

Mercury Contamination from Metal Scrap Processing Facilities – A Study by Ohio EPA

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Radhica Sastry

Ohio Environmental Protection Agency
Lazarus Government Center
P.O. Box 1049
Columbus, OH-43216

James Orlemann, P.E.

Ohio Environmental Protection Agency
Lazarus Government Center
P.O. Box 1049
Columbus, OH-43216

Paul Koval

Ohio Environmental Protection Agency
Lazarus Government Center
P.O. Box 1049
Columbus, OH-43216

ABSTRACT

Mercury is a pollutant that causes great concern to regulators in the nation, and especially to the states that are located in the Great Lakes Region of the United States. Mercury is considered a significant environmental problem due to its ability to bioaccumulate in the aquatic food chain, and eventually affect human health. Mercury is released into the atmosphere by natural as well as anthropogenic sources. Some of the anthropogenic sources include coal-fired utility plants and other industrial processes. In Ohio, we have taken a proactive approach to identify some of the other sources that emit mercury into the atmosphere. Routine emission testing in mid-1999 showed that steel scrap processing facilities could be fairly large sources of mercury emissions. Following this finding, Ohio EPA sent out a survey to all facilities that melt or otherwise process scrap metal to determine the possible extent of mercury emissions caused by scrap processing/melting facilities. After analyzing the results of the survey, Ohio EPA has required certain facilities to conduct tests for mercury emissions. This paper outlines the methodology implemented by Ohio EPA to identify these possible sources of mercury emissions in Ohio.

INTRODUCTION

Background

Mercury occurs in the earth's crust mainly in the form of a mineral ore called cinnabar, a reddish brown mercury sulfide. It is usually extracted from its ore by heating the mercury (II) sulfide in air to form mercury (II) oxide. Thermal decomposition of this oxide produces mercury vapor that is then condensed to form liquid mercury. Mercury is the only metal that exists as a liquid at room temperature. Mercury is used in a wide variety of applications. Measuring devices, switching devices and dental amalgams are just a few examples of how mercury is used.

Mercury is widely known as a persistent toxic substance. Being an extremely volatile substance, mercury prevails in all waste pathways – air, water, and solid waste, and can often be transported great distances. In aquatic systems, mercury is often converted by bacteria to methylmercury (the organic form of mercury) that can be accumulated up the aquatic food chain, posing a potential risk to humans and wildlife that consume fish.¹ Due to its bioaccumulative properties, combined with the fact that it never disappears in the environment,² mercury is a proven threat not only to this generation, but also to future generations all over the world. It has been recognized by regulators in the U.S. and other nations that the release of mercury must be adequately controlled or eliminated. This concern has resulted in the issuance of fish advisories in 40 states, warning consumers not to eat fish caught in over a thousand lakes and streams² in the U.S. According to the International Chemical Safety Program of the United Nations, the organic form of mercury, methylmercury, is one of the six most serious pollution threats on the planet.

Mercury enters the environment through natural and human (anthropogenic) sources. Once it enters, it cycles through the various pathways of the environment. In air, mercury remains primarily in the elemental form. Once it enters the water or soil, it is converted into methylmercury. The human contribution of mercury emissions has been steadily increasing. Atmospheric levels of mercury in the northern hemisphere have increased two-to-five-fold in the past 150 years. Today, it is estimated that as much as two thirds of the atmospheric mercury level can be attributed to anthropogenic sources.¹ U.S. EPA's Mercury Study Report to Congress states that the "best point estimate of annual anthropogenic U.S. emissions of mercury in 1994-1995 is 158 tons." Combustion sources account for almost 87% of these emissions.² U.S. EPA's 1995 mercury emissions inventory indicates that coal-fired utility boilers were responsible for 51.6 tons of mercury emissions annually. The 1999 update of the Draft Report on Mercury Sources and Regulations by EPA³ states that coal-fired utility boilers are the largest anthropogenic source of mercury.

