GUIDELINES ON BEST AVAILABLE TECHNIQUES AND PROVISIONAL GUIDANCE ON BEST ENVIRONMENTAL PRACTICES

relevant to Article 5 and Annex C of the Stockholm Convention on Persistent Organic Pollutants

Shredder plants for the treatment of end-of-life vehicles

UNEP

This publication may be reproduced in whole or in part in any form for educational or non-profit purposes without special permission, provided acknowledgement of the source is made. The Secretariat of the Stockholm Convention and UNEP would appreciate receiving a copy of any publication that uses this publication as a source. No use of this publication may be made for resale or for any other commercial purpose whatsoever without prior permission in writing from the United Nations Environment Programme.

Published by the Secretariat of the Stockholm Convention on Persistent Organic Pollutants in October 2008. For more information please contact:

Secretariat of the Stockholm Convention on Persistent Organic Pollutants
United Nations Environment Programme
International Environment House
11-13 chemin des Anémones
CH-1219, Châtelaine, Geneva, Switzerland
ssc@pops.int - www.pops.int

Designed and printed by: SRO-Kundig - Geneva

GUIDELINES ON BEST AVAILABLE TECHNIQUES AND PROVISIONAL GUIDANCE ON BEST ENVIRONMENTAL PRACTICES

relevant to Article 5 and Annex C of the Stockholm Convention on Persistent Organic Pollutants

May 2007, Geneva, Switzerland

Contents

Section I: Introduction

I.A Purpose
I.B Structure of document and using guidelines and guidance
I.C Chemicals listed in Annex C: Definitions, risks, toxicity
I.D Article 5 and Annex C of the Stockholm Convention
I.E Relationship to the Basel Convention
I.F Relationship to other environmental concerns

Section II: Consideration of alternatives in the application of best available techniques

II.A Consideration of alternatives in the Stockholm Convention
II.B The Stockholm Convention and new sources
II.C An approach to consideration of alternatives
II.D Other considerations of the Stockholm Convention

Section III: Best available techniques and best environmental practices: Guidance, principles and cross-cutting considerations

III.A Guidance
III.B General principles and approaches
III.C Cross-cutting considerations:
(i) Chemicals listed in Annex C: Formation mechanisms
(ii) Waste management considerations
(iii) Co-benefits of best available techniques for chemicals listed in Annex C
(iv) Management of flue gas and other residues
(v) Training of decision makers and technical personnel
(vi) Testing, monitoring and reporting

Section IV: Compilation of summaries from the source categories included in sections V and VI

Summaries of section V: source categories included in Part II of Annex C
Summaries of section VI: source categories included in Part III of Annex C

Section V: Guidance/guidelines by source categories: Source categories in Part II of Annex C

V.A Waste incinerators
(i) Municipal solid waste, hazardous waste and sewage sludge
(ii) Medical waste
V.B Cement kilns firing hazardous waste
V.C Production of pulp using elemental chlorine or chemicals generating elemental chlorine
V.D Thermal processes in the metallurgical industry
(i) Secondary copper production
(ii) Sinter plants in the iron and steel industry
(iii) Secondary aluminium production
(iv) Secondary zinc production

Section VI: Guidance/guidelines by source categories: Source categories in Part III of Annex C

VI.A Open burning of waste, including burning of landfill sites
VI.B Thermal processes in the metallurgical industry not mentioned in Annex C Part II
(i) Secondary lead production
(ii) Primary aluminium production
(iii) Magnesium production
(iv) Secondary steel production
(v) Primary base metals smelting

VI.C	Residential combustion sources
VI.D	Fossil fuel-fired utility and industrial boilers
VI.E	Firing installations for wood and other biomass fuels
VI.F	Specific chemical production processes releasing chemicals listed in Annex C
VI.G	Crematoria
VI.H	Motor vehicles, particularly those burning leaded gasoline
VI.I	Destruction of animal carcasses
VI.J	Textile and leather dyeing (with chloranil) and finishing (with alkaline extraction)
VI.K	Shredder plants for the treatment of end-of-life vehicles
VI.L	Smouldering of copper cables
VI.M	Waste oil refineries

Section VI.K

Guidance/guidelines by source category: Source categories in Part III of Annex C

Part III Source category (k): Shredder plants for the treatment of end-of-life vehicles

Contents

VI.K Shredder plants for the treatment of end-of-life vehicles 9

1. Preamble 9
2. Process description 10
3. Composition of shredder waste 11
4. Emission concentrations from shredder plants 13
5. Recommended measures 14
6. Minimum technical requirements for treatment 14
7. Primary measures 15
8. Secondary Measures 15

