearance and the faithful preservation and restoration of corresponding roofs still require lead sheets, rolled lead, lead wool and lead ingots/cast lead for sealing joints and lugs. This is the only way to authentically reproduce even tightly curved, complex historic shapes and therefore preserve the original overall impression of the building.

2.5. **for the preservation, repair and restoration of historic structures, buildings and other objects made of natural stone** (see section 1.5.). The special elasticity and thermal properties of the material make lead wool, rolled lead sheets and lead ingots/cast lead indispensable here. Only in this traditional way the necessary sealing of joints and joining techniques can be carried out which can withstand weathering, UV radiation and extreme temperature changes for a long time.

2.6. **for the design and restoration of works of art and artisanal objects** made of lead and lead alloys (see section 1.5.). The special properties of lead as a material have enabled artists of all epochs to make express particular designs and create unique works of art. At the same time, corresponding materials are indispensable for the faithful and durable completion or restoration of the related objects.

2.7. **in the field of stained glass-windows of all eras** (see section 1.7.). The use of lead rods and lead-containing solder materials with a low melting point remains essential here, because only traditional materials have the necessary malleability, elasticity, and the required thermal properties (→ heat/cold changes on large window panels!) for this cultural technique that has been handed down for centuries. This is especially true for the preservation of historic windows in exterior areas, because a safe and permanent adhesion of lead-free repair materials to historic lead-containing materials/soldered joints cannot be guaranteed. Here, the partial application of modern replacement materials would also lead to significant tensions between the different materials and further damage to the historic structure. These centuries-old working techniques can also only be preserved if the necessary materials remain available.

2.8. **in the preservation of industrial heritage and objects connected to the history of technology** (see section 1.8.). Since the functionality of such objects is an important part of the historic importance, they are often kept in working condition and presented in working order.
Different lead-based soldering materials with low melting points are required for the restoration of radiators, electrical components, and body parts, since safe and durable adhesion of lead-free repair materials to historic lead-containing materials (historic solder joints, leaded sheet metal, lead alloy components) cannot be achieved. At the same time, special requirements for the elasticity and load-bearing capacity of joints in radiators and other components play a decisive role. These are not met by replacement materials.
Particularly when applying alluvial tin (an important working and repair technique in historic body construction), it should be noted that lead-free replacement materials can only be formed in a much higher and much more narrowly limited temperature range than the traditionally used lead-containing alloys. For this reason, modern replacement materials cannot be used for this true-to-the-original restoration technique[4].
Lead-containing materials are also needed for the replacement of plain bearings (axles,

[4] Ergebnisse von Versuchen mit bleifreien Ersatzmaterialien, zusammengefasst im Januar 2023 vom Referatsleiter Technik des Zentralverbandes Karosserie- und Fahrzeugtechnik (ZKF).

crankshafts, etc.), without which functionality cannot be preserved.
Another important field is the replacement as well as repair and restoration of historic lead-acid starter batteries, which are required for the operation of numerous technical cultural assets. Their often very special designs in terms of nominal voltage, nominal capacity and internal and external dimensions are frequently incompatible with today's starter batteries. As a result, such batteries/accumulators cannot be replaced by modern components in some cases. Instead, they would also have to be restored or repaired in order to preserve the functionality and authenticity of technical cultural assets.
The traditional craft techniques and processes required to preserve such cultural assets, as well as the knowledge surrounding their historic function and operation, can only be preserved if the materials required for this purpose also remain available.

2.9. for traditional letterpress techniques (see section 1.9.).
Lead-free surrogate materials are not suitable for authentic printing in these procedures. Only the lead-based materials historically used are strong enough to stand up well to the wear and tear of the printing process and at the same time are sufficiently pliable not to damage the paper.
The sophisticated working procedures that have been handed down for the corresponding processes, as well as the knowledge around the practical implementation of this intangible cultural heritage, can only be preserved if the materials required for types and clichés remain available.

Denmark already introduced far-reaching regulations for the use of metallic lead and its alloys in 2000. These include exceptions for the repair of existing objects and for restoration[5]. While they cover the preservation and restoration of cultural heritage, current artistic and artisanal works, or the construction of new musical instruments (see sections 1.1., 1.2., 1.3., 1.6., 1.7. and 1.9.) have unfortunately not been considered so far.