The states located around the Great Lakes have cause for the utmost concern for mercury emissions. Mercury deposition in the Great Lakes has been and is poisonous to the aquatic life in and around the region. The U.S. EPA and the Great Lakes Commission have initiated a number of programs directed towards quantifying and reducing the mercury emissions in the Great Lakes states. Mercury reduction programs and

regulations also have been initiated by a number of states such as Minnesota, Michigan, and Indiana.

Sources of mercury emissions

As mentioned above, combustion facilities have been identified as the main source of mercury emissions. In addition, there are a number of other sources that are responsible for mercury emissions, for example, chlor-alkali plants. Chlor-alkali plants are among the few source categories that are regulated for mercury under the National Emission Standards for Hazardous Air Pollutants (NESHAP). Other sources that are being investigated for mercury emissions are scrap metal processing facilities. The use of mercury in switching devices in automobiles and large appliances has led many states to believe that facilities processing scrap metal potentially could be high sources of mercury emissions. The Minnesota Office of Environmental Assistance has identified mercury switches in cars as a major cause for the mercury emissions from shredders and other scrap processing facilities. A 1999 amendment of Minnesota law requires a “good faith effort” from auto dismantlers and scrap yards to remove the switches before vehicles are crushed and shredded.⁴

Ohio has also recognized the severity of the problem, and has been working closely with the Great Lakes Commission and U.S. EPA Region 5 on mercury-related issues. Ohio EPA recognizes that mercury switches in cars and appliances could be potential sources of mercury emissions and, as a result, has initiated a study to investigate the possibility of high mercury emissions from scrap processing facilities in Ohio. The underlying rationale of the study and a detailed description of the methodology that was used are presented in this publication.

OVERVIEW

According to the Mercury Report to Congress,² the larger urban areas of the Midwest and the Ohio Valley are among the areas that have the highest concentration of mercury from anthropogenic sources. In addition to power plants, Ohio has a large number of scrap metal processing facilities. These facilities obtain scrap metal from various sources such as auto-shredders and other metal shredding facilities. This scrap metal is melted in electric arc furnaces, electric induction furnaces, and cupolas.

During mid-1999, Ohio EPA discovered, as a result of stack emission tests, that a relatively large amount of mercury was being emitted from a mini-mill. This led Ohio EPA to believe that similar facilities could potentially be large sources of mercury emissions. Additional stack tests were conducted by the facility, using different types of scrap metal. The results of these tests suggested that the melting of two types of scrap, i.e., shredded (frag) scrap and No. 2 bundles, resulted in the highest amounts of mercury emissions. These two grades of scrap contain scrap from automobiles and/or large appliances (see Table 1).

Ohio EPA sent out a survey to all the scrap melting facilities in Ohio. The intention of this survey was to gather information on the type of scrap that was being melted and to determine if any emission tests had been conducted to quantify the amount of mercury being emitted. The survey was sent to approximately 100 facilities in Ohio. Approximately 73% responded to the survey. The survey results are presented below (see Table 4).

As explained in the following sections, mercury switches in cars and appliances are the main cause of mercury emissions from scrap processing facilities. Hence, in order to narrow the list of possible mercury sources, the survey results were examined to identify sources that melted shredded (frag) scrap and/or No. 2 bundles. It was found that seven facilities melted either shredded scrap or No. 2 bundles, or both. A letter has been sent to these facilities requesting them to test for mercury using U.S. EPA Method 29 during the first quarter of 2001. The test results will determine whether or not these types of facilities are significant sources of mercury emissions in Ohio.

SPECIFICATION OF SCRAP METAL

Scrap shredding facilities receive all kinds of scrap metal. These include automobiles, appliances, and other types of scrap metal. The scrap metal is passed through shredders and sorted out into bundles or grades.

The Institute of Scrap Recycling Industries (ISRI)⁵ has developed and published standard specifications that provide descriptions of each scrap grade. Specifications are provided for ferrous scrap as well as non-ferrous scrap. Some scrap grades are uniform in chemistry, while others are a mixture of different types of scrap that are within a predictable range of chemistry values. The grade of scrap used by mini-mills depends largely on the specifications of the final product. It also depends on the chemistry and performance of the scrap grade in the melt. Some scrap grades, for example railroad wheels, may claim to have a better chemistry than say, automobiles, but the latter melts faster and lends itself to automatic charging systems.

