Drum-Top Crushing of Mercury Lamps

Cathy Davis
US EPA Office of Solid Waste

Presented to:

Northeast Regional Mercury Science & Policy Conference

April 26, 2006

What is Drum-Top Crushing?

- Drum-Top Crushers (DTCs) are devices designed to reduce the volume of waste fluorescent lamps
  - DTCs fit on the top of a 55 gallon drum
  - DTCs are designed to contain the Hg released from lamps when they are broken

Why are Mercury Fluorescent Lamps Important?

- Many waste fluorescent lamps are hazardous waste because they exhibit the toxicity characteristic for Hg
  - However, many generators of waste lamps are conditionally exempt small quantity generators (CESQGs)
  - Some low-Hg lamps do not fail the TCLP
- Lamp crushing is considered waste treatment because it:
  - changes the physical form of the waste and reduces volume to make storage and transport safer and easier (40 CFR 260.10)

How is Drum-Top Crushing Regulated?

Hazardous Waste

- Hazardous Waste treatment usually requires a RCRA waste treatment permit.
  - Exception: Waste generators may treat wastes without a RCRA treatment permit, under 40 CFR 262.34 accumulation regulations
  - However, lamps crushed under this provision cannot subsequently be handled as UW

Universal Waste

- In the UW rule preamble, EPA said states could allow crushing by UW handlers if the state program includes a demonstration of equivalency to the federal ban on treatment without a RCRA permit, including:
  - Effective Hg emissions controls
  - Compliance assurance

Use of Drum Top Crushers

- The key questions in operating DTCs are:
  - How much Hg is released?
  - Who is exposed?
  - What are exposure levels?
  - How much Hg ultimately enters the environment?

EPA's DTC Study

- The lack of detailed guidance in the UW rule preamble, and the prompting of one state, led Region 3 to draft guidance to state programs interested in allowing crushing
- Discussion of the draft guidance led to interest in a better understanding of DTC performance
- Region 3 took the lead in conducting a study of DTCs
- Goal of study: provide information about DTC performance and potential for Hg exposure

DTC Study Overview

- Four DTCs*
- Five rounds of testing
  - Approximately 5500 lamps crushed per device
- Three locations
  - Tests conducted in Virginia, Arizona and Florida

*One DTC did not complete the Study due to poor performance

DTC Study Overview

- Testing was done inside at permitted commercial lamp recyclers:

  Thank You

  AERC and EPSI

- Before each test a 12'x12'x10' polyethylene containment was constructed to:
  - reduce the effects of variations in air circulation on Hg levels
  - isolate the test from background Hg

DTC Study Scope

- Initial Components of Study Design
  - Performance Validation Study
  - Extended Field Test Study
    - Overnight Tests
    - U-Tube Tests
  - Mass Balance Study
- Additional Components
  - Box Tests