References 16

Other Sources 16

Tables

Table 1. Organics in shredder residues defined in the original reference as "fuel fractions" and "disposal fractions" 12

Table 2. Dibenzo-*p*-dioxins and dibenzofurans emissions in German shredder plants 13

Table 3. Measured data for emission concentrations from shredder plants 13

Illustrations

Figure 1. Overview of the shredder process 10

Figure 2. Composition of shredder waste 11

VI.K Shredder plants for the treatment of end-of-life vehicles

Summary

Shredder plants for treatment of end-of-life vehicles are lbisted in Annex C of the Stockholm Convention as a source that has the potential to form and release chemicals listed in Annex C. Shredders are large-scale machines equipped inside with one or more anvils or breaker bars and lined with alloy steel wear plates. An electric motor drives the rotor with the free-swinging alloy steel hammers. Beneath the shredder is a vibratory pan, which receives the shredded material discharged through the grates. Typically a ferrous metal stream is produced, which is relatively clean and consists of small (50 mm) pieces of steel and a "fluff" stream, which contains the fragments of non-ferrous metals and other materials that entered the shredder (also known as fragmentizer).

Very few data of stack emission measurements at shredder plants are available. However, the results of some studies have shown levels of dioxin compounds greater than 0.1 ng I-TEQ/m^3. At present there is not sufficient evidence that in the (mechanical) shredding of vehicles, household electrical equipment or other electrical appliances new formation occurs of polychlorinated dibenzo-*p*-dioxins (PCDD), polychlorinated dibenzofurans (PCDF) or polychlorinated biphenyls (PCB). The data available indicate that the PCDD/PCDF and PCB released from shredder plants are from industrial, intentional production and have been introduced with oils, dielectric fluids, and other materials contained in these vehicles or consumer goods and which are simply set free through this mechanical process.

In any case, measures to prevent accidental fires (which could result in the formation of chemicals listed in Annex C) should be in place at shredder plants. Shredder light fluff consists of flammable plastic films and fibrous dust, which forces a careful plant operation for the prevention of accidental fire. Systems for dust suppression (e.g. wet shredding) or dust collection (e.g. cyclones, venture scrubbers or baghouse) are normally installed on shredder plants for the treatment of end-of-life vehicles. Dust suppression or collection systems would help to reduce potential emission of persistent organic pollutants. To improve emission control of the dust, fine dry residues should be stored in such a way that dispersion is minimized. Other sources of dioxin precursors that may result in the formation of PCDD/PCDF when burnt include PCB-containing condensers, PCB- or chlorobenzene-contaminated waste oils or textiles, and polymers containing brominated flame retardants (formation of polybrominated dibenzo-*p*-dioxins (PBDD) and polybrominated dibenzofurans (PBDF) as contaminants).

1. Preamble

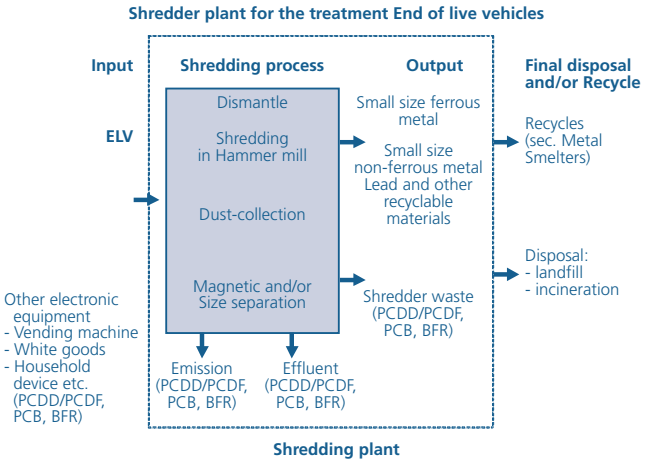
Shredder plants for the treatment of end-of-life vehicles are listed in Annex C of the Convention as a source that has the potential to form and release unintentional persistent organic pollutants. At present, however, there is insufficient evidence that, in this mechanical process, dibenzo-*p*-dioxins and dibenzofurans or polychlorinated

biphenyls are newly formed. The data available indicate that the dibenzo-*p*-dioxins and dibenzofurans and polychlorinated biphenyls released from shredder plants are from industrial/intentional polychlorinated biphenyl production and have been introduced with the oils and dielectric fluids, etc., contained in the vehicles or more probably in consumer goods. The shredders simply free these contaminants.

