Research Update: Leaching of Hazardous Chemicals from Discarded Electronics

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Presented on September 23, 2002

National Electronic Equipment Management and Compliance Assistance Workshop

Atlanta, GA

E-Waste Contains Toxic Chemicals

- Heavy metals
  - Lead
  - Mercury
  - Cadmium
- Organic chemicals
  - Polychlorinated biphenyls
  - Brominated flame retardants

Project Currently Being Funded by Regions 4 and 5

- Leaching of Hazardous Chemicals from Discarded Electronic Devices

Focuses on TCLP methods development for discarded electronic devices and toxicity characterization of computer CPUs

Projects Funded by the Florida Center for Solid and Hazardous Waste Management

- Past -- Investigation of TCLP Leachability of Leaded CRT Glass
- Current -- Assessment of True Impacts of E-Waste Disposal in Florida

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Presentation Objectives

- Summarize previous and current research on leaching of hazardous chemicals from discarded electronics
  - Cathode Ray Tubes
  - Printed Wire Boards
- Present future research areas

Background

- The question is frequently raised: “Are discarded electronic devices toxicity characteristic hazardous wastes?”
- Dilemma: How do you perform a TCLP on a device like a television or a computer?
  - Size reduction
  - Representative sampling

Research

- Toxicity characterization of:
- Cathode Ray Tubes
  - Computer Monitors
  - Televisions
- Printed Wire Boards
  - Computers
  - Many other devices

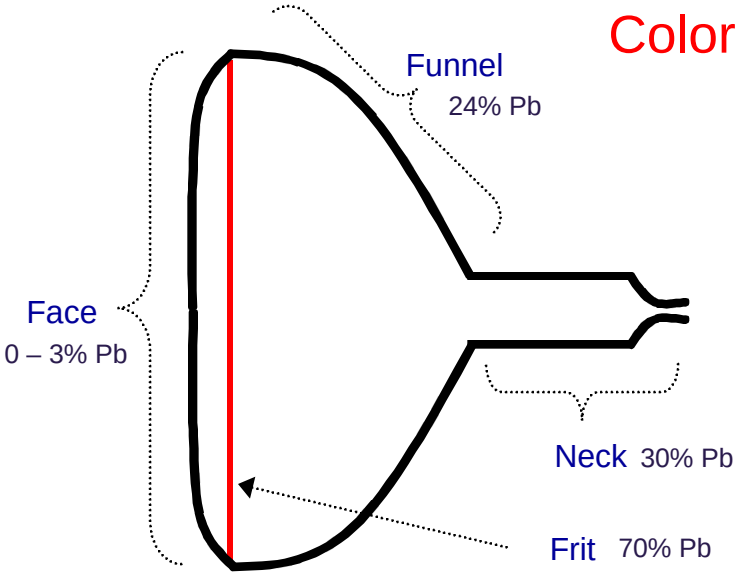
Focus on Lead

Pb

Results of Toxicity Characteristic Testing of CRTs

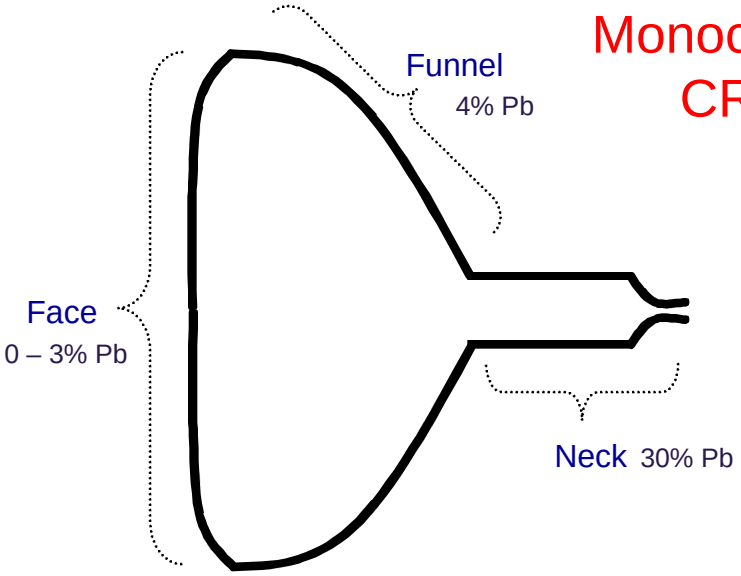
CRTs: Where is the Lead?

Color CRTs



CRTs: Where is the Lead?

