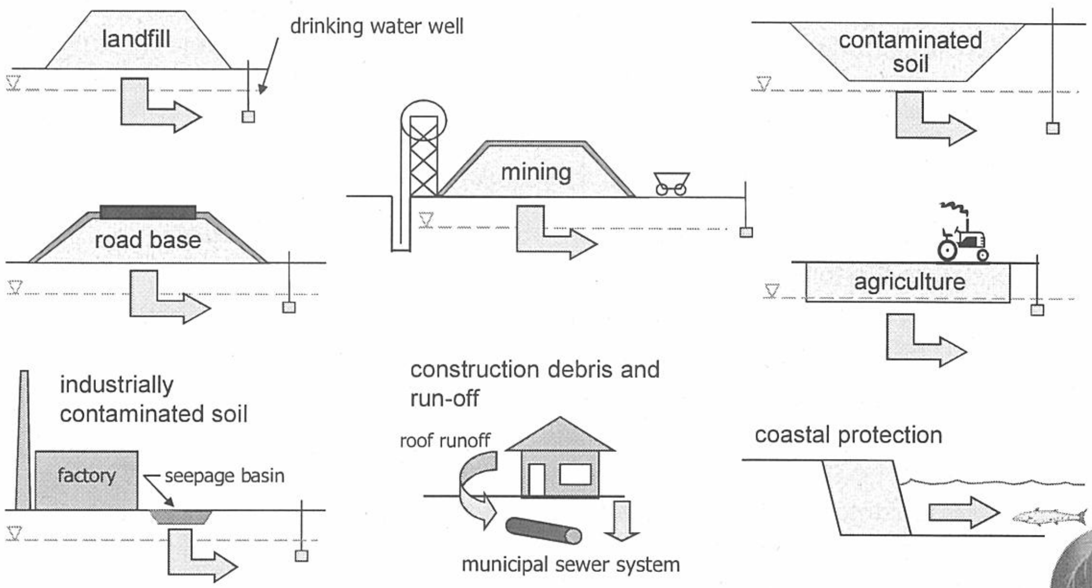
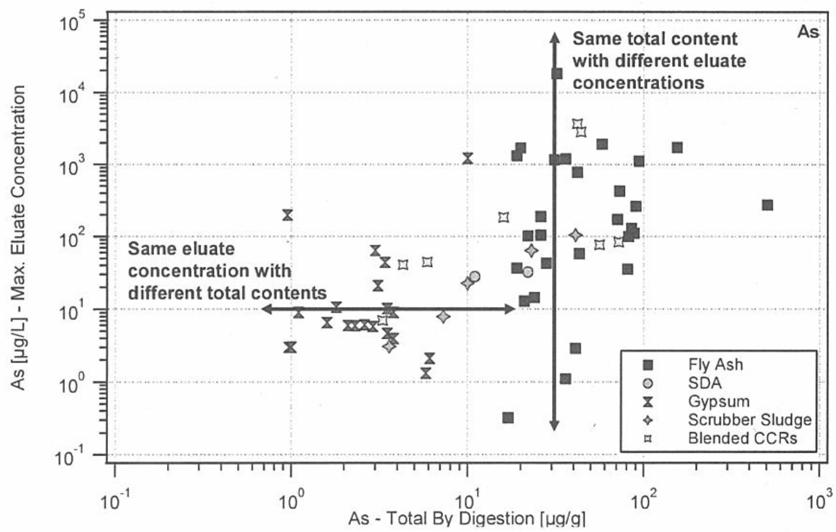
Many Leaching Scenarios …



Total Content

Total Content **Does Not** Correlate to Leaching



Leaching Method Development

Leaching characterization applied to anticipated release conditions resulting in improved accuracy and more reliable environmental decision making

"An Integrated Framework for Evaluating Leaching in Waste Management and Utilization of Secondary Materials," D.S. Kosson, H.A. van der Sloot, F. Sanchez, and A.C. Garrabrants, Environ. Engr. Sci., 19(3): 159-204, 2002.

Parallel and coordinated methods development in the EU

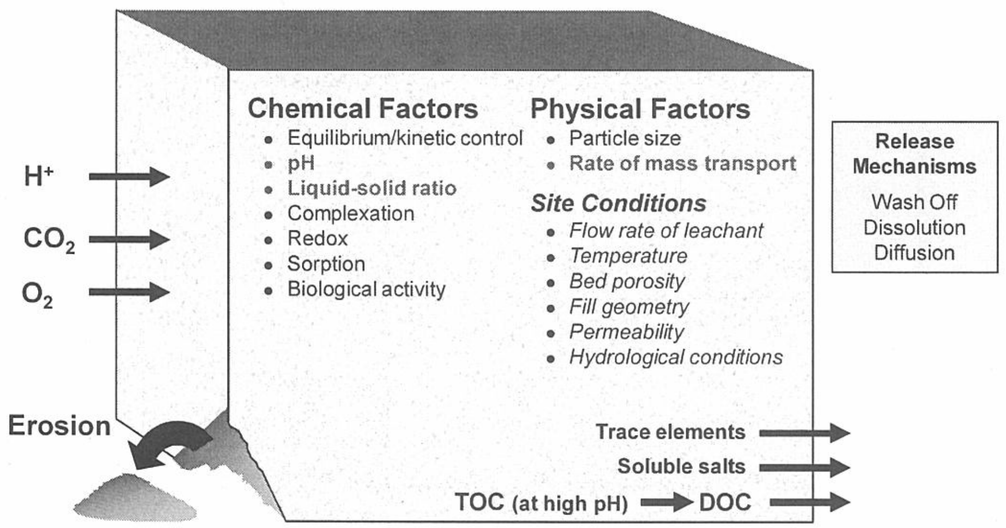
Designed to address concerns of EPA Science Advisory Board

- Considers the form of the material (e.g., monolithic)
- Primary focus on parameters that affect leaching [(e.g., pH, liquid-solid ratio (L/S), release rate)]

Intended for situations where TCLP is not required or best suited

- Assessment of materials for beneficial reuse
- Evaluating treatment effectiveness (determination of equivalent treatment)
- Characterizing potential release from high-volume materials
- Corrective action (remediation decisions)

Controlling Factors



Leaching Environmental Assessment Framework

LEAF is a collection of …

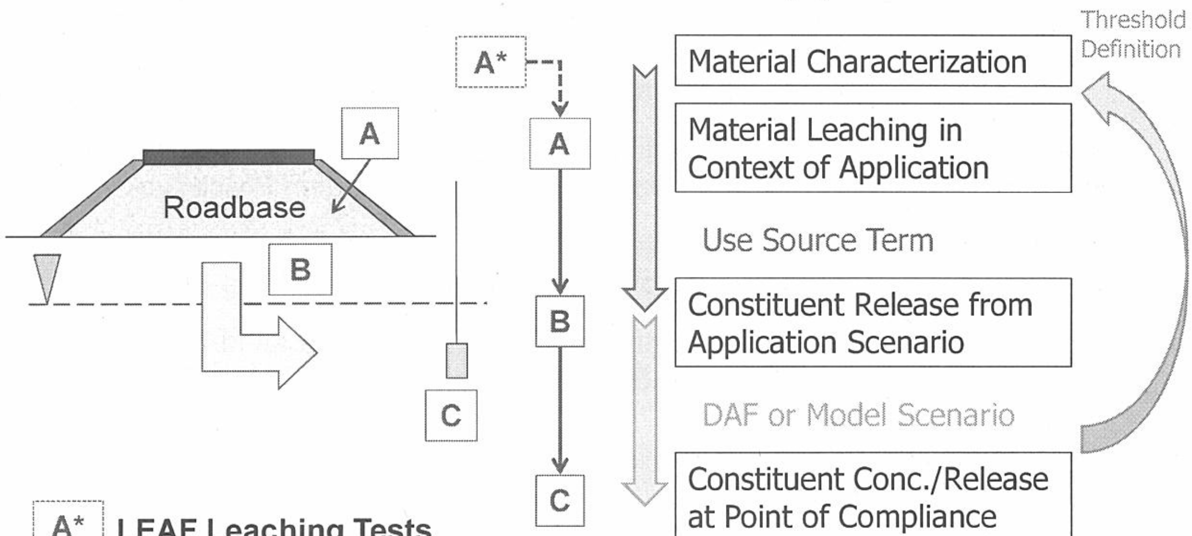
- Four leaching methods
- Data management tools
- Leaching assessment approaches

… designed to identify characteristic leaching behaviors in a wide range of materials.