2. Process description

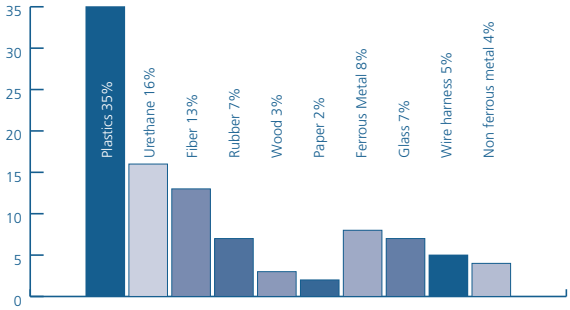
End-of-life-vehicles are processed through shredders. The practice is to shred them along with other end-of-life metal products (such as bicycles, office furniture, vending machines and so-called white goods, such as household devices). In the plant, a high-performance-hammer mill produces sized pieces of ferrous scrap of a high physical and chemical purity. The ferrous scrap is sought after by steel makers and other secondary metal producers. An overview of the process is shown in figure 1.

Figure 1 Overview of the shredder process



Many components of vehicles and other electrical devices are made of non-ferrous materials, such as copper, aluminum and zinc. In the shredding process, magnetic separation is used to remove the magnetic ferrous fraction from other materials. The non-ferrous metals, such as copper and aluminum, are normally sorted out at a later stage. The remainder is the so-called shredder waste and is estimated at between 25% and 35% of the weight of end-of-life vehicles (Environment Australia, Department of the Environment and Heritage, 2002). Shredder waste consists of glass, fibre, rubber, automobile liquids, plastics and dirt. Figure 2 illustrates the composition of shredder waste.

Figure 2 Composition of shredder waste



Source: Environment Australia, Department of the Environment and Heritage (2002)

3. Composition of shredder waste

The composition of shredder fluff will vary considerably from batch to batch and shredder to shredder – due to the different mixes of raw materials being processed and the differing levels of pre-processing and inspection by shredder operators. It should be noted that shredder fluff is likely to vary significantly between shredders due to varying requirements under state and territory licensing conditions and the changes in those conditions over time.

An investigation from Sweden (Börjeson, L.; Löfvenius, G.; Hjelt, M.; Johansson, S.; Marklund, S., 2000) shows that levels of PCDD/PCDF per gram in dry samples of shredder fluff are low in all the fractions (table 1). This conforms to expectations that levels of dioxins and furans should generally be very low, because dibenzo-*p*-dioxins and dibenzofurans is neither used nor deliberately produced for any technical product or substance.

Unlike the dibenzo-*p*-dioxins and dibenzofurans levels, however, the levels of polychlorinated biphenyls were high, especially in fractions originating from industrial waste or waste white goods. The presence of polychlorinated biphenyls in white goods contributes most heavily to polychlorinated biphenyls in the shredder process, but is not a result of unintentional formation during the shredder process. Therefore, it is desirable to know and identify before the shredder process which components of an electrical device may include these compounds and to try to dismantle them before shredding.

Table 1. Organics in shredder residues defined in the original reference as "fuel fractions" and "disposal fractions"

Organics	PCDD/F I-TEQ ng g^{-1} Fuel fr	PCDD/F I-TEQ ng g^{-1} Disposal fr	PCB µg g^{-1} Fuel fr	PCB µg g^{-1} Disposal fr	PCBz µg g^{-1} Fuel fr	PCBz µg g^{-1} Disposal fr
P1 half dism.	<0.6	–	6.7	–	2.2	–
P1 full dism.	<0.20	–	6.1	-	0.4	-
P1 mixed cars	<0.03	0.04	1.1	41	0.7	0.4
P1 mixed waste	<0.2	0.03	12	77	0.8	0.3
P1 white goods	<0.15	0.04	34	114	0.9	0.4
P1 industrial waste	<0.3	0.04	24	62	0.3	0.2
P2 half dism.	<0.2	–	2.1	–	1.9	–
P2 half dism.	<0.11	–	0.5	–	1.5	–
P2 full dism.	<0.6	–	0.6	–	0.4	–
P2 mixed cars	<0.3	0.06	1.5	14	1.5	0.3
P2 mixed waste	<0.2	0.15	39	217	1.9	0.4
P2 white goods	<0.16	0.11	102	254	0.7	0.5
P2 industrial waste	<0.12	0.14	25	295	0.4	0.15