3. Environmental and health protection, recycling

There is no doubt that metallic lead is toxic, has teratogenic effects, can damage the nervous system of organisms, and can accumulate in the body and the environment.
Occupational health and safety as well as health monitoring measures for the handling of lead-containing materials are already regulated by existing legal provisions that have been recognized by the European Commission as controlling risks.
In Germany, for example, all professionals who work on and with stained glass-windows are medically examined for a possible exposure to lead on a regular basis. To the medical experts, employers' liability insurance and trade associations working in this field in Germany only one case of occupational lead poisoning is known within the last 20 years[6]. Blood tests for craftsmen working in pipe organs, which are also routinely supervised by the professional associations, have so far shown no case of exposure above the valid limit values[7]. The processes used in the field of stained glass-windows and pipe organ building (e.g., transporting, storing, handling, cutting, shaping, joining, melting, soldering) are comparable to the working techniques used by skilled users with corresponding materials on other art and cultural objects. There, too, for example, the soldering and casting of lead alloys is carried out at melting temperatures of 300 to 350 degrees Celsius, which are still far below the critical threshold for the release of lead vapors (at about 480°C).
Moreover, the specialists entrusted with such activities are already being intensively trained in the necessary environmental protection and safety requirements (prevention of input into the environment, avoidance of dusts during cutting and shaping, melting temperatures below the formation of lead fumes, personal protective equipment, etc.) and apply these in their work.
In the objects and after restoration measures, the lead materials used usually remain unchanged in

[5] s. z. B. https://www2.mst.dk/Udgiv/publications/2006/87-7052-314-2/pdf/87-7052-315-0.pdf, session vom 11. 9. 2022, S. 20, section 16.
[6] Statement of Prof. Dr. Ivo Rauch, president of the International Scientific Committee for the Conservation of Stained Glass (ISCCSG) in ICOMOS/CVMA. This one case can clearly be traced back to an interaction of construction-related conditions (connection joints of a glass window to the masonry) that was not known at the time. The knowledge gained from this case has in the meantime been transferred to new occupational health and safety regulations.
[7] Report of Bund Deutscher Orgelbaumeister e. V., the crafts trade association in the field of pipe organs in Germany, from April 2022.

place for a very long time and are not released into the environment (e.g. in organ building, in stained glass-windows or for natural stone facades usually well over a hundred years). The objects in question are also not normally subject to any wear and tear that would release the material. Leftover materials and components containing lead that can no longer be used have been handed over for decades in well-established, safe recycling cycles and are used to produce new materials. For end users (e.g. musicians, listeners, users of premises with stained glass-windows or natural stone facades, museum visitors, guests and operators of museum railroads, etc.), the metallic lead and lead bound in alloys in the area of cultural assets do not pose any risk, as they have no direct contact with it.

4. The manufacturers and users of the materials concerned.

Compared to industrial processes and applications to which the regulations of REACH usually refer, craft, artisanal, artistic and restoration work on and with objects of cultural and/or historic value are, from an economic point of view, only very limited niche applications. However, these are of great importance from a cultural and historical point of view.

The specialists working on and with cultural objects mostly work as solo self-employed persons or in small businesses and the corresponding applications are not industrial processes[8].
Due to their limited personnel capacities and financial resources, the specialized companies and specialists would not be able to undergo lengthy and expensive certification procedures to obtain individual exemptions for the application of lead materials. This would inevitably limit their ability to practice their profession or would make this entirely impossible. A ban would therefore have far-reaching socio-economic consequences for those affected. At the same time, the preservation of many objects belonging to our cultural heritage could no longer be ensured in the EU.
The manufacturers of special lead-containing products, such as for example lead rods for stained glass-windows, also traditionally are small companies with rarely more than 10 employees. In terms of their structure and financial resources, they also would not be able to undergo lengthy and expensive certification procedures to obtain individual exemptions from a ban. This would inevitably lead to the closure of these specialized companies, and the corresponding products would no longer be available for artists and the preservation of historic objects.
Regarding the few larger manufacturers who currently still produce lead-containing soldering materials, lead sheet materials, lead wool, lead ingots, lead-containing alluvial tin rods or similar products for the working techniques described above, experience has shown that costly certification procedures lead to the niche materials that are thus unprofitable no longer being offered and their production being discontinued. As a result, these materials will become unavailable for the preservation of cultural heritage.

5. Outlook

The undersigned would like to ask ECHA not to disregard the work for, on and with cultural heritage also in upcoming regulations. The processes concerned in this field do not comply with the usual industrial processes for which REACH and the ECHA procedures were initially designed. It should therefore be borne in mind that, particularly in the conservation and restoration of cultural heritage, a wide range of materials and procedures historically applied play an important role, which often cannot be replaced by modern materials and processes.

