A Comparison of Proposed PM CPMS Limits

Paper #11, IT3 Conference - 2013

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ABSTRACT

Particulate matter (PM) monitoring has been proposed and implemented through several rule making activities which includes PM continuous emission monitoring systems (CEMS) or PM continuous parametric monitoring system (PM CPMS). This paper will provide a general comparison of both PM CEMS and PM CPMS applications based on current experience. We will also compare the different techniques proposed by the Environmental Protection Agency (EPA) to establish alarm limits.

BACKGROUND

Our original thoughts were to obtain raw PM data and process it through the different proposed techniques. Based on initial conversations with several companies, it seemed like we would have access to some blind data. However this turned out to be more difficult that everyone thought. But while searching other avenues for raw PM data sources, we discovered that RMB Consulting ("RMB") in Raleigh, NC had already performed the same analysis for the power industry. RMB was kind enough to allow us to use their data set for this paper. We had a discussion with Ralph Roberson, of RMB, on the background and basis of the PM data set. We do not know and did not want to know the facility location. However it is good to understand some basics about the system.

The PM data is from a coal fired power plant using an electrostatic precipitator (ESP) for PM control. The facility was conducting a test of three (3) different PM monitors; 2 optical devices and 1 beta attenuation device. However there is no way of knowing, from the data provided which device is which. The data is labeled CPMS-1, CPMS-2 & CPMS-3. RMB's efforts for this evaluation are summarized in a memo to Utility Air Regulatory Group as "Comments on EPA's Proposed Use of PM CPMS Under the MATS Rule", dated January 7, 2013.

The MATS Rule has several proposed options compliance options for PM CPMS devices. The options are virtually identical to the ones proposed in the Boiler MACT and PC MACT. Therefore the RMB analysis is valid for the purposes of this paper.

DETERMINING THE PM CPMS OPERATING PARAMETER LIMIT (OPL)

EPA has proposed several potential techniques for determining your compliance operating limit for PM CPMS devices. This paper will discuss the following proposed techniques for establishing the OPL:

- Highest 1-Hour Average
- Average Results
- Scaling to 75%

The following sections are summaries of each technique.

Technique 1 - Highest 1-Hour Average

This technique does not directly use the Method 5 (M5) results from your compliance testing and is the simplest to determine your operating limit moving forward. The M5 results just have to show that your unit is less than 75% of the allowable emissions limit. If this is true, then your operating limit is defined as the highest 1-hour average PM CPMS output value recorded during the performance test.

Technique 2 – Average Results

The second technique also does not directly use the Method 5 (M5) results from your compliance testing and is the equally as simple as Technique 1. The M5 results just have to show that your unit is less than 75% of the allowable emissions limit. If this is true, then your operating limit is defined as the average of all PM CPMS hour averages recorded during the performance test.

Technique 3 – Scaling to 75%

The third technique using the Method 5 (M5) results from your compliance test. This technique involves a 2-point scaling of the emission standard against the PM CPMS output from your three (3) compliance test runs.

The overall equation is:

$$O_L = I_z + \frac{0.75(E_L)}{R}$$

Where,

O_L = Operating/Compliance Limit
I_z = PM CPMS Instrument (milliamps) at Zero (0) PM
E_L = Emission Limit
R = The ratio of the emission limit per PM CEMS output from performance test results

The emission limit will be different for different rules and facilities.

- Cement – lbs PM/ton-clinker
- EGU - lbs PM/MWh
- Boiler – lbs PM/MMBtu

By the same token, the emission limit ratio (R) will be on the same units as the emission limit above.

- Cement – lbs PM/ton-clinker per PM CPMS milliamp
- EGU - lbs PM/MWh per PM CPMS milliamp
- Boiler – lbs PM/MMBtu per PM CPMS milliamp

The emission limit ratio is calculated based on:

$$R = \frac{(E_a)}{(I_a - I_z)}$$

Where,

R = The ratio of the emission limit per PM CEMS output from performance test results
E_a = Average Emissions Results from the 3 compliance test runs
I_z = PM CPMS Instrument Output (milliamps) at Zero (0) PM
I_a = Average PM CPMS Instrument Output (milliamps) from the 3 compliance test runs

Both E_a and I_a are simple averages from the results of the three (3) compliance test runs.