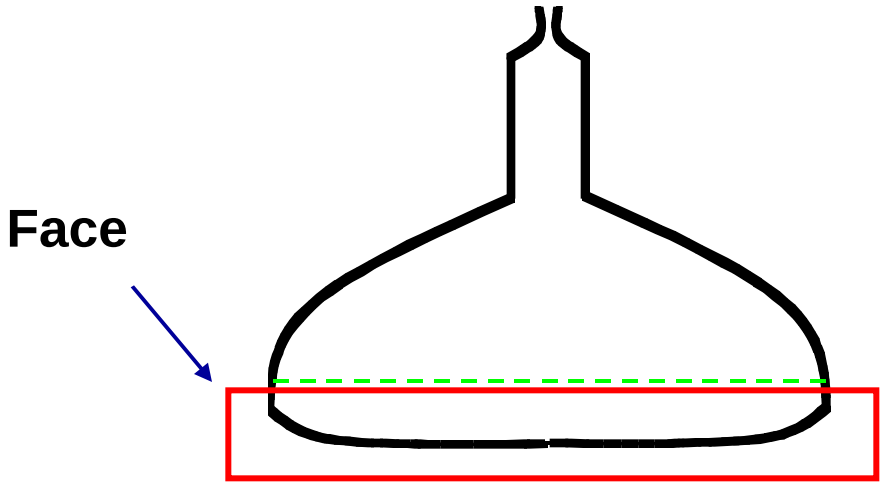
Monochrome CRTs

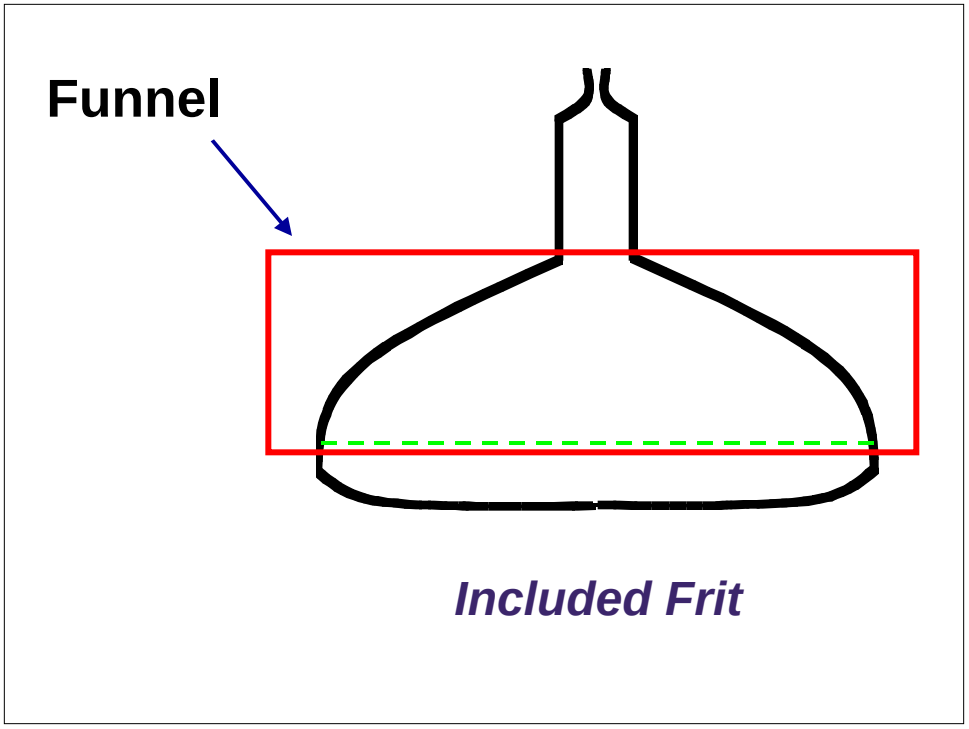


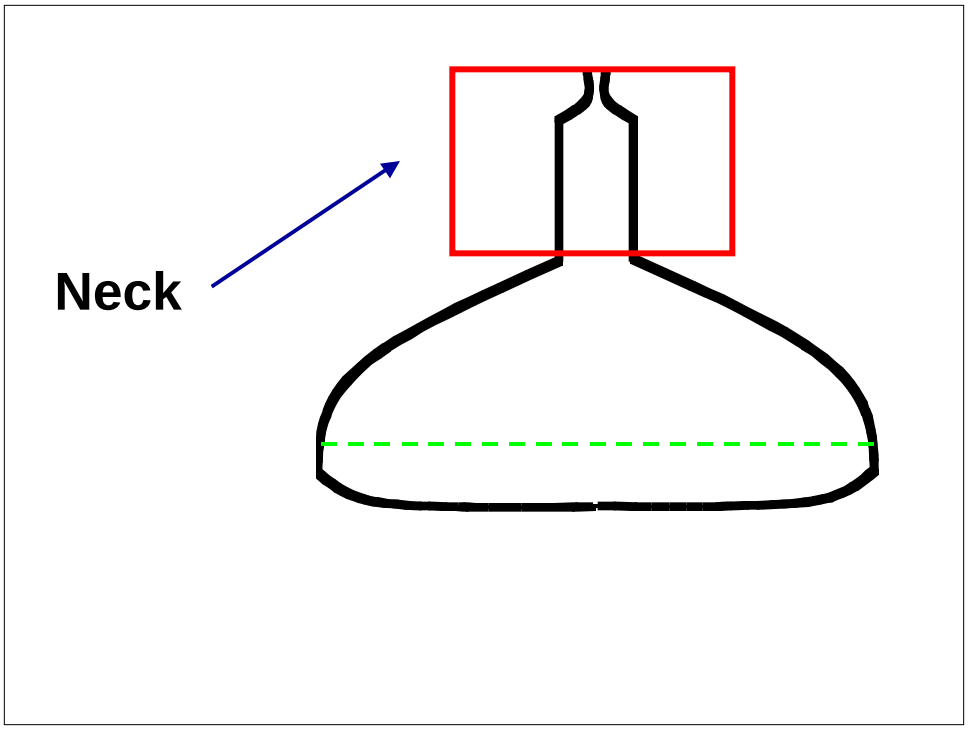
Methods

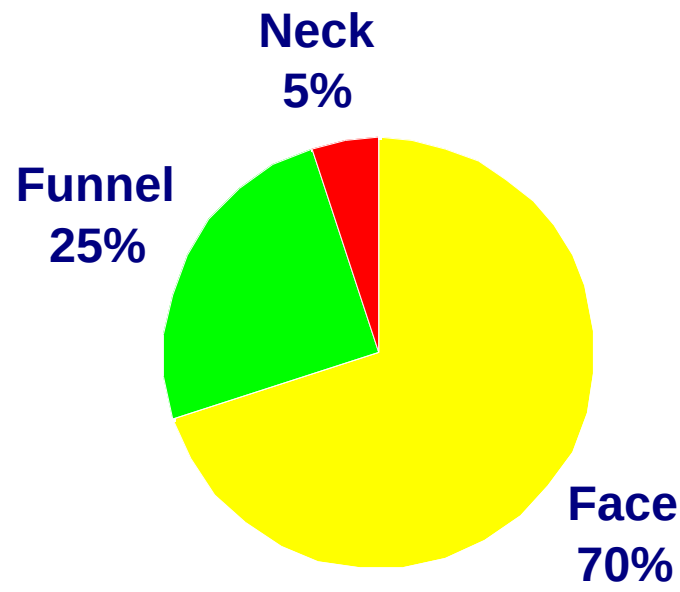
Each CRT divided into three fractions

- Face, Funnel, Neck




Funnel
Included Frit


Neck



Methods

Samples of glass (200 to 500g) were selected and crushed to pass a 9.5mm sieve.

Methods

TCLP performed on crushed samples

- 36 CRTs x 3 fractions
- plus replicates and blanks

Methods

A weighted average TCLP lead concentration was calculated using fraction masses

$$\overline{TCLP} = \frac{TCLP_N M_N + TCLP_{Fu} M_{Fu} + TCLP_F M_F}{M_N + M_{Fu} + M_F}$$

Results

- Face
  - Color: 1 of 30 exceeded 5 mg Pb/L
  - Monochrome: 0 of 6 exceeded 5 mg Pb/L
- Funnel
