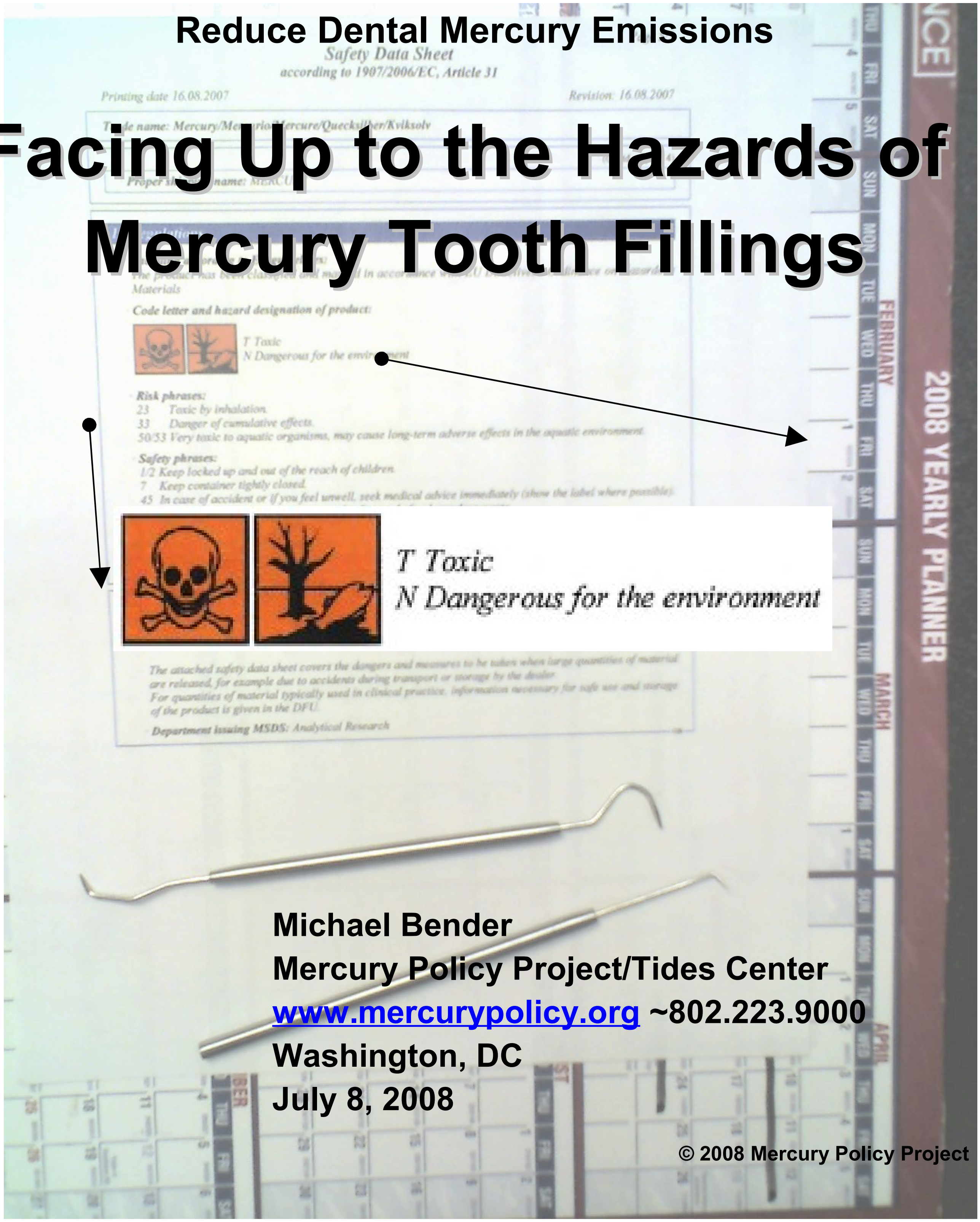
A Report to US House of Representatives
Government Oversight Subcommittee on Domestic Policy

Assessing State and Local Regulations to Reduce Dental Mercury Emissions

Facing Up to the Hazards of Mercury Tooth Fillings



Michael Bender
Mercury Policy Project/Tides Center
www.mercurypolicy.org ~802.223.9000
Washington, DC
July 8, 2008

Acknowledgments

The Mercury Policy Project would like to thank the following people for their assistance with the research, writing and/or editing of this report:

- Peter Maxson, Concorde East/West
- Eric Uram, Headwater Consulting

The Mercury Policy Project would like to thank the Garfield Foundation for their generous support.

This report is available via World Wide Web at: www.mercurypolicy.org

The Mercury Policy Project (MPP) is a project of the Tides Center and works to promote policies to eliminate mercury uses, reduce the export and trafficking of mercury, and significantly reduce mercury exposures at the local, national, and international levels. We strive to work harmoniously with other groups and individuals who have similar goals and interests.

Mercury Policy Project
1420 North St.
Montpelier, VT 05602
www.mercurypolicy.org

Mercury
Policy Project

Introduction

It's becoming increasing clear that the recent improvements in technology for the non-mercury filling—most commonly the "composite"—have rendered the mercury tooth filling—aka "amalgam"—obsolete. One only has to look at the recent bans on new amalgam placement in Norwegian or Swedish dental patients or elimination of insurance coverage for amalgam restorations in Danish patients to document mercury-free tooth restoratives as a viable substitute.

Practically speaking, the age of amalgam is over.

So why do over 60 million mercury tooth fillings still get placed into Americans' mouths every year?

Is it because it is simply cheaper and quicker for your dentists to place an amalgam and they make more money doing so?

Is it because, as the expression goes, "you can't teach an old dog new tricks," and in some cases dentists are reluctant to change or take the time to master the new techniques for placement of composites?

Or is it because the US dental sector, led by the American Dental Association and its state associations, remains in denial that mercury is a neurotoxin — a hazardous material before it is placed in the mouth, and a hazard that releases toxic vapors after it is in the mouth? And could concerns about potential legal liability reinforce this denial?

Or finally, is it because dentists are not aware or held accountable to the fact—undisputed by the US EPA since it was presented to the US House subcommittee last fall-- that the continued use of amalgam is resulting in the release of upwards of 10 tons—and growing—of mercury into the air and water each year in the U.S. And that at least some of that mercury gets taken up in the fish Americans eat and, in particular, poses the most acute risk to pregnant women and their developing fetus and young children?

The answer certainly includes some or all of the above points, depending upon the expert you may be talking with.

While the calculations here are necessarily based on a certain number of assumptions, estimates and projections, the basic fact remains that up until now significant added costs of using amalgam—the so-called "externalities"—have not been factored into the fee charged by your dentist. This report demonstrates when factoring in these external costs, even under multiple scenarios, the cost of placing an amalgam filling virtually meets or surpasses the cost of placing a non-mercury composite filling.

Assuming that it is not yet politically viable for decision-makers in the US to ban amalgam outright, this report – for the first time ever-- lays out the rationale for placing a user fee on the continued use of dental mercury as a means to cover the costs of preventing dental mercury pollution from environmental release.

This report also clearly shows the cost-effectiveness of amalgam separators at preventing mercury from getting into the environment. It also clearly demonstrates that voluntary programs are not effective in convincing dentists to install and properly maintain separators.

1 Dental mercury, wastes and emissions

1.1 Mercury in the environment

Mercury is a naturally occurring metal and a persistent, bio-accumulative neurotoxin, especially affecting the brain and nervous system. It enters the environment via natural events, such as volcanic eruptions, but more-so through human activities. Methylmercury is more mobile and even more toxic than elemental mercury, and it easily finds its way into the food chain, contaminating fish. Methylmercury is synthesized by microbial action on mercury-polluted sediments and soils. The consumption of fish from waters contaminated with mercury is the source of greatest risk of exposure to this pollutant (NACWA 2002).

