NACWA/WERF 2004 SURVEY OF TOTAL HYDROCARBON/CARBON MONOXIDE CONTINUOUS EMISSIONS MONITORING SYSTEMS

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ABSTRACT

On February 19, 1993, the United States Environmental Protection Agency (EPA or Agency) published in the *Federal Register* its new "*Standards for the Use or Disposal of Sewage Sludge (40 CFR Part 503).*"

The new Part 503 Regulation required that the Total Hydrocarbon (THC) concentration in the exit stack gases for all biosolids (sewage sludge) incinerators not exceed 100 parts per million (ppm), as Propane, corrected to zero percent moisture and seven percent oxygen, on a monthly average basis. EPA noted that the THC limit was a surrogate for the emissions of potentially toxic organic compounds.

In order to demonstrate compliance with the new THC limit, Publicly Owned Treatment Works (POTWs) that practice incineration were required under the Part 503 Regulation to install an instrument that measures and records the THC concentrations in their biosolids incinerator exit stack gases.

In 1994, the Part 503 Regulation was modified to allow the monitoring of Carbon Monoxide (CO) as an alternative to THC monitoring. This action was taken since biosolids incinerators located in the State of New Jersey were already subject to a CO limit of 100 ppm (a more stringent level of control than the 100 ppm THC limit). As a result, the Agency set the alternative limit at 100 ppm CO, corrected to zero percent moisture and seven percent oxygen, on a monthly average basis.

In the mid 1990s THC/CO continuous emissions monitoring systems (CEMS) were purchased and installed by the POTWs that practiced incineration. Over the past few years, a substantial number of these POTWs have reported that they are encountering major operational and maintenance problems with their THC/CO-CEMS, while a limited number have indicated that they are subject to more stringent State or locally-mandated operating requirements than are contained in the Part 503 Regulation.

For example:

- A number of POTWs have already replaced some if not all of the components within their existing THC-CEMS, in some cases after less than seven years of service, due to operational and maintenance related problems.

- POTWs are encountering higher than anticipated O&M costs with their THC-CEMS.

- A number of POTWs are subject to minimum THC/CO capture rate requirements, while the Part 503 Regulation does not establish minimum capture rates.

Given the problems that POTWs are encountering with their THC/CO-CEMS and the differing interpretations of the Part 503 Regulation's requirements concerning THC/CO-CEMS, the National Association of Clean Water Agencies (NACWA) and the Water Environment Research Foundation (WERF) decided to conduct a joint survey to determine the following:

- Current THC/CO emissions from biosolids incinerators,
- O&M problems being encountered with THC/CO-CEMS,
- Cost to purchase, install, operate and maintain the THC/CO-CEMS, an
- State and Local THC/CO-CEMS requirements that differ from the requirements contained in the Part 503 Regulation.

The NACWA/WERF THC/CO-CEMS survey, which contains twenty-six (26) questions, was divided into the following sections:

Section 1. Responder/Responding Agency Information
Section 2. Number and type of CEMS and biosolids incinerators, along with CEMS related design, purchase and installation costs.
Section 3. Plant & Process Background Information
Section 4. THC/CO Performance Information
Section 5. THC/CO-CEMS Regulatory Information
Section 6. THC/CO-CEMS Design and Maintenance Information
Section 7. Follow-Up Information and Questions

The NACWA/WERF THC/CO-CEMS survey was issued in May 2004 to all of the known wastewater treatment agencies located within the United States that practice incineration. (A limited number of the agencies that received the survey indicated that they no longer incinerate their biosolids.) Participants were given the option of completing the survey on-line at the NACWA/WERF Clean Water Central website (www.cleanwatercentral.org) or by submitting a paper copy of the survey.

This paper presents detailed information, obtained through the NACWA/WERF THC/CO-CEMS survey and follow-up interviews with the participants, concerning THC/CO-CEMS that were installed in the mid 1990s.

