Status Update for End-of-Life Vehicle (ELV) Directive; Replacement of Hexavalent Cr in Automotive Industry

Harish Bhatt, Visteon Corp., Canton, MI

The End-of-Life Vehicle (ELV) Directive from the European Union (EU) was established in September 2000. The mandate prohibited/restricted four heavy metals: lead, mercury, cadmium and hexavalent chromium. Implementation date of July 2003 had a restriction of 2.00 g of hexavalent Cr per vehicle. Annex II of the ELV Directive was revised in June 2002. The new requirement is 0.00 g of hexavalent Cr with implementation d ate of July 2007. OEMs, however, have set their dates earlier than 2007. This presentation will discuss the ELV initiatives, OEM position, and available options to replace hexavalent chromium.

For more information, contact:
Harish Bhatt
Visteon Corp.
Phone 734-484-8787
FAX 734-484-9075
hbhatt@peoplepc.com

Introduction

A mandate was proposed in 1997 to restrict the usage of heavy metals in the motor vehicles by the European Union (EU). The four heavy metals included cadmium, lead, mercury, and hexavalent chromium. The bill was introduced in the EU parliament in May 2000, and in September 2000 it became a EU directive 2000/53/EC on End-of-Life Vehicles (ELV). This Directive aims at the prevention of wastes from vehicles and at the reuse, recycling and other forms of recovery so as to reduce the disposal of waste, while at the same time improving the environmental performance of all of the economic operators involved. This Directive restricted the total content of hexavalent chromium to 2.0 grams per vehicle prior to shredding, incineration, or recycling. The usage of hexavalent chromium is only for corrosion protection purpose; for all other purposes, the limit is 0.0 gram. The Annex II of the directive has been recently revised (6/02); hexavalent chromium restriction is 0.00 grams per vehicle. This directive is effective July 2007 for any vehicles sold within European Union's member nation states.

Background History

The European Parliament and the Council of The European Union signed the End-of Life Vehicles directive on September 18th, 2000. The End-of Life Vehicles Directive has now officially been published as 2000/53/EC. The content has not been deviated from the agreed text of the Conciliation Committee as advised in VRD EU/P/384 dated July 17th, 2000. The most essential items of the Directive are as follows.

- **Objectives –**
  The Directive lays down measures which aim at the prevention of waste from vehicles and also the reuse, recycling, and other forms of recovery of end-of life vehicles and their components so as to reduce the disposal of waste. It also covers the improvement in the environmental performance of all of the economic operators involved in the life cycle of vehicles, and especially the operators directly involved in the treatment of end-of life vehicles.
- **Scope –**
  M1 passenger vehicles and N1, light duty trucks up to 3500 kg GVM including their components and materials, as well as spare or replacement parts in accordance with the appropriate Community and domestic provisions.
- **Prevention –**
  Member States shall ensure that materials and components of vehicles put on the market (first registered) after July 1, 2007 do not contain lead, mercury, cadmium or hexavalent chromium other than in specific cases listed in the Directive. Hexavalent chromium is specified as corrosion prevention coating on numerous key vehicle components with zero grams per vehicle. Vintage vehicles, meaning historic vehicles or vehicles of value to collectors or intended for museums, kept in a proper and environmentally sound manner, either ready for use or stripped into parts, are not covered by the definition of waste laid down by Directive 75/442/EEC and do not fall within the scope of this directive.
- **Collection –**
  Member States shall take the necessary measures to ensure that the delivery of the vehicle to an authorized treatment facility occurs without any costs for the last holder and/or owner as a result of the vehicles having no, or a negative, market value. This applies to vehicles first registered from 1 July 2002 and from 1 January 2007 to vehicles registered before 1 July 2002. However, Member States may apply these provisions in advance of the above dates.