While mercury releases to wastewater should clearly be avoided, most methylmercury is generated from the by-products of the combustion of mercury-containing materials. The release of mercury by combustion occurs in a variety of settings, including coal-fired power plants, municipal incinerators, sludge incinerators, hazardous waste incinerators, industrial boilers, cremation chambers and other industrial processes including metal refining and cement production.

The widely documented effects of mercury exposure on human health and wildlife have driven a great range of efforts, in the US and overseas, to significantly reduce the level of this toxic, persistent, and bio-accumulative metal in the environment. The rest of this paper will address one key source of mercury releases to the environment, which is the use of mercury in dentistry.

1.2 Dental mercury wastes

The primary sources of mercury waste that originate in the dental clinic include amalgam waste generated producing amalgam for use in the procedure; the excess material carved from new amalgam fillings; the removal of old amalgam fillings; the removal of teeth containing amalgam; other mercury going to solid waste or wastewater; mercury emissions directly to the air; the traps, filters and other devices in dental clinics to remove mercury from the wastewater – and the "downstream" flows of mercury from there.

Most dental mercury waste results from the removal of previous fillings from patients' teeth. Together with waste generated during the replacing of fillings, removed teeth, etc., these dental wastes typically follow these main paths. They may be

- Captured for subsequent recycling or disposal,
- Washed down drains that lead to the general municipal wastewater system,
- Placed in special containers as medical waste, or
- Discarded as municipal waste.

It is commonly accepted that most municipal wastewater systems encounter significant levels of mercury, and it has been determined that typically close to 50% of that mercury originates from dental practices (AMSA 2002a). Some observations are summarized in the following table.

City	Mercury load from dental offices
Duluth, Minnesota	36%
Seattle, Washington	40-60%
Palo Alto, California	83%
Greater Boston Area, MA	13-76%

1.3 Dental mercury emissions

Dental amalgam is a large source of mercury waste in the environment. According to EPA, “Mercury discharges [in wastewater] from dental offices far exceeded all other commercial and residential sources.” (EPA 2006) EPA cited an estimate that 36 percent of mercury reaching municipal sewage treatment plants is released by dental offices. Other investigations have put the figure closer to 50 percent (NEG-ECP 2007). The costs of largely eliminating discharges of dental mercury to wastewater are assessed in Section 3 of this report.

Despite regulations regarding the characterization and disposal of mercury bearing wastes, many solid dental wastes still follow the low-cost route of disposal as municipal solid waste and are subsequently disposed of in landfills or by municipal incineration. Depending on the characteristics of the landfill, dental amalgam may decompose over time and the mercury may enter the leachate (which may itself be disposed of in a manner that permits the mercury to be released), groundwater, soils, or volatilize into the atmosphere. Studies have documented methylmercury in gases emitted from landfills (Lindberg *et al.* 2001).

Mercury from dental amalgams is also a significant source of airborne emissions. EPA has estimated airborne mercury attributable to wastewater sludge incineration to be 0.6 ton per year, but the discussion in Section 4 below provides evidence that the EPA estimate is seriously underestimated. Among other failings, EPA emissions estimates do not include total mercury emitted during the cremation of human remains. However, cremation has been shown to be a significant source - over 3 tons of emissions - due to the large amount of mercury in existing dental fillings. In comparison, the largest source of airborne mercury is coal-burning power plants, which emit an estimated 48 tons of mercury per year.

The 2002 EPA National Emissions Inventory (version 3) put atmospheric emissions related to dental mercury at 1.5 tonnes, as in the first column of the table below. The EPA numbers are compared with the more rigorous estimates submitted in testimony last fall, summarized in the second and third columns, which suggest air emissions at least 5 times higher than the EPA estimates. (Bender 2007) The EPA has not contested these revised estimates.

Atmospheric emissions of dental mercury (tons)			
Pathway	**EPA National Emissions Inventory 2002**	**This report 2005 (low estimate)**	**This report 2005 (high estimate)**
Human cremation	0.3	3.0	3.5
Dental clinics	0.6	0.9	1.3
Dental mercury sewage sludge incineration	0.6	1.5	2.0
Dental mercury sludge spread on land and landfilled	n.a.	0.8	1.2
Dental mercury MSW incineration and landfill	n.a.	0.2	0.5
Dental mercury infectious and hazardous waste	n.a.	0.5	0.7
Human respiration	n.a.	0.2	0.2
Total	**1.5**	**7.1**	**9.4**

1.4 Quantities of dental mercury consumed

Contrary to what the US dental sector maintains, there has been very little evidence of reduction in the amounts of mercury used in dental restorations in recent years.

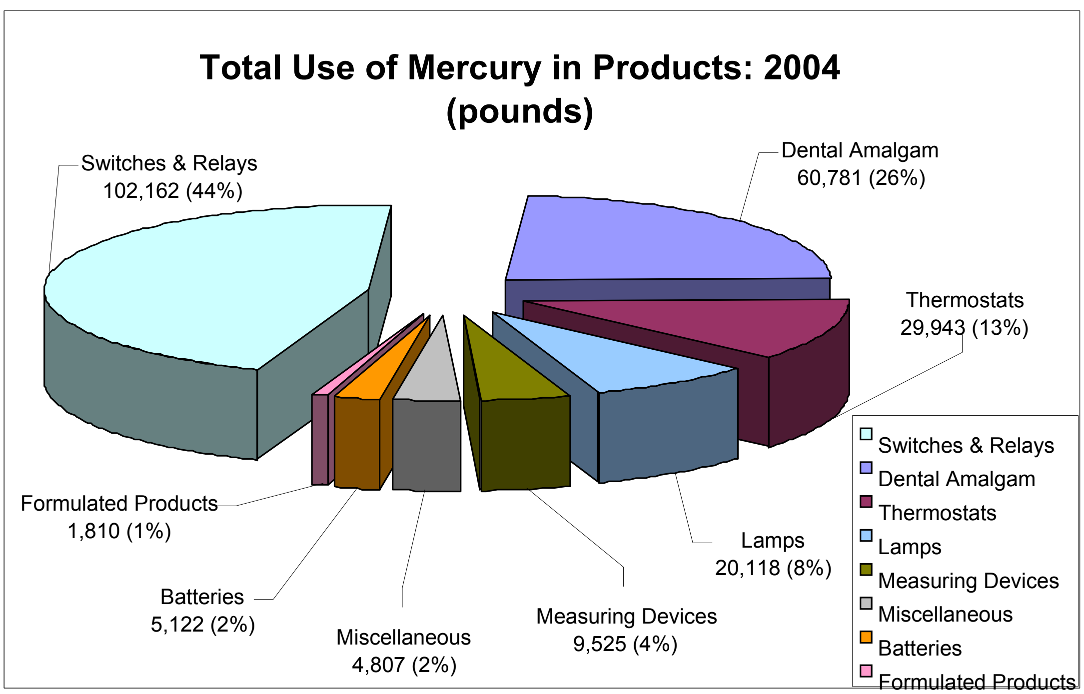
The Interstate Mercury Education and Reduction Clearinghouse (IMERC), a program of the Northeast Waste Management Officials' Association (NEWMOA), published a report online showing that mercury use in products sold in the U.S. declined from 131 tons in 2001 to 117 tons in 2004, an 11 percent reduction. The IMERC study, *Trends in Mercury Use in Products: Summary of the Interstate Mercury Education and Reduction Clearinghouse (IMERC) Mercury-added Products Database* (IMERC 2008), summarizes mercury use in products sold in the United States in 2001 and 2004 from information submitted by hundreds of manufacturers.