KEYWORDS

Biosolids, Biosolids Incinerators, Total Hydrocarbon (THC) Emissions, Carbon Monoxide (CO) Emissions, Continuous Emissions Monitoring Systems (CEMS), Multiple Hearth Incinerators (MHIs), Fluidized Bed Incinerators (FBIs), 40 CFR Part 503

SURVEY RESULTS SUMMARY

1. Responder/Responding Agency Information

Completed surveys were received from 34 wastewater treatment agencies that practice incineration at a total of 46 POTWs located in 18-different states.

2. Number and type of CEMS and biosolids incinerators, along with CEMS related design, purchase and installation costs.

The survey participants own and operate a total of 105 multiple hearth incinerators (MHIs) and 10 fluidized bed incinerators (FBIs). The participants have purchased and installed a total of 78 THC-CEMS and 12 CO-CEMS at a total cost of roughly
$20 million.

3. Plant & Process Background Information

a. Biosolids Conditioning

The vast majority of agencies that participated in this survey chemically condition their biosolids prior to incineration. See Table 1 for details.

Table 1: Methods used to Condition Biosolids

	Number of Agencies
Chemically Condition	22
Chemically Condition at one POTW and Thermally Condition at another POTW	5
Other (digested solids, primary and WAS, primary only, no conditioning)	6
No Response	1

b. Biosolids Dewatering

The vast majority of agencies that participated in this survey use belt filter presses to dewater their biosolids prior to incineration. See table 2 for details.

Table 2: Methods used to Dewater Biosolids

	Number of Agencies
Belt Filter Presses	19
Centrifuges	9
Centrifuges and Belt Filter Presses	3
Centrifuges and Roll Presses	1
Centrifuges, Vacuum Filters and Belt Filter Presses	1
Plate and Frame Presses	1

c. Quantities of Biosolids Incinerated

Table 3 contains a summary of the tons of biosolids incinerated by the survey participants in 2002 and 2003.

Table 3: Quantity of Biosolids Incinerated

	2002	2003
Wet U.S. Tons	2,880,000	2,692,000
Dry U.S. Tons	719,200	677,300
Wet Metric Tons	2,613,000	2,442,000
Dry Metric Tons	652,400	614,400

In 1993, EPA reported that 865,000 dry metric tons of biosolids were being incinerated in the United States on an annual basis. If this is still the case today, the 46 POTWs covered by this survey are responsible for burning 70 – 75% of the biosolids incinerated in the United States.

d. Solids Content of Biosolids Incinerated

Table 4 contains a summary of the percents solids in the biosolids incinerated.

Table 4: Percent Solids in the Biosolids Incinerated

	2002	2003
Average	25 %	26 %
Maximum	44 %	45 %
Minimum	16 %	18 %
Median	24 %	24 %

The average solids contents are reflective of the fact that most of the participants incinerate chemically conditioned, belt filter press dewatered biosolids.

e. Annual Average Incinerator Top Hearth or Afterburning Zone Temperature

Previous studies by both EPA and National Association of Clean Water Agencies (NACWA) member agencies revealed that the THC emissions are a function of top hearth or afterburning zone temperature. As these temperatures increase, THC emissions decrease.

Table 5 contains a summary of the annual average top hearth or afterburning zone temperatures for the participants' biosolids incinerators.

Table 5: Annual Average Top Hearth or Afterburning Zone Temperatures

Average	1253 deg-F
Maximum	1620 deg-F
Minimum	900 deg-F
Median	1200 deg-F

One respondent indicated that a few States are requiring or are considering requiring a minimum exit gas temperature for biosolids incinerators.

4A. THC Performance Information

a. THC Emission Concentrations

During 2002 and 2003, the yearly average THC concentration (average of the 12 monthly averages) for the 78 biosolids incinerators was just shy of 27 ppm, as Propane corrected to 7% oxygen and 0% moisture. Table 6 contains information concerning the yearly average THC concentrations in the participants' exit stack gases.

Table 6: Annual Average THC Concentrations

	2002	**2003**
Average	27.11	26.65
Maximum	72.00	94.00
Minimum	1.00	0.40
Median	20.63	21.54

(Note: All values are in ppm, as Propane, corrected to 7% moisture and 0% oxygen)

The highest monthly average THC concentrations are contained in Table 7.

