SUMMARY PROJECT PLAN
FRONTIER GEOSCIENCES
PLUME DILUTION SAMPLING

"MERCURY REACTIONS IN POWER PLANT PLUMES: PLANT BOWEN"

PROJECT GOAL

To continue to make advances in the determination of the physical and chemical transformations of Hg emitted from coal combustion plumes, using the previously tested Static Plume Dilution Chamber (SPDC) method and also a Dynamic Plume Dilution (DPD) method.

SPECIFIC OBJECTIVES

- Mass balance of total Hg using a sum of species method for the SPDC
- How much conversion of gaseous Hg(II) to Hg^0 occurs at a full-scale plant during non-SCR operation?
- Does the conversion of gaseous Hg(II) to Hg^0 occur within the first 30 seconds as observed with the DPD?
- Is the conversion of Hg(II) to Hg^0 significantly affected by the reaction time (5 to 30 seconds) or dilution ratio (20:1 to 300:1)?
- The fraction of gaseous Hg(II) dry deposited to the SPDC walls and what form it takes, particulate or dissolved, in a simulated rainwater washout.
- What fraction of each Hg species is removed to the aqueous phase during a real-time simulated rainwater washout using the SPDC method.
- Comparison of the SPDC and DPD results with airplane plume measurements and modeling studies

SCIENTIFIC APPROACH

Static Plume Dilution Chamber (SPDC)

The SPDC and DPD will be located at mid-stack height, well downstream of any pollution control devices. The SPDC method is described in detail elsewhere (Prestbo et al., 1999). The SPDC is loaded with a measured amount of flue gas (3-5 liters) into the trace metal cleaned SPDC using a heated isokinetic sampling probe. The flue gas is diluted with filtered ambient air and allowed to react for a known amount of time, typically 4 minutes, before sampling begins. The air pressure is maintained near ambient (1 atm) in the SPDC. For these experiments, dilution ratios will be approximately 140:1. The Tekran will determine an initial mass-balance of gas-phase Hg^0. Simultaneous to plume introduction into the SPDC, speciation of the flue gas will be determined using the Ontario-Hydro and CEMs (EERC) and also the FMSS methods (Frontier). Semi-automated Hg speciation measurements in the SPDC will be accomplished using a Tekran 2537A total gaseous Hg instrument with a KCl-denuder and particulate filter inlet. This method has been shown in lab and field tests to be precise, accurate, and free of artifacts (Landis et al., 2002, in-press). Both Hg(II) and particulate Hg will require longer sampling times, but staggered samples may provide a picture of changing Hg(II) with time. Elemental Hg will be determined continuously in the SPDC using the Tekran 2537A. During the time that the Tekran 2537A is measuring Hg^0, both gaseous Hg(II) and particulate Hg will be collected by the KCl-denuder and filter inlet. By collecting a number of Hg(II) and particulate Hg samples in series, the changes in these species can also be observed with respect to time. This will require that several KCl-denuders and particulate filters be prepared for each sample run. After the sampling has concluded, the KCl-denuders and particulate filters are immediately analyzed directly into the Tekran 2537 by thermal desorption.

Dynamic Plume Dilution (DPD) Method

The Dynamic Plume Dilution (DPD) method is required to capture the mercury speciation in the 5 to 30 second reaction time frame. It has been observed that the potential conversion of gaseous Hg(II) to Hg^0 is faster than the SPDC can observe (<3-4 minutes). It is important to investigate the relationship of this flue gas Hg reduction reaction with respect to both the reaction time and dilution ratio. The DPD, unlike the SPDC, has the capability to easily change the flue gas dilution ratio and reaction time during the course of a sample run while observations of Hg^0 are being made. However, the maximum reaction time should be kept below about 30 seconds to minimize wall losses.