From IMERC's latest report, we see little change from 2001-2004 in the amount of amalgam provided to dental facilities from these five major manufacturers. For both years analyzed, 2001 and 2004, about 30 tons (61,537 in 2001 and 60,781 pounds in 2004) of mercury was used for the placement of almost 60 million amalgam fillings. This is detailed in the following table provided by IMERC.

Total Amount of Mercury Sold in Fabricated & Formulated Products **U.S. For Calendar Years 2001 & 2004**				
Products/Components	**Total Mercury (pounds)**		**Number of Total Manufacturers Reporting**	
	2001	**2004**	**2001**	**2004**
Switches & Relays	119,660	102,162	53	46 + 3 nr*
Dental Amalgam	61,537	60,781	5	5
Thermostats	30,971	29,943	9	8 + 1 nr
Lamps	21,438	20,118	177	185 + 8 nr
Miscellaneous	8,505	4,807	12	10 + 2 nr
Batteries	5,914	5,122	40	41
Measuring Devices:				
Sphygmomanometers	4,305	2,219	2	2
Thermometers	5,347	4,524	13	8 + 4 nr
Manometers	1,936	2,545	4	4
Barometers	353	234	1	1
Psychrometers/Other Measuring Equipment	4	3	3	3
Chemicals & Solutions	2,060	1,810	20	20 + 1 nr
Total	**262,030** (131 tons)	**234,268** (117 tons)	**339**	**352**

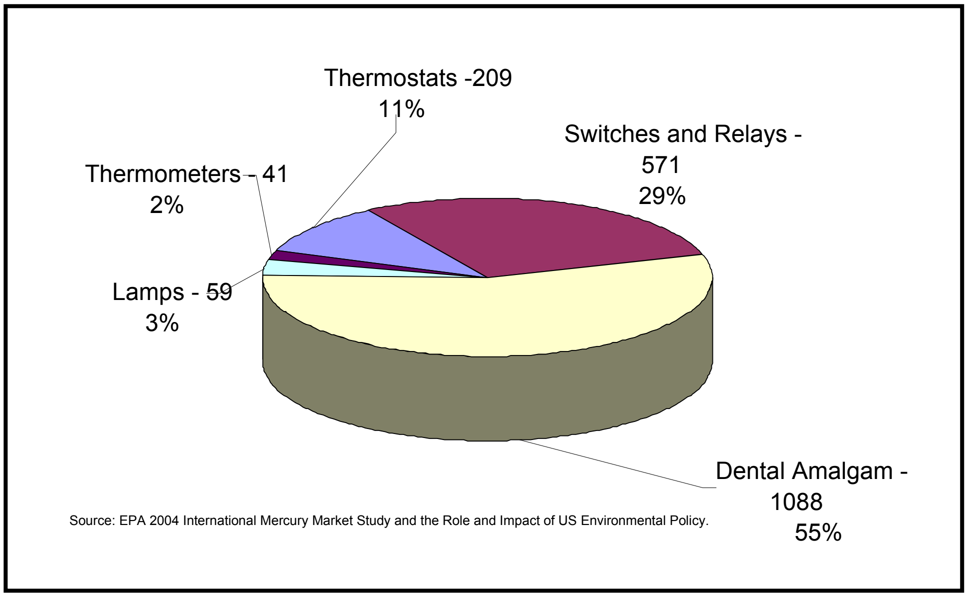
With regard to nationwide consumption of mercury, as shown in the NEWMOA figure below, dental offices are the second largest user of mercury, after switches and relays.

Figure 1 – Mercury consumption in the USA in 2004



Finally, as seen in the following EPA figure, mercury contained in the existing dental fillings of Americans comprises over half of all mercury “circulating in the economy” today, amounting to over 1000 tons. (EPA 2004) All of this mercury will eventually have to be dealt with in order to keep it out of the environment.

Figure 2 - Mercury circulating in the U.S. economy



1.5 Quantities of mercury in dental wastes

Following the methodology used by EPA (Cain 2007), of the 30 tons of "new" mercury consumed in a typical year by dental clinics, some amalgam is carved away or otherwise lost during a typical clinical procedure – averaging some 20-25% of the total amalgam used. However, most of the mercury lost is not due to "carving" and fitting a new filling, but due rather to the amount of old amalgam that is removed to make room for the new filling. Considering that about 70% of fillings are replacements, that not all new fillings are amalgams, etc., some 31 tons of mercury have been calculated to go to emissions and waste (Bender 2007).

The quantities of mercury consumed and mercury wastes generated by the dental profession are directly related to the average life of a filling. In a US Geological Survey report published in 2000, it was noted that the average life of a mercury amalgam filling is reported to be from 5 to 8 years, while a 1995 article in a Swiss dental medical journal reported the average life to be 10 years. Other estimates have ranged as high as 10-20 years (Reindl 2007).

2 Status of efforts to minimize the risks of amalgam

2.1 Norway, Sweden Ban Amalgam

Starting in January 2008, Norway banned amalgam. In announcing the ban, Norwegian Minister of Environment Erik Solheim said:

> "Mercury is among the most dangerous environmental toxins. Satisfactory alternatives to mercury in products are available, and it is therefore fitting to introduce a ban. When the environmental toxin mercury is released to the environment it is very harmful, and *inter alia* the development of children may be damaged as a result."

According to the Norwegian Ministry, mercury is among the most dangerous environmental toxins. Satisfactory alternatives to mercury in products are available, and it is therefore fitting to introduce a ban. Minister Solheim further stated that the Norwegian ban shows that Norway is taking responsibility at home. It is an important signal, to the EU and other countries scrutinizing various uses of mercury, that there are satisfactory alternatives to mercury, the minister concluded.

Sweden announced a similar ban on amalgam, and Denmark announced that it will not provide public insurance to cover mercury in fillings after April 1, 2008. Such measures would be politically impossible if entirely satisfactory mercury-free alternatives were not available, or if these governments were not absolutely convinced that amalgam carries a higher risk than mercury-free alternatives.

2.2 FDA Settles Lawsuit, Agrees to Classify Amalgam as a Medical Device, Revamps Website

After 32 years of delay, the Food and Drug Administration has finally agreed to comply with Federal law and set a date to classify mercury amalgam as a substance that poses a health risk, especially to pregnant women and unborn babies, and to children. This about-face resulted from settling the lawsuit, *Moms Against Mercury et al. v. Von Eschenbach, Commissioner, et al.*, in which the judge cited FDA for an "*unreasonable delay*" and "*a reasonable case of failure to act*." As reflected in the May 16, 2008, court transcripts, Judge Ellen Huvelle stated that the "*probability of harm is enormous*," and asked the FDA: "*How could you drag your feet for 32 years? Do what you are supposed to do*." Judge Huvelle also stated that she couldn't "*order a ban, but can compel [FDA] to act*," observing that this was "*government at its worst*" and that she wanted this "*public safety issue to be resolved*." The FDA must now finish classification within one year of the close of the public comment period on its amalgam policy, that is, by July 28, 2009.

As part of the settlement, the FDA agreed to, and with uncharacteristic speed has already, change its website— dramatically. The updated June 3, 2008 FDA website now states, for example:

> "*Dental amalgams contain mercury, which may have neurotoxic effects on the nervous systems of developing children and fetus*." … "*Pregnant women and persons who may have a health condition that makes them more sensitive to mercury exposure, including*

> *individuals with existing high levels of mercury bioburden, should not avoid seeking dental care, but should discuss options with their health practitioner*."

The FDA website (FDA 2007) also states, "Some other countries follow a 'precautionary principle' and avoid the use of dental amalgam in pregnant women," and provides links to advice about amalgams from regulatory agencies in other countries, including Canada, France and Sweden. For example, the FDA website link to Health Canada advises dentists to take the following measures:

- Non-mercury filling materials should be considered for restoring the primary teeth of children where the mechanical properties of the material are suitable.
- Whenever possible, amalgam fillings should not be placed in, or removed from, the teeth of pregnant women.
- Amalgam should not be placed in patients with impaired kidney function.

