Research on Correspondence between ELV Exemption and Auto Parts Products

Meng Hou, Longhui Li and Lei Wang
China Automotive Technology and Research Center Co., Ltd. No.68, East Xianfeng Road, Dongli Economic-Technological Development Area, Tianjin, China
Email: houmeng@catarc.ac.cn

Abstract. Restricting the use of hazardous substances in automobiles has become an inevitable trend for the green development of automotive products. In China, the technical requirements for hazardous substances in automobiles stem from GB/T30512 “Requirements for Prohibited Substances in Automobiles”, and the standard is currently undergoing strong revisions. One of the core contents of the standard is the exemption list, which stipulates the compliance content and distribution of hazardous substances in automobile products. This article analyzes the scope of auto parts and materials covered by each exemption list for the exemption list, constructs the corresponding relationship between the exemption list and auto parts in principle, and provides guarantee for the implementation of subsequent standards.

1. Introduction
As green development is an inevitable development trend of manufacturing industry in the new era, environmental protection issues have become challenges that our automobile industry is forced to deal with. According to statistics, in 2018, passenger car inventory in China exceeded 200 million. The amount of scrapped vehicles in China will exceed 7 million in 2018 given the 8-10 years of service life or 500,000-600,000 km of actual service life of general vehicles. The pollution caused by automobile industry has started to threaten natural environment and human survival and aroused growing concern [1]. Since the implementation of Management Requirements on Vehicle Noxious Substance and Recycling Rate in 2016, the reduction in hazardous substances in automobiles have achieved initial success. However, compared with countries and regions with developed automobile industry, such as Japan and EU, China is still lagging behind, which is mainly reflected in the revision of exemption list in terms of automobile hazardous materials control. To achieve effective management of scrapped vehicles, lower environment pollution and eliminate green trade barrier of member countries, EU Parliament and EU Council released ELV directive on September 18, 2000. Following that, EU has revised exemption lists in 2000/53/EC appendix II of ELV directive for eight times. The exemption list continues to be subdivided, which puts stricter control requirements on hazardous substances. It maintains the leading position in ELV field.

To closely follow the ELV development trend, the revision on execution standard on hazardous substances control GB/T 30512, on the basis of taking into account the domestic automobile industry development status, has started. In addition to the transition of standard nature to compulsive standard, the exemption list is also the core contents for the standard revision. This paper, through interpreting
the exemption list in the latest ELV directive released by EU, in combination with the auto parts and materials features in China, studied the correspondence between exemption terms and auto parts and analyzed the parts and materials covered by all exemption items. Meanwhile, it gave brief introduction to the alternative technology on exemption items.

2. Interpretation on Exemption List

2.1. Current Exemption Items List in China

At present, 6 hazardous substances under China’s ELV control correspond to 23 exemption items, 11 of which are still in effective exemption period. Refer to table 1 for details.

| Item                                                                 | Description                                                                 |
|----------------------------------------------------------------------|-----------------------------------------------------------------------------|
| Lead alloys                                                          | 6 Solder in electronic circuit boards and other applications                 |
| 1 Steel for mechanical processing and galvanized steel (lead≤0.35%)  | 7 Electrical components which contain lead in a glass or ceramic matrix compound except glass in bulbs and glaze of park plugs |
| 2 Aluminium product (lead≤0.4%)                                      | 8 Absorption air conditioner in motorcaravans                                |
| 3 Copper alloys (lead≤4%)                                            | 9 Mercury                                                                    |
| Lead and lead compound for parts                                     | 10 Discharge lamps for head light application                                |
| 4 Battery                                                            | 11 Fluorescent tubes used in instrument panel displays                       |
| 5 Vibration dampers                                                  | BFR Decabromodiphenyl ether                                                 |

At present, the valid exemption items mainly cover lead, mercury, chromium VI and BFRs. It requires attention that the three kinds of exemption materials involved by lead are subject to exemption limit and other exemption items are subject to no such requirements.

2.2. Analysis of the Difference of the Exemption List in China and EU

The comparison of exemption list in China and 2017/2096/EU directive exemption list is as follows.

