JV TASK 125 – MERCURY MEASUREMENT IN COMBUSTION FLUE GASES SHORT COURSE

Final Report

(for the period of April 1, 2008, through September 30, 2008)

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JV TASK 125 – MERCURY MEASUREMENT METHODS SHORT COURSE AND HANDS-ON TRAINING

ABSTRACT

The short course, designed to train personnel who have an interest in measuring mercury in combustion flue gases, was held twice at the Drury Inn in Marion, Illinois. The short course helped to provide attendees with the knowledge necessary to avoid the many pitfalls that can and do occur when measuring mercury in combustion flue gases. The first short course, May 5–8, 2008, included both a classroom-type session and hands-on demonstration of mercury-sampling equipment. The hands-on demonstration of equipment was staged at Southern Illinois Power Cooperative. Not including the Illinois Clean Coal Institute and the U.S. Department of Energy project managers, there were 12 attendees. The second short course was conducted September 16–17, 2008, but only included the classroom portion of the course; 14 people attended. In both cases, lectures were provided on the various mercury measurement methods, and interaction between attendees and EERC research personnel to discuss specific mercury measurement problems was promoted. Overall, the response to the course was excellent.

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EXECUTIVE SUMMARY

Two mercury measurement short courses funded by the Illinois Clean Coal Institute (ICCI) and the U.S. Department of Energy (DOE) were conducted by the Energy & Environmental Research Center (EERC) at the Drury Inn in Marion, Illinois. The short courses were designed to help provide attendees with the knowledge necessary to avoid the many pitfalls that can and do occur when measuring mercury in combustion flue gases. The first short course, held May 5–8, 2008, included both a classroom-type session and hands-on demonstration of mercury-sampling equipment. The hands-on demonstration of equipment was staged at Southern Illinois Power Cooperative. A total of 12 people attended the course, not including the ICCI and DOE project managers, both of whom attend at least a portion of the short course. The second short course was conducted September 16–17, 2008, and only included the classroom portion of the course. A total of 14 people attended the second course. For both short courses, the lectures were designed to provide information on the various mercury measurement methods, and interaction between attendees and EERC research personnel to discuss specific mercury measurement problems was promoted.

The following main topics were discussed in detail over 2 days in a lecture format that facilitated discussion:

- Introduction and background
- Compliance monitoring
- Mercury reference methods
- Wrap-up

For the first short course, following the classroom discussion, attendees were taken to Southern Illinois Power Cooperative where mercury measurement equipment was set up to sample flue gas. The equipment included a Tekran continuous mercury monitor (CMM), the OhioLumex for analyzing sorbent traps, and sorbent trap-sampling systems.

At the end of the short courses, an evaluation form was handed out. For the first course, 10 of 12 attendees filled out the form. For the second course, 14 of 14 responded. In all aspects of the short course, all the attendees rated the course excellent or good, with over 80% of the responses being excellent.

Comments included the following:

- Very informative course – great job.
- Excellent! Should continue with additional courses for other Illinois companies!
- This was very informative and well thought out.

JV TASK 125 – MERCURY MEASUREMENT METHODS SHORT COURSE AND HANDS-ON TRAINING

INTRODUCTION

In June 2005, the U.S. Environmental Protection Agency (EPA) finalized the Clean Air Mercury Rule (CAMR). As part of the rule, all coal-fired power plants would have been required to do continuous mercury measurements. Although CAMR has now been vacated by the courts, based on discussion with EPA, it is expected that the mercury measurement requirements as written in 40 Code of Federal Regulations (CFR), Parts 75 and 60, will be part of any future mercury regulations. This most likely will be the case whether regulations are developed based on a maximum achievable control technology rule-making process or through legislative action. In addition, a number of states, including Illinois, have developed mercury requirements independent of CAMR. The mercury measurement requirements for the state rules are in many ways the same as those that were included in CAMR. Therefore, for the short courses, the procedures under CAMR were proscribed.

Continuous mercury measurements can be done in one of two ways. The first is to install continuous mercury monitors (CMMs); the second is to use mercury sorbent traps known as Appendix K (40 CFR Part 75, Appendix K). It should be noted that the state of Illinois is also intending to allow quarterly flue gas mercury sampling using wet-chemistry methods or sorbent traps. However, this option has a sunset provision after 3 years. To install a CMM, the instrument must first be certified (Part 75 for existing plants and Part 60 for new plants). Then after the CMM has been certified, the calibrations and relative accuracy test audit (RATA) protocols under 40 CFR, Part 75, Appendices A and B must be followed. For the sorbent traps, initial certification is not required; however, 40 CFR, Part 75, Appendix K protocols must be done. These protocols require that an annual RATA be done. Initially, the only reference methods allowed for conducting a RATA were the wet-chemistry methods: Ontario Hydro (OH) mercury speciation method (ASTM International D6784-02) or EPA Method 29. However, EPA has developed a sorbent trap reference method and an instrumental reference method (IRM) entitled EPA Methods 30B and 30A, respectively. Therefore, to help train personnel who have an interest in measuring mercury in combustion flue gases, the Energy and & Environmental Research Center (EERC) provided two short courses, one in May and the other in September 2008, in Marion, Illinois.