  - Color: 30 of 30 exceeded 5 mg Pb/L
  - Monochrome: 0 of 6 exceeded 5 mg Pb/L
- Neck
  - Color: 28 of 30 exceeded 5 mg Pb/L
  - Monochrome: 0 of 6 exceeded 5 mg Pb/L

Weighted Average Results

- Total CRT
  - Color: 21 of 30 exceeded 5 mg Pb/L
  - Monochrome: 0 of 6 exceeded 5 mg Pb/L

Are Monitors and Televisions TC Hazardous Wastes?

- Variability of sample concentrations resulted from sampling method
- A follow up study was conducted:
  - All CRT funnel glass combined
  - TCLP performed on different particle sizes

TCLP Pb Concentrations of Funnel Glass

- Ranged from:

  108 mg/l to 238 mg/l

Large particles 108 mg/l

Small Particles 238mg/l

Color CRTs are Hazardous

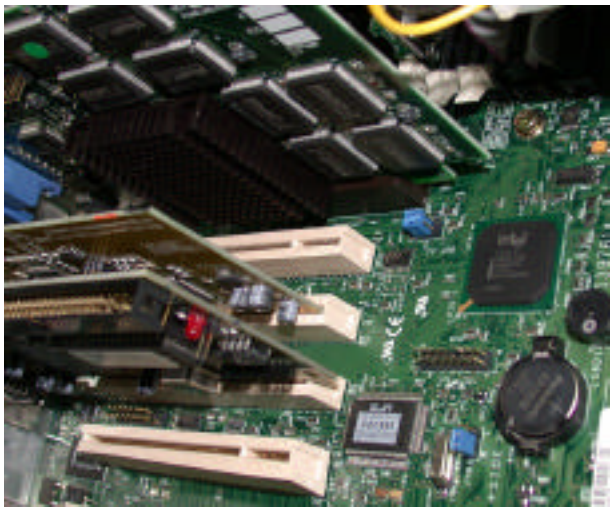
- Even at largest particle size
- Remember, 25% of CRT is funnel and frit.

