SUCCESSFUL SERVICE SUPPORT STRATEGIES FOR 40CFR75 CEM SYSTEMS

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ABSTRACT

Title IV of the 1990 Clean Air Act Amendments has created the need for highly accurate and reliable operation of continuous emission monitoring systems (CEMS) for the electric utility units and other units subject to this law. The purpose of this paper is to outline CEMS service support strategies for accomplishing these goals and to provide some initial results on the success achieved through use of these strategies. These strategies deal with: 1) organization design for the service functions, 2) training, 3) monitoring performance of the service personnel and 4) building ownership for accomplishing the goals of the service function. They are based, in part, on the authors' and Enviroplan's experience in providing service support to many of the 200 electric utility units using Enviroplan's CEMS to satisfy the 40CFR75 regulation adopted to implement Title IV. These strategies are also applicable to other CEMS requiring high levels of accuracy and reliability

INTRODUCTION

Title IV of the 1990 Clean Air Act Amendments created both air pollution emission limitations and financial opportunities for over 1,800 affected electric utility units. CEMS were the primary method specified for assuring compliance with these emission limitations and for providing a validation and credibility to the currency in the new financial market for SO2 allowances. Thus, maintaining a high level of accuracy and reliability for the CEMS at these electric utility units is of paramount importance.

The need to attain these goals is further heightened by the responsibility and personal liability of the senior executive at each electric utility company designated to represent and legally bind his company, as a matter of federal law, in all matters pertaining to the Acid Rain Program (Designated Representative).

The purpose of this paper is to outline CEM service support strategies for accomplishing these goals. These strategies are based, in part, on the authors' experience and Enviroplan's experience in providing service support to many of the 200 electric utility units using Enviroplan CEMS to satisfy 40CFR75.

First, we outline CEM service support strategies that we believe will help achieve the goals of high accuracy and high reliability. Second, we present initial results on the impact these strategies have on the accuracy and reliability of CEMS. Finally, we present our conclusions.

CEMS SERVICE SUPPORT STRATEGIES

These strategies may be divided into the following four areas:

1) Organization Design
2) Training
3) Monitoring Service Personnel Performance
4) Building Ownership for Accomplishing the Goals of the Service Function

Organization Design

At its simplest, organization design consists of deciding who will carry out what and when.

Who. There are several choices concerning who will carry out each of the major CEM service functions. They involve choices between using internal dedicated versus rotating personnel with other responsibilities and choices between using internal personnel versus contractors. Table 1 provides a matrix of these choices and recommendations on the approaches to take to achieve high levels of accuracy and reliability.

Concerning internal dedicated versus internal rotating personnel, dedicated personnel should provide a higher level of performance than rotating personnel having other responsibilities. The complexity of 40CFR75 CEMS and the need for 24-hour per day, 7-day per week support of them mandate that knowledgeable, highly trained and dedicated individuals carry out these functions to achieve the best results. This may mean having internal personnel service more than one plant at a company if there are an insufficient number of CEMS at one plant to create a full time job. Doing this may represent an organizational challenge given the traditional plant specific autonomy in servicing of instrumentation.

Concerning use of internal personnel versus contractors, the best approach depends on the availability, skill and cost of internal personnel versus the contractor. A contractor advantage is its use of dedicated personnel with no other responsibility than service support for CEMS.

For certain CEMS service functions, use of contractor personnel (or independent internal personnel) as independent third parties can provide an additional level of assurance that the CEMS are being operated to achieve the highest accuracy and reliability. Such service functions include quarterly preventive maintenance visits, linearity checks and RATA tests.

For the quarterly linearity checks and annual (semi-annual) RATA's, one of the most important roles a contractor can play in the absence of dedicated highly trained internal personnel is to be on site to repair equipment immediately if it fails a linearity test or RATA. This is important to minimize the period that the CEMS is out of control.

The contractor who supplied the CEMS software should be used to provide 24-hour, 7-day per week emergency service support for the software. Every function of the CEMS is controlled by the computer software and all needed data is assembled, calculated and archived by this software. Given the complexity of this software, only the contractor supplying the CEMS software can provide support. CEMS users should not revise source code provided by the supplier. The interrelationship of software modules creates great risks if anyone attempts such revisions. It also decreases the ability of the original supplier to provide any service support in the future. Notwithstanding the above recommendation, internal personnel or another contractor can use the software to carry out all service functions as long as the emergency software service support is available. Contractor support is also recommended for periodic training and retraining of customer personnel in use of the CEMS and for providing information on system updates available.