These warnings are similar to those sent by amalgam manufacturers. Encapsulated dental amalgam is shipped from manufacturers to a dentist's office with a skull-and-crossed-bones affixed next to the words: "*POISON, CONTAINS METALLIC MERCURY*." (MSDS 2007) Amalgam manufacturers – Kerr, Vivadent and Dentsply, among others – advise dentists against placing amalgam in the teeth of pregnant women, nursing mothers, children under six, and anyone with kidney disease. Dentsply, for example, warns:

> "Contraindication [N.B.: "Contraindication" is a directive to forbid, not just a "warning"]: "*In children 6 and under*" and "*In expectant mothers*."

15 Regulations

· ***Labelling according to EU guidelines:***
The product has been classified and marked in accordance with EU Directives / Ordinance on Hazardous Materials

· ***Code letter and hazard designation of product:***

T Toxic
N Dangerous for the environment

· ***Risk phrases:***
23 Toxic by inhalation.
33 Danger of cumulative effects.
50/53 Very toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.

· ***Safety phrases:***
1/2 Keep locked up and out of the reach of children.
7 Keep container tightly closed.
45 In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible).
60 This material and its container must be disposed of as hazardous waste.
61 Avoid release to the environment. Refer to special instructions/safety data sheets.

· ***National regulations***

· ***Waterhazard class:*** *Water danger class 3 (Assessment by list): extremely hazardous for water.*

However, these warnings are apparently not being passed along to the public, based on the results of a national poll conducted for the Mercury Policy Project by Zogby International whereby:

- Most Americans (76 percent) don't know mercury is the primary component of amalgam fillings;
- 92 percent of Americans overwhelmingly want to be informed of their options with respect to mercury and non-mercury dental filling materials prior to treatment; and
- 77 percent of Americans would choose higher cost fillings that do not contain mercury if given the choice.

2.3 ADA & State Dental Associations Blocking Amalgam Separator Installations

The American Dental Association (ADA) now recommends that amalgam separators be installed in all dental offices as part of their "best management practices (BMPs)," but they maintain that adequate levels of compliance with their recommendation can be achieved through a voluntary program. (ADA 2007) Meanwhile, they have successfully blocked amalgam separator initiatives across the country. For example, it's clear that the ADA is actively helping State Associations find ways to avoid installing separators, or block any kind of requirements to do so, at least in the following states and local jurisdictions.

<u>California</u> The CA Dental Association (CDA) was the sole opponent of Assembly Bill 966 in 2005, authored by Assemblymember Lori Saldaña, and stopped the bill in the Assembly. The bill would have mandated separators. In 2003, CDA was sole opponent of AB 611, authored by Assemblymember Gloria Negrete-McLeod, which also would have required separators. They actually hijacked the bill and got the author to substitute a mere codification of BMPs. The bill then died in Appropriations Committee.

<u>Michigan</u> In Michigan, a colleague had a very brief conversation with a MI Dental Association director who informed him that the ADA lawyer who was "helping" with the separator issue told him that they would not have to deal with the issue until 2011.

<u>Montana</u> According to the *ADA News,* "Immediately after the drafting of HB 665, members and staff of the Montana Dental Association, including two dentists in the Montana legislature, promptly met with the bill's sponsor, Rep. Teresa Henry. At what MDA executive director Mary McCue described as a congenial, professional meeting with a very reasonable lawmaker, the MDA explained its nearly two-year efforts, statewide, to educate dentists and promote voluntary adoption of the ADA's Best Management Practices for handling amalgam waste. The one-two punch was successful; MDA was able to convince Rep. Henry to amend her bill, who shortly removed all language Feb. 18 requiring dentists to install separators. The issue is no longer on the table. "Thanks to the assistance of the ADA, we got out ahead of the issue and it certainly helped us," said Ms. McCue.

<u>Oregon</u> After many delays, an amalgam separator bill was passed with an extraordinarily long compliance date (2011) due to the efforts of the lobbyist for the Oregon Dental Association. Yet the Oregon Dental Association was a bit too clever in how it arranged for such a long lead time. The provision that the ODA inserted into SB 704 deferred the effective date if the dentist is "certified by a special district that manages wastewater

treatment to be following 'best management practices.'" There are a few such districts in the state, but none of them were the least bit interested in becoming a certifying agency for 11,000 Oregon dentists. So, in Oregon's first-ever even-year legislative assembly, the ODA dropped a bill seeking a fix to SB 704, expanding the kind of entities that could certify a dentist's BMPs. Instead, a shorter time frame was adopted for the separator requirement to become law (2010).

<u>Philadelphia</u> Last year, the PA Dental Association blocked a proposed ordinance by the Philadelphia City Council would have required most dentists residing in Philadelphia to install amalgam separators. According to their newsletter, the PA Dental Association worked in conjunction with the ADA, its lobbyists and public relations team and other dental organizations in what they termed a “strong lobbying effort to amend the ordinance.” The ADA and PDA were explaining the financial hardships that would be encountered by the Dentists and the city's poorer population because composites were more expensive and the "poor", who could not afford the more expensive fillings, would not take their children to the dentist, causing untold hardships and disease to the less fortunate.

While multiple and complex factors may influence the success, or lack thereof, of a voluntary program, there is a growing body of evidence that a mandatory approach, while administratively more demanding, is necessary to achieve a faster and more comprehensive result. Even more importantly, this creates a level playing field that does not discriminate against the vast majority of dentists who wish to comply with the ADA recommendation to install separators.

The use of amalgam separators is highly cost effective in preventing releases of mercury to the environment, particularly when compared to the cost to remove mercury at a wastewater treatment plant of approximately $21 million per pound, or $46,000 per gram (AMSA 2002b).

Recent data from the Boston area Metropolitan Water Resources Authority (MWRA) (see figure below) showed a 48% reduction in mercury concentration in sludge as amalgam separator use increased from less than 20% to over 80%. Additional data is being collected and assessed to evaluate whether these reductions are typical across the region, and to estimate the overall regional reduction in mercury releases attributable to these programs (NEG-ECP 2007).

King County in Seattle may be taken as an example. King County employed three distinct strategies to limit or control the amount of mercury discharged from dental offices over the 13-year time frame of this case study. The initial resistance of the ADA and dental community to installing separators contributed to the length of time and the changing strategies that had to be employed by the county. The King County Program 1995-2000 focused on an intensive outreach program for dentists, including an annual poster, monthly ads in a local journal, a Voucher Incentive Program, EnviroStars, information dissemination, and trade shows/mercury roundups.

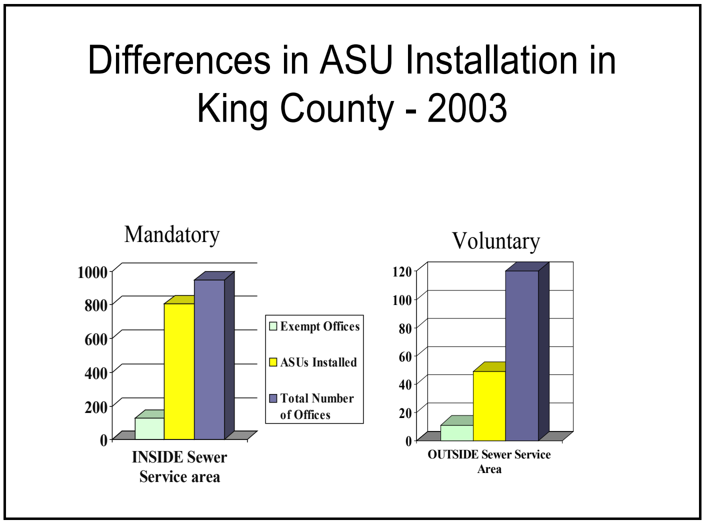
Even after these efforts, a 2000 study in King County found that more than three-quarters of dental offices did not recycle or sequester mercury-bearing waste captured in chairside traps and vacuum pump filters. Rather, they put it in the waste bin, included it with medical waste, stored it onsite for eventual disposal or flushed it down the drain (Savina 2003).