TCLP = 25%(108mg/l) = 27 mg/l

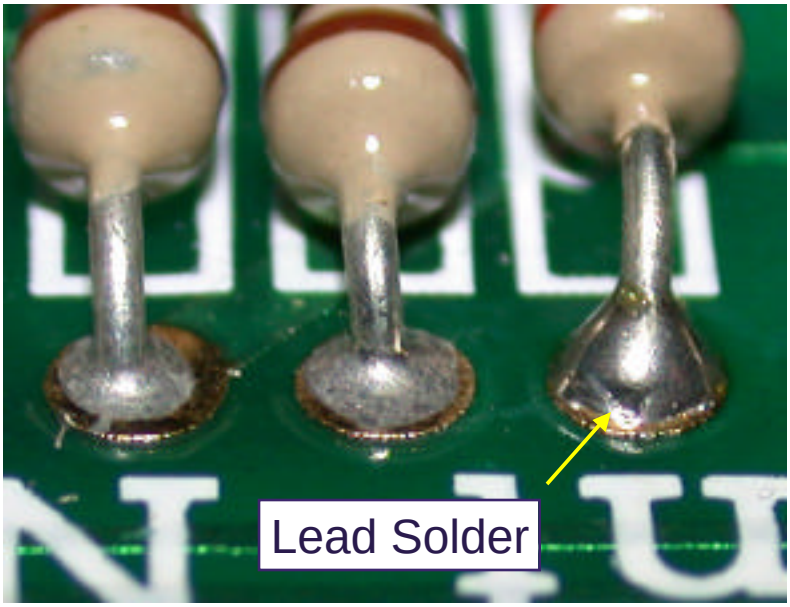
Are Televisions and Monitors a Hazardous Waste?

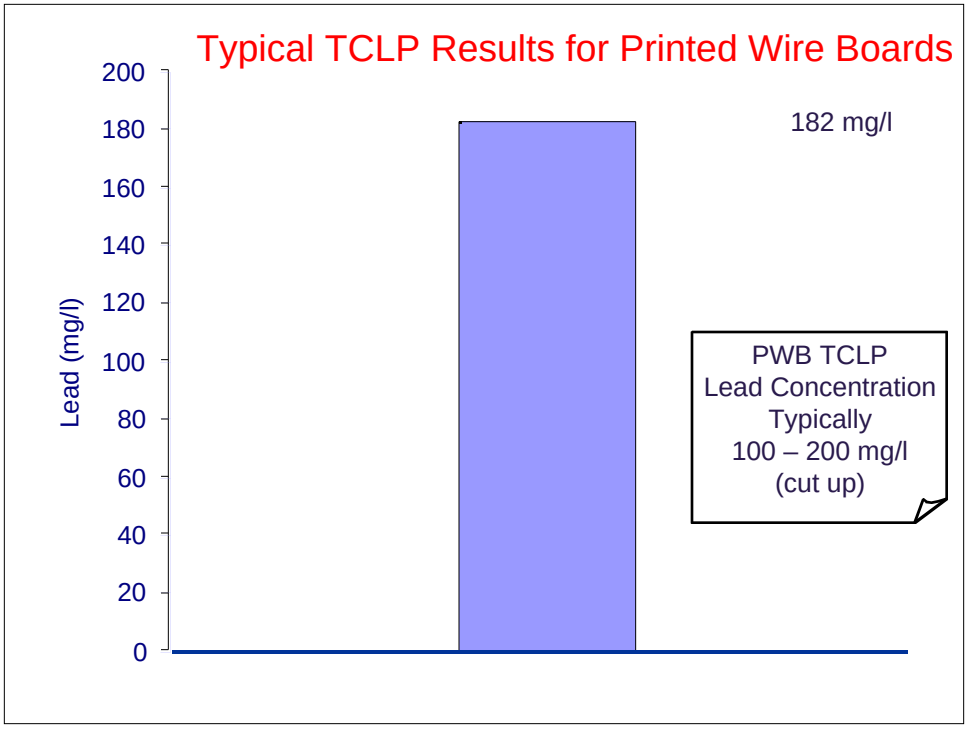
- In this study, CRTs made up >50% of TV or monitor mass. Median value = 55%.
- ***TCLP = 27 mg/l x 0.55 = 15 mg/l***

Toxicity Characteristic Testing of PWBs



Where Does Lead Come From?



