Michigan Mercury Switch Study

December 19, 2002

Michigan Mercury Switch Study

TEAM COMPOSITION

Steering Group

(Provided overall guidance on study purpose, scope, and direction)

Alliance of Automobile Manufacturers (Alliance)

Ecology Center

Michigan Department of Environmental Quality (MDEQ)

Schram Auto Parts

Sustainable Research Group

Work Group

(Designed and conducted study)

Dan Adsit – Ford, representing the Alliance

Ross Good – DiamlerChrysler, representing the Alliance

Marcia Horan - MDEQ

Steve Kratzer - MDEQ

Ken Schram – Schram Auto Parts

Bill Stough - Sustainable Research Group

In Cooperation With

Kalamazoo County Household Hazardous Waste Center

Michigan Mercury Switch Study

Study Outline

Michigan Mercury Switch Study

Executive Summary

The purpose of this study was to jointly conduct a cooperative project that evaluates the technical, logistical, and procedural factors associated with the removal of mercury (Hg) convenience light switches from end-of-life vehicles and subsequent management of the switches. Although there have been many switch removal programs, information on switch removal is mostly anecdotal and little data exists. To address this gap the study took a systematic approach including a literature review and gathered the data listed below.

Convenience light switches are located either under the hood, to illuminate the engine compartment, or in the trunk, to illuminate the storage area. They are visible upon opening the hood or trunk. Each mercury containing switch assembly has approximately 0.8 grams of mercury (SAE, 1996) that is secured in a pellet normally constructed out of steel. Convenience light switches were chosen for the study as they are estimated to account for over 85 percent of the mercury found in automobiles. Also, their removal is substantially easier than other mercury containing components such as ABS switches.

Data Gathered

- Year, make, and model of vehicles entering recycling facilities
- Existence of light assembly and location (hood, trunk)
- Assembly removal method
- Assembly removal time
- Pellet removal time
- Pellet condition
- Percent of pellets containing Hg

Michigan recyclers participated in this study with the goal of obtaining a representative mix of vehicle ages and yard types. These recyclers dealt with late model vehicles, older vehicles, domestic and foreign manufacturers, or were traditional / U-pull it facilities.

The Alliance of Automobile Manufacturers (Alliance), Michigan Department of Environmental Quality (MDEQ), Schram Auto Parts, and the Sustainable Research Group formed a work group to collect and analyze data over a period of three months on light switch removal. A larger steering group, which included the Ecology Center, additional automakers, and additional MDEQ representatives, provided overall guidance to the study, reviewed the data and commented on the report before its release. In addition, the Kalamazoo County Household Hazardous Waste Center provided assistance in the removal and recycling of the mercury pellets. The team composition including specific roles and responsibilities are listed in Appendix 1.

Results

- Data was collected from 1474 vehicles produced between 1971 and 2003.
- 801 switch assemblies were found in 1474 vehicles resulting in an average of 0.54 switches per vehicle.
- 44% of vehicles had at least one switch present in either the hood or trunk.
- 34% of hoods had a switch assembly.

- 24% of trunks had a switch assembly.
- The average removal time for each switch assembly was 51 seconds
- The average removal time for each pellet from the switches was 44 seconds.
- The average removal time for a switch assembly from a vehicle and the pellet from a switch assembly is 95 seconds.
- 98% of the pellets in this study contained mercury.
- No switch assemblies showed signs of mercury leakage prior to pellet removal. In addition, none of the pellets removed by recyclers showed any sign of mercury leakage.
- 7 pellets (approximately 1%) leaked during the switch disassembly process at the Kalamazoo County Household Hazardous Waste Center.

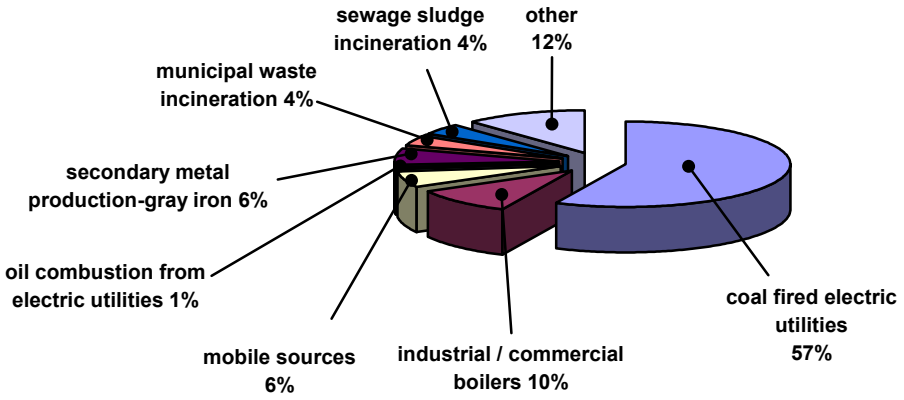
Conclusions

- It is recommended that recyclers who chose to remove switches at end of life:
    - Routinely remove switch assemblies as a standard practice upon receipt of the automobile when fluids are drained and collected
    - Incorporate switch assembly removal into standard operating procedures
    - Conduct a facility wide yard sweep if just starting switch assembly removal
    - Manage switches as a universal waste
- Switch assemblies are quickly and easily removed from end of life vehicles using readily available and simple tools.
- For most instances, specially trained individuals accomplish pellet removal best. However, for switch assemblies such as those used in General Motors vehicles, pulling out the pellet presents little risk of mercury release, and is quicker than removing the entire assembly. Therefore, the automotive recycler could easily remove the pellet from this type of assembly.
- All the facilities appreciated having the opportunity to participate in the study and most indicated they would continue to collect switches after the project's completion.

II. Introduction and Study Purpose

Mercury has unique properties that make it ideal for electrical applications under a wide range of temperatures and operating conditions. As a result, mercury has been used in a multitude of consumer products, including thermostats, chest freezers, washing machines, clothes irons, electric space heaters, light switches, fluorescent lamps, HID lamps, LCD screens for laptop computers and televisions, sumps and bilge pumps. Industrial use of mercury has dropped significantly over the past several years as substitutes are found for mercury. The vast majority of anthropogenic mercury releases to the environment in Michigan come from releases into the air through coal burning utility boilers, municipal waste combustors, sewage sludge incinerators, commercial and industrial boilers (MDEQ, 2002). It should be noted that there are some data deficiencies in this emissions inventory. For example, there is a lack of data for steel making electric arc furnaces that may represent mercury emissions from auto switches.

Michigan Mercury Air Emissions



Historically, the main automotive uses of mercury are in convenience light switches and Antilock Braking System (ABS) g-sensor switches. Convenience light switches are located either under the hood to illuminate the engine compartment or in the trunk to illuminate the storage area. They are visible upon opening the hood or trunk. Each switch assembly contains approximately 0.8 grams of mercury (SAE, 1996) that is secured in a pellet normally constructed out of steel (Figure 1).

Figure 1. Typical Pellet Construction

Michigan Mercury Switch Study

Automakers have voluntarily phased out the use of mercury in convenience light switches and Antilock Braking System (ABS) g-sensor switches in new motor vehicles (the last use of a mercury switch will be phased out by the end of 2002). Today mercury is still used in trace amounts in optional components. These components include high intensity discharge (HID) headlamps, instrument cluster displays, and navigation / entertainment screens. The mercury used in these components serves as an illuminant primarily for the back lighting of displays. This study does not address these sources of mercury.

When mercury switches are not removed from end-of-life vehicles prior to shredding, the reclaimed metals can become contaminated with Hg. These metals are then processed in electrical arc furnaces where the mercury can be vaporized and released out of the stack. These mercury emissions eventually deposit on land and water where the mercury can be converted into methylmercury, a known neurotoxin, that bioaccumulates through the food chain.

There are essentially two points in the automobile's life cycle where mercury switch removal is possible: collection at vehicle end-of-life, and switch replacement or removal in on-road vehicles (in-service vehicles). An end-of-life vehicle study was selected because:

- The vast majority of vehicles are processed by recyclers, which represent the last opportunity for switch removal prior to potential mercury emissions.
- Even with an effective in-service program, switches would still have to be removed from end of life vehicles. This is due to the limited number of vehicles affected by in-service programs, and the inability to recognize mercury containing from non-mercury containing switch assemblies at the end of a vehicle's life.
- There is no evidence of a mercury release in switches that are left in vehicles until the vehicles are recycled.

Convenience lights were chosen for the study as this switch source is estimated to account for over 85 percent of the mercury found in automobiles (SAE, 1996) and removal of convenience light switches is substantially easier than removal of other mercury containing switches (e.g. ABS switches – further study of ABS switch removal at end of life is needed). Although there have been many switch removal programs, information on switch removal is anecdotal and little data presently exists. The purpose of this study is therefore to conduct a cooperative project that evaluates the technical, logistical, and procedural factors associated with the removal of mercury convenience light switches from end-of-life vehicles and the subsequent management of those switches.

