2017

Existing Assessments of Lead Batteries Compared to Alternatives Assessment Factors

A CRITICAL ANALYSIS DEMONSTRATES LEAD BATTERIES DO NOT MEET CRITERIA SET BY THE CALIFORNIA DEPARTMENT OF TOXIC SUBSTANCES CONTROL (DTSC)

PREPARED BY WILEY REIN LLP | 1776 K ST NW, WASHINGTON, DC 20006

WHITE PAPER

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I. INTRODUCTION

Recent events have suggested that the California Department of Toxic Substances Control (DTSC) may consider including lead batteries in the next revision of the Safer Consumer Products Work Plan for further evaluation as a potential priority product. Inclusion of lead batteries in the Work Plan is not warranted because the initial analyses that DTSC would conduct have already been conducted by industry and other government entities, including under programs analogous to the Safer Consumer Products program. Those analyses have repeatedly found that there is no viable alternative technology available today or that will be available in mass consumer quantities for the foreseeable future.

A summary of those existing analyses is provided below, along with a description of how these analyses address each of the key factors DTSC would evaluate under California Health & Safety Code §§ 25253(a)(2)(A)-(M). Each factor is discussed below with a reference to the source documents responding to those factors, all of which are included in Appendix B. An index of the documents in Appendix B is included as Appendix A.

In addition to these considerations, the Safer Consumer Products Regulations require that any product-chemical combination identified and listed as a Priority Product must meet both of the following criteria: 1) there must be potential exposure to the Candidate Chemical(s) in the product and 2) there must be the potential for exposures to contribute to or cause significant or widespread adverse impacts.[1] Lead exposures in California arise predominantly from legacy sources, such as deposition from historical use of leaded gasoline, leaded paint and lead pipes in older residential structures, and localized exposures from certain manufacturing and processing facilities. In the latter case, the few such facilities remaining in California that manufacture and recycle lead batteries are now subject to the most stringent lead emissions standards in the world. Moreover, unlike the types of consumer products DTSC is currently evaluating, there is no pathway by which the consumer can be exposed to lead during use of the product. Lead batteries are sealed in durable casings and in the vast majority of applications are physically isolated from the user.[2] Furthermore, the existing closed loop recycling system, with a recovery rate approaching 100%, minimizes the potential for the lead in the battery to cause or contribute to significant or widespread adverse human or

[1] Division 4.5, Title 22, California Code of Regulations, Chapter 55, Safer Consumer Products, Section 69503.2(a).

[2] The U.S. EPA Toxic Substances Control Act (TSCA) regulations exempt batteries and the chemicals they contain from new chemicals review and TSCA Inventory reporting because the chemicals in a battery are contained in an "article" without potential for release or exposure. *See* 40 C.F.R. §§ 720.30(h)(5), 710.4(d)(3)-(6), and 711.10(b).

environmental impacts that could result from improper or illegal disposal. Accordingly, lead batteries do not meet either of the key regulatory criteria for further consideration as a potential Priority Product.

Moreover, the Safer Consumer Products regulations do not allow DTSC, in picking priority products, to pick products that are already sufficiently regulated under existing California and federal laws, *i.e.*, subject to the same protections that priority product listing would provide, unless it would meaningfully enhance protection of human health and/or the environment. As you will see below, lead and lead batteries are already among the most stringently regulated chemicals and products in the state and nation.[2] And, as discussed below, there are no readily available safer alternatives, which is suggested for consideration before listing a priority product.[3]

II. EXISTING ANALYSES ADDRESSING DTSC'S STATUTORY FACTORS

A core set of documents that address nearly all the factors represent the extensive analyses performed as part of recurring evaluation of lead batteries under the European End-of-Life Vehicles Directive. Directive 2000/53/EC of the European Parliament and of the Council. Since 2000, that Directive has mandated that lead batteries be reviewed every few years to determine whether a viable replacement existed for lead batteries in vehicular applications. The most recent review cycle was initiated in 2014 and is expected to be completed later this year.

To undertake the government's analysis, the European Commission's Directorate-General for Environment (DG Environment) retained an independent consultant, the Oeko-Institut, to independently evaluate the pertinent considerations and to solicit and review industry input.

As part of the industry input process, a coalition of industry groups performed extensive alternatives analyses and submitted numerous reports and comments to the Oeko-Institut and the DG Environment. The coalition included EUROBAT (the European battery association), several automotive manufacturer associations (ACEA, JAMA, and KAMA), and the International Lead Association (ILA). Their analysis evaluated the most promising battery chemistries for automotive applications, including lead, lithium, nickel and sodium-based chemistries. It shows that there is no current or reasonably foreseeable replacement for lead batteries in the majority of automotive applications.

In 2016, the Oeko-Institut issued a report confirming the industry's findings, and earlier this year the DG Environment released for public review and comment a draft Directive adopting the Oeko-Institut's recommendation to extend the exemption for lead batteries for another four years. Notably, the reports and the proposed directive do not conclude that there will infact be a replacement at the end of that four-year period, but rather only that another revisitation of the question will be appropriate at that time.

[2] Cal. Code Regs., tit. 22 § 69503.2(b)(2).

[3] Cal. Code Regs., tit. 22 § 69503.2(b)(3).

A. **Factor A – Product Function or Performance**

California Health & Safety Code § 25253(a)(2)(A) requires consideration of product function or performance.

These considerations have been fully evaluated by industry and government agencies. These evaluations have consistently found that there is no currently or foreseeably available massmarket alternative to lead batteries for use in traditional automotive applications. Most notably, no other chemistry provides the performance and safety characteristics needed to act as a reliable starting, lighting and ignition (SLI) power source. Other SLI battery chemistries do not provide comparable performance or reliability either at very low or very high temperatures.