The DPD has 4 essential parts: 1) Isokinetic inlet, 2) multiple-orifice dispersion plate, 3) Teflon coated reaction cell and 4) sampling manifold (Figure 2). The heated isokinetic inlet is inserted into the flue gas stream to pull a known amount of a representative flue gas sample into the DPD. The flue gas remains at stack temperature until it is quickly diluted with a custom designed, multiple orifice dispersion plate that ensures complete mixing. As an example, a 0.4 liter/minute flue gas flow into a total of 100 liters/minute of dilution airflow will result in a 250:1 dilution ratio. Ambient air will be used for dilution after passing through a cyclone separator or impactor to remove particles larger than 2.5 µm. The diluted plume mixture then travels through the highly cross-linked Teflon reaction cell. This cell will likely be heated slightly above ambient temperature (30 to 50 °C) to avoid losses of gaseous Hg(II) on the walls. The use of the cross-linked Teflon is also important, as it has been shown to be less adsorptive to gaseous Hg(II) than typical Teflon FEP, or PFA. At the end of the DPD is the sampling manifold. Here a set of three KCl-denuders and quartz fiber filter trains will be mounted to collect 10-minute samples in series, while the Tekran 2537A is analyzing Hg^0 continuously on a 2.5 minute cycle time. The set of 3 KCl-denuders will have a valve behind them to switch sample trains at 10-minute intervals. The KCl-denuders and particulate filters will be analyzed by thermal desorption into a calibrated Tekran 2537A as described in Landis et al., 2002.

TEST PLAN

A likely test plan is summarized in Table 3. On-site planning and discussions as well as in-field operational decisions will likely optimize this test plan for the project. At this stage it is assumed that the SPDC and DPD sampling will be coordinated with the airplane sampling. However, it is very likely that the SPDC/DPD sampling will not be simultaneous to the airplane sampling. This is primarily due to the long setup, sampling, washing, cleaning and turn-around time for each SPDC experiment.

Table 3. Suggested Test Matrix at the Bowen Plant

Day	Location	Device	Rxn Time Prior to sampling	Light Input?	Rain Input?
1	Unit 2	SPDC	Setup SPDC		
2	Unit 2	SPDC	Setup SPDC		
3	Unit 2	SPDC	Setup SPDC		
4	Unit 2	SPDC	4 min.	No	No
5	Unit 2	SPDC	4 min.	No	No
5	Unit 2	SPDC	4 min.	Yes	No
6	Unit 2	SPDC	4 min.	Yes	No

6	Unit 2	SPDC	4 min	No	Yes
7	Unit 2	Change out	Setup DPD		
8	Unit 2	Change out	Setup DPD		
9	Unit 2	DPD	3sec	NA	NA
9	Unit 2	DPD	3 sec	NA	NA
10	Unit 2	DPD	5 sec	NA	NA
10	Unit 2	DPD	5 sec.	NA	NA
11	Unit 2	DPD	15 sec.	NA	NA
11	Unit 2	DPD	15 sec.	NA	NA