LEAF facilitates integration of leaching methods which provides a material-specific "source term" release for support of material management decisions.

More information at http://www.vanderbilt.edu/leaching

Common Assessment Approach



A* **LEAF Leaching Tests**
Provide broad-based characterization of intrinsic leaching behavior

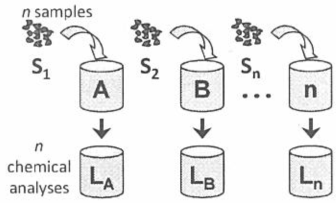
Method 1313 Overview

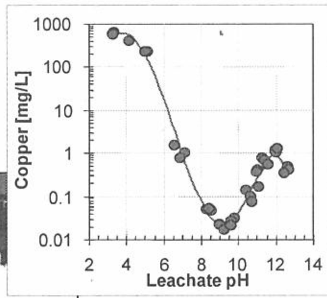
Equilibrium Leaching Test

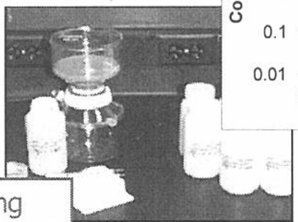
- Parallel batch as function of pH

Test Specifications

- 9 specified target pH values plus natural conditions
- Size-reduced material
- L/S = 10 mL/g-dry
- Dilute HNO_3 or NaOH
- Contact time based on particle size
  - 18-72 hours
- Reported Data
  - Equivalents of acid/base added
  - Eluate pH and conductivity
  - Eluate constituent concentrations







Titration Curve and Liquid-solid Partitioning (LSP) Curve as Function of Eluate pH

LEAF Leaching Methods

Method 1313 – Liquid-Solid Partitioning as a Function of Eluate pH using a Parallel Batch Procedure

Method 1314 – Liquid-Solid Partitioning as a Function of Liquid-Solid Ratio (L/S) using an Up-flow Percolation Column Procedure

Method 1315 – Mass Transfer Rates in Monolithic and Compacted Granular Materials using a Semi-dynamic Tank Leaching Procedure

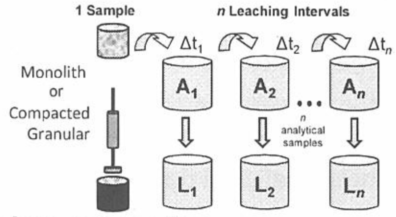
Method 1316 – Liquid-Solid Partitioning as a Function of Liquid-Solid Ratio using a Parallel Batch Procedure

Note: Incorporation into SW-846 is ongoing; method identification numbers are subject to change

Method 1315 Overview

Mass-Transfer Test

- Semi-dynamic tank leach test

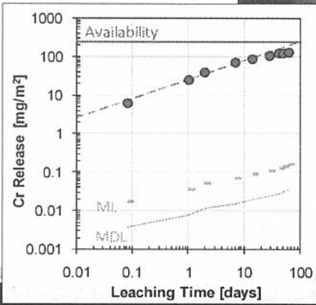


Monolithic

Granular

Test Specifications

- Material forms
  - ❑ monolithic (all faces exposed)
  - ❑ compacted granular (1 circular face exposed)
- DI water so that waste dictates pH
- Liquid-surface area ratio (L/A) of 9±1 mL/cm^2
- Refresh leaching solution at cumulative times
  - ❑ 2, 25, 48 hrs, 7, 14, 28, 42, 49, 63 days
- Reported Data
  - ❑ Refresh time
  - ❑ Eluate pH and conductivity
  - ❑ Eluate constituent concentrations



Flux and Cumulative Release as a Function of Leaching Time

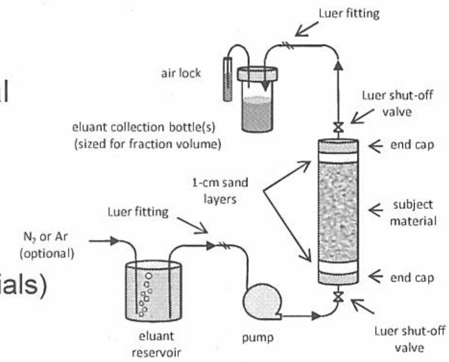
Method 1314 Overview

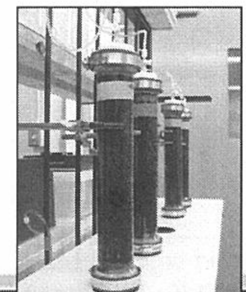
Equilibrium Leaching Test

- Percolation through loosely-packed material

Test Specifications

- 5-cm diameter x 30-cm high glass column
- Size-reduced material
- DI water or 1 mM $CaCl_2$ (clays, organic materials)
- Upward flow to minimize channeling
- Collect leachate at cumulative L/S
  - ❑ 0.2, 0.5, 1, 1.5, 2, 4.5, 5, 9.5, 10 mL/g-dry
- Reported Data
  - ❑ Eluate volume collected
  - ❑ Eluate pH and conductivity
  - ❑ Eluate constituent concentrations





Liquid-solid Partitioning (LSP) Curve as Function of L/S; Estimate of Pore Water Concentration

Data Management Tools

Data Templates

- Excel Spreadsheets for Each Method
  - ❑ Perform basic, required calculations (e.g, moisture content)
  - ❑ Record laboratory data
  - ❑ Archive analytical data with laboratory information
- Form the upload file to materials database

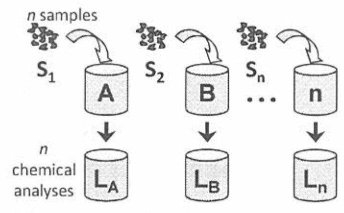
LeachXS (Leaching eXpert System) Lite

- Data management, visualization and processing program
- Compare Leaching Test Data
  - ❑ Between materials for a single constituent (e.g., As in two different CCRs)
  - ❑ Between constituents in a single material (e.g., Ba and SO_4 in cement)
  - ❑ To default or user-defined "indicator lines" (e.g., QA limits, threshold values)
- Export leaching data to Excel spreadsheets
- Freely available at http://www.vanderbilt.edu/leaching

