Research on vehicle recycling based on ELV Directive

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Abstract: Based on researches on ELV directive at home and abroad, this paper developed an ELV directive-based vehicle recycling test program and offered solutions for the government and enterprises to manage end-of-life vehicles. The vehicle ELV test realized the verification by tests and scrutiny of the ELV directive and the self-inspection of enterprises, and improved the ELV management system.

1. BACKGROUND

ELV refers to the End-of-Life Vehicle Directive. The ELV Directive is the recycling directive on end-of-life vehicles formulated by the European Commission and the European Parliament to protect the environment and reduce the waste generated from vehicle scrapping. The directive on one hand limits the content of prohibited substances like lead, cadmium, mercury, hexavalent chromium in automotive materials and on the other hand stipulates the recyclability rate/recoverability rate (RRR) of the scrapped cars.\textsuperscript{[1]} China issued the "Requirements for Prohibited Substances on Automobiles" in February 2014 and the category and limits of prohibited substances are consistent with the ELV directive.\textsuperscript{[2]}

Our country keeps pace with the EU at the legal level, but still falls behind at the management level by now. Both China and the EU adopt the management mode of "front-end reporting and back-end supervision", while the realization of this mode requires the coordination of the entire supply chain of the automotive industry. As Europe has nearly 20 years of experience in controlling ELV since 2003, the entire supply chain system has fully understood and adapted to this mode. With the sound and perfect legal system and corresponding law enforcement agencies to impose punishment in Europe, the cost of violation is high. Thus, the entire supply chain will fill in the information in strict accordance with the requirements and keep true to facts. While the controlling of ELV just starts in China, the entire industry supply chain is still not well understood and the corresponding laws and regulations are inadequate, there might be inconsistency between the reported and actual information. As the responsible subject of ELV, OEMs should carry out vehicle ELV verification and require ELV inspection reports from their suppliers to avoid risks.

Since the requirements of ELV directive is on the material level, the verification has to be realized through disassembling of the whole vehicle.\textsuperscript{[3]} There are already mature ways to test the prohibited substances and calculate the RRR for reference, but without the standard guidance on the operational level, the dismantling of the whole vehicle is yet to be studied. Based on the ELV Directive and the "Requirements for Prohibited Substances on Vehicles", this article developed an ELV vehicle test program to learn about the use of prohibited substances in vehicles and obtain the RRR of vehicles.
2. RESEARCH ON ELV VEHICLE TEST PROGRAM

2.1. Research on dismantling of the whole vehicle
To disassemble the whole vehicle into homogeneous materials is first to dismantle the whole vehicle to parts, and then parts to homogeneous materials. To take safety factors and requirements of the ELV directive into consideration when dismantling the whole vehicle, preparatory work is necessary. And that means first, verify vehicle information including vehicle type, engine number, VIN code/frame number e.t.c and record with photos, including the photos of left front 45°, right rear 45°and top view of the side 45°. Then check the integrity of the vehicle to see if there is defect of the appearance and surface, whether the accessories are complete, whether the systems function well, and whether there is oil or liquid leakage. Check whether the components like bumper, rear view mirror and others are intact and complete, whether the window glass is intact and whether the chassis is damaged or severely corroded, then open the engine hood to check if the components of engine system are complete and effective.

The dismantling stage is to disassemble the whole vehicle into parts, and code the parts in the form of "the last four digits of the vehicle VIN code [4]+ the name of the parts". According to the research data of 5 finished vehicles, the vehicle can be disassembled into 300-500 parts. And with analysis of the dismantling of 5 vehicles, it comes to the conclusion that the disassembling of vehicles can be divided into three steps: vehicle weighing, vehicle pretreatment and vehicle dismantling. Dismantling components should be recorded with photos and that includes photos of the dismantling location and the disassembled components. First, use the axle load meter to test the weight of the vehicle and then step into the pretreatment dismantling stage, which includes retrieving the liquid like fuel, engine oil, transmission/gearbox (including rear differential and / or transfer case) oil, power steering oil, coolant, brake fluid, damping fluid, air conditioning refrigerant, windshield cleaning fluid, engine installation oil and hydraulic suspension fluid. Then disconnect the battery and confirm that all oil pipes and gas lines are under high pressure. Different liquid should be collected in different plastic bottles and then weighed, photographed and recorded.