APPROACH

The mercury measurement short courses were funded by the Illinois Clean Coal Institute (ICCI) and the U.S. Department of Energy (DOE). The first offering of the short course included both a classroom-type session and a hands-on demonstration of mercury-sampling equipment at Southern Illinois Power Cooperative's (SIPC's) power plant located near Marion, Illinois. In addition to presenting the short courses, a number of activities were conducted by the EERC that were an essential part of conducting a successful short course. These activities included developing and continuing to update the short course content with current information; receipt

and coordination of course registrations; preparation and reproduction of course materials; conversion and reproduction of the course materials to CD; reproduction of an instructional DVD; arranging facility, food, and beverage logistics for the course; compilation of course evaluations; final updates to the mailing list; and updating the Web site with a summary of the event.

The lectures, held at the Drury Inn in Marion provided detailed discussion on the various mercury measurement methods, and interaction between attendees and EERC research personnel to discuss specific mercury measurement problems was promoted.

The following topics were discussed in detail over the first 2 days of the short course:

- Introduction and background
  - Health issues
  - Emissions
  - Mercury regulations
  - Mercury control

- Compliance monitoring
  - Planning
  - Appendix K sorbent trap sampling
  - CMMs
  - Comparison of the two methods on an economic basis

- Mercury reference methods
  - Wet-chemistry methods
  - EPA Methods 30A and 30B (instrumental reference method and sorbent traps)
  - Conducting a RATA

- Wrap-up

The equipment demonstration and hands-on training for the May course only were at SIPC. For all the demonstrations, flue gas from the power plant was sampled and analyzed.

RESULTS AND DISCUSSION

For short courses, the results of the project are based on attendance and the satisfaction of the attendees. The May 5–8, 2008, short course had a total of 12 attendees (not including the DOE and ICCI project managers), and the September 16–17, 2008, course had 14 participants. Attendees included the following:

- Engineers
- Instrumentation technicians
- Government regulators
- Environmental managers

- Advanced scientists
- Plant operators

Details of each of the topic areas are discussed below.

Introduction and Background

A brief introduction was provided to attendees that included discussion on mercury health issues and the types and quantity of mercury emissions from various sources. An important aspect of the introduction was discussion on both the state of federal mercury regulations and those implemented by the states, in particular, the mercury rule that is being implemented by the state of Illinois. Several of the attendees (list provided in Appendix A) were from the Illinois Environmental Protection Agency. The vacatur of CAMR and the Clean Air Interstate Rule (CAIR) and what that means as it relates to mercury measurement requirements were discussed in some detail.

Compliance Monitoring

As stated previously, continuous mercury measurements can be done in one of two ways: installing CMMs or doing Appendix K sorbent trap sampling. Each of these methods was discussed in detail.

Mercury Measurement Planning

Prior to mercury sampling, it is important that a plan be developed as to why and how the sampling will occur. This plan needs to include the following:

- Defining overall sampling objectives
- Defining the purpose for measuring mercury
- Determining measuring methods
- Determining the data needed to be taken to meet objectives
- Managing results
- Preparing a quality assurance plan (QAP)

Once continuous mercury measurements are being done, the overall planning objectives and QAP must be continuously evaluated and updated based on experience.

Appendix K Sorbent Trap Sampling

The course covered 40 CFR Part 75, Appendix K, which defines the protocols for using sorbent traps as a continuous mercury measurement method under CAMR. A schematic of the sampling system is shown in Figure 1, and photographs of the probe and traps are shown in Figure 2. The following information was included in the discussion:

- What it is.