We recommend quarterly Electronic Data Report (EDR) generation be run weekly rather than only once at the quarter's end. With this approach, any problems will be immediately detected thereby preventing small problems from turning into large ones and avoiding possibly large losses of valid data.

Concerning EDR preparation, there are two main choices -- decentralized preparation by personnel at each plant or centralized preparation for the company as a whole either by internal staff or by a contractor followed by internal staff review. The advantages of decentralized plant preparation are that personnel most familiar with plant operations are preparing the EDR and a high degree of ownership for the CEMS program may be fostered in plant personnel by having total responsibility for this program. The advantage of centralized preparation is that dedicated and expert staff devoted to EDR preparation and review will prepare the EDR's. They will be the company experts on 40CFR75 and EDR. They will provide critical independent review of the data collected at the plants and they will assure total consistency of the EDR's from all plants owned by

the company. On balance, we believe the latter approach of centralized EDR preparation will better achieve the goals of high accuracy and reliability.

What and When. The other major part of organization design for the CEMS service functions is the specification of what service support functions are to be conducted with what frequency.

Table 2 shows a recommended matrix of these service support functions for the extractive dilution CEMS that almost 90% of all electric utility units purchased to satisfy 40CFR75. This matrix also outlines service support functions for the flow monitors and opacity monitors under this regulation. For each service function, there should be a clear description of the tasks to be conducted that are incorporated in the plant's operation and maintenance manual and QA/QC program.

Training

Table 3 shows the major elements of a complete training program for the service technicians who will be conducting the daily site inspections and be executing the QA/QC program for the CEMS. Also shown are major elements of the training program for use of the CEMS computer system and preparation of the Electronic Data Reports.

It is important to maintain records of the training completed by each service technician and to have schedules for periodic retraining.

Monitoring Performance of Service Personnel

A key to achieving high levels of accuracy and reliability of the CEMS is to have an effective program in place to provide service personnel and their manager with information on how well the service personnel are achieving their performance goals.

Reporting should be weekly with exception reporting at the time any such event occurs. Table 4 lists information we recommend the service technician include in his weekly report. The process of the service technician preparing such a weekly report focuses his attention on assuring all required tasks are completed, on the performance of the CEMS in achieving its accuracy and reliability goals, on planning what nonroutine tasks must be carried out in the future and what additional support the service technician needs from the electric utility/contractor to complete his future tasks.

Weekly meetings with the service manager to review the weekly reports are important to achieving the CEMS performance goals. Since service technicians are typically not in touch with their managers on a daily basis, the scheduled weekly meeting provides the support and guidance to make sure the service technician is accomplishing his mission.

Building Ownership for Accomplishing the Goals of the Service Function

Motivating service personnel to achieve the performance goals of the CEMS program goes far beyond providing adequate training, competitive compensation and a safe working environment. We think that motivating service personnel to achieve the accuracy and reliability performance goals of the CEMS program also require:

1) Instilling an understanding in the service personnel of the importance of the data generated from the CEMS and the impact on the electric utility if the CEMS performance goals are not achieved as well as the benefits of exceeding these performance goals.
2) Decentralizing decision making so the service technician is empowered to make the daily detailed service decisions himself and, thus, develop a sense of full responsibility for the performance of his CEMS.
3) Providing benchmarking comparisons on a periodic basis of the performance of the CEMS under the service technician's control with the performance of other CEMS at the same plant, at the same company, of the same equipment manufacturer

industrywide and of all CEMS nationwide subject to the requirements of 40CFR75.

Enviroplan now is routinely generating these benchmarking comparisons from the quarterly Electronic Data Reports each utility must submit to U.S. EPA. Providing this information to the service technician in charge of a group of CEMS and his manager can both empower and motivate him to achieve and exceed his accuracy and reliability performance goals.

IMPACT OF THESE STRATEGIES ON CEMS ACCURACY AND UPTIME

The quarterly Electronic Data Reports submitted by each electric utility provide a rich source of information for measuring the performance of CEMS in accomplishing their accuracy and reliability goals.

To provide some indication of the effectiveness of implementing a service support strategy as discussed herein, we compared the accuracy and uptime of the Enviroplan Phase I CEMS that had purchased service contracts with the performance of the Enviroplan Phase I CEMS that had no service contract in place. We used the fourth quarter of 1994 for the comparison. Since all Phase I CEM had been operating for at least a year by that time, site specific startup/shakedown problems with initial installation and training would have passed and performance in this quarter would better indicate the impact of different service support strategies.

