Eliminating Particle-Related Artifacts in the Real-Time Measurement of Mercury in Flue Gases

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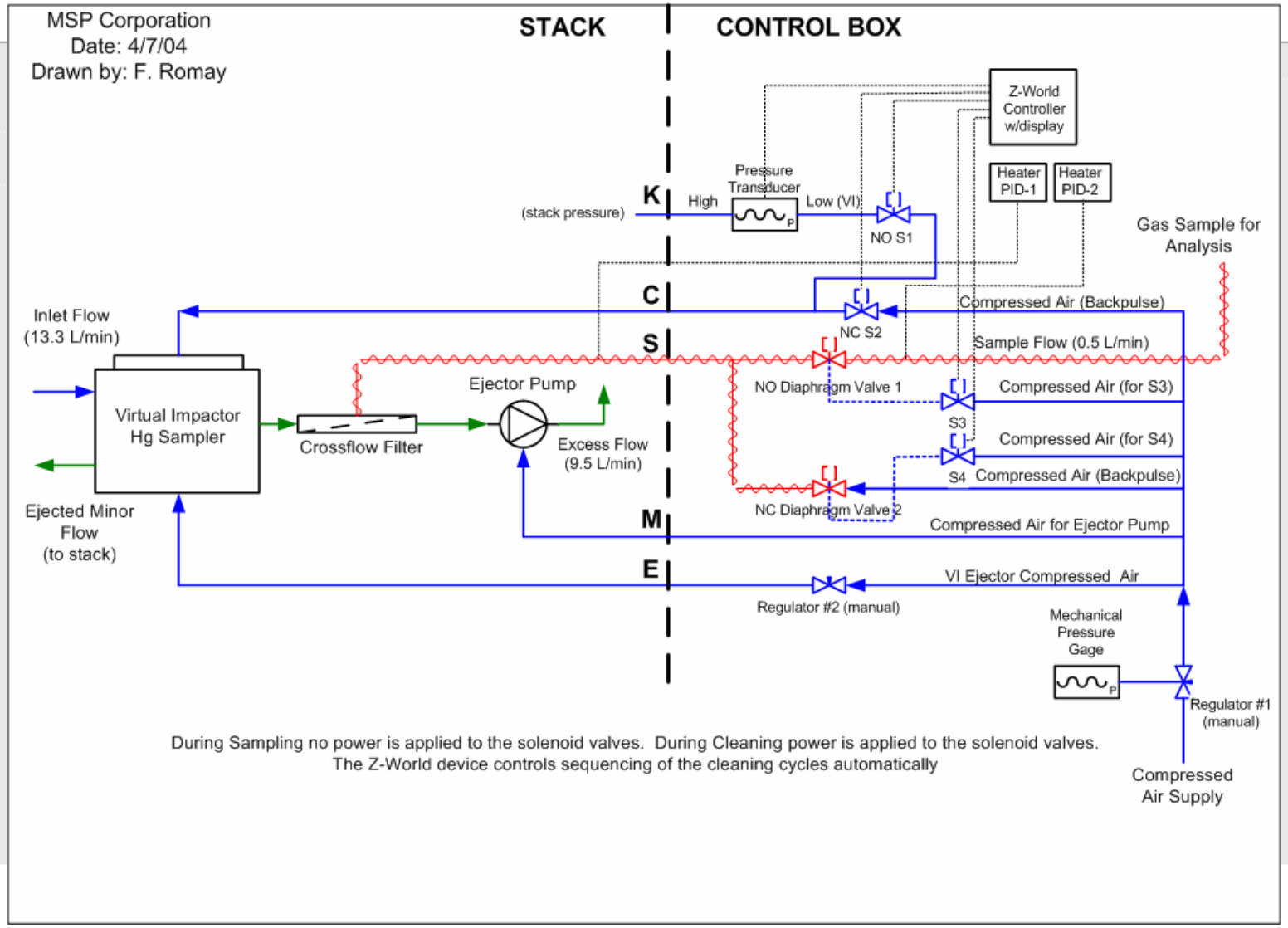
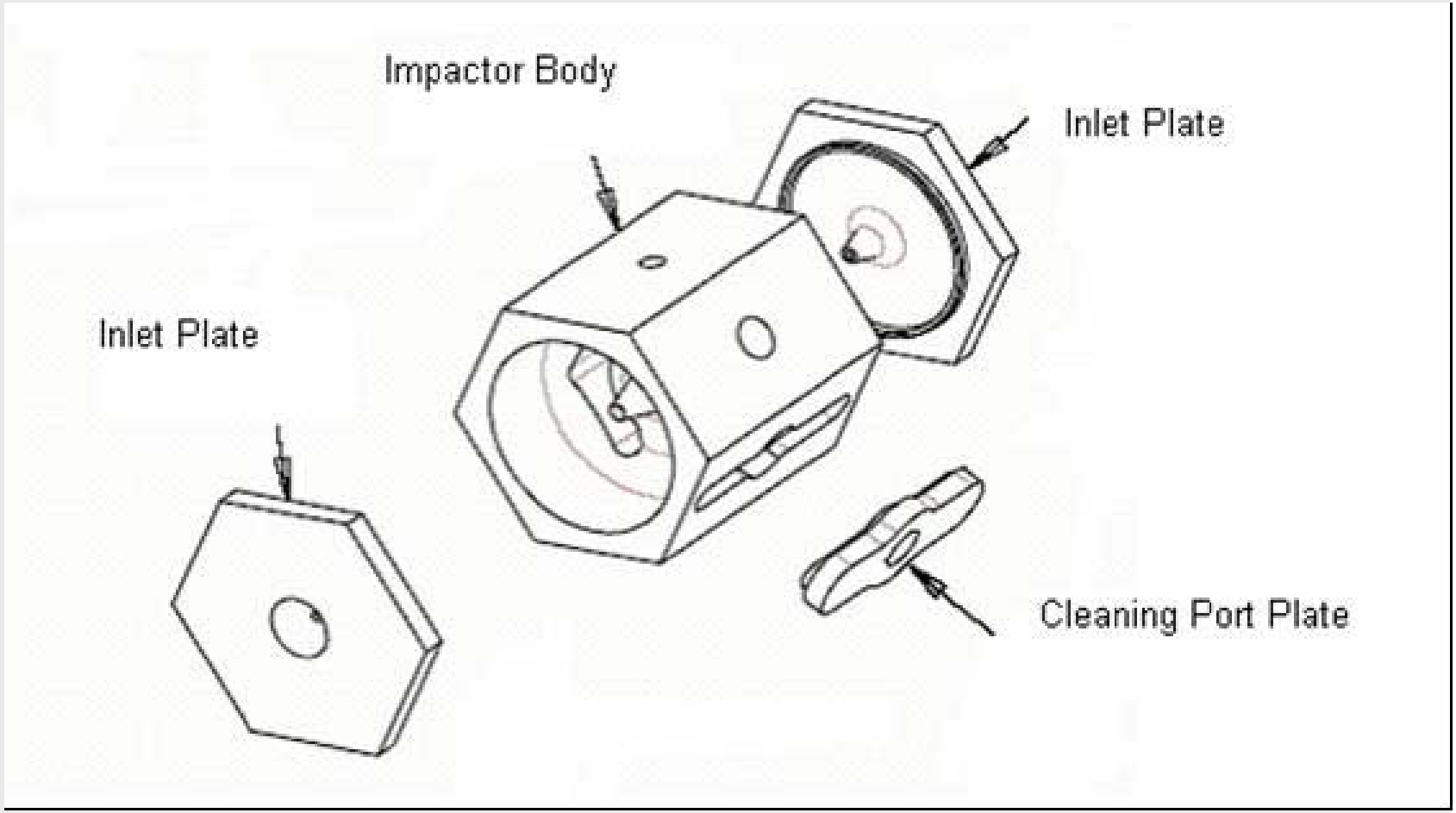
Abstract

