



CPSA 6 (b)(1) Cleared

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No Mfrs/PrvtLbrs or
Products Identified
Excepted by Petition
Firms Notified,
Comments Processed

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HP 00-3

WASHINGTON, D C 20207-0001

OFFICE OF GENERAL COUNSEL

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March 17, 2000

Public Citizen
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Washington, DC 20009-1001

ATTN: Howard L. Sobel, M.D., M.P.H., M.S.
Research Associate

Sidney M. Wolfe, M.D.
Director

Peter Lurie, M.D., M.P.H.
Deputy Director
Public Citizen's Health Research Group

Gentlemen:

Your letter to Ann Brown dated February 24, 2000 has been forwarded to the Office of General Counsel for a determination of whether it should be docketed as a petition for rulemaking.

Your request for a ban of lead-containing candles and wicks sold for candle-making that contain lead has been docketed as a petition under the Federal Hazardous Substances Act (FHSA). For the reasons explained below, the other requests in your submission have not been docketed as part of the petition. We have also received a joint request for a ban of lead in candle wicks from the National Apartment Association (NAA) and the National Multi-Housing Council (NMHC). Accordingly, your request and theirs have been docketed collectively as Petition No. HF 00-3.

The recalls you requested would not require rulemaking to implement. Therefore, the Commission's procedural rules for petitions, at 16 C.F.R. § 1051, do not apply to that request, and the request for recalls is not being docketed as part of the

Public Citizen
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petition. This request will be considered separately by CPSC's Office of Compliance.

Your request for a ban of candles in metal containers that contain lead has not been docketed as a petition because it does not meet the requirements of the Commission's rules for petitions. Specifically, the submission does not contain information on the risk to consumers from such candles and thus does not contain facts showing that the ban is necessary. 16 C.F.R. § 1051.5(a)(4). Further, it is not clear what products would be covered by this request. If you wish to supplement your submission in these regards, please do so within 30 days

The Office of the Secretary will keep you advised of the status of your petition.

Sincerely,



Stephen Lemberg



HP 00-3

CPSA & (b)(1) Cleared
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No Mis/Prvilbr or
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Comments Processed

Buyers Up • Congress Watch • Critical Mass • Global Trade Watch • Health Research Group • Litigation Group
Joan Claybrook, President

2000 FEB 25 AM 11
CPSC/OFFICE OF
THE SECRETARY
February 24, 2000

Ann Brown, Chairperson
US Consumer Product Safety Commission
Washington, DC 20207-0001

Dear Chairperson Brown:

We are petitioning the Consumer Product Safety Commission to immediately ban and recall all candles with lead-containing wicks, candles in metal containers that contain lead, and wicks sold for candle-making that contain lead as an imminent hazard to the public health on the grounds that continued sale of these items violates provisions of the Federal Hazardous Substances Act and the Consumer Product Safety Act. Additionally, we urge the Consumer Product Safety Commission to warn consumers of the potential dangers from exposure to ambient air metals emitted from candles containing metallic cores such as zinc or tin but do not contain lead.

In 1973, Public Citizen's Health Research Group petitioned the Consumer Product Safety Commission to remove candles with lead-containing wicks from the market.¹ However, in 1974, in lieu of a complete ban, the candle industry and CPSC arrived at a voluntary agreement to immediately stop making candles with lead-containing wicks. To determine whether this voluntary agreement has been effective, especially because of reports that these candles were once again being sold, we conducted a survey this month of 285 types of candles in 12 stores in the Baltimore-Washington D.C. area. We found that 3% (9/285) of all types of candles on store shelves had wicks containing significant quantities of lead, ranging from approximately 24,000 ug to 118,000 ug (33-85 percent lead by weight). Each of these 9 candles, when burned for 3 hours daily in a 15 ft. by 15 ft. by 8 ft. room, would result in average 24-hour air lead levels ranging from 14-49 ug/m³, 9-33 times the EPA Air Quality Standard for lead. Other studies done in the past two years found that candles purchased in Michigan and Florida also had lead-containing wicks. History has shown that the 1974 voluntary agreement has failed. Furthermore,

¹Public Citizen's Health Research Group, Letter to Richard D Simpson, Chairman, Consumer Product Safety Commission, December 6, 1973

Ralph Nader, Founder

labeling of lead-containing candles will not suffice to protect the people most susceptible to lead toxicity. fetuses, infants and young children Even if all U.S. candle manufacturers, who currently sell \$2.3 billion dollars worth of candles annually,² stopped using lead now, millions of candles with lead-containing wicks would remain on the shelves and imports would probably continue or might even increase. These reasons necessitate a complete ban and recall of these hazardous products.

At least one country has recently tackled this problem definitively. In September 1999, Australian Minister of Financial Services and Regulation Joe Hockey ordered the ban of all candles with wicks containing lead. He recognized that "Public health experts have confirmed that lead emissions from any source pose an unacceptable public health risk and can result in increased blood lead levels in unborn babies, babies and young children...Public health experts have confirmed that the candles pose a risk to public health if burned in a confined space."³

In this petition, Public Citizen's Health Research Group documents the following:

1. ***Candles with wicks containing lead are currently on store shelves and millions are sold annually.***
2. ***Burning candles with wicks containing lead causes high lead exposure both through air and surface contact.***
3. ***The air and surface lead levels produced by candles with lead-containing wicks are sufficient to significantly raise blood lead levels.***
4. ***The increased blood lead levels from burning these candles can cause permanent deficits in development, behavior, and intelligence.***
5. ***Alternatives to lead-containing wicks exist.***
6. ***Labeling will not adequately protect candle-users.***
7. ***The Consumer Product Safety Act and the Hazardous Substances Act require the Consumer Product Safety Commission to ban and recall these products.***

BACKGROUND ON LEAD

Effects of lead exposure: Lead has been known to adversely affect health since antiquity. Hippocrates (370 BC) noted lead to have caused a severe attack of colic.⁴ The ruling class of Romans was heavily exposed to lead through wares and lead in syrups used to sweeten wine. Consequently, gradual lead poisoning may explain the eccentric behavior and insanity of many

²Candle industry facts The National Candle Association home page. Internet web site (<http://www.candles.org/facts.htm>). National Candle Association, 1030 15th Street, Suite 870, Washington, DC 20005

³The Honorable Joe Hockey, The Minister for Financial Services & Regulation, Australia. Hockey Bans Lead Candle Wicks. Press release, 9/1/99 Available at <http://www.minfsr.treasury.gov.au/>

⁴Hunter D The Diseases of Occupations The English Universities Press LTD, 4th ed. p. 235, 1969.

of the Roman emperors that ultimately led to the fall of the Roman Empire.⁵ Similar exposures may explain eccentric behaviors of the British ruling class in the 18th century.⁶ More recently, chronic lead exposure has been implicated in high blood pressure, digestive problems, nerve disorders, memory and concentration problems, muscle and joint pain,⁷ encephalopathy (pathologic changes of the brain) and death.⁸ Furthermore, decreased intelligence,⁹ minor antisocial behavior,¹⁰ increased high school dropout rates,¹¹ and impaired development,¹²

⁵ Emsley, J. When the Empire struck lead. The gradual poisoning of the ruling classes in ancient Rome with lead may have caused the downfall of their empire. Did the British Empire suffer the same fate? *New Scientist*, 25 December 1986- 1 January 1987, pp. 64-67.

⁶ Ibid.

⁷ Consumer Product Safety Commission, Protect your family from lead in your home. CPSC Document #426. EPA747-K-94-001, May 1995.

⁸ Klaassen CD Heavy metals and heavy-metal antagonists, in Goodman and Gilman's: The pharmacological basis of therapeutics. 9th ed. Chapter 66, p.1650-1652, Mc Graw-Hill, New York. 1996.

⁹ Baghurst PA, McMichael AJ, Wigg NR, et al. Environmental exposure to lead and children's intelligence at the age of seven years. The Port Pirie Cohort Study. *The New England Journal of Medicine* 327: 1279-1284, 1992.

Dietrich KN, Berger OG, Succop PA, et al. The developmental consequences of low to moderate prenatal and postnatal lead exposure: Intellectual attainment in the Cincinnati lead study cohort following school entry. *Neurotoxicology and Teratology* 15:37-44, 1993.

Fulton M, Raab G, Thomson G, et al. Influence of blood lead on the ability and attainment of children in Edinburgh. *Lancet* 1:1221-1226, 1987

Needleman HL, Gatsonis CA. Low-level lead exposure and the IQ of children. A meta-analysis of modern studies. *Journal of the American Medical Association* 263: 673-678, 1990.

Needleman HL, Gunnoe C, Leviton A, et al. Deficits in psychologic and classroom performance of children with elevated dentine lead levels. *The New England Journal of Medicine* 300:689-695, 1979

Needleman HL, Geiger SK, Frank R. Lead and IQ Scores: A reanalysis. *Science* 227, 701-704, 1985.

Schwartz J. Low-level lead exposure and children's IQ. A meta-analysis and search for a threshold. *Environmental Research* 65:42-55, 1994.

Tong S, Baghurst PA, Sawyer MG, et al. Declining blood lead levels and changes in cognitive function during childhood. The Port Pirie Cohort Study. *Journal of the American Medical Association* 280: 1915-1919, 1998

Tong S, Baghurst P, McMichael A, et al. Lifetime exposure to environmental lead and children's intelligence at 11-13 years. The Port Pirie Cohort Study. *British Medical Journal* 312 1569-1575, 1996.

¹⁰ Needleman HL, Schell A, Bellinger D, et al. The long-term effects of exposure to low doses of lead in childhood: An 11-year follow-up report. *The New England Journal of Medicine* 322: 83-88, 1990.

¹¹ Ibid.

coordination,¹³ learning¹⁴ and reading¹⁵ occur at lead levels previously considered acceptable.

Routes of exposure to lead: In general, environmental lead is either inhaled or ingested. Lead in candles can enter the blood by both routes. The route of entry plays a major role in determining the amount of lead that enters the bloodstream.

The candlewick lead content and the percent lead vaporized determine the total lead emitted. In the past, industry argued that lead in wicks does not vaporize. In 1974, Corning claimed that "at candle temperature, lead vaporizes at the same rate as ice does at 13 degrees below zero."¹⁶ However, two studies, one by EPA in 1973 and another recent study, have shown that 20-35% of the lead in pure lead candle wicks is vaporized.^{17,18} The total lead emitted and the size and ventilation of the room determine the ambient air lead concentration. The respiratory rates and volume, time of exposure and ambient air lead concentration determine the amount of lead that reaches the lung lining (the epithelium) and about 90% of that is absorbed into the blood.¹⁹

¹² Baghurst PA, Robertson EF, McMichael AJ, et al. The Port Pirie Cohort Study: Lead effects on pregnancy outcome and early childhood development. *Neurotoxicology* 8: 395-402, 1987.