Under the premise of ensuring safety, the integrity of the components should be guaranteed when dismantling vehicles. A two-post lift is used in this research and the study of dismantling of 5 vehicles demonstrates that the front and rear weight of the vehicles must be consistent during the dismantling process to ensure the stability of the whole vehicle on the lift. As disassembling the whole vehicle is the reverse operation of the installation, certain special conditions are required for dismantling some special parts. For example, disassembling special parts like window glass requires power. Therefore, the dismantling of the whole vehicle must follow certain rules.

2.2. Research on dismantling parts
The parts assembly should be divided into general parts and special parts before dismantling. The purpose of disassembling parts is to get homogeneous materials and then perform prohibited substances test and recycling phase calculation. When test result exceeds the standard limit or shows other problems, the material should be source traced and rectified. So a part dismantling form is necessary to record the name, code, dismantling location photos, and material photos of different components. Studies show that normal forms don't work on tracing the source, while the tree structure effectively solves this problem. The homogeneous materials disassembled from parts can be coded according to the tree structure of the form. The level of disassembled components is coded as ABCD. Grade A represents
that the component can be obtained directly from dismantling the parts. If grade A is not homogeneous material, the grade of the material obtained from dismantling of grade A is grade B, and so on. Studies show that there are at most four levels from parts to materials, so the code is also up to D. And the number of materials in each level is less than or equal to 1000, so it’s enough to add three numbers after each level to indicate the order. For example, the homogeneous material obtained from disassembling Part A is coded as "Part A-A001-B001-C001-D001", and there is no order in the same level.

Figure 2. Tree structure of parts dismantling

2.2.1. Research on dismantling of general parts

It’s better to use physical ways to dismantle the general parts to avoid chemical contamination caused by methods like cutting and content change of prohibited substances in components caused by heat. The research shows that heat causes content change of polybrominated biphenyls and polybrominated diphenyl ethers in the material and the residues of the saw blade used for high-speed cutting remain at the cut of the material, which also affect the subsequent element analysis and test.

It’s necessary to collect test information such as the category, quantity, weight, and photos of the parts and homogeneous materials while dismantling, and create a tree structure dismantling form with the material codes. All parts should be photographed before and after dismantling. Put the parts on a suitable and uniform background and indicate the approximate dimension with the ruler in the horizontal and vertical directions. To ensure the accuracy of the weight of parts and homogeneous materials, some may need to be cleaned before weighing to remove grease and stains on the surface. Choosing the cleaning fluid should follow the rule that there will be no chemical reaction between the fluid and the component materials. Components like rubber parts, oil seals, non-metallic friction plates, various bakelite gears and plastic parts, aluminum alloys, zinc alloys and other parts cannot be cleaned with lye. Metal parts cannot be cleaned with acid solution and some plastic and rubber parts cannot be cleaned with organic solution. After cleaning with lye, acid or organic solution, rinse the parts with clean water and wipe with clean cloth or air-dry. Make sure that the camera is perpendicular to the top of the sample when taking pictures, and the photos should demonstrate the characteristic of the sample to trace the source. Studies show that blue is preferred for the photo background. The same material in the components can be regarded as the same part when named and coded, but the quantity should be recorded in the form.

The disassembled homogeneous material should be screened by EDXRF. If it’s identified as suspicious material, chemical quantitative analysis is necessary to determine whether the material is up to standard. Therefore, the size of the disassembled homogeneous material should meet the requirement of subsequent tests. The energy dispersive XRF used in this study has certain requirements on the size, thickness and degree of flatness of the sample. The sample should have a thickness of about 2 cm, a diameter of 2 cm as a circle, and a as flat as possible test surface. Therefore, we also have to process the disassembled homogeneous materials into the sample specifications required by EDXRF.
2.2.2. Research on dismantling special parts
Special parts refer to those that may be dangerous during the disassembling process and can’t meet the disassembling requirement of general parts. So preparation work is necessary before disassembling the special parts. Special treatment and protection before dismantling is necessary for the special parts involved with safety. For example, the air bag must be exploded before being disassembled.