In this study, Ohio EPA has considered only ferrous scrap originating from automobiles and appliances. After a careful review of the different scrap descriptions, Ohio EPA identified the scrap grades suspected of containing mercury switches, such as automobile and appliance scrap. Table 1 lists the different grades of scrap selected for this study, along with their descriptions.

Table 1. Scrap Grade Description
(ISRI, 1998, except as noted)

Scrap Grade	Description
Scrap types that were considered as Hg sources	
Shredded scrap	Homogenous iron and steel scrap, originating from automobiles, miscellaneous bailing and sheet scrap.
No. 2 Heavy melt	Wrought iron and steel scrap, black and galvanized. May include automobile scrap properly prepared.
Bundled No. 2	Wrought iron or steel scrap, black or galvanized, weighing not less than 75 pounds per cubic foot. Auto body and fender stock may constitute a maximum of 60%, by weight.
Shredded auto*	Auto scrap that is shredded.
Some scrap types that were not considered as Hg sources	
Turnings	Clean steel or wrought iron turnings free of iron borings and tangled or matted material.
No. 1 Heavy Melt	Wrought iron and/or steel scrap ¼ inch and over in thickness.
Busheling	Clean steel scrap, not exceeding 12 inches in any dimension. May not include old auto body and fender stock.

* Not specified by ISRI

MERCURY IN SAFETY SWITCHES

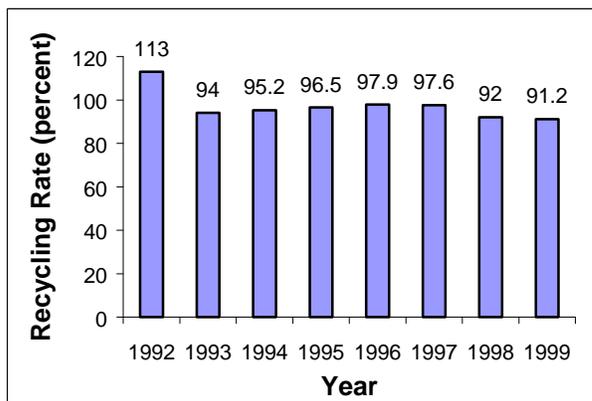
Due to its high electrical conductivity, mercury is widely used in switching devices. Mercury switches are used in a variety of items such as chest freezers and sump pumps. Mercury-containing tilt switches are also used under the lids of clothes washers. They are responsible for turning on a light or stopping a spin cycle. Mercury switches can be motion-sensitive and position-sensitive. These types of mercury safety switches can be found in clothes irons and space heaters. Automobile trunks and hoods have a mercury switch that turns a light on as the trunk/hood is being opened.⁶ The reason that mercury switches are preferred to other switching devices is that mercury switches are well known for their hermetically sealed construction, outstanding consistent operation throughout their electrical life, high load capability, and moderate cost. Mercury switches are available in different shapes, sizes and electrical ratings so that they can perform reliably in home thermostats, sensitive instruments and heavy industrial controls.⁸

Mercury is released into the environment when any of the above appliances or automobiles are scrapped. At the end of their useful lives, these appliances/automobiles are sent to the recycling yard, where they are shredded and packed into bundles that are eventually melted in mini-mills. At present, there is no law in Ohio that requires the scrap recyclers to remove mercury switches before the shredding operation. This results in possible mercury emissions during the shredding operation as well as the presence of mercury in the shredded scrap that is melted in the mini-mills and other facilities.

Most vehicles in the years from the 1960's through the 1990's have been found to contain mercury switches.⁴ Appendix A gives a list of vehicles that currently contain mercury switches. Mercury switches in cars are used in various applications, such as some 4-wheel drive antilock braking systems (ABS), high intensity discharge lamps, etc.⁸ A mercury switch contains around 0.8-1 gram of mercury. According to a 1995 industry report, the U.S. auto industry uses roughly 22,000 pounds of mercury in automobiles each year.⁹ A study conducted by the Minnesota Pollution Control Agency notes that 43 mercury switches were found for every 100 cars sampled.⁸

Most of this mercury eventually ends up in scrap processing facilities. According to the Steel Recycling Institute, the steel industry recovered and recycled enough steel from old cars to produce more than 13 million new automobiles in 1999, a recycling rate of 91%. The appliance recycling rate was 77% in 1999.¹⁰ Figure 1 shows the recycling rate of automobiles in the U.S. from 1992 through 1999.