Mendelsohn AL, Dreyer BP, Fierman AH, et al. Low-level lead exposure and cognitive development in early childhood. *Journal of Developmental and Behavioral Pediatrics*. 20: 425-431, 1999

McMichael AJ, Baghurst PA, Wigg NR, et al. The Port Pirie Cohort Study: Environmental exposure to lead and children's abilities at the age of four years. *The New England Journal of Medicine* 319: 468-475, 1988.

Wigg NR, Vimpani GV, McMichael AJ, et al. Port Pirie Cohort Study: Childhood blood lead and neuropsychological development at age two years. *Journal of Epidemiology and Community Health* 42: 213-219, 1988

¹³ Dietrich KN, Berger OG, Succop PA. Lead exposure and the motor developmental status of urban six-year-old children in the Cincinnati Prospective Study. *Pediatrics* 91: 301-307, 1993.

¹⁴ Needleman HL, Schell A, Bellinger D, et al. The long-term effects of exposure to low doses of lead in childhood: An 11-year follow-up report. *The New England Journal of Medicine* 322: 83-88, 1990.

¹⁵ Needleman HL, Schell A, Bellinger D, et al. The long-term effects of exposure to low doses of lead in childhood: An 11-year follow-up report. *The New England Journal of Medicine* 322: 83-88, 1990.

¹⁶ Press Release by Corning, January 8, 1974

¹⁷ Bridbord K, Medical Officer. Memo to Stanley Greenfield, Assistant Administrator for Research and Development, and Vaun A. Newill, Special Assistant to the Administrator: Hazards of burning candles with lead. US EPA, Research Triangle Park, December 14, 1973

¹⁸ Van Alphen M. Emission testing and inhalational exposure-based risk assessment for candles having Pb [lead] metal wick cores. *Science of the Total Environment*. 243-244: 53-65, 1999.

¹⁹ Goyer RA, Toxic effects of metals. In Casarett and Doull's, *Toxicology, The Basic Science of Poisons*. 4th ed. Pergamon Press, 1991

Particulate airborne lead from burning candles settles as house dust. Children inhale and ingest dust stirred during crawl and play. They track it on their hands or clothes, pick up dust-laden objects and put them in their mouths. As lead tastes sweet, they may lick the dust from their hands. Furthermore, most vacuum cleaners stir up huge dust loads.²⁰ Finally, ventilation duct turbulence causes fine particulate matter typical of candle emissions, to become charged and attracted to plastic surfaces. Krause notes that this matter particularly covers kitchen surfaces, such as plastic utensils, ice cube trays and refrigerator/freezer surfaces.²¹

Additional lead exposure can occur from dust settling in food after being warmed by lead-containing warming candles and, less likely, from children ingesting the wick.

Current Regulations: There are four relevant government standards referred to in this petition:

1. **Blood lead levels:** The Centers for Disease Control and Prevention (CDC) currently recommend keeping children's blood lead levels below 10 ug/dl (100 ml). The CDC has stated that no threshold is known below which lead is safe and that harmful effects may occur at levels below 10 ug/dl, but that the body of information accumulated thus far is insufficient to prove this.²²
2. **Average total daily dose of lead:** The Consumer Product Safety Commission (CPSC) recommends limiting chronic lead ingestion in children less than 6 years old to less than 15 ug/day to prevent blood lead levels from exceeding 10 ug/dl.²³
3. **Ambient air lead level:** The Environmental Protection Agency (EPA) ambient air guideline for lead is 1.5 ug/m³.²⁴ This level corresponds to an average total daily dose of inhaled lead of 30 ug for an average child less than 6 years old,²⁵ double what the CPSC reports as a safe level.
4. **Surface lead levels:** The U.S. Housing and Urban Development (HUD) standard for surface lead dust levels of carpeted or bare floors, window sills and window wells are 100 ug/ft² (1075 ug/m²), 500 ug/ft² (5400 ug/m²) and 800 ug/ft² (8610 ug/m²).²⁶ As several studies have

²⁰ Liroy PH, Wainman T, Zhang J, et al. Typical household vacuum cleaners: the collection efficiency and emissions characteristics for fine particles. *Journal of the Air and Waste Manage Association*. 49:200-206, 1999.

²¹ Krause D., personal communication, 10 Feb 99. Mr Krause has written a Master's thesis on candle emissions.

²² U S Department of Health and Human Services, Public Health Service, Centers for Disease Control. Preventing lead poisoning in young children. pp. 7-8, October 1, 1991.

²³ Consumer Product Safety Commission. CPSC Staff report on lead and cadmium in children's polyvinylchloride (PVC) products. Page 5. 21 November 1997.

²⁴ Code of Federal Regulations. Title 40--Protection of Environment, Chapter I--Environmental Protection Agency, Part 50, Sec 50.12 National primary and secondary ambient air quality standards for lead.

²⁵ Krause JD. Characterization of scented candle emissions and associated public health risks. Thesis. Department of Environmental and Occupational Health. University of South Florida August 1999.

²⁶ <http://www.hud.gov/80/lea/leach1.pdf> Chapter 1 Introduction Legislative Basis and Relationship to Federal Programs and Regulations. In *The Guidelines for the Evaluation and Control of Lead-Based Paint Hazards in*

correlated high blood lead levels with these levels, the EPA is proposing lowering them to 50 ug/ft² (540 ug/m²) and 250 ug/ft² (2700 ug/m²) for bare floors and windowsills, respectively.²⁷ Even the latter may not be sufficiently low. One study found that 20% of children living with a lead dust level of 430 ug/m² had blood lead levels above 10 ug/dl and that lower lead dust levels predicted lower blood lead levels.²⁸ Another study found that decreasing the lead dust level from 240 ug/m² (less than half the EPA recommendation) to 160 ug/m² reduced average blood lead levels from 12.4 to 10.3 ug/dl,²⁹ still above the CDC levels.

1. Candles with wicks containing lead are currently on store shelves and millions are sold annually.

In February 2000, Public Citizen's Health Research Group conducted a study of the lead content of candles in the Baltimore-Washington area. We selected 11 chain stores and one dollar store to represent the places where candles are most commonly purchased. These were: CVS Pharmacy, The Dollar Shop, Hallmark, Walmart, Kohl's, Bath and Body Works, The Body Shop, Hecht's, Target, BJ's Wholesale, Jo-Anne Fabrics, and Bed, Bath and Beyond. We excluded candle stores because we believe that candles are more commonly purchased from non-specialty stores. (In fact, candle stores may be more likely to sell candles containing lead-wicks because of the properties lead confers on candles.) In each store, we selected one candle of each brand and type. Examples of candle types are pillars, containers, votives, tea lights, and novelty candles. Different colors, sizes and shapes of the same candle were considered a single type of candle. For each candle, we recorded the store name and location, manufacturer, candle type, and the presence or absence of a metallic wick. We then purchased one candle of each type containing a visible metallic wick. Each metallic wick was extracted from the wax, measured for length and mass, and tested for lead using Inductively Coupled Plasma Spectroscopy (ICP) by a laboratory accredited by the American Industrial Hygiene Association Environmental Lead Laboratory Accreditation Program.³⁰ The technique involves dissolving the samples in a known amount of nitric acid, performing spectroscopy on the solution, and comparing the intensity of the lead lines with samples of known quantities of lead.³¹

Thirty percent (86 of 285) of types of candles contained metallic wicks. We found that 10%

Housing, 1995.

²⁷ US Environmental Protection Agency. EPA Fact Sheet. Proposed rule on identification of lead-based paint hazards #747-F-98-001, June 1998

²⁸ Lanphear BP, Weitzman M, Winter NL et al Lead-contaminated house dust and urban children's blood lead levels. American Journal of Public Health 86 1416-21, 1996.

²⁹ Rhoads GG, Ettinger AS, Weisel CP, et al The effect of dust lead control on blood lead in toddlers: a randomized trial Pediatrics 103. 551-555, 1999

³⁰ Specimens were analyzed at RJ LeeGroup, Inc, Monroeville, PA.

³¹ Elements by ICP, Method 7300, Issue 2. In NIOSH Manual of Analytical Methods (NMAM), 4th ed., August 14, 1994.

(9/86) of candles with metallic wicks contained lead for an overall prevalence of candles containing lead of 3% (9/285). Table 1 shows that the total lead content of the nine candles containing lead wicks ranged from approximately 24,000 ug to 118,000 ug, (accounting for 33% to 85% of the weight of the metal in the candlewick). Assuming that only 20% of the lead in the candlewick is emitted into the air, this corresponded to 4700 ug to 24,000 ug of airborne lead from a single wick. As the percentage of lead from a candlewick emitted into the air ranges from 20-35%,³² the actual amount emitted may be considerably higher. A typical room of 15 ft. x 15 ft. x 8 ft. has a total volume of 51 m³. If these candles burned at a rate of 2 cm/hour for three hours daily (and were extinguished after 3 hours) in such a room with 25% per hour ventilation rates, they would yield ambient air lead concentrations ranging from 14 to 49 ug/m³, which is 9-33 times the EPA Ambient Air Quality Standard. If we assume instead that we burned the candle emitting the least lead under the same conditions, except that the burn rate is only 0.5 cm/hour (1/4 the original assumption), and that the room has a ventilation rate of 50% (twice the original assumption), we still get ambient air levels of 1.2 ug/m³, approximating the EPA Ambient Air Lead Standard.

Furthermore, lead exposure may occur due to dust and dust may accumulate even with vacuuming. Using van Alphen's assumption that between 5-10% of dust deposits on the floor,³³ and the results of Roberts et al. who found that only 10% of lead dust was trapped by vacuuming,³⁴ even with weekly vacuuming, dust lead levels may reach 540 ug/m², the proposed limit set by the EPA.³⁵

We found that 2 lead-containing candles were pillars, 6 were containers, and 1 was a votive. None of the tapers, novelty or tea lights tested contained lead.