III. Literature Review

In recent years several programs have been conducted in different areas of the North America to remove mercury containing convenience lighting switches from automobiles. Efforts such as the “Switch-the-Switch” campaign sponsored by the Clean Car Coalition, and the “Pull the Switch!” project sponsored by the Automotive Recyclers of Michigan (ARM) serve as primary examples. Other switch removal programs are also underway in Minnesota, Wisconsin, New York, New Jersey, and Ontario. These programs are often referenced by interested parties in policy discussions on how to address the collection and disposal of mercury switches.

The Work Group collected and examined information about these programs in an attempt to review their methodology and to determine whether the data collected and conclusions drawn might be applicable to the Michigan study (an overview of this information is in Appendix 2). The Work Group was unable to identify any studies or programs that took a systematic approach to collecting data on the removal of mercury convenience light switches. The absence of data further substantiated the need for this study and will help enable stakeholders to make informed decisions.

IV. Study Methodology

a. Overview of automotive recycling

The automotive recycling industry — with $8.2 billion annual sales in North American (Axiom Research Company, 1997) — plays a crucial role in the efficient, ecological recycling or disposal of inoperable motor vehicles. Although sometimes known as auto salvage dealers, professional automotive recyclers deal strictly in the recycling of motor vehicles — i.e., domestic and foreign automobiles, light and heavy-duty trucks, buses and motorcycles.

From the earliest days of motorized travel, automotive recyclers have been leaders in recycling vehicles. These entrepreneurs developed a disassembly process for salvaged automobiles in order to reclaim reusable parts and components. For more than 75 years, automotive recyclers have been providing employment, consumer service, and environmental conservation, worldwide.

Automotive recycling serves a vital role in preserving natural resources and reducing the demand for scarce landfill space. For example, the industry recycles over 14 million motor vehicles annually (in the U.S. and Canada alone), thereby saving an estimated 11 million gallons of oil that would otherwise be used in the manufacture of new replacement parts (Axiom Research Company, 1997). Additional energy and resource conservation is realized by recycling rebuildable "core" parts to the automotive parts rebuilding industry.

In addition to conserving natural resources, automotive recycling plays an important role in reducing air and water pollution, and solid waste generation. Automotive recyclers must abide by stringent local and national regulations on dealing with waste generated by salvaged automobiles. Many individual automotive recyclers have also instituted their own unique programs to further reduce the potential effects of harmful materials to their businesses and communities.

Automotive recycling has evolved into a sophisticated market and technology-driven industry that constantly changes to keep abreast of innovations in automotive technology and manufacturing techniques. Rather than merely crushing wrecked, abandoned, and mechanically disabled motor vehicles, today's modern recycling facilities have a definitive operational scheme that maximizes the vehicle's true market value, all the while providing an economic and environmental benefit to the community.

In a typical modern recycling business, inoperative motor vehicles are brought into a facility where the hazardous and recyclable fluids are properly drained. Undamaged parts are then dismantled from the vehicle, cleaned, tested, inventoried, and stored in a warehouse until sold. The remaining vehicle hulk is then prepared for materials recycling.

Automotive recyclers are a valuable source for economical and often hard to find used motor vehicle replacement parts. Professional auto recyclers use computer and satellite communication systems that enable direct inventory assessment as well to locate parts across town or across the continent, by simply entering the appropriate data into their computer system. This technology allows recyclers to maximize their inventory turnover and provide quick and efficient service to their customers.

The exact number of automotive recyclers is undeterminable because of ambiguity in the state licensing laws. The Automotive Recyclers of Michigan (ARM) has a membership of 160 recyclers that represents most of the on-going business concerns. ARM estimates the total number of automotive recycling facilities in Michigan is over 400 (ARM, 2002).

b. Method for choosing sampled recycling facilities

The methodology for selecting specific recyclers used in this study was to determine a cross section of small to large facilities that would represent recycling in the state of Michigan. The selection process also examined the types of facilities by make, model and years of the vehicles they process and the type of operation from being a full-service facility to a self-service facility. Many of the facilities selected were also determined on throughput of vehicles to capture as many data points as possible during this 3-month study.

Terminology for describing the facilities is as follows:

- Late Model - A facility that processes current to 5 years old vehicles and offers full service to its customers. These facilities pre-dismantle their vehicles and have the parts available in inventory.
- Middle Model - A facility that processes 5 to 10 year old vehicles and offers some full service and U Pull it service. These facilities pre-dismantle some of the parts and the others would either be pulled by an employee or a “do it yourselfer.”
- U-Pull It - A facility that is exclusively a “do it yourselfer.”

The Work Group compensated the recycling facilities for the time required to collect data.

c. Description of recycling facilities participating in the study

Eagle Auto Parts, 2707 E. Michigan Ave., Kalamazoo, MI. Eagle Auto Parts was established in 1974 and processes 2000 vehicles a year of all makes and models with 9 employees on 20 acres. Eagle would be considered a Middle Model facility.

Grand Rapids Auto Parts, 1810 Turner Ave. N.W., Grand Rapids, MI. Grand Rapids Auto Parts was established in 1947 and processes 350 vehicles a year of all makes and models with 12 employees on 11 acres. Grand Rapids Auto would be considered a Middle Model facility.

JVS Auto Parts, 1445 S. M 30, Gladwin, MI. JVS Auto Parts was established in 1996 and processes 200 vehicles a year of all makes and models with 2 employees on 14 acres. JVS Auto Parts would be considered a Middle Model/EOL facility.

Morris Rose Auto Parts, 2129 E. Michigan Ave., Kalamazoo, MI. Morris Rose Auto Parts was established in 1940 and processes 550 vehicles a year of all makes and models with 20 employees on 8 acres. Morris Rose would be considered a Late Model facility.

Richland Auto Parts, 6379 E. AB Ave., Richland, MI. Richland Auto Parts was established in 1991 and processes 1000 vehicles a year of all make and models with 3 employees on 160 acres. Richland Auto Parts would be considered a Middle Model facility.

Schram Auto Parts Lansing, 1325 N. Cedar, Mason MI. Schram Auto Parts Lansing was established in 1999 and processes 550 GM vehicles a year with 18 employees on 20 acres. Schram Auto Parts Lansing would be considered a Late Model Facility.

Shroyers Auto Parts, 2740 Eaton Rapids Rd., Lansing MI. Shroyers Auto Parts was established in 1959 and processes 2500 vehicles a year of all makes and models with 15 employees on 14 acres, Shroyers Auto Parts would be considered a Middle Model facility.

U-Wrench It, 11431 Chicago Dr., Holland, MI. U-Wrench It was established in 1987 and processes 3,600 vehicles a year of all makes and models with 14 employees on 15 acres. U-Wrench It would be considered a U-Pull It facility.

Weller Auto Parts, 2535 Chicago Dr, Grand Rapids, MI. Weller Auto Parts was established in 1935 and processes 1000 vehicles a year of all makes and models with 40 employees on 8 acres. Weller Auto Parts would be considered a Late Model facility.

Weller Auto Parts, 1629 Douglas Avenue, Kalamazoo, MI. Weller Auto Parts was established in 1990 and processes 350 vehicles a year of all makes and models with 12 employees on 4 acres. Weller Auto Parts would be considered a Late Model Facility.

d. Description of variables under study

The work group developed seven basic variables (some were used for both the switch assembly and the pellets) to be included as data points in the study. The variables selected sought to maximize the amount of information that could be gathered and verified within the constraints of the project's goals and objectives. The variables were organized on a Data Collection Form (see Appendix 3) for the participants to enter the requested information as they processed vehicles during their normal daily activities. The variables used in the study are:

1. Yard sweep or in-coming – did the information come from a sweep of existing vehicles in inventory or did the information come from a new in-coming vehicle?
2. Year, make, and model – each vehicle included in the study was identified by the model year of production (usually by the vehicle identification number or VIN), the make (major brand name such as Chevrolet, Chrysler or Ford), and the model of the major brand (such as Malibu, Sebring, or Taurus) as identified on the vehicle at the time of processing.
3. Switch / location (hood, trunk) – was a switch assembly found on the vehicle, and if so, was it located on the hood, the trunk, in both locations, or "unknown" (describing circumstances where there was no access, such as a damaged vehicle, hood or truck missing, or bees or wasps prevented inspection).
4. Removal times – the time to remove the switch assembly and/or the pellet in total seconds.
5. Method of removal – information on the most commonly used actions required to remove the switch assembly or pellet (such as pry off, unbolt, unscrew etc.).
6. Tools used – information on the tools used to remove the switch assembly or the pellet (such as wrench, ratchet, pry bar, or screw driver.)
7. Pellet – did the removed pellet contain mercury, and was there visible corrosion and / or evidence of leakage?

