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Fluorescent and other Mercury-Containing Lamps and the Environment

Mercury Use

Environmental Benefits

Disposal Requirements

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Lamps & Mercury

Over the past decade, state and federal regulations concerning mercury-containing lamp disposal have become increasingly complex, affecting a wide range of US businesses. Almost all fluorescent lamps and high intensity discharge (HID) lamps contain a small quantity of mercury. Concerns over mercury releases to the air and water are driving stricter disposal regulations.

The National Electrical Manufacturers Association (NEMA) Lamp Section, whose members include all of the major lamp manufacturers in the United States, has produced this brochure to educate our customers, the public, and decision-makers on the role of mercury in lamps and on appropriate approaches to ensure that spent lamps are managed in an environmentally responsible way,

This brochure provides answers to the following questions:

Lamp Technology

- Why do lamps need mercury?
- How much mercury do lamps contain?

Environmental Concerns

- What are the energy and environmental benefits of fluorescent and high intensity discharge (HID) lamps?
- How do generators (users) dispose of spent lamps?
- How much mercury is released to the atmosphere from mercury-containing lamp disposal?

Industry Efforts

- What is the lighting industry doing to reduce mercury use?

Regulatory Efforts

- How are mercury-containing lamps regulated?
- What are the current federal government regulations?
- What are state regulatory options?

NEMA believes a common understanding of these issues will lead to sensible and protective policies for lamp management.

Lamp Technology

Why Do Lamps Need Mercury?

Mercury is an essential ingredient for most energy efficient lamps. Fluorescent lamps and high intensity discharge (HID) lamps are the two most common types of lamps that utilize mercury. Fluorescent lamps provide lighting for most schools, office buildings, and stores. HID lamps, which include mercury-vapor, metal halide, and high-pressure sodium lamps, are used for streetlights, floodlights, and entertainment, sports and industrial lighting. Mercury-containing lamps also are used for medical treatment, semiconductor, integrated circuit board and other industrial production, and water and air purification.

A typical fluorescent lamp is composed of a phosphor coated glass tube with electrodes located at either end. The tube contains mercury, of which only a very small amount is in vapor form. When a voltage is applied, the electrodes energize the mercury vapor, causing it to emit ultraviolet (UV) energy. The phosphor coating absorbs the UV energy, causing the phosphor to fluoresce and emit visible light. Without the mercury vapor to produce UV energy, there would be no light. Manufacturers use mercury in HID lamps for light generation, voltage control and easier starting.

A typical four-foot fluorescent lamp has an average rated life of 18,000 - 20,000 hours. Longer life lamps are rated at 24,000 to 36,000 hours depending on the lamp design, the on-off operating cycle, and the ballast used in the lighting system. To achieve this long life, lamps must contain mercury. The amount of mercury required is very small, typically measured in milligrams, and varies by lamp type, year of manufacture, manufacturing plant and manufacturer. The mercury content is critical to the lamp meeting rated specifications such as energy efficiency and lamp life.

How Much Mercury Do Lamps Contain?

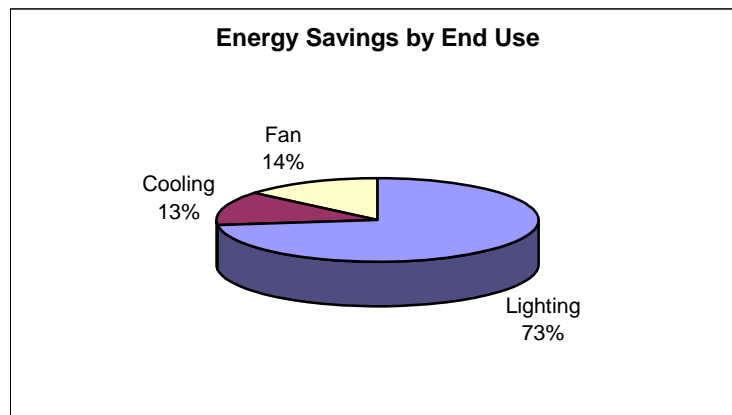
Based on a 2001 NEMA survey, the average four-foot fluorescent lamp contains about 8.3 milligrams (mg) of mercury. This number has been steadily declining as lamp manufacturers work to reduce mercury content to the minimum amount technically feasible without reducing lamp life. Over the past 15 years, the lighting industry has achieved dramatic reductions in mercury use. Today, the average four-foot lamp contains approximately 85% less mercury than the same lamp produced in 1985.