DTC Study Methods

- Mercury vapor concentrations were measured using

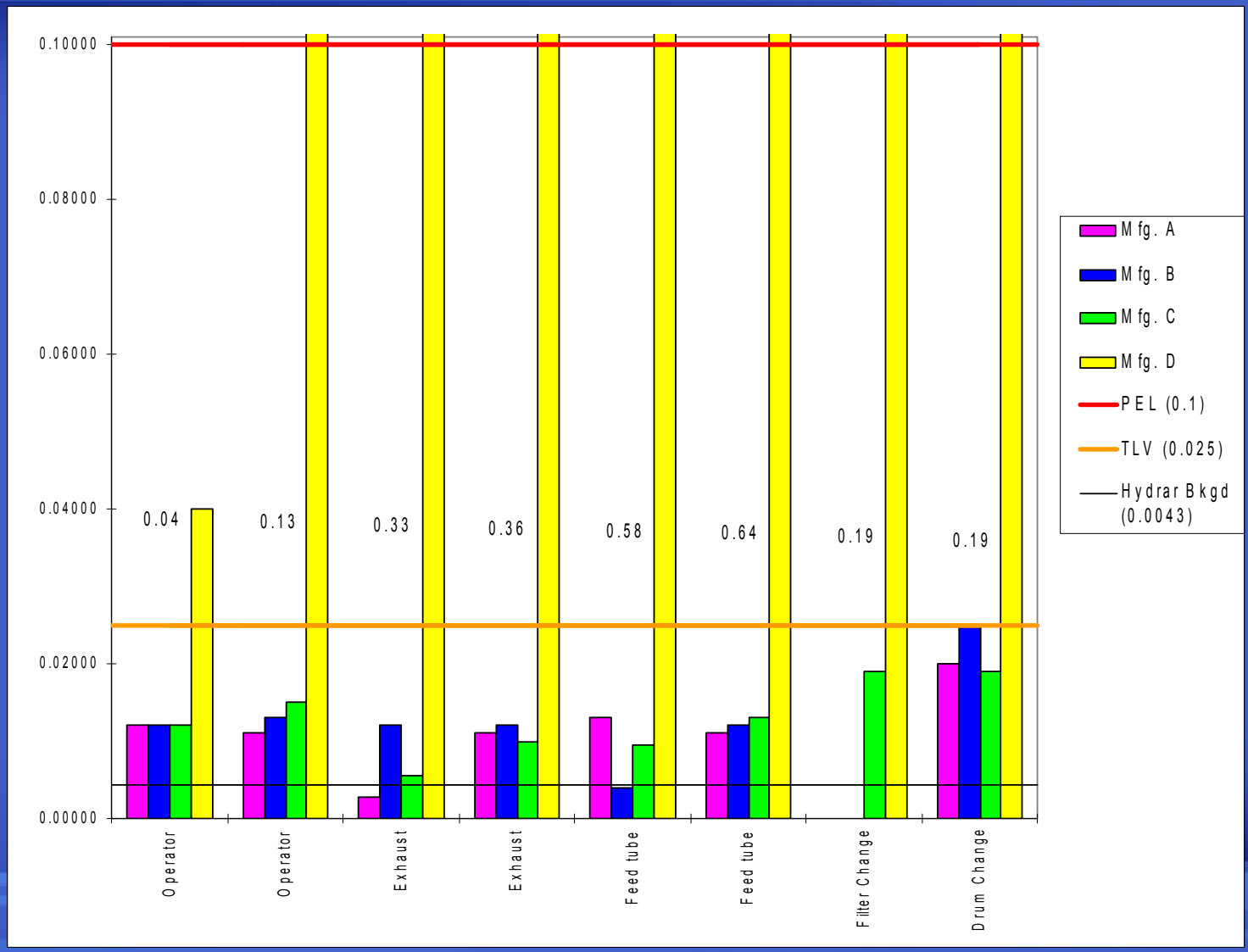
  - Hydrar sample media
    - In the operator's breathing zone (shoulder)
    - Near DTC exhaust ports and DTC feed tubes
    - During drum changes (shoulder)
    - During non-operations periods (overnight)
  - Jerome Mercury Vapor Analyzers
    - In the ambient air within and outside the containment

DTC Study Results

- A total of 185 Hydrar samples were collected during device operation (not including overnight and background samples)
- 65 samples (35.1%)
  < ACGIH TLV (0.025 mg/m^3)
- 84 samples (45.4%)
  ≥ ACGIH TLV (0.025 mg/m^3)
  < OSHA PEL (0.1 mg/m^3)
- 36 samples (19.5%)
  ≥ OSHA PEL (0.1 mg/m^3)
- Values would be expected to be lower with normal ventilation in an environment that did not have the same level of background mercury