V. Switch Removal Process and Disposal

a. Switch removal procedures - All participants were provided with the same equipment to help minimize discrepancies in data collection. Each dismantler had a legal sized clipboard to hold the standardized Data Collection Forms and a stopwatch. Participants were asked to start timing their actions when they begin an activity related to removing the switch assembly that was different from their normal procedures. As an example; if they already opened the hood and trunk as part of their normal dismantling procedures, they should not start timing until they started on the convenience switch assembly. However, if they did not normally open the hood or trunk, then they were instructed to start timing when they began to look for the convenience switch assembly. The timing included the time it took to get the appropriate tools needed for the removal; normally dismantlers had the tools with them at the time of inspection.

b. Employee training – Before any of the participating recyclers started collecting data, they were required to attend a training session. Each of the automotive recycling facilities received training consisting of the following:

1. the reason and rationale for the project

2. a description of project goals
3. the important role participants played in ensuring accurate data
4. instructions on properly completing the Data Collection Forms
5. demonstration and instruction on the proper storage, labeling, and use of the mercury spill kit provided.

A training manual was passed out at each location that contained educational information that identified potential convenience switch locations, instruction sheets from the automobile manufacturers on how to disassemble various types of convenience lighting switch assemblies, a background report on proper management of mercury containing convenience switches from the Society of Automotive Engineers, information from the MDEQ on the proper management, storage and disposal of "Universal Waste" in the state of Michigan, and instruction on properly responding to a mercury spill. See Appendix 4 for copies of the training manual table of contents.

c. Storage issues – Based on past experiences of similar mercury switch studies, the Work Group determined that the best and most practical storage option was to provide plastic 5-gallon buckets with lids to store collected switch assemblies and pellets (Figure 2). New containers were provided to each recycler at the training sessions. When the container became full, a new container was made available to them. Each container was labeled with a "Universal Waste" label and according to Michigan regulations, dated at the time storage began. The participants were instructed to keep the lids on the containers at all times except when adding switches to the container.

Figure 2. 5 gallon buckets used to store switch assemblies.

d. Transportation and disposal logistics – Participating automotive recycling facilities were instructed to collect and store the switch assemblies and pellets obtained from the study so that they could be transported by the work group to the Kalamazoo County

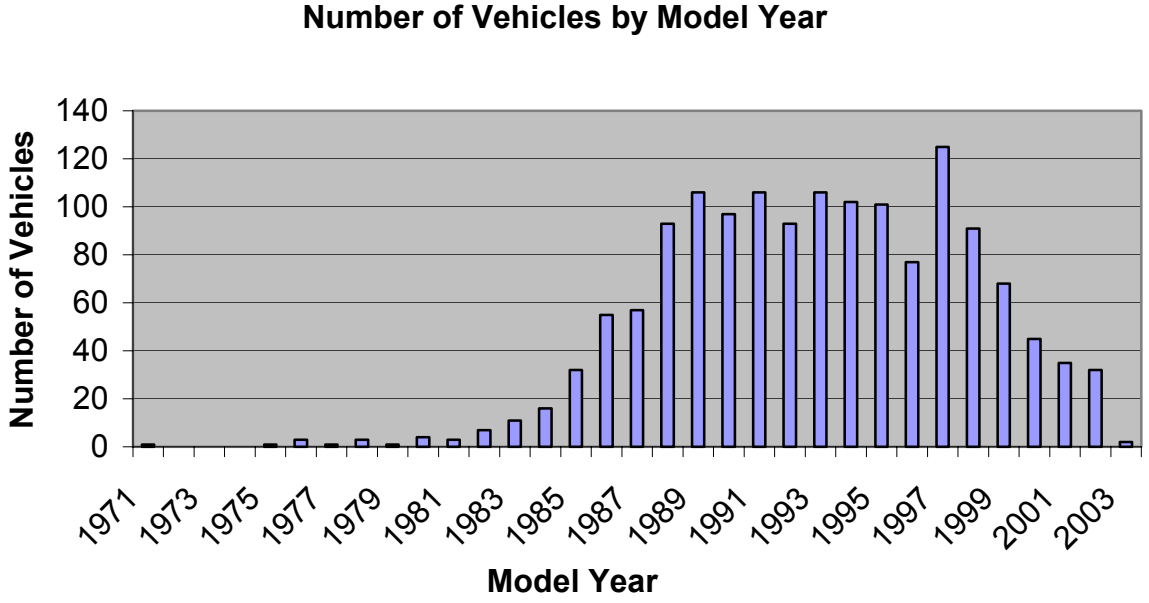
Household Hazardous Waste Center (KCHHWC). KCHHWC agreed to provide disassembly services for those participating companies that did not chose to remove the pellets from the switch assemblies. The KCHHWC measured the amount of time it took to remove the pellets, determined if the pellet contained mercury or a ball bearing and properly managed and recycled the pellets at the end of the project. Two "milk-run" collections (a route was developed and stops were made at each participating facility in one run) were made to collect and transport the switch assemblies and pellets to the KCHHWC. During transportation, the collected materials remained in their original containers to better facilitate documentation efforts.

VI. Findings

a. Overview and analysis of data collected

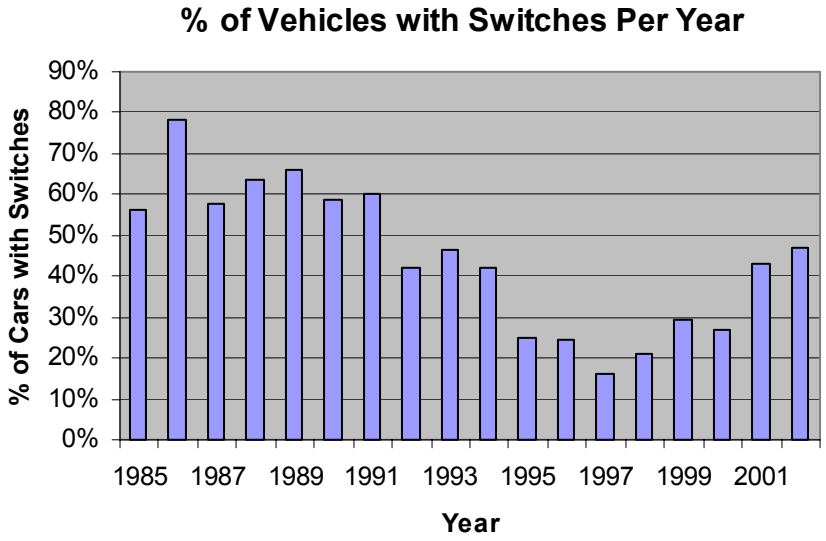
Data collection occurred over a three-month period between July and September 2002. The consultant collected data sheets (see Appendix 5 for the data summary and Appendix 6 for the raw data sheets) from each participant on a three to six week basis, depending on the volume of vehicles inspected. Data was verified and entered into an Excel spreadsheet for analysis. The following information was obtained from the study:

1. Data was collected from 1474 vehicles produced between 1971 and 2003.
2. The highest number of vehicles (125) occurs in the 1997 model year.

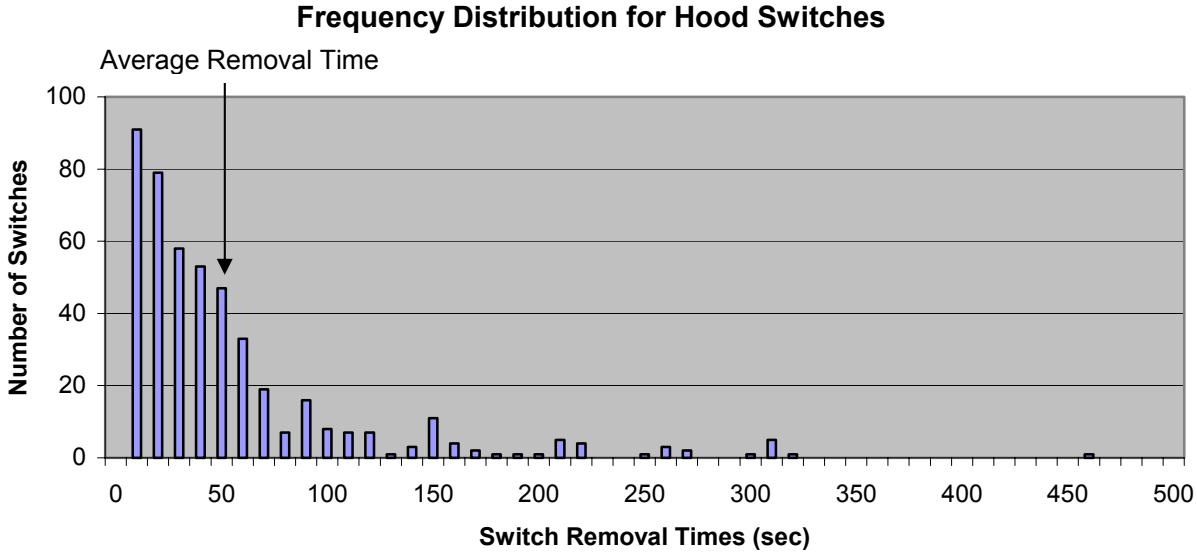


3. 801 switch assemblies were found in 1474 vehicles resulting in an average of 0.54 switches per vehicle.
4. 44 percent of vehicles had at least one switch present in either the hood or trunk.
5. 34 percent of hoods had a switch assembly.
6. 24 percent of trunks had a switch assembly.