MSP has developed this sampler to eliminate the particle-related artifacts commonly found in the measurement of mercury in flue gases. This sampler accumulates no particulate matter but rather disengages the particles from the mercury sample gas via virtual impaction, a technique based on inertial separation of particles as the sample gas flows through carefully designed nozzles with corresponding receiving tubes. A small fraction of the aerosol mass, typically 1 to 4%, remains in the sample line. This additional remaining mass of particles in the sample line should also be removed before the sample can enter a continuous mercury monitor. For this reason, a high-efficiency cross-flow filter with a stainless steel porous metal element is used in the sampling system. Therefore, the sample provided to the mercury analyzer is completely particle-free (no additional filtration is required to protect the mercury analyzer). In addition to the particle removal capabilities of the virtual impactor and the cross-flow filter, the sampling system incorporates a programmable backpulse cleaning cycle to eliminate any accumulation of particulate matter inside the virtual impactor and the filter element.

Flow Diagram of the Sampling System



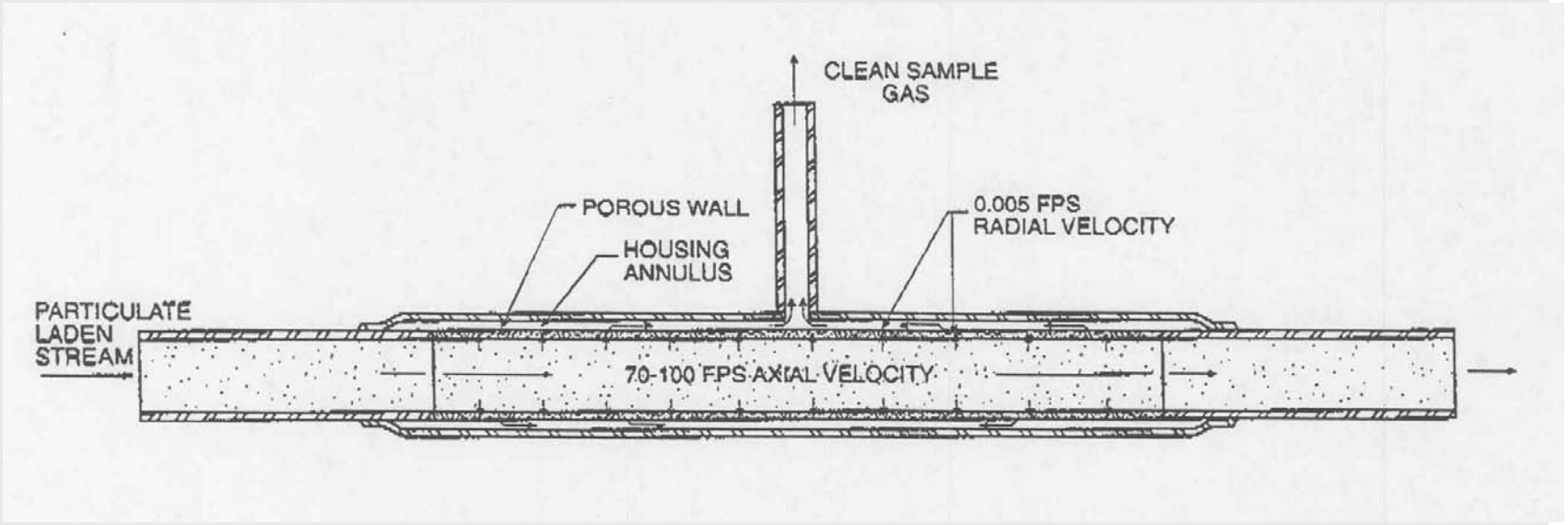
Single-stage Virtual Impactor



Virtual Impactor Design Parameters

Parameter	Value
Total Flow (L/min)	15.0
Minor/Total (%)	25
Minor Flow (L/min)	3.75
Major Flow (L/min)	11.25
$(Stokes_{50})^{1/2}$	0.45
Cutpoint, $D_{p,50}$ (mm)	0.94
Slip Correction Factor	1.18
Number of Nozzles	2
Nozzle Diameter (cm)	0.172
Pressure Drop (in wg)	10.67
Reynolds Number	6034