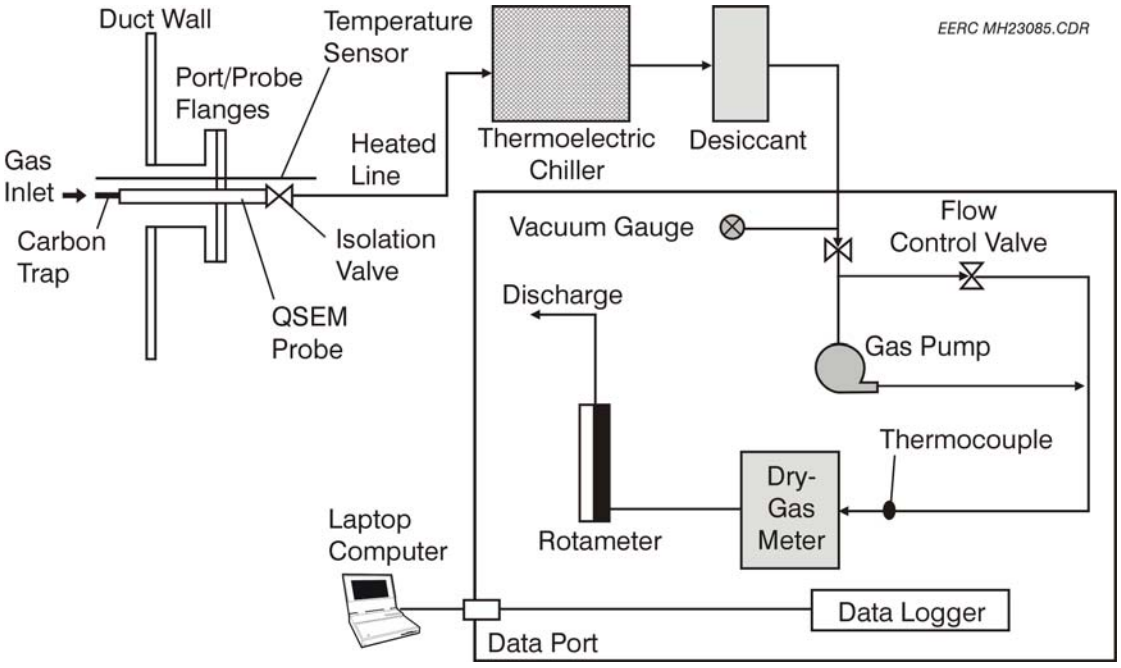

Figure 1. Schematic of an Appendix K sampling system.

Figure 2. Photographs of an Appendix K/EPA Method 30B sampling probe.

- Sorbent trap-handling procedures.

- Sampling procedures.

- Analytical procedures, including a comparison of sending the traps to a laboratory and analyzing them using a modification of EPA Method 1361 and doing them on-site using a thermal desorption instrument such as the OhioLumex.

- Regulatory requirements.

- Quality assurance/quality control (QA/QC).

- What can go wrong and how to avoid it.

CMMs

A major discussion topic was CMMs and their status. A wide range of topics was discussed, including the following:

- The advantages and disadvantages compared to Appendix K.

- The availability of CMMs and their current stages of development.

- The various components of a complete CMM system for use in a power plant as shown in Figure 3.

- Inertial separation probes: why they are needed and how they work.

- Analysis techniques (cold-vapor atomic absorption [CVAA], cold-vapor atomic fluorescence [CVAF]), including the advantages and limitations of each.

- Pretreatment/conversion systems, including the different types.

- Calibration systems and overall QA/QC procedures.

- Maintenance requirements.

- EERC field experience including using CMMs under extreme conditions, such as high temperature, pressure, ash, and acid gases (including SO_3).

- Although discussion centered on the Tekran and Thermo Scientific systems, as these are the ones being purchased by the utilities, a list of all current vendors and Web pages where additional specific information about each CMM could be obtained was provided to each attendee.