Table 7: Highest Monthly Average THC Concentrations

	2002	**2003**
Average	54.72	54.53
Maximum	336.00	391.00
Minimum	2.00	0.97
Median	35.30	32.50

(Note: All values are in ppm, as Propane, corrected to 7% moisture and 0% oxygen)

One agency reported the two maximum THC concentrations listed above. The reasons for these high THC concentrations, and higher than normal monthly average THC concentrations at other POTWs, are as follows:

- Incorrect oxygen readings that result in corrected THC concentrations that were substantially higher than actual.
- THC and oxygen readings are incorrectly recorded during startup and planned or emergency shutdowns of their incinerators.
- Software related problems resulting in instantaneous peaks being recorded instead of daily averages.
- Operator related errors.

b. THC Data Capture Rate

The monthly average THC data capture rate is defined as:

$$\frac{\text{Hours in the month that THC data was collected, while biosolids were being incinerated}}{\text{Hours in the month that biosolids were being incinerated}} \times 100$$

While EPA does not require a minimum data capture rate, NACWA/WERF decided to see if the participants have capture rate data for their THC-CEMS. Table 8 contains a summary of the THC data capture rate as reported by 22 participants that have THC monitors. A number of respondents noted that their capture rate data was not readily available.

Table 8: THC Capture Rates (Yearly Basis)

	2002	**2003**
Average	79 %	84 %
Maximum	100 %	100 %
Minimum	0 %	0 %
Median	94 %	97 %

The two participants that reported 0% and 1% capture in 2002 indicated that their units were down since they were in the process of procuring/installing new CEMS for failed THC-CEMS. Two participants reported 0% capture in 2002 and 2003. One is in the process of installing THC-CEMS, while the other is in discussions with its Part 503 Regulatory Agency to determine what it should do next. The THC-CEMS that were originally installed at this POTW never worked satisfactorily.

4B. CO Performance Information

a. CO Emissions Concentrations

During 2002 and 2003, the yearly average CO concentration (average of the 12 monthly averages) for 12 incinerators was just shy of 30 ppm, corrected to 7% oxygen and 0% moisture. Table 9 contains information concerning the yearly average CO concentrations in the participants exit stack gases.

Table 9: Annual Average CO Concentrations

	2002	**2003**
Average	32.82	26.62
Maximum	75.00	75.00
Minimum	5.20	3.95
Median	23.75	21.54

(Note: All values are in ppm, corrected to 7% moisture and 0% oxygen)

The highest monthly average CO concentrations are contained in Table 10.

Table 10: Highest Monthly Average CO Concentrations

	2002	**2003**
Average	57.64	52.43
Maximum	114.00	110.00
Minimum	9.30	10.00
Median	54.50	56.40

(Note: All values are in ppm, corrected to 7% moisture and 0% oxygen)

The two maximum CO concentrations were from POTWs that measure CO emissions from their MHIs in lieu of THC emissions. The higher than normal readings were a result of lower than normal afterburner temperatures.

b. CO Data Capture Rate

The monthly average CO data capture rate is defined as:

$$\frac{\text{Hours in the month that CO data was collected, while biosolids were being incinerated}}{\text{Hours in the month that biosolids were being incinerated}} \times 100$$

While EPA does not require a minimum data capture rate, NACWA/WERF decided to see if the participants have capture rate data for their CO-CEMS. Table 11 contains a summary of the CO data capture rate as reported by 5 participants that have CO monitors. A number of respondents noted that their capture rate data was not readily available.

Table 11: CO Capture Rates (Yearly Basis)

	2002	2003
Average	99 %	98 %
Maximum	100 %	99 %
Minimum	97 %	95 %
Median	98 %	98 %

5. THC/CO-CEMS Regulatory Information

a. CEMS Regulatory Requirements

Only one participant has received a Part 503 permit. This is most likely due to the fact that the Part 503 Regulation's incineration requirements are "self-implementing" and that very few States have received delegation.

It was also discovered that a limited number of States have or are considering applying for delegation only for land application and surface disposal practices, but not for incineration.