- **Treatment –**

  Member States shall take the necessary measures to ensure all end-of life vehicles are stored and treated in accordance with the general requirements laid down per Directive 75/442/EEC. Technical requirements, obtaining a permit, safety and health precautions, and other necessary requirement shall also be per 75/442/EEC.
- **Re-Use and Recovery –**

  Member States shall take the necessary measures to ensure that the following targets are attained by Economic Operators (i.e. OEMs, automotive suppliers, dismantlers, shredders, recyclers, recoveries, and other treatment operators of end-of life vehicles, including their components and materials).
  - No later than 1/1/2006 for all end-of life vehicles, the re-use and recovery shall be increased to a minimum of 85% by an average weight per vehicle and year. For vehicles produced before 1/1/80, the target set at 75% for re-use and recovery and 70% for re-use and recycling.
  - By 1/1/2015, the re-use and recovery shall be increased to a minimum of 95% by an average weight per vehicle and year. Re-use and recycling shall be increased to a minimum of 85% for the same time frame.
  - The European Parliament and the Council shall re-examine the targets referred above on the basis of a commission report, which would cover material composition of vehicles and related environmental aspects.
- **Coding standards/dismantling information –**

  Member States shall take the necessary measures to ensure that the OEMs use component and material standards suitable for re-use and recovery. OEMs shall provide dismantling information within six months. Automotive component manufacturers to provide appropriate information, to treatment facilities, concerning dismantling, storage and testing of components, which can be reused.
- **Reporting and information –**

  Member States shall require the relevant economic operators to publish information on *(a)* the design of vehicles and their components for recovery and recycling, *(b)* the environmentally sound treatment of end of life vehicles, in particular the removal of all fluids and dismantling, *(c)* the development and optimization of ways to reuse, recycle, and recover end of life vehicles and their components, and *(d)* the progress achieved with regard to recovery and recycling to reduce the waste to be disposed of and to increase the recovery and recycling rates. The OEMs must make this information accessible to prospective buyers and must include in promotional literature during marketing.
- **Implementation –**

  Member States shall bring into force the laws, regulations and administrative provisions necessary to comply with the Directive by 21 April 2002.
- **Committee procedure –**

  The committee who will adopt its rules of procedure shall assist the commission.
- **Entry into force –**

  The Directive entered into force on 21 October 2000.

Body

The automotive manufacturers and also the suppliers of automotive components were aware of the mandate, which was proposed in 1997. It was expected that the mandate would pass by the European Parliament and the Council. The bill was introduced in May 2000 and the presidents of the European Parliament and the Council signed it on September 18 2000. Article 4(2)(a) states that "Member States shall ensure that materials and components of vehicles put on the market after July 2007 do not contain lead, mercury, cadmium or hexavalent chromium other than in cases listed in Annex II under the conditions specified therein". The directive 2000/53/EC restricts the usage of hexavalent chromium for corrosion protection purpose to 0.0 grams per vehicle effective July 2007.

The test methods to measure the amount of hexavalent chromium have been identified to a certain extent. Most common method is a leaching method and is used by most of the chemical suppliers. However, the stripping process incurs some conversion of hexavalent chromium to trivalent chromium resulting in a slight inaccuracy for the exact calculations. The most accurate method is XPS (X-ray Photoelectron Spectroscopy). The cost however, is an issue due to a high cost of the instrument and consequently a higher sample testing cost. The calculation of exact amount of hexavalent chromium and the test method are important factors in determining the total amount of hexavalent chromium for each component in a vehicle. The analytical procedure for determination of hexavalent chromium content is not sufficiently harmonized yet, and although car manufacturers are interested, it is not expected that a reliable and straightforward analytical procedure to be used directly in the production process would soon be available.

Zinc chromate and chromium chromate are used in vehicle (car) manufacturing as anti-corrosion coatings with active corrosion preventive properties. Hexavalent chromium is used in two main fields: The cathodic corrosion prevention which is applied mainly for smaller steel parts and the rinsing solutions containing hexavalent chromium which are used in paint shops following a pretreatment with phosphatization as an adhesion layer (or fixation ground) before additional layers of paint are applied. Protective coatings based on hexavalent chromium are very effective because of their sacrificial nature of deposit (self healing).