As shown in table 2, the current valid exemption items are different from those in EU exemption list, mainly reflected in aluminium materials, batteries, solders, electrical parts, chromium VI and BFRs. EU subdivides aluminium materials and batteries into 2 items, subdivides solders into 11 items, electrical parts into 4 items. Moreover, most of the exemption items have passed exemption period. The control level over hazardous materials lead is above the current implementation standard in China.

3. Correspondence between Exemption Items and Parts

The correspondence relationship between exemptions items and parts is shown in table 3.

3.1. Steel for Mechanical Processing and Galvanized Steel (Lead ≤0.35%)

Steel for mechanical processing generally refers to the low-carbon free-cutting steel. The introduction of lead is mainly for the improvement of machining performance and better surface smoothness and more accurate size control. The lead-bearing free-cutting steel is widely applied due to low cost, mature technology and long history. Meanwhile, free-cutting steel is an inevitable trend for the steel development. GB/T8731-2008 Free-Cutting Structural Steel includes the lead-bearing free-cutting steel as an independent category into standard. Its lead-bearing amount is generally between 0.15%-0.35%, which is basically consistent with the exemption limit.
### Table 2. Difference of exemption list in China and EU.

| Exemption list in China | Difference with exemption items of EU |
|------------------------|---------------------------------------|
| (1) Steel for mechanical processing and galvanized steel (lead ≤ 0.35%) | Subdivided into 2 items |
| (2) Aluminium product (lead ≤ 0.4%) | Subdivided into 4 items |
| (3) Copper alloys (lead ≤ 4%) | No difference |
| (4) Battery | Subdivided into 2 items |
| (5) Vibration dampers | Different definition, which refer to counterbalance |
| (6) Solder in electronic circuit boards and other applications | Subdivided into 11 items |
| (7) Electrical components which contain lead in a glass or ceramic matrix compound except glass in bulbs and glaze of spark plugs | |
| (8) Absorption air conditioner in motorcaravans | Different items, which refer to heat-absorbing refrigerator |
| (9) Discharge lamps for head light application | Passed exemption period |
| (10) Fluorescent tubes used in instrument panel displays | Passed exemption period |
| (11) Decabromodiphenyl ether | No exemption item |