Performance measures used were percent uptime averaged over all monitored parameters, average RATA results and average daily calibration drift.

Of the 26 Phase I units with Enviroplan CEMS that reported EDR's in 1994 Q4, nine had full or partial service contracts in place and 17 did not yet have service contracts.

Results are presented in Table 5. They show units with service contracts on average had 1.95% high uptime and a 3.86% lower average RATA. Units without service contracts had slightly lower (.18%) average daily calibration drifts. Since only two of the nine Phase I units with service contracts had RATA's performed during the quarter, and because of the comparable results on daily calibration drifts, this limited data set provides no evidence on improvement in accuracy through use of service contracts utilizing some of the service strategy principles discussed in this paper.

These results do show a significantly higher uptime of CEMS with these service contracts compared to CEMS without service contracts.

There are important qualifications to these conclusions. First, the sample size is small and results need to be corroborated using future quarters of data. Second, not all of the strategies discussed herein were in place in the Enviroplan service contract programs in 1994 Q4. All new service programs are incorporating these strategies and, thus, better comparisons of performance will be possible at the end of 1995. Finally, the 17 utility units without service contracts may have included some of these strategies in their own internal programs thereby preventing a conclusive comparison of the impact of using these strategies.

CONCLUSIONS

Achieving a high degree of accuracy and reliability of CEMS subject to the requirements of 40CFR75 or other similar requirements depends on implementing successful service support strategies. This paper provides recommendations for these strategies and presents limited results that suggest that using these strategies will significantly increase CEMS uptime. Further study is needed to confirm these results.

Table 1. Choices for Who Conducts the CEMS Service Functions and Recommendations to Achieve the Best Performance

RECOMMENDATIONS

Function	Internal Personnel		Contractor
	Dedicated	Rotating	
1. Daily Site Checks and Preventive Maintenance	X		X
2. Quarterly Linearity Checks	X		X
3. Technical Support to Prepare CEMS for and Immediately Repair CEMS if Fail Linearity Check	X		X
4. Semiannual/Annual RATA's	X		X
5. Technical Support to Prepare CEMS for and Immediately Repair CEMS if Fail RATA	X		X
6. 24-Hour, 7-Day per Week Emergency Service Support For CEMS Hardware	X		X
7. 24-Hour, 7-Day per Week Emergency Service Support for CEMS Software			X
8. EDR Preparation	X		
9. Training			X

Note: "X" is recommendation. If more than one choice is indicated, either one is recommended.

Table 2: Recommended Service Support Functions for Extractive Dilution CEM Systems, Opacity Monitors and Flow Monitors Subject to 40CFR75

Activity: QC Checks	Daily	Weekly	Monthly	Quarterly	Semi Annual	Annual	As Required
SYSTEM CHECKS							
Verify Zero Value	X						
Verify Span Value	X						
Routine Data Observation	X						
Cal Gas Pressure	X						
Verify Dilution Air Pressure/Vacuum	X						
Sample Gas Pressure/Flows Analyzer	X						
Replace Filters-Analyzers				X			
Replace/Clean Filters - Probe				X			
Check Shelter Temperature and Humidity Values	X						
AC Filter Cleaned			X				
Clean Interior of Enclosure Analyzer Screens		X					X
Leak Check Gas Connections			X				
Probe Heater Checkout						X	
Test Umbilical Heater						X	
Check Alarms Log	X						
Analyzer Purge Air Pressure				X			
Backup CEMDAS Software Using Tape Drive							X
Perform Printer Maintenance		X					X

Table 2: Recommended Service Support Functions for Extractive Dilution CEM Systems, Opacity Monitors and Flow Monitors Subject to 40CFR75 (Continued)

Activity: QC Checks	Daily	Weekly	Monthly	Quarterly	Semi Annual	Annual	As Required
OPACITY							
Perform Opacity System Check	X						
Perform Opacity Diagnostic Check			X				
Replace Opacity Purge Filters				X			
Check Opacity Blower Operation			X				
Clean Opacity Shroud Cavity							X
Check Opacity Multi-day Cal. Reports			X				
Check Alignment of Opacity Receiver and Reflector				X			
Replace Opacity Transmissometer Filter Elements				X			
Perform Opacity Audit				X			
NO_x ANALYZER							
Perform Functionality Check	X						
Verify Zero & Span Values	X						
Preventive Maintenance				X			
Check Multiday Calibrations		X					
CO_2 ANALYZER							
Perform Functionality Check	X						
Verify Zero & Span Values	X						
Preventive Maintenance				X			
Check Multiday Calibrations		X					
SO_2 ANALYZER							
Perform Functionality Check	X						
Verify Zero & Span Values	X						
Preventive Maintenance				X			
Check Multiday Calibrations		X					