| Auto parts                              | Dangers          |
|-----------------------------------------|------------------|
| Airbags                                 | Explosion        |
| Seat belt emergency locking device      | Explosion        |
| Back door jumping pole                  | High pressure    |
| Vibration absorber                      | High pressure    |
| Lead-acid Batteries                     | Corrosion injury |
| Fuel tank                               | Inflammable      |
| Vehicle liquid                          | Corrosion injury |
| Tyre                                    | Respirable dust injury |
| Electrical/ Electronic Assemblies       | Chemistry injury |

Electrical and electronic components may not meet the disassembling requirement of general parts due to their particularity. And contamination between different samples is inevitable during the disassembling process so the subsequent test result might show false positive. For example, metal contains no polybrominated biphenyls and polybrominated diphenyl ethers, but decabromodiphenyl ether in the circuit board may adhere to the pins or solders when disassembling the pins or solders on the circuit board and contaminates the samples. So it should be specially marked in the disassembling form to ensure successful subsequent test.

3. STATUS QUO AND DEVELOPMENT TENDENCY OF ELV DIRECTIVE MANAGEMENT AT HOME AND ABROAD

3.1. Status quo of ELV directive management at home and abroad
In order to reduce the environmental pollution of end-of-life vehicles and maintain sustainable development of automobile industry, the European Commission and the European Parliament have formulated the End-of-Life Vehicle Directive, referred to as ELV Directive. The directive sets a standard for the content limit of prohibited substances in the car and RRR of the vehicles, and thus drives the whole industry to develop into environmentally friendly industry. As companies violate the ELV directive will be punished with high fines and even be suspended for rectification, the cost of violation in Europe is high. So the whole supply chain will strictly follow the ELV directive and avoid violation.

The vehicle holdings in China are larger than that in the USA now. As the country with most cars in the world, environmental problems caused by end-of-life vehicles have come into sight of relevant departments in China. The Ministry of Industry and Information Technology issued the "Management Requirements for Automobile Hazardous Substances and Recyclable Rates" (hereinafter referred to as "Management Requirements"), which proposes specific requirements to the content limit of six hazardous substances, namely lead, mercury, cadmium, chromium, polybrominated biphenyls and polybrominated diphenyl ethers in M1 vehicles in the automotive industry and also to the recyclability rate/recoverability rate. It’s stated that the above indicators will be included in the "Announcement of Vehicle Manufacturers and Products" (referred to as "Announcement") from January 1, 2016. Therefore, using “Announcement” as an effective management tool for the ELV in Chinese automobile industry demonstrates the efforts and determination of our country in managing ELV. After the introduction of
the "Management Requirements", the OEMs responded actively to ensure the compliance of their products. This management method not only prevents ELV management from becoming a dead letter but also promotes the healthy and stable development of ELV in our country.

3.2. The development tendency of ELV directive
As the organization that proposed the ELV directive, the European Union has been revising the management requirements to meet the growing demands of the automotive industry. The ELV directive has the following development trends inferring from the EU's management process: stricter limits of prohibited substances; expanding scope of prohibited substances; increasing in detection methods for prohibited substances; stricter limits of recyclability rate/recoverability rate and gradual exclusion of certain exemption options from the exemption list, etc. These trends indicate the progress of ELV on a global scale and the development of the automotive material industry in the field of alternative materials. The stricter requirements further promote the development of the global automotive industry to an environmentally friendly industry.

The "Requirements for Prohibited Substances in Automobiles" is part of China's ELV directive, and its revision represents the development of our country's ELV. Except the original six prohibited substances (lead, cadmium, mercury, hexavalent chromium, polybrominated biphenyls, polybrominated diphenyl ethers), asbestos and polycyclic aromatic hydrocarbons are gradually added to the scope of management. The expired exemption clauses in the list will be deleted, and the original exemption clauses will be revised. This indicates that our country does not just simply copy the EU's ELV directive. It’s updated and is the ELV directive appropriate to the Chinese automobile industry.

4. CONCLUSION
In conclusion, as a globally recognized directive for automobile recycling, the ELV directive has made important contributions to global environmental protection. The vehicle recycling test program based on the ELV directive has realized the vehicle ELV test verification and improved the ELV directive management in our country.

The ELV test data also assist companies in analyzing the actual use of vehicle materials and put forward new ideas for the companies’ consistency control. Analyzing the RRR of vehicles and the prohibited substances in the vehicles in our country provides a data basis for the localization of the ELV directive and helps to shorten the gap between our country and the ELV developed countries and regions like Europe and the United States, and promotes the development of the automobile industry.

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