### Table 3. Correspondence of exemption list and auto parts/materials.

| New version of exemption list | Covered parts or materials |
|-------------------------------|-----------------------------|
| (1) Steel for mechanical processing and galvanized steel (lead ≤ 0.35%) | Bolts, screws, nuts, hollow screws, valve pins, spring guides, valve pistons, valve seats, sleeves, piston rods, magnets /magnetic cores, solenoids, bushings, housings, spacers, air vent screw, shaft, stub, socket, lock, bracket, rotor and so on. Wheel hub, cylinder block, cylinder head, steering wheel, instrument panel skeleton, piston, heat shield, heat exchange part, variable case, differential case, motor case, power battery case, wheel frame, track, pipe, fastener and so on. Tire cycle valves, valve guides, tire valves, fuel injectors, nozzles, battery terminals, temperature sensor shell, carburetor nozzles, radios, wiper systems, door locks, power window lifts, parts of brake systems, bushings in grouped lamps, palping foot, small shafts in the seat, etc. It refers to high-voltage system parts with a voltage >75 in the power battery, such as fuse resistors, high-voltage power distribution boxes, etc. |
| (2) Aluminium (lead ≤ 0.4%) | |
| (3) Copper alloy (lead ≤ 4%) | |
| (4a) Lead in batteries in high-voltage systems that are used only for propulsion in M1 and N1 vehicles | It refers to vehicle starting-type lead batteries, lead-bearing parts include polar plates, grids, binding posts and so on. |
| (4b) Lead in batteries for battery applications not included in entry 4a | |
| (5) Vibration dampers | It can be flexibly applied to all positions of |
| New version of exemption list | Covered parts or materials |
|-------------------------------|---------------------------|
| (6a) Lead in solders to attach electrical and electronic components to electronic circuit boards and lead in finishes on terminations of components other than electrolyte aluminium capacitors, on component pins and on electronic circuit boards. | Solder for PCBA connection in ECU, PEU, BCM, BMS, MCU, MCS, VCU, T-BOX |
| (6b) Lead in solders in electrical applications other than soldering on electronic circuit boards or on glass | Pin coating of electrical parts |
| (6c) Lead in finishes on terminals of electrolyte aluminium capacitors | Pin coating of electrolytic capacitor / aluminium capacitor |
| (6d) Lead used in soldering on glass in mass airflow sensors | Glass solder in engine air flow sensor |
| (6e) Lead in high melting temperature type solders | It refers to the solder for internal sealing of electrical parts, functional modules and connection solder of coil and terminal in the relay as well as the carbon brush connection solder in the generator |
| (6f-1) Lead in compliant pin connector systems | Solder on the connector and harness connection terminals, distributed in each control unit IC |
| (6f-2) Lead in compliant pin connector systems other than the mating area of vehicle harness connectors | Solder on the connector and the IC connection terminal, distributed in each control unit IC |
| (6g) Lead in solders to complete a viable electrical connection between semiconductor die and carrier within integrated circuit flip chip packages | It specifically refers to flip chip, typically the headlight LED chip. |
| (6h) Lead in solders to attach heat spreaders to the heat sink in power semiconductor assemblies with a chip size of at least 1 cm² of projection area and a nominal current density of at least 1 A/mm² of silicon chip area | Typical parts such as IGBTs, MOSFETs, etc. |
| (6i) Lead in solders in electrical glazing applications on glass except for soldering in laminated glazing | It refers to the solder used to connect the rear windshield to electrical parts. |
| (6j) Lead in solders for soldering in laminated glazing | It refers to the solder used to connect the front windshield to the electrical parts. |
| (7a) Electrical and electronic components which contain lead in a glass or ceramic, in a glass or ceramic matrix compound, in a glass-ceramic material, or in a glass-ceramic matrix compound. This exemption does not cover the use of lead in: | Various ceramic/glass matrix electrical parts such as chip resistors, capacitors, diodes, PZT, etc. |
| —glass in bulbs and glaze of spark plugs, | |
| —dielectric ceramic materials of components listed under 7(b), 7(c) and 7(d). | |
New version of exemption list | Covered parts or materials
---|---
(7b) Lead in PZT based dielectric ceramic materials of capacitors being part of integrated circuits or discrete PZT dielectric ceramic capacitors. | Ceramic matrix capacitor with rated voltage below the requirements
(7c) Lead in dielectric ceramic materials of capacitors with a rated voltage of less than 125 V AC or 250 V DC | Ceramic matrix capacitor with rated voltage below the requirements
(7d) Lead in the dielectric ceramic materials of capacitors compensating the temperature-related replenishment in an ultrasonic sensor, such as an deviations of sensors in ultrasonic sonar systems | Ultrasound sensor in car backing radar
(8) As an anti-corrosion agent of the carbon steel cooling system in absorption refrigerators in motor caravans up to 0.75 weight % in the cooling solution except where the use of other cooling technologies is It refers to the heat-absorbing refrigerator practicable (i.e. available on the market for the preservatives in motor caravan. application in motor caravans) and does not lead to negative environmental, health and/or consumer safety impacts | It refers to the heat-absorbing refrigerator practicable (i.e. available on the market for the preservatives in motor caravan. application in motor caravans) and does not lead to negative environmental, health and/or consumer safety impacts
(9) Lead-containing thermoelectric materials in automotive electrical applications to reduce CO2 emissions by recuperation of exhaust heat | Thermoelectric conversion materials, such as brake energy recovery systems in new energy vehicle recycling systems
(10) Decabromodiphenyl ether | It is mainly used for leather, rubber, plastic, electronic, and electrical parts with flame retardant requirements.

The lead in galvanized steel mainly comes from hot-dip galvanizing process. To increase the liquidity of galvanizing zinc, make it convenient for residue recycling, and protect crucible, the hot-dip galvanizing process will add a certain amount of lead to introduce part of the lead in the coating.