Five participants indicated that the Part 503 incineration requirements were included in their Title V permits, while 5 other participants indicated that the Part 503 incineration requirements were contained in their National Pollutant Discharge Elimination System (NPDES) permits. The remaining participants submit annual Part 503 reports to their respective EPA regional biosolids coordinators.

b. More Stringent Requirements

Nine of the 34 participants reported that they are subject to more stringent requirements than are contained in the Part 503 Regulation, as follows:

1. While a THC capture rate is not specifically mentioned in the POTW's Title V permit, language within the permit indicates that THC must be measured whenever its incinerator is in operation. The POTW informs its Regulatory Agency whenever the THC analyzer is out-of-service.

2. A THC capture rate of 94% on an annual basis is required. The incinerator must be removed from service whenever the CEMS is out-of-service for more than 72-hours.

3. A THC capture rate of 80% on a monthly basis is required.

4. A CO capture rate of 90% on a monthly basis is required. The incinerator must be removed from service when the CEMS is out-of-service for more than 72-hours.

5. A THC capture rate of 90% and successful daily calibration are required.

6. A CO capture rate of 90% on an annual basis is required.

7. A THC capture rate of 90% on a monthly basis is required.

8. While there isn't a THC capture rate requirement, the regulatory agency must be notified if the CEMS is out-of-service for more than 72-hours.

9. A CO limit of 100 ppm, on an hourly basis, must be complied with.

c. 40 CFR Part 60 (Standards of Performance for New Stationary Sources)

Fourteen of the 35 participating wastewater treatment agencies indicated that they are subject to the requirement contained within 40 CFR Part 60 Appendix B (Performance Specifications for CEMS) and 40 CFR Part 60 Appendix F (QA/QC requirements for CEMS). Some of the other agencies reported that since construction of their incinerators commenced prior to June 11, 1973, there incinerators are not subject to the requirements contained in 40 CFR Part 60 Subpart O (Standards of Performance for Sewage Treatment Plants), nor those contained in Appendices B & F to 40 CFR Part 60.

6. THC/CO-CEMS Design and Maintenance Information

a. Manufacturer Information

Table 12 contains information concerning the 78 THC monitors installed by the participants:

Table 12: THC Monitor Information

Manufacturer	Model Number	Number of Units in Service
Thermo Environmental	51	28
Thermo Environmental	330	3
Siemans	Fidamat 5E	27
Rosemount	40	11
Horiba	FIA-236	7
Eagle	EM-12	2

Table 13 contains information concerning the 11 CO monitors installed by the participants.

Table 13: CO Monitor Information

Manufacturer	Model Number	Number of Units in Service
Thermo Environmental	48	5
Siemans	Ultramat 5E	4
Rosemount	880a	2

One participant did not know the name of the manufacturer of his CO monitor.

b. Software Problems

Eight participants indicated that their software has not performed adequately. Complaints ranged from not being Y2K compliant to recording of peaks instead of daily averages. Here is a summary of the complaints:

- A number of respondents cannot make changes to their software since it is proprietary.
    - One remarked that getting the manufacturer to make the required changes is like pulling teeth.
    - Another indicated that he ended up with proprietary software even though the specifications called for non-proprietary software.
- For some proprietary software, "Invalid Data" is listed for any time period the incinerator is not in service. This has led a Regulatory Agency to question the reliability of the CEMS system.
- Unexplained system lockups and/or complete failure of the software.
- The software was not Y2K compliant.
- The software records instantaneous peaks instead of daily averages.

It should be noted that where one participant reported that they did not have any problems with a particular software, another participant reported major problems. This could be a result of a system related programming problem, site-specific conditions or problems with the computer system. The majority of the participants reported that they had to replace outdated computers.

c. Moisture Content in Exit Stack Gases

The majority of participants indicated that since they have saturated exit stack gases, they use a thermocouple to measure the exit stack gas temperature and determine the moisture content by using a psychometric chart. A limited number have installed units to dry their exit stack gas samples prior to their THC or CO analyzers, while others have installed both wet and dry oxygen analyzers.