To give an example, this also applies to special pigments containing lead, such as basic lead white, lead-tin yellow, lead red lead, but also other chemical compounds like pigments containing cadmium or chromium. These niche materials are important for the preservation of historic objects and therefore have to remain available for professional users.
For this reason, we would like to suggest that, in the case of possible further regulations within the framework of REACH, the area of art and cultural assets plus the possible resulting effects on society and the preservation of its heritage should be considered from the outset. To this end, it is important

[8] According to estimations, for example, the pan-European organ building industry has an annual turnover of approx. 400 million euros and approx. 11,000 employees, including subcontractors (data from Bund Deutscher Orgelbaumeister e. V. of April 2022).

to involve the international expert bodies specifically concerned with these issues in the consultations from the outset (e.g., the European Confederation of Conservator-Restorers' Organisation (ECCO), the International Centre for the Study of the Preservation and Restoration of Cultural Property (ICCROM), The International Committee for the Conservation of Industrial Heritage (TICCIH), but also the International Council of Museums (ICOM) and the International Council of Monuments and Sites (ICOMOS), which also supported this position paper). If a planned regulation within the framework of REACH poses a threat to the cultural heritage and thus endangers the historic legacy of our societies, it should be possible to spare the field of historic crafts, artisan, artistic and restoration work on and with cultural assets within the framework of future regulations.

6. Summary

The responsible application of materials made of and containing metallic lead is indispensable for the creation, conservation, and restoration of cultural heritage. These are not industrial processes, but artisanal, craft, artistic and restoration procedures, which today only are used for highly specialized niche applications.
A ban on the substance lead and the resulting costly individual approval procedures for the historically and socially relevant area of cultural assets would be an essential threat to their continued existence. At the same time, important traditional cultural techniques would be irretrievably lost. This also applies to the production of the materials required for this purpose, the possibility of storing and marketing them, and the storage and public display of objects containing lead. The damage to the public, the cultural legacy of society and the collective memory resulting from a ban would be immense.
We would therefore urge ECHA to exclude the work on and with cultural and historic objects from a possible ban.

7. appendix: pictorial references and annotations

Figure 1 Church organ by Berendt Hus (built 1659), in the Marienkirche Mariendrebber (https://www.welt.de/wissenschaft/article148870948/Bleifrass-beschaedigt-barocke-Orgeln.html, session of 11. 9. 2022).

Figure 2 View of the swell inside of a pipe organ (https://de.wikipedia.org/wiki/Orgelpfeife, session of 11. 9. 2022).

Figure 3 Soldering of an organ pipe (http://www.schantzorgan.com/pipemaking.html, session of 11. 9. 2022).

Figure 4 "Reed Organ", 1st half of the 17th century, with integrated bellows weights in the form of two massive lead blocks (Germanisches Nationalmuseum Nürnberg).

Figure 5 craft production of a trombone with lead solder (https://www.wfb-bremen.de/de/page/stories/bremer-erfolgsgeschichten/meisterliches-blech, session vom 11. 9. 2022).

Figure 6 historical brass instrument, restored with lead solder (https://www.etsy.com/de/listing/1000117407/rare-vintage-trompete-vega-fred-berman, session of 11. 9. 2022).

Figure 7 historical French dragonhead trombone, around 1830, restored with leaded soldering material (http://www.muerner-restaurierungen.ch/de/index.php, session of 11. 9. 2022).

Figure 8 Fortepiano from 1828, with keyboard containing leaden weights (Germanisches Nationalmuseum).

Figure 9 historical glass harmonica with lead flywheel (https://ahojausprag.wordpress.com/category/musik/, session of 11. 9. 2022).

Figure 10 Caulking of wall joints with lead wool in a church facade (https://www.bauhandwerk.de/artikel/bhw_Fugenverschluss_mit_Blei_Magdeburger_Dom_Sandstein_Restaurierung_Spaetgotik_1959345.html, session of 11. 9. 2022).

Figure 11 Potting a steel element in natural stone with liquid lead (http://www.bildhauerei-schmidt.de/steinmetzarbeiten.htm, session of 11. 9. 2022).

Figure 12 Lead-plate roofing of the Cologne Cathedral (https://www.traumwanderungen.de/der-stein-vom-koelner-dom/, session of 11. 9. 2022).

Figure 13 complex baroque roof ornament restored with rolled lead in traditional technique (https://www.roehr-stolberg.de/dach-fassade/, session of 11. 9. 2022).

Figure 14 Roman statuette of Venus from the 2nd or 3rd century BC, cast from lead https://www.catawiki.com/de/l/23026069-romisches-reich-blei-figur-der-venera-venus-6-7-cm, session vom 11. 9. 2022).

Figure 15 medieval pilgrim badge of the 15th century made of lead casting (https://www.catawiki.com/de/l/27701487-mittelalterlich-zinn-blei-legierung-pilgerabzeichen-von-maria-und-kind-drei-weisen-0x6x6-cm, session of 11. 9. 2022)

Figure 16 Medal from 1596 made of bronzed lead with the portrait of Andreas Imhoff (Germanisches Nationalmuseum Nürnberg).

Figure 17 „Mariensäule" by Wolfgang and Johann Baptist Hagenauer from 1771 in front of the cathedral to St. Rupert and Vergil in Salzburg, with figures and ornamental parts made of lead (https://www.sn.at/wiki/Mariens%C3%A4ule_auf_dem_Domplatz, session of 11. 9. 2022).