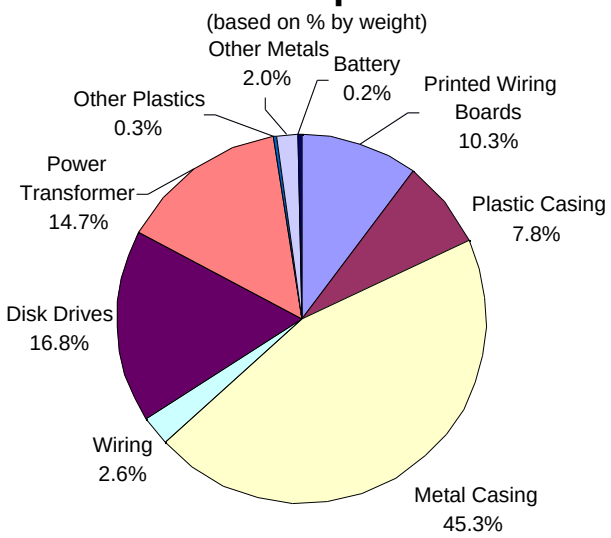


Are Computers a Toxicity Characteristic Hazardous Waste?

- Use weighted average approach:
- Assume 150 mg/l Pb. If PWBs make up 10% of the mass of a computer:

CPU Components

(based on % by weight)



Average of 12 CPUs

Are Computers a Toxicity Characteristic Hazardous Waste?

- Use weighted average approach:
- Assume 150 mg/l Pb. If PWBs make up 10% of computers:

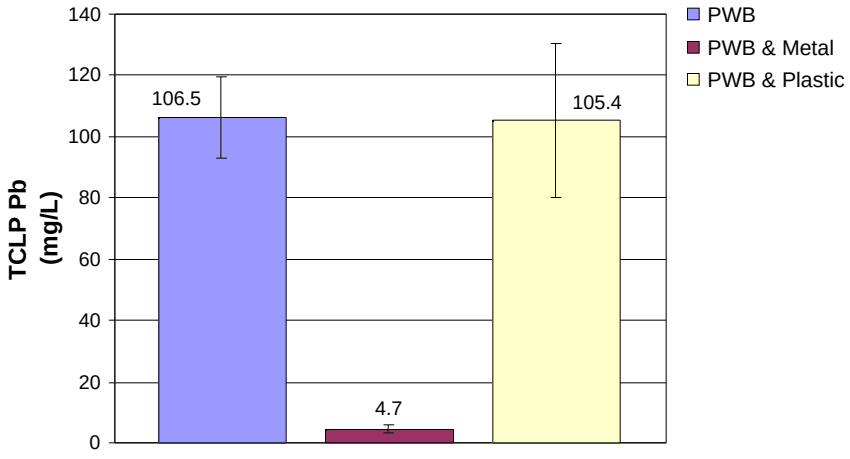
- ***TCLP = 150 mg/l x 0.10 = 15 mg/l***

Caution! The presence of other chemicals may impact lead leachability

Impact of Other Materials

- An experiment was performed to evaluate the impact that the components of a CPU have on Pb leaching during TCLP.
- Samples:
  - 50g PWB
  - 50g PWB & 50g Plastic
  - 50g PWB & 50g Metal

Analysis of Materials Mixing TCLP Leachates



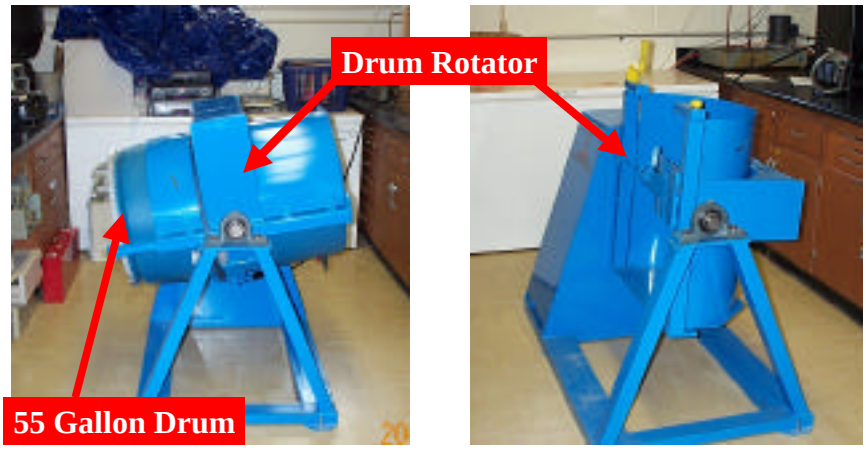
Other Materials Matter!

- Questions:
- How does this impact previous results for CRTs?
- How do we perform a TCLP that allows us to factor this in?