According to the US EPA, total annual global natural and manmade emissions to the environment are 7,000 tons.¹ Manmade sources in the US released 120 tons of mercury in 1999. For comparison, all of the lamps sold in the United States in 2003 by NEMA members *contained* only an estimated 7 tons of mercury (21 tons worldwide); of which only a fraction will be released as an air emission. Proper lamp disposal or recycling will result in keeping most of this mercury out of the environment.

Environmental Issues

What Are the Energy and Environmental Benefits of Mercury-Containing Lamps?

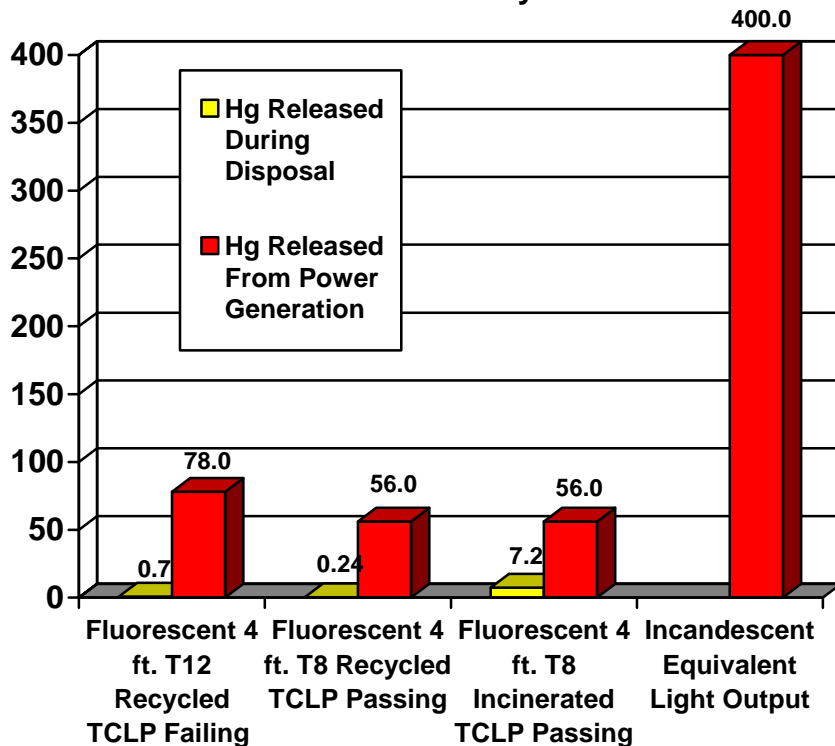
Both fluorescent and HID lamps are typically *three to four times more energy efficient* than incandescent lamps. Through Energy Star Buildings, Rebuild America and Federal Energy Management programs, the US Environmental Protection Agency (EPA) and the US Department of Energy actively promote energy efficient lighting, such as modern fluorescent lamps. In addition, utilities promote energy efficient lamp conversions through rebate incentive programs. The use of energy efficient mercury-containing lamps can play a significant role in the nation's energy consumption. A California study concerning the efficiency of newly constructed commercial buildings concluded that 73% of all energy savings compared to energy use in existing buildings came from the use of newer energy efficient fluorescent lighting systems.



Source: *California Non-Residential New Construction Baseline Report*, July 1999.

The use of energy efficient lighting reduces the amount of coal, oil, and gas burned in power plants, as well as the amount of air pollutants released from power plants. Mercury is a common pollutant emitted from power plants burning coal, oil, or gas. Because of the significant energy savings, using high efficiency fluorescent lamps to replace incandescent lamps or older fluorescent lamps results in a net *reduction* in mercury emissions. EPA estimates that full implementation of energy efficient lighting programs nationwide would result in a reduction of close to 10 tons per year of mercury due to reduced power generation.²

Lifetime Mercury Emissions



Emissions in milligrams of mercury. *Mercury from fluorescent lamp disposal is small compared to the Hg released from power generation required to operate the lamp. Incandescent lamps contain no mercury but result in the highest mercury emissions.*

Source: "Environment & Health Aspects of Lighting," *Journal of the Illuminating Engineering Society*, Summer 1994.