One respondent remarked that his Regulatory Agency indicated that his POTW was in violation of the Part 503 Regulation since they did not install a device that specifically measures the moisture content in the exit stack gases. After explaining that the exit stack gases are saturated gases, and that they measure the exit gas temperatures with a thermocouple and determine the moisture content using a psychometric chart, the Regulatory Agency agreed that the POTW was in compliance.

d. Sample Tube Collection System

Twenty-four of the participants have heated Teflon® Tubing
Four of the participants have heated PVC Tubing
Six of the participants have heated Stainless Steel Tubing

Kinks in the tubing and failure of the tubes have been major problems encountered with the collection system. Another problem is that the length of the tubing was too long and had to be coiled.

A number of participants have already replaced their sample tube collection systems. Teflon® seems to be the most common replacement type, however, one agency replaced Teflon® tubing with new stainless steel tubing.

e. Operation and Maintenance of the CEMS

The participants reported that they have to spend an average of 20 person-hours per week maintaining their CEMS and data acquisition systems. Twenty-four respondents reported spending an average of $25,000 per agency per year to operate and maintain their CEMS. Combined O&M costs for the 24 respondents totals $600,000 per year. The ten other participants did not submit O&M data.

A major problem being encountered by the majority of participants is that it is impossible to find parts for some of the older CEMS. In many cases the THC and CO monitors have to be returned to the manufacturer for servicing. A number of individuals remarked that they encountered corrosion problems with differential metals within their existing THC monitors. This problem has been corrected by having the units rebuilt with similar metals or by buying new units that contain similar metals.

The following is a summary of some of the typical problems encountered:

- Difficulty in obtaining the calibration gases; Cost seems to be excessive
- Plugging of sample lines
- Clogging of filters
- Sample pump failures
- Problems keeping the THC monitors in service.

The problems reported by the POTWs that have CO monitors were negligible compared to the problems being reported by those who monitor THC. The annual maintenance costs for CO monitors were also very low.

f. Replacement of Original Equipment

Three participants replaced their entire THC-CEMS systems after approximately 7-years of service. In one case the original manufacturer was no longer in business, so servicing was no longer an option. In the other cases the equipment had reached the end of its useful service life.

Others have replaced monitors, pumps, computers, and collection systems. The cost to replace the original equipment was roughly $7.5 million or approximately 37 % of the original costs.

Seventeen participants are planning on replacing items within their CEMS within the next two years.

7. FOLLOW-UP INFORMATION AND QUESTIONS

a. Comments and Questions from Participants

1. Our THC-CEMS has been of no value. We are constantly seeing single digit ppm values, due to our high exit gas temperatures. It would be great if we could shut down our THC-CEMS and demonstrate THC compliance during our incinerator performance tests.

2. The permitted value for CO is 100 ppm. This value is far more stringent limit than a THC limit of 100 ppm. Would EPA consider a more realistic CO limit for MHIs? CO monitors are easier to operate and maintain than THC monitors. However, the only way for a MHI to meet a CO limit of 100 ppm is to install a sizable afterburner. The operation of an afterburner will result in a substantial increase in operating costs and NOx emissions.

3. Seven years seems to be the life span of the THC monitors. With the limited number of manufacturers, whom will I be able to purchase new THC monitors from four years from now?

4. How many POTWs have had to install redundant systems to meet the data capture requirements? It is also our understanding that EPA does not list a capture requirement in the Part 503 rule. Why then are a number of regulatory agencies requiring a minimum data capture? What difference does it make, since we are always in compliance?

5. Is seven years the normal service life for the flame ionization detector (FID) that is used to monitor THC emissions? We bought top of the line units and still ran into major maintenance problems.

   Is anyone having problems with excessive use of calibration gases? We are.

   How are the terms “startup” and “shutdown” being defined by the various regulatory agencies?

Is anyone using standard or modified off-the-shelf software instead of proprietary software?

Given the problems that we are encountering with our THC-CEMS, would EPA consider another method for monitoring potentially toxic organic emissions from our biosolids incinerators? We would consider installing CO monitors if EPA would establish a realistic CO limit.

