

Continuous Emissions
Monitoring Specialists

- **Mercury CEMS Sample Line
Temperature Reduction Study**
“Turn Down the Heat”

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Combined Study, Conducted 2011


Presented EUEC January 2012

Agenda and Purpose

- Sample lines on Thermo Scientific Mercury Freedom CEM Systems have been heated to 120° C since the product was developed.
- Sample transport occurs at very low pressure, and samples are diluted from 40:1 up to 100:1.
- Many technical experts conclude that high temperature transport is not necessary.
- Testing was needed to prove that no issues will occur with lower temperatures.
- This study will show the results and new operational temperature requirements.

Sample Lines are Expensive, Difficult to Install, and Contribute to Risk..

Example Instructions:



GENERAL INFORMATION
70402 heated hoses come electrically and hydraulically complete. **DO NOT** cut or alter the enclosed hose under any circumstances.



CONSTRUCTION
See Drawing No. 70402 Rev. C (attached) for core and wiring information.

INSTALLATION
Hoses should not be pulled or supported by fittings or tubing alone. Care needs to be taken when making hydraulic connections to avoid kinking of core. When installing multiple hoses, please allow a minimum distance of 1" between each hose. When using cable ties or pipe straps, use care to avoid compressing thermal insulation. For lengths over 50', support hose with Kelleem Grips™ (right) at 50' intervals.


OPERATION
DO NOT operate hose in a coil or an overlapped configuration. The concentration of heat may cause severe damage. 70402 heated hoses are designed to run using 220 VAC @ 30 watts/ft. Maximum operating temperature of 350° F must not be exceeded.

WIRING
Heat/Line hoses are not self-controlled and must be used in conjunction with a temperature controller. 70402 heated hoses have two (2) built-in K Thermocouples sensors, located at the midpoint of the hose.

INSPECTION AND HANDLING
At this time, please read all tags attached to hose to check for operating specifications. When removing hose from shipping container or spool, care should be taken to avoid kinking. Avoid walking on, running over, or crushing hose in any way.



Heater Wire



K Thermocouple

PLEASE NOTE
The temperature inside the core will be higher than the temperature outside the core where the sensor is located.
The temperature difference will vary with each application.

CAUTION
Do not wrap hose with tape or other insulating materials.
Do not operate hose with frayed or damaged insulation.
Employ this hose only with chemicals that will not affect

Benefits of Reducing Temperatures to 50°C

- Longer sample line life.
- Added safety feature: Heating circuit can be designed such that it will be impossible for a runaway condition that will damage line.
- Smaller diameter sample lines can be used, making installation easier and less costly.
- Lower capital cost for sample lines.
- Sample lines easier to terminate and cut to fit at location in the field.

50 C = 122 Fahrenheit

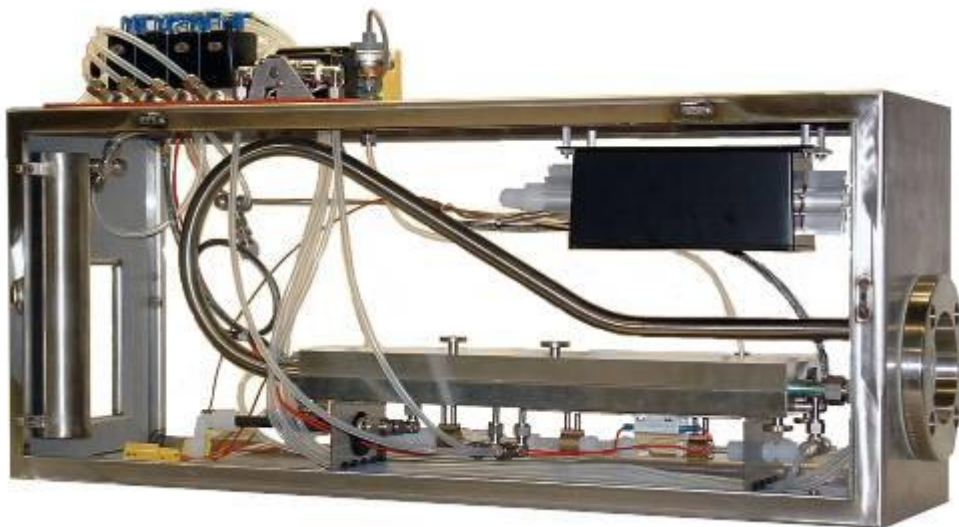
Benefits of Reducing Temperatures to 50°C