As a result, the following practices were made mandatory by July 1, 2003:

- Use best management practices (BMPs) for amalgam waste;

- Demonstrate compliance with King County local limits (0.2 mg/l) for mercury discharge to sewer (0.1 mg/l for > 5000 gpd, and 0.2 mg/l for < 5000 gpd). These limits are readily achievable for dental offices with adequate amalgam separators.

The following figure demonstrates the difference in compliance by 2003 in King County between an area with mandatory requirements and an area with voluntary requirements, despite the fact that the county's outreach program was targeted at the entire county. By 2005 there was a 97% compliance rate in the King County sewer service area – where separators are mandatory.



For these reasons, a growing number of states (9 states thus far) have opted for a mandatory requirement for amalgam separators in dental offices, either through law or regulation.

3 Costs of Controlling Amalgam Releases to Wastewater

The purpose of this section is to calculate the cost of removing Hg from the wastewater effluent of dental clinics. A formula to calculate this cost was developed and is explained below. (It should be noted that in order to account for uncertain developments in the future with regard to inflation, and also to facilitate cost comparisons, "constant dollars" of 2005 have been used in the calculations.)

$$C_t = N (E/10 + I/10 + O)$$

C_t = total cost for all US dental offices
N = number of dental offices requiring an installation
E = average equipment cost per separator (amortized over 10 years)
I = installation costs per separator
O = operating and maintenance costs per year

In order to derive the total cost (C_t) for installing dental amalgam separators nationally, the total number of dental offices (N) was obtained from ADA records. This information included the number of dentists in general practice as well as those operating as dental specialists. These specialists include oral surgeons, orthodontists, and cosmetic dental specialists. It could be assumed that about half of these might require amalgam separators since patients would have dental work done that would affect restorative materials and allow this material to get into the wastewater discharge from that office. We chose to use only the number of GP dental facilities for our baseline and made the worst case scenario all GP and specialist facilities having to install the separators. ADA's records indicate the number of general practice dental facilities in the USA operating at 183,480. The additional registered dental specialist facilities number 44,635, for a total of 228,115 dental facilities in operation throughout the USA.

The average costs for equipment (E), installation cost (I), and operating and maintenance (O) were derived from an industry publication on the efficacy of amalgam separators. This document made comparisons between the costs and efficacies of amalgam separators and the American Dental Association's Best Management Practice (vacuum pump filters) for diverting amalgam materials from being transferred outside the facility in wastewaters.

Three manufacturers' amalgam separators were chosen for the comparison. Equipment cost ranged from a low of $595.00 to as high as $1195.00 and averaged $846.67. This cost was then amortized over 10 years as the expected life of the system, rather than the traditional five years which is the usual IRS timeline for fully depreciating equipment. We assumed that the lifetime of the operation of the unit was a more reasonable timeframe rather than the depreciation of costs since the units were designed to operate over a longer period of time.

Estimated installation costs by the manufacturer for all options were considered to be identical. To plumb a separator into the existing systems was defined as costing $250.00 for labor and miscellaneous materials not included with the separator. This cost was also amortized over a 10-year timeframe to reflect cost over the lifetime of the unit.

Operating and maintenance costs varied with the separators. These costs ranged from $474.00 to $570.00, and averaged $528.00 per year. Included in these costs are the removal and replacement with a new separator or replacement of the filter material under a maintenance contract depending on the manufacturer's recommended O&M guidance.

Final calculation of the total annual cost (C_f) only for GP dental facilities to install, operate and maintain dental amalgam separators was then calculated at $117 million, with the worst case scenario for installation at all dental facilities of about $145 million.

Based on IMERC data showing that at least 30 metric tons of Hg were used in the US in 2004 for amalgam fillings, it is evident that at least 60 million amalgam fillings were placed in 2004, and probably 2005 as well, since this quantity has been relatively stable since 2001.

Therefore, the "best-estimate" cost of adequately controlling the mercury releases from one amalgam filling in the United States through the use of typical separator equipment would run $1.95 per filling in 2005 dollars, or about $2.42 per filling if all specialist dental facilities are included in the calculation as well. Based on a further sensitivity analysis, i.e., varying some of the basic assumptions, this estimate could vary by perhaps plus-or-minus 20%.

Dental facility amalgam separator cost per amalgam filling		

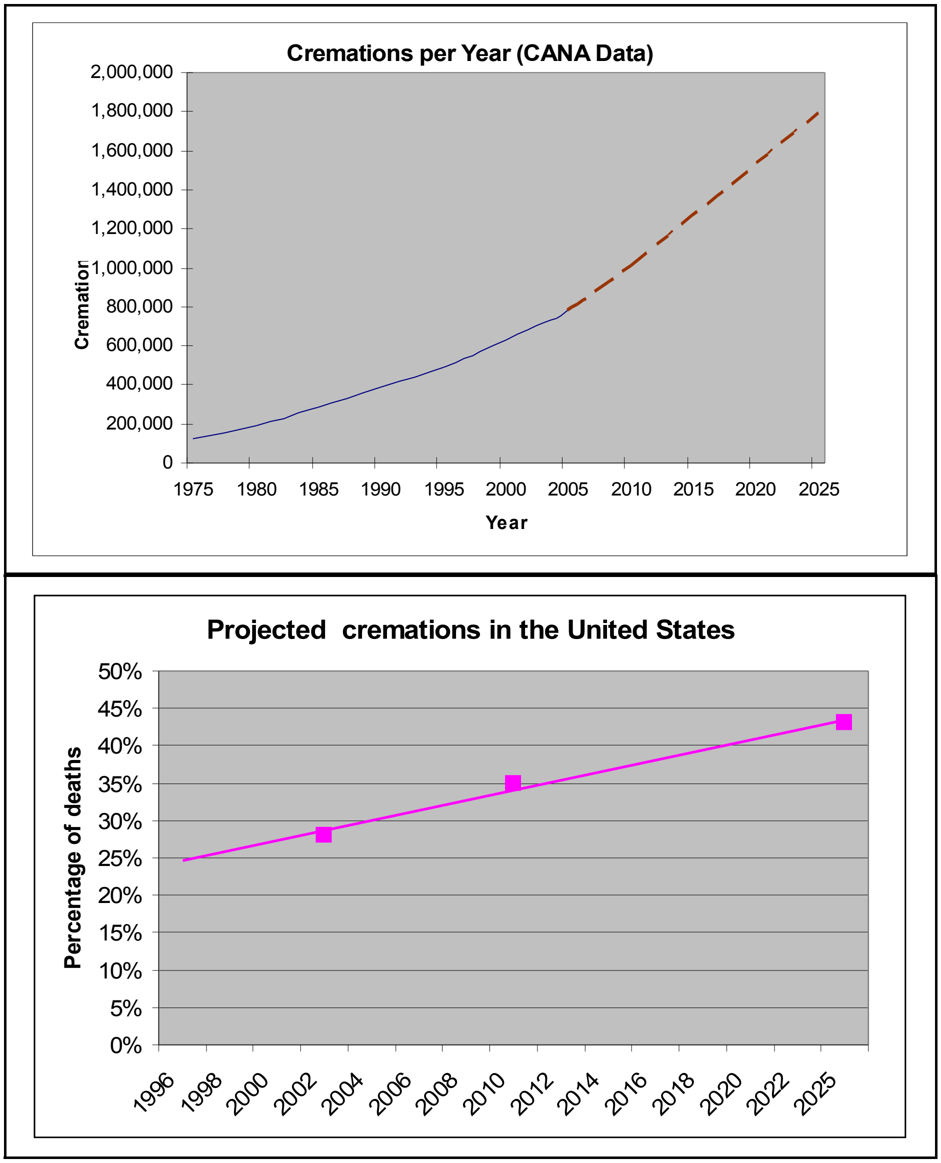
[All costs given in "2005 dollars"]			
	low	high	average
Separator equipment cost	$595	$1,195	$846.67
Equipment installation cost			$250.00
Combined equipment & installation cost			$1,096.67
Lifetime of separator equipment (yrs.)			10
Amortized equipment & installation cost per year			$109.67
Operating, maintenance, recycling cost per year	$474	$570	$528
Total equipment and operating cost per year per facility			$638
General practice (GP) dental facilities			183480
Registered dental specialist (RDS) facilities			44635
Total GP and specialist facilities			228115
Total cost for all GP facilities per year			$116,999,141
Total cost for all GP & RDS facilities per year			$145,461,408
Total mercury used in dental amalgam (metric tons/yr.)			30
Approx. mercury per amalgam filling (gram)			0.5
Number of amalgam fillings placed per year			60000000
Separator cost per filling for all GP facilities			**$1.95**
Separator cost per filling for all GP & RDS facilities			**$2.42**

