Exposure Assessment: A Statistical Validation of Mercury Exposures in the Workplace

An Analysis of Potential Workplace Exposure to Mercury from Broken Compact Fluorescent Lamps

March 4, 2008

Charles Vidich and Terry Grover
Overview

- Purpose of Study
- Study Hypothesis
- Study Design & Methodology
- Regulatory Background
- Exposure Assessment
- Cleaning Protocol Premises
- Findings
- Implications
- Recommendations
Purpose of Study

- **Assess potential exposures** to mercury from broken Compact Fluorescent Lamps (CFL)
- **Establish a controlled testing environment** to ensure analytical results are scientifically defensible and statistically validated
- **Develop safe work practices** for Broken CFL cleanup
  - Focus on Postal Worker Cleanups
  - Identification of Contractor Response Strategies
Study Hypothesis

Compact Fluorescent Lamps, whether broken or intact, are recyclable but may cause adverse health effects if not properly managed in an occupational setting.
Focus on Outcome: Work Practice Development

- Two driving factors:
  - Employee Safety in the workplace
  - Guidance for Product Take Back Pilot Program
Study Design & Methodology

- **Critical Factors:**
  - 1) CFL Lamp Mercury Exposure
  - 2) Quantity of CFLs Broken

- **Physical design of test chambers (2):**
  - 8 by 12 by 11.5 feet - full double Poly containment over VAT covered concrete floors

- **Regulatory & Industry Standards Review**

- **Statistical Validation – Price & Associates**
  - Repetitive tests – 5 Independent Tests
Regulatory Background

- Occupational References Standards Drove the Analysis

Mandatory Standards:
- OSHA PEL of 100 ug/m$^3$ (TWA over 8 hours)

Industry and Government Exposure Guidelines
- NIOSH REL and Ceiling Values
  - REL = .05 mg/m$^3$ Time Weighted Average (TWA)
  - Ceiling Value .1 mg/m$^3$
  - NIOSH Ceiling (ILDH) 1.0 mg/m$^3$
- ACGIH PEL and STEL
  - PEL = .025 mg/m$^3$
  - STEL = Not Applicable
- EPA Reference Concentration
Mercury Standards/Advisories

Yellow = Advisories & Red = Mandatory OSHA PEL

Concentration (mg/m³)

- NIOSH IDLH
- NIOSH Ceiling
- OSHA PEL TWA
- NIOSH REL TWA
- ACGIH TLV
- EPA LOAEL
- EPA RfC
- ATSDR MRL
Continuous Exposure Data for Breakage of 30 CFLs: All Trials

All trials 30 Bulb CFL

NIOSH Ceiling

Hg (µg/m³)

minutes s/p breakage
Continuous Exposure Data for Breakage of 4 CFLs: Run 2

Run 2, 4 GE CFL

- Lumex low
- Lumex High

Cleanup
scoop & dump
sulfur
ventilate

Hg ug/m³

Minutes s/p breakage
Continuous Exposure Data for Breakage of 4 CFLs: All Trials

All trials 4 GE CFL

Minutes s/p breakage

Hg ug/m³

Trial 1  Trial 2  Trial 3  Trial 4  Trial 5
4 CFL Exposure Compared to Mercury Standards/Advisories

8 Hour TWA for 4 CFLs
30 CFL Exposure Compared to Mercury Standards/Advisories

8 Hour TWA for 30 CFLs
Exposure Assessment

- Built on Previous Exposure Assessment in August 2004
- Two test chambers; One CFL type Tested (GE Energy Smart – 100 Watt)
- Lumex RA-915 Mercury Analyzer and Jerome 471 Mercury Analyzer meters used for real time readings
  - Covered the Spectrum of Exposures
    - Jerome used for > 100 ug/m³
    - Lumex used for < 100 ug/m³
- Exposures also analyzed with NIOSH test method 6009
Exposure Assessment

- Two Scenarios Investigated: - Each with 5 repetitions
- Scenario 1: 4 CFLs broken simultaneously
- Scenario 2: 30 CFLs broken simultaneously
- Exposure may be affected by the method of breakage and anomalies in mercury levels in manufacturing production
  - Statistical methods address this variation
Cleaning Protocol Premises

- Initial Approach Based on NEWMOA guidance
- Minimize costs – no mercury HEPA vacuums
- Assume breakage in a worst case confined area
- Manual cleaning and use of flowers of sulfur
- Ventilation and temperature controls if possible
  - Ventilation is a Key Exposure Variable
  - Time delay in response is also a key variable
- Proper Personal Protective Equipment (PPE)
  - Cleanups based on exposures below the need for respiratory protection
Cleaning Protocol Premises

- Key Cleaning Assumptions
  - 1 cleaning per day
  - 5 minute wait before response
  - Maximum of four broken CFLs
  - Cleanups limited to Impervious Surfaces
Findings

- 10 clean-up simulations conducted for GE CFLs
- The 4 GE CFLs when broken did not exceed 1 microgram per cubic meter for an 8 hr TWA
- The 30 GE CFLs when broken did not exceed 6 micrograms per cubic meter for an 8 hour TWA
- NIOSH REL Ceiling was exceed three minutes after breakage when 30 CFLs were broken
- OSHA PEL TWA could be exceeded if cleanup exceeded 4.4 hours in containment.

Study Hypothesis is validated for breakage of large quantities of CFLs.

- There are health concerns associated with uncontrolled breakage of 30 CFLs or more (e.g., bulb crushing operations).
**Implications**

- Work Practice and Job Safety Analysis (JSA) Guidance can now be used to respond to incidents involving 4 or fewer CFLs in the USPS

- Draft Report was Prepared November 2007

- Final Report is being reviewed by USPS Headquarters’ Industrial Hygienist

- Union Briefings are Planned for Spring 2008

- Business Development has already been Briefed
  - Product Take Back Implications are Huge

- Strategy for Formal Release of Document is still Pending
Recommendations

- Findings are applicable to both governmental and private workplace environments
- USPS Recommends Limiting Cleanup of 4 or fewer CFLs to avoid potentially exceeding ACGIH and NIOSH Ceiling Guidelines
  - Initial and refresher training is a prerequisite
- The actual upper limit of acceptable exposure may be greater than identified in this study.
  - However, out of an abundance caution, the concept of “incidental breakage” should be limited to 4 or fewer CFLs
  - Regulatory Agencies should re-evaluate their “incidental bulb breakage” cleanup guidelines.