Further, lead batteries are used in virtually all hybrid and electric vehicles today as the power source for critical features such as SLI, braking, power steering and air bags. The Ni-MH or Liion batteries in those vehicles typically only power the drivetrain. In such vehicles, the lead battery even powers the battery management system that monitors and keeps the Ni-MH or Liion battery operating within safe parameters. *See* Appendix B.2, pp. 2-3. Past reviews are reflected in the following source documents:

- EUROBAT documents submitted to the European Commission o A Review of Battery Technologies for Automotive Applications: A joint industry analysis of the technological suitability of different battery technologies for use across various automotive applications in the foreseeable future; EUROBAT, ILA,
  ACEA, JAMA and KAMA. *See* Appendix B.1, pp. 7-9; 11-16; 24-33. o Stakeholder Consultation Questionnaire: Exemption No. 5 "Lead and lead compounds in components: Batteries"; Industry contribution of ACEA, JAMA, KAMA, CLEPA, ILA and EUROBAT (Dec. 2014). *See* Appendix B.2, pp. 1-3; 11-13;
  15; 22-23. o ACEA, JAMA, KAMA, EUROBAT and ILA position on 'Lead-based batteries and
  Exemption 5 of the EU End of Vehicle Life Directive (Apr. 2017). *See* Appendix B.3, pp. 2-3.
- Oeko-Institut report for European Commission End-of-Life Vehicles directive analysis.
  - 8th Adaptation to scientific and technical progress of exemptions 2(c), 3 and 5 of Annex II to Directive 2000/53/EC (ELV) – OEKO Report for the European Commission DG Environment under Framework Contract No. ENV.C.2/FRA/2011/0020 – Final Report (17 Feb. 2016). *See* Appendix B.4, pp. 87-91.

B. **Factor B – Useful Life**

California Health & Safety Code § 25253(a)(2)(B) requires consideration of a product's useful life.

The useful life of lead batteries is regularly evaluated by industry. Recent versions of these analyses have found that the average life span of a modern lead battery is as follows:

- 12 volt SLI batteries for automotive applications have an average useful life of 55 months (4.5 years).
- Motive power lead batteries (e.g, forklifts, floor sweepers) have an average useful life of 6 years.
- Stationary/standby lead batteries (e.g, telecom, uninterrupted power supply (UPS)) have an average useful life of 10 years.

Use of non-lead-based batteries in SLI applications, such as lithium or Ni-MH chemistries, can be expected to significantly reduce the useful life of the battery due to the high temperatures in the engine compartment. *See* Appendix B.1, p. 31.

These findings are presented in the following source documents:

- EUROBAT documents submitted to the European Commission for its End-of-Life Vehicles directive analysis. These documents fully describe the expected life span of batteries entering global vehicle fleets. o A Review of Battery Technologies for Automotive Applications: A joint industry analysis of the technological suitability of different battery technologies for use across various automotive applications in the foreseeable future; EUROBAT, ILA,
  ACEA, JAMA and KAMA. *See* Appendix B.1, pp. 14-16; 31. o Stakeholder Consultation Questionnaire: Exemption No. 5 "Lead and lead compounds in components: Batteries"; Industry contribution of ACEA, JAMA, KAMA, CLEPA, ILA and EUROBAT (12/2014). *See* Appendix B.2, p. 7.
- BCI's 2014 National Recycling Rate Study. The calculation of the industry's recycling rate is based in part on a failure rate analysis which evaluates the typical actual service life of batteries returned for recycling in the relevant period. This data is presented in Appendix B.5, pp. 2 and 5-6.

C. Factor C – Materials and Resources Consumption

California Health & Safety Code § 25253(a)(2)(C) requires consideration of a product's materials and resource consumption.

Nearly all used lead batteries are recycled,[4] and essentially 100% of the lead and plastic in each battery are recycled and put to new use, typically in new batteries. There is no other battery chemistry with a known recycling rate of measurable success, let alone one nearing 100%. For example, the reported collection and recycling rate for lithium-ion batteries is 3%, and the recovery of lithium from those batteries is "negligible."[5]

[4] Industry data is calculated using the tonnage of lead recycled rather than unit numbers, and show a 99% battery lead recycling rate.

[5] *Opportunities to Improve Recycling of Automotive Lithium Ion Batteries*, Alexandru Sonoc et al., p. 1. *See* Appendix B.17.

Recycling enables new lead batteries to be manufactured using a very high percentage of recycled lead and plastic, and, at one major manufacturing plant, reclaimed acid. Indeed, 3/4ths of the lead used to manufacture new lead batteries is recycled lead.[6] Materials not used in new batteries are recycled into other products: reclaimed acid is used to make fertilizers, glass, textiles and detergent products, and reclaimed plastic is used in other plastic products.

Moreover, manufacturers have succeeded in redesigning their batteries to reduce the amount of lead that is needed. Without this expansion of energy density, the growing power demands of today's vehicles would otherwise require an increase in the amount of lead used in batteries.

These considerations have been fully evaluated by industry and government agencies in recent years. These reviews are reflected in the following source documents:

- EUROBAT documents submitted to the European Commission for its End-of-Life Vehicles directive analysis. These documents fully describe materials and resource reduction by the lead battery industry. o A Review of Battery Technologies for Automotive Applications: A joint industry analysis of the technological suitability of different battery technologies for use across various automotive applications in the foreseeable future; EUROBAT, ILA,
  ACEA, JAMA and KAMA. *See* Appendix B.1, pp. 14-16. o Stakeholder Consultation Questionnaire: Exemption No. 5 "Lead and lead compounds in components: Batteries"; Industry contribution of ACEA, JAMA, KAMA, CLEPA, ILA and EUROBAT (12/2014). *See* Appendix B.2, p. 7.
- BCI's 2014 National Recycling Rate Study. The Recycling Rate Study includes the data and recycle rate calculations that show the large volume of battery lead that is recycled and therefore source reduced (i.e, reducing virgin ore mining). *See* Appendix B.5, pp. 2 and 5-6.
- Environmentally Sound Management of Spent Lead-acid Batteries in North America: Technical Guidelines, NAFTA Commission for Environmental Cooperation (CEC). Provides numerous examples of materials and resource consumption reduction. *See* Appendix B.6, pp. 17-19; 25-27; 42-44.
- *Opportunities to Improve Recycling of Automotive Lithium Ion Batteries*, Alexandru Sonoca and Jack Jeswieta*, Vi Kie Soo, Procedia CIRP 29 (2015) 752 – 757. *See* Appendix B.17, p. 1.

D. Factor D – Water Conservation

California Health & Safety Code § 25253(a)(2)(D) requires consideration of a product's contribution to water conservation.