4 Costs of Controlling Mercury Releases During Cremation

4.1 Cremation trends

Cremation is an increasingly common practice in the US, as the cost of burials rises. Cremation is typically carried out at a high temperature that vaporizes virtually all of the mercury in any dental amalgams, although it has proven quite difficult to balance the amount of mercury present in dental amalgams with measurements of mercury emissions in the crematorium flue gases. Often crematoria are located within cities and close to residential areas, and stacks tend to be relatively low (UNEP 2003). According to the Cremation Association of America, there are about 1,900 crematoria in the US. Nationally, over 30% of Americans are now cremated, a figure that is anticipated to rise to 43% by 2025. Figure 3 provides an indication of US cremation trends and projections to 2025.

Figure 3 – Projected cremations in the USA (1996-2025)



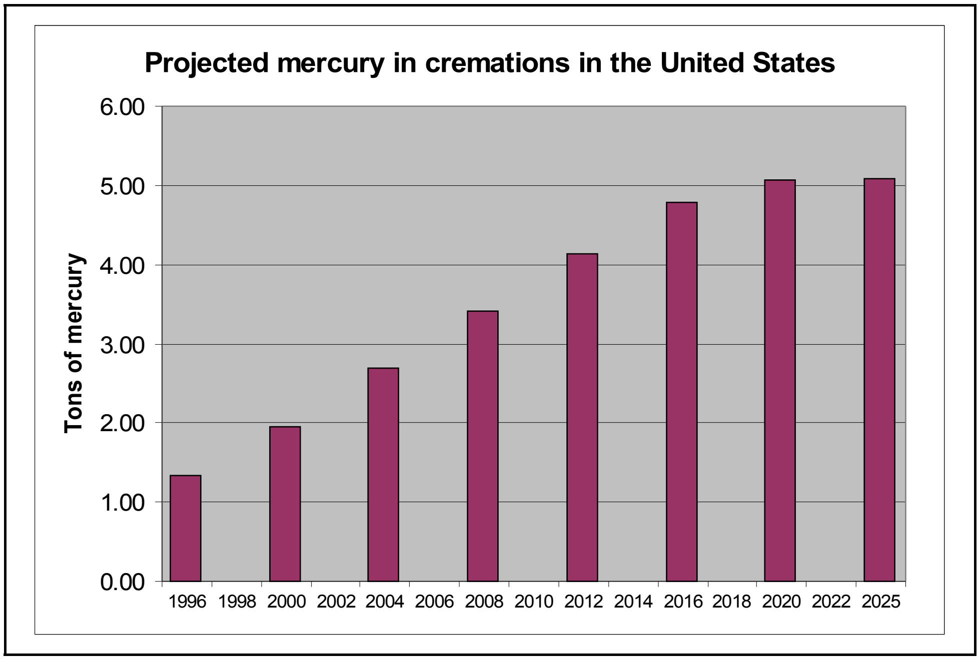
Source: Derived from CSGB 2004; Reindl 2007.

The 1998 Northeastern States Mercury Study estimated that each person cremated had an average of 2.9 grams of mercury in fillings.

Cain et al. (2007) have estimated that about 3.3 tons of mercury were emitted by crematoria in 2005. In the model used, 25% of these emissions were assumed attached to particulates, which would settle to the ground locally and be classified as land deposition, and 75% assumed to be elemental mercury emissions to the atmosphere. Based on a literature review including ground deposition studies in New Zealand and Norway (Reindl 2007), it appears justifiable to allocate up to 90% of the mercury entering crematoria as emissions to the atmosphere, with some of the balance retained, at least temporarily, in combustion equipment and the stack.

In the next 15 years, emissions from crematoria are expected to rise considerably. There are two simultaneous trends contributing to this: a rise in the average number of fillings per person cremated and a rise in the number of cremations. Figure 4 demonstrates how the increasing number of cremations combines with the increased retention of teeth per person cremated to magnify the quantities of mercury potentially released during cremations.

Figure 4 – Rapidly increasing quantities of dental mercury to be dealt with by crematoria



Source: P. Maxson projections based on data in Reindl (2007)

4.2 Cremation mercury control costs

The purpose of this section is to calculate the cost of removing Hg from US crematoria flue gases. A formula to calculate this cost was developed and is explained below. (It should be noted that in order to account for uncertain developments in the future with regard to inflation, and also to facilitate cost comparisons, "constant dollars" of 2005 have been used in the calculations.)

$$C_f = (E + L*M + L*N_c*O)/(L*N_c*N_f)$$

C_f = total cost for a crematorium to treat mercury air emissions from one amalgam filling
E = the total cost for equipment installation and operation
L = lifetime of pollution control equipment
M = the additional annual maintenance cost for monitoring emissions
N_c = number of cremations per year
O = increased environmental service costs per cremation
N_f = number of fillings per cremation

We were unable to find any detailed examples of flue gas control devices installed at crematoria in North America to date. On the other hand, we were able to find a report from the UK by the Department of Environment, Food and Rural Affairs used in a consultation from 2003 and 2004 on *Mercury Emissions from Crematoria*. In that consultation, costs for installation of pollution control devices and their operation were given for the crematoria in operation in the UK.

For the flue gas control equipment installation and operation, the document specifies costs consisting of equipment, building and commissioning costs, the running costs including energy, maintenance and supervision, and the purchase and disposal of sorbent used for the removal of mercury.

For (E) the actual flue gas control equipment purchase and installation, based on real costs at facilities in operation in the UK, DEFRA estimated this cost at about $525,000 (£265,000). The cost of this pollution control equipment is assumed here to be amortized over 15 years (L). This was felt to be a reasonable lifespan for these pollution control systems, although we have also looked at the implications if we were to assume a lifespan of 20 years.

In order to determine the number of cremations carried out by the typical crematorium, we took the most recent Cremation Association of North America's report from 2006. In this report it is identified that in 2005, there were 1971 registered crematoria in the United States. Next, we took the 740,698 cremations in 2005 and divided that by the number of crematoria to get a throughput of the average facility of 376 cremations. Assuming some consolidation of crematoria in the future, especially as the total number of cremations (and the number of crematoria) are expected to increase significantly in the coming years, we roughly estimated 400 cremations per year (N_c) at the typical crematorium during the period 2005-2020.

Estimates for the increase in operation (O) costs due to the presence of the pollution control were based on real cost data and placed at $17.43 (£8.80) per person cremated. These are defined as the cost for environmental services, and include the costs of additional labor, sorbent purchase and disposal, and any increase in costs for operation.