Table 2: Recommended Service Support Functions for Extractive Dilution CEM Systems, Opacity Monitors and Flow Monitors Subject to 40CFR75 (Continued)

Activity: QC Checks	Daily	Weekly	Monthly	Quarterly	Semi Annual	Annual	As Required
FLOW MONITOR(ΔP)							
Change Blower Filters				X			
Clean Transducers							X
Perform Daily System Check	X						
Verify Zero & Span Values	X						
AIR SYSTEM							
Air Hose Check					X		
Check and Service Air System		X					
Check Purafil. Replace As Required	X						
AUDIT							
Walk-through Audit				X			
RATA					X	X	
Linearity Audit				X			

Table 3. Elements of CEMS Training Program

I. For CEMS with SO_2, NO_2, CO_2, Flow, Opacity:

1. Equipment and Work Environmental Safety: Discuss complete safety requirements for CEMS system. Includes MSDS sheets, all safety equipment required, notification policies, and equipment precautions.

2. System/Equipment Description: Detailed system overview covering the entire CEMS system. Includes CEMs purpose, locations, configuration, equipment types, and basic functionality.

3. Theory of Operations: Detailed discussion of equipment operational theory, covering gas analysis techniques, detection, amplification, A/D conversion and display/output of data.

4. Operations and Maintenance: Discussion of equipment operations including operating parameters, calibration procedures, analyzer checkout, display panel indicators, etc. Discuss preventive maintenance procedures for all gas analyzers and flow/opacity systems. Discuss troubleshooting and corrective actions for each system including typical problems and appropriate corrective action.

5. Quality Assurance and Control: Read and understand system specific service functions as written in site QA/QC manual. Review all scheduled maintenance for system(i.e., daily, weekly, monthly, quarterly, semiannual, annual). Overview of required forms and reporting requirements. Understand the company structure of notification of "out-of-control" period caused by equipment failure, calibration drift, linearity failure and excessive relative accuracy. Understand weekly reporting to service manager.

II. For CEMS Computer System:

1. Theory of Operation

- The CEMDAS environment
- Data collection and storage
- Data processing
- Report generation
- System operations

2. Sampling: The methods of real time conversions and how it is repeated.

3. Input/Output: Analog and digital.

4. CEMDAS Sampling Screen: Contents and functions of the main screen and function keys.

5. Alarms: Process alarms on various system processes.

6. Reports: Report generation.

7. Editing: Edit system constants, alarm files and period averages.

8. Data Substitution: Retrieve missing data thru data substitution.

9. Electronic Data Report preparation.

10. PLC Downtime Recovery.

Table 4. Information To Be Included in Weekly Service Reports

1. Confirmation that all routine tasks as outlined in the CEMS QA/QC Program (e.g., Table 1) have been completed on schedule and, if not, identification of each exception and reason for it.

2. When monitor calibration error exceeds equipment performance specification in 40CFR75 Appendix A, Section 3.

   · Time of calibration error
   · Magnitude of calibration error
   · Corrective actions taken
   · Time of recalibration
   · Out of control period, if any.

3. For each monitor, the monitor uptime % for preceding week and the Percent Monitor Data Availability (PMDA) for the preceding 365 days (or since certification date if less than 365 days since certification). Comparison with the reliability goal set for CEMS.

4. Confirmation that spare parts inventory has been checked and that all inventories plus parts on order are above the reorder point.

5. Non-routine planned activities for future.

6. Additional support needed for future activities.

7. Potential problems affecting future CEMS performance needing attention.

Table 5. Uptime and Accuracy of Enviroplan Phase I CEMS at Electric Utility Units With Service Contracts and Without Service Contracts for Fourth Quarter 1994

Plant Units With Enviroplan CEM Service Contracts During 1994 Q4	% Uptime	Average RATA	Average Daily Calibration Drift
Average	**99.00%**	**1.09%**	**0.76%**
Number Units: 9			
Plant Units Without Enviroplan Service Contracts During 1994 Q4			
Average	**97.04%**	**4.95%**	**.58%**
Number Units: 17			
Benefit of Service Contract	**+1.95%**	**+3.86%**	**-.18%**

Source: U.S. EPA Electronic Data Reports, 4th Quarter 1994.

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