The battery industry reduces water consumption significantly in multiple ways. SLI battery electrolyte is a mixture of water (~60%) and sulfuric acid (~40%). The industry reduces the use of water during the manufacture of new electrolyte by, at one major secondary lead smelter where battery manufacturing is co-located, reusing electrolyte reclaimed from recycled batteries. And, in accordance with federal and state regulations, many battery manufacturing

[6] The Facts About Lead: Energy Storage/Standby, BCI (2010). *See* Appendix B.26, p.1.

and recycling plants reuse their process water to conserve on water usage in addition to treating the water on-site to reduce or eliminate the discharge of industrial process waste water to municipal sewer systems.

Many of these considerations have been fully evaluated by industry and government agencies in the past. These reviews are reflected in the following source documents:

- Environmentally Sound Management of Spent Lead-acid Batteries in North America: Technical Guidelines, NAFTA Commission for Environmental Cooperation (CEC). Describes water treatment and electrolyte recovery by battery recyclers. *See* Appendix B.6, pp. 17-19; 25-27; 42-44.

E. <u>Factor E – Water Quality Impacts</u>

California Health & Safety Code § 25253(a)(2)(E) requires consideration of a product's water quality impacts.

The lead battery manufacturing and recycling industries comply with strict Clean Water Act regulations for wastewater and storm water discharges to waters of the U.S. under National Pollution Discharge Elimination Standard (NPDES) permits that are prepared and enforced by the states. There are separate pretreatment regulations for wastewater treatment prior to discharging to POTWs. Many manufacturing sites have significantly reduced or nearly eliminated the discharge of manufacturing waste water from their facilities. Water discharges that do occur have strict effluent limits. For example, a typical battery manufacturer's NPDES permit controls discharges of lead, total suspended solids (TSS), ammonia, pH and requires monitoring for copper and zinc. *See* Appendix B.21, p. 468. At battery manufacturing plants, pretreatment standards control for copper and lead. *See* Appendix B.22, pp. B-7; B-8. The CEC Technical guidelines further discuss water treatment at battery recycling plants, also called secondary lead smelters. *See* Appendix B.6, pp. 43; 58.

These considerations have been fully evaluated by industry and government agencies in the past. Past reviews are reflected in the following source documents:

- EPA Abstracts of Industrial NPDES Permits, U.S. Environmental Protection Agency, October 1989, OWEP 89-01, *See* Appendix B.21, p. 468 at https://www.epa.gov/nscep.
- Guidance Manual for Battery Manufacturing Pretreatment Standards, U.S. Environmental Protection Agency, August 1987, EPA 440/1-87/014. *See* Appendix B.22, pp. B-7 – B-8.
- Environmentally Sound Management of Spent Lead-acid Batteries in North America: Technical Guidelines, NAFTA Commission for Environmental Cooperation (CEC). Among other things, this report describes water treatment controls by lead battery recyclers, which are similar to practices followed by lead battery manufacturers. [7]*See* Appendix B.6, pp. 43; 58.

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[7] C.F.R. pt. 63, Subpart PPPPPP; 40 C.F.R. pt. 63, Subpart X; 40 C.F.R. pt. 60, Subpart KK, 40 C.F.R. pt. 60, Subpart L.

F. Factor F – Air Emissions

California Health & Safety Code § 25253(a)(2)(F) requires consideration of a product's life cycle air emissions.

The lead battery manufacturing and recycling industries comply with Clean Air Act National Emission Standards for Hazardous Air Pollutants (NESHAP) and New Source Performance Standards (NSPS) for stack and fugitive air lead emissions.[7] These standards also limit emissions of particulate matter, dioxin/furans, and total hydrocarbons (THCs) emissions at the recycling facilities. Facilities must also monitor and meet federal and local ambient air lead concentration standards. All currently operating battery manufacturing and recycling facilities in California are located within the South Coast Air Quality Management District (SCAQMD), and thus adhere to that district's lead emissions standards, which are the strictest in the nation. SCAQMD Rules 1420.1 (recycling) and 1420 (manufacturing). *See* Appendix B.27. Compliance with the federal and local lead standards requires utilization of state-of-the art indoor dust collection systems (local exhaust ventilators) and filters (e.g, bag house filters) and scrubbers to control stack emissions. Facility management practices also control fugitive lead dust emissions from materials handling, vehicle traffic, etc.

According to the U.S. Geological Survey more than 85% of the lead consumed in the U.S. goes into batteries, but EPA data shows that the lead battery industry's combined contribution makes up less than 2.9 % of total lead emissions. Indeed, of all sources, battery manufacturers and recyclers were ranked #14 and #7 of all industrial lead emitters, respectively based on 2008 data. *See* Appendix B.8, pp. 2-4, 6-13 and Appendix B.20, p. 97. The 2014 data shows an even lower level of emissions attributable to the lead battery industries.[8] *See* Appendix B.28, p. 1end. The greatest contribution of air lead emissions comes from aviation fuel use. That said, EPA NAAQS trends data show a 91% decrease in the average ambient level of lead in air from all sources between 2000 and 2015, now below the 2008 0.15 µg/m^3 lead NAAQS standard.[9] These considerations have been fully evaluated by industry and government agencies in the past. Past reviews are reflected in the following source documents:

- Environmentally Sound Management of Spent Lead-acid Batteries in North America: Technical Guidelines, NAFTA Commission for Environmental Cooperation (CEC). *See* Appendix B.6, pp. 28-42.
- Policy Assessment for the Review of the Lead National Ambient Air Quality Standards (NAAQS); U.S. Environmental Protection Agency; EPA-452/R-14-001 (May 2014). *See* Appendix B.8, pp. 2-4; 6-13.
- Lead, U.S. Geological Survey, Mineral Commodity Summaries, Jan. 2017. *See* Appendix B.20, p. 97.

[8] https://www.epa.gov/air-emissions-inventories/2014-national-emissions-inventory-nei-data

[9] https://www.epa.gov/air-trends/lead-trends

G. Factor G – Production, In-Use, and Transportation Energy Inputs

California Health & Safety Code § 25253(a)(2)(G) requires consideration of a product's energy use during production, use and transportation.

As reported by the CEC Technical Guidelines, lead recycling is far more energy efficient than lead mining and refining. *See* Appendix B.6, p. 5. Thus, energy inputs are reduced by minimizing the use of virgin lead in manufacturing through the use of recycled lead. Moreover, according to the UNEP metals flow report, primary lead has one of the lowest energy inputs to mine and extract compared to numerous other metals, including aluminum, lithium, and nickel which are used in lithium-ion batteries. *See* Appendix B.9, pp. 82-83.