Additional maintenance costs (M) were included by DEFRA to reflect the need for monitoring the emission source for compliance assurance. This was estimated to run about £500-1000 per crematorium per year. For simplification, we used a conservative annual cost of $2000.

As the typical mercury releases during one cremation are estimated at 3 grams, it may be assumed that the average person cremated has about 6 amalgam fillings (N_f).

The final numbers we arrived at were on the order of $660,000 total costs (in 2005 dollars) for one crematorium to deal with 6,000 cremations comprising some 36,000 amalgam fillings over the period 2005-2020.

Based on these figures, the "best-estimate" cost (C_f) of adequately controlling the mercury releases from one amalgam filling at a crematorium in the United States would run $18.32 in 2005 dollars. Based on a further sensitivity analysis, i.e., varying some of the basic assumptions, this estimate could vary by perhaps plus-or-minus 30%.

Crematorium Hg treatment cost per filling	

[All costs given in "2005 dollars"]	
Best estimate assumptions:	
Take a single facility as an example	
Install pollution control equipment in "base year"…	2005
Investment for pollution control equipment	$525,000
Lifetime of pollution control equip. (yrs.)	15
Actual US cremations in base year	740698
Number of US crematoria in base year	1971
Actual US cremations per crematorium per year	376
Assume average yearly cremations 2005-2020	400
Total cremations handled by this equipment 2005-2020	6000
Average Hg per cremation (grams)	3
Average Hg per amalgam filling (grams)	0.5
Average number of amalgam fillings per cremation	6
Total amalgam fillings handled by this equipment	36000
Additional environmental services cost per cremation	$17.43
Total additional environmental services cost	$104,580
Annual emissions monitoring cost	$2,000
Total emissions monitoring cost for this equipment	$30,000
Total costs for this pollution control equipment	$659,580
Total fillings cremated and sequestered	36000
Effective crematorium Hg treatment cost per filling	**$18.32**

It should also be noted that the basic flue gas controls for mercury will also control dioxins/furans, so a co-benefit of the mercury controls would also be achieved.

5 Conclusion: Costs of Composites Similar to Amalgam When Pollution Control Costs Are Factored In

Dentists typically charge more for composite fillings than for amalgams. Dental outlets and insurance companies say these cost differences are largely due to increased time required to place composite fillings, especially in rear teeth. Consolidating dental fees in urban areas across the US, as in the table below, confirms the estimate of dental colleagues that the cost of an average composite filling is 20-25% higher than an average amalgam filling.

Silver Amalgam Fillings, Permanent teeth	
Ave. 1, 2 and 3 surface	$108
Composite Resin Filling - Front & Rear teeth	
Ave. 1, 2 and 3 surface	$139

Reference: Dental fees (2004)

In order to understand the true cost of amalgam use, however, one needs to factor in "external" costs associated with preventing mercury pollution due to amalgam. This pollution comes primarily from wastewater releases during placement and removal of amalgam, and the growing culturally acceptable practice of cremation. Ultimately, society pays for the uncontrolled mercury pollution from dental amalgam through additional pollution control costs, the loss of common resources, and the heath effects associated with mercury contamination.

Even with chair-side traps in place for biologic material control and vacuum pump filters to remove materials suctioned from a patient's mouth, dental offices can release amalgam waste as very fine material that eventually ends up at sewage treatment plants. Here, they add to the other dental mercury that we inhale or ingest that passes through our systems and into sewerage. While our mercury dose comes mostly from food (fish), one must add the mercury continually released from amalgam in our mouths. Specifically because of dental mercury, many publicly owned treatment works are out of compliance with water quality standards for their effluent. Where separators have been required, effluent levels have returned to compliance with Clean Water Act standards.

Controls that remove more than 95% of amalgam from dental office wastewater have been used for years in many practices where dentists have voluntarily installed them as a choice of conscience. Amalgam separator technology is well-refined and has been in use in numerous U.S. Armed Forces dental clinics, including a very large facility operated at the Great Lakes Naval Training Center in North Chicago, IL.

Amalgam reaches the end of its useful life when we do. As demand for cremation as a culturally-acceptable practice grows, and more people retain their teeth throughout their lives, the release of mercury into the air from uncontrolled cremation flue gases increases the amount of mercury that amalgam is responsible for releasing to the environment. As with other combustion processes used to destroy materials – such as medical waste incinerators – cost-effective pollution controls for mercury exist that can be applied to crematoria.

The following table shows that when only two of these external costs are included, the real cost of using amalgam is already quite close to that of mercury-free fillings.

	Amalgam	**Composite**
Filling cost at the dental clinic	$108	$139
"External" costs:		
- separator mercury removal	$2	--
- crematorium mercury removal	$18	--
- municipal solid waste mercury removal, etc.	??	--
"Full cost" of an amalgam filling	**$128+**	**$139**

Drawing obvious conclusions from this simple cost comparison, combined with the clear risks of using amalgam, as finally admitted by the FDA, Congress should follow in the path already blazed by some progressive European countries that have decided to adopt strong measures to either discourage or ban amalgam use.

Measures that Congress should consider include:

- Require dental clinics that replace amalgam to install and properly operate amalgam separators, and to report annually on quantities of mercury collected.
- Assess a modest user fee of $30.00 for the production of each additional mercury tooth filling, payable by the manufacturer at time of sale. Funds collected should be placed into a designated account to cover the costs of controlling mercury pollution.
- Phase-out the use of mercury tooth fillings within the next 3-5 years.

6 References

ADA (2003) – Draft ADA Assessment of Mercury in the Form of Amalgam in Dental Wastewater in the United States, Environ report to the American Dental Association, November 2003.

ADA (2007) – Best Management Practices for Amalgam Waste, available at http://www.ada.org/prof/resources/topics/topics_amalgamwaste.pdf , November 2007, last visited 7/7/2008.

AMSA (2002a) – "Household Mercury Poses National Clean Water Compliance Concerns," Association of Metropolitan Sewerage Agencies, Evaluation of Domestic Sources of Mercury, August 2002.

AMSA (2002b) – AMSA Review of American Dental Association (ADA) Scientific Assessment, "Evaluation of Mercury in Dental Facility Wastewater," October 2002.

Bender (2002) – M Bender, Dentist the Menace? The Uncontrolled Release of Dental Mercury, Mercury Policy Project/Tides Center, Montpelier VT, USA, June 2002.

Bender (2007) – Testimony to Congress November 14, 2007 available at http://www.mercurypolicy.org/new/documents/MPP_Testimony_US_House_Oversight_111407.pdf , November 2007, last visited on 7/7/2008.

Berglund (2005) – P Berglund, "ISO 11143 Standard for Testing Amalgam Separators, Certification of Amalgam Separators, and Mercury Loadings from Dental Clinics to WWTPs," presentation at Dental Office Pollution Prevention Symposium (21 April 2005, San Francisco, California), Metropolitan Council Environmental Services, St. Paul, Minnesota, USA.

Cain et al (2007) – A Cain, S Disch, C Twaroski, J Reindl and CR Case, Substance Flow Analysis of Mercury Intentionally Used in Products in the United States, Journal of Industrial Ecology, Volume 11, Number 3, copyright Massachusetts Institute of Technology and Yale University.

Carpi et al (1997) – A Carpi, SE Lindberg, EM Prestbo and NS Bloom, Methyl Mercury Contamination and Emission to the Atmosphere from Soil Amended with Municipal Sewage Sludge, *J Environ Qual 26:*1650-1655.

Christensen *et al.* (2004) – CL Christensen, S Skårup, J Maag and SH Jensen, Mass Flow Analyses of Mercury 2001. Environmental project no. 917, COWI Consulting Engineers and Planners AS for Danish EPA, 2004. http://www2.mst.dk/common/Udgivramme/Frame.asp?pg=http://www2.mst.dk/Udgiv/publications/2004/87-7614-287-6/html/helepubl_eng.htm.

