

Materials Characterization Paper
In Support of the
Proposed Rulemaking:
Identification of Nonhazardous Secondary Materials That Are Solid Waste
Auto Shredder Residue

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1. *Definition of Auto Shredder Residue*

Auto shredder residue (ASR) is the 15 to 20 percent of vehicle materials remaining after a vehicle has been shredded and removed of reusable parts and metals. ASR is composed of plastics, rubber, foam, residual metal pieces, paper, fabric, glass, sand, and dirt (EPA, 2008; USCAR, 2008). It is also termed “auto fluff” or “auto shredder fluff.”

2. *Annual Quantities of Auto Shredder Residue Generated and Used*

(1) Sectors that generate auto shredder residue

Auto shredding operations, categorized under NAICS 423930 (Recyclable Material Merchant Wholesalers) are the only known generators of ASR. There are approximately 185 to 200 auto shredders in the U.S. (Boughton, 2006; DeGaspari, 1999).

(2) Quantities of auto shredder residue generated

The U.S. generates approximately 5 million tons of ASR annually and nearly all of this is landfilled (Hook, 2008; EPA, 2008).

(3) Trends in generation of auto shredder residue

Quantities of ASR produced are likely to increase in the future, due to the growing number of cars scrapped each year and the increased use of plastics in automobile production (Nourreddine, 2007).

3. *Uses of Auto Shredder Residue*

(1) Combustion uses of auto shredder residue

Currently, nearly all ASR is landfilled and a small portion is incinerated, primarily owing to the lack of cost-effective technology to process and use ASR (Argonne, 2003). An additional barrier to using it as fuel is that unprocessed ASR has high ash, heavy metal, and chlorine content (Boughton, 2006).

Approximately 20 to 50 percent of dry ASR is combustible, including plastics, fabric, and rubber; incombustibles include metals, glass, dirt, and ash. The first step in processing ASR for fuel use would be removal of incombustibles (Tai, 2006; Boughton, 2006).

ASR could potentially be used as a supplement to conventional fuel in cement kilns or steel mill blast furnaces. Use of ASR in cement kilns may be more easily accomplished than in boilers and other combustion units because kilns can tolerate high ash content and heterogeneous materials. A recent evaluation of ASR use in cement kilns conducted by the California Department of Toxic Substances Control suggests that, despite the obstacles of separating combustibles from incombustibles and reducing contaminant concentrations, processing ASR for use in cement kilns would be cost-effective, due largely to the avoided transportation costs and tipping fees associated with landfilling (Boughton, 2006). This effect, however, would vary throughout the U.S. due to regional differences in transportation distances and landfill tipping fees. In addition, the Environment and Plastics Industry Council and the American Plastics Council have conducted research investigating methods to process ASR into a more suitable fuel for steel mill blast furnaces (Cirko, 1999).

(2) Non-combustion uses of auto shredder residue

As mentioned above, nearly all ASR is landfilled, and it appears that virtually no ASR is currently beneficially used. 40 CFR 761.62, "Disposal of PCB bulk product waste," states, however, that ASR may be disposed in landfills as daily cover or used under asphalt as part of road bed, but no data on such applications have been identified. In addition, other potentially recoverable materials contained in ASR and their potential uses include:

- Foam, which accounts for 5 percent of vehicles by weight but 30 percent by volume, can be rebounded and used as carpet padding and seat cushions in cars (DeGaspari, 1999).
- Plastics, which account for 30 percent of vehicle weight, can be recycled into battery trays (Hook, 2008).
- Iron oxide residuals can be used as an ingredient in cement production (Argonne, 2003).

(3) Quantity of auto shredder residue landfilled

Sources generally state that most, if not all, ASR is landfilled (Hook, 2008; EPA, 2008; Boughton, 2006). This would suggest that approximately 5 million tons of ASR are landfilled annually.

4. Management and Combustion Processes

(1) Types of units using auto shredder residue

Currently most ASR is landfilled, though development of methods to use ASR is underway. Potential users of ASR include:

- Cement kilns
- Steel mill blast furnaces
- Car manufacturers

(2) Sourcing of auto shredder residue

Approximately 12 to 15 million automobiles are disposed of annually in the U.S. (USCAR, 2008). Once automobiles reach the end of their useful life, they are sent to one of roughly 12,000 auto dismantlers, where the car is stripped of reusable parts. The stripped cars are then sent to one of approximately 185 to 200 auto shredding operations, where hammermills crush them into smaller pieces. Metal chunks are recovered and sold to metal scrap processing industries (DeGaspari, 1999). Over 25 million tons of materials are recovered for reuse or recycling. The remaining material comprises the ASR (EPA, 2008).