Transportation energy inputs are significantly reduced because used lead batteries are typically collected for recycling from retailers in the same trucks that deliver the new batteries. This saves fuel by avoiding the empty truck trips that would be required if the new and old batteries were not handled by the same carrier. The U.S. Department of Transportation (DOT) recognized the importance of this practice in a rule it adopted on June 2, 2016. *See* Appendix B.17, pp. 35499-35500. Transportation energy input increases are also avoided by the increasing energy density of lead batteries, which— with increasing power demands in vehicles—avoids an increase in the lead weight of batteries that are hauled as new product and for recycling.

Many of these considerations have been fully evaluated by industry and government agencies in the past. These reviews are reflected in the following source documents:

- Environmentally Sound Management of Spent Lead-acid Batteries in North America: Technical Guidelines, NAFTA Commission for Environmental Cooperation (CEC) (2010). *See* Appendix B.6, p. 5.
- Environmental Risks and Challenges of Anthropogenic Metals Flows and Cycles, Global Metal Flows Working Group of the International Resource Panel of UNEP, *See* Appendix B.9, pp. 82-83.
- The Facts About Lead: Sustainability and Recycling (2010). BCI presents here factors that reduce energy inputs during lead battery manufacturing and recycling. *See* Appendix B.7.
- 81 Fed. Reg. 35,484 (June 2, 2016), Hazardous Materials: Miscellaneous Amendments (RRR); Final Rule. *See* Appendix B.16, pp. 35499-35500.
- A Review of Battery Technologies for Automotive Applications: A joint industry analysis of the technological suitability of different battery technologies for use across various automotive applications in the foreseeable future; EUROBAT, ILA, ACEA, JAMA and KAMA. *See* Appendix B.1, pp. 14-16.

H. Factor H – Energy Efficiency

California Health & Safety Code § 25253(a)(2)(H) requires consideration of a product's contributions to energy efficiency.

The lead battery furthers energy efficiency in multiple ways. Lead batteries are used for power storage in multiple renewable energy applications, in particular solar and wind. They are enabling more rapid penetration of renewable energy generation, consistent with California's ambitious Renewable Portfolio Standard mandates. Also, as noted above and discussed in further detail below, lead batteries are installed in combustion engine cars with start-stop and micro-hybrid systems in order to improve vehicle fuel efficiency. In micro-hybrid vehicles, the use of a drive train lead battery also is more efficient, because Ni-MH or Li-ion hybrid vehicles would also require a supplemental 12-volt lead battery. *See* Appendix B.18, pp. 1-end. And, they are manufactured using predominantly recycled lead, the production of which is more energy efficient than mining and refining virgin lead, or virgin materials for alternative chemistries.[10] *See* Appendix B.7, p. 5.

Many of these considerations have been fully evaluated by industry and government agencies in the past. These reviews are reflected in the following source documents:

- A Review of Battery Technologies for Automotive Applications: A joint industry analysis of the technological suitability of different battery technologies for use across various automotive applications in the foreseeable future; EUROBAT, ILA, ACEA, JAMA and KAMA. *See* Appendix B.1, pp. 9; 12-16.
- Stakeholder Consultation Questionnaire: Exemption No. 5 "Lead and lead compounds in components: Batteries"; Industry contribution of ACEA, JAMA, KAMA, CLEPA, ILA and EUROBAT (12/2014). *See* Appendix B.2, pp. 2-8.
- Environmentally Sound Management of Spent Lead-acid Batteries in North America: Technical Guidelines, NAFTA Commission for Environmental Cooperation (CEC) (2010). *See* Appendix B.6, pp. 5, 17-19; 25-27; 42-44.
- The Facts About Lead: Hybrid Electric Vehicles (2010). BCI presents here the use of lead batteries in micro-hybrid and hybrid electric vehicles to increase energy efficiency. *See* Appendix B.18., pp. 1-end.

I. Factor I – Greenhouse Gas Emissions

California Health & Safety Code § 25253(a)(2)(I) requires consideration of a product's greenhouse gas emissions (GHGs).

Data comparing GHG emissions of the mining and production of various metals industries has been reported by the United Nations Environment Program. Most notably, lithium, nickel and aluminum – all used to manufacture li-ion and other batteries – emit significantly more GHGs per kilogram than lead. *See* Appendix B.10, p. 147. EUROBAT documents submitted to the European Commission for its End-of-Life Vehicles directive analysis also address reduced GHG emissions tied to lead batteries.

Also, as noted above, lead batteries are increasingly installed in combustion engine cars as part of start-stop/micro-hybrid systems. Stop-start systems can deliver up to a 5% improvement in vehicle fuel efficiency and reduce GHG emissions by up to 5%. Their use in this capacity is fast

[10] 3/4ths of the lead used to manufacture new lead batteries is recycled lead. *See* Appendix B.26, p.1.

becoming more prevalent with some estimates suggesting at least a 50% market share by 2020 in the U.S.[10] Market adoption of these vehicles is expected to be much more rapid and expansive than full electric vehicles. *See* Appendix B.1, pp. 3; 9; 11-16 and B.2, pp. 7-8.

Moreover, the California Air Resources Board (ARB) now explicitly recognizes lead battery powered electric forklifts as a greenhouse gas emission reduction technology as part of the Low Carbon Fuel Standard (LCFS), and offers credits for the adoption and use of electric forklifts. *See* 17 CCR Section 95483 (e)(7). During the rulemaking, the ARB found that "An increase in electric forklift use … is expected to result in decreased GHG emissions and contribute to meeting the goals of the LCFS program." *See* Initial Statement of Reasons for Proposed Rulemaking: Proposed Re-adoption of the Low Carbon Fuel Standard, December 2014 at https://www.arb.ca.gov/regact/2015/lcfs2015/lcfs15isor.pdf, p. 3-9. ARB also references EPRI guidance that recognizes that lead batteries form the cornerstone of these forklift trucks and, in addition to providing electric power, provide counter-weight attributes. *See* https://www.arb.ca.gov/fuels/lcfs/electricity/epri_2015.pdf.