Development of Large-Scale Testing Device for TCLP

- A large drum rotator has been modified to run a scaled-up modified TCLP.
- Entire devices can be leached.

The Large Extractor

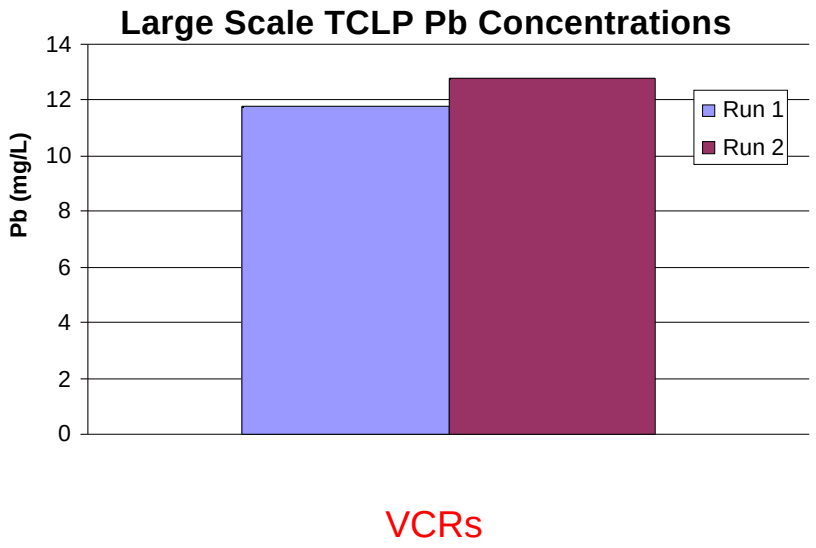


Notes on Data

- Data presented for large-scale runs are only preliminary. They are intended to provide an idea of what typical results might look like.
- Only CPUs are being evaluated in detail as part of the grant agreement. Results from other devices may not be representative of all such devices.

Large Scale TCLP On VCR

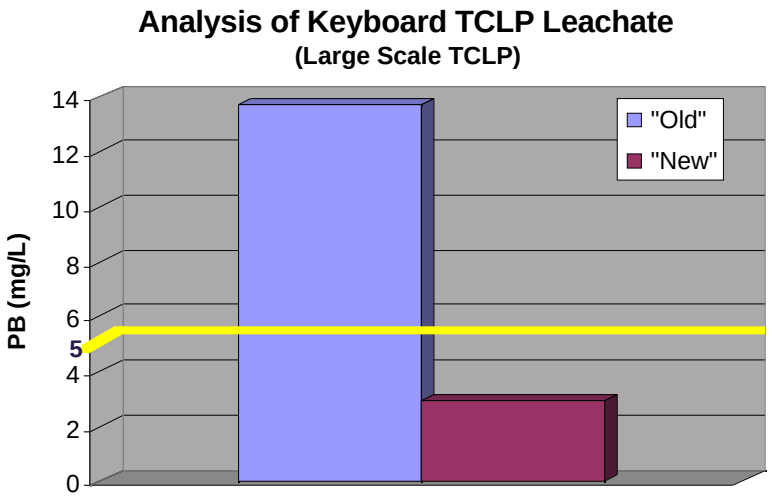
- 2 Runs
- Each run contained 3 VCRs
- Dissembled and placed into extractor



Large Scale TCLP On Keyboards

- Runs
  - “Old” – 4 keyboards
  - “New” – 5 keyboards
- Dissembled and placed into extractor