Source. Börjeson, L; Löfvenius, G; Hjelt, M.; Johansson, S.; Marklund, S. 2000

Studies have confirmed that automotive shredder residues derived from end-of-life vehicles contain PCB in the ppm-range (=mg/kg) (Urano *et al.* 1999, Sakai *et al.* 1998, 2000). dibenzo-*p*-dioxins and dibenzofurans contamination in engine oil from end-of-life vehicles could not be detected. Taking congener profiles into account, it can be considered that the major reason for this is that polychlorinated biphenyls -containing materials manufactured in the past were mixed in the recycling and waste processes. While emissions of persistent organic pollutants from shredding plants were not examined in these studies, given the levels of PCB in the ppm-range (=mg/kg) in automotive shredder residues, potential emissions of persistent organic pollutants through flue gas should be considered. This polychlorinated biphenyl release originates from the commercial polychlorinated biphenyl mixture that is used in automobiles. These PCBs are not unintentionally generated persistent organic pollutants and thus, in a strict sense, not subject to the polychlorinated biphenyl release inventory under the provisions of Article 5 of the Stockholm Convention. Since there is no way, however, to differentiate between intentional and unintentional polychlorinated biphenyls in shredder wastes and emissions, best available techniques and best environmental practices should be applied to minimize or eliminate release of any polychlorinated biphenyls from the shredder process.

Copper and chlorine in significant amounts are constituents of shredder waste and promote in case of burning the formation of dibenzo-*p*-dioxins and dibenzofurans and other unintentionally released persistent organic pollutants.

4. Emission concentrations from shredder plants

A report on a European dioxin inventory stated that measured dibenzo-*p*-dioxins and dibenzofurans data exist for a few shredder installations. Generally, very low concentrations (<0.01 ng I-TEQ/m³) were found in a plant investigated in Sachsen-Anhalt (Germany). The available data are summarized in table 2 below, showing emissions and emission factors to air.

■ Table 2. Dibenzo-p-dioxins and dibenzofurans emissions in German shredder plants

	Minimum	Maximum	Geometric mean	Arithmetic mean
Emission concentration (ng I-TEQ/m³)	0.002	0.430	0.056	0.140
Emission factor (mg I-TEQ/t)	0.059	0.667	0.236	0.303

Source: LUA 1997.

A further investigation from Belgium (François, F., Blondeel, M., Bernaert, P., Baert, R., 2004) considered potential specific sources of unintentionally released PCB and PCDD/PCDF from a shredder plant turning end-of-life vehicles and waste from electronic and electrical equipment into various reusable fractions. An overview of a number of stack emission measurements of dibenzo-*p*-dioxins and dibenzofurans and unintentionally released polychlorinated biphenyls is given in table 3. The shredders are equipped with at least a cyclone filter system for de-dusting the flue gases. Flue gas flow rates are typically about 75,000 Nm³/h. All dibenzo-*p*-dioxins and dibenzofurans concentrations, except one, were below 0.1 ng TEQ/Nm³.

■ Table 3. Measured data for emission concentrations from shredder plants

Emission measurements	PCDD/F ng TEQ Nm³	dioxin-like PCB (sum of 12) ng TEQ/Nm³
Shredder 1	0.0098	0.048
	0.012	0.41
	0.0048	0.073
	0.0004	0.025
Shredder 2	0.077	0.74
	0.043	1.06
	0.022	0.30
Shredder 3	0.0088	0.171
	0.37	0.34
	0.025	0.73

Source: François, F., Blondeel, M., Bernaert, P., Baert, R. 2004

Dioxin precursors which may result in the formation of polychlorinated dibenzo-*p*-dioxins and dibenzofurans (PCDD/PCDF) when burnt include polychlorinated biphenyls -containing condensers, polychlorinated biphenyls or chlorobenzene contaminated waste oils or textiles, and polymers containing brominated flame retardants (formation of polybrominated dibenzo-p-dioxins (PBDD) and polybrominated dibenzofurans (PBDF) as contaminants).

5. Recommended measures

An important best environmental practice is to strengthen the responsibility of the operators of shredders. An analysis should be undertaken to identify hazardous components and fluids with incoming material and to provide facilities to remove them before the shredder process.

It is crucial to control treated scrap, especially electric devices, transformers and condensers, which must be identified, dismantled and eliminated separately to avoid the introduction of polychlorinated biphenyls into the plant. This is also a measure to reduce the contamination of shredder residues by polychlorinated biphenyls.

Nevertheless, shredder residues are always contaminated and must only be disposed of in an incineration dedicated plant.

By dismantling and recycling big plastic parts, for instance bumpers, a considerable reduction of the remaining plastic fraction in the end-of-life vehicles and in the resulting shredder waste can be achieved.

By further treatment of shredder wastes, for instance by eddy current separation, a considerable proportion of the metals contained in the waste, such as copper and aluminium, can be recovered.