CSGB (2004) – International Cremation Statistics 2004, The Cremation Society of Great Britain. http://www.srgw.demon.co.uk/CremSoc5/Stats/Interntl/2004/StatsIF.html

Dental fees (2004) – Average fees from 300 urban areas across the US for July 2004, as compiled and presented at www.bracesinfo.com.

Ekroth (1978) – G Ekroth, "Anrikning i fisk av kvicksilver från tandamalgam" (Concentration of Mercury from Tooth Amalgam in Fish), Swedish National Environmental Protection Board (SNV), Research and Testing Dept., 7 July 1978.

Engman (2004) – A Engman, Kvicksilverförorening i avloppsrör i Lunds kommun. (Mercury contamination in wastewater pipes of Lund municipality). MSc thesis. Stockholm University, Stockholm, Sweden. 2004.

EPA (2004) -- International Mercury Market Study, as cited in Mercury Policy Project, "Current Status of US Dental Mercury Reduction Initiatives" (Oct. 12, 2007)

EPA (2006) – Roadmap for Mercury (online at http://www.epa.gov/mercury/roadmap/htm) last visited 7/7/2008

HCWH (2002) – "Stericycle: Living Up To Its Mission? An Environmental Health Assessment of the Nation's Largest Medical Waste Company," Health Care Without Harm, 6 May 2002.

Heintze *et al.* (1983) – U Heintze, S Edwardsson, T Derand and D Birkhed. Methylation of mercury from dental amalgam and mercuric chloride by oral streptococci in vitro. *Scand. J. Dent. Res. 91:*150-152.

Hylander *et al.* (2006a) – LD Hylander, A Lindvall and L Gahnberg, High mercury emissions from dental clinics despite amalgam separators. *Sci. Total Environ. 362*:74-84.

Hylander *et al.* (2006b) – LD Hylander, A Lindvall, R Uhrberg, L Gahnberg and U Lindh. Mercury recovery in situ of four different dental amalgam separators. *Sci. Total Environ. 366*:320– 336.

IMERC (2008) – Trends in Mercury Use in Products, June 2008. Available at http://www.newmoa.org/prevention/mercury/imerc/FactSheets/mercuryinproducts.pdf , last visited on 7/7/2008.

JADA (2003) – "Dental mercury hygiene recommendations," ADA Council on Scientific Affairs, American Dental Association, *Journal of the American Dental Association Vol. 134*, November 2003.

KCDNR (2000) – "Management of Hazardous Dental Wastes in King County, 1991 – 2000," King County Department of Natural Resources, Hazardous Waste Management Program, Water and Land Resources Division, Washington State, USA, 2000.

KemI (2004) – Report 4/04. Mercury — investigation of a general ban. Report by the Swedish Chemicals Inspectorate (KemI) in response to a commission from the Swedish Government, October 2004. http://www.kemi.se/upload/Trycksaker/Pdf/Rapporter/Rapport4_04.pdf

KemI (2005) – Mercury-free Dental Fillings: Phase-out of amalgam in Sweden, prepared by the Swedish Chemicals Inspectorate KemI & Miljö Konsulterna AB, Sundbyberg, Sweden, December 2005.

Kennedy (2003) – CJ Kennedy, Uptake and accumulation of mercury from dental amalgam in the common goldfish, *Carassius auratus*. *Environmental Pollution 121* (2003) 321–326. Elsevier Science Ltd.

Leistevuo *et al.* (2001) – J Leistevuo, T Leistevuo, H Helenius, L Pyy, M Osterblad, P Huovinen and J Tenovuo. Dental amalgam fillings and the amount of organic mercury in human saliva. *Caries Res 2001 May-Jun; 35(3):*163-6.

Leistevuo *et al.* (2002) – J Leistevuo, T Leistevuo, H Helenius, L Pyy, P Huovinen, J Tenovuo. Mercury in saliva and the risk of exceeding limits for sewage in relation to exposure to amalgam fillings. *Arch Environ Health 2002, 57*:366-370.

Lindberg *et al.* (2001) – SE Lindberg, D Wallschlager, EM Prestbo, NS Bloom, J Price and D Reinhart. "Methylated mercury species in municipal waste landfill gas sampled in Florida, USA." *Atmospheric Environment, 35:*23 (4011-4015).

Maxson (2007) – Mercury in dental use: Environmental implications for the European Union, Concorde East/West Sprl for the European Environmental Bureau, Brussels, May 2007.

MPP *et al.* (2006) – What Patients Don't Know: Dentists' sweet tooth for mercury, published by Mercury Policy Project, Consumers for Dental Choice, New England Zero Mercury Campaign, Sierra Club California and Clean Water Action California, USA, February 2006.

MSDS (2007) – Dentsply EU MSDS for all products including amalgam materials Megalloy® and Dispersalloy® available at their website http://www.dentsply.at/docs/index_katalog.asp?id=20389&domid=1042&sp=E&addlastid=&m1=20367&m2=20416&m3=29912&m4=20389

NACWA (2002) – Mercury Source Control and Pollution Prevention Evaluation Executive Summary, March 8, 2002

NEG-ECP (2007) – Report to 31st Conference of New England Governors and Eastern Canadian Premiers, Mercury Task Force Activities and Work Plan, Conference of New England Governors and Eastern Canadian Premiers, June 2007.

NESCAUM (2005) – Inventory of Anthropogenic Mercury Emissions in the Northeast, Northeast States for Coordinated Air Use Management, November 2005.

Reindl (2007) – J Reindl, Summary of References on Mercury Emissions from Crematoria, Dane County Department of Public Works, Madison, Wisconsin, 27 August 2007.

Rubin and Yu (1996) – PG Rubin and M-H Yu, "Mercury Vapor in Amalgam Waste Discharged from Dental Office Vacuum Units", *Archives of Environmental Health Vol51 No.4*, pp335-337*,* July/August 1996.

Savina (2003) – G Savina, "Mercury in Waste Dental Amalgam: Why Is It Still a Problem?" Local Hazardous Waste Management Program in King County, Washington State, USA. December 2003.

Scarmoutzos and Boyd (2004) – LM Scarmoutzos and OE Boyd, Environmental and Toxicological Concerns of Dental Amalgam and Mercury, MVS Solutions, Inc. (LMS) and SolmeteX, Inc. (OEB), Massachusetts, USA.

Scarmoutzos and Boyd (2007) – LM Scarmoutzos and OE Boyd, Environmental Concerns of Dental Mercury, MVS Solutions, Inc. (LMS) and SolmeteX, Inc. (OEB), Massachusetts, USA.

Skare & Engqvist (1994) – I Skare and A Engqvist, Human exposure to mercury and silver released from dental amalgam restorations. *Arch Environ Health 1994;49*(5):384–94.

Stone *et al.* (2005) – ME Stone, ME Cohen, L Liang and P Pang, Determination of methyl mercury in dental-unit wastewater, *Dental Materials 19 (2003)* 675–679, Elsevier Ltd.

UNEP (2003) – Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases, 1st edition, UNEP Chemicals, Geneva, Switzerland, May 2003.

US EPA (1997) – Mercury Study Report to Congress. EPA-452/R-97-003. US Environmental Protection Agency, Washington DC, USA; 1997.

US EPA (2004) – International Mercury Market Study and the Role and Impact of US Environmental Policy.

US EPA (2006) – Roadmap for Mercury, July 2006 – see http://www.epa.gov/mercury/roadmap/htm

Wisconsin Mercury Sourcebook (1999) – Wisconsin Mercury Sourcebook (section "Dentists"), Department of Natural Resources, State of Wisconsin, USA.