- Sample lines are easier to rinse out and clean.-increased uptime.
- Less power consumption is a direct savings.
 - Example: 500 foot line with 30 watts/foot heating can be reduced to 15 watts/foot.
 - Using \$0.06 per kWh and a reduction of 15 watts= \$3,931 per year

Device Name:	15 w/ft umbilical 500 ft long	Cost Per Hour:	\$0.450000
Wattage of Device:	7500	Cost Per Day:	\$10.800000
Kilowatt Hour Cost:	0.06	Cost Per Week:	\$75.600
Hours of use per day:	24	Cost Per Month:	\$302.40
Calculate Cost		Cost Per Year:	\$3,931.20

* www.electricity-usage.com

Mercury CEMS Overview



- **Sample Extraction (Probe)**
 - Filter with Dilution
- **Sample Pretreatment with stack converter**
 - Dry Thermal Converter
- **Sample Transport (Umbilical)**
 - Heated PFA Teflon
- **Mercury Analyzer**
 - Continuous CVAF
- **Mercury Analyzer Calibration System**
 - Oxidized Hg Generator at Probe and Elemental Hg via vapor pressure/mass flow control



82i Probe Controller

80i Mercury Analyzer

81i Mercury Calibrator

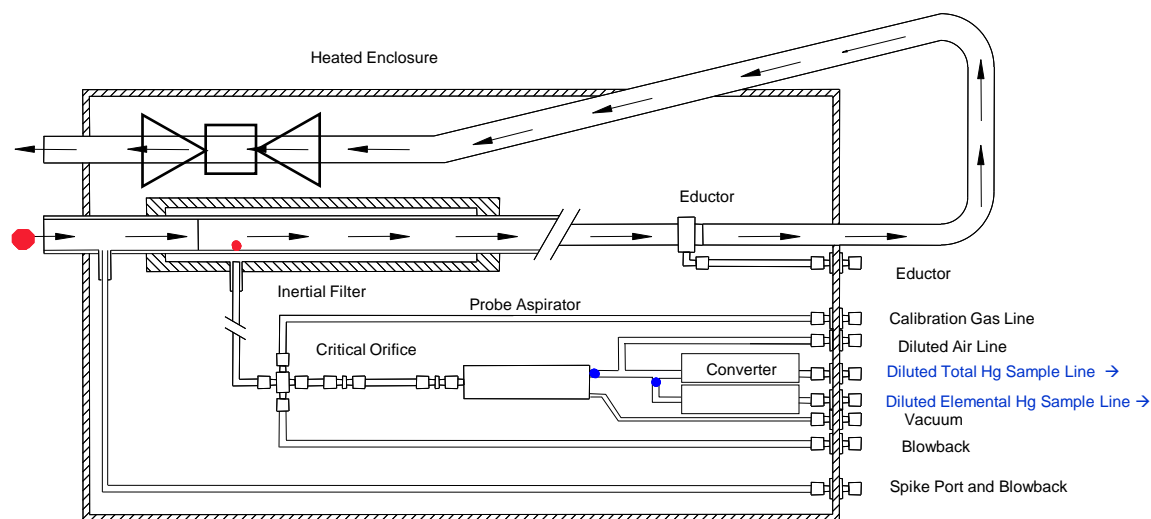
Zero air supply
And Nitrogen
Generator

Mercury Freedom CEMS

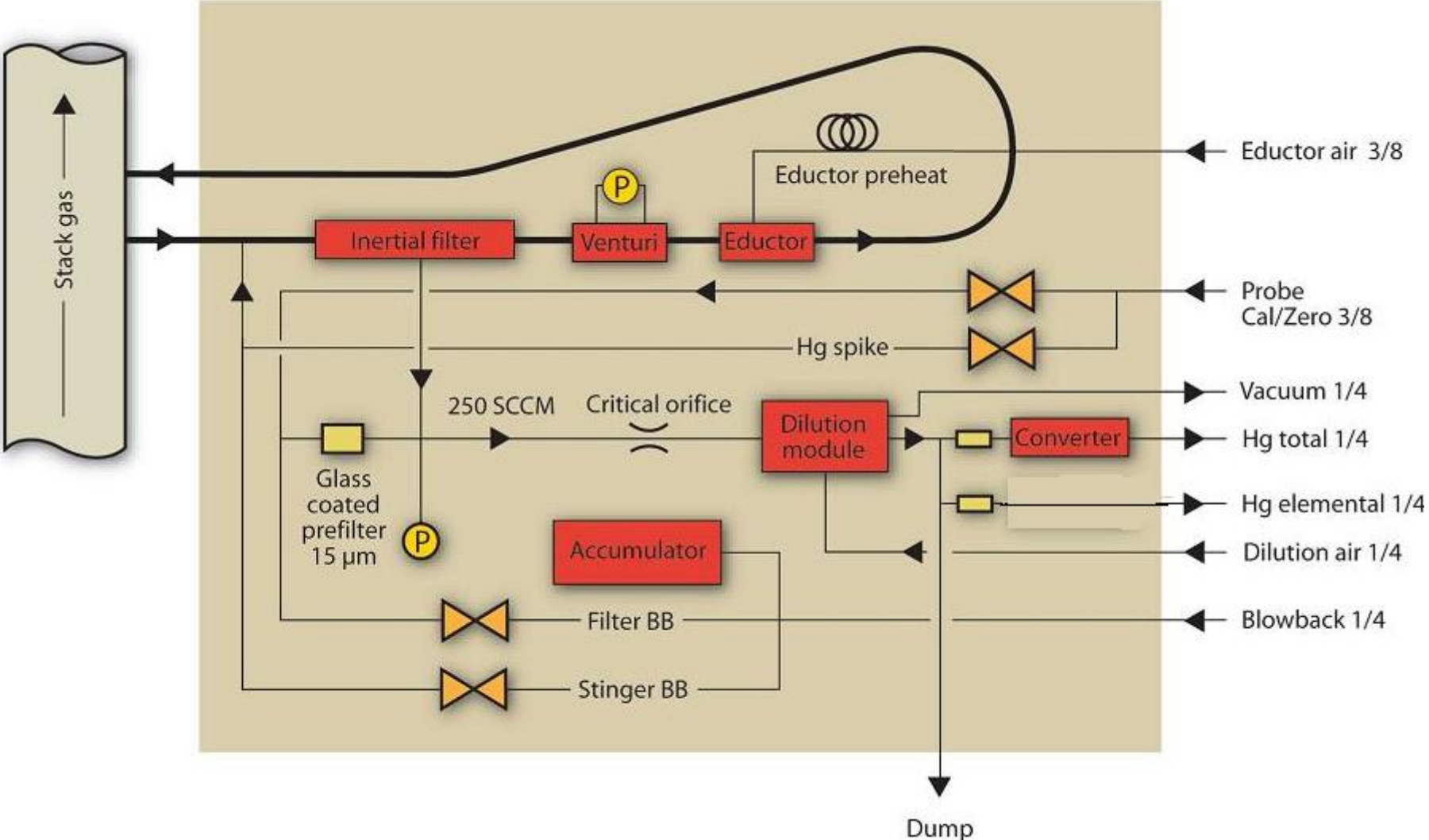


Model 83*i* Inertial Filter Probes

- Material: Silica Coated Stainless Steel or Hastelloy C-276
- Design Flow Rate (lpm): 10 – 50 liters/minute
- Heated Filter/Inlet Stinger/Outlet Stinger Blowback
- Inertial Separation Mechanism separates Vapor Hg from Particulate Matter



Model 83i Probe/Converter Flow Scheme



Sample Transport

How is the sample transported in the Thermo Scientific Mercury Freedom CEMS?

- Only Elemental Hg is transported, not Oxidized.
- Conversion of oxidized Hg occurs at the stack.
- The system uses wet-based dilution technology, as employed at most coal fired utilities in the United States.
- The sample is transported at a very low pressure(Vacuum).
 - 70 mm Hg