- A Review of Battery Technologies for Automotive Applications: A joint industry analysis of the technological suitability of different battery technologies for use across various automotive applications in the foreseeable future; EUROBAT, ILA, ACEA, JAMA and KAMA. *See* Appendix B.1, pp. 3; 9; 11-16.
- Stakeholder Consultation Questionnaire: Exemption No. 5 "Lead and lead compounds in components: Batteries"; Industry contribution of ACEA, JAMA, KAMA, CLEPA, ILA and EUROBAT (12/2014). *See* Appendix B.2, pp. 7-8.
- Environmental Risks and Challenges of Anthropogenic Metals Flows and Cycles, Global Metal Flows Working Group of the International Resource Panel of UNEP, (June 2014). *See* Appendix B.9, p. 147. https://issuu.com/unep/docs/environmental_challenges_metals-ful
- Application of Life-Cycle Assessment to Nanoscale Technology: Lithium-ion Batteries for Electric Vehicles, U.S. Environmental Protection Agency, April 2013 (EPA 744-R-12-001). *See* Appendix B.10, pp. 71-74.
- Factsheet: Introducing Stop-Start, Johnson Controls [http://www.johnsoncontrols.com/~/media/jci/ps/applications/files/jc_startstopfactsheet_2016.pdf]. See Appendix B.19, pp. 1-end.
- Initial Statement of Reasons, Jan. 2, 2015.

J. Factor J – Waste and End-of-Life Disposal

California Health & Safety Code § 25253(a)(2)(J) requires consideration of a product's waste and end-of-life disposal impacts.

The recycle rate of lead batteries is unsurpassed by any other product, including any other battery type. BCI's National Recycling Rate Study shows a 99% collection and reclamation rate

[10] http://www.autonews.com/article/20160704/OEM02/307049991/johnson-controls-bets-big-on-stopstartsystems. *See* Appendix B.19, p. 1-end.

for the years 2009 - 2013.[11] *See* Appendix B.6, pp. 2 and 5-6. Thus, lead battery use produces minimal waste at end-of-life. This is a true example of a closed-loop system. EPA's Advancing Sustainable Materials Management report recognizes that lead batteries are the clear leader in post-consumer product recycling. *See* Appendix B.12, pp. 5; 9; 11.

Lead batteries are comprised of three materials: 1) lead and lead compounds (plates and terminals), 2) polypropylene plastic (case), and 3) sulfuric acid (electrolyte). The lead, lead compounds, and plastic from returned batteries are all reclaimed for use in new batteries or other products. The electrolyte is reclaimed for use in new batteries at one major recycler which has a co-located battery manufacturing plant, and at many facilities used acid is converted for use in other products.[12] *See* Appendix B.8, p. 3.

Further, the manufacturing process for lead batteries generates little to no lead waste. Leadbearing wastes generated at battery manufacturing plants are sent directly to a battery recycler (secondary smelter) for lead recovery, which in certain cases is at the same location where batteries are manufactured.

As noted above, there is no other battery chemistry with a known recycling rate of measurable success, let alone one nearing 100%. For example, the reported recycling rate for lithium-ion batteries is 3%, and the recovery of lithium from those batteries is "negligible."[13] The future of Li-ion battery recycling is much more complicated and uncertain. *See* Argonne National Laboratory presentation, Appendix B.15, p. 25.

Many of these considerations have been fully evaluated by industry and government agencies in the past. These reviews are reflected in the following source documents:

- BCI's 2014 National Recycling Rate Study. The Recycling Rate Study includes the data and recycle rate calculations that show the large volume of battery lead that is recycled and therefore source reduced (i.e, reducing virgin ore mining). *See* Appendix B.6, pp. 2 and 5-6.
- Advancing Sustainable Materials Management: Assessing Trends in Material Generation,
  Recycling, Composting, Combustion with Energy Recovery and Landfilling in the United States, 2014 Fact Sheet, U.S. Environmental Protection Agency (November 2016). *See* Appendix B.11, pp. 5; 9; 11.
- The Facts About Lead: Sustainability and Recycling (2010). BCI presents here factors that reduce energy inputs during lead battery manufacturing and recycling. *See* Appendix B.7.
- Stakeholder Consultation Questionnaire: Exemption No. 5 "Lead and lead compounds in components: Batteries"; Industry contribution of ACEA, JAMA, KAMA, CLEPA, ILA and EUROBAT (12/2014). *See* Appendix B.2, pp. 4; 17-19; 25-27.

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[11] Based on lead-weight.

[12] Some facilities alternatively neutralize waste electrolyte prior to discharge to POTWs.

[13] *Opportunities to Improve Recycling of Automotive Lithium Ion Batteries*, Alexandru Sonoc et al., p. 1. Appendix B.17.

- Recycling of Automotive Lithium Ion Batteries: Government Perspective, Linda Gaines and Jeff Spangenburger, Argonne National Laboratory, Jan. 26, 2017. *See* Appendix B.15, p 5.
- *Opportunities to Improve Recycling of Automotive Lithium Ion Batteries*, Alexandru Sonoca and Jack Jeswieta*, Vi Kie Soo, Procedia CIRP 29 (2015), pp. 752 – 757. *See* Appendix B.17, p. 1.

K. Factor K – Public Health Impacts, Including Sensitive Subpopulations

California Health & Safety Code § 25253(a)(2)(K) requires consideration of a product's public health impacts.

The hazards of lead to human health are well known. The European lead industry completed a thorough risk assessment of lead under the EU REACH program in 2008. The U.S. National Institutes of Health's (NIH) National Toxicology Program (NTP) produced a comprehensive report in 2012 on the human health effects of low levels of lead. The NTP report compiles together in one place a summary of the related health studies and findings that have been conducted on low level lead exposures.