According to the automotive industry, 4 to 8 grams of hexavalent chromium is used per car as an average though some will contain more than 10 grams. Every year end-of life vehicles in the EU Community generate between 8 and 9 million tones of waste, which must be managed correctly. It is a further fundamental principle that waste should be reused and recovered, and that preference be given to reuse and recycling.

It is technically possible to produce cars without hexavalent chromium in most applications. Hex chromium is used for corrosion prevention on numerous steel parts in form of zinc dichromate. Additionally to corrosion protection some parts must fulfill requirements like disconnectability even after several years of use or special sealing or similar function in high-pressure liquid system applications (e.g. high-pressure fuel injection, brake liquids). For these applications, which are also safety relevant, extensive time for introduction of alternative corrosion or sealing systems will be needed. In some other cases, it cannot be excluded that certain parts are

chromated for merely aesthetic purposes today (e.g. to yield a blue, black or yellow chromate surface).

A wide variety of strategies to substitute hexavalent chromium have been developed, including thick layers based on zinc combined with an organic coating, and zinc powder alloys in duplex lamina, which offer a better corrosion protection. There are several trivalent chromates available to replace hexavalent chromates. In most cases, their performance is enhanced with a final coating of a sealer. There are also some no-chrome alternatives available though the applications and availability are limited due to the nature of deposit. The substitutes are readily available for rinsing solutions after phosphatizing and are in widespread usage for car bodies.

Several trivalent chromates are commercially available. Their performance is at least as good to meet the current specifications with hexavalent chromates, and in most cases, (the performance) is enhanced with a topcoat or a sealer following an immersion in a heated chromate bath. It is important to run test samples for evaluation to meet your engineering specifications. The final finish and color of a trivalent chromated part depends on the proprietary formulation of a chemical supplier. Some suppliers offer a color dye as a final immersion in the plating process, which facilitates laser marking on the part surface.

No-chrome substitutes are also available, as more research and development have taken place in recent years. In most cases, the application involves more than one coat, and also limited to either a spray and spin or dip and spray operation. This prohibits its usage for any finer thread size fasteners. The colors are also limited to gray, black or silver finish. Chrome free substitutes are desirable and offer excellent performance.

The Annex II of the Directive has been revised for zero gram of hexavalent chromium by the year 2007. This step-wise phase out should enable the market to change in an appropriate time scale. Taking into account the time required for diffusion of information, retooling of plating shops, creation of full capacity, qualification and validation of parts and components for series manufacturing phase out on a case-by-case basis is a reasonable route. Okopol suggests differences to the phase out plan proposed by the experts from industry for those systems where alternatives are well established and already in use.

The main concerns about hexavalent chromium are related to occupational safety and health issues, and to production waste and discharge waters. For these reasons, car manufacturers have already significantly reduced its use in recent years. Zinc chromate and chromium chromate are carcinogenic substances, which upon inhalation cause cancer to the bronchial tract. Skin contact may cause sensitization towards allergic reactions. Human exposure can occur mainly during production, in repair shops during grinding, and in recycling processes.

Status of ELV

As mentioned earlier in this text, hexavalent chromium is restricted to 0.00 grams by July 2007. This mandate applies to any vehicles sold within the European Union member nation states. At present, there are fifteen (15) member nation states – Belgium, Denmark, Germany, Greece, Spain, France, Ireland, Italy, Luxembourg, the Netherlands, Austria, Portugal, Finland, Sweden,

and United Kingdom. European Union is scheduled for expansion to 25 member nation states by 2004. Countries on the verge of joining the EU are Hungary, the Czech Republic, Poland, Cyprus, Lithuania, Slovenia, Estonia, Latvia, Slovakia, and Malta. Bulgaria and Romania will be included by 2007 bringing the total of member nation states to twenty-seven (27). Turkey will be added later on. ELV is now law in Germany and Denmark and the Netherlands are very close.