Method 1316 Overview

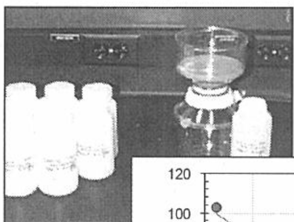
Equilibrium Leaching Test

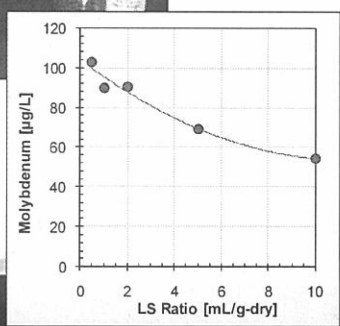
- Parallel batch as function of L/S



Test Specifications

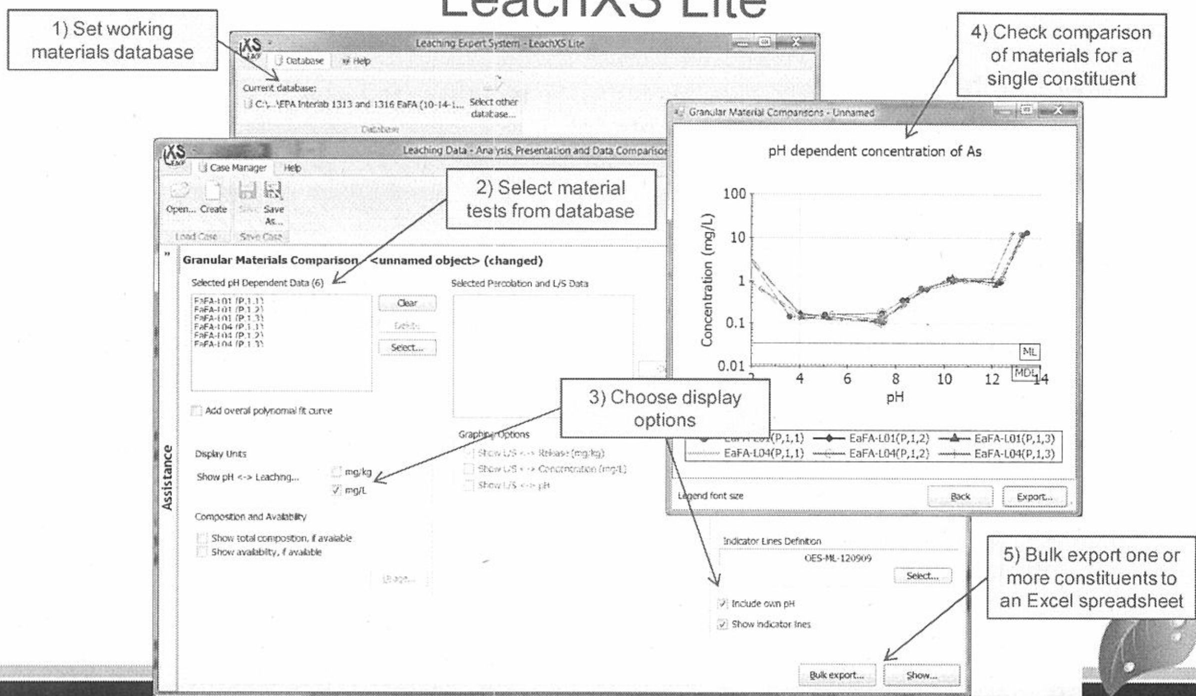
- Five specified L/S values (±0.2 mL/g-dry)
  - ❑ 10.0, 5.0, 2.0, 1.0, 0.5 mL/g-dry
- Size-reduced material
- DI water (material dictates pH)
- Contact time based on particle size
  - ❑ 18-72 hours
- Reported Data
  - ❑ Eluate L/S
  - ❑ Eluate pH and conductivity
  - ❑ Eluate constituent concentrations





Liquid-solid Partitioning (LSP) Curve as a Function of L/S; Estimate of Pore Water Concentration

LeachXS Lite



Data Templates

DRAFT METHOD 1313 (Liquid-Solid Partitioning as a Function of pH) LAB DATA

1) Enter particle size and solids content

	Code	Description *(optional)*
Project	ABC	Example project
Material	XYZ	Exaple material
Replicate	A	

Test conducted by:

Solids Information

Maximum Particle Size	0.3	[mm]
Minimum Dry Equivalent Mass *	20.00	[g-dry]
Solids Content (default = 1)	0.901	[g-dry/g]
Mass of "As Tested" Material / Extraction	22.20	[g]

Extraction Information

LS Ratio	10	[mL/g-dry
Liquid Volume / Extraction	200	[mL]
Recommended Bottle Size *	250	[mL]

2) Enter acid/base type & normality

Nominal Reagent Information

Acid Type	HNO3	
Acid Normality	2.0	[meq/mL]
Base Type	NaOH	
Base Normality	1.0	[meq/mL]

	Date	Time
Test Start	1/2/xx	2:00 PM
Test End	1/3/xx	1:45 PM

Required Contact Time * 23-25 [hr]

* Data based on Draft Method 1313 Table 1.

4) Follow "set-up" recipe

Schedule of Acid and Base Addition

Test Position	T01	T02	T03	T04	T05	T06	T07	T08	T09	B01	B02	B03	totals
"As Tested" Solid [g] (±0.05g)	22.20	22.20	22.20	22.20	22.20	22.20	22.20	22.20	22.20	no solid	no solid	no solid	199.8
Reagent Water [mL] (±5%)	147.80	167.80	185.80	197.80	195.80	193.80	189.80	185.80	178.80	200.00	181.00	150.00	2174.2
Acid Volume [mL] (±1%)	-	-	-	-	2.00	4.00	8.00	12.00	19.00	-	19.00	-	64.0
Base Volume [mL] (±1%)	50.00	30.00	12.00	-	-	-	-	-	-	-	-	50.00	142.0
Acid Normality [meq/mL]	-	-	-	-	2.0	2.0	2.0	2.0	2.0	-	2.0	-	
Base Normality [meq/mL]	1.0	1.0	1.0	-	-	-	-	-	-	-			

3) Enter target equivalents from titration curve

Target pH	13.0±0.5	12.0±0.5	10.5±0.5	natural	8.0±0.5	7.0±0.5	5.5±0.5	4.0±0.5	2.0±0.5			
Acid Addition [meq/g]	-2.5	-1.5	-0.6	0	0.2	0.4	0.8	1.2	1.9	Water	Acid	Base
Eluate pH	12.80	12.20	10.80	9.20	7.80	5.98	4.79	3.60	2.30			
Eluate EC [mS/cm]												
Eluate Eh [mV]												
? (enter "a" or "r")	✓	✓	✓	✓	✓	×	×	✓	✓			
Notes						pH out of range	pH out of range					

5) Record pH, conductivity, Eh (optional)

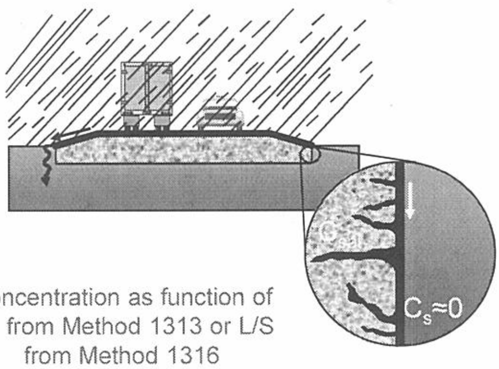
6) Verify that final pH is in acceptable range

Mass Transport Scenarios

Water Contact
- Flow-around low permeability material
  - monolithic material
  - compacted granular material

Rate of Release
- Often controlled by diffusion
- Local equilibrium as a generation term

Roadbase Material



Effective diffusivity value derived from Method 1315

Concentration as function of pH from Method 1313 or L/S from Method 1316

$$\frac{\partial C_i}{\partial t}\left[\frac{\mathrm{mg_i/L}}{\mathrm{s}}\right] = \frac{\partial}{\partial x}\left(D_i \cdot \frac{\partial C_i}{\partial x}\right) + R\langle pH, IC, etc\rangle$$