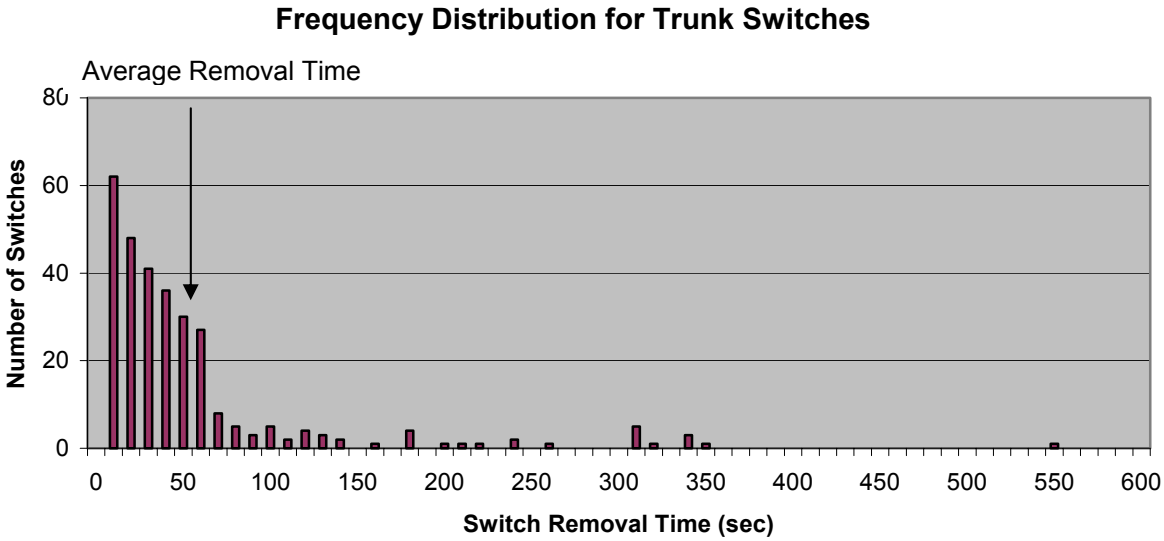
7. The percentage of switches per vehicle generally declined from 1986 – 1997 and has fluctuated from 1998 – 2002. Model years prior to 1985 are not shown due to the low number of vehicles found in those years.



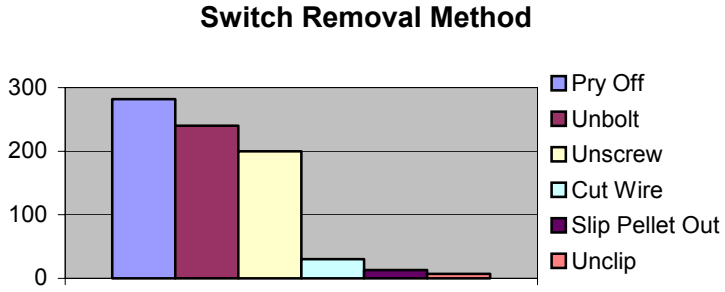
8. The average removal time of each hood switch assembly is 51 seconds.



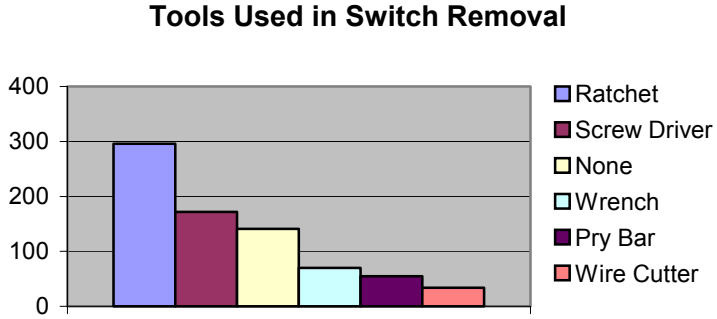
9. The average removal time of each trunk switch assembly is 51 seconds.



10. The average removal time for each switch assembly is 51 seconds.
11. The time range for removal of switch assemblies is 2 to 545 seconds.
12. Recyclers that conducted yard sweeps had longer switch removal times (64 seconds) as opposed to switches removed from initial vehicle processing (29 seconds).
13. The most common switch assembly removal method is to pry off.

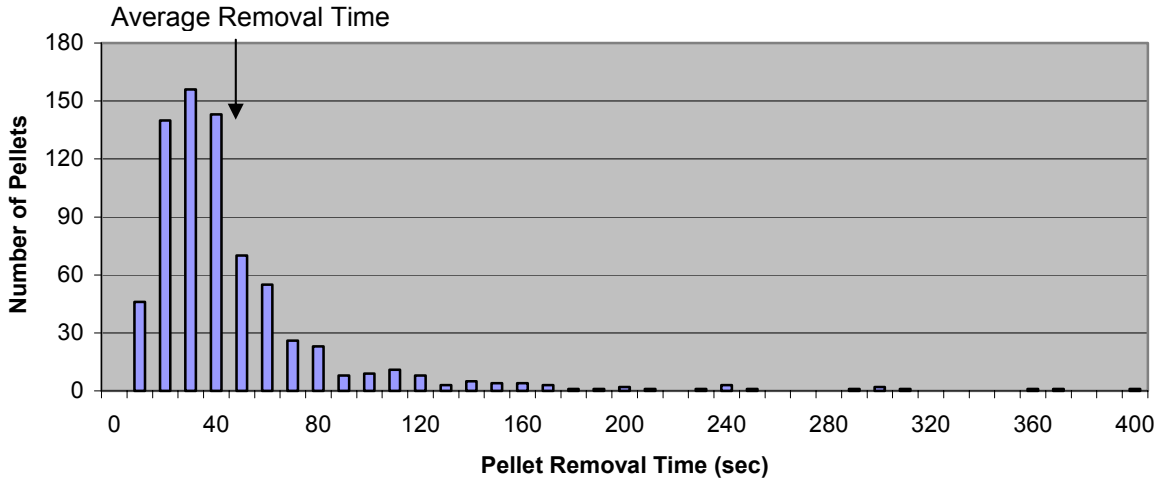


14. The most common tool for switch assembly removal is the ratchet.



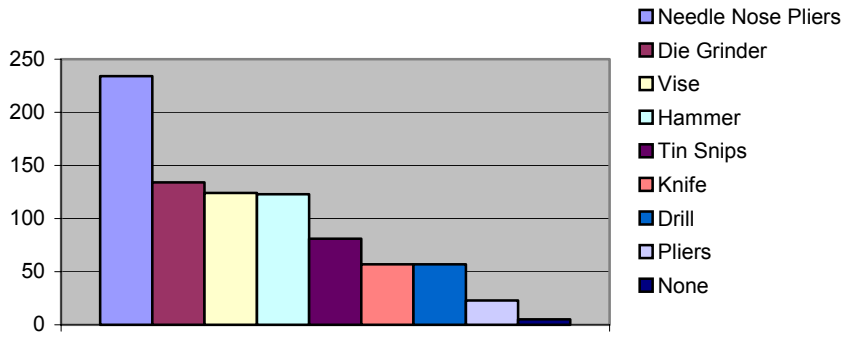
15. The average removal time for each hood pellet (removed by recyclers) from the switch assembly is 44 seconds.
16. The average removal time for each trunk pellet (removed by recyclers) from the switch assembly is 51 seconds.
17. The average pellet removal time from the switch assembly (removed by KCHHWC) is 43 seconds.
18. The average removal time for each pellet (combining those removed by recyclers and KHHWC) from the switch assembly is 44 seconds.