6. While we are meeting all of the THC-CEMS requirements, we feel that we are not doing so in the most cost-efficient manner. In particular, the calibration and calibration checks are of concern. More information about reliability of various system and manufacturers would be helpful. Maintenance and troubleshooting tips would be beneficial.

7. We inherited our Part 503 program after retirement of person who was involved with this from the beginning - he left minimal notes/background info. We found an application for a Part 503 permit dated 1995, but no actual permit. As much as possible, we follow the 1993/94 guidance and the 1999 amendments - We check Federal Register for updates/changes. We get little feedback from EPA or our State Agency. Addition training, updated information and guidance would be great.

8. How are others addressing the maintenance problems that they are encountering with their THC-CEMS?

9. More guidance for the Relative Accuracy Test Audits (RATAs) and other Quality Assurance/Quality Control (QA/QC) activities would be useful and allow the utilities to defend the cost of these activities.

10. Originally we depended upon an outside contractor to assure CEM compliance. We found some discrepancies with the corrected value readings and have never gotten satisfactory answers as to how and why these corrected values are different from one incinerator to another. Is anyone else having the same problem?

11. It would be appreciated if someone could provide training on the Part 503 Regulation and Title V permits for POTWs that practice incineration, and how a CO limit of 100 ppm differs from a THC limit of 100 ppm.

l2. Given the problems that we are encountering with out THC-CEMS it is clear that the FIDs were not developed for our industry, but were standards units for other industries that were sold to us for experimentation. Has anyone found a THC monitor that was specifically developed for a biosolids incinerator?

13. Everyone must realize that EPA's Part 503 Guidance Document is only "guidance" and that it is not a regulatory document. Regulators should refer to EPA's *"A Plain English Guide to the EPA Part 503 Biosolids Rule"*.

14. The THC monitors that EPA initially tested in Minnesota in the late 1980s, that became the basis for the THC requirement, were not manufactured for biosolids

incinerators. They were standard units from another industry that were maintained by dedicated maintenance personnel and grad students. EPA should revisit the problems that we are encountering with our THC-CEMS.

b. CEMS for Other Pollutants

Five participants are required to continuously monitor the opacity of their exit gases, while 2 participants are required to continuously monitor NOx emissions. None of the other participants have CEMS requirements for other pollutants. However a few are concerned that they may be subject to CEMS for other pollutants in the not too distant future.

CONCLUSIONS AND NEXT STEPS

The Part 503 Regulation has successfully reduced emissions of potentially toxic organic compounds from biosolids incinerators. The survey revealed that the THC and CO emissions are consistently in compliance with the regulatory limits, due to high incinerator exhaust gas or afterburner temperatures.

Prior to the promulgation, POTWs that practiced incineration were only required to demonstrate compliance with a particulate emissions limit and the NESHAPS' mercury emission limit of 3200 grams per 24-hours. However, with the promulgation of the Part 503 Rule, POTWs had to find ways to reduce the emissions of potentially toxic organic compound from their biosolids incinerators.

The survey also revealed, as detailed in this paper, the numerous problems with the THC-CEMS that were installed in the mid 1990s to achieve compliance with the Part 503 Regulation. In addition, the cost to install, operate and maintain these units is far beyond what EPA had originally anticipated. On the other hand, a CO-CEMS is substantially easier to operate and maintain than a THC-CEMS.

While FBIs do not have any problems complying with a CO limit of 100 ppm, MHIs cannot meet the CO limit unless equipped with high temperature afterburners. Due to the costs required to procure, operate and maintain high temperature afterburners, very few MHIs are equipped with CO-CEMS. However, CO monitoring could be a viable alternative for MHIs if a more realistic CO limit is implemented.

Based on the problems being encountered, we are suggesting that EPA, NACWA, the Water Environment Federation (WEF), and WERF work together to develop solutions to the current operational and maintenance THC-CEMS related problems, explore alternative technologies for monitoring these emissions, investigate the feasibility of implementing a more realistic CO limit for MHIs, and provide additional training and guidance to the biosolids incinerator community on various issues surrounding the use of THC-CEMS.