$$E_a = \frac{(E_{r1} + E_{r2} + E_{r3})}{3}$$

Where E_{r1}, E_{r2} & E_{r3} = emission results for Runs 1, 2 & 3

$$I_a = \frac{(I_{r1} + I_{r2} + I_{r3})}{3}$$

Where I_{r1}, I_{r2} & I_{r3} = average PM CPMS output for Runs 1, 2 & 3

The PM CPMS output at zero PM can be obtain through several options depending on your application:

1. In-situ instruments can determine the zero point output by removing the instrument from the stack and monitoring ambient air on a test bench.
2. Extractive instruments can determine the zero point output by removing the extractive probe from the stack and allowing it to draw in clean ambient air.
3. In-situ or extractive instruments can perform reference method measurements when the flue gas is free of PM emissions or contains very low PM concentrations (e.g., when your process is not operating, but the fans are operating or your source is combusting only natural gas) and plotting these with the compliance data to find the zero intercept.
4. If none of the above is possible then you must use the zero output provided by the manufacturer.

COMPLYING WITH YOUR PM CPMS OPL

Once you have determined your OPL, now it is time to comply with the limit. The compliance is based on a 30 day rolling average of the PM CPMS output. The 30-day rolling average is an arithmetic average of the measurement output values collected during each hour will be calculated, and for each operating day the arithmetic average of all hourly measurement output values will be calculated for the previous 30 operating days.

DISCUSSION OF RMB RESULTS

RMB requested and received nearly (6) months of the raw hourly average data from the three PM instruments in the field test and then computed the 30-day rolling averages using the requirements of the MATS Rule. These results were then compared to the four (4) OPLs:

- Maximum 1-Hour Average
- Average Results
- Scaling to 75% to New coal-fired Units (0.09 lb/MWh)
- Scaling to 75% to Existing coal-fired Units (0.30 lb/MWh)

The results of these computations are in the following table:

Approach Used	CPMS-1		CPMS-2		CPMS-3	
	Exceedences	Time	Exceedences	Time	Exceedences	Time
Maximum	59	42%	35	25%	32	23%
Average	71	51%	38	27%	67	48%
75% - New	18	13%	0	0%	32	23%
75% - Existing	0	0%	0	0%	0	0%

RMB was able to calculate 139 data-points of 30-day rolling averages. These values were then compared to each of the tested limits for each instrument. The number of exceedences observed are provided for each approach and each instrument. The exceedence time is a calculation just a percentage of the exceedences divided by the number of data points. This column seems to add some magnitude to the results when you start to think of the exceedences in terms of percentage of data.

Based on the PM CPMS results the facility would have had numerous exceedences. Therefore it is time to provide a little more information beyond the raw instrument data. The facility was conducting this field trial for the selection of a PM CEMS instrument. Therefore a PS11 calibration effort was conducted at the beginning of the field trial. Based on the PS11 calibrated device outputs from each device, RMB can say with certainty that the facility did not exceed the filterable PM limit during the study period.

If should also be noted that different facilities have different PM limit units (e.g., lbs PM/ton-clinker, lbs PM/MWh, lbs PM/MMBtu, etc) and PM CPMS are PM concentration (e.g., mg/m^3, gr/dscf, etc.) monitors only. Therefore it is possible that a facility could maintain or even reduce permitted PM values but have the PM concentration in the gas increase.

Just to provide a concentration based reference to the analyzed data-set and for the purposes of this document we will just assume that 0.09 lb/MWh is the same as 9 mg/m^3 and 0.30 lb/MWh is the same as 30 mg/m^3. The units of “lb/MWh” can not be directly converted to “mg/m^3” because one is mass per energy and the other is mass per volume. It would take several other parameters and site specific information to accurately calculate one from the other. However the estimates above are good estimates.

Since this is a small data-set, it is virtually impossible to draw any final conclusions on which, if any, PM CPMS technique might be a viable compliance option. However it appears that a PM CPMS could be a reasonable site specific option with a little study and understanding of your facility.

PM CEMS or PM CPMS

This paper was intended to compare the different PM CPMS OPL generation techniques. But based on RMB's results, we wanted to take a look at the level of effort for PM CPMS vs PM CEMS. The installation of the PM CPMS and PM CEMS are the same. The biggest difference between the two application, in both cost and effort, is related to the PM CEMS calibration and Response Correlation Audit (RCA) efforts.