We are aware of one previous case study and two previous lead wick prevalence studies. In 1999 in Australia, van Alphen reported that 7 candles imported from China had almost pure lead-core wicks (95-99% lead).³⁶ That same year Nriagu and Kim purchased 14 candles with wicks

³²Bridbord K, Medical Officer Memo to Stanley Greenfield, Assistant Administrator for Research and Development, and Vaun A. Newill, Special Assistant to the Administrator: Hazards of burning candles with lead. US EPA, Research Triangle Park, December 14, 1973

Van Alphen M. Emission testing and inhalational exposure-based risk assessment for candles having Pb [lead] metal wick cores. *Science of the Total Environment*. 243-244: 53-65, 1999.

³³ van Alphen M. Emission testing and inhalational exposure-based risk assessment for candles having Pb metal wick cores. *Science of the Total Environment* 243-244: 53-65, 1999

³⁴ Roberts JW, Glass GL, and Spittler TM. Measurement of deep dust and lead in old carpets. In: *Measurement of toxic and related pollutants*, Air and Waste Management Assoc., Pittsburgh, pp.186-191, 1995

³⁵ US Environmental Protection Agency. EPA Fact Sheet. Proposed rule on identification of lead-based paint hazards #747-F-98-001, June 1998.

³⁶ van Alphen M. Emission testing and inhalational exposure-based risk assessment for candles having Pb metal wick cores. *Science of the Total Environment* 243-244: 53-65, 1999

containing metallic cores in stores in Ann Arbor, Michigan. They reported that all 14 candles with metallic wicks emitted lead during burning.³⁷ In August 1999, Krause purchased candles with metallic wicks from every store selling candles in a mall in Tampa, Florida. He noted that each store was part of a different nationwide chain. He found that the 24% (5 of 21) of metallic candlewicks that contained lead did so at levels of 1.25, 9.5, 14, 42, and 46 weight % lead.³⁸ In an earlier study, he purchased 91 candles over a two-year period in both Florida and California. None of the 21 candles with metallic wicks and one with a metallic containers from California emitted lead. However, 4 of 6 candles with metallic wicks purchased in Florida emitted lead. Combining these results with previous work, he found that approximately 9 of 27 candles with metallic wicks contained lead. All candles with wicks containing lead were purchased in Florida.³⁹

Atkins and Pierce, the major U.S. manufacturer of all types of wicks, admitted that because some candle makers kept using such wicks "since there wasn't an actual ban", they resumed the practice of making and selling wicks containing lead "in the late 70s or early 80s."⁴⁰ The company claims to have stopped the practice last year,⁴¹ however, our study and others demonstrate that candles with lead-containing wicks are prevalent in many states.⁴² Moreover, lead-containing wicks for candle making are currently sold directly over the Internet.⁴³

³⁷Nriagu JO, Kim MJ, Emissions of Lead and Zinc from Candles with Metal-Core Wicks. *Science of the Total Environment*, in press, 2000

³⁸ Krause D. Personal communication, 26 January 2000

³⁹Krause JD. Characterization of scented candle emissions and associated public health risks. Thesis. Department of Environmental and Occupational Health. University of South Florida. August 1999.

Krause D Personal communication, 26 January 2000

⁴⁰Notes from the Meeting with CPSC and National Candle Association on 12/15/99.

⁴¹Ibid

⁴² Krause JD Characterization of scented candle emissions and associated public health risks. Thesis. Department of Environmental and Occupational Health. University of South Florida. August 1999.

Krause D Personal communication, 26 January 2000

Nriagu JO, Kim MJ, Emissions of Lead and Zinc from Candles with Metal-Core Wicks. *Science of the Total Environment*, in press, 2000

van-Alphen M, Emission testing and inhalational exposure-based risk assessment for candles having Pb metal wick cores, *Science of the Total Environment* 243-244 53-65, 1999

⁴³ CANDLECHEM COMPANY, Inc <http://www.alcasoft.com/candlechem/>

Candle sales exceeded \$2.3 billion last year.⁴⁴ We estimate that over 300 million candles were sold in the U S in 1999 based on our finding that the average candle costs \$7.35. If 3% of the candles sold contain lead, approximately 12 million candles sold in the United States each year contain lead, assuming our sample is representative of all candles sold.

2. Burning candles with wicks containing lead causes high lead exposure both through air and surface contact.

A. Ambient Air Exposure: The work of four groups of researchers discussed in this section pertains to the high ambient lead levels that result from burning lead-wick containing candles. The last study pertains to the resulting high surface lead concentration.

In 1973, immediately following our petition to ban lead wicked candles,⁴⁵ EPA researchers determined that burning candles with lead-containing wicks exceeded the current EPA air quality standard by over 10 times. In this experiment, they burned 4 candles with lead-core wicks on a dining room table in a 10 square foot dining room and monitored air lead for 13 hours. Over this period, the air lead concentrations averaged 16 $\mu\text{g}/\text{m}^3$ —over 10 times the current EPA air lead guideline. Their experimental apparatus was unable to detect lead in particles below 0.1 μm and therefore the average lead concentrations may have been higher. The EPA researchers concluded, “Based upon these observations it would not be unreasonable to expect average indoor air lead levels in the range of 10-20 $\mu\text{g}/\text{m}^3$ [6-12 times above EPA’s air quality standard] as a result of regularly burning candles with lead wire core wicks in the home. Further...the remaining lead residue from these candles could also be a hazard by inadvertent contamination of food or by being available for children to ingest.”⁴⁶

From October 1997 until August 1999, Krause purchased 85 candles of which 21 had metallic wicks and 1 had a container in California and 6 from Florida for a total of 27 candles with metallic wicks and one with a metallic container. He burned the candles in a chamber and characterized their emissions. For those candles containing metallic wicks, he estimated exposure using his own model and using an EPA exposure model (US EPA RISK V1.0 Indoor Air Quality Exposure Model), which produced similar results. Finally, he calculated lead exposure for children. None of the 21 candles with metallic wicks and the one metallic container candle from California emitted lead. However, 4 of 6 candles

⁴⁴Candle industry facts The National Candle Association home page. Internet web site (<http://www.candles.org/facts.htm>) National Candle Association, 1030 15th Street, Suite 870, Washington, DC 20005

⁴⁵Public Citizen’s Health Research Group, Letter to Richard D Simpson, Chairman, Consumer Product Safety Commission, December 6, 1973.

⁴⁶Bridbord K, Medical Officer Memo to Stanley Greenfield, Assistant Administrator for Research and Development, and Vaun A. Newill, Special Assistant to the Administrator Hazards of burning candles with lead. US EPA, Research Triangle Park, December 14, 1973

with metallic wicks purchased in Florida emitted lead. When burning one candle for 4 hours daily, he estimated that two of these candles would result in children under 6 inhaling an average daily dose of lead of 40 and 95 ug, respectively.⁴⁷ Both exceeded the maximum acceptable level recommended by the CPSC (15 ug) by several times.⁴⁸ A third candle resulted in an average daily dose of 13 ug.⁴⁹

In 1999 in Michigan, Nriagu and Kim burned 15 types of candles (14 purchased in Michigan) with metallic wicks over 2 to 7 hours and measured the lead emitted into an experimental chamber. Lead emitted after burning one candle in a typical room for 2 hours extrapolated to air lead concentrations of 0.02 to 13.1 ug/m³ with five candles exceeding the U.S. EPA ambient air lead guideline of 1.5 ug/m³.⁵⁰ However, 24-hour average air lead concentrations were not calculated.

In 1999, Van Alphen burned seven candles with high lead content in an experimental chamber to determine the amount of lead emitted. From this, he estimated average 24-hour air lead levels. He reported that burning one candle with high lead content for 3 hours could achieve a 24-hour average lead concentration of 10 ug/m³,⁵¹ almost seven times the EPA ambient air guideline of 1.5 ug/m³.

Therefore, three studies have shown that episodic burning of candles with a lead-core wick can expose people to average ambient lead concentrations above the limit set by EPA and one study showed that inhaled lead exceeded the limits set by the CPSC for children.⁵²

⁴⁷Krause JD Characterization of scented candle emissions and associated public health risks. Thesis. Department of Environmental and Occupational Health University of South Florida. August 1999.

Personal communication with David Krause, 26 January 2000.

⁴⁸ Consumer Product Safety Commission. CPSC Staff report on lead and cadmium in children's polyvinylchloride (PVC) products. Page 2. 21 November 1997

⁴⁹Krause JD Characterization of scented candle emissions and associated public health risks. Thesis. Department of Environmental and Occupational Health University of South Florida August 1999.

⁵⁰Nriagu JO, Kim MJ, Emissions of Lead and Zinc from Candles with Metal-Core Wicks. Science of the Total Environment, in press, 2000.

⁵¹Van Alphen M Emission testing and inhalational exposure-based risk assessment for candles having Pb [lead] metal wick cores Science of the Total Environment. 243-244: 53-65, 1999

⁵²Bridbord K, Medical Officer Memo to Stanley Greenfield, Assistant Administrator for Research and Development, and Vaun A. Newill, Special Assistant to the Administrator: Hazards of burning candles with lead. US EPA, Research Triangle Park, December 14, 1973

Krause JD Characterization of scented candle emissions and associated public health risks. Thesis. Department of Environmental and Occupational Health. University of South Florida. August 1999

Van Alphen M. Emission testing and inhalational exposure-based risk assessment for candles having Pb [lead] metal

Thirty-five percent of candles in the Michigan study exceeded the EPA standards; however, Nriagu and Kim did not calculate 24-hour average air lead concentrations.⁵³

B. Surface Lead Exposure: Particulate vaporized lead eventually settles in the form of house dust and soot. Unlike ambient air lead, which requires a daily or weekly source to keep levels high, surface lead may accumulate from infrequently burning candles even with regular vacuuming, leading to ongoing exposure.⁵⁴ Van Alphen reports that "A single 38 cm long candle [with high lead content] can emit 104,000 ug Pb [lead] into the air. The deposition of as little as 5 to 10 % of that onto the floor of a 5x5 m room would result in a floor Pb loading of approximately 150 to 300 ug/m². Such a floor loading would readily be associated with elevations in child blood lead."⁵⁵ Burning only two to four of these candles will result in surface lead concentrations exceeding even the EPA proposed limits of 540 ug/m² for floor surface lead concentration.⁵⁶ Recall that these limits are not sufficient to protect children from high blood lead levels.⁵⁷

3. The air and surface lead levels produced by candles with lead-containing wicks are sufficient to significantly raise blood lead levels.