Frequency Distribution for Pellet Removal Times



19. The time range for removal of pellets from switch assemblies is 1 to 394 seconds.
20. The average pellet removal time was shorter at KCHHWC (43 seconds) than at the recycling facilities (48 seconds). This demonstrates that there is a benefit to training a select group of persons in pellet removal from the switch assemblies.
21. The most common tool for pellet removal from the switch assembly was needle nose pliers.

Tools Used in Pellet Removal from Switch Assembly



22. The average removal time for a switch assembly from a vehicle and the pellet from a switch assembly is 95 seconds.

23. 98% of the pellets in this study contained mercury.
24. No switch assemblies showed signs of mercury leakage prior to pellet removal.
25. 7 pellets (approximately 1%) leaked during the switch disassembly process at the Kalamazoo County Household Hazardous Waste Center.
26. Based on visual inspection of the pellets (Figure 3):
    - 93% had no visible or minimal corrosion (<10% corrosion)
    - 5% were slightly corroded (10 to 50% corrosion)
    - 2% were highly corroded (over 50% corrosion)

Figure 3. Degree of Surface Corrosion

0% ~ 10% ~ 50% 100%

27. The distribution of vehicles by model year obtained in this study was compared to a prior study regarding automotive recycling which had a much larger sample size (SAE, 1999). This comparison was made in order to determine how representative the study sample was in terms of the age of vehicles in dismantling facilities. The study sample was somewhat newer (typically about 3 years) and did not contain as many vehicles over 20 years old as the larger sample (see Appendix 7 for analysis).
28. Unanticipated components such as mercury containing glass ampoules from aftermarket remote car starters or burglar alarm systems were also collected as part of the study.

b. Factors that inhibited switch collection

The following observations from dismantlers were noted to inhibit switch collection.

1. Environmental conditions such as unusually hot summer weather, insect infestations like bees and wasps.
2. Turnover of employees
3. Commitment of company manager to project
4. Business cycles (sometimes company was too busy to collect)
5. Perceived liability of collecting mercury switches and removing pellets
6. Access to properly managed and affordable recycling and disposal options
7. Variation of switch assembly design

c. Regulatory considerations

The following is not a complete analysis of the legal requirements that may apply to mercury switches nor is it intended to provide legal advice on how to comply with legal requirements that apply to mercury switches and their removal.

i) Managing switches as universal or hazardous waste?
In Michigan, auto recyclers can choose to handle mercury switches and other waste devices containing elemental mercury under either the universal waste regulations or under the applicable hazardous waste rules. The universal waste management requirements are a simpler alternative to the more complex hazardous waste regulations. While setting up a switch removal program, auto recycler's should contact the mercury recycler or the hazardous waste treatment, storage, and disposal company for any possible additional requirements to the following regulatory requirements. The hood and trunk switches collected during the project were handled and managed as universal waste.

ii) Universal waste
When auto recyclers manage switches as universal waste they become 'universal waste handlers'. Employees must be informed how to properly handle the universal waste. Proper universal waste management requires mercury switches to be stored in closed containers that are kept in good condition, and are compatible with the waste. The container can be as simple as a 5-gallon plastic bucket with a lid. Containers holding the switches managed as universal waste must be labeled "Universal Waste-Mercury Switches" or substitute the wording "Waste" or "Used" instead of "Universal Waste."

A universal waste handler may accumulate universal waste for a maximum period of one year. (This is a longer time period than is allowed for either small or large quantity hazardous waste generators.) A tracking system is required to document the length of time that universal waste is accumulated on-site. This requirement may be met by labeling each container with the first date waste mercury switches were placed into it, or by using other tracking systems such as a log sheet that identifies when the universal waste was placed in the container.

There are additional requirements for large quantity handlers of universal waste. This would pertain to auto recyclers handling more than 11,000 pounds of all types of universal waste at any time. Go to the DEQ web site at www.michigan.gov/deq and select "Waste," "Hazardous Waste," "Hazardous Waste Management" and under the Information heading select "Disposal of Hazardous Waste Types" to link to a DEQ universal waste publication.

iii) Mercury spills or release
Any damaged universal waste switch that is leaking, or that could cause the release of mercury or other hazardous constituents, must be immediately contained. Leaking switches can no longer be managed under the universal waste regulations. A mercury spill kit should be kept on-site and accessible in the event of a spill. Employees must be

knowledgeable in how to respond to an emergency. Any cleaned-up waste or spill residue must be stored in a sealable unbreakable container. The container should be kept closed to prevent any release of mercury vapors. The auto recycler will need to determine if any of the materials or contaminated residue would be hazardous waste and manage them under the applicable hazardous waste regulations. This characterization will determine the specific labeling that is necessary.

Depending on the amount of the spill, several release reporting regulations may apply. A spill involving one pound or more (two tablespoons or more) of mercury must be immediately reported to the MDEQ's, Pollution Emergency Alerting System (PEAS) at (800) 292-4706. A follow-up written report will be necessary. If the spill also impacts the environment, or threatens public health, the National Response Center (800) 424-8802 must also be notified.

iv) Hazardous waste

There are significant differences in hazardous waste requirements as compared to universal waste requirements for labeling, accumulation, record keeping, training, shipping, etc. The specific hazardous waste requirements will depend on the auto recyclers' hazardous waste generator status. The following materials must be managed under all the applicable state and federal hazardous waste regulations:

- ✓ Any collected item the auto recycler decides to manage as a hazardous waste instead of universal waste.
- ✓ Any device that contains other hazardous waste constituents besides elemental mercury.
- ✓ Any elemental mercury that was contaminated.
- ✓ Any universal waste switch that was broken or damaged to the extent it could cause the release of mercury to the environment, and any contaminated residuals associated with the leakage, breakage, or damage.

If an auto recycler chooses to manage mercury switches as hazardous waste they will need to determine if this additional amount impacts their existing generator status. Go to the DEQ web site at www.michigan.gov/deq and select "Waste," "Hazardous Waste," "Hazardous Waste Management" for links to information on these requirements, or call the Waste and Hazardous Materials Division district office or the Environmental Assistance Center at 800-662-9278.

v) Transportation options

Before transporting mercury switches, an additional layer of leak protection packaging should be added to provide 'secondary containment' for the mercury devices. One example would be the use of a clear plastic bag placed around the outside of the plastic bucket. It is always easier and far less expensive to incorporate additional safety measures than it is to properly clean up a mercury spill.

Auto recyclers can choose to transport the universal waste switches themselves, hire a contracted hauler, or can mail them to another universal waste handler in Michigan, including Clean Sweep Programs, or to a destination facility that treats, disposes, or

recycles the material. There are no additional transport requirements for recyclers choosing to transport the universal waste themselves. Before taking universal waste to a universal waste handler or destination facility, arrangements must be made ahead of time to ensure the facility will accept the mercury switches. In the event a shipment is refused after it is received, additional regulations apply.

The amount of mercury switches collected is useful in determining the most effective means of transporting and recycling or disposing of the switches. For this project, the 'work group' collected the recovered switches from the recyclers and delivered them to the Kalamazoo County Clean Sweep Program Site for recycling. Employees or volunteers may transport 'universal waste' and are exempt from the federal hazardous material transportation requirements.

vi) Manifest or receipt
A hazardous waste manifest is not necessary to ship the intact switches managed as universal waste within Michigan. If the material is being taken out of Michigan, recyclers must check with the receiving state's environmental agency as to any additional or different universal waste requirements. There are manifesting requirements if the switch is being handled as hazardous waste.

Universal waste regulations do not require a small quantity handler to keep records of their shipments, although in some instances shipping papers are required under the Federal Hazardous Materials Regulations described below. Even if no manifest or shipping paper is required, it is still good practice to retain a tracking receipt or some type of written, signed and dated record that identifies the hauler, destination facility, and how much mercury was sent off-site. It is recommended that records of shipments should be retained for a minimum of 3 years.

vii) Shipping by contracted carriers
When using contracted carriers to transport mercury switches, auto recyclers need to meet all applicable transportation regulations. Transporters that haul universal waste in solid form are not required to be permitted and registered by the DEQ. However, the recycler may choose to hire a permitted and registered hazardous waste transporter to haul universal waste but it is not required.