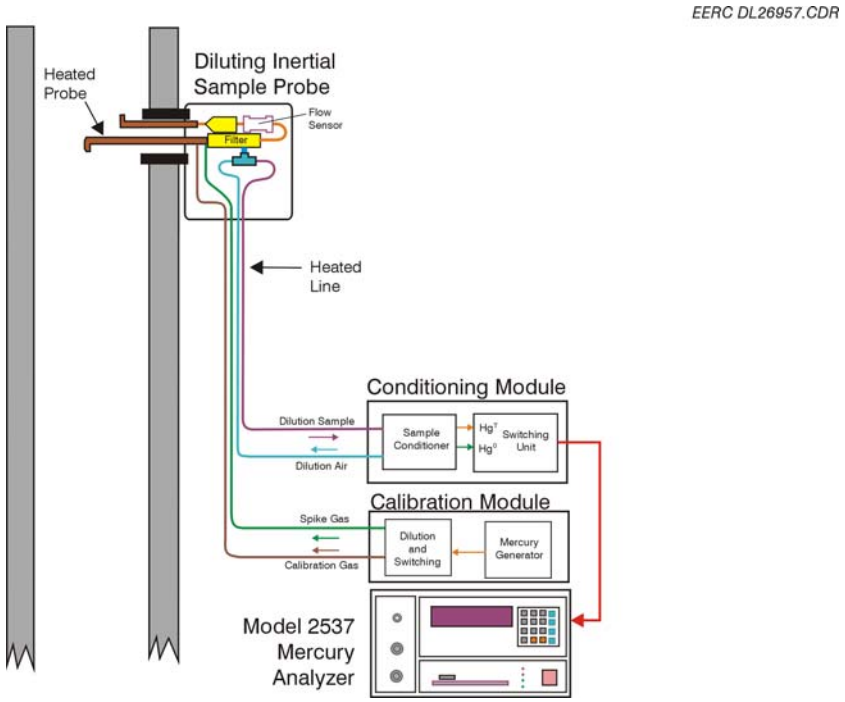

Figure 3. Schematic of a complete CMM (Tekran).

Economic Comparison of the Two Mercury Compliance Measurement Methods

An estimated cost for the two compliance sampling methods, Appendix K and CMMs, was discussed. The estimated costs (based on 2007 $) are shown in Tables 1 and 2. As can be seen in the tables, the costs for Appendix K sampling are estimated based on whether or not the samples are sent to a laboratory and analyzed using the wet-chemistry EPA Method 1631 technique or analyzed on-site using an OhioLumex.

Mercury Reference Methods

Each of the four mercury measurement reference methods that can be used for conducting a RATA on CMMs or Appendix K traps were discussed:

- OH mercury speciation method (ASTM D6784-02)
- EPA Method 29 (Multimetals train)
- EPA Methods 30B (sorbent trap method)
- EPA Method 30A (IRM)

In addition to discussing each method, the procedures for doing a RATA were covered.

Table 1. Estimated Capital Costs for Mercury Compliance Sampling, 2007 $

Cost Item	Appendix K (EPA 1631)	Appendix K (thermal desorption)	CMM
Purchased Equipment (PE)			
Instrument/Console/Probes	50,000	85,500	165,370
Calibration Unit	0	0	35,000
Equipment Installation			
Labor	2,280	5,280	12,500
Materials	5,000	6,500	10,500
Overhead	500	1560	2,500
Certification RATA	0	0	35,000
Total Capital Requirement	***57,780***	***98,840***	***262,870***

Table 2. Estimated Annual Operating and Maintenance Costs for Mercury Compliance Sampling, 2007 $

Cost Item	Appendix K (EPA 1631)	Appendix K (thermal desorption)	CMM
Training	2,400	4,900	24,000
Sorbent Traps and Analyses	30,750	9,500	0
Maintenance and Operating Labor	4,560	5,560	13,130
Supervision Labor	1,270	1,270	1,830
Replacement Parts (10% of PE)	5,000	8,550	15,740
Utilities	1,720	1,890	9,510
Depreciation (10 yr)	5,000	8,550	20,040
Overhead (20% of labor)	4,700	4,900	6,530
Annual RATA	35,000	35,000	35,000
Reporting and Record Keeping	12,700	12,700	12,700
Total Annual O&M Costs	***103,100***	***92,820***	***138,480***

Wet-Chemistry Methods (OH and Method 29)

A schematic of an OH method train is shown in Figure 4. An EPA Method 29 train is very similar except there are no KCl solutions and there are two bottles of HNO_3/H_2O_2 solution. As can be seen, these are very complex methods involving a substantial amount of wet chemistry. Therefore, the discussion centered on the advantages and disadvantages of these methods, with