A. Ambient Air lead: Exposing adult males 23 hours per day over 18 weeks to air lead levels of either 3.2 ug/m³ or 10 ug/m³ increased their blood lead concentrations by 12 ug/dl and 22 ug/dl, respectively.⁵⁸ The WHO reports that each 1 ug/m³ ambient concentration of lead contributes 1.9 ug/dl of blood lead in children (approximately linearly in the lower part of the range), but that inhalation is relatively less important in children compared to ingestion. Thus, correcting for ingestion, the WHO estimates that each 1 ug/m³ increase

wick cores. *Science of the Total Environment*. 243-244: 53-65, 1999.

⁵³Nriagu JO, Kim MJ, Emissions of Lead and Zinc from Candles with Metal-Core Wicks. *Science of the Total Environment*, in press, 2000

⁵⁴ Roberts JW, Glass GL, and Spittler TM. Measurement of deep dust and lead in old carpets. In: *Measurement of toxic and related pollutants*, Air and Waste Management Assoc., Pittsburgh, pp. 186-191, 1995.

⁵⁵Van Alphen M. Emission testing and inhalational exposure-based risk assessment for candles having Pb [lead] metal wick cores. *Science of the Total Environment*. 243-244: 53-65, 1999.

⁵⁶ US Environmental Protection Agency EPA Fact Sheet Proposed rule on identification of lead-based paint hazards

⁵⁷ Lanphear BP, Weitzman M, Winter NL et al Lead-contaminated house dust and urban children's blood lead levels *American Journal of Public Health* 86 1416-21, 1996.

Rhoads GG, Ettinger AS, Weisel CP, et al the effect of dust lead control on blood lead in toddlers: a randomized trial. *Pediatrics* 103. 551-555, 1999

⁵⁸Griffin TB, Coulston F, Wills H, et al Clinical studies on men continuously exposed to airborne particulate lead. *Environmental Quality and Safety Supplement* 2 221-40, 1975

in ambient air lead level contributes 5 ug/dl to the blood lead level.⁵⁹ Brunekreef critically reviewed 19 studies and found that in children the relationship between blood lead and ambient air lead is logarithmic. In young children at blood levels less than 25 ug/dl, he found that 1 ug/m³ increases in air lead concentrations contributed 3-5 ug/dl increases in blood lead level. At lower air levels, increases in exposure produce even greater increases in blood lead levels. Brunekreef states that up to "a few ug/m³," each 1 ug/m³ can increase blood lead levels by over 5 ug/dl.⁶⁰

To our knowledge, only Krause and Van Alphen directly relate ambient air lead levels emitted from candles to children's blood lead levels. Krause determined that burning the candle with the highest lead content in his study for four hours daily may raise a 2-3 year-old child's blood lead level by 4.2 ug/dl to 13.4 ug/dl. He determined this using the Integrated Exposure Uptake Biokinetic Lead Model, a model that calculates serum lead levels by incorporating parameters such as ventilation rates, baseline indoor air lead concentrations, time indoors, and soil and house dust concentrations.⁶¹

Van Alphen burned candles with wicks containing very high lead content to determine the amount of lead emitted. From this, he estimated average 24-hour air lead levels and corresponding blood lead levels from burning one candle for three hours under varying conditions including room sizes, ventilation rates, and rates of increase of blood lead level for every unit increase in air lead level. Using a wide range of assumptions, he estimated that burning one candle three hours per week will raise a child's blood lead level by 3-11 ug/dl above the unexposed baseline and that burning one candle daily could raise it by 12-40 ug/dl. Van Alphen concludes, "There is the potential for entire families to have high Pb [lead] exposures because of such a Pb source. Where multiple Pb metal wick core candles are burned on a regular basis, for periods of >3 to 6 hours, in poorly ventilated settings, extreme levels of Pb exposure are possible. Clinical child Pb poisoning and death could be predicted."⁶²

B. Surface lead. Rhoads et al. compared household lead dust levels to blood lead levels in children randomized to groups where members of the intervention group were instructed to regularly clean their household to reduce lead exposure. Prior to the intervention, the

⁵⁹World Health Organization Guidelines for Air Quality, 1999. Chapter 3 Health-based Guidelines, 41.

⁶⁰Brunekreef B. The Relationship between Air Lead and Blood Lead in Children: A Critical Review Science of the Total Environment, 38 79-123, 1984

⁶¹Krause JD Characterization of scented candle emissions and associated public health risks. Thesis. Department of Environmental and Occupational Health University of South Florida. August 1999.

Krause D. Personal communication, 26 January 2000

⁶²Van Alphen M Emission testing and inhalational exposure-based risk assessment for candles having Pb metal wick cores. Science of the Total Environment 243-244 53-65, 1999

intervention group had a mean floor dust lead level of 237 ug/m² and a mean blood lead level of 12.4 ug/dl. After the intervention, their floor dust lead levels decreased to 163 ug/m², and their blood lead decreased to 10.3 ug/dl. The control group had floor dust lead levels of 275 at baseline and 207 ug/m² at follow up and the blood lead levels remained constant at 11.6 ug/dl.⁶³

As Van Alphen estimated that burning one 38 cm long candle with a pure lead wick in a 5x5 m room will result in 150 to 300 ug/m² surface lead dust levels on floors, infrequent burning of these candles could easily accumulate lead sufficiently to cause elevated blood lead levels.⁶⁴

4. The increased blood lead levels from burning these candles can cause permanent deficits in development, behavior, and intelligence.

Most recent studies have shown that blood lead levels above 10 ug/dl adversely affect children. Unborn and young children are particularly susceptible to even low blood lead levels. Placental exposure may result in miscarriage or early neonatal death,⁶⁵ premature births⁶⁶ and decreased mental ability.⁶⁷ For example, table 2 shows two longitudinal studies. After adjusting for confounding, Bellinger et al. showed that infants previously exposed to umbilical cord blood lead levels of 10 ug/dl or greater performed 5.8 points lower at six months and 7.3 points lower at

⁶³ Rhoads GG, Ettinger AS, Weisel CP, et al. the effect of dust lead control on blood lead in toddlers: a randomized trial. *Pediatrics* 103: 551-555, 1999.

⁶⁴ Van Alphen M. Emission testing and inhalational exposure-based risk assessment for candles having Pb [lead] metal wick cores. *Science of the Total Environment*. 243-244: 53-65, 1999.

⁶⁵ Wibberley DG, Khara AK, Edwards JH, et al. Lead levels in human placentae from normal and malformed births. *Journal of Medical Genetics* 14: 339-345, 1977

⁶⁶ Baghurst PA, Robertson EF, McMichael AJ, et al. The Port Pirie Cohort Study: Lead effects on pregnancy outcome and early childhood development. *Neurotoxicology* 8: 395-402, 1987.

⁶⁷ Bellinger DC, Needleman HL, Leviton A, et al. Early sensory-motor development and prenatal exposure to lead. *Neurobehavioral Toxicology and Teratology* 6: 387-402, 1984

Bellinger DC, Leviton A, Waternaux C, et al. Methodological issues in modeling the relationship between low-level lead exposure and infant development: Examples from the Boston lead study. *Environmental Research* 38: 119-129, 1985.

Bellinger D, Leviton A, Needleman HL, et al. Low-level lead exposure and infant development in the first year. *Neurobehavioral Toxicology and Teratology* 8: 151-161, 1986

Bellinger D, Leviton A, Waternaux C, et al. Longitudinal analyses of prenatal and postnatal lead exposure and early cognitive development. *The New England Journal of Medicine* 316: 1037-1043, 1987.

Dietrich KN, Krafft KM, Bornschein RL, et al. Low-level fetal lead exposure effect on neurobehavioral development in early infancy. *Pediatrics* 80: 721-730, 1987

twelve months on the Mental Development Index (MDI) of the Bayley Scales of Infant Development than those with blood levels less than 3 ug/dl.⁶⁸ The MDI is a commonly used test based on the IQ scale for assessing early cognitive development.⁶⁹ In a second study, mean levels were 8.0 and 6.3 for maternal blood and umbilical cord blood, respectively. No blood levels were above 30 ug/dl. After adjusting for confounding, for every ug/dl increase in blood lead, there was a 0.34 point decrease in Bayley MDI score.⁷⁰ In summary, both studies found that at each level, as the umbilical cord blood or maternal blood lead level increased over a range starting well below 10 ug/dl, performance on a developmental test declined.

Lead has also been implicated in prematurity. One study found that those with maternal blood lead levels of greater than 14 ug/dl had 4.4 times the risk of prematurity of those with blood lead levels less than 8 ug/dl.⁷¹

There is evidence that damage caused by low-level lead exposure in children becomes evident at an early age and persists into adulthood. Tables 3 and 4 show that, after adjusting for socioeconomic factors and other potential confounders, this damage includes deficits in development, intelligence, learning, and behavior in early childhood-preschool children,⁷² school-aged children,⁷³ and young adults.⁷⁴ Table 3 shows that incremental increases in blood

⁶⁸Bellinger DC, Leviton A, Needleman HL, et al. Low-level lead exposure and infant development in the first year. *Neurobehavioral Toxicology and Teratology* 8: 151-161, 1986

⁶⁹ Bayley N. *Bayley Scales of Infant Development*. New York, The Psychological Corporation, 1969.

⁷⁰Dietrich KN, Krafft KM, Bornschein RL, et al. Low-level fetal lead exposure effect on neurobehavioral development in early infancy *Pediatrics* 80: 721-730, 1987.

⁷¹Baghurst PA, Robertson EF, McMichael AJ, et al. The Port Pirie Cohort Study: Lead effects on pregnancy outcome and early childhood development. *Neurotoxicology* 8: 395-402, 1987.

⁷² Baghurst PA, Robertson EF, McMichael AJ, et al. The Port Pirie Cohort Study: Lead effects on pregnancy outcome and early childhood development. *Neurotoxicology* 8: 395-402, 1987

Mendelsohn AL, Dreyer BP, Fierman AH, et al. Low-level lead exposure and cognitive development in early childhood *Journal of Developmental and Behavioral Pediatrics* 20: 425-431, 1999.

McMichael AJ, Baghurst PA, Wigg NR, et al. The Port Pirie Cohort Study: Environmental exposure to lead and children's abilities at the age of four years. *The New England Journal of Medicine* 319: 468-477, 1988.

Wigg NR, Vimpani GV, McMichael AJ, et al. Port Pirie Cohort Study: Childhood blood lead and neuropsychological development at age two years. *Journal of Epidemiology and Community Health* 42: 213-219, 1988

⁷³Baghurst PA, McMichael AJ, Wigg NR, et al. Environmental exposure to lead and children's intelligence at the age of seven years. The Port Pirie Cohort Study. *The New England Journal of Medicine* 327: 1279-1284, 1992.