However, most recently publicized public lead exposures (generally identified by elevated blood lead levels), are not related to battery use. They instead are most closely correlated to exposures to pre-1978 residential lead paint and drinking water from old lead pipes.[14] Elevated blood lead levels have also been found near airports due to aviation gas emissions.[15]

Other battery chemistries pose similar concerns. The metals and metal compounds in competing battery chemistries (Ni-MH, Ni-Cd and Li-ion) include cobalt, cadmium and nickel, among other metals and chemicals with documented health hazards:

- Cobalt: Cobalt and compounds were recently listed in the NTP's Fourteenth Report on Carcinogens as a probable human carcinogen. See Appendix B.13, p. 3.
- Cadmium and nickel compounds: Cadmium and compounds and nickel compounds have long been on the NTP list as known carcinogens. *See* Appendix B.13, p. 1. EPA lists significant human health concerns with nickel compounds in addition to carcinogenicity in its August 2010 TSCA New Chemicals Program Chemical Categories document. The listed concerns, identified in rat studies, include genotoxicity, fetotoxicity, neonatal mortality, dermatotoxicity and organ weight impacts. *See* Appendix B.14, pp. 88-89. Under California

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[14] "Data show that from 1976 – 1980 the median blood lead level of a child (1-5 years old) was 15 micrograms per deciliter. That median level has been reduced dramatically since then, to 1 microgram per deciliter, based on the most recent data.… These improvements were made by removing lead from toys and lead solder in cans, taking lead out of gasoline, reducing exposure to lead in paint and dust in homes and during renovations, greatly reducing the allowable content of lead in plumbing materials in homes and other buildings, and further reducing lead in drinking water through the federal Lead and Copper Rule (LCR). Although we have taken significant steps to protect our children from the detrimental effects of lead poisoning, there is more to do… However, the [LCR] regulation and its implementation are in urgent need of an overhaul." *See* Lead and Copper Rule Revisions White Paper, U.S. Environmental Protection Agency, Oct. 2016. *See* Appendix B.23, p. 3.

[15] A Geospatial Analysis of the Effects of Aviation Gasoline on Childhood Blood Lead Levels, Marie Lynn Miranda, Rebecca Anthopolos, Douglas Hastings, Environmental Health Perspectives Online, July 13, 2011. *See* Appendix B.24, p. 3.

Proposition 65, nickel and compounds are under consideration for listing as developmental, male reproductive and female reproductive toxicants.

- Nickel: Metallic nickel is on the NTP list for being a probable carcinogen. *See* Appendix B.13, p. 4.

All of these substances are included in the Candidate Chemical list used by DTSC to prioritize products for consideration as potential Priority Products under the Safer Consumer Products regulation.[16]

In addition, not just lead -- but also cadmium, nickel and cobalt and their compounds are among eighty EPA Work Plan chemicals that EPA must consider for priority listing for risk evaluation under the TSCA reform rules to be adopted this month. Numerous health and environmental concerns are listed for these substances here. *See* Appendix B.25, pp. 6, 7 and 20.

The risks that may be posed by chemical releases associated with lithium ion batteries are not well understood, largely because there has been relatively little experience using them in applications other than consumer electronics. However, EPA also lists numerous possible concerns with human health impacts from Li-ion battery components in its life-cycle assessment of Li-ion batteries for electric vehicles. *See* Appendix B.11, pp. 85-91.

Many of these considerations have been fully evaluated by industry and government agencies in the past. These reviews are reflected in the following source documents:

- National Toxicology Program Monograph on Health Effects of Low-Level Lead (June 13, 2012). *See* Appendix B.12.
- Stakeholder Consultation Questionnaire: Exemption No. 5 "Lead and lead compounds in components: Batteries"; Industry contribution of ACEA, JAMA, KAMA, CLEPA, ILA and EUROBAT (Dec. 2014). *See* Appendix B.2, p. 15.
- National Toxicology Program Report on Carcinogens, Fourteenth Edition, Substances Listed in the Fourteenth Report on Carcinogens. *See* Appendix B.13, pp. 1-5.
- TSCA New Chemicals Program Chemical Categories, Office of Pollution Prevention and Toxics, U.S. Environmental Protection Agency, Aug. 2010. *See* Appendix B.14, pp. 88-89.
- Application of Life-Cycle Assessment to Nanoscale Technology: Lithium-ion Batteries for Electric Vehicles, U.S. Environmental Protection Agency, April 2013 (EPA 744-R-12-001). *See* Appendix B.10, pp. 85-91.

L. Factor L – Environmental Impacts

California Health & Safety Code § 25253(a)(2)(L) requires consideration of a product's environmental impacts.

[16] Division 4.5, Title 22, California Code of Regulations, Chapter 55, Safer Consumer Products, Section 69502.2(a); https://calsafer.dtsc.ca.gov/chemical/search.aspx.

Lead batteries are the single most sustainably recycled consumer good in the world, with more than 99% of batteries (by lead weight) recycled each year. *See* Appendix B.5, pp. 2 and 5-6 and Appendix B.12, pp. 5; 9; 11. This means that lead batteries are neither a significant waste stream for landfill or incinerator disposal sites, nor a significant source of environmental impacts from improper or illegal disposal.

Lead battery manufacturing and recycling are subject to strict air and water release limits, which facilities meet every single day. The EPA concluded in 2016 that the current NAAQS for lead did not merit modification because it was sufficiently protective of public health. Moreover, all facilities located in California's SCAQMD are compliant with its more stringent emission rules. *See* Appendix B.27.

Metals in Li-ion and Ni-MH batteries have been found to pose environmental risks equivalent to or greater than those for lead. The UNEP Environment Program, for example, ranks lead for terrestrial ecotoxicity, but it also ranks lithium, nickel and aluminum at higher levels of concern than lead. EPA's New Chemicals Program Chemical Categories report lists multiple aquatic and terrestrial ecotoxicity concerns for cobalt and aluminum and aquatic ecotoxicity concerns for nickel. *See* Appendix B.14, pp. 17-22; 52-55; 88-89. There also are significant environmental impacts from the mining and processing of the lithium source material needed to make the lithium compounds used in Li-ion batteries. These impacts are discussed in both the UNEP and EPA life cycle assessment reports. EPA also lists numerous possible concerns with environmental and ecological impacts from Li-ion battery components in its life-cycle assessment of Li-ion batteries for electric vehicles. *See* Appendix B.11, pp. 63-85.