Cross-Flow Filter



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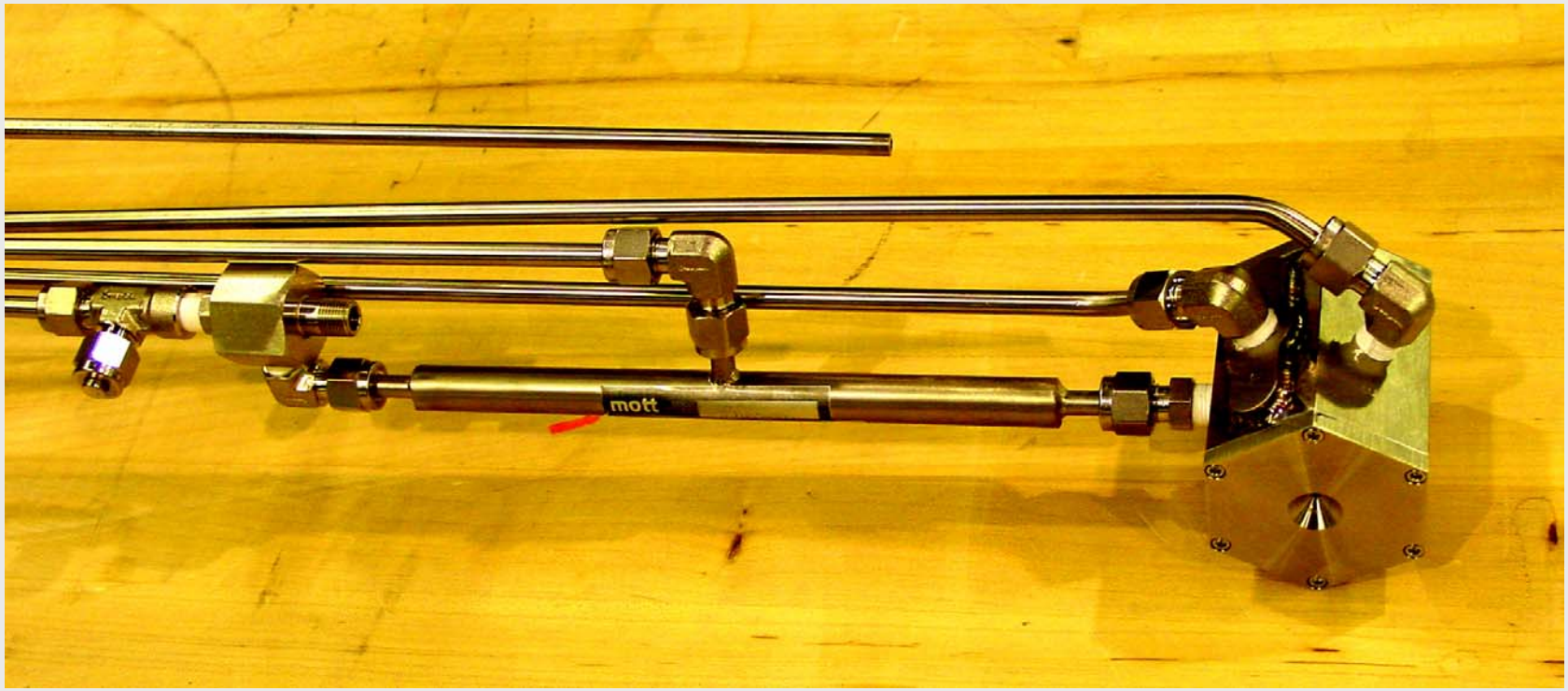
The Sampling Probe



Control Enclosure

Field Test Power Plants

Plant	Coal	Boiler Type	Boiler Size, MW	NO_x Control	Particulate Control	Sulfur Control
S1	Low-sulfur WV, KY, PA bit.	Wall-fired	190	None	Fabric filter	None
S2	Low-sulfur KY and WV bit.	Concentric-fired	700	SCR[1] and LNB[2]	ESP[3]	None
S3	OH bit.	Wall-fired	1300	SCR and LNB	ESP	Wet scrubber
S4	ND lignite with an additive	Wall-fired	220	LNB with overfire air	ESP	None

1 Selective catalytic reduction.
2 Low–NO_X burner.
3 Electrostatic precipitation.

Coal Composition

Analysis*	S1	S2	S3	S4
Mercury, µg/g dry	0.14	0.07	0.14	0.06
Chlorides, µg/g dry	946	1020	523	7
Moisture Content, %	7.4	6.1	6.1	36.9
Ash, %	11.7	11.6	9.4	8.8
Sulfur, %	1.5	1.0	3.9	0.7
Heating Value, Btu/lb	11,891	12,019	12,097	6194

* Coal results are on an as-received basis, except where noted as dry.