3.2. Aluminium Product (≤ 0.4%)
Aluminium is added with lead element to improve the machining performance, improve anti-corrosion ability. According to the requirements of national standards on the parts of aluminium alloy, in GB/T3190-2008 Wrought Aluminium and Aluminium Alloy—Chemical Composition and GB/T15115-2009 Die Casting Aluminium Alloys, the lead content in aluminium alloys is required to be ≤0.1%, which satisfies current GB/T30512 standard limit requirements. However, according to the common aluminium alloy marks ADC12, AlSi<sub>9</sub>Cu<sub>3</sub>(Fe) and EN-AC AlSi<sub>9</sub>Cu<sub>4</sub>(Fe) of automobiles, the lead content is generally <0.35%. Although exceeding the standard limit, it is lower than exemption limit. In addition, the lead in the scrapped aluminium is inseparable. However, the aluminium wastes are necessary raw materials in aluminium alloy manufacturing. Moreover, the lead content controlled at certain level will not have significant influence on aluminium alloy performance. Therefore, a certain amount of lead will be found in secondary aluminium.

3.3. Copper Alloy (≤ 4%)
Lead elements added in cooper alloy will improve the machining performance of materials, lower the cracking trend of materials, improve the anti-corrosion performance of materials and will not influence the strength and electrical conductivity of cooper alloy. In most cases, the lead content of cooper alloy falls between 0.15%–4%. According to statistics, over 7000 parts contain lead-bearing cooper alloy in
automobile products and most of the parts contain over 3% lead. According to GB/T5231-2012 Wrought Aluminium and Aluminium Alloy—Chemical Composition, the type of copper alloy that contains lead is lead brass with lead content as high as 3.5-4.5% (HPb57-4), which is higher than the exemption limit of copper alloy specified in GB/T30512.

3.4. Batteries
Batteries include power batteries and starter batteries. Only lead in the high-voltage system of power batteries falls into exemption items. Lead in other batteries is still in exemption status, such as starter lead batteries.

3.5. Vibration Dampers
The current ELV management standard in China is executed following the suspension damper, which is inconsistent with the definition of EU dampers in practice.

3.6. Solder in Electronic Circuit Boards and other Applications
Solders can be subdivided into 11 exemption items. Each item corresponds to different purposes. It requires attention that the solders covered by exemption items are not traditional PCB solder for welding. It also includes pin coating, internal solders for electrical parts and glass solder and other solder purposes related to electricity in general sense.

3.7. Electrical Components that Contain Lead in a Glass or Ceramic Matrix Compound except Glass in Bulbs and Glaze of Spark Plugs
This exemption item is subdivided into 4 items. The first item mainly refers to all ceramic or glass matrix electrical parts. The second, third and fourth items are respectively designed for specified ceramic matrix capacitor, aiming to prepare for the follow-up exemption tightening.

3.8. Lead in Absorption Refrigerator within Motor Caravan Serves as Preservatives of Carbon Steel Cooling System
For this exemption item, EU is different from China. The former one specifies exemption limit on heat-absorbing refrigerator, namely ≤ 0.75%; the latter one targets heat-absorbing air conditioner.

3.9. Lead in Vehicle Electronic Parts Thermoelectric Materials Used in Waste Heat Recovery System to Reduce Carbon Dioxide Emission
Newly added exemption items are mainly used for thermoelectric conversion materials in new energy braking energy recovery system.

3.10. Decabromodiphenyl Ether
It is still exempted and rarely used in the industry and mainly concentrated in circuit board flame retardant application area.

4. Application of Exemption Items Alternative Technology
To learn about the domestic applicability of exemption items, this paper conducts material data analysis on part of the exemption parts of hot-sale vehicle products to further study the application of alternative technology for automobile products in China and its reasonable exemption period.

4.1. Tire Valve
The lead-bearing brass enjoys the widest application. The typical parts include tire cycle valve. In most cases, the cycle valves apply HPb59-1, which contains lead of 0.8-1.9%. This paper conducted
thorough study on the cycle valve in 37 types of vehicles that enjoy good sales performance in the industry and found that 14 types’ tire valves use leadless bismuth brass with HB\textit{Bi}59-1 and content of bismuth of 0.8-2.0%. Research shows that when the bismuth brass contains 0.9% of bismuth, its cutting performance is close to HPb59-1 [2].