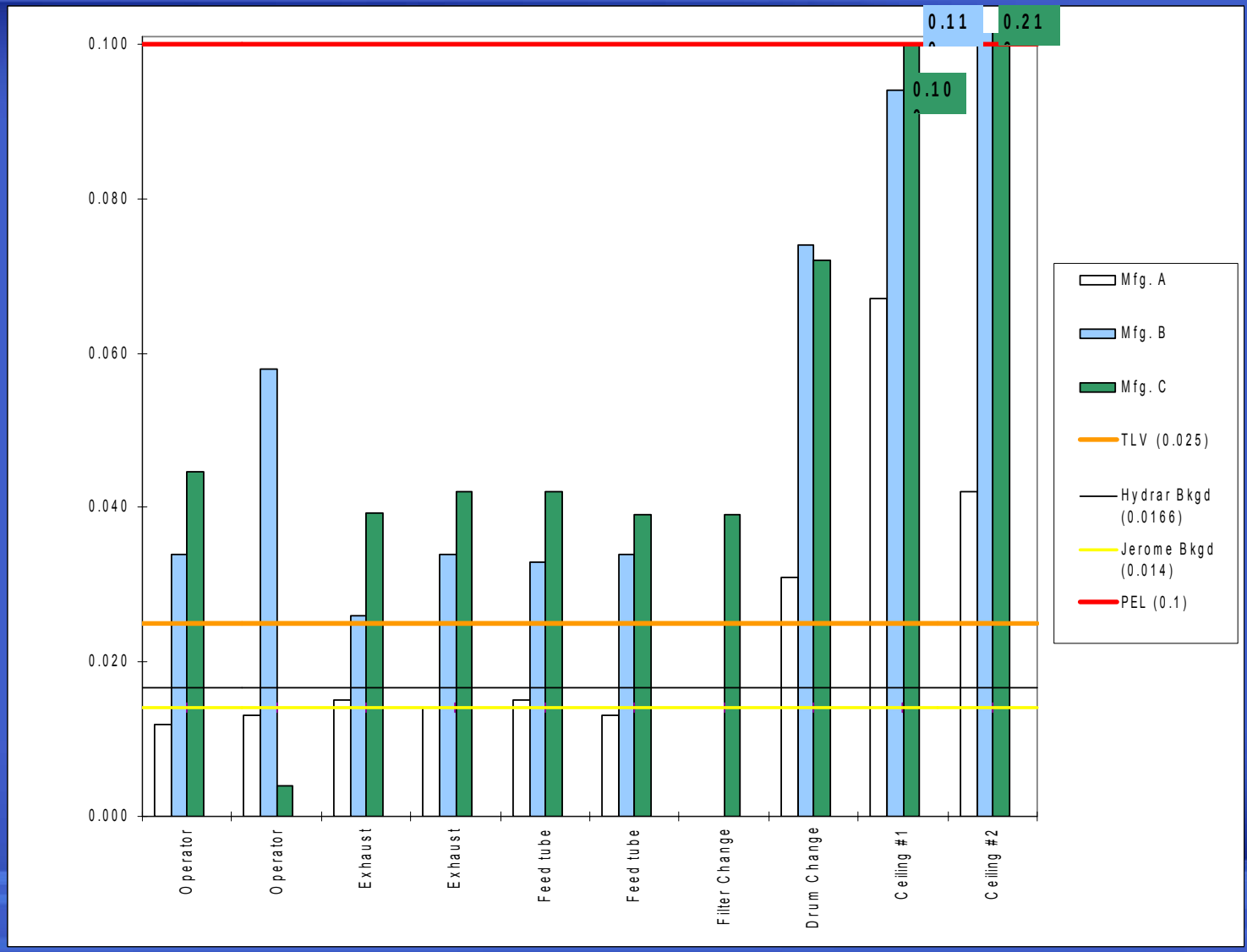
DTC Study Results

Performance Validation Study - I



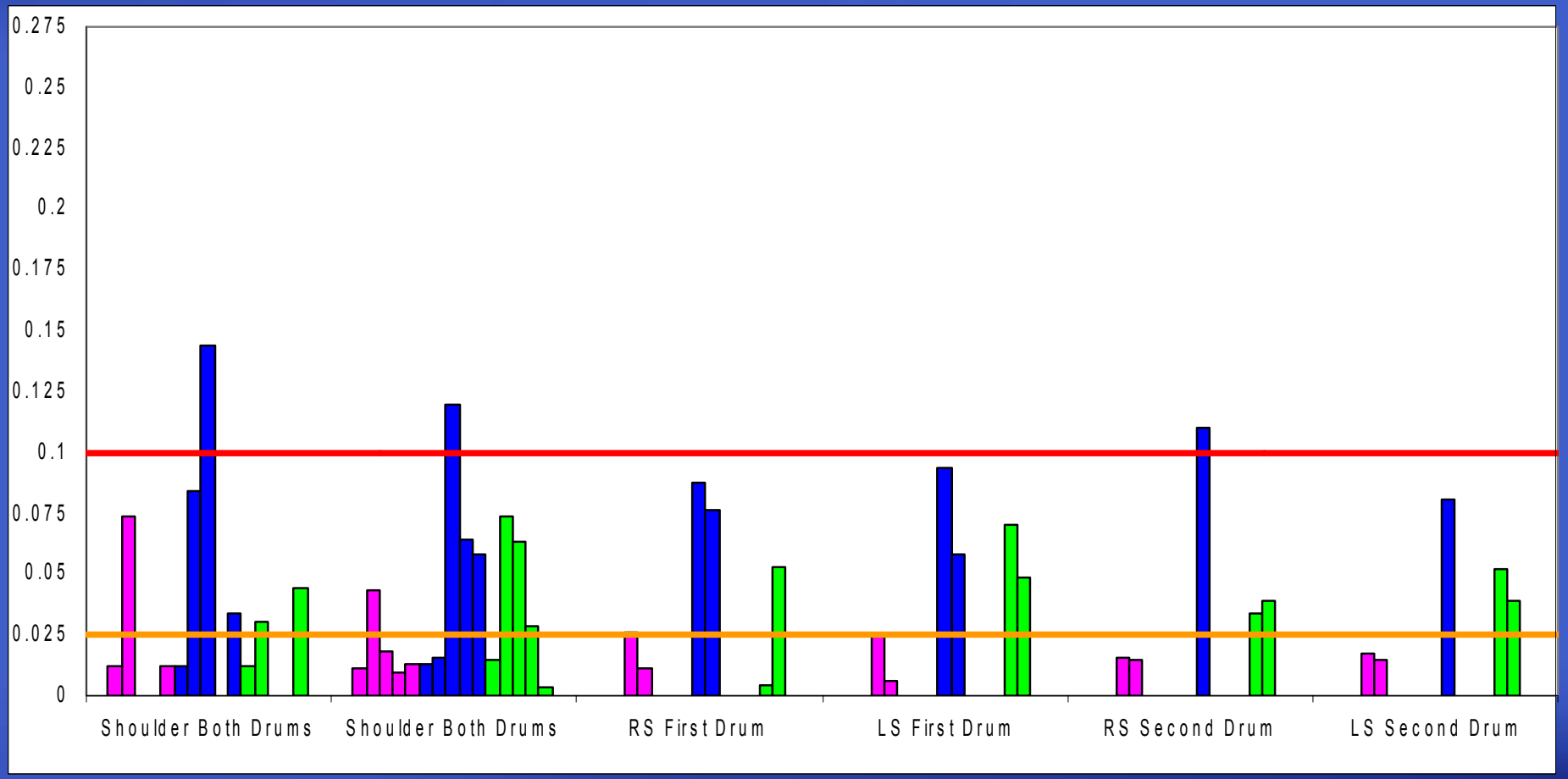
DTC Study Results

Performance Validation Study - II



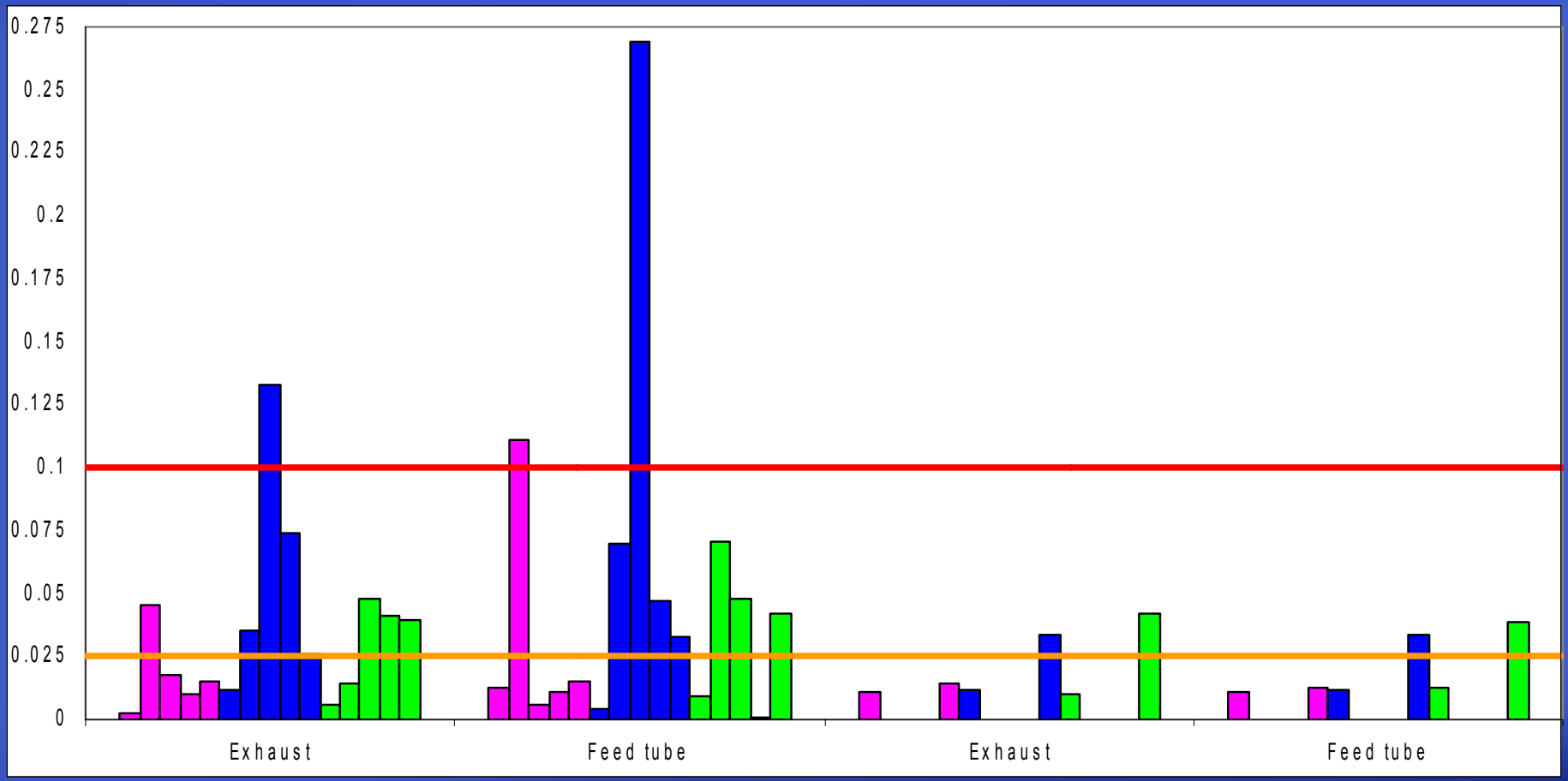
DTC Study Results

Operator Shoulder Samples



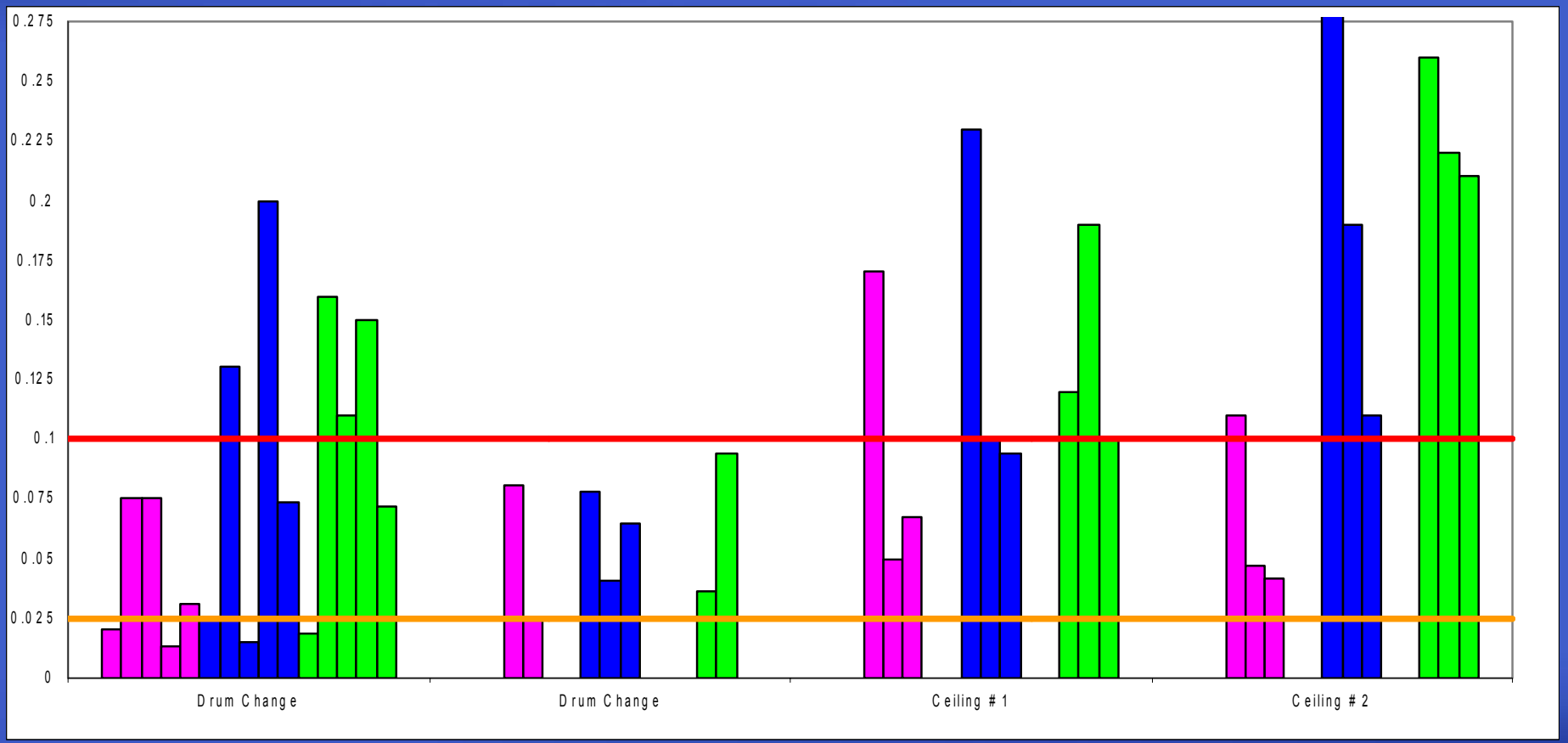
DTC Study Results

Exhaust and Feed Tube Samples



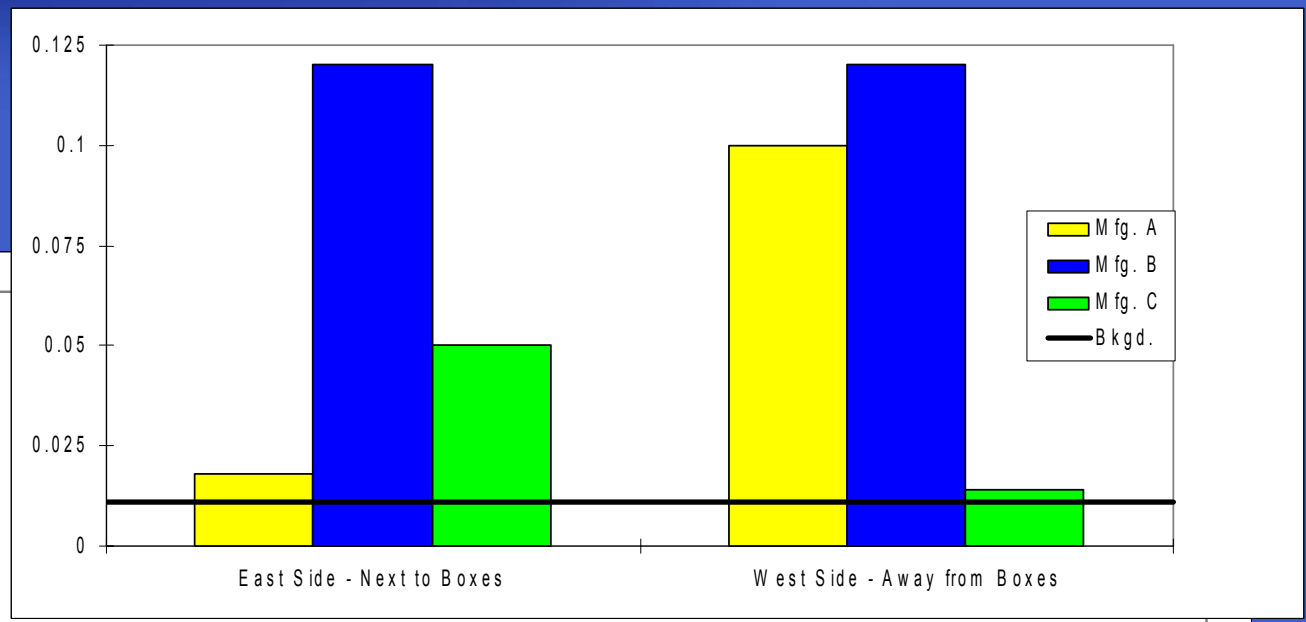
DTC Study Results

Drum Change and Ceiling Samples



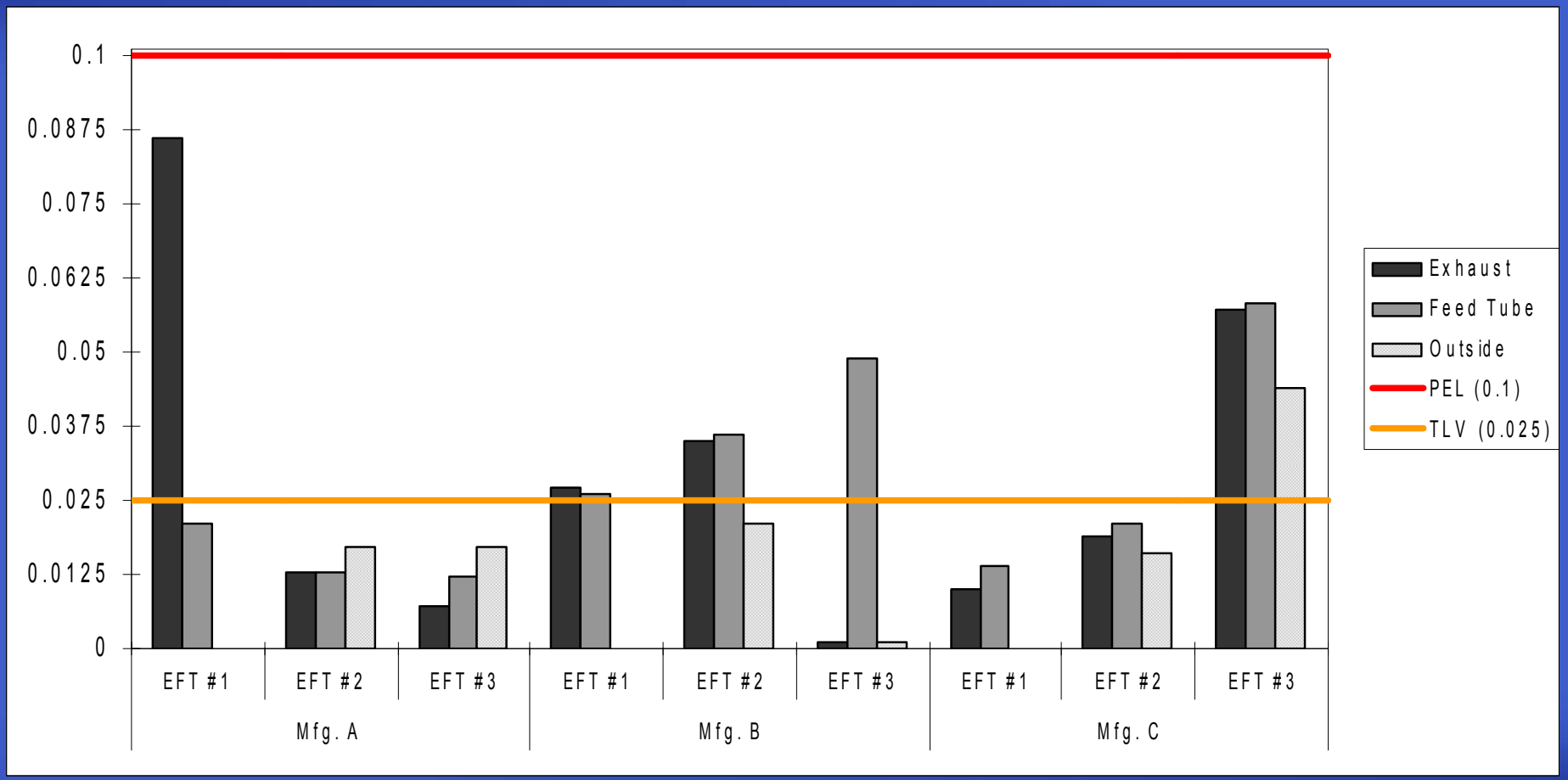
DTC Study Results

Box Test



DTC Study Results

Overnight Samples



DTC Study Results
Mass Balance Study

- The Mass Balance Study was unable to establish a concrete relationship between mass input and output
- For all three devices, the total Hg mass accounted for in the crushed lamps, pollution control media, and air samples was about ⅓ to ⅔ of the estimated Hg input (from measurements of whole, spent lamps)