The U.S. Department of Transportation (DOT) and Michigan State Police Motor Carrier Division regulate the transportation of hazardous materials. Universal waste packages containing one pound or more of mercury would be regulated as a hazardous material when shipped by highway. Mercury instruments in packages of less than one pound are only regulated in transportation by air. It is estimated that 567 switches (one pellet per assembly) would contain a pound of mercury (0.8 gram each). When shipped by air or vessel, elemental mercury would be regulated as a hazardous material. Switches being manifested as hazardous waste would also be transported as hazardous material. The shipping requirements include proper labeling, marking, placarding, shipping papers and other requirements. Questions concerning the transportation requirements of hazardous materials should be directed to the Michigan State Police, Motor Carrier Division at

(517) 336-6580.

viii) Mailing
Recyclers may not mail mercury via the U.S. Postal Service unless they meet all relevant legal requirements. To obtain complete details call (202) 268-5168. Specify that the question is regarding the proper shipment of mercury and specify the UN number (UN2809). United Parcel Service, Fed Ex, and other shippers also employ stringent requirements about shipping mercury instruments and in some cases, prohibit it all together. Contact them directly for details.

VII. Conclusions

- 44% of the vehicles in the study had one or more switches resulting in an average of 0.54 switches per vehicle. 98% of these switches contained mercury.
- Switch assemblies are quickly and easily removed from end of life vehicles using simple tools.
- Recyclers that conducted yard sweeps had longer switch removal times (64 seconds) as opposed to switches removed from initial vehicle processing (29 seconds). This is because the time for opening the hood or trunk was included in the yard sweep times, since this step is not usually part of their normal procedure.
- Outlier data for the few switches that took a very long time to remove (4 minutes and longer) indicate that they were pried off of models that had bolted on assemblies. The data indicates that unbolting the assemblies in these cases would have resulted in significantly quicker assembly removal times.
- Interviews with recyclers indicated that it was largely a standard procedure to open the hood and trunk as part of normal dismantling functions. There were times when it was impractical to try to gain access to the hood or trunk. Examples of this type of situation included vehicles stacked on top of each other, those with substantial insect infestations (especially bee and wasp nests), and collision damage. When there was not an opportunity to access the hood or trunk, the dismantler placed a “U” for "Unknown" in the appropriate space on the data collection sheet. The unknown sources of switches (4.2% of autos in the study), represents an insignificant portion of the collected data and was not an important factor identified in the study.
- 93% of the pellets had no visible or minimal corrosion (<10% visible corrosion). 5% were slightly corroded (10 to 50% visible corrosion). 2% were highly corroded (over 50% visible corrosion). Less than 1% leaked upon removal from their switch assemblies.
- No switch assemblies showed signs of mercury leakage prior to pellet removal.
- In removing pellets from switch assemblies it is critical that a mercury spill kit be kept nearby in the infrequent case that there is a mercury spill.
- Not all pellets collected contained mercury (2% of the switches collected had ball bearing type pellets). Additionally, some of the switches collected were aftermarket products that were not installed by the automobile manufacturers (i.e. remote starter switches, burglar alarm switch, etc.).
- Existing lists or manuals of types and model year of autos believed to contain

mercury switches were of little use to auto recyclers as the study uncovered discrepancies between the directories and actual experience in the field. It proved easier to inspect a vehicle for switch assemblies rather than consult a list.

- Minimal training (about 15 minutes) on best practices for switch assembly removal is very useful.
- Since the switches were managed as a universal waste under Michigan's Universal Waste Rules, the time it took for proper record keeping and storage by the participating auto recyclers was minimal.
- In Michigan, generators of universal waste have one-year to collect from the start date on the collection container label. For the three-month collection time period used in the study, transportation issues were not a significant concern. Transportation was provided through two "milk-runs" where switches from multiple sites were picked up and transported to the KCHHWC.
- Size and type of automotive recycling facility did not influence the ability to participate in the study and effectively remove switches.
- All the facilities indicated that participating in the study was a positive experience and most indicated they would continue to collect switches after the project's completion.

Recommendations

- It is recommended that recyclers who chose to remove switches at end of life:
    - Routinely remove switch assemblies as a standard practice upon receipt of the automobile when fluids are drained and collected
    - Incorporate switch assembly removal into standard operating procedures
    - Conduct a facility wide yard sweep if just starting switch assembly removal
    - Manage switches as a universal waste
- Managing switches as universal waste is advantageous for recyclers when compared to the more complex and stringent hazardous waste regulations. (Universal waste guidelines must be followed, such as proper labeling and recording the initial date of collection.)
- It is further advised for the sake of simplicity, that switches be transported by the recycler (generator) or by a volunteer third party (association). Even in this case it is highly advisable that the generator maintain written documentation that contains where and when the universal waste was collected and delivered. This information should be retained for a period of three years. A contracted shipper is subject to more stringent transportation requirements under DOT transportation laws, but an employee or volunteer is not bound by these hazardous material restrictions.
- As a rule of thumb, recyclers should not remove pellets from switch assemblies. In most instances efficient pellet removal is best accomplished by individuals specifically trained for this purpose. However, for switch assemblies such as those used in General Motors vehicles, pulling out the pellet presents little risk of mercury release, and is quicker than removing the entire assembly. Therefore, the automotive recycler could easily remove the pellet from this type of assembly.
- Household hazardous waste and clean sweep programs should be encouraged to partner with affected stakeholders and to accept switch assemblies and mercury pellets as resources allow.

Areas for further investigation

- The best practice for removing pellets from switch assemblies and where in the process this should occur.
- In service analysis for convenience light switch removal.
- Removal and management of ABS switches at end of life.
- Retirement options for recovered mercury.
- Further discussions are required to use the information in this study to develop an approach to encourage end-of-life switch removal.

Citations

Michigan Department of Environmental Quality, 1999 Mercury Emissions Inventory as updated December 16, 2002.

Nachtman, J. and D. Hill. "Mercury in Automotive Systems – A White Paper." International Congress & Exposition, Paper # 960409, Society of Automotive Engineers. Detroit, Mi. February 26-29, 1996.

Waste News, Volume 7, Issue 20, January 21, 2002.

Paper # J2456, Society of Automotive Engineers, 1985.

Axiom Research Company, 1997 Survey of ARA.

Automotive Recyclers of Michigan, Barb Utter, October 30, 2002.

Duranceau, C. and T. Lindell. "Automotive Recycling as Reuse: Investigation to Establish the Contribution of Reuse on Recyclability." International Congress & Exposition, Paper # 1999-01-0987, Society of Automotive Engineers. Detroit, Mi. March 1-4, 1999.

Appendix 1

TEAM COMPOSITION

Diverse groups representing this issue were invited to participate in the study. Not all groups elected to participate. The participants are shown below.

STEERING GROUP

Alliance of Automobile Manufacturers:
Dan Adsit – Ford Motor Company
Casimer Andary – Alliance of Automobile Manufacturers
Doug Berens – Ford Motor Company
Rich Bell – Ford Motor Company
Jeff Braun - GM
Terry Cullum – GM
Ross Good – DaimlerChrysler
Kevin Weber – Toyota
Ron Williams – GM

Ecology Center
Jeff Gearhart
Charles Griffith

Kalamazoo County Household Hazardous Waste Center
Tom Dewhirst

Michigan Department of Environmental Quality
Julie Brunner
Marcia Horan
Steve Kratzer
Paul Zugger

Schram Auto Parts
Ken Schram

Sustainable Research Group
Bill Stough

Steering Group Roles and Responsibilities

1. Provides overall guidance on study purpose, scope, and direction;
2. Recommends issues that should be addressed by study methodology and included in the written report;
3. Identifies and shares relevant data, studies, and other information that should be taken into consideration in the study;
4. Provides feedback on quality control; and
5. Reviews and participates in the report's release.

WORK GROUP

Dan Adsit – Alliance of Automobile Manufacturers
Ross Good – Alliance of Automobile Manufacturers
Marcia Horan - MDEQ
Steve Kratzer - MDEQ
Ken Schram – Schram Auto Parts
Bill Stough - Sustainable Research Group

Work Group Roles and Responsibilities

1. Designs and oversees study;
2. Undertakes tasks identified in the study work plan;
3. Oversees consultant activities, including statement of work, selection, and supervision;
4. Assists consultant in training participating facilities;
5. Identifies and responds to regulatory issues that arise in conducting the study;
6. Writes and releases the report; and
7. Reports monthly to the large group for feedback and further direction.