Recent international car recycling workshop in Munich, Germany included heavy metals in automobile applications, design for recycling, labeling, reporting to governments, and methods of detecting hexavalent chromium. One item which received a lot of attention was proposed fine of 20,000 to 50,000 euro per vehicle for out of compliance to ELV. Four countries have unofficially signed up so far- Germany, Denmark, Spain, and the Netherlands. It has not been drafted by the European Union.

The Council of European Union has scheduled this directive and its Annex II for a revision in the year 2005.

OEM Position

As the European Union revised Annex II of the ELV directive, vehicle manufacturers also have revised their targets for compliance to zero grams of hexavalent chromium. Some of the major manufacturers have established earlier dates (at least a year or two ahead of July 2007), while others have also extended in line of European Union's dates. Some vehicle manufacturers have selected dichromates by the color finish and corrosion protection for a gradual elimination process. Most OEMs have established a task force and budget to address this issue.

Tier I and Tier II suppliers have responsibility to comply with their customer's requirements regardless of the dates established by the European Union. At times, it makes it difficult for them to meet different due dates for more than one OEM customer.

Other Directives

There are some other important directives from the European Union that have direct or indirect effects on ELV directive. WEEE (Waste of Electric and Electronic Equipment) and RoHS (Restriction of Hazardous Substance) have tremendous impact on ELV. The European Council and the European Parliament have reached reconciliation on the text of this pair of directives. These directives are now expected to become law by December 31, 2002 with transposition into national legislation within 30 months (latest by June 2005) with material restrictions applying from January 1, 2006 at point of sale to a consumer. The WEEE directive is the first true "producer responsibility" directive. In other words, the producer must finance the total cost of disposal (including collection from the last user) of the product at the end of its life and prove that recycling targets laid down have been met. These requirements start December 31, 2004. There is now a real incentive for every manufacturer to create products of which more parts can be recycled more completely.

Summary and Conclusions

It has to be acknowledged that corrosion protection needs to be tested on a long-term basis. The widespread usage of hexavalent chromium in the automotive industry makes this elimination program very complex. The different functions of hexavalent chromium in addition to the corrosion protection and the safety and human health issues make a phase-out of hexavalent chromium following a case-by-case process reasonable.

It is suggested to replace hexavalent chromium with a suitable trivalent chromium coating. There are several commercially available substitute trivalent chromates on the market. Most of them are offered with a topcoat or a sealer to enhance the performance to meet your engineering specifications. Some products have a pale and lighter finish that can be darken with a dye. One should consider a no-chrome finish wherever possible to avoid a future replacement of interim coating. No-chrome substitutes are available for limited applications. There are color or finish limitations and the number of suppliers. It may also be a good time to evaluate your specifications as well as manufacturing process; either could be modified to an appropriate level.

Two major critical factors are the timing and cost of this program. The magnitude of the program is rather large. The timing to run samples, evaluation of test data to meet your engineering specifications, and the acceptance by the customer would perhaps take four to six months or even longer. The date established by the Directive is July 2007, and in turn, the OEMs have set up their own dates as the time line for acceptance of components with no hexavalent chromium. The cost may depend on several factors – major factors are the selection of a particular process and the supplier's capability. Production volume also plays an important role for the cost. In general, higher raw material cost, shorter bath life, and higher concentration are the contributing factors for higher cost of a trivalent chromate. Limited availability for no-chrome substitutes and higher raw material cost are the major factors for higher cost of no-chrome deposits.

The replacement of hexavalent chromium from automotive components is a tremendous environmental task that will require a team approach among the chemical suppliers, the electroplaters (applicators), and automotive manufacturers. This is not an option; it is a legal requirement by the European Parliament and the Council of European Union. Even though ELV directive is implemented for the sale of motor vehicles within the EU member nation states, it has expanded globally due to global manufacturing of automotive components and vehicles. In addition, CARB (California Air Resource Board) has also proposed banning hexavalent chromium and cadmium from motor vehicles, which makes it an extremely difficult and time-consuming task. The objective is to re-use and recover with a preference to re-use and recycle wherever possible. This is to reduce waste, while at the same time improving the environmental performance by related industries.