Burns JM, Baghurst PA, Sawyer MG, et al. Lifetime low-level exposure to environmental lead and children's emotional and behavioral development at ages 11-13 years. The Port Pirie Cohort Study. *American Journal of Epidemiology* 149: 740-749, 1999

lead over a range from 0 to 67 ug/dl at six months of age predicted poorer development and cognitive function in preschoolers using the MDI. Most children in these studies had blood lead concentrations below 30 ug/dl.⁷⁵ For example, Mendelsohn et al. found that children with blood levels between 0 and 9.9 ug/dl had 6.2 points higher MDI scores than children with blood lead levels between 10 and 25 ug/dl.⁷⁶

Dietrich KN, Berger OG, Succop PA, et al. The developmental consequences of low to moderate prenatal and postnatal lead exposure. Intellectual attainment in the Cincinnati lead study cohort following school entry. *Neurotoxicology and Teratology* 15: 37-44, 1993.

Fulton M, Raab G, Thomson G, et al. Influence of blood lead on the ability and attainment of children in Edinburgh. *Lancet* 1: 1221-1226, 1987.

Needleman HL, Gatsonis CA. Low-level lead exposure and the IQ of children. A meta-analysis of modern studies. *Journal of the American Medical Association* 263: 673-678, 1990.

Needleman HL, Gunnoe C, Leviton A, et al. Deficits in psychologic and classroom performance of children with elevated dentine lead levels. *The New England Journal of Medicine* 300: 689-695, 1979.

Needleman HL, Geiger SK, Frank R. Lead and IQ Scores: A reanalysis. *Science* 227, 701-704, 1985.

Schwartz J. Low-level lead exposure and children's IQ: A meta-analysis and search for a threshold. *Environmental Research* 65: 42-55, 1994.

Tong S, Baghurst PA, Sawyer MG, et al. Declining blood lead levels and changes in cognitive function during childhood. The Port Pirie Cohort Study. *Journal of the American Medical Association* 280: 1915-1919, 1998.

Tong S, Baghurst P, McMichael A, et al. Lifetime exposure to environmental lead and children's intelligence at 11-13 years: the Port Pirie Cohort Study. *British Medical Journal* 312: 1569-1575, 1996.

⁷⁴Needleman HL, Schell A, Bellinger D, et al. The long-term effects of exposure to low doses of lead in childhood: An 11-year follow-up report. *The New England Journal of Medicine* 322: 83-88, 1990.

⁷⁵ Baghurst PA, Robertson EF, McMichael AJ, et al. The Port Pirie Cohort Study: Lead effects on pregnancy outcome and early childhood development. *Neurotoxicology* 8: 395-402, 1987.

Mendelsohn AL, Dreyer BP, Fierman AH, et al. Low-level lead exposure and cognitive development in early childhood. *Journal of Developmental and Behavioral Pediatrics*. 20: 425-431, 1999

McMichael AJ, Baghurst PA, Wigg NR, et al. The Port Pirie Cohort Study: Environmental exposure to lead and children's abilities at the age of four years. *The New England Journal of Medicine* 319: 468-475, 1988

Wigg NR, Vimpani GV, McMichael AJ, et al. Port Pirie Cohort Study: Childhood blood lead and neuropsychological development at age two years. *Journal of Epidemiology and Community Health* 42: 213-219, 1988

⁷⁶ Mendelsohn AL, Dreyer BP, Fierman AH, et al. Low-level lead exposure and cognitive development in early childhood. *Journal of Developmental and Behavioral Pediatrics*. 20: 425-431, 1999.

Table 4 shows that increases in blood lead levels in the range of 0 to 39 ug/dl at ages from birth to 6 years of age continue to predict impaired cognitive function into school age (6.5 to 13 year olds). Measures used to assess lead exposure include a single blood lead level, average lifetime blood lead levels, and dentin tooth lead levels. Lead in dentin shed from primary teeth (incisors), in bone, and average lifetime lead, consisting of 22 blood lead levels drawn over the first six years, are long-term measures of blood lead.⁷⁷ Higher blood lead levels, average lifetime blood lead levels or dentin lead levels predicted poorer IQ (or other intelligence) scores,⁷⁸ number

⁷⁷Baghurst PA, McMichael AJ, Wigg NR, et al. Environmental exposure to lead and children's intelligence at the age of seven years. The Port Pirie Cohort Study. *The New England Journal of Medicine* 327: 1279-1284, 1992.

Burns JM, Baghurst PA, Sawyer MG, et al. Lifetime low-level exposure to environmental lead and children's emotional and behavioral development at ages 11-13 years. The Port Pirie Cohort Study. *American Journal of Epidemiology* 149: 740-749, 1999

Dietrich KN, Berger OG, Succop PA, et al. The developmental consequences of low to moderate prenatal and postnatal lead exposure: Intellectual attainment in the Cincinnati lead study cohort following school entry. *Neurotoxicology and Teratology* 15: 37-44, 1993.

Fulton M, Raab G, Thomson G, et al. Influence of blood lead on the ability and attainment of children in Edinburgh. *Lancet* 1: 1221-1226, 1987.

Needleman HL, Riess JA, Tobin MJ, et al. Bone lead levels and delinquent behavior. *Journal of the American Medical Association* 275: 363-369, 1996.

Needleman HL, Gatsonis CA. Low-level lead exposure and the IQ of children. A meta-analysis of modern studies. *Journal of the American Medical Association* 263: 673-678, 1990

Needleman HL, Gunnoe C, Leviton A, et al. Deficits in psychologic and classroom performance of children with elevated dentine lead levels. *The New England Journal of Medicine* 300: 689-695, 1979.

Needleman HL, Geiger SK, Frank R. Lead and IQ Scores: A reanalysis. *Science* 227, 701-704, 1985.

Schwartz J. Low-level lead exposure and children's IQ: A meta-analysis and search for a threshold. *Environmental Research* 65: 42-55, 1994.

Tong S, Baghurst PA, Sawyer MG, et al. Declining blood lead levels and changes in cognitive function during childhood. The Port Pirie Cohort Study. *Journal of the American Medical Association* 280: 1915-1919, 1998.

Tong S, Baghurst P, McMichael A, et al. Lifetime exposure to environmental lead and children's intelligence at 11-13 years: the Port Pirie Cohort Study. *British Medical Journal* 312: 1569-1575, 1996.

⁷⁸Baghurst PA, McMichael AJ, Wigg NR, et al. Environmental exposure to lead and children's intelligence at the age of seven years. The Port Pirie Cohort Study. *The New England Journal of Medicine* 327: 1279-1284, 1992.

Dietrich KN, Berger OG, Succop PA, et al. The developmental consequences of low to moderate prenatal and postnatal lead exposure. Intellectual attainment in the Cincinnati lead study cohort following school entry. *Neurotoxicology and Teratology* 15: 37-44, 1993

Fulton M, Raab G, Thomson G, et al. Influence of blood lead on the ability and attainment of children in Edinburgh.

skills,⁷⁹ word reading,⁸⁰ and fine and gross motor development.⁸¹ Additionally, children with average lifetime blood lead levels greater than 15 ug/dl had more attention problems, delinquent and aggressive behavior, social problems, anxiety, depression and withdrawal than children with blood lead levels below 15 ug/dl.⁸² Similar results were found for high bone lead levels.⁸³ For example, Schwartz conducted a meta-analysis and found that for an increase of blood lead from 10 to 20 ug/dl, there was a decrease in IQ of 2.6 points. The studies with average blood lead concentrations of 15 ug/dl or lower had higher estimated decreases in IQ per unit increase in blood lead. Further analysis led him to conclude that there was no evidence of a threshold even down to 1 ug/dl.⁸⁴ Another study found that children with average lifetime blood lead levels of less than or equal to 10 ug/dl had 7 points higher IQ scores than children with blood lead levels above 20 ug/dl.⁸⁵ Another study in Table 4 shows that blood lead levels also correlate negatively

Lancet 1: 1221-1226, 1987.

Needleman HL, Gatsoms CA. Low-level lead exposure and the IQ of children. A meta-analysis of modern studies. *Journal of the American Medical Association* 263: 673-678, 1990

Needleman HL, Gunnoe C, Leviton A, et al. Deficits in psychologic and classroom performance of children with elevated dentine lead levels. *The New England Journal of Medicine* 300: 689-695, 1979.

Needleman HL, Geiger SK, Frank R. Lead and IQ Scores: A reanalysis. *Science* 227, 701-704, 1985.

Schwartz J. Low-level lead exposure and children's IQ: A meta-analysis and search for a threshold. *Environmental Research* 65: 42-55, 1994.

Tong S, Baghurst PA, Sawyer MG, et al. Declining blood lead levels and changes in cognitive function during childhood. The Port Pirie Cohort Study. *Journal of the American Medical Association* 280: 1915-1919, 1998.

Tong S, Baghurst P, McMichael A, et al. Lifetime exposure to environmental lead and children's intelligence at 11-13 years: the Port Pirie Cohort Study. *British Medical Journal* 312: 1569-1575, 1996.

⁷⁹ Fulton M, Raab G, Thomson G, et al. Influence of blood lead on the ability and attainment of children in Edinburgh. *Lancet* 1: 1221-1226, 1987

⁸⁰ *Ibid*

⁸¹ Dietrich KN, Berger OG, Succop PA. Lead exposure and the motor developmental status of urban six-year-old children in the Cincinnati Prospective Study. *Pediatrics* 91: 301-307, 1993.

⁸² Burns JM, Baghurst PA, Sawyer MG, et al. Lifetime low-level exposure to environmental lead and children's emotional and behavioral development at ages 11-13 years. The Port Pirie Cohort Study. *American Journal of Epidemiology* 149: 740-749, 1999.

⁸³ Needleman HL, Ruesch JA, Tobin MJ, et al. Bone lead levels and delinquent behavior. *Journal of the American Medical Association* 275: 363-369, 1996.