PARTICIPATING AUTOMOTIVE RECYCLERS

Eagle Auto Parts, 2707 E. Michigan Ave, Kalamazoo, MI
Grand Rapids Auto Parts, 1810 Turner Ave. NW, Grand Rapids, MI
JVS Auto Parts 1445 S. M 30, Gladwin, MI
Morris Rose Auto Parts, 2129 E. Michigan Ave., Kalamazoo, MI
Richland Auto Parts, 6379 E. AB Ave., Richland, MI
Schram Auto Parts Lansing, 1325 N. Cedar, Mason MI
Shroyers Auto Parts, 2740 Eaton Rapids Rd., Lansing MI
U-Wrench It, 11431 Chicago Dr., Holland, MI
Weller Auto Parts, 2535 Chicago Dr., Grand Rapids, MI
Weller Auto Parts, 1629 Douglas Avenue, Kalamazoo, MI

Appendix 2

LITERATURE REVIEW

Pilot programs and research summary
Some of the programs reviewed include:

- "Pull the Switch!" is a joint voluntary program between the Automotive Recyclers of Michigan and the Michigan Department of Environmental Quality (MDEQ). A package of material including mercury information, a step-by-step instruction sheet, poster and information on what to do with the collected switches was forwarded to all Automotive Recyclers of Michigan members. Although the pilot program ceased operation after one year, many members are still removing mercury switches.

- The Clean Car Campaign's *"Switch the Switch"* program targets the recovery of mercury from vehicles currently on the road. The main goal of this program is to demonstrate the feasibility of an in-service automotive mercury switch removal and replacement. The following web site can be visited to obtain further information: http://www.cleancarcampaign.org/switch_the_switch.html

- The New Jersey Mercury Task Force has produced a comprehensive report regarding the exposure, impacts and the sources of mercury in New Jersey's environment. With regards to automotive related mercury sources, the New Jersey Department of Environmental Protection (NJDEP) "is organizing a mercury recycling partnership with auto recyclers, automotive shredding facilities and other businesses to remove electrical switches and other parts containing mercury from the recycling stream." (Waste News, 2002) The complete report can be found at the following web site:
  http://www.state.nj.us/dep/dsr/mercury_task_force.htm

- The state of Wisconsin is working with "Concerned Auto Recyclers of Wisconsin and the Wisconsin chapter of the institute of Scrap Recyclers – to organize a statewide collection program aimed at removing mercury switches before vehicles are recycled." (Waste News, 2002)

- The Canadian based study sponsored by Pollution Probe entitled *Mercury Elimination* and Reduction Challenge (MERC) covered a six-month period and involved 11 dismantling facilities all located in Ontario, Canada. The MERC program:
  - Demonstrated a successful, voluntary program
  - Collected 2550 lighting switches
  - Developed by multi-sectoral partnerships with government and industry, including Ontario Power Generation, the Ontario Automotive Recycling Association, the Automotive Recyclers of Canada, the Canadian Association of recycling Industries, the Canadian Steel

Producers Association, Florescent Lamp Recyclers, and Comus International.
- Established a provincial collection, transfer and storage facility for mercury switches at lamp recyclers.
- Developed a closed loop recycling system for the mercury.

The complete report can be found at the following web site: http://www.cleanairfoundation.org/switch_out/index.htm

Overview of existing state laws impact on mercury switches

A list of legislative activity in the United States compiled by John Reindl (Recycling Manager Dane County, WI Dept. of Public Works) and Michael Bender (Mercury Policy Project) can be found at: http://www.mercurypolicy.org/new/documents/StateandFedHgLegislation012902.pdf. The sources of this information are: Internet Web pages of the various legislative bodies, updates via the email lists Mercury Policy Project, http://www.mercurypolicy.org, the Mercury Policy Project email list, (mercury_policy@lyris.newmoa.org) and Hg-WG (mwg-mercury@igc.topica.com).

Posters, videos and other available training materials

Several training devices, removal instructions and "how to" aids are available on the internet and were made available from the MDEQ and the Alliance of Automobile Manufactures. In addition, the switch recognition and removal procedures used by the Michigan project consultant were taken from the Clean Car Campaign's web site. A copy of Society of Automotive Engineers paper J2456 1998-05 (SAE, 1996) was also supplied by the Alliance and was incorporated into the training program. See the following list for additional information and resources:
http://www.cleancarcampaign.org/switch_the_switch.html
http://www.cleanairfoundation.org/switch_out/index.htm
http://www.state.me.us/dep/mercury/hgvehiclereport.htm

Appendix 3
DATA COLLECTION SHEETS

Mercury Switch Removal Form

Submitted By: _____
Date: _____

Year	Make	Model	Switch	Location	Switch Removal Time	Method of Removal	Tools Required	Pellet Removal Time	Mercury Switch (Y/N) and Notes
				Hood					
				Trunk					
				Hood					
				Trunk					
				Hood					
				Trunk					
				Hood					
				Trunk					
				Hood					
				Trunk					
				Hood					
				Trunk					
			Yes-**Y** No-**N** Unknown-**?**	**Circle** Hood or Trunk	In Seconds	Unbolt, Pry Off Unscrew, Slip Pellet Out	Pry Bar-**PB**, Wrench **W**, Ratchet-**R**, Screw Driver-**SD**, None-**N**	In Seconds	Vehicle Damage or Other Difficulties

Separate sheets were used for yard sweeps and in-coming processing of vehicles.

Appendix 4
TRAINING MANUAL TABLE OF CONTENTS

INFORMATION SHEETS

1. *Switchout*: Automotive Dismantlers' Guide – Automotive Mercury Switches and Lighting 2000-2001 Model Years
2. Breakdown of Study Vehicles that Contain Mercury – Automobile Shredder Residue Report Appendix N
3. Getting Mercury Out of Cars! – Society of Automotive Engineers
4. Save the Fish Poster – Michigan Study
5. Free Replacement of Your Mercury Switch – New York

EXAMPLE INSTRUCTIONS

1. Chrysler Hood Lighting Assembly: 1985-1995
2. Ford Hood and Trunk Lighting Assembly
3. Ford Removal & Replacement of Mercury Switch in Trunk Lighting Assembly: 1998
4. GM Removal and Replacement of Mercury Switch in Hood Lighting Assemblies: 1970-1998
5. GM Removal and Replacement of Mercury Switch in Rectangular Hood Lighting Assemblies: 1980-1998
6. GM Removal and Replacement of Mercury Switch in Trunk Lighting Assemblies: 1970-1998

MICHIGAN WASTE MANAGEMENT REGULATIONS

1. Michigan Department of Environmental Quality Universal Waste Management Guidance

Appendix 5
DATA SUMMARY

SWITCH REMOVAL TIMES	Sec.	Sec.	Median	# of Data Points	Standard Deviation
Average Removal Time for Hood Switches (sec):	51.4		32	472	62.76
Average Removal Time for Trunk Switches (sec):	51.2		30	298	72.68
Average Switch Removal Time Per Auto (sec):	51.3			770	67.81
Removal Time Range Per Auto (min and max)	2	545			
Incoming Autos					
Average Hood Switch Removal Time (sec):	34		24	195	33.74
Average Trunk Switch Removal Time (sec):	24		16	94	22.63
Average Switch Removal Time Per Auto (sec):	29				
Yard Sweep Autos					
Average Hood Switch Removal Time (sec):	64		40	277	74.49
Average Trunk Switch Removal Time (sec):	64		36	204	83.59
Average Switch Removal Time Per Auto (sec):	64				

SWITCH REMOVAL METHOD

Pry Off	282
Unbolt	240
Unscrew	200
Cut Wire	30
Slip Pellet Out	13
Unclip	7

TOOLS REQUIRED FOR SWITCH REMOVAL

Ratchet	296
Screw Driver	172
None	141
Wrench	70
Pry Bar	55
Wire Cutter	34

NUMBER OF SWITCHES

Number of Switches Present*	801
Number of Locations Without Switches	1950
Number of Hood/Trunk Switches Unknown	63
Number of Vehicles with at least one Switch	641
Percent of Vehicles with at least one Switch	44%
Number of Hood Switches	493
Percent of vehicles with Hood Switches	34%
Number of Trunk Switches	308
Percent of vehicles with Trunk Switches**	24%

*This number consists of the total number of switches removed, plus a portion of the pellets removed by recyclers (see page 32). Some of these pellets were removed from switch assemblies after the assembly was removed from the vehicle, and some pellets were removed without removing the switch assembly from the vehicle.
** Not all vehicles in sample have trunks (e.g. pickup trucks).