Figure 1. Automobile Recycling Rate
(Steel Recycling Institute)



(Reproduced from the original)

Based on stack test results, the New Jersey Department of Environmental Protection estimated that three sources (one electric arc steel furnace and two iron foundry cupolas) were responsible for around 719 lbs/year of mercury emissions.³ Extrapolation of these results on a national level indicates that iron and steel production using automobile scrap currently releases 7 to 18 tons of mercury annually.³ This number is almost 10 times the emission statistics for 1995.⁹

PROCEDURE AND ANALYSIS

Ohio EPA has been extremely concerned about mercury releases into the atmosphere and has been working actively with the Great Lakes Program Office to try to quantify mercury emissions in the southern portion of the Great Lakes. The focus, however, increased when emission testing at a mini-mill in Ohio revealed approximately 660 lbs/year of mercury emissions. This finding prompted the company to conduct some research on the cause for such emissions. The facility also conducted additional emission tests with different grades of scrap metal. Although the test results showed a high degree of variability, it was found that, in general, the melting of shredded scrap and No. 2 bundles resulted in higher amounts of mercury emissions than the use of any other grades of scrap. The results from these stack tests are shown below. Table 2 and Figure 2 show the correlation between the type of scrap and the amount of mercury emissions recorded.

Figure 2. Correlation Between the Type of Scrap and the Amount of Mercury Emissions

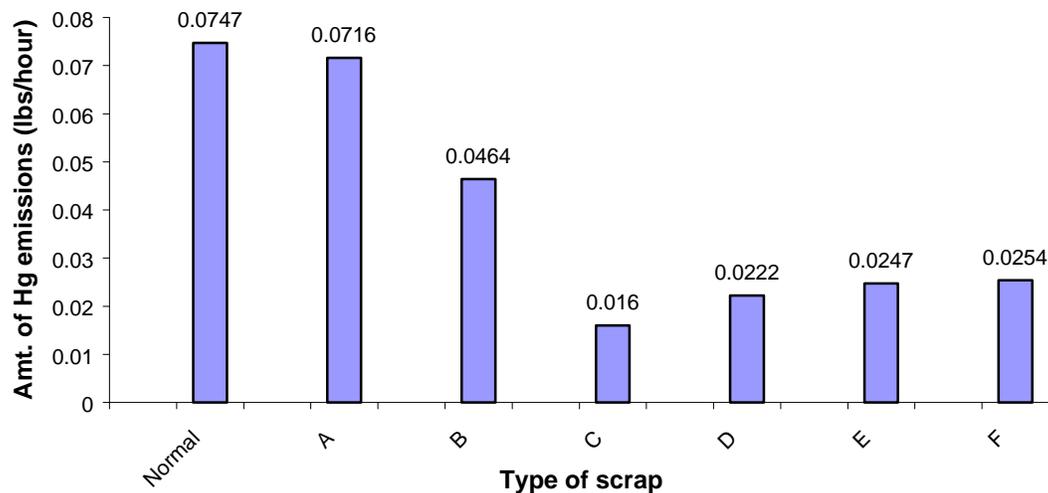


Table 2. Scrap Metal Mix Identification Chart

Scrap Type	Normal	A	B	C	D	E	F
Shredded (frag)	20	30	20	10	10	0	0
Bundles 2	10	0	0	25	0	0	20

* All numbers are in percentages. Other scrap grades used are not specified.

Table 3. Amounts of Scrap Metal Melted per Heat

Scrap Type	Normal	A	B	C	D	E	F
Shredded (frag)	22,800	34,200	22,800	11,400	11,400	0	0
Bundles 2	11,400	0	0	28,500	0	0	22,800

* All numbers are in lbs/heat. Other scrap grades used are not specified.