Figure 18 Installation "Shevirat-ha-kelim" by Anselm Kiefer, 1990 - 2020, made of lead sheets, glass and other materials (https://kultur-online.net/inhalt/j%C3%BCdische-geschichte-und-gegenwart-deutschland, session of 10. 10. 2020).

Figure 19 Statuette "Mother and Child" made of cast lead, created around 1939 by Henry Moore (https://news.artnet.com/market/henry-moore-lead-sculpture-mantelpiece-2061326, session of 11. 9. 2022).

Figure 20 Installation "Three Bodies" with three lead sculptures by Antony Gormley, 1981(https://www.antonygormley.com/works/sculpture/series/three-part-object-works/three-bodies, session of 11. 9. 2022).

Figure 21 painted historical "tin soldiers" around 1870 made of lead-tin alloy (https://www.stadtmuseum.de/objekte-und-geschichten/seltene-zinnsoldaten, session of 11. 9. 2022).

Figure 22 decorated sarcophagus for Princess Hedwig Eleonor of Sachsen-Merseburg in the Magdeburg Cathedral, made of a lead-tin alloy in 1693 (https://www.kunst-denkmal-metall.de/2010/03/merseburg-dom-furstengruft-restaurierung-der-sarkophage/, session of 11. 9. 2022).

Figure 23 lead-framed stained glass windows from the 13th century in the Saint Chapelle Paris (https://de.wikipedia.org/wiki/Sainte-Chapelle, session of 11. 9. 2022).

Figure 24 Church window designed in 1960 by Marc Chagall for Metz Cathedral (https://www.saarbruecker-zeitung.de/saarland/blickzumnachbarn/frankreich/centre-pompidou-in-metz-fuehrt-virtuell-durch-neue-ausstellung-chagall-ueberbringer-des-lichts_aid-54737203, session of 11. 9. 2022).

Figure 25 lead framed art nouveau window from Belgium, around 1900, (https://www.pinterest.co.kr/pin/294422894384670276/, session of 11. 9. 2022).

Figure 26 abstract church window with lead frames from 1957, designed by Georg Meistermann for the Holy Cross Church Bottrop (https://www.deutschlandfunk.de/kuenstler-gestalten-kirchenfenster-verwandeltes-licht-100.html, session of 11. 9. 2022).

Figure 27 Lead rods for stained glass windows (https://de.wikipedia.org/wiki/Bleiglasfenster, session of 11. 9. 2022).

Figure 28 Restoration of a stained-glass window, soldering the lead rods (https://de.wikipedia.org/wiki/Datei:Soldering.JPG, session of 11. 9. 2022).

Figure 29 historical diving equipment from 1912, made with lead solder and lead weights in the German Museum Munich (https://www.deutsches-museum.de/museum/sammlung/highlights/tauchgeraet, session of 11. 9. 2022).

Figure 30 historical railroad signal station from 1911 in Lindau (https://www.lindau.de/so-ein-schrankenposten-ist-eine-einsame-sache/, session of 11. 9. 2022).

Figure 31 Generator of the historic hydroelectric power plant Friedrichssegen in Lahnstein, this facility from 1910 is still in active operation today (https://www.daslahntal.de/info/infosystem/Historisches-Wasserkraftwerk-Friedrichssegen_Lah/poi.html, session of 11. 9. 2022).

Figure 32 Historical steamship "Stettin", an icebreaker built in 1933, which today is a museum ship in active use in Hamburg (http://www.dampf-eisbrecher-stettin.de, session of 16. 12. 2022).

Figure 33 Circuit board of a 1966 Tektronix 454 oscilloscope (https://www.radiomuseum.org/r/, session of 11. 9. 2022)

Figure 34 „Tinning“ of sheetmetal parts in traditional handicraft car body restoration (https://www.hwk-reutlingen.de/ausbildung/ueberbetriebliche-ausbildung-ueba/inhalt-auszubildende/ueba-lehrgaenge/karosserie-und-fahrzeugbaumechanikerin.html, session of 11. 9. 2022).

Figure 35 historic vehicle radiator in disassembled condition (https://classic-portal.com/autokuehler-mayr/, session of 11. 9. 2022).

Figure 36 Soldering of a historic radiator during restoration (https://www.aks-dommermuth.de/de/portfolio-item/kuehlerbauundreparatur/, session vom 11. 9. 2022).

Figure. 37 Type case with movable letters made of lead-tin-antimony alloy (https://de.wikipedia.org/wiki/Setzkasten#/media/Datei:Metal_movable_type.jpg, session of 17. 1. 2023).

Figure. 38 Working with a historic letterpress (http://www.kentuckymonthly.com/culture/arts-entertainment/2020-writer-s-hall-of-fame-gray-zeitz/, session of 17. 1. 2023).