 - 0.1 Atmosphere
 - 1.35 psia(9.3 kPa)

Low moisture and low pressure “Freeze the Chemistry”.

Overview of the Test Group

- Qty. 5 CEMS at large Power Utility Company in the Southeast US.
- Qty. 3 units in Wisconsin from separate Power Utility Companies
- Qty. 1 Unit Power Utility in the Western US. (data not shown)
- Qty. 1 Cement Plant Stack from major Cement Producer in the Midwest
 - *Ten Thermo Scientific Mercury Freedom CEM Systems were part of the official study.*
 - *Wet, dry, warm climate, cold climate, and one cement plant.*

Power Utilities Tested in the Southeast

- **Plant A (Dry)** - Duct Mounted / Non-FGD (Split Duct, so direct comparisons could be made between them)
- **Plant A (Wet)** - FGD (JBR) (Stack Mounted) ESP
- **Plant B (2 Units to 1 Duct) (Dry)** – Dry Stack and the probe is in the upper duct and on the outside exposed to the weather. Both Units with precipitators but only 1 unit has a bag house
- **Plant C (Dry)** – Dry Stack with 2 small units combined into the one stack. There is only a precipitator for each unit with no bag house or other controls.
- **Plant D (Wet)** - FGD (Spray Type) (Stack Mounted) ESP

Plant A (2 Systems Tested): No Bias on Readings

- The sample line temp was lowered to 50c to see the effects (if any) over time on 2 systems at Plant A on Sept 20.
- Initial change saw no difference in readings or calibrations.
- The change was done on a system where the probe is mounted on an FGD stack and the sample line is approximately 500 foot long.
- The other system is a duct mounted probe with the sample line approximately 100 ft.
- The duct mounted probe has duplicate system on other duct (A and B) from the same source and run identical numbers so good comparison was seen.
- The sample lines were flushed a few months prior to change and have not been flushed at this time.