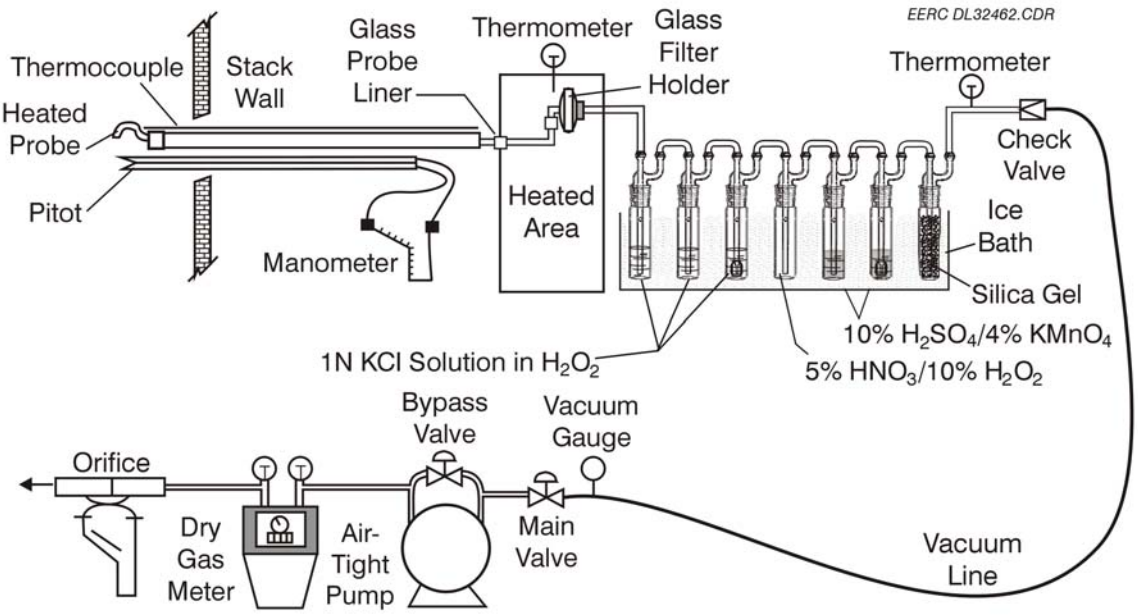

Figure 4. Schematic of OH method train.

most of the discussion on the problems associated with doing them. As part of the discussion, the follow topics were included:

- When to use these methods
- Train setup, teardown, and analytical procedures
- QA/QC
- What can go wrong and how to avoid it
- Using these methods as a reference method for conducting RATAs
- Biases

EPA Method 30B (sorbent trap reference method)

EPA Method 30B is a procedure for measuring total vapor-phase mercury emissions from coal-fired combustion sources using extractive sampling through a mercury sorbent trap which is then analyzed. Although the primary sampling technique is the same as Appendix K, with a known quantity of flue gas extracted from a stack and passed through paired mercury sorbent tubes, it is important to understand the difference between the two methods. The simple difference is that a reference method is designed to certify or prove that another method is working properly, in this case, a CMM. Appendix K, on the other hand, is considered a CMM. There are several differences in the traps, as shown in Figure 5.

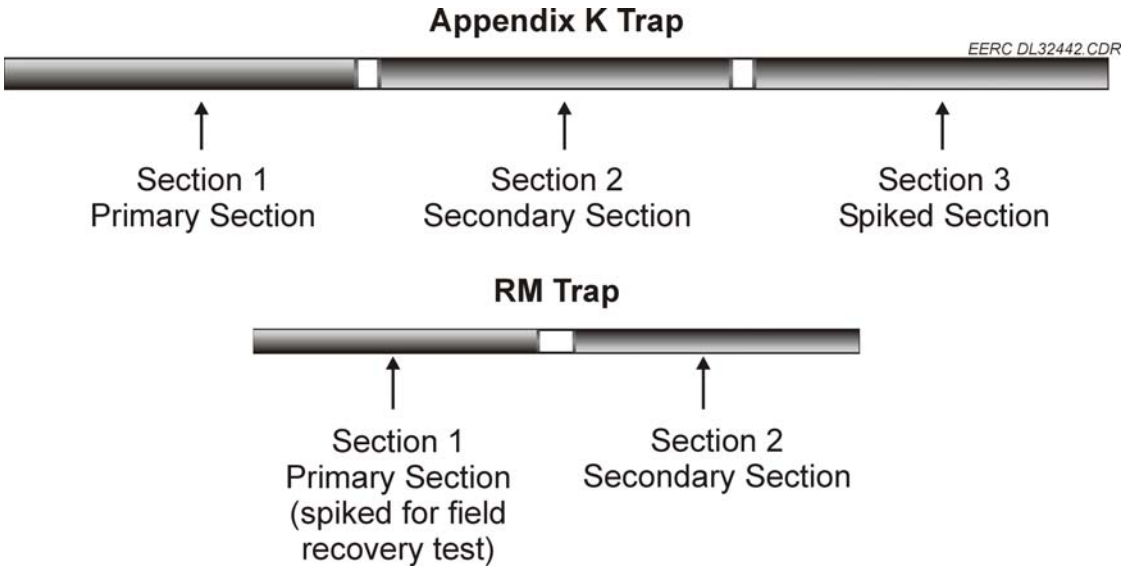

Figure 5. Schematic of an EPA Method 30B and Appendix K trap.

EPA Method 30B consists of the following protocols; each was discussed in detail:

- Sample point selection
- Sampling procedures and handling
- Analytical procedures
- Measurement performance tests
  - Minimum detection limits
  - Determination of minimum mass of mercury to be collected
  - Analytical bias tests
  - Field recovery tests

EPA Method 30A (IRM)

EPA Method 30A was not discussed in the same detail as EPA Method 30B, as it is still under development. Currently, Thermo Scientific and OhioLumex are working on instruments to serve in this capacity. The key requirements for an IRM were discussed, along with the advantages and challenges of using this reference method. Some field data were presented.