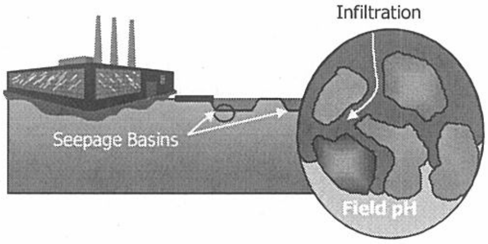
accumulation diffusion generation

Percolation Scenarios

Water Contact
- Percolation through permeable material
  - soils or sediments
  - granular wastes

Release
- Local equilibrium controlled

Contaminated Soil



Liquid-to-solid ratio under application conditions (site or scenario information)

Concentration as function of pH from Method 1313 or L/S from Method 1316

$$\text{Release}\left[\frac{\mathrm{mg_i}}{\mathrm{kg_{mat}}}\right] = \mathrm{L/S}\left[\frac{\mathrm{L}}{\mathrm{kg_{mat}}}\right] \times \mathrm{C_i}\left[\frac{\mathrm{mg_i}}{\mathrm{L}}\right]$$

Study Materials

Coal Combustion Fly Ash
- Collected for EPA study
- Selected for validation of …
  - ❑ Method 1313/1316 Phase I
  - ❑ Method 1314 Phase I

Solidified Waste Analog
- Cement/slag/fly ash spiked with metal salts
- Selected for validation of …
  - ❑ Method 1313/1316 Phase II
  - ❑ Method 1315 Phase I
  - ❑ Method 1314 Phase II

Contaminated Field Soil
- Smelter soil
- Collection in process
- Selected for validation of…
  - ❑ Method 1313/1316 Phase II
  - ❑ Method 1315 Phase II
  - ❑ Method 1314 Phase II

Foundry Sand
- Collection in process
- Selected for validation of …
  - ❑ Method 1315 Phase II
  - ❑ Method 1314 Phase II

LEAF Test Methods Validation Process

Based on “Guidance for Methods Development and Methods Validation for the RCRA Program”

Phase I – Demonstration of Proficiency
- Participating labs perform the test method on a single material to show that reliable results can be obtained
- Data is statistically processed
- Interim report draft

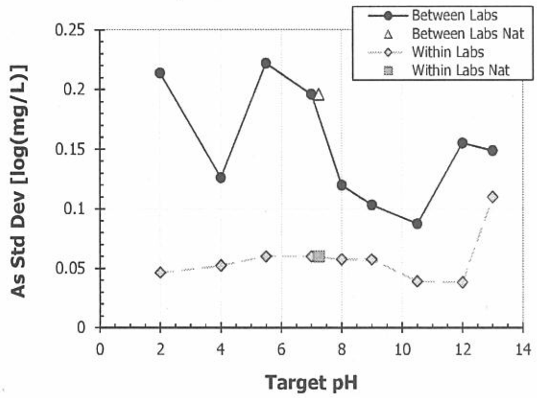
Phase II – Method Validation
- Advancing labs perform the test method on two additional materials.
- Data is statistically processed.
- Final report to include Phase II and Phase I materials

L E A F

Statistical Analysis

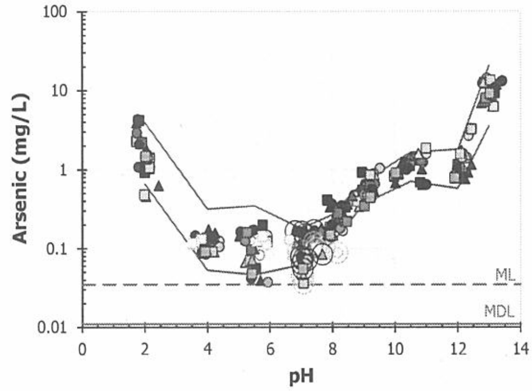
Standard Deviations

- Repeatability (within lab deviation)
- Reproducibility (between lab deviation)



95% Robust Confidence Limits

- Prediction interval within which 95% of mean $\log_{10}$ transformed data from a lab would fall



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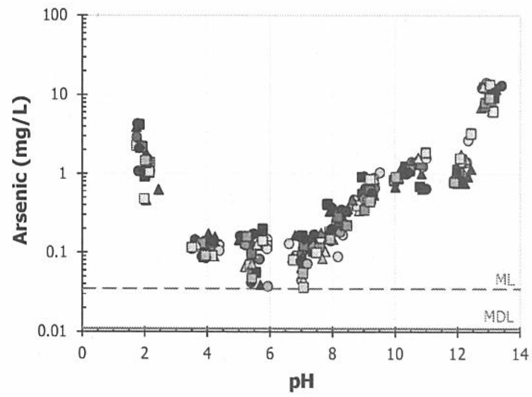
Method 1313 Phase I Results

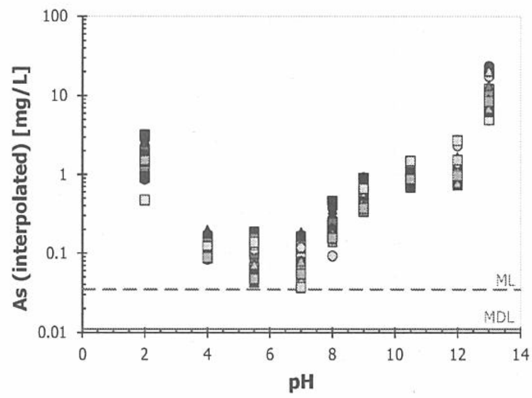
Raw Data

- Recorded data varies with
  - pH measurement
  - concentration



Interpolated Data

- $\log_{10}$ transform
- Linear interpolation/extrapolation



Test Validation Schedule

Method 1313 and Method 1316
- ✓ Phase I – completed in August 2010
- Phase II – initiated in October 2010
  – completion in January 2011 (*projected*)

Method 1315
- ✓ Phase I – initiated in November 2010
  – completion in February 2011 (*projected*)
- Phase II – scheduled for March 2011

Method 1314
- Phase I – scheduled for May 2011
- Phase II – scheduled for July 2011

L E A F

Validation Lessons Learned

Modifications to Methods 1313 and 1316
- Tolerance for contact time have been added
- Requirement that pH values to be measured within 1 hr after separation of solids and liquids due to lack of buffering in aqueous samples

Modifications to Data Templates
- Mandatory information has been highlighted
- Instructions more closely follow method text

Other Recommendations
- Calibration of pH meters should cover entire pH range to extent possible
- Reagents should be freshly prepared, stored in vessels of compatible materials (e.g., strong alkalis not be stored in borosilicate glass)
- Labs should establish a QC regiment to check the quality of reagent water (method blanks are important)

LEAF Supporting Documentation

A.C. Garrabrants, D.S. Kosson, H.A. van der Sloot, F. Sanchez, and O. Hjelmar (2010) Background Information for the Leaching Environmental Assessment Framework Test Methods, EPA/600/R-10/170, December 2010; http://www.epa.gov/nrmrl/pubs/600r10170/600r10170.html.

S.A. Thorneloe, D.S. Kosson, F. Sanchez, A.C. Garrabrants, and G. Helms (2010) "Evaluating the Fate of Metals in Air Pollution Control Residues from Coal-Fired Power Plants," *Environmental Science & Technology*, 44(19), 7351--7356 http://pubs.acs.org/doii/abs/10.1021/es1016558.