(3) Processing of ASR for combustion uses

Unprocessed ASR has poor fuel characteristics, due to its high ash content; the presence of contaminants, including heavy metals, chlorine, and PCBs; and the heterogeneity of ASR, which is made up of approximately 20 to 50 percent incombustibles (Tai et al, 2006; Boughton, 2006). Prior to use as a fuel, ASR would therefore require significant separation and processing to isolate combustible materials with low ash content and low contaminant concentrations.

The California Department of Toxic Substances Control has developed methods for separating and beneficiating the ASR stream to make it suitable fuel for cement kilns. First, trommels are used to create ASR sub-streams of different sizes, which also results in some rough separation by material (e.g., residual metal fines are small, while plastic and rubber pieces are larger). Then further separation is performed by hand and through density separation techniques, with the goal of developing a mixture of ASR that maximizes energy content, while minimizing content of ash, chlorine, and heavy metals. This process achieves a mixture of ASR that represents 30 percent of the original mixture and has a heating value of approximately 13,240 Btu per pound, which is higher than that of most types of coal (Boughton, 2006).

The Environment and Plastics Industry Council and the American Plastics Council coordinated with eight automobile shredders to develop a procedure for processing ASR for use in steel mill blast furnaces. This process, which would reduce the ash content of ASR and increase its energy content, would yield an ASR material with a thermal value of approximately 10,000 Btu per pound (Cirko, 1999).

Researchers in Taiwan have taken further steps in the development of ASR for fuel use by processing it into ASR-derived fuel (ASRDF) rods, for ease of transportation and storage. The first step in this process is the manual removal of glass, electrical wires, dirt and gravel, and metal components, yielding an ASR mixture with a heat value of approximately 10,500 Btu/pound. Then the ASR is placed into an extrusion apparatus, where it is exposed to high pressure and temperature and formed into rods. The extrusion process reduces the heat value

by approximately 1,800 Btu/pound, but the rods have a higher heat per unit of mass than does the un-compacted material (Tai et al, 2006).

(4) Processing of ASR for non-combustion uses

As indicated above, virtually no ASR is used for non-combustion applications because of the heterogeneity of ASR material. The Department of Energy's Argonne National Laboratory, however, has recently developed methods for separation, recovery, and use of ASR. After undergoing separation and cleaning processes, certain constituent materials of ASR can be recovered. Argonne has found that up to 60 percent of ASR can be recovered as usable material (Hook, 2008).

The process developed by Argonne begins with bulk separation through use of a two-part trommel, which separates ASR into three streams: a polymers-concentrated stream (45 percent of ASR, by weight), foam (10 percent), and small inorganic particles (45 percent). The first part of the trommel is equipped with a fine mesh, through which the inorganic particles are separated. The second part of the trommel has larger slots, through which plastics and rubber pieces fall, leaving behind the foam. Each of these three streams is then further processed to extract the useful materials. The polymers undergo density separation and froth-flotation to be separated by type, in order to recover those plastics and rubbers that are present in the largest volumes or that have the highest value. The foam, which contains automotive fluids and some residual inorganic particles, is run through a series of stages for cleaning, and is then dried and baled. The inorganic particles, which include metal residuals, dirt, and glass, are exposed to magnets to extract iron oxides, and the rest is discarded (Argonne, 2003; DeGaspari, 1999)

At present, Argonne's system is not yet used in the United States, though it has been licensed to Salyp N.V., a recycler in Belgium, which completed construction of an ASR recycling plant in 2003 (DeGaspari, 1999; Hook, 2008).

(5) State regulatory status of auto shredder residue beneficial use

According to state responses to a 2006 survey by the Association of State and Territorial Solid Waste Management Officials (ASTSWMO), Florida has approved ASR as landfill initial cover, while Kentucky, Maryland, Massachusetts, Michigan, New Hampshire, New York, Tennessee, Virginia, and Wisconsin have approved it as an alternate daily landfill cover. ASTSWMO also reports that Michigan and Texas have approved ASR for liquid solidification. Wisconsin has pre-approved ASR for landfilling and Washington has pre-approved ASR in a few cases as alternative daily cover (ASTSWMO, 2007).