In order to achieve a higher proportion of recyclable fractions, the use of recyclable material and simple disassemblies should be encouraged in the stage of product design. This is not only valid for end-of-life vehicles.

6. Minimum technical requirements for treatment

Sites have to be constructed to prevent the contamination of soil, water and air. For this reason, appropriate storage facilities, including impermeable surfaces with spillage collection facilities; decanters and cleanser-degreasers should be provided, as well as equipment for the treatment of appropriate storage tanks for water, including rainwater. In addition, appropriate storage for dismantled spare parts, including impermeable storage for oil-contaminated spare parts, appropriate containers for the storage of batteries (with electrolyte neutralization on site or elsewhere), filters and PCB/PCT-containing condensers and appropriate storage tanks for fluids are necessary.

7. Primary measures

Fluids, like brake fluid, petrol, steering fluid, motor oil, coolants and transmission fluid should generally be removed from the end-of-life vehicle or other devices before shredding. This is especially applicable in the case of PCBs, which should be identified and removed from any device to be shredded. Specific attention should be given to transformers and condensers. Measures should include:

- The removal of batteries and liquified gas tanks;
- The removal or neutralization of potential explosive components, (e.g., air bags);
- The removal and separate collection and storage of fuel, motor oil and oil from other components;
- The removal of catalysts;
- The removal of tyres and large plastic components (such as bumpers, dashboards, fluid containers, etc.), if these materials are not segregated in the shredding process in such a way that they can be effectively recycled as materials.

8. Secondary Measures

Measures to prevent releases of persistent organic pollutants at shredder plants include:

The advanced treatment of flue gas (with bag filters and activated carbon filters to remove both gaseous and particle emissions);

The proper disposal of residuals and liquid shredder wastes containing a mixture of organic materials, heavy metals such as copper and, in many cases, polychlorinated biphenyls and other chlorinated substances. Treating this waste in an inappropriate manner will lead to emissions of unintentionally released persistent organic pollutants. This is especially the case in open burning. Shredder wastes should be never burned in an open fire or in inappropriate facilities;

The appropriate treatment of shredder waste is incineration in a facility meeting the requirements for best available techniques and best environmental practices. If such a facility is not available, disposal in a sanitary landfill may be preferred to other forms of disposal.

References

Basel Convention Secretariat. 2002. *Technical Guidelines on the Environmentally Sound Management of the Full and Partial Dismantling of Ships*. Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, United Nations Environment Programme. Geneva.

Börjeson, L.; Löfvenius, G.; Hjelt, M.; Johansson, S.; Marklund, S. 2000. "Characterization of automotive shredder residues from two shredding facilities with different refining processes in Sweden", Waste Manage Res. (2000) 18 p.358±366

European Commission. 2000. Directive 2000/53/EC of the European Parliament and of the Council of 18 September 2000 on end-of life vehicles. Official Journal of the European Communities, L 269/34-269/42 EN, 21.10.2000

Environment Australia, Department of the Environment and Heritage .2002. "Environmental Impact of End-of-Life Vehicles: An Information Paper"

François F., M. Blondeel, P. Bernaert, and R. Baert .2004. Diffuse Emissions of PCDD/F and Dioxin-like PCB from Industrial Sources in the Flemish Region. Organohalogen Compd. 66, 906-912

Fahrni, H.-P., 2005. Präsentation - Seminar der Abteilung Abfall "Situation RESH" 2005, BUWAL, Switzerland,

Fiedler, H.; Sakai, S. 2004. Shredder Plants for Treatment of end-of-life-vehicles. Information document prepared for the third Session of the Expert Group on BAT/BEP. www.pops.int

LUA .1997. Identification of Relevant Industrial Sources of Dioxins und furans in Europe. Materialien No. 43. Landesumweltamt Nordrhein-Westfalen, Essen, Germany

Sakai S., S. Urano, and H. Takatsuki .2000. Leaching behavior of PCB and PCDDs/DFs from some waste materials. Waste Management 20, 241-247

Sakai S., S. Urano, and H. Takatsuki .1998. Leaching Behavior of Persistent Organic Pollutants (POPs) in Shredder Residues. Chemosphere 37, 2047-2054

Towa Kagaku Co. 2001. Research report on current status of recycling plaza

Urano S., S. Sakai, and H. Takatsuki .1999. *PCB in Automobile Shredder Residue and its origin.* 8th Symposium on Environmental Chemistry Program and Abstracts, pp 50-51 (in Japanese)

Other Sources

Nourreddine, M. 2006. *"Recycling of auto shredder residue"* Journal of Hazardous Materials-5423.

http://www.pops.int

UNEP/SSC/BATBEP/2008/16