Plant B and C Results: No Bias on Readings

Plant B: Dry DUCT Installation

- The sample line temp was lowered to 50c on Sept 29.
- Initial change saw no difference in readings or calibrations.
- The change was done on a system where the probe is mounted on a Dry stack and the sample line is approximately 250 foot long.
- The lines have not been flushed recently.

Plant C results- DRY STACK

- The sample line temp was lowered to 50c to see the effects (if any) over time on 2 systems at Plant A on Sept 21.
- Initial change saw no difference in readings or calibrations.
- The change was done on a system where the probe is mounted on an FGD stack and the sample line is approximately 300 foot long.
- The lines have not been flushed in approximately a year.

Plant D: Wet FGD Installation

- The sample line temp was lowered to 50 C on Oct 3rd.
- Initial change saw no difference in readings or calibrations.
- The change was done on a system where probe is mounted on an FGD stack and the sample line is approximately 500 foot long.

Summary of Southeast plant 50C Testing.

- Normal daily calibrations were done as well as weekly System Integrity Checks and passed with no difference seen between 120C and 50C systems
- Calibration coefficients were adjusted as necessary to keep system operating in specification.
- Slight background increases were seen but the number of times the 50C systems needed to be calibrated was no different than 120C systems and can be attributed to typical lamp decay and pump wear.
- Overall no difference was seen and no extra line flushes were needed on any system.
- RATAs were not conducted at all plants, but no RATA tests failed or evidence of any bias.

Summary of Northern Test CEM System

- Plant A in Wisconsin ran with upper half of heated Umbilical not working for 10 months.
- All calibrations and RATA were normal.
- Plants B and C have performed tests that agree with findings.
- Both have wet FGDs.
- Probes are a mix of 83i and 83i-GC units in all cases.

Midwest Plant: Dry, Horizontal Kiln w/o Inline Mill



Midwest Cement Plant – Installed Freedom[®] System



Sample line for this installation was never energized for the 6 month duration of the testing. (Installed 2009)

RATA Results at Midwest Cement Plant

	Test Run	Date	Start Time	End Time	Reference Method Hg μg/scm	CEM Output Hg μg/scm	(RM-CEM) Difference (di)	Difference ² (di ²)
1	1	09/22/09	0945	1015	12.1	11.7	0.35	0.13
1	2	09/22/09	1053	1123	11.2	11.4	-0.23	0.05
0	3	09/22/09	1148	1218	12.5	11.5	1.01	1.02
1	4	09/22/09	1251	1321	12.1	11.3	0.82	0.67
1	5	09/22/09	1354	1424	10.3	10.8	-0.47	0.22
1	6	09/22/09	1446	1516	11.7	11.8	-0.05	0.00
1	7	09/22/09	1545	1615	12.0	12.0	0.03	0.00
1	8	09/22/09	1638	1708	11.4	12.1	-0.73	0.53
1	9	09/22/09	1730	1800	12.1	11.9	0.19	0.03
1	10	9/23/2009	0855	0925	9.7	9.6	0.06	0.00

n	9	
t(0.025)	2.306	
Mean RM Value	11.396	RM
Mean CEM Value	11.400	CEM avg
Sum of Differences	-0.035	di
Mean Difference	-0.004	d avg
Sum of Differences ²	1.638	di ²
Standard Deviation	0.452	sd
Confidence Coefficient	0.348	CC
Relative Accuracy based on % of RM Value	3.1	%
Relative Accuracy based on difference	0.0	Mean Difference

Results and Summary

- Operation of Thermo Scientific Mercury Freedom Sample line temperature at **70 Degrees C is proven acceptable**.
- If the sample line is in a situation where it may be above 50C, the utility may elect to raise to 80C (176F).
 - Example, if line is installed directly onto hot metal stack or other very hot ambient location. The line needs to be simply held slightly above ambient conditions.
- The sample line needs temperature control, not self limiting systems.

Acknowledgements

We would like to thank Spectrum Systems and their customers for providing a majority of the test information for this study.