4.2. PCB Solders

With the improvement in intelligence level of automobile, the variety of electronic products of automobile is also on the rise. Leadless solder becomes the control focus for the prohibited substances of vehicles. Research shows that SnAgCu braze filler metal, due to its good wettability, high contact reliability and excellent thermal fatigue resistance performance, is widely recognized as the most potential alternative [3]. The paper analyzed PCB solder usage of electronic pivot window control unit of 44 types of vehicles, 38 types of which apply leadless solders which are mainly SnAgCu and SnCu series solders. It indicates that the current PCB leadless solders have been widespread and the technology has been mature. Cancellation of exemption can be considered.

4.3. Starter Batteries

The starter batteries of automobile have always been lead batteries. The main lead-bearing parts include polarity and grid. In the state of charge, the anode is lead dioxide and the cathode is lead. The grid materials contain Pb-Ca alloy and Pb-Sb alloy, which is the major lead source of the vehicle, accounting for over 95% of the total lead content of the vehicle [4].

As the starter batteries of automobile, lithium ion battery as the alternative of lead batteries has been the focus of industrial research. It has deemed as the inevitable development trend. Since 2014, BYD new energy vehicles have successively realized the replacement of lead batteries with lithium iron phosphate batteries as the starter batteries of automobile, which boasts better energy density, high-low temperature discharge, high current output, security and environmental protection than lead batteries. At present, the main technical challenges in popularization lie in the high one-time input cost, which has significant influence on the price of the vehicle.

4.4. Central Electric Appliance Control Unit

The electrical parts of automobile have a great variety, many of which involve lead element. Except for solder, lead mainly exists in ceramics and glass materials. For typical parts such as knock sensor, the PZT must be invisible. This paper analyzed the materials of knock sensor of 11 domestic mainstream vehicle types and found all knock sensors still use traditional PZT ceramic materials. PZT or lead zirconate titanate, features lead oxide contents of around 60% [5]. The future development direction of leadless PZT mainly includes the following three categories: KNN, BNT and BZT and already started commercial application, such as BZT PZT [6]. The main application parts of PZT include knock sensors and buzzers [7].

5. Conclusion

This paper gave a detailed interpretation on the exemption items of the latest ELV directive of EU, made comparison with existing exemption list in China, analyzed the reference significance of EU exemption items on the revision of our GB/T30512 standard and clarified the auto parts and materials scope corresponding to each exemption item so as to provide basic research on the implementation of new exemption list. Meanwhile, the paper carried out thorough analysis on the application status of exemption item alternative technology, aiming to provide reference for the formulation of exemption list and exemption period of China.
References

[1] Zhang H and Chen M 2013 Inventory analysis on the effect of end-of-life passenger vehicle plastic bumper recycling in China Progress in Rubber, Plastics and Recycling Technology 29 21-38.

[2] He Q, Xie S, Xia Q, Tang Z and Gao S 2016 Influence of bismuth content on the cutting performance of brass Light Industry Science and Technology 2 52-58.

[3] Zeng Q, Gu X and Zhao X 2008 Progress of study on the lead-free of high temperature Pb-rich solder Electronic Parts & Materials 27 16-19.

[4] Zhang C, Yao S, Wu G, Xu S and Shen P 2015 Corrosion performance of lead alloys as current collectors Power Supply Technology Research and Design 8 1694-96.

[5] Wang K, Shen Z and Zhang B 2014 (K, Na)NbO₃-based lead-free piezoceramics: Status, prospects and challenges Journal of Inorganic Materials 29 13-19.

[6] Shen Z, Li Y and Wang Z 2012 new research progress of the three main lead-free piezoelectric ceramic systems Journal of Synthetic Crystals 41 309-13.

[7] Hou M, Li L and Xu S 2016 Current Situation of application of prohibited substances and alternative technologies in automotive products Auto Time 10 17-18.