Existing analyses of these factors include:

- BCI's 2014 National Recycling Rate Study. The Recycling Rate Study includes the data and recycle rate calculations that show the large volume of battery lead that is recycled and therefore source reduced (i.e, reducing virgin ore mining). *See* Appendix B.6, pp. 2 and 5-6.
- Advancing Sustainable Materials Management: Assessing Trends in Material Generation,
  Recycling, Composting, Combustion with Energy Recovery and Landfilling in the United States, 2014 Fact Sheet, U.S. Environmental Protection Agency (Nov. 2016). *See* Appendix B.11, pp. 5; 9; 11.
- Environmental Risks and Challenges of Anthropogenic Metals Flows and Cycles, Global Metal Flows Working Group of the International Resource Panel of UNEP, *See* Appendix B.9, p. 147. https://issuu.com/unep/docs/environmental_challenges_metals-ful
- TSCA New Chemicals Program Chemical Categories, Office of Pollution Prevention and Toxics, U.S. Environmental Protection Agency, Aug. 2010. *See* Appendix B.14, pp. 1722; 52-55; 88-89.
- Application of Life-Cycle Assessment to Nanoscale Technology: Lithium-ion Batteries for Electric Vehicles, U.S. Environmental Protection Agency, Apr. 2013 (EPA 744-R-12-001). *See* Appendix B.10, pp. 63-85.

M. Factor M – Economic Impacts

California Health & Safety Code § 25253(a)(2)(M) requires consideration of a product's economic impacts.

Lead batteries have a positive impact on the economy. First, they are the most affordable choice for automotive starter batteries, micro-hybrid (stop start) and hybrid vehicle batteries, industrial motive power batteries, and standby/back-up power batteries. EUROBAT discusses the cost savings of lead batteries in comparison to other battery chemistries in documents submitted to the European Commission for its End-of-Life Vehicles directive analysis.

Further, lead battery manufacturers and recyclers employ more than 20,000 workers in the U.S, with more than 1,000 directly employed in California. As of today, the clear majority of Li-ion batteries are manufactured in Asia, and it remains unclear whether a significant portion of that manufacturing base will ever transition to the U.S.

Lead batteries are also serving a key role in allowing renewables such as solar and wind to connect the grid, contributing to the new green energy economy.

Existing analyses of these factors include:

- A Review of Battery Technologies for Automotive Applications: A joint industry analysis of the technological suitability of different battery technologies for use across various automotive applications in the foreseeable future; EUROBAT, ILA, ACEA, JAMA and KAMA. *See* Appendix B.1, pp. 12; 24-33.
- Stakeholder Consultation Questionnaire: Exemption No. 5 "Lead and lead compounds in components: Batteries"; Industry contribution of ACEA, JAMA, KAMA, CLEPA, ILA and EUROBAT (Dec. 2014). *See* Appendix B.2, pp. 13-14.
- ACEA, JAMA, KAMA, EUROBAT and ILA position on "Lead-based batteries and Exemption 5 of the EU End of Vehicle Life Directive" (Apr. 2017). *See* Appendix B.3, pp. 2-5.

III. CONCLUSION

In circumstances such as this where a functionally acceptable and technically feasible alternative is not available, the Safer Consumer Products regulation would require the responsible entity to undertake research to address the potential impacts associated with continued use of the product.[17] In fact, this research is already well underway. BCI member companies Advanced Battery Concepts, The Hammond Group and The Doe Run Company have submitted technology demonstration project proposals to DTSC as part of DTSC's Hazardous Waste Reduction Initiative. These projects will explore advancements in lead battery chemistry, battery design and lead recycling technology that promise significant reductions in the lead volume in the product, improved battery life, reduced energy consumption during

[17] Division 4.5, Title 22, California Code of Regulations, Chapter 55, Safer Consumer Products, Section 69506.8. [19] H&SC section 25253 (a)(2): "The regulations adopted pursuant to this section shall establish a process that includes an evaluation of the availability of potential alternatives and potential hazards posed by those alternatives, as well as an evaluation of critical exposure pathways. This process shall include life cycle assessment tools that take into consideration, but shall not be limited to, all of the following (A-M)."

recharge and reduced lead emissions in both the battery manufacturing and recycling processes. It is highly unlikely that another formal evaluation of lead batteries through the Safer Consumer Products regulation would result in a different outcome.

Accordingly, there is no reasonable justification for identifying lead batteries as a priority product, or placing lead acid batteries in DTSC's 3-year Priority Products Work Plan. Either course would divert DTSC's limited program resources from products that pose more direct risks to consumers or the environment, and which would not otherwise be subject to rigorous evaluation of potential alternatives.

Appendix A

Index of Source Documents and Alignment with the Safer Consumer Products Statutory Factors[19]

Appx.	Source Documents	Statutory Factors
B.1	A Review of Battery Technologies for Automotive Applications: A joint industry analysis of the technological suitability of different battery technologies for use across various automotive applications in the foreseeable future; EUROBAT, ILA, ACEA, JAMA and KAMA.	(A) Product function or performance: (pp. 7-9; 11-16; 24-33) (B) Useful life: (pp. 14-16) (C) Materials and resource consumption: (pp. 1416) (G) Production, in-use, and transportation energy inputs : (pp. 14-16) (H) Energy efficiency: (pp. 9; 12-16) (I) Greenhouse gas emissions: (p. 3) (M) Economic impacts: (pp. 12; 24-33)
B.2	Stakeholder Consultation Questionnaire: Exemption No. 5 "Lead and lead compounds in components: Batteries"; Industry contribution of ACEA, JAMA, KAMA, CLEPA, ILA and EUROBAT (Dec. 2014).	(A) Product function or performance: (pp. 1-2; 11-13; 15; 22-23) (B) Useful life: (p. 7) (C) Materials and resource consumption: (p. 7) (H) Energy efficiency: (pp. 2-8) (I) Greenhouse gas emissions: (pp. 7-8) (J) Waste and end-of-life disposal: (pp. 4; 17-19; 25-27) (K) Public health impacts, including sensitive subpopulations: (p. 15, Pb, Ni an Li batteries) (M) Economic impacts: (pp. 13-14)
B.3	ACEA, JAMA, KAMA, EUROBAT and ILA position on 'Lead-based batteries and Exemption 5 of the EU End of Vehicle Life Directive (Apr. 2017).	(A) Product function or performance: (pp. 2-3) (M) Economic impacts: (pp. 2-3)