Equipment Demonstration (first short course only)

The equipment demonstration took place at the SIPC power plant located several miles from Marion on Lake of Egypt. The following equipment was demonstrated:

- Tekran® Series 3300 with inertial separation probe
- OhioLumex RA-915+ Hg analyzer with RP-324 attachment
- Apex Appendix K/EPA Method 30B sampling system
- Sorbent traps made by OhioLumex

- OH method sampling train

The Tekran is a CVAF instrument that uses a gold trap to preconcentrate the mercury and argon to carry the mercury to an analyzer after being desorbed from the gold trap. The pretreatment/conversion system utilizes thermal dilution technology. The dilution occurs at the probe; however, the separate thermal converter is rack-mounted along with the analyzer and calibration systems. A schematic of the Tekran CMM was shown previously in Figure 3. The inertial separation probe with dilution was located on one side of a split duct at the inlet to the wet flue gas desulfurization unit (outlet of the electrostatic precipitator). A 200-ft heated umbilical line connected the probe to the remainder of the instrument located in a temperature-controlled shelter on the ground. Although the Tekran was the CMM that was demonstrated as part of the short course, the difference and similarities between it and the Thermo Scientific Freedom mercury analyzer were pointed out.

On the other side of the split duct, the Apex Appendix K/EPA Method 30B sampling system was located. During the demonstration, three pairs of EPA Method 30B sorbent traps were sampled. These traps were then analyzed using the OhioLumex Hg analyzer that was set up in an on-site EERC trailer. Although the sampling portion of the OH method was not demonstrated, an OH method train was set up, and setup and teardown procedures were explained.

CONCLUSIONS

At the conclusion of the short courses, evaluation forms were distributed to each attendee. The results of the course evaluations were very positive. Ten out of 12 attendees (not including the ICCI and DOE project manager) completed the form for the first short course offering and 14 of 14 attendees for the second. For both courses, the evaluation included the following:

- Welcome and Overview
- Background
- Mercury Regulations
- Mercury Measurement Planning
- Compliance Monitoring
- Economic Comparison for Compliance Monitoring Methods
- Mercury Sampling Reference Methods
- Conducting a RATA
- Wrap-Up
- Overall Rating
- General Comments

For the first short course presentation, the evaluation also included the following topics:

- Southern Illinois Power Cooperative: Sampling
- Southern Illinois Power Cooperative: CMM
- Southern Illinois Power Cooperative: Analytical

In all aspects of the short course, the attendees rated the courses excellent or good, with over 80% of the responses being excellent. Overall, the short courses went very well, both from the standpoint of logistics and as demonstrated by the overall positive evaluations from the attendees. The list of attendees is provided in Appendix A, and a summary of evaluation forms is in Appendix B.

ACKNOWLEDGMENTS

The author of this report wishes to acknowledge the following organizations and people, without whose support, funding, and expertise, this project would not have been possible:

ICCI
Francois Botha – Project Manager

DOE National Energy Technology Laboratory
Robie Lewis – Project Manager

SIPC
Leonard Hopkins

EERC
LaRae Foerster
Stacie Klegstad
Richard Schulz
Don Toman
Dave Westerman
Eric Zacher

APPENDIX A

PARTICIPANT LIST

MERCURY MEASUREMENT METHODS SHORT COURSE
AND HANDS-ON TRAINING
Drury Hotel and Southern Illinois Power Cooperative – Marion, Illinois
May 5–8, 2008

Final Participant List
12 Participants

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Mr. David Heath
AmerenEnergy Newton Power Plant
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Mr. Grover Hopkins
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Mr. Brian Lawson
City Water, Light & Power
Springfield, IL

Mr. Paul Pierre Louis
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Mr. Paul Nass
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Springfield, IL

Mr. Dan Wheeler
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MERCURY MEASUREMENT METHODS SHORT COURSE
Drury Hotel – Marion, Illinois
September 16–17, 2008