5. Commodity Composition and Impacts

(1) Composition and energy content of auto shredder residue

(a) Composition:

- 30 percent polymers (by weight)

- 10 percent residual metals
- 5 percent foam
- The remainder is a mixture of glass, wood, paper, sand, dirt, rocks, and automotive fluids (Hook, 2008; DeGaspari, 1999)

(b) Energy content:

- Unprocessed ASR – roughly 5,000 Btu/pound (Boughton, 2006)
- After removal of incombustibles – 9,000-10,500 Btu/pound (Tai et al, 2006; Cirko, 1999)
- After removal of incombustibles and additional processing to isolate combustibles with high energy content - 13,240 Btu/pound (Boughton, 2006)

(2) Impacts of auto shredder residue use

a. Cost impacts

The recycling and use of ASR may result in cost savings. The California Department of Toxic Substances Control conducted an economic analysis of ASR use in cement kilns, and found that the processing and use of all annually-generated ASR for cement kilns would save the cement manufacturing industry \$50 million per year through reduced energy costs. It would also save auto shredding operations \$20 million per year in avoided landfilling costs. While the costs of processing the ASR for use in cement kilns would also amount to \$20 million per year, auto shredding operations could also generate \$20 million per year in revenue from the sale of copper, which is extracted during processing (Boughton, 2006). Alternatively, if all ASR were to be used as a fuel in steel mill blast furnaces, it could reduce fuel costs for operators by as much as \$20 per ton of coke replaced (Cirko, 1999).¹

Regarding the use of ASR for non-fuel applications, savings could be achieved through avoided production of virgin foam. While clean recycled foam sells for \$0.25 to \$0.30 per pound, virgin foam costs approximately \$1 per pound (Argonne, “Recovering Foam from Scrapped Autos”). In addition, the savings referenced above with respect to copper recovered from ASR prior to its use as a fuel would presumably apply to beneficial use for non-fuel applications as well. Savings could also be realized through the re-use of other materials contained in ASR, but no information on these savings has been identified.

b. Environmental impacts

Comprehensive data on the environmental impacts of using ASR as a substitute for virgin materials have not been identified. Available data sources, however, contain the following information regarding these impacts:

¹ The figures presented in this paragraph could change over time, owing to variations in virgin fuel prices, landfilling costs, and the value of copper. The California Department of Toxic Substances Control assumed the following prices and values: a price of \$50/ton of coal, landfilling tipping fee of \$17/ton, trucking cost of \$2/mile, average distance to landfill of 20 miles, and \$0.85/pound value of scrap copper wiring.

- Argonne estimates that the recovery and reuse of polymers and residual metals, for non-fuel applications, from all of the ASR produced annually in the United States would save the equivalent of 24 million barrels of oil per year and reduce CO₂ emissions by 12 million tons (Hook, 2008).²
- Benefits from the use of ASR as a fuel may also include reduced CO₂ emissions from substitution for coal (Boughton, 2006). The California Department of Toxic Substances Control estimates that if all ASR produced in the United States were processed for use in cement kilns, it could potentially provide 6 percent of the cement industry's energy needs and result in the conservation of approximately one million tons of coal annually.
- Additionally, diverting ASR from landfills prevents potential leachate contaminated with ASR constituents (Boughton, 2006).

It is important to note that the presence of contaminants in ASR raises concerns about emissions from the combustion of this material. The California Department of Toxic Substances Control found that, while its processing techniques for developing ASR as a fuel for cement kilns minimizes contaminant concentrations, chlorine and heavy metals still remain at levels that may limit the rate at which ASR may be fed into a cement kiln (Boughton, 2006). Additionally, although ASRDF rods have low heavy metals concentrations, the chlorine content of these rods may represent a potential hazard (Tai et al, 2006).³ Additional efforts to eliminate PVC from ASR prior to its combustion for fuel purposes may mitigate chlorine-related contamination issues, given that PVC is typically 50 percent chlorine (Boughton, 2006).

² It is unclear whether these figures represent estimates of direct or lifecycle energy and emissions impacts. In addition, it is unclear whether this CO₂ emissions value is net of the emissions associated with burning ASR.

³ In the Taiwanese study, no efforts were taken to remove combustibles with high chlorine contents, so chlorine contamination is more of a concern than in the California study. Yet, in the Taiwanese study, metals were removed more thoroughly by hand, so the rods present less of a threat of metal concentrations.

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