- Several variables may have contributed to the differences between inputs and outputs
  - inaccuracies in the determination of Hg in the crushed lamps (due to Hg stratification in the drum)
  - inaccuracies in the determination of Hg in the filter media
  - absorption of Hg on the containment structure and inside the DTC device
  - inaccuracies in the estimation of Hg in the whole, spent lamps

DTC Study Limitations

- A number of factors were identified that may have affected the study results
  - Hg background levels inside the facilities where the tests were performed
  - Differences in environmental conditions (i.e., temperature and relative humidity) at each test site resulting in greater or lesser volatilization of Hg
  - Cross-contamination from lamps broken during shipment to the processing site

DTC Study Observations

- One device allowed Hg concentrations to reach nearly 9 x the PEL during crushing, even when outside temperatures were low and only Alto® lamps were crushed
- Proper DTC assembly and operation are critical
  - A gasket was missing from the Mft. A device during the first EFT, and the samples collected were significantly higher (based on ANOVA) than those collected during the other two EFTs

DTC Study Observations

- Higher level Hg release during drum changes are inevitable
- Release can be reduced through:
  - Practicing the drum change procedure
  - Use of a 2-person team
- The only device that maintained its ability to contain the Hg over the duration of the Study had 3 to 10 times more activated carbon in its pollution control system than the other devices

DTC Study Observations

- Operator Safety – PPE was used by the study team