D. Kosson, F. Sanchez, P. Kariher, L. Turner, D. Delapp, P. Seignette and S. Thorneloe (2009) *Characterization of Coal Combustion Residues from Electric Utilities -- Leaching and Characterization Data,* EPA-600/R-09/151, December 2009; http://www.epa.gov/nrmrl/pubs/600r09151/600r09151.html.

F. Sanchez, D. Kosson, R. Keeney, R. DeLapp, L. Turner, P. Kariher, and S. Thorneloe (2008) *Characterization of Coal Combustion Residues from Electric Utilities Using Wet Scrubbers for Multi-Pollutant Control,* EPA-600/R-08/077, July 2008; www.epa.gov/nrmrl/pubs/600r08077/600r08077.pdf.

F. Sanchez, R. Keeney, D. Kosson, R. Delapp and S. Thorneloe (2006) *Characterization of Mercury-Enriched Coal Combustion Residues from Electric Utilities Using Enhanced Sorbents for Mercury Control*, EPA-600/R-06/008, February 2006; http://www.epa.gov/ORD/NRMRL/pubs/600r06008/600r06008.pdf.

F. Sanchez, C.H. Mattus, M.I. Morris, and D.S. Kosson (2002) "Use of a new framework for evaluating alternative treatment processes for mercury contaminated soils," Environmental Engineering Science, 19(4), 251-269.

D.S. Kosson, H.A. van der Sloot, F. Sanchez, and A.C. Garrabrants (2002) "An integrated framework for evaluating leaching in waste management and utilization of secondary materials," *Environmental Engineering Science*, 19(3), 159-204.

Validation Acknowledgements

Participating Labs

- Government
  - Oak Ridge National Lab
  - Pacific Northwest National Lab
  - Savannah River National Lab
- Academia
  - Ohio State University
  - University of Wisconsin – Madison
  - University of Missouri – Rolla
  - Vanderbilt University
- Commercial
  - ARCADIS-US, Inc.
  - TestAmerica Laboratories, Inc.
  - URS Corporation

International Labs

- Energy Research Centre of The Netherlands
- DHI (Denmark)

Support

- Electric Power Research Institute (EPRI)
- Recycled Materials Research Center (RMRC)
- Tennessee Valley Authority (TVA)

LEAF Methods Focus Group

Conclusions

The LEAF test methods

- Evaluate leaching behavior of materials using a tiered approach that considers the effect of leaching on pH, liquid-to-solid ratio, and form
- Prepared for inclusion into SW846 – EPA's compendium of test methods for waste and material characterization

Current efforts are to conduct interlaboratory comparisons and provide information on the

- Relationship between the LEAF testing results and field leaching
- Application of LEAF test methods for evaluating CCR use and disposal

LEAF Reports in Preparation

Results of Inter-laboratory Validation of LEAF Test Methods

- Drafts developed as data is available
- Final report projected for Fall 2011 release

Relationship Between LEAF Testing Results and Field Leaching

- Report projected for Summer 2011 release

Application of LEAF Test Methods for Evaluating Use and Disposal of Coal Combustion Residues (CCRs)

- Report projected for Spring 2012 release

United States Environmental Protection Agency

Overview

- Overview of SIP/Transport Requirements of the CAA
- Transport Rule 1 Proposal
- Plans for Transport Rule 2

Overview of Transport Rules in Progress

Tim Smith, OAQPS/AQPD

AWMA Information Exchange

12-8-10

EPA United States Environmental Protection Agency

CAA Transport Requirements

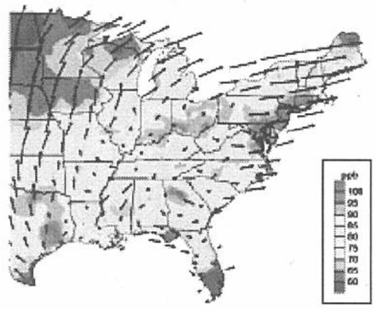
- 110(a)(2)(D)(i)(II)
- Requires, within 3 years of a new NAAQS, that SIPs:
  - "contain adequate provisions prohibiting… any source or other type of emissions activity within the State, from emitting any air pollutant in amounts which will…. *contribute significantly to nonattainment in,* or *interfere with maintenance by,* any other State..

EPA United States Environmental Protection Agency

Transport of Air Pollution

- Air pollution can travel hundreds of miles and cause multiple health and environmental problems on regional or national scales.
- Many areas are still violating the 1997 ozone and the 1997 and 2006 fine particulate health-based air quality standards.
- Additional areas would violate the reconsidered ozone standard, depending on final standard chosen
- Nonattainment has a local component and a transport component

Transport Winds and Ozone Patterns on High Ozone Days

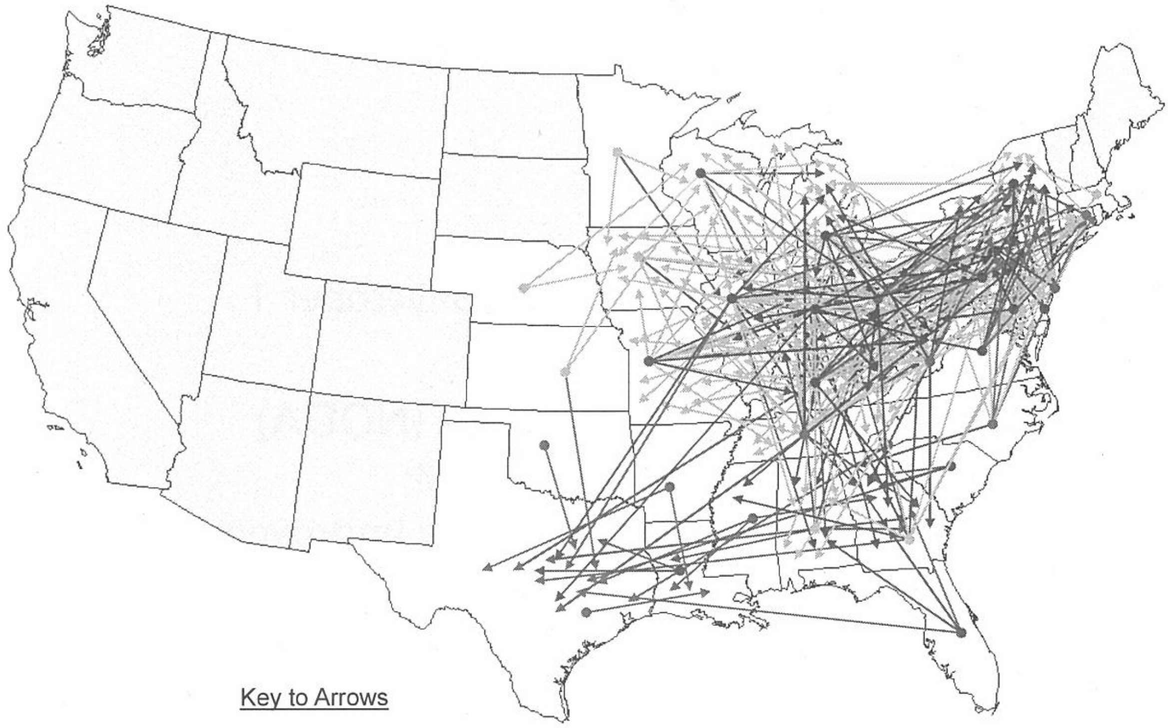


EPA United States Environmental Protection Agency

EPA Transport Rule Efforts

- NOx SIP call (1998): Addressed Ozone transport.
- CAIR (2005) with accompanying FIP (2006):
  - Addressed PM and ozone under 97 NAAQS.
  - July and December 2008 court decisions.
- Transport Rule 1:
  - Proposed August 2010
  - Addresses PM under 97 and 2006 NAAQS, ozone transport under 97 NAAQS
- Transport Rule 2:
  - Targeting ozone under reconsidered NAAQS, and any ozone "unfinished business" under transport rule 1