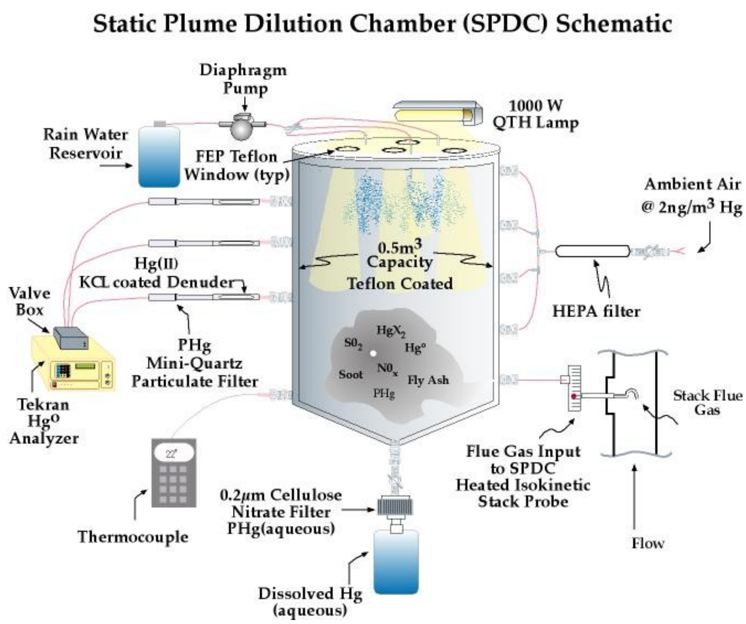

Figure 1. Static Plume Dilution Chamber Schematic

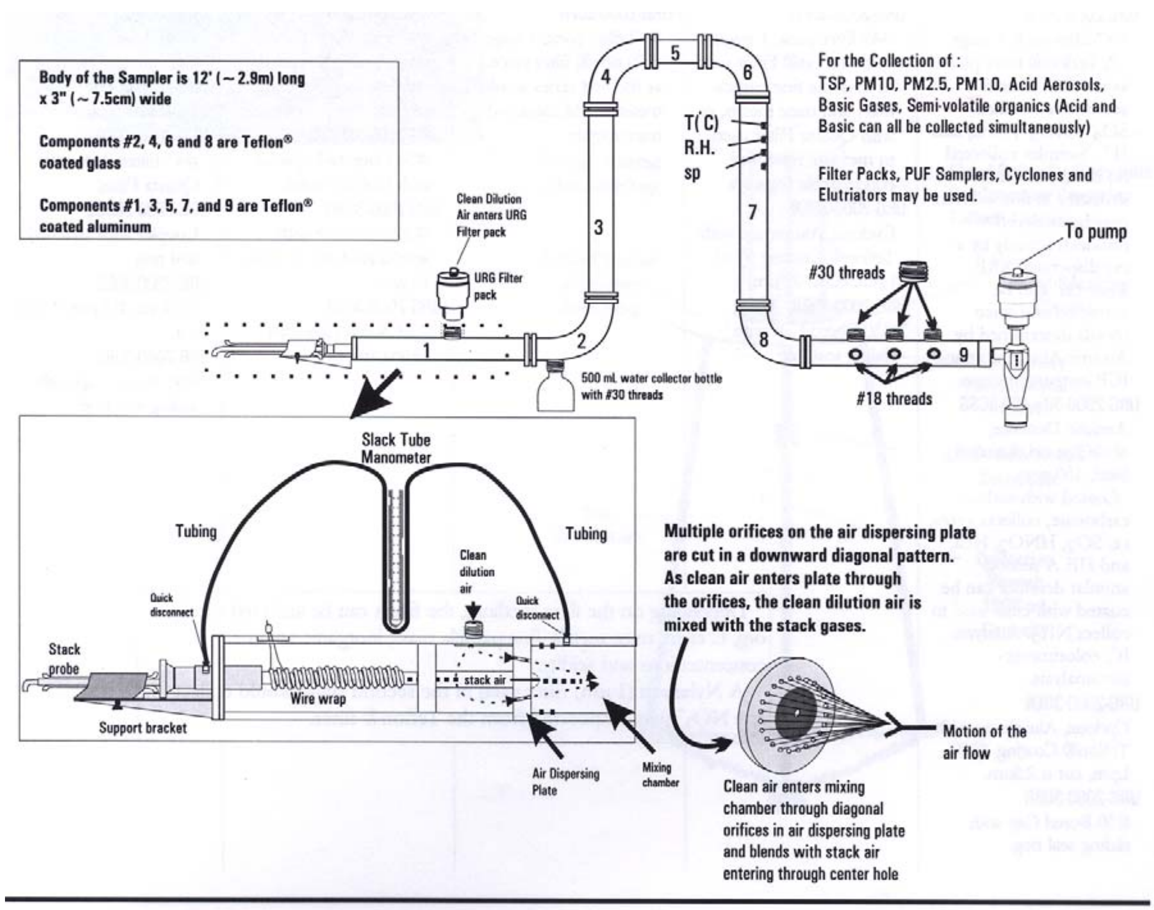

Figure 2. Schematic of the Dynamic Plume Dilution (DPD) method.