⁸⁴ Schwartz J. Low-level lead exposure and children's IQ. A meta-analysis and search for a threshold. *Environmental Research* 65: 42-55, 1994

⁸⁵ Dietrich KN, Berger OG, Succop PA, et al. The developmental consequences of low to moderate prenatal and

with motor development. Six-year old children were divided into four quartiles according to their average lifetime blood lead level. The lowest group had a level of 5-9 ug/dl and the highest group had a level of 17-39 ug/dl. After adjusting for confounding, children with blood lead levels in the lowest quartile exhibited the best motor development and those in the highest quartile exhibited the worst motor development.⁸⁶

These problems continue into adulthood. Needleman et al. collected primary teeth from children over an eleven-year period. He found that after adjusting for confounders, 18 year olds who had previously shed teeth with dentin lead levels greater than 20 parts per million were 7.4 times more likely to drop out of high school, 5.8 times more likely to have a reading disability, had lower grammatical reasoning and vocabulary and had longer reaction times than those with dentin lead levels below 10 parts per million.⁸⁷

Low-level lead exposure is also associated in adults with increased blood pressure,⁸⁸ renal impairment,⁸⁹ and gout.⁹⁰

5. Alternatives to lead-containing wicks exist.

Cored wicks are used in long-burning scented candles with self-supporting wicks in containers, votives, pillars, and novelties.⁹¹ Metal cores in wicks are used to prevent the wick from bending

postnatal lead exposure: Intellectual attainment in the Cincinnati lead study cohort following school entry. *Neurotoxicology and Teratology* 15: 37-44, 1993.

⁸⁶Dietrich KN, Berger OG, Succop PA, et al. Lead exposure and the motor development status of urban six-year old children in the Cincinnati Prospective study. *Pediatrics* 91: 301-307, 1993.

⁸⁷Needleman HL, Schell A, Bellinger D, et al. The long-term effects of exposure to low doses of lead in childhood: An 11-year follow-up report. *The New England Journal of Medicine* 322: 83-88, 1990.

⁸⁸ De Kort WLAM, Verschoor MA, Wibowo AAE, et al. Occupational exposure to lead and blood pressure: A study in 105 workers. *American Journal of Industrial Medicine* 11: 145-156, 1987.

Harlan WR. The relationship of blood lead levels to blood pressure in the U.S. population. *Environmental Health Perspectives* 78: 9-13, 1988

Harlan WR, Landis JR, Schmouder RL, et al. Blood lead and blood pressure: Relationship in the adolescent and adult US population. *Journal of the American Medical Association* 253: 530-534, 1985

Batumen V, Landy E, Maesaka JK, et al. Contribution of lead to hypertension with renal impairment. *The New England Journal of Medicine* 309: 17-21, 1983

⁸⁹ Batumen V, Landy E, Maesaka JK, et al. Contribution of lead to hypertension with renal impairment. *The New England Journal of Medicine* 309: 17-21, 1983

⁹⁰ Batumen V, Maesaka JK, Haddad B, et al. The role of lead in gout nephropathy. *The New England Journal of Medicine* 304: 520-523, 1981

⁹¹Wick n'Clip, Inc, 1999Quality Wick Products. Web Site <http://www.wicknclip.com/types2.html>.

and extinguish in the molten wax of the candle. However, alternatives exist, including cotton and paper core-wicks that remain erect during burning.⁹² Waxing the wick prior to candle-making constructs a sturdier wick.⁹³ Leaded wicks also burn more slowly and evenly. However, Krause indicated that 4 of 5 votives (2 in. candles burned in pans) with lead-containing candlewicks burned almost completely in 2 hours despite being advertised to burn for 15 hours.⁹⁴ Thus this assertion seems questionable. Finally, in our study, lead-containing wicks were a fraction of those not containing lead for every type of candle proving that the alternatives are viable options.

6. Labeling will not adequately protect candle-users.

Some public health risks are too great to be handled by labeling. This is one. Besides, there are no public health benefits to lead-containing candles. Furthermore, the most at-risk populations, fetuses, infants and young children, do not choose whether a candle is burned. Labeling may ward off some from the danger of burning candles with lead-containing wicks, but it will not protect children, particularly if their parents cannot read or comprehend the warning. The only solution is to completely ban candles containing leaded wicks. Finally, as millions of such candles are sold each year because they are currently on store shelves, you must immediately order a recall of candles with lead-containing wicks.

7. The Consumer Product Safety Act and the Hazardous Substances Act require the Consumer Product Safety Commission to Ban and Recall these products.

The provision of the Consumer Product Safety Act concerning "imminent hazards" posed by products as the basis for the Commission to issue a recall of lead-containing candles operates where products present "imminent and unreasonable risk of death, serious illness, or severe personal injury." 15 U.S.C. §2061(a).

Our study showed that the burning of presently-available lead-wicked candles, with wicks containing from 33% to 85% lead, could result in air lead levels as high as 50 ug/ m³, well in excess of the 1.5 ug per cubic meter EPA guideline for air lead levels. The Van Alphen study cited on pages 11-12 concluded that burning one high lead candle for three hours could achieve an average 24 hour air lead concentration of 10 ug per cubic meter, more than six times in excess of the EPA's ambient air guideline of 1.5 ug of lead per cubic meter. EPA's own earlier research found that burning candles with lead wicks also resulted in air lead levels similarly in excess of the EPA guideline. That air lead levels resulting from burning such candles can cause a dangerous increase in blood lead levels in children was determined by the aforementioned research of Van Alphen who estimated that burning one lead-wicked candle for three hours per week could raise the blood lead level in children by 3-11 ug/dl above what the levels were before exposure. For many children, this would raise their blood lead levels to well above 10 ug/dl, levels which both the Consumer Product Safety Commission and the Centers for Disease Control

⁹²Ibid

⁹³Ibid.

⁹⁴ Krause D Personal communication, February 11, 2000.

and Prevention have found to be dangerous. Additional lead exposure to children can occur from the ingestion of lead-containing dust from the burning of the candles which settles in rooms where candles are burned.

All of these findings clearly demonstrate that lead-based wicks in candles pose an imminent risk of injury. Although the manifestations of exposure to lead may not be immediately apparent--as in the ultimate lowering of IQ in lead-exposed children--the legal standard is imminent risk, not imminent injury.

The provision of the Consumer Product Safety Act pertaining to "banned hazardous products" authorizes the Commission to initiate rulemaking to ban consumer products that present an "unreasonable risk of injury" where "no feasible consumer product safety standard...would adequately protect the public from the risk of injury associated with such product." 15 U.S.C. §2057.

Finally, the Federal Hazardous Substances Act's "imminent hazard" provision, 15 U.S.C. §1261(q)(2), authorizes a ban only as a temporary remedy during the course of regulatory proceedings. However, Section 1261(q)(1) empowers the Commission to classify household products as "banned hazardous substances," as a permanent designation, upon a finding that "the degree or nature of the hazard involved in the presence or use of such substance in households is such that the objective of protection of the public health and safety can be adequately served" only by a ban. 15 U.S.C. §1261(q)(1)(B).

Several years ago, the CPSC asked manufacturers of vinyl miniblinds to stop using lead in the production of these blinds because of the "lead poisoning hazard" they posed to children. The CPSC found that "in some blinds, the levels of dust [from the deterioration of the blinds] was so high that a child ingesting dust from less than one square inch of blind a day for about 15 to 30 days could result in blood levels at or above the 10 microgram per deciliter amount CPSC considers dangerous for young children." (CPSC Press Release, June 25, 1996)

In summary, the Consumer Product Safety Commission has the legal authority, under the Consumer Product Safety Act and the Hazardous Substances Act, to immediately ban the manufacture, stop the importation and order the recall from all channels of commerce of all candles with lead-containing wicks and all lead-containing wicks sold for subsequent incorporation into candles. Any failure to do so will continue to jeopardize the health of millions of people, including tens if not hundreds of thousands of children by exposing them to the completely unnecessary risks of lead poisoning.

Lead-containing wicks are a dangerous product. Through this petition, we have demonstrated that candles with lead-containing wicks are present on store shelves despite the voluntary agreement between the candle industry and the CPSC. We have shown that the candles with lead-wicks emit sufficient lead to exceed EPA air lead standards,⁹⁵ HUD floor surface lead

⁹⁵Bridbord K, Medical Officer Memo to Stanley Greenfield, Assistant Administrator for Research and

concentrations⁹⁶ and the CPSC's own recommendations for maximal lead intake by children.⁹⁷ Furthermore, we have demonstrated that the concentrations attained by burning these candles can raise children's blood lead levels sufficiently to impair intelligence and cause behavioral problems.⁹⁸ Finally, we have shown that 3% of candles have high lead content. In 1974, Russell Train, then Administrator of EPA, stated "Inhabitants of homes in which lead-wicked candles are burned could be exposed to substantial incremental quantities of lead which, if continued on a regular basis, would pose a significant risk to health especially among children with already elevated lead body burdens. In my opinion candles represent an unnecessary incremental source of lead that can readily be controlled."⁹⁹ His concern is as relevant now as it was then.

Development, and Vaun A. Newill, Special Assistant to the Administrator: Hazards of burning candles with lead. US EPA, Research Triangle Park, December 14, 1973.

Krause JD. Characterization of scented candle emissions and associated public health risks. Thesis. Department of Environmental and Occupational Health. University of South Florida. August 1999.

Van Alphen M. Emission testing and inhalational exposure-based risk assessment for candles having Pb [lead] metal wick cores. *Science of the Total Environment*. 243-244: 53-65, 1999

Code of Federal Regulations. Title 40--Protection of Environment, Chapter 1--Environmental Protection Agency, Part 50, Sec 50.12 National primary and secondary ambient air quality standards for lead.

⁹⁶ Van Alphen M. Emission testing and inhalational exposure-based risk assessment for candles having Pb [lead] metal wick cores. *Science of the Total Environment*. 243-244: 53-65, 1999

<http://www.hud.gov/80/lea/leach1.pdf>. Chapter 1 Introduction Legislative Basis and Relationship to Federal Programs and Regulations. In The Guidelines for the Evaluation and Control of Lead-Based Paint Hazards in Housing, 1995.

⁹⁷ Consumer Product Safety Commission. CPSC Staff report on lead and cadmium in children's polyvinylchloride (PVC) products Page 3. 21 November 1997.

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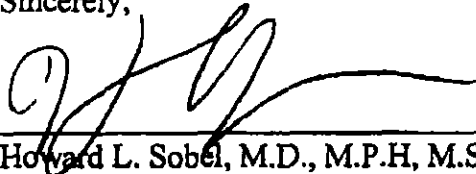
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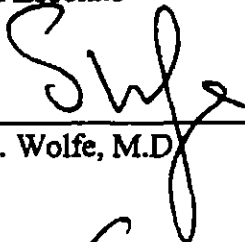
⁹⁹Letter to Mr Simpson, Chairman of CPSC, from Russell Train, Administrator of EPA, March 1974.