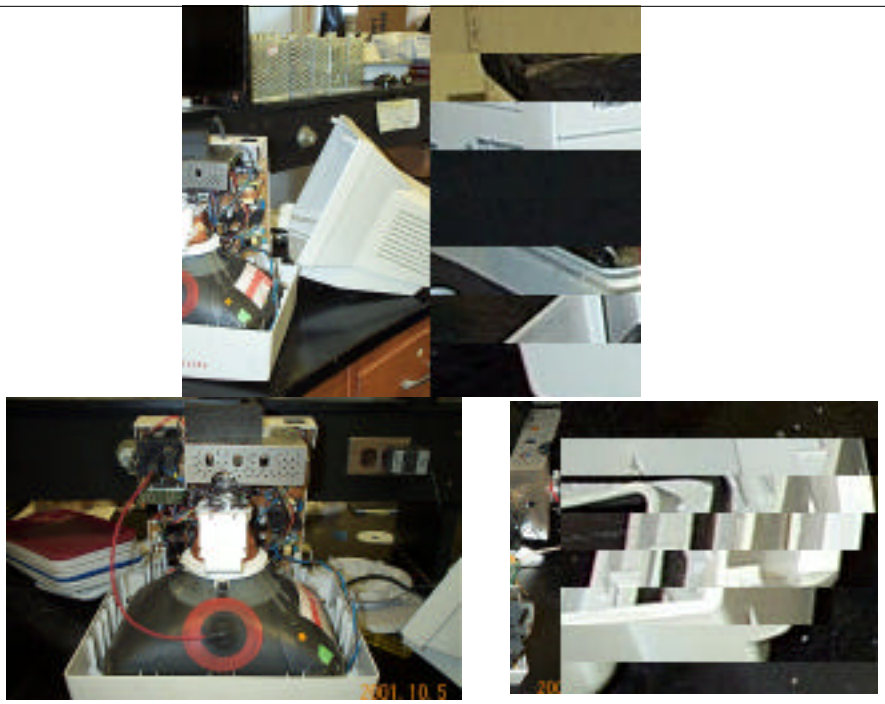
Keyboards



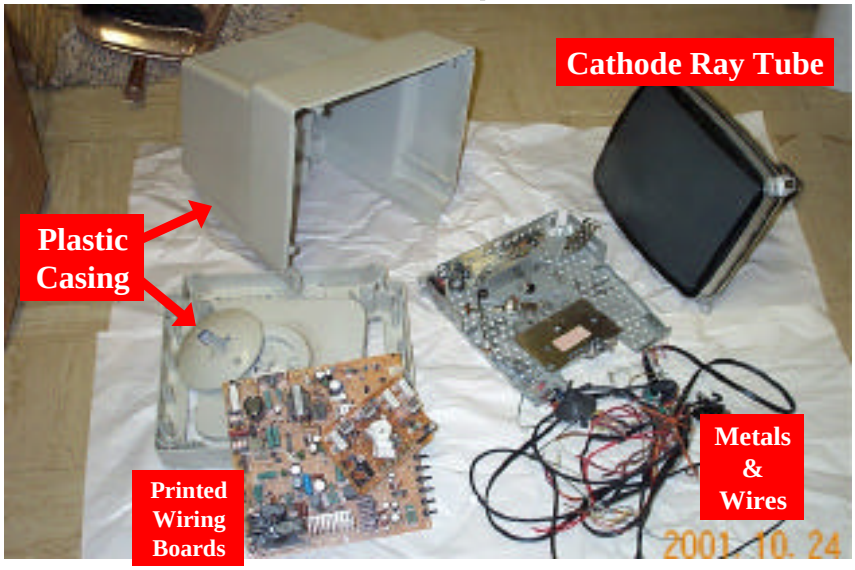
"Old" – 4 keyboards
"New" – 5 keyboards

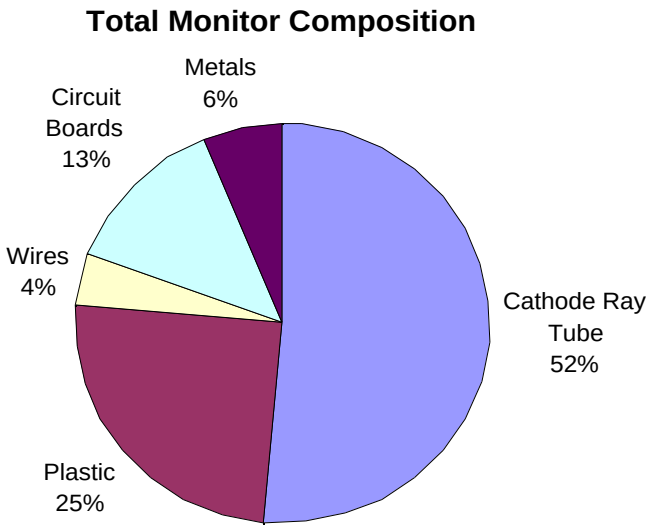
Large Scale TCLP On Computer Monitor

- 3 Runs
- 1 Monitor Per Run
- The Monitor Was Dissembled And The CRT Removed
- CRT Broken Up
- Entire Monitor Placed Into Extractor
  - Up to 20 lbs