Below is a table showing the efforts involved with each approach.

Activity	PM CPMS	PM CEMS
Initial Testing	3 runs from Compliance Test	18 data points, ~3 days of testing
Annual Testing	3 runs at normal conditions, but establishes new Operating Limit for the following year	RRA (3 runs at normal conditions)
Establish New Operating Limit	Annually	---
Audit of Curve	---	RCA 3 or 5 Years, = 12 data points
Max. Operating Limit	75% of Limit	100% of permitted limit or 125% of highest PM CEMS response in Initial Curve.
Compliance Period	30-day Rolling Avg	30-day Rolling Avg

SUMMARY & CONCLUSIONS

The ultimate decision as to whether a PM CPMS is the best compliance choice has to be very site specific. From the limited data-set analyzed by RMB, some facilities may need to collect raw PM and conduct their own analysis.

REFERENCES

Roberson, R., Barton, R., *Comments on EPA's Proposed Use of PM CPMS Under the MATS Rule*. RMB Consulting & Research, Inc., January 7, 2013

Hutson, N., *75 Percent CPMS Operating Limit Approach – MATS Reconsideration*, Docket No. EPA-HQ-OAR-2009-0234, U.S. EPA Office of Air and Radiation, November 16, 2012

Johnson, S., *Establishing an Operating Limit for PM CPMS*, Mercury and Air Toxics Standards (MATS) Docket, EPA-HQ-OAR-2009-0234, Measurement Policy Group, SPPD, November 16, 2012

Addendum – Slides Summary

As with many papers and presentations, the paper is written weeks or months before the slides for the presentation are put together. There if new information comes available or we just look at the data in a different way, the paper may not reflect the content of the slides accurately. This is very true for this situation. Therefore this section is being added to provide some additional information that was not present at the original writing of the paper.

B3 Systems has direct experience with numerous PM CEMS devices and how they respond. Since we did not see or work with RMB's raw data, we were very curious why the PM CPMS results showed very high percentages of non-compliance since the approach seemed to make logical sense. A lot of our experience is at power plants where the limits generally back calculate to approximately 10-12 mg/m3 but the emissions normally run around 1-2 mg/m3.

Therefore we chose one PS11 application where correlation data was available and applied the base load PM runs to the PM CPMS scaling calculations. All data points were used instead on trying to select only the three required that are required for PM CPMS. We did not want to be accused of cherry picking the data. The base data points and the Average, Highest and 75% limits are shown on the chart on Slide 13.

Slide 14 shows the result of applying the extrapolated slope to the base loaded data-points. As you can see, the instrument was very repeatable but the variation in M5 results can create a steep relationship. The curve would be the one use for compliance documentation.

Since the purpose of this program was to generate a full PS11 curve, Slides 15 & 16 show all of the data points taken and the final PS11 curve for the facility. This type of situation could explain why a high number of exceedence events using the PM CPMS curve without the facility really exceeding any PM limit. Although the intent was to utilize 75% of the permitted PM limit, this data set would be using less than 10%, based on the PM CEMS output from the base load data only.

And if that wasn't enough, just for the fun of it we used the PS11 mid level points to calculate the PM CPMS limit. That curve is shown on Slide 17. Then the same exercise was conducted with the high PS11 concentration data only. Slide 18 shows that curve. Both of those curves more closely resemble the PS11 curve and are more realistic at estimating PM emissions.

It appears that the biggest issue is related to the M5 results at very low levels. But if the PM concentration near or greater to 50% of the limit, the PM CPMS curve looks more realistic. Therefore planning must be considered when conducting PM CPMS testing.

One of the questions I have is, "Do the rules allow a facility to elevate their PM during the PM CPMS testing as long as they do not exceed their limit?" Otherwise some facilities could be penalized for have very good PM control.

Additional Thoughts

This information was not presented at the conference or in the paper, however we felt it was worth putting into this document to provide a full picture.

Method 5 is results can be improved by taking special precautions. If any of the base load PM runs were taken for compliance documentation then none of us would pay attention to them because they are so far below the permitted limit. But since they are being used to calibrate an instrument (PM CEMS) or create an extrapolated curve (PM CPMS) we are now more critical. One possible method is to extend the run time to 2 or 3 hour PM runs.