As a result of lighting industry efforts to improve lighting efficiency such as by the development of smaller fluorescent bulb diameters (T8 and T5 lamps) and the development of compact fluorescent lamps, the lighting industry estimates that in 2003, utility air emissions were reduced by 75 billion pounds of carbon dioxide, hundreds of million pounds of nitrogen oxides and sulfur oxides, and millions of pounds of carbon monoxide, volatile organic compounds and particulate matter.³ Other advances such as the development of ceramic metal halide lamps and pulse start metal halide lamps result in additional energy efficiency and further reduction of air pollution.

What is the Lighting Industry Doing to Reduce Mercury Use?

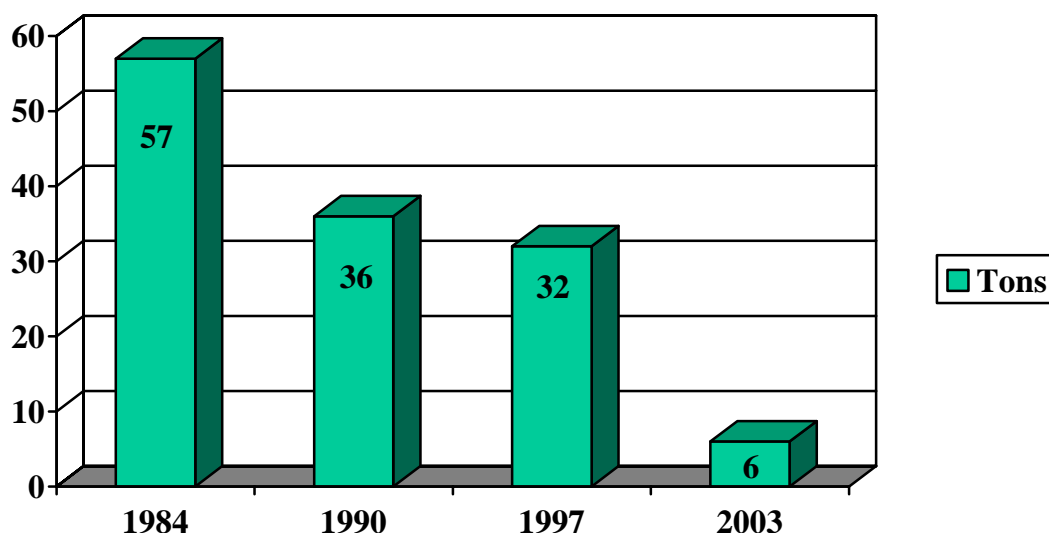
The amount of mercury used by the lamp industry has steadily declined over the past 20 years. According to data from the US Department of the Interior, the US lighting industry has reduced its own mercury purchases from 57 tons in 1984 to 32 tons in 1997. A recent NEMA survey showed even more dramatic reductions in mercury use over the last 7 years. Lighting manufacturers in the US used only 6 tons of mercury to manufacture lamps sold in 2003, nearly a 90% reduction.

NEMA estimates that the 500 million mercury-containing lamps sold in 1990 contained 23.6 tons of mercury. This is lower than the mercury purchase number because lamps do not contain all of the mercury purchased by the lighting industry. Mercury is used in some manufacturing processes. The mercury used in the manufacturing process is captured and returned to mercury distillers for purification and reuse.

Since 1990, NEMA has conducted a number of surveys showing that the total amount of mercury contained in all lamps declined to 17 tons in 1994, 13 tons in 1999, 9 tons in 2001 and 7 tons in 2003. The 7 tons contained in lamps is higher than the 6 tons used by the US lighting industry in 2003 because it includes imported lamps.