Final Participant List
14 Participants

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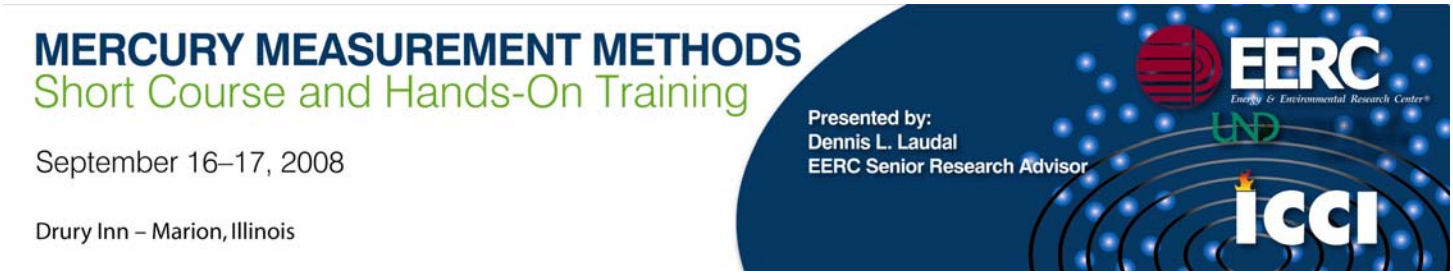
APPENDIX B

EVALUATION SUMMARY



EVALUATION SUMMARY FOR FIRST SHORT COURSE

10 Evaluations Returned/12 Participants = 83% Return

1. Please give an overall rating of the following short course sessions:

Welcome and Overview
Excellent (8) Good (2) Fair Poor Did Not Attend N/A

Background
Excellent (9) Good (1) Fair Poor Did Not Attend N/A

Mercury Regulations
Excellent (9) Good (1) Fair Poor Did Not Attend N/A

Mercury Measurement Planning
Excellent (8) Good (2) Fair Poor Did Not Attend N/A

Compliance Monitoring
Excellent (7) Good (3) Fair Poor Did Not Attend N/A

Mercury Sampling Reference Methods
Excellent (9) Good (1) Fair Poor Did Not Attend N/A

Conducting a RATA
Excellent (7) Good (3) Fair Poor Did Not Attend N/A
Comments:
- Too much, too fast

Economic Comparison for Compliance Monitoring Methods
Excellent (7) Good (3) Fair Poor Did Not Attend N/A
Comments:
- Could have had discussion from participants.

Southern Illinois Power Cooperative: Sampling
Excellent (9) Good Fair Poor Did Not Attend N/A (1)

Southern Illinois Power Cooperative: CMM
Excellent (8) Good (1) Fair Poor Did Not Attend N/A

Southern Illinois Power Cooperative: Analytical
Excellent (10) Good Fair Poor Did Not Attend N/A
Comments:
- First exposure to Ohio Lumex – technician was very informative.

2. Please give your rating of the short course overall:

Excellent ..... Needs Improvement

1 (9) 2 (1) 3 4 5

Comments:

- Very informative course – great job.
- Excellent! Should continue with additional courses for other Illinois companies!
- This was very informative and well thought out. This material, classroom and actual, will definitely be used in the future.

3. What information was most useful to you and why?

- Method 30A & B and K
- Method history and comparison.
- History of regulation and 30B information and hands on demonstration. Those were the most applicable aspects for me.
- The Apex Appendix K system and the Ohio Lumex. We are purchasing Apex and are looking at the Ohio Lumex.
- Mercury testing accuracy.
- Good balance between theory and practice.
- Description of various test methods and hands-on at site was very good!
- The sampling methods and on site work was well received.

4. What topics would you like to see added/deleted from the Mercury Measurement in Combustion Flue Gases Short Course?

- None.
- None.
- Topic choice was satisfactory.
- Good course.
- Compliance monitoring, RATA, QA/QC of reference methods, calculation references.
- I'm fairly green at this, so I think the information was appropriate for all levels of experience.
- All good.

5. Overall, the level of information presented was:

Too Technical Challenging (3) Appropriate (7) Too General N/A

In a good way (Challenging).

6. Please rate the quality of the short course materials binder:

Excellent (8) Good (2) Fair Poor N/A

Comments:

- CD's will come in useful. Print on some slide print outs are difficult to read.
- Job well done.

7. Please rate the on-site short course staff assistance:

Excellent (9) Good (1) Fair Poor N/A

Comments:

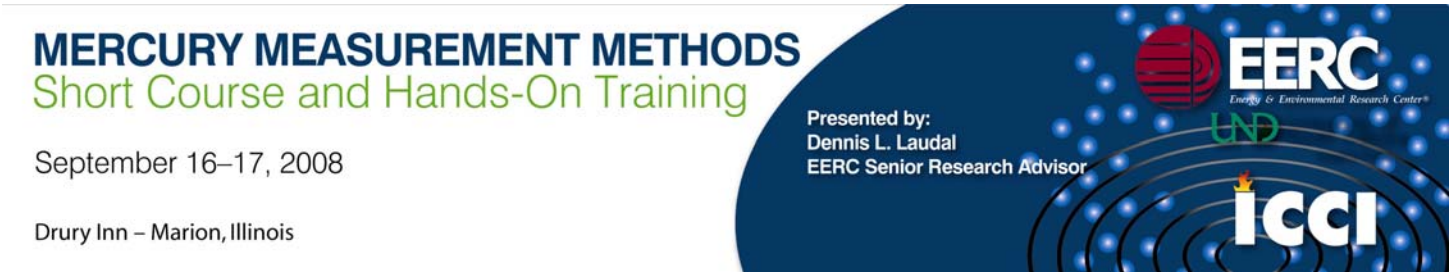
- Very knowledgeable.
- Great job! Food, accommodations, and information all top rate!
- Job well done.