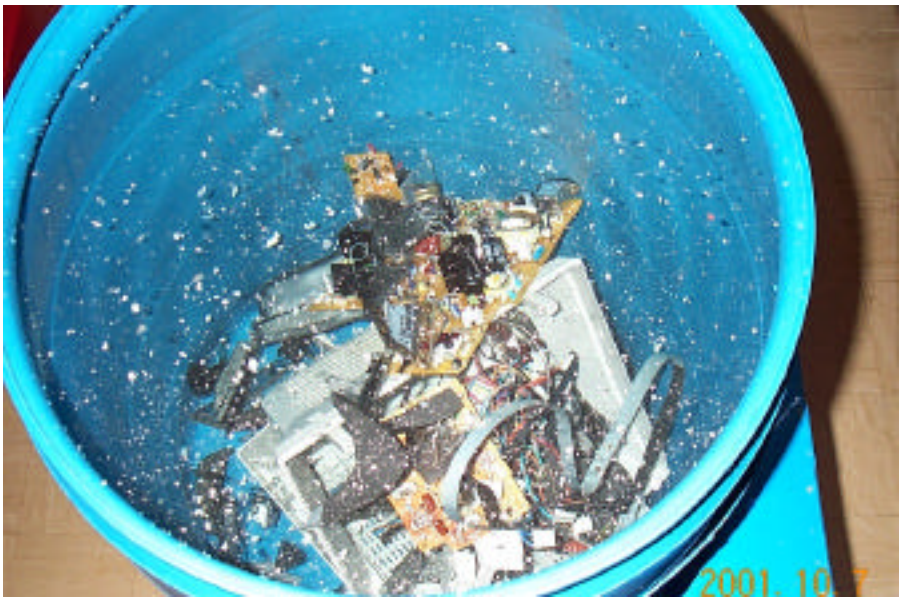
Monitor Components




Total Monitor Composition
Metals
6%
Circuit
Boards
13%
Wires
4%
Cathode Ray
Tube
52%
Plastic
25%

One monitor


2001. 10. 7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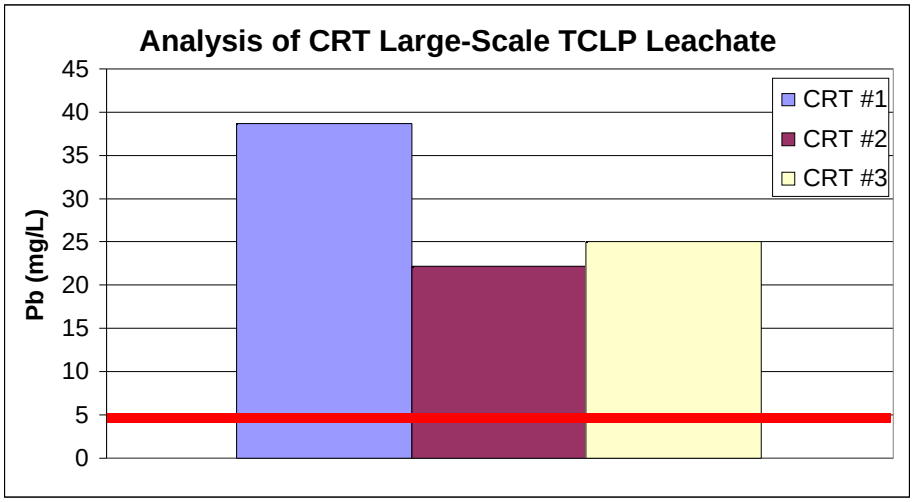


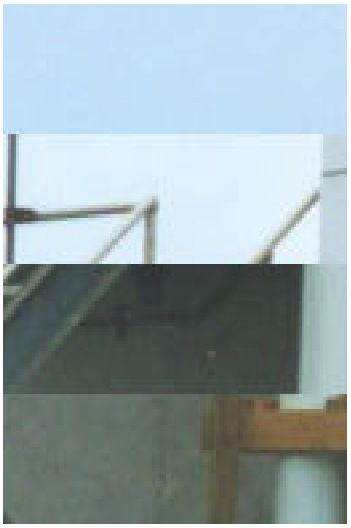
Status

- Currently in the process of selecting and evaluating methods for conducting the TCLP on CPUs

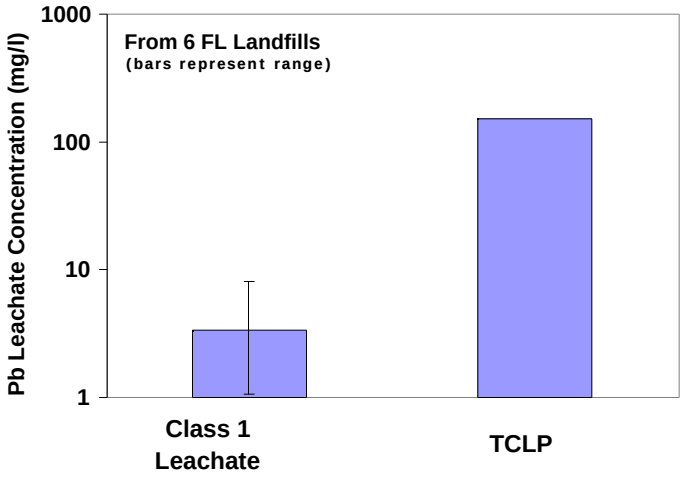
Other Areas of Research

- Simulated E-waste disposal in landfills
- Measurement of brominated flame retardants in landfill leachate
- Compare TCLP leaching concentrations with concentrations obtained when leached with actual landfill leachate

Assess fate of heavy metals in E-waste when co-disposed with MSW



Comparing E-Waste Metal Leachability in Landfill Leachate to TCLP



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