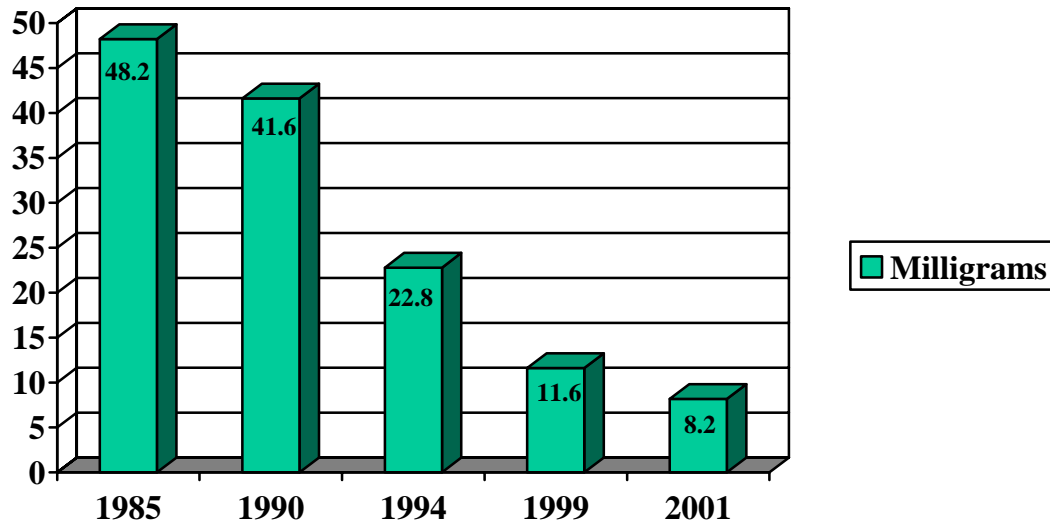
The lighting industry accomplished these dramatic reductions by collectively investing millions of dollars in new lamp manufacturing equipment and new lamp manufacturing processes. In the same time frame, sales by NEMA lamp section members have increased to 650 million mercury-containing lamps while the average mercury-content per lamp has been reduced by over 75%.

Mercury Used in Lighting Industry 1984-2003



The most common type lamp is a four-foot linear fluorescent lamp. NEMA surveys show that the average mercury content of a four-foot lamp declined from 48.2 mg in 1985 to 22.8 mg in 1994 to 11.6 mg in 1999 to 8.3 milligrams in 2001.⁴

Mercury Contained in Four-Foot Fluorescent Lamp – Industry Average



It is unlikely that an energy efficient mercury-free fluorescent lamp will be commercially available in the near future. The lamp industry and the research community have not found a substitute that has mercury's unique energy efficient properties. Research shows that a fluorescent lamp made without mercury would consume approximately 3 times more energy than a mercury-containing lamp to produce the same light output.

Ceramic metal halide lamps, first introduced in the 90's, use about 50% less mercury than quartz metal halide lamps, for the same power and light output.

How Are Fluorescent and HID Lamps Managed After Being Used?

After a fluorescent lamp or other mercury-containing lamp is used it is either:

- Disposed of in a municipal or hazardous waste landfill;
- Recycled to recover most of the mercury and other lamp materials; or
- Placed in a municipal waste combustor.

All of these disposal and management options have different environmental and economic costs. Proper lamp disposal will result in keeping a significant portion of the mercury used in lamps from adding to air emissions.

What Are The Environmental Impacts of Different Management Methods?

Recycling: Recycling has the advantages of 1) keeping mercury out of the solid waste system where a portion of it could be released to the environment and 2) reusing certain raw materials from mercury-containing lamps, including mercury. Studies indicate that mercury releases into the air from well-managed lamp recycling equipment and facilities is extremely small, somewhere between 0.2 and 0.4%. The market value of the reclaimed materials from lamps is negligible, so that lamp recycling is never economically self-sufficient. Waste generators themselves or government programs must pay for the recycling. *However, the cost of recycling is typically less than 1% of the electric savings from the reduced energy use of these lamps compared to non-mercury containing lamp technology.*

Today, lamp-recycling services are available across the US. A list of recyclers is available at www.lamprecycle.org.

Landfills: Landfilling has been the traditional means of disposing of spent lamps. Numerous environmental studies have shown that lamps disposed in landfills do not pose a human health or environmental risk when properly disposed. A 2004 study concludes that modern landfills “can provide for the safe, efficient and long-term management of disposed products containing RCRA heavy metals without exceeding limits that have been established to protect public health and the environment.”⁴ A very small percentage of the lamp mercury will be released when lamps are broken during landfilling activity. The mercury released from individual lamp breakage is insignificant both from a human health and environmental perspective. Collectively, the total amount of mercury released from lamp breakage will add slightly to the overall mercury emissions in the United States. Increased lamp recycling is recommended to even further reduce this small emission source.

Incineration: Historically, most municipal waste combustors did not have special controls to reduce mercury emissions. The incineration of mercury-containing lamps, therefore, released up to 90% of the mercury to the air.³ By the end of the year 2000, most incinerators were equipped with stringent new EPA-mandated mercury controls, dramatically reducing the amount of mercury that incinerators release from any mercury-containing product. EPA estimates that mercury emissions from municipal solid waste combustors have declined from 42 tons of mercury in 1990 to 2 tons in 2001.⁵ NEMA believes that generators should divert spent lamps from incinerators to other management methods to avoid the release of mercury.