The average amount of total scrap melted during these tests was 57 tons or 114,000 pound per heat. Table 3 shows the amount of individual types of scrap that was melted during each test in pounds/heat. Each heat lasted for approximately 75 minutes, and mercury emissions were measured in pounds per hour. As can be seen from the above figures, scrap mixes described as Normal, A and B show a strong correlation with respect to frag scrap and No. 2 bundles. Only one run was conducted for scrap mix C due to a plant shutdown. The reason for lower mercury emissions from scrap mixes D and F could be attributed to the lower amounts of frag scrap in the heat. Scrap mix E contained 10% No. 1.5 bundles. The No. 1.5 bundles do not contain auto or appliance scrap metal. At this point, there is no reasonable explanation for the mercury emissions from scrap mix E. In general, despite the variability, the stack tests indicate that mercury emissions are largely dependent on the type of scrap that is melted.

The discovery of high mercury emissions at the mini-mill led Ohio EPA to believe that other similar industries in Ohio may also be contributing to the mercury problem. A survey was sent out to all facilities that operated an electric arc furnace, an induction furnace or a cupola, and were believed to be melting scrap metal. The survey requested information such as the type and amount of scrap melted in each furnace each year, whether any emission tests were conducted for metals, etc. The response to the survey was very good. Out of 70 facilities that the mailing was sent to, 51 facilities responded, almost a 73% response rate.

The results of the survey were organized in a spreadsheet and analyzed. Facilities that melted shredded scrap and No. 2 bundles were identified. In addition, scrap grades that contained automobile and/or appliance scrap were identified by referring to the scrap grade descriptions provided by the ISRI. In total, seven facilities were found to be melting scrap containing automobile and/or appliance scrap. The results of the survey are summarized in Table 4.

Table 4. List of Facilities Melting Scrap Containing Automobile/Appliance Scrap

FACILITY NAME	Furnace #	No. 1 Shredded (tons/yr)	No. 2 Heavy Melt (tons/yr)	No. 2 Bundles (tons/yr)	No. 2 Shredded (tons/yr)	Shredded Auto (tons/yr)
Facility A	A - 1	0	53,200	3,700	0	9,000
Facility B	B - 1	0	19,946	0	240,277	30,000
	B - 2	0	0	0	52,130	0
	B - 3	0	0	0	52,130	0
Facility C	C - 1		28,908			
	C - 2					
Facility D	D - 3	3,840				5,648
	D - 4	92,160				135,544
Facility E (foundry)	E - 1					39,559
	E - 2					11,817
Facility F	F - 1	300,000	0	0	436,000	0
Facility G (foundry)	G - 1	1,462				
	G - 2	21,159				
	G - 3	33,450				
	G - 4	30,877				

Out of the seven facilities that were identified, five facilities are mini-mills and two facilities are foundries. These facilities have been requested to test for mercury emissions using U.S. EPA Method 29. The results from these stack tests are expected to be documented sometime between June 1 and July 1, 2001. Judging from the stack test results obtained from the one mini-mill, we expect to see significant mercury emissions from the above facilities. From the results of the additional stack tests, we will be able to determine whether or not scrap metal melting facilities are indeed a significant mercury problem. If the stack test results show high mercury emissions, Ohio EPA may consider further corrective actions that could involve either voluntary actions or regulation.

CONCLUSIONS

With a national focus on mercury, every possible source of mercury needs to be investigated and identified. It has been estimated that mercury switches will continue appearing at scrap recycling facilities for at least 11 years from the last day that vehicle manufacturers discontinue their usage.⁸ Hence, it is of the utmost importance to identify and control mercury emissions from this source category. The next step will be to identify scrap shredders in Ohio and quantify mercury emissions from these facilities. Preliminary work in trying to identify these facilities has already begun. Based on the results of the studies, Ohio EPA may initiate a voluntary program to remove mercury switches before shredding and melting automobiles and appliances.

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KEY WORDS

Mercury
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Appliances