The Consumer Product Safety Commission has a clear mandate to protect the American public from these hazardous products.

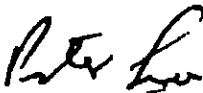
Sincerely,



Howard L. Sobel, M.D., M.P.H, M.S.
Research Associate



Sidney M. Wolfe, M.D.
Director



Peter Lurie, M.D., M.P H.
Deputy Director
Public Citizen's Health Research Group

Table 1. Lead content of lead-containing candles purchased for February, 2000 Health Research Group candle study.

Total lead in wick (ug)	Total lead emitted from wick (ug) ¹⁰⁰	Average 24-hour Air lead levels (ug/m ³) ¹⁰¹	Multiples of EPA Ambient Air Lead Levels of 1.5 ug/dl
39400.0	7880.0	19.3	13
68058.0	13611.6	25.0	17
117935.5	23587.1	43.3	29
66956.5	13391.3	49.2	33
32112.9	6422.6	17.2	11
37795.3	7559.1	22.2	15
62152.2	12430.4	22.8	15
25785.7	5157.1	15.2	10
23618.4	4723.7	13.9	9
			Average: 17
			Median: 15

¹⁰⁰ Assumes that only 20% of lead in candlewicks is emitted. In previous studies, the actual amount emitted into the air ranged from 20 to 35%.

¹⁰¹ First, the amount of lead emitted per cm was calculated. We assumed the burn rate was 2 cm/hour and that people burn candles only for 3 hours and then extinguish the candle. Other assumptions include that the ventilation rates are 25% per hour and that the room dimensions are 15 ft. x 15 ft. x 8 ft which converts to 51 m³. We then calculated lead concentrations for each of 24 hours.

For the first hour, the concentration was the lead/cm times 2 cm/hour times 20% (giving the total lead emitted during the first hour) divided by 51 m³, the total volume of the room. We then multiply this concentration by 0.75, because 25% is exchanged per hour.

For the second and third hour, it was 75% of the lead concentration at the end of the previous hour plus the newly emitted lead which is the lead/cm times 2 cm times 0.2 divided by 51 m³, as before.

For the fourth to 24th hour, because the candle was extinguished, the lead concentrations decrease by 25% of the value at the end of the previous hour each hour.

Finally, the hourly lead concentration were added and divided by 24 hours to determine the average concentration.

A Microsoft Excel Spreadsheet was used to perform these calculations.

Table 2. Comparison of prenatal exposure to low-level lead with clinical effect.

Clinical effect	Lead Exposure Level	Study finding
In Utero Exposure Placental lead in Normal Birth Miscarriage Early Neonatal Death	Placental lead 0.93 ug/g 1.45 1.73	Placental lead concentration is lower in placentas of children who survived the neonatal period than those who did not. ¹⁰²
Premature birth	> 14 ug/dl vs. <8 ug/dl maternal blood lead concentration at delivery.	4.4 times the risk of premature delivery in high compared to the low blood lead group. ¹⁰³

¹⁰²Wibberley DG, Khara AK, Edwards JH, et al. Lead levels in human placentas from normal and malformed births. *Journal of Medical Genetics* 14: 339-345, 1977.

¹⁰³Baghurst PA, Robertson EF, McMichael AJ, et al. The Port Pirie Cohort Study: Lead effects on pregnancy outcome and early childhood development. *Neurotoxicology* 8: 395-402, 1987.

Decreased mental or cognitive development	<3 ug/dl, 6-7 ug/dl, and >10 ug/dl umbilical cord blood	Highest cord blood lead level group performed 4-8 points lower on the Bayley Scale of Infant Development-Mental Development Index with incremental increase of umbilical cord blood level. ¹⁰⁴
	4.5 ug/dl (mean) in utero blood lead, maximum <30 ug/dl	For each 1-ug/dl increase in blood lead level, the MDI decreased 0.34 points (9.2 points across the range). ¹⁰⁵

¹⁰⁴Bellinger DC, Needleman HL, Leviton A, et al. Early sensory-motor development and prenatal exposure to lead. *Neurobehavioral Toxicology and Teratology* 6: 387-402, 1984.

Bellinger DC, Leviton A, Wateraux C, et al. Methodological issues in modeling the relationship between low-level lead exposure and infant development: Examples from the Boston lead study. *Environmental Research* 38: 119-129, 1985

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Bellinger DC, Leviton A, Wateraux C, et al. Longitudinal analyses of prenatal and postnatal lead exposure and early cognitive development. *The New England Journal of Medicine* 36: 1037-1043, 1987.

¹⁰⁵ Dietrich KN, Kraft KM, Bornschein RL, et al. Low-level fetal lead exposure effect on neurobehavioral development in early infancy *Pediatrics* 80: 721-730, 1987

Table 3 Comparison of post-natal exposure to low-level lead with clinical effect in preschoolers.

Lead Exposure Level	Age	Effect
14-22 ug/dl blood level Compares lowest quartile to highest.	2	1.9 point decrease in scores of the Mental Development part of the Bayley Scales of Infant Development for every 10 ug/dl increase in blood lead over the range of 14-22 ug/dl. ¹⁰⁶
10, 18.4, 29.9 ug/dl integrated postnatal blood lead.	2	1.6 point decrease in scores of the Mental Development part of the Bayley Scales of Infant Development for every 10 ug/dl increase in blood lead for levels <30 ug/dl. ¹⁰⁷
0-9.9 vs. 10-24.9 ug/dl blood lead.	1-3	Higher blood lead group had 6.2 points lower scores of the Mental Development part of the Bayley Scales of Infant Development than the lower blood group ¹⁰⁸
5-57 ug/dl blood lead	4	Incremental increases in blood lead level from 10 to 30 ug/dl corresponds to a decrease of 7.2 units of the General Cognitive Index. Memory also impaired. ¹⁰⁹

¹⁰⁶ Baghurst PA, Robertson EF, McMichael AJ, et al. The Port Pirie Cohort Study: Lead effects on pregnancy outcome and early childhood development. *Neurotoxicology* 8. 395-402, 1987.

¹⁰⁷ Wigg NR, Vimpani GV, McMichael AJ, et al. Port Pirie Cohort Study Childhood blood lead and neuropsychological development at age two years. *Journal of Epidemiology and Community Health* 42: 213-219, 1988.

¹⁰⁸ Mendelsohn AL, Dreyer BP, Fierman AH, et al. Low-level lead exposure and cognitive development in early childhood. *Journal of Developmental and Behavioral Pediatrics* 20. 425-431, 1999.

¹⁰⁹ McMichael AJ, Baghurst PA, Wigg NR, et al. The Port Pirie Cohort Study: Environmental exposure to lead and children's abilities at the age of four years. *The New England Journal of Medicine* 319. 468-475, 1988.

Table 4. Comparison of post-natal exposure to low-level lead with clinical effect in school-age children

Lead Exposure Level	Age	Effect
>24 PPM vs. <6 PPM lead in dentin	7-8	Higher lead levels corresponded to poorer performance on test of IQ, auditory and verbal processing, attention, and teachers behavioral rating. (1 st and 2 nd graders) ¹¹⁰
6-100 ug/dl blood lead lead 2.4 to >150 PPM tooth lead levels	Meta-analysis	11/12 studies employing multiple regression found that increasing blood or tooth lead levels were associated with lower IQ. ¹¹¹
10 groups with mean blood lead levels from 5.6-22.1 ug/dl	6-9	Overall ability and attainment, and specifically, number skills and word reading decreased with increasing blood lead concentration. ¹¹²
0-10, >10-15, >15-20, >20 ug/dl average lifetime blood lead.	6.5	IQ is 7 points lower in the lowest than the highest lead group. ¹¹³
7.5-30 ug/dl average lifetime lead level	7	IQ decreases approximately 5 points for increases of blood lead from 10 to 30 ug/dl ¹¹⁴
11-18.6 ug/dl average lifetime lead level	11-13	Cognitive deficits in children whose blood lead concentration was high improve only partially with a subsequent decline of blood lead level. ¹¹⁵
11-18 6 ug/dl average lifetime lead level	11-13	Mean IQ decreased 3 points for an increase in blood lead level from 10 ug/dl

¹¹⁰ Needleman HL, Gunnoe C, Leviton A, et al. Deficits in psychologic and classroom performance of children with elevated dentine lead levels. *The New England Journal of Medicine* 300:689-695, 1979
 Needleman HL, Geiger SK, Frank R. Lead and IQ Scores: A reanalysis. *Science* 227, 701-704, 1985.

¹¹¹ Needleman HL, Gatsonis CA. Low-level lead exposure and the IQ of children. A meta-analysis of modern studies *Journal of the American Medical Association* 263 673-678, 1990.

¹¹² Fulton M, Raab G, Thomson G, et al. Influence of blood lead on the ability and attainment of children in Edinburgh. *Lancet* i. 1221-1226, 1987

¹¹³ Dietrich KN, Berger OG, Succop PA, et al. The developmental consequences of low to moderate prenatal and postnatal lead exposure: Intellectual attainment in the Cincinnati lead study cohort following school entry *Neurotoxicology and Teratology* 15. 37-44, 1993

¹¹⁴ Baghurst PA, McMichael AJ, Wigg NR, et al. Environmental exposure to lead and children's intelligence at the age of seven years. The Port Pirie Cohort Study. *The New England Journal of Medicine* 327: 1279-1284, 1992.

¹¹⁵ Tong S, Baghurst PA, Sawyer MG, et al Declining blood lead levels and changes in cognitive function during childhood. The Port Pirie Cohort Study *Journal of the American Medical Association* 280: 1915-1919, 1998.

¹¹⁶ Tong S, Baghurst P, McMichael A, et al Lifetime exposure to environmental lead and children's intelligence at

		to 20 ug/dl. ¹¹⁵
>15 vs <15 ug/dl lifetime average lead level.	11-13	Higher lead levels were associated with higher behavioral problem score. Boys had higher attention problems, delinquent behavior, and aggressive behavior. Girls had these and additionally had higher social problems, anxiety/depression, and withdrawal. ¹¹⁷
5-9, 9-12, 13-17, 17-39 ug/dl average lifetime blood lead	6	Fine and gross motor development decrease with increasing average blood lead level. (6 year olds) ¹¹⁸
Mean blood lead levels of 11-23 ug/dl	Meta-analysis	An increase from 10 to 20 ug/dl reduces IQ by 2.6 points. There is no threshold. Decreases in IQ continue to below 5 ug/dl. ¹¹⁹
Quintiles according to Bone lead levels by backscattered Xray peak intensity vs. standards.	7	Higher bone lead levels were associated with higher risk of antisocial and delinquent behavior. ¹²⁰

11-13 years: the Port Pirie Cohort Study. *British Medical Journal* 312. 1569-1575, 1996.