Addressing Transport is Complex

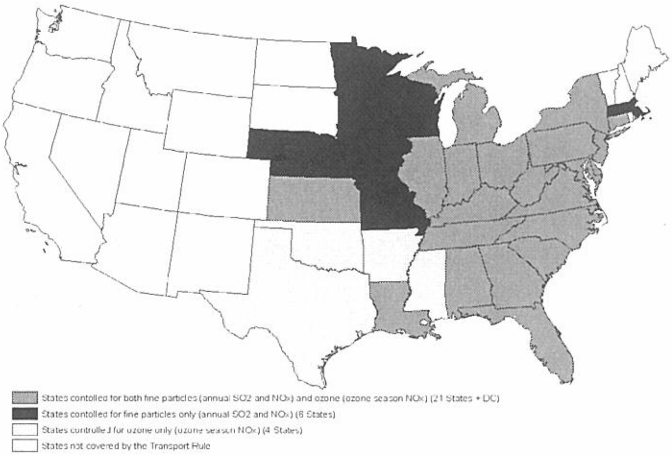


Key to Arrows

- Linkage of Upwind to Downwind for Ozone
- Linkage of Upwind to Downwind for Annual $PM_{2.5}$
- Linkage of Upwind to Downwind for 24 hour $PM_{2.5}$

EPA United States Environmental Protection Agency

Transport Rule 1
Proposal Would Reduce Emissions in 31 States + DC



- Proposal includes separate requirements for:
  - Annual SO_2 reductions
  - NO_x reductions (2012)
  - Ozone-season NO_x reductions (2012)
- Sets emissions budgets for each state

EPA United States Environmental Protection Agency

Transport Rule 1

- Covers EGUs
- Proposed early August
  - 60-day comment period closed October 1
- 2 Notices of Data Availability (NODA)
  - September 1: new version of IPM
  - October 27: emissions inventory improvements
- Targeting final rule for signature June 2011

EPA United States Environmental Protection Agency

Transport Rule 1 Replaces CAIR

This proposal:

- Responds to the Court ruling remanding the 2005 CAIR and the 2006 CAIR Federal Implementation Plans (FIPs).
- Addresses the December 2008 court decision.
  - The decision kept the requirements of CAIR in place temporarily and directed EPA to issue a new rule addressing the provisions of the Clean Air Act concerning the transport of air pollution across state boundaries.
- Would achieve emissions reductions beyond those originally required by CAIR through additional air pollution reductions from power plants beginning in 2012.

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EPA United States Environmental Protection Agency

Significant NO_X and SO_2 Reductions from Transport Rule 1 Proposal

- By 2014, EPA modeling projects that implementation of the Transport Rule, as proposed, combined with other state and EPA actions, would reduce 2005 emissions from electric generating units in the covered states by:
  - 6.3 million tons of SO_2 per year
  - 1.4 million tons of NO_X per year
    - 300,000 tons of NO_X during ozone season (included in NO_X estimate above)
- These reductions represent a 71% reduction in SO_2 and a 52% reduction in NO_X emissions from power plants from 2005 levels in the covered states.
- In the states and DC covered by the proposed Transport Rule, in 2014, SO_2 emissions would be capped at 2.5 million tons per year annually and NO_X emissions would be capped at 1.4 million tons per year (ozone season NO_X emissions will be capped at 600,000 tons per year).

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Transport Rule 2

- Steps:
  - Identify contributing states
  - Quantify "significant contribution" that must be prohibited
  - Identify appropriate remedies
- Current status:
  - Beginning analytic effort
  - Upcoming senior management discussions

Transport Rule 2

- Anticipated schedule for the rule:
  - Proposal: 2011
  - Final: 2012
- Will address CAA responsibility of upwind states to downwind state ozone problems
  - Emissions reductions needed for all states in the nation contributing to nonattainment/interfering with maintenance of upcoming 2010 ozone standards
  - Will look at upwind states and their emissions levels across not only the utility sector, but other sectors as well

EPA United States Environmental Protection Agency

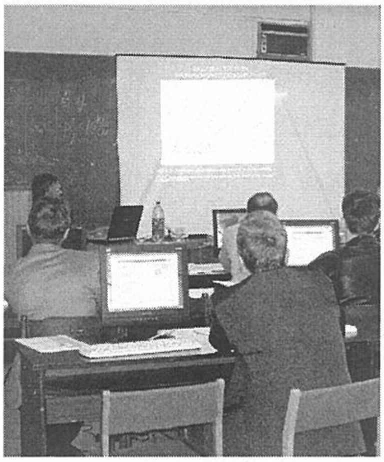
More information

- www.epa.gov/airtransport

- Contacts:
  - Transport Rule 1:
    - General: Meg Victor 202 343 9193
    - Allocations issues: Brian Fisher 202 343 9633
  - Transport Rule 2:
    - Tim Smith 919 541 4718

Outline

- Background
- Contents
- Control Approaches
- Decision Tree
- Emissions and Plant Inventories
- Demonstrations



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UNEP Coal Combustion Partnership Area Activities in Preparation for the Global Mercury Negotiations

Wojciech Jozewicz, Lesley Sloss, and Gunnar Futsaeter

35th Annual A&WMA / EPA Information Exchange
Research Triangle Park, North Carolina
December 2010

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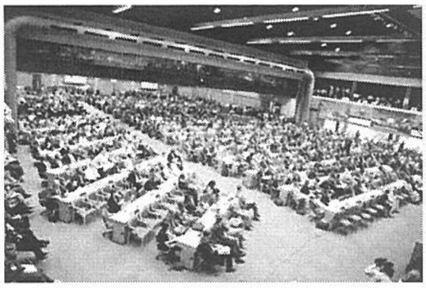
Partnership Areas

- Established to contribute to reduction of risk from releases of mercury
  - Mercury Control from Coal Combustion
  - Mercury Reduction in Chlor-alkali Sector
  - Mercury Reduction in Products
  - Mercury Air Transport and Fate Research
  - Reducing Mercury in Artisanal and Small-scale Gold Mining
  - Mercury Waste Management
  - Mercury Supply and Storage
  - *Cement and Non-ferrous Metals Production*
- Coal Combustion Area funding received from the European Commission
  - Four target areas: China, India, Russia, and South Africa
  - http://www.unep.org/hazardoussubstances/mercury/interimactivities/partnerships



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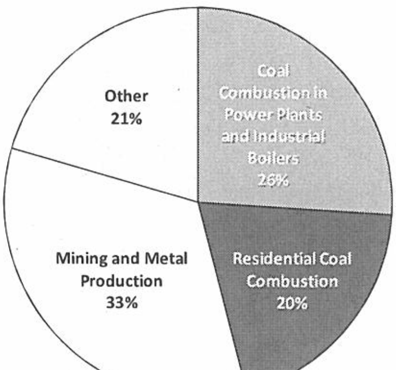
Background

- Mercury is a global problem (UNEP Global Mercury Assessment, 2003)
- Coal combustion is the largest anthropogenic mercury emission source (UNEP, 2008)
- UNEP Governing Council (2009) decided to elaborate a global "legally binding instrument on mercury" by 2013