Crushing: Crushing lamps prior to transportation reduces the volume of waste by approximately 80%. High quality crushers utilize mercury filters and other technology to limit mercury emissions. All crushers must comply with OSHA air quality standards. Crushing can significantly reduce transportation and storage costs for generators. It also eliminates the chance of lamps releasing mercury to the air when accidentally broken during storage and transportation. EPA continues to evaluate the use of crushing as a disposal option. At the present time, unregulated lamp crushing is not allowed in many states.

Regulation of Spent Lamps

Who is Responsible for the Disposal of Spent Lamps?

The generator (user) of lamps bears the primary responsibility for the correct disposal of spent mercury containing lamps. That responsibility may be shared with, but not passed to, a contractor.

What Are the Current Federal Regulations?

For many years, EPA considered mercury-containing lamps to be ordinary municipal solid waste that generators would dispose of along with everyday garbage. The 1990 Resource Recovery and Conservation Act (RCRA) revised the test used to identify a hazardous waste. The new test was named the "Toxicity Characteristic Leaching Procedure" (TCLP). Under this new test, many spent mercury-containing lamps manufactured in 1990 failed and were classified as hazardous waste. In response to regulatory mandates and commercial pressures, the industry has developed many lamp types that pass the TCLP test and are, therefore, not classified as hazardous wastes. Federal law exempts households and conditionally exempt small quantity generators (< 100 kg/month) from handling spent lamps that do not pass the TCLP test as hazardous waste. While most states apply these exemptions, *a small but growing number of states ban the disposal of all most or all lamps in solid waste.*

When a waste is classified as hazardous, a large quantity generator of the waste is subject to a uniform set of stringent regulations, including burdensome paperwork requirements.

EPA, along with companies that manufacture lamps and others, recognized that the regulation of spent mercury-containing lamps as traditional hazardous wastes was inappropriate. EPA designed hazardous waste regulations to control the management of highly toxic industrial wastes, not the management of widely dispersed, low-risk wastes. These stringent requirements are not fully needed to manage lamps properly. Moreover, the requirements impose new costs on the millions of businesses, schools, and other organizations that use and dispose of mercury-containing lamps.

In 1999, EPA enacted a regulation that allows generators to manage lamps under a new set of modified hazardous waste regulations EPA developed for other commonly generated wastes such as batteries. These modified regulations, known as the “Universal Waste” rule, allow more flexibility in the collection and storage of wastes prior to disposal and in the transportation of lamps to the recycler. However, those treating and reclaiming lamps still need to comply with all hazardous waste rules. Generators still cannot incinerate hazardous waste lamps under universal waste rules.

The “Universal Waste” regulation allows users of mercury-containing lamps to:

- Characterize spent lamps using the TCLP test to determine hazardous waste classification for appropriate disposal,
- Process spent hazardous waste lamps at a lamp recycler, or
- Dispose spent hazardous waste lamps in hazardous waste landfills.

Almost all states have adopted the EPA rule without amendment. **NEMA recommends that generators contact their state authorities to determine the spent lamp management requirements applicable to them. Generators can obtain information about state lamp management requirements at www.lamprecycle.org.**

NEMA ENCOURAGES LAMP RECYCLING

NEMA encourages businesses and consumers to voluntarily recycle their spent mercury-containing lamps.

Minimizing the release of mercury into the environment is desirable, and mercury-containing lamps should be managed responsibly. This means:

- Manufacturers limit their use mercury to levels that are needed for good lamp performance. NEMA lamp manufacturers are committed to continued mercury source reduction where feasible.
- Lamps should be handled in such a way that accidental breakage (and subsequent mercury release) is minimized.
- At the end of life, spent lamps should be disposed of in a way that prevents the release of mercury into the environment. The best way to do this is to dispose of the lamp at a recycling facility that captures mercury.

The fact that lamps contain mercury does not necessarily mean that they are classified as hazardous wastes. This depends on factors such as the state the user is in, the amount of mercury in the lamp, and who is generating the spent lamp.