Michigan Mercury Switch Study

PELLET REMOVAL TIMES FROM SWITCH ASSEMBLIES	Sec.	Sec.	# of Data Points	Standard Deviation
Pellets Removed by Recyclers				
Average Removal Time for Hood Pellets (sec):	44		115	37.84
Average Removal Time for Trunk Pellets (sec):	51		42	32.34
Average Pellet Removal Time Per Auto (sec):	48		157	37.65
Pellet Removal Time Range Per Auto (min and max):	1	240		
Pellets Removed at KCHHWC				
Average Pellet Removal (sec):	43		574	47.10
Pellet Removal Time Range (min and max):	4	394		

PELLET REMOVAL METHOD

Needle Nose Pliers	234
Die Grinder	134
Vise	124
Hammer	123
Tin Snips	81
Knife	57
Drill	57
Pliers	23
None	5

NUMBER OF VEHICLES IN SAMPLE BY MODEL YEAR

Year	# of Vehicles
1971	1
1975	1
1976	3
1977	1
1978	3
1979	1
1980	4
1981	3
1982	7
1983	11
1984	16
1985	32
1986	55
1987	57
1988	93
1989	106
1990	97
1991	106
1992	93
1993	106
1994	102
1995	101
1996	77
1997	125
1998	91
1999	68
2000	45
2001	35
2002	32
2003	2

Michigan Mercury Switch Study

NUMBER OF VEHICLES BY BRAND

Acura		Buick		Cadillac		Chevrolet		Chrysler	
Integra	1	5th Ave	1	Brougham	2	250	1	Caravan	1
Legend	1	Century	20	CTS	1	1500	3	Cirrus	4
		Electra	4	DeVille	20	2500	1	Concorde	7
		LeSabre	31	ElDorado	3	Astro Van	9	K Car	1
		Park Ave	11	Escalade	1	Avalanche	1	Lazer	1
		Regal	13	SeVille	4	Beretta	8	Lebaron	12
		Riviera	7	Standard	6	Blazer	5	LHS	4
		Skylark	14			C10	1	New Yorker	6
		Ultra	1			Camaro	1	Sebring	5
						Caprice	12		
						Cavalier	47		
						Celebrity	8		
						Corsica	16		
						Impala	1		
						Lumina	37		
						Malibu	12		
						Monte Carlo	11		
						Passport	1		
						Pick-Up	10		
						S10 Blazer	7		
						S10 Pickup	11		
						Silverado	1		
						Suburban	4		
						Tahoe	1		
						TChev1500	1		
						Van	4		
						Venture	5		
Total	2	**Total**	102	**Total**	37	**Total**	219	**Total**	41

Note: Not all vehicles listed had convenience light switches.

Michigan Mercury Switch Study

Dodge		Eagle		Ford		Geo		GMC	
150 Van	1	Medallion	1	Aerostar	5	Metro	7	G20 Van	1
250 Van	1	Premier	2	Aspire	5	Prism	4	Jimmy	7
3500 Van	1	Talon	5	Bronco	3	Storm	2	Nova	2
Aspen	1	Vision	3	Bronco II	2	Tracker	7	Pickup 1500	2
Avenger	2			Contour	12			Safari Van	4
B350 Van	1			Crown Victoria	8			Spectrum	1
Caravan	15			Escort	54				
Charger	1			Explorer	13				
D100	1			F150	24				
Dakota	7			F250	6				
Daytona	5			F350	1				
Diplomat	1			Festiva	1				
Sundance	1			Focus	3				
Truck	1			Pickup	1				
Voyager	2			Van	5				
Durango	2			Granada	0				
Duster	1			LTD	1				
Dynasty	13			Mustang	7				
Intrepid	11			Probe	25				
Lancer	2			Ranger	48				
Landan	1			Taurus	88				
Neon	21			T-bird	4				
Omni	2			Tempo	21				
Pacifica	1			Windstar	8				
Ram	3								
Roadstar	1								
Shadow	9								
Spirit	8								
Stratus	6								
Total	122	**Total**	11	**Total**	345	**Total**	20	**Total**	17

Honda		Hyundai		Infiniti		Isuzu		Jeep	
Accord	2	Accent	1	G20	1	Amigo	1	Cherokee	9
Civic	2	Elantra	2					Grand Cherokee	5
Prelude	3	Sonata	1					Wrangler	4
Station Wagon	1								
Total	8	**Total**	4	**Total**	1	**Total**	1	**Total**	18

Note: Not all vehicles listed had convenience light switches.

Michigan Mercury Switch Study

Kia		Land Rover		Lincoln		Mazda		Mercedes	
Rio	1	Discovery	1	Continental	9	323	1	380SE	1
Sephia	1			Mark	3	626	8		
				Town Car	3	929	1		
				Lincoln	1	B2000	1		
						MPV Van	1		
						MX6	1		
						MZ1X	1		
						Navajo	1		
						Protégé	2		
						RX-7 Turbo	1		
Total	2	**Total**	1	**Total**	16	**Total**	18	**Total**	1

Mercury		Mitsubishi		Nissan		Oldsmobile		Plymouth	
Cougar	5	Diamante	1	Acura	1	88	10	Acclaim	13
Grand Marquis	6	Eclipse	2	Altima	1	98	12	Breeze	1
Lynxs	1	Galant	1	DeCoupe	1	Achieva	12	Horizon	4
Mystique	2	Montero	1	Maxima	3	Alero	7	Laser	1
Sable	34			Truck	2	Aurora	2	Reliant	6
Scorpio	1			Sentra	6	Calais	3	Sundance	14
Topaz	5			Sentra SER	1	Ciera	4	Voyager	14
Tracer	7					Cutlass	28		
						Cutlass			
Villager	6					Supreme	19		
XR4TI	1					Delta 88	15		
						Firenza	1		
						Intrigue	2		
						Omega	1		
						Royale	4		
						Silhouette	3		
						Toronado	3		
						Toronado			
						Trofeo	2		
Total	68	**Total**	5	**Total**	15	**Total**	128	**Total**	53

Note: Not all vehicles listed had convenience light switches.

Michigan Mercury Switch Study

Pontiac		Saab		Saturn		Subaru		Toyota	
		9000	1	LS	1	GL	1	Camry	13
2000	1			SC	2	Legacy	1	Camry Coupe	1
6000	2			SL	7			Celica	2
6000LE	1			S-series	1			Corolla	7
Bonneville	28							Cressida	2
Firebird	4							Lexus	1
Grand Am	56							Paseo	2
Grand Prix	34							Pickup Truck	1
Lemaus	2							SR5	1
Montana	4							Tercel	7
Parisienne	1							Tacoma	1
Sunbird	6								
Sunfire	14								
Trans Sport	7								
Vibe	1								
Total	161	**Total**	1	**Total**	11	**Total**	2	**Total**	38

Volkswagon	
Golf	2
Jetta	3
Total	5

Grand Total*	1474

* One vehicle was incorrectly labeled and is not listed.
Note: Not all vehicles listed had convenience light switches.

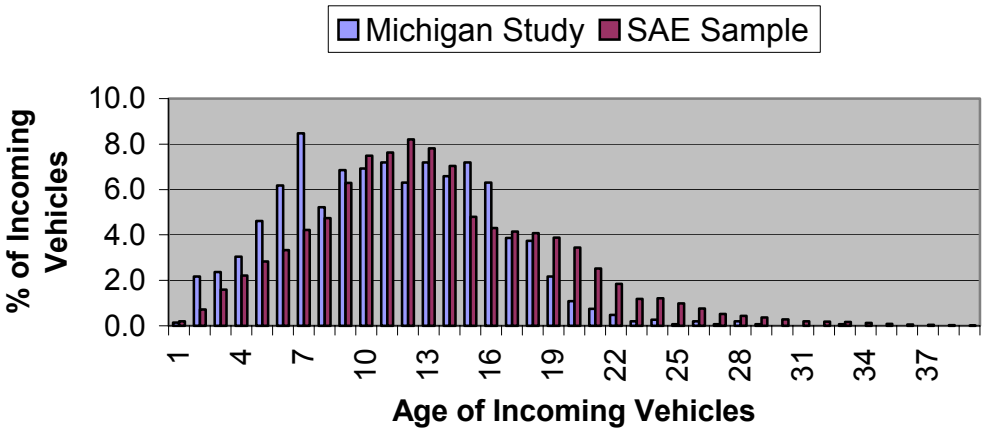
Appendix 6
RAW DATA (DATA SHEETS)

See attached Excel spreadsheet.

Appendix 7
HOW REPRESENTATIVE WAS THE STUDY SAMPLE?

The distribution of vehicles by model year obtained in this study was compared to a prior study in order to determine how representative the age of vehicles were when compared to a larger sample. The comparator data came from a study that utilized 48 dismantlers and looked at data from 334,530 incoming vehicles (SAE, 1999). When the age of the vehicles looked at in the Michigan study was plotted against the comparator data in the chart below, it shows that the Michigan study sample was somewhat newer and had a smaller number of vehicles over 20 year old than the SAE sample.

Michigan Study by Model Year vs. SAE Sample



The Michigan data was then shifted three years to determine the best fit of the graphs (see chart below). This illustrates that on average, the age of the vehicles study in Michigan were 3 years younger than the one examined in the larger study.

Michigan Distribution Shifted 3 Years