Human Sources of Mercury Emissions in 2005

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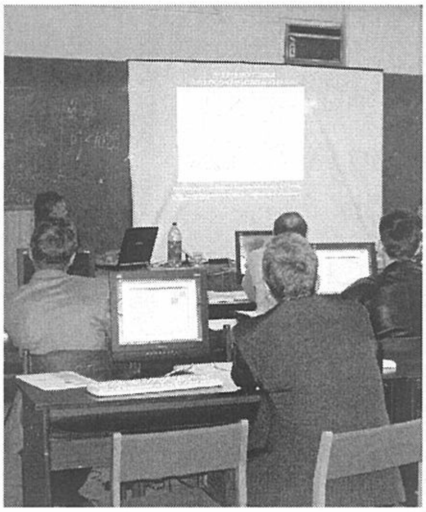
Process Optimization Guidance (POG)



Approach

- Promotes the simplest and most economic
  methods of mercury control
- Economic co-benefit approaches emphasized
- Being translated into target languages
- Accompanied by training workshops
- Decision Tree diagram planned as an on-line tool

6

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Coal Combustion Project

Objectives

Overall

- Provide background information to negotiating countries

More specifically (three activities):

1. Develop guidance material on how to optimize multi-pollutant control techniques - Process Optimization Guidance (POG)
2. Improve the accuracy of emissions inventories for the sector and develop inventories of emissions and plants (number, type and size)
3. Implement demonstration studies

5

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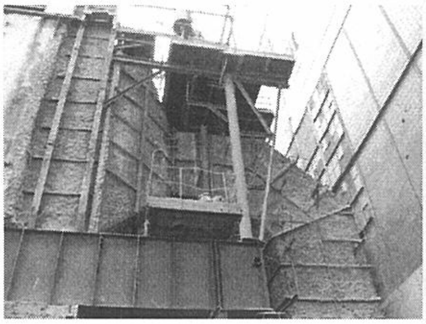
Importance of "Co-benefit" Maximization



- 80 to 90 per cent possible with SO_2 and NO_X controls
- Oxidation of mercury
- Coal blending for chlorine
- Coal and gas phase additives
- Fine tuning of existing APC equipment's operation
- Prevention of re-emission

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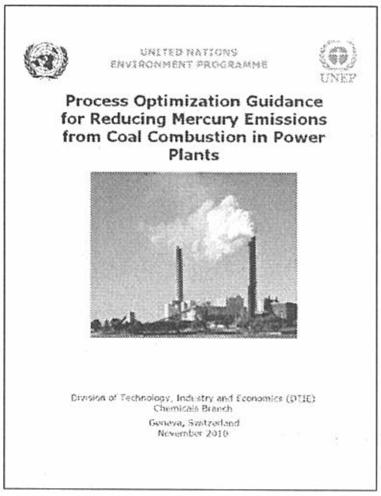
POG Outline



UNITED NATIONS
ENVIRONMENT PROGRAMME

UNEP

Process Optimization Guidance for Reducing Mercury Emissions from Coal Combustion in Power Plants

Division of Technology, Industry and Economics (DTIE)
Chemicals Branch

Geneva, Switzerland
November 2010

- Summary of mercury emissions from coal
- Plant control options:
  - Improving plant efficiency
  - Coal treatment
  - Improving PM control device operation
  - Improving SO_2 and NO_X control device operation
- Mercury-specific control options
- Multipollutant control options
- Decision Tree
- Post-control issues (wastes)
- Examples of control costs

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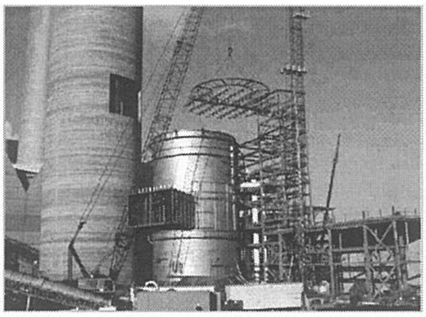
Co-benefit: Fine-tuning of Wet FGD and SCR Systems



- High Hg removal for some coals (80 – 90 per cent)
- Additional measures needed for others
  - Oxidizers upstream of the scrubber
  - Stabilizers to prevent re-emission
  - Coal additives
  - Coal blending

SCR systems can increase Hg^{2+} by up to 85 per cent and enhance Hg capture in wet FGD

Hg removal of up to about 90 per cent in wet FGD

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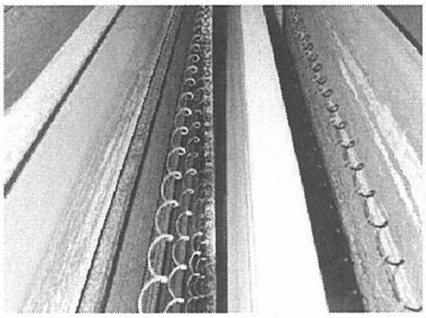
Co-benefit: Fine-tuning of ESP



- ESP efficiency improvement important
- Mercury condenses preferentially on small particles
- Mechanical
  - Rapping system repair, rapping sequence
  - Elimination of in-leakages
- Electrical
  - Alignment of electrodes
  - Elimination of short circuits
  - Compensating for ash resistivity

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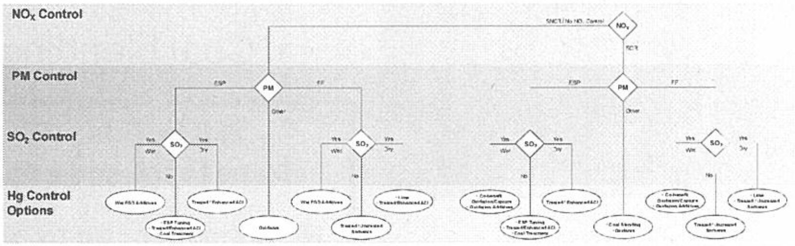
Decision Tree

- Basic tool currently being developed to determine control options for specific plants
- Conditions are very site specific
- Expert help is needed to determine optimal approaches
- Aim to make it interactive on-line



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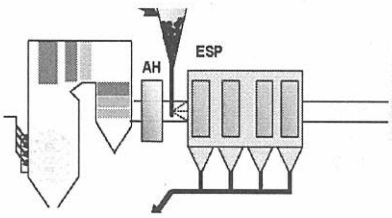
Mercury-Specific Removal Technology

- Dry sorbent (most often activated carbon) injected upstream of particulate matter control device
- Sorbents can be tailored to match coal type burnt and the resultant mercury speciation
- Widely demonstrated and commercially available technology



Source: DOE 2005

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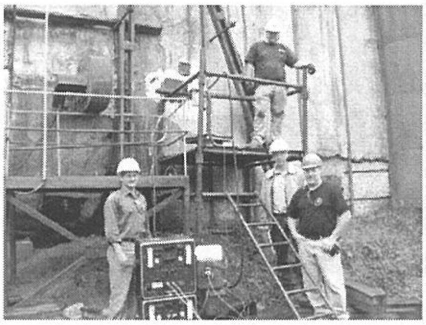
Activity 2 in Russia



- Coordinated by SRI Atmosphere
- Analyzed samples of coals from major basins for Hg
- Method 30B sampling with support of US EPA
  - Two power plants participated
  - Units in both plants equipped with ESPs
- Analytical support from USGS