Appx.	Source Documents	Statutory Factors
B.4	8th Adaptation to scientific and technical progress of exemptions 2(c), 3 and 5 of Annex II to Directive 2000/53/EC (ELV) – OEKO Report for the European Commission DG Environment under Framework Contract No ENV.C.2/FRA/2011/0020 – Final Report (17 Feb. 2016).	(A) Product function or performance: (pp. 87-91)
B.5	BCI's 2014 National Recycling Rate Study. As part BCI's calculation of the industry's recycling rate, BCI conducts a failure rate analysis which evaluates the typical actual service life of batteries returned for recycling in the relevant period.	(B) Useful life: (pp. 2; 5-6) (C) Materials and resource consumption: (pp. 2; 5-6) (J) Waste and end-of-life disposal: (pp. 2; 5-6) (L) Environmental impacts: (pp. 2; 5-6)
B.6	Environmentally Sound Management of Spent Lead-acid Batteries in North America: Technical Guidelines, NAFTA Commission for Environmental Cooperation (CEC). Provides numerous examples of materials and resource consumption reduction.	(C) Materials and resource consumption: (pp. 17-19; 25-27; 42-44) (D) Water conservation: (pp. 17-19; 25-27; 42-44) (E) Water quality impacts: (pp. 43; 58) (F) Air emissions: (pp. 28-52) (G) Production, in-use, and transportation energy inputs: (p. 5)
B.7	The Facts About Lead: Sustainability and Recycling (2010). BCI presents here factors that reduce energy inputs during lead battery manufacturing and recycling.	(G) Production, in-use, and transportation energy inputs: (pp. 1-end) (J) Waste and end-of-life disposal: (pp. 1-end)
B.8	Policy Assessment for the Review of the Lead National Ambient Air Quality Standards (NAAQS); U.S. Environmental Protection Agency; EPA-452/R-14-001 (May 2014).	(F) Air emissions: (pp. 2-4; 6-12; 6-13)
B.9	Environmental Risks and Challenges of Anthropogenic Metals Flows and Cycles, Global Metal Flows Working Group of the International Resource Panel of UNEP.	(G) Production, in-use, and transportation energy inputs: (pp. 82-83) (I) Greenhouse gas emissions: (p. 147) (L) Environmental impacts: (p. 147)
B.10	Application of Life-Cycle Assessment to Nanoscale Technology: Lithium-ion Batteries for Electric Vehicles, U.S. Environmental Protection Agency; EPA 744R-12-001 (Apr. 2013).	(I) Greenhouse gas emissions: (pp. 71-74) (K) Public health impacts, including sensitive subpopulations: (pp. 85-91) (L) Environmental impacts: (pp. 63-85)

B.11	Advancing Sustainable Materials Management: Assessing Trends in Material Generation, Recycling, Composting, Combustion with Energy Recovery and Landfilling in the United States, 2014 Fact Sheet, U.S. Environmental Protection Agency (Nov. 2016).	(J) Waste and end-of-life disposal: (pp. 5; 9; 11)
B.12	National Toxicology Program Monograph on Health Effects of Low-Level Lead (Jun. 13, 2012).	(K) Public health impacts, including sensitive subpopulations: (pp. 1-end)
B.13	National Toxicology Program Report on Carcinogens, Fourteenth Edition, Substances Listed in the Fourteenth Report on Carcinogens.	(K) Public health impacts, including sensitive subpopulations: (pp. 1-5)

Appx.	Source Documents	Statutory Factors
B.14	TSCA New Chemicals Program Chemical Categories, Office of Pollution Prevention and Toxics, U.S. Environmental Protection Agency (Aug. 2010).	(K) Public health impacts, including sensitive subpopulations: (pp. 88-89) (L) Environmental impacts: (pp. 1722; 52-55; 88-89)
B.15	Recycling of Automotive Lithium Ion Batteries: Government Perspective, Linda Gaines and Jeff Spangenburger, Argonne National Laboratory (Jan. 26, 2017).	(J) Waste and end-of-life disposal: (p. 5)
B.16	81 Fed. Reg. 35484 (Jun. 2, 2016), Hazardous Materials: Miscellaneous Amendments (RRR); Final Rule.	(G) Production, in-use, and transportation energy inputs: (pp. 35499-35500)
B.17	*Opportunities to Improve Recycling of Automotive Lithium Ion Batteries*, Alexandru Sonoca and Jack Jeswieta*, Vi Kie Soo, Procedia CIRP 29 (2015).	(C) Materials and resource consumption: (p. 1) (J) Waste and end-of-life disposal: (p. 1)
B.18	The Facts About Lead: Hybrid Electric Vehicles (2010). BCI presents here the use of lead batteries in microhybrid and hybrid electric vehicles to increase energy efficiency.	(H) Energy efficiency: (pp. 1-end)

B.19	Factsheet: Introducing Stop-Start, Johnson Controls http://www.johnsoncontrols.com/~/media /jci/ps/applications/files/jc_startstopfactsheet_2016.pdf	(I) Greenhouse gas emissions: (pp. 1-end)
B.20	Lead, U.S. Geological Survey, Mineral Commodity Summaries (Jan. 2017).	(F) Air emissions: (p. 97)
B.21	Guidance Manual for Battery Manufacturing Pretreatment Standards, U.S. Environmental Protection Agency, EPA 440/1-87/014 (Aug. 1987).	(E) Water quality impacts: (pp. B-7; B-8)
B.22	EPA Abstracts of Industrial NPDES Permits, U.S. Environmental Protection Agency, OWEP 89-01 (Oct. 1989) https://www.epa.gov/nscep.	(E) Water quality impacts: (p. 468)
B.23	Lead and Copper Rule Revisions White Paper, U.S. Environmental Protection Agency (Oct. 2016).	(K) Public health impacts, including sensitive subpopulations: (p. 3)
Appx.	**Source Documents**	**Statutory Factors**
B.24	A Geospatial Analysis of the Effects of Aviation Gasoline on Childhood Blood Lead Levels, Marie Lynn Miranda, Rebecca Anthopolos, Douglas Hastings, Environmental Health Perspectives, Online (Jul. 13, 2011).	(K) Public health impacts, including sensitive subpopulations: (p. 3)
B.25	TSCA Work Plan for Chemical Assessments: 2014 Update, U.S. Environmental Protection Agency (Oct. 2014).	(K) Public health impacts, including sensitive subpopulations: (pp. 6; 7; 17; 20)
B.26	The Facts About Lead: Energy Storage/Standby, BCI (2010)	(C) Materials and resource consumption: (p. 1) (H) Energy efficiency: (p. 1)
B.27	SCAQMD Rules 1420 and 1420.1	(F) Air emissions: (pp. 1-end) (L) Environmental impacts: (pp.1-end)
B. 28	EPA NEI lead air emissions data	(F) Air emissions: (p. 1-end)

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