8. Please rate the following items regarding short course facilities:

A. Catered Meals and Refreshment Breaks ...Excellent (9) Good (1) Fair Poor N/A
B. Meeting Rooms .....Excellent (10) Good Fair Poor N/A
C. Hotel Rooms (if applicable) .....Excellent (7) Good (1) Fair Poor N/A (2)

9. Do you have any other suggestions for how we could improve this short course?

- None.
- Greater advertisements to Operators/Regulators.
- Update and return in two years.
- For me, the background and introductory information was a review. It was very good and well presented. More emphasis on RATA testing – monitor performance would be helpful as this goes forward.
- A couple of the slides were difficult to see details. I assume slides are on CD??
- Everything was well done. Follow up class would be beneficial. Best and most informative class I have attended.



EVALUATION SUMMARY FOR SECOND SHORT COURSE

14 Evaluations Returned/14 Participants = 100% Return

1. Please give an overall rating of the following short course sessions:

Welcome and Overview
Excellent (11) Good (2) Fair Poor Did Not Attend (1) N/A

Background
Excellent (11) Good (3) Fair Poor Did Not Attend N/A

Mercury Regulations
Excellent (11) Good (3) Fair Poor Did Not Attend N/A

Mercury Measurement Planning
Excellent (8) Good (6) Fair Poor Did Not Attend N/A

Compliance Monitoring
Excellent (9) Good (5) Fair Poor Did Not Attend N/A

Mercury Sampling Reference Methods
Excellent (10) Good (4) Fair Poor Did Not Attend N/A

Conducting a RATA
Excellent (8) Good (5) Fair (1) Poor Did Not Attend N/A

Economic Comparison for Compliance Monitoring Methods
Excellent (7) Good (5) Fair (1) Poor Did Not Attend N/A

2. Please give your rating of the short course overall:

Excellent				Needs Improvement
1 (11)	2 (3)	3	4	5

Comments:

- Very good. I knew almost nothing coming in, and I followed pretty well. Very informative.
- I have learned a lot. It has been very good for me since I am new at this.
- Great course!

3. What information was most useful to you and why?

- Hg measurement methods
- Since I'm new to the field, all of it was very important
- Current and future state of regulations. This is something that is difficult to acquire if not involved in the industry for some time.
- Everything was useful – put the full picture together in one place.

- Many of the topics will help me prepare for new plant operation and help me plan for the needs for compliance.
- CMMs
- History of what brought us to today.
- Method 30B, because that is what we are using.
- Planning and reference methods
- The RATA and reference method sections.
- All
- The regulations – history, where they are now and were they may be going.

4. What topics would you like to see added/deleted from the Mercury Measurement in Combustion Flue Gases Short Course?

- Some case studies
- I don't know enough yet to suggest anything here.
- None
- Course OK as is.
- Leave the OH method out of class – will never be used.
- Add calculations for Appendix K.

5. Overall, the level of information presented was:

Too Technical Challenging Appropriate (14) Too General N/A

- Put tabs on supplemental info.

6. Please rate the quality of the short course materials binder:

Excellent (5) Good (8) Fair Poor N/A (1)

Comments:

- I like having an area to take notes.
- I like the reference materials.

7. Please rate the on-site short course staff assistance:

Excellent (9) Good (3) Fair Poor N/A (2)

Comments:

- Instructor very knowledgeable.
- Great job! Food, accommodations, and information all top rate!
- Job well done.

8. Please rate the following items regarding short course facilities:

A. Catered Meals and Refreshment Breaks ...Excellent (10) Good (3) Fair (1) Poor N/A
B. Meeting Rooms .....Excellent (7) Good (7) Fair Poor N/A
C. Hotel Rooms (if applicable) .....Excellent (7) Good (7) Fair Poor N/A

9. Do you have any other suggestions for how we could improve this short course?

- No – you did a great job, Denny.
- List of attendees and contact information
- Good course.
- More detail and example calculations to determine 30B sample run times as described in 30B.
- More detail on calculations for field recovery tests including spike recoveries.

- You didn’t touch on certifying a laboratory to run Appendix K samples
- More detail on Appendix K