¹¹⁷ Burns JM, Baghurst PA, Sawyer MG, et al. Lifetime low-level exposure to environmental lead and children's emotional and behavioral development at ages 11-13 years. The Port Pirie Cohort Study. *American Journal of Epidemiology* 149: 740-749, 1999

¹¹⁸ Dietrich KN, Berger OG, Succop PA. Lead exposure and the motor developmental status of urban six-year-old children in the Cincinnati Prospective Study. *Pediatrics* 91 301-307, 1993

¹¹⁹ Schwartz J. Low-level lead exposure and children's IQ. A meta-analysis and search for a threshold. *Environmental Research* 65: 42-55, 1994

¹²⁰ Needleman HL, Riess JA, Tobin MJ, et al. Bone lead levels and delinquent behavior. *Journal of the American Medical Association* 275 363-369, 1996



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February 23, 2000

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The Honorable Ann Brown
 Chairman
 U.S. Consumer Products Safety Commission
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 Bethesda, Maryland 20814

Dear Chairman Brown,

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 AIMS Administrator

The National Apartment Association (NAA) and the National Multi-Housing Council (NMHC) represent the owners, managers, developers and financiers of the majority of the nation's multifamily rental housing units. Our members bear a strong commitment to safe, affordable and accessible housing and as such, respectfully ask that you ban the use of lead in candle wicks based on the hazard they pose to health, particularly that of children.

Scientific analyses indicate that candles manufactured in the United States and China often contain wicks that have lead cores. When these candles are burned, a significant portion of the volatilized lead is released into the room's airspace resulting in toxic levels of lead exposure. According to a study conducted by Professor Jerome Nriagu, of the University of Michigan in Ann Arbor, the burning of candles containing lead wicks, under conditions of normal use, can result in more than a 30-fold increase over the airborne levels considered as safe by the U.S. Environmental Protection Agency (EPA).¹

Additional information on this matter has been published by Dr. Mike van Alphen in the journal, *The Science of the Total Environment*, (attached) which indicates that the lead which is released as a result of candle burning is in a chemical form which is highly biologically available to those who come in contact with the lead particles. According to this analysis, not only is the lead in its aerosolized form likely to pose a significant poisoning potential for children but the lead particles which will ultimately settle out as house dust, will pose a second source of exposure to residents of homes in which these candles are used.

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Our industry has worked closely with CPSC, EPA, the U.S. Department of Housing and Urban Development, the U.S. Occupational Safety and Health Commission to bring about the end of childhood lead poisoning. Recent data from the U.S. Centers for Disease Control and Prevention finds that the nation

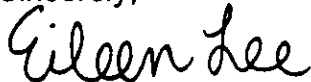
Quoted by Reuters newservice; manuscript submitted for publication.

is well on the way to eliminating childhood lead poisoning. In fact, we understand that federal officials plan to announce that childhood lead poisoning could be vanquished by 2010 as a result of strong federal policies which have sought to control the use of lead.

We must not permit this public health success story to be compromised by the sale and use of candles with lead-containing wicks. There are many alternative materials which could be substituted for the lead compounds in wicks which would still permit the candle to be burned without creating toxic lead vapors and dust.

As property owners, we are subject to laws on the local, state and federal level which require that in many circumstances, we test our properties for "lead hazards." According to guidance published in 1995 by the EPA, in advance of the issuance of a rule still pending under the Toxic Substances Control Act, certain levels of lead in house dust are considered to be "lead hazards." Once a "lead hazard" is identified, property owners must act (pursuant to other controlling authorities), to abate the hazard. Our efforts to maintain a lead safe residential environment for our residents is significantly compromised by the use of consumer products which release harmful levels of toxic lead.

Sincerely,



Eileen Lee Ph D.

Vice President of Environment

Attachment

cc: Honorable C. Browner
Honorable A. Cuomo



Emission testing and inhalational exposure-based risk assessment for candles having Pb metal wick cores

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Received 15 June 1999; accepted 14 July 1999

Abstract

Segments of seven candles with wicks having a Pb metal core have been tested in a purpose-built combustion chamber to assess air Pb emissions. Emissions were collected on glass fibre filters that have been digested in concentrated HNO_3 and analysed by flame atomic absorption spectroscopy (FAAS). Despite an indication of a bimodal distribution in Pb emission rates, and a range from 450 to 1130 $\mu\text{g Pb/h}$, the mean rate from the seven candles was 770 $\mu\text{g Pb/h}$. The 38-cm long candles are, on average, capable of emitting 104 000 μg of Pb into the air over ~ 127 h. A mean value of 20% of the Pb metal in the wick consumed by the candle is emitted into the air, the remainder appears to accumulate at the base of a molten wax-pool adjacent to the wick. Individual Pb-bearing particles from the combustion of candles were observed in a field emission scanning electron microscope (FESEM) to have a diameter of 1 μm or less. The emission from the candles has been analysed by X-ray diffraction (XRD) and identified as Sodium Lead Carbonate Hydroxide [$\text{NaPb}_2(\text{CO}_3)_2\text{OH}$]. This compound, being a Pb carbonate, is likely to be easily absorbed in the lungs and gastrointestinal tract. Risks associated with inhalational exposure have been assessed after determining indoor lead in air (PbA) concentrations. Given a lack of information on the duration of use of candles, a range of scenarios from worst possible case to daily and weekly burning regimes are evaluated. Detailed evaluations of PbA are based on the emission from a single candle at rates of 500 and 1000 $\mu\text{g Pb/h}$, room volumes of 25 and 50 m^3 , durations of emission of 1.5, 3 and 6 h and air infiltration rates of 0, 0.25, 0.5, 0.75 and 1.0 air volume changes per hour (ACH). A candle burnt for 3 h at 1000 $\mu\text{g/h}$ in a 50 m^3 room having poor ventilation at 0.25 ACH is estimated to yield a 24-h average lead in air concentration of 9.9 $\mu\text{g}/\text{m}^3$ with a peak PbA value of 42.1 $\mu\text{g}/\text{m}^3$. Daily exposure to such candle burning where children spend 80% of their time indoors is likely to elevate PbB in children by a minimum of 24 to 40 $\mu\text{g}/\text{dl}$, according to the PbB/PbA relationship of Brunekreef, 1984 (The relationship between air lead and blood lead in children - a critical review). Estimating child Pb uptake from first principles using a range of exposure factors, a child would obtain some 85 to 127% of the provisional tolerable weekly Pb intake (PTWI) from such daily exposure. Child blood lead levels could readily exceed levels of 10 $\mu\text{g}/\text{dl}$, largely due to exposure to emissions from burning Pb wick core candles for several hours once per week. The regular burning of multiple candles in small, poorly ventilated spaces could readily be associated with clinical Pb poisonings.

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and death. High levels of exposure could occur with Pb metal core wick candles in less developed countries where candles are used on a daily basis for indoor lighting purposes in small dwellings. Prolonged burning of candles may occur in religious and in ceremonial circumstances or restaurants where they may be of particular concern. On the basis of the limited investigation carried out, candles having a wick with a Pb metal core have the potential to present highly unacceptable and avoidable risks to human health. © 1999 Elsevier Science B.V. All rights reserved.

Keywords: Candles, Wick, Pb, Lead, Combustion, Lead in air, $\text{NaPb}_2(\text{CO}_3)_2\text{OH}$, Indoor air quality, Inhalational exposure, Risk assessment

1. Introduction

A range of candles sold in Adelaide, South Australia and manufactured in the Peoples Republic of China have metal cores to a fabric-based candle wick sheath.

The risks associated with the candles were considered to relate mostly to any potential for air emission of metal fumes and subsequent inhalational exposure. A proportion of metal particles released into the air could be deposited indoors as dust and then pose a hazard particularly to young children due to the potential for ingestion owing to normal hand-to-mouth and mouthing behaviours.

The potential for children to access wicks containing hazardous metal or metal combustion products such as metal oxides is a related issue.

A survey of the metals in wick cores encountered a range of metals and metal alloys in the candle wicks, but the investigation here evaluates a relatively tall 38-cm long candle form that had Pb metal wick cores.

Particular concerns exist in relation to Pb exposure of women of reproductive age, pregnant women and young children. There is a need to prevent such exposures (Alliance to End Childhood Lead Poisoning and Environmental Defence Fund, 1994, NSW LRC, 1997; Silbergeld, 1997). This initial risk assessment must focus on the most susceptible group namely children. Blood Pb levels (PbB) of 10 $\mu\text{g}/\text{dl}$ and of 150 $\mu\text{g}/\text{dl}$ represent, respectively, a currently accepted concentration that child-populations should preferably not exceed and a level at which death is highly likely (NSW LRC, 1997).

One unknown is the frequency and duration of burning of candles and initially precautionary es-

timates of risk may be warranted to account for this and other uncertainties. A wide range of possible exposure scenarios including worst case scenarios need to be evaluated so as to account for a wide range of conditions of use of candles. The relatively low cost of these particular candles makes both extensive and repeated use possible. High levels of exposure may occur with this generic type of metal core wick candle in less developed countries where candles are used on a daily basis for indoor lighting purposes in small dwellings. Prolonged burning of candles may occur in religious and in ceremonial circumstances.

1.1 Risk assessment

The determinants of inhalational exposure include the emission rate from the candle, numbers of candles burnt, the duration and frequency of burning of candles, the volume of the room or house, the infiltration of diluting air and the duration of exposure of home occupants. In addition the risks will depend on the particle size of any emitted materials and propensity for deposition in the lung and the solubility of any such Pb compounds.

Limited guidance is available from existing lead in air (PbA) standards. In Australia the recommended maximum outdoor ambient lead in air level is 1.5 $\mu\text{g Pb}/\text{m}^3$ (Brown, 1997) and the standard for occupational exposure (NOHSC, 1995) is 150 $\mu\text{g Pb}/\text{m}^3$. These exposure standards are 90-day running means and 8 hour averages respectively. The occupational exposure standard is neither appropriate for children, women of childbearing age nor indoor residential exposures.