  - Safety glasses – to protect from flying glass shards
  - Full-face shields – to protect from flying glass shards
  - Puncture-resistant (Kevlar®) gloves
  - Hearing protection
  - Respirators – when air monitoring readings were above pre-determined safe levels
  - Disposable Tyvek® coveralls – to reduce skin exposure to Hg and the possibility of tracking Hg out of the testing facility

DTC Study Observations

Potential Design Modifications

- Possible design modification noted by the study team:
  - Development of leak detection systems
  - Improvement of Hg capture during Drum Change
  - Develop sulfiding agent injector to convert Hg vapor in drum to HgS
  - Increase the amount of pollution control used in the device
- This Study was not designed to assess these options, so research and development would be needed to determine whether these modifications would improve performance

DTC Study Observations
Benefits of DTC Use

- Disposal of lamps in dumpster will cause lamps to break and some of the Hg in the lamps will be released to the environment by volatilization, by leaching from landfills, or in landfill gas
- DTCs may make it easier for generators to recycle fluorescent lamps by reducing lamp volume, thereby reducing storage and shipping costs, and likely, recycling costs (on a per-lamp basis)
- Shipping sealed drums of crushed lamps may release less Hg than shipping whole lamps

DTC Study Observations Drawbacks of DTC use

- Use of DTCs will create new Hg exposures
  - Direct Exposure
  - Indirect Exposure
    - Could avoid indirect exposures by keeping the ventilation of the lamp crushing room completely separate from the general building ventilation (as done at industrial lamp recycling facilities)
- None of the DTCs evaluated in this Study completely controlled Hg emissions while crushing lamps, even when operating conditions were optimal
- Maintaining optimal performance over years of DTC use, for the devices tested, will be challenging
- Operation of DTCs under study conditions lead to non-compliance with the OSHA PEL

Guidance to State Programs on Drum-Top Crushing

After the study report is released we expect to return to the development of guidance to states on drum-top crushing programs

Conclusions

- Strong interest in lamp crushing to reduce volume and save transportation cost
- Lamp crushing can reduce overall environmental releases but will create new exposures:
  - Crusher operator
  - Potential co-worker exposures
  - Potential exposures to the general public
  - Potential point-source releases to the environment