The benefits of recycling are:

- Recycling, along with mercury source reduction, is the most effective way to limit mercury release into the environment from using mercury-containing lamps
- More generally, recycling makes the best use (and re-use) of our natural resources
- It keeps lamps out of wholly inappropriate waste disposal streams (especially incineration)

- It is consistent with all states' permitted disposal practices

Lamp recycling is not self-supporting since spent lamps have little reclaimable components of intrinsic commercial value. The cost of lamp recycling, however, is a small portion of the energy savings from using these energy efficient lamps. Recycling also has an important societal value as it controls and contains the mercury when it no longer fulfills its important illumination function. NEMA companies support lamp recycling as one part, and an important part, of their environmental responsibility.

NEMA Promotion of Lamp Recycling

NEMA Lamp Section members have undertaken a number of efforts to encourage lamp recycling, particularly among businesses that use 85+% of all mercury-containing lamps. In year 2000, NEMA established a website, www.lamprecycle.org, that provides a one-stop source for lamp recycling information nationwide. The website contains a list of recyclers as well as links to all state websites with information about spent lamp management. Lamp recyclers actively promote the use of this website. NEMA also partnered with the Association of Lighting and Mercury Recyclers (ALMR) and the Solid Waste Association of North America (SWANA) to undertake lamp-recycling promotion for businesses on a nationwide scale funded by an EPA grant. The three groups have established a management committee and have produced a comprehensive educational CD-ROM, available at no charge to the public. .

NEMA and ALMR also developed a lamp recycling training module for the Department of Energy's Rebuild America program. The module is available free from the Department and material from the module will be incorporated into the EPA funded lamp recycling promotion effort.

Individual companies also have their own lamp disposal promotion efforts.

Lamp manufacturers have adopted a nationwide labeling program. A standardized label on lamp packaging informs the user that the product contains mercury, and encourages the user to visit the lamprecycle.org website for lamp recycling information that applies to their jurisdiction. Since the label is also present on any replacement lamp, users are constantly reminded of their disposal obligations with each lamp replacement.

As a result of these and efforts by all levels of government, lamp recyclers and lamp users, lamp recycling has increased from less than 10 million in 1990, to 70 million lamps in 1997, to 156 million lamps in 2003.

Recommended Policies for State Management of Spent Lamps

The changing status of mercury-containing lamps creates a confusing environment for generators of spent lamps. States that have received authority from EPA to run their waste programs may not enforce regulations that are less stringent than those EPA has adopted. However, many states have not strictly enforced the EPA rules. Other states have adopted their own rules for lamps, many of which are inconsistent with the federal regulations. Some states have not added lamps to their universal waste rule. Most but not all states have adopted the Federal rules that exempt lamps that pass the TCLP test or lamps from households or conditionally exempt small quantity generators from hazardous waste disposal requirements.

NEMA believes there are actions states can take to facilitate the safe, efficient, and cost-effective collection and management of spent lamps.

States can:

- Educate generators about requirements in their states and the benefits of recycling and as appropriate enforce state laws.
- Adopt the EPA Universal Waste rule for lamps without amendment.
- Remind households and conditionally exempt small quantity generators, if applicable, that they are exempt from hazardous waste regulations.
- If household hazardous waste facilities exist, they should be open to conditionally exempt small quantity generators;
- Ban the incineration of lamps.
- Oppose additional lamp labeling requirements since there is a national lamp-labeling program.

Conclusion

NEMA and its members continue to promote the use of energy efficient lighting to reduce mercury emissions from power generation. NEMA members continue to reduce the amount of mercury used in lamps. NEMA believes the best way to minimize mercury emissions to the environment is to:

- Increase the use of energy efficient lamps,
- Continue to reduce the amount of mercury used in energy efficient lamps, and
- Increase the recycling of lamps.

REFERENCES

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4. "The Effectiveness of Municipal Solid Waste Landfills in Controlling Releases of Heavy Metals to the Environment," Solid Waste Association of North America Applied Research Foundation (March 2004).
5. "Emissions from Large MWC Units at MACT Compliance," Memorandum from Walt Stevenson, Combustion Group, UAQPS, EPA, June 20, 2002

The lamp section of the National Electrical Manufacturers Association prepared this brochure. The section's members include:

EYE Lighting International
GE Lighting
Light Sources, Inc.
OSRAM SYLVANIA, Inc.
Panasonic North America
Philips Lighting Company
Ushio America
Venture Lighting International
Welch Allyn, Inc.
Westinghouse Lighting International

NEMA is the leading US organization representing and serving America's electro-industries' companies.

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