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Examples of Control Costs

- Costs are very site specific
- Specialized help is needed

Approach	Capital Cost	Incremental O&M Cost
Energy efficiency improvement	Moderate	Low
Coal treatment - Pre-combustion	High	Moderate
Coal blending	Low	Low
Coal additives	Low	Low
ESP upgrade	Low	Low
Co-benefit maximization – FGD	Low	Low
Co-benefit maximization - SCR	Moderate	Moderate
ACI	Low	Moderate to High [a]
TOXECON	High	Moderate

a. Costs may vary with plant and reduction requirements

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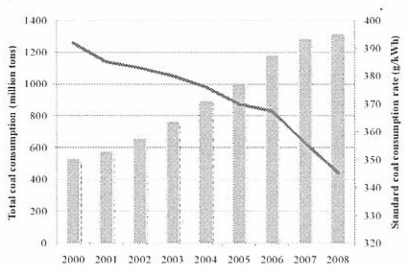
Activity 2 in China

Coal Information

- Amount of coal for electricity
- Available information on mercury in coal
- Coal sample analysis

Power Plant Information

- National and provincial information on installed power plant capacity and electricity generation
- Information on the installed configuration of any air-pollution control equipment and its typical operational efficiency
- More than 95 per cent of power plants with ESP, efficiency over 99 per cent
- More than 60 per cent of power plants with FGD, efficiency of 90 to 95 per cent
- About 20 GW of power from plants with SCR or SNCR, efficiency of SCR over 60 per cent



Source: CEC, 2010

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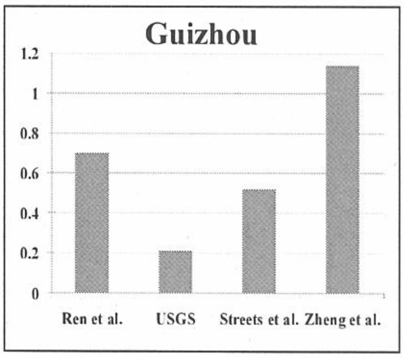
Activity 2 in China

- Coordinated by Tsinghua University for the Ministry of Environmental Protection
- Scope
  - Coal information
  - Power plant information
- Draft report being reviewed



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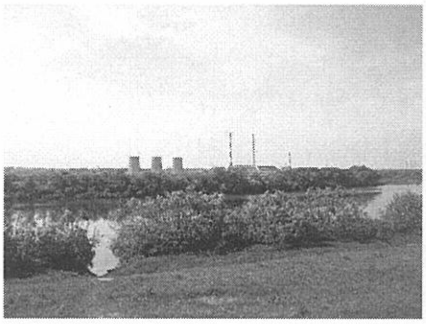
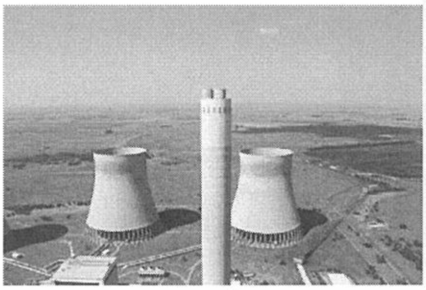
Activity 3 in Russia

- Two demonstrations:
  - A. Slip stream ESP with ACI
  - B. Wet PM scrubber with additives



Activity 2 in South Africa

- Method 30B sampling with support of US EPA
- Two power plants participated
  - One with ESPs only, another with ESP and FF
  - 0.15 to 0.45 ppm Hg in coal
  - Samples of coal, fly ash, and bottom ash are being analyzed
  - Order of magnitude lower emissions for units with FF than for ones with ESPs
- Analytical support from USGS



Summary

- The POG document is designed to be a simple summary of a very complex problem
- Successful stack mercury concentration measurements conducted in Russia and South Africa
- Significant amount of new information received on coals and power plants in China
- Two demonstrations on-going in Russia for mercury emission reduction
- Demonstrations planned in South Africa and India

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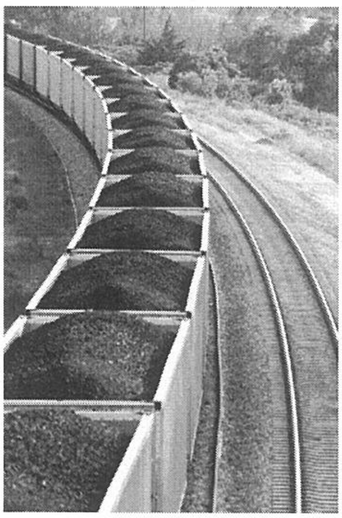
Activity 3 in South Africa and India



- Projects contemplated:
  - Demonstration of Hg removal via coal cleaning
  - ESP upgrade

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More Information

United Nations Environment Programme
Chemicals

UNEP Mercury Programme

http://www.unep.org/hazardoussubstances/

附件四 大氣汞監測合作規劃資料

Taiwan/U.S. Atmospheric Mercury Monitoring Quality Assurance Workshop

Taiwan, EPA

EPA United States Environmental Protection Agency

National Atmospheric Deposition Program

November 11-14, 2010
Taipei, Taiwan
Yushan National Park, Mt. Lulin

Workshop Participants

US Delegation
David Schmeltz, USEPA/OAR/OAP/CAMD
Tim Sharac, USEPA/OAR/OAP/CAMD
David Gay, NADP
Mark Olson, NADP/USGS

Universities
Guey-Rong Sheu, National Central University
George Lin, National Central University
Tsung-Wen Chien, National Cheng Kung University
Various students and monitoring technicians

Taiwan Environmental Protection Administration
Si-Yu Yu, Environmental Monitoring Engineer
Sun, Hone-Ling, Specialist
Jyh-Jian Liu, Section Chief
Shuenn-Chin Chang, Senior Specialist
Ms. Quo
Chih-Hsiu, Shen, Deputy Director General
Y.F. Liang, Advisor, International Cooperation

November 11, 2010

The U.S. delegation conducted a 1.5 day training workshop for EPAT and NCU on the North American Atmospheric Mercury Monitoring Network (NADP/AMNet). The goal of the workshop was to facilitate collaboration on atmospheric mercury monitoring by:

- Exchanging information and data from programs in the U.S. and Taiwan to monitor speciated ambient mercury, and wet/dry mercury deposition
- Sharing plans, protocols, and best practices for quality assurance of field operations and data management
- Harmonizing, to the extent possible, field measurements across programs to expand globally coordinated mercury monitoring capacity.

The workshop agenda is attached.

Key points/findings from day one of the workshop:

- USEPA, Environment Canada and the National Atmospheric Deposition Program have collaborated to establish a North American network to monitor atmospheric mercury species. The network is based on a standard set of protocols for field operations, data management and quality assurance.

- The US delegation found the operation of atmospheric mercury instrumentation at the Mt. Lulin Atmospheric Background Station comparable to the North American atmospheric mercury monitoring program. The Mt. Lulin site was operating very close to AMNet Standard Operating Procedures for field measurements, and a few changes and recommendations were made to achieve full conformance. Recommendations for supplies, parts, and equipment upgrade include estimated costs (in USD). For monitoring mercury in wet deposition, the EPAT-sponsored mercury wet deposition monitoring network uses a sample collector different than NADP/MDN. Use of the different collector will likely impact the comparability of measurements across programs. EPAT and NCU should consider having a NADP/MDN NCON collector running side by side with the Taiwan wet Hg collector to examine variability across wet deposition mercury programs.

- The US delegation evaluated and presented Mt. Lulin sample speciated ambient mercury concentration data through the NADP quality assurance screening tool. The sample data were found to be high quality, consistent and comparable to data generated from the NADP/AMNet. In addition, the US delegation found that NCU has very capable scientists and technicians, skilled in the operation and maintenance of the Tekran speciation system. Continued consistency in monitoring operations, including maintaining support and participation from these reliable personnel will likely be one of the key factors to successful long-term operations at Mt. Lulin.