Particle Removal Efficiency Measured at Field Location S1

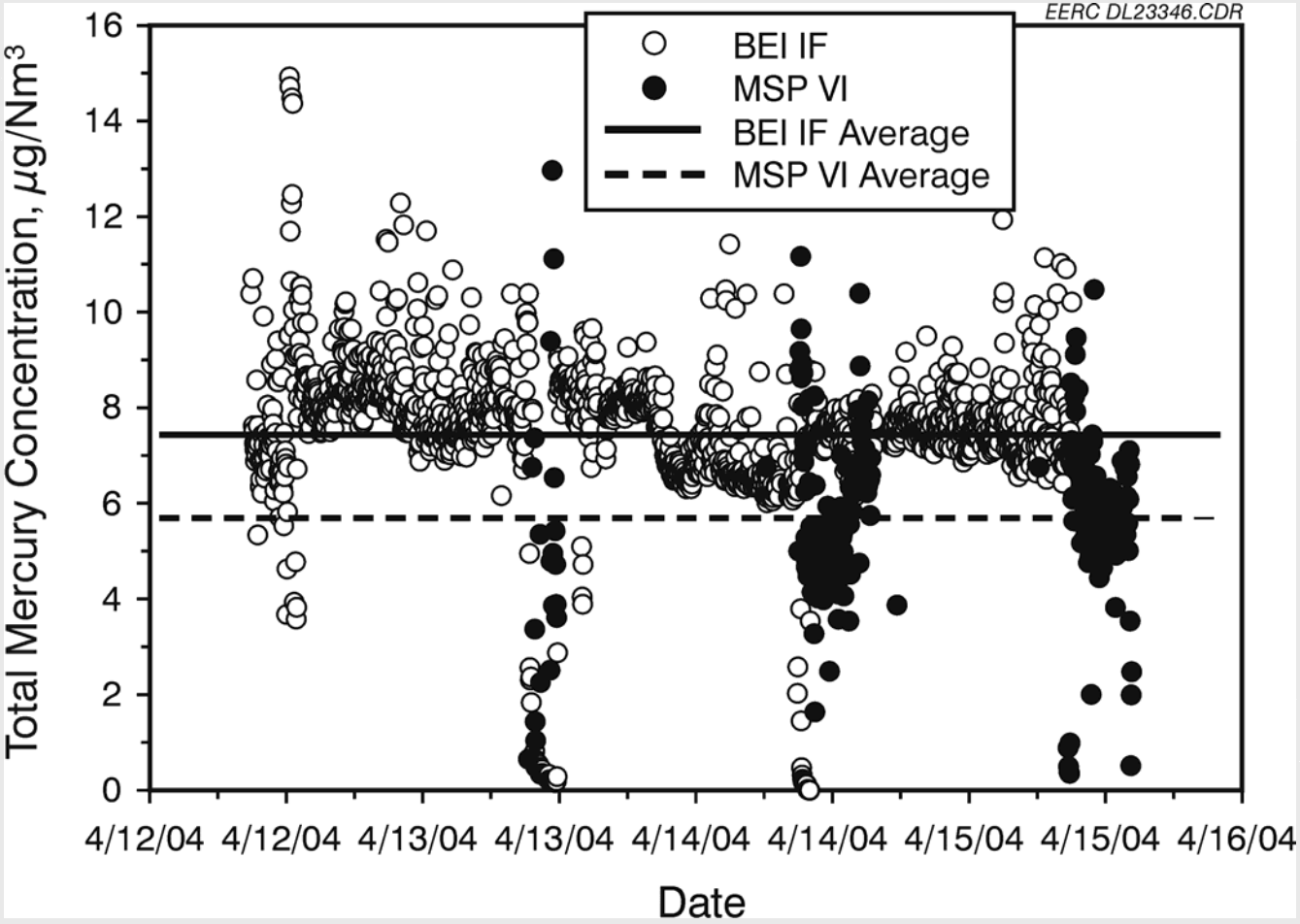
Device	Day Tested	Inlet Dust Loading, grains/scf[1]	Loading on Backup Filter of the Device, grains/scf	Particulate Removal Efficiency of the Device, %	Particulate Removal Efficiency of the Fabric Filter,%
Thimble Filter	1	3.3249	NA[2]	>99.99	99.36
Apogee QSIS	2	3.6150	– 0.00001[3]	100[3]	99.27
MSP VI	3	5.4919	0.00498	99.91	99.92
BEI IF	4	4.3521	0.00393	99.91	99.96

[1] Based on the OH tests.

[2] Not Applicable. All inlet dust loading results were collected using thimble filters. The collection efficiency of thimble filter is 99.99%, based on manufacturing specifications.

[3] Little dust was collected on the filter. The negative weight is a result of very small of amounts of the filter mass lost when removing it from the holder.

Total Gas-Phase Hg at S4



Comparison of Average Hg Concentrations at S4

CMM Results for the Two Particulate Separation Devices at Site S4

Mercury Species	BEI IF	MSP VI
Hg(Total), $\mu g/Nm^3$	7.43±1.81	5.69±1.01
Hg^0, $\mu g/Nm^3$	5.39±1.20	4.20±0.61

Conclusions

- The MSP VI is a viable and probably better alternative to conventional inertial filtration systems. The field test results show it provides good speciation even for difficult ashes.
- The virtual impactor itself is less susceptible to plugging compared to any other barrier filter. However, due to the fact that the VI removes only about 95 to 99% of the particles, a backup filter is still necessary to remove the small fraction of particles that remains in the sample stream. A small cross-flow filter has been shown to work very well with the VI system.
- Automatic backpulse cleaning cycles ensure long–term sampling without having to remove the probe from the stack.
- The system MSP VI sampling system is smaller and easier to set up than other commercially available systems.
- Additional engineering is needed to improve the reliability of the complete sampling system, in particular the cycled backpulsing and the heat tracing of the sample line.

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