Reliability of Selective Catalytic Reduction (SCR) and Flue Gas Desulfurization (FGD) Systems for High Pollutant Removal Efficiencies on Coal Fired Utility Boilers

The 2004 MEGA Symposium, Paper # 04-A-56-AWMA

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ABSTRACT

SCR and FGD are making a significant contribution to the control of NOx and SO_2 emissions from coal-fired generating units. These technologies are expected to contribute to further reductions in pollutant emissions in response to proposed emission reduction rules. The ability of these technologies to make significant contributions to pollution reduction in a cost-effective manner depends, in part, on the reliability of these technologies in providing high levels of pollution reduction.

A study of reliability of these technologies in providing high levels of pollutant reduction was conducted. The study included a review of CEMS data and input from operators of facilities. Operators of facilities that use these technologies were provided a questionnaire to collect their input on the reliability of these technologies. Information collected included emissions reductions guaranteed and achieved, reliability overall, and reliability by system component. The information provided by users was compiled and analyzed for statistical trends. In this paper we will present summary results of this study.

INTRODUCTION

Selective Catalytic Reduction (SCR) and Flue Gas Desulfurization (FGD) are technologies used to reduce emission of air pollution from power plants, especially, coal-fired plants. These technologies are currently in use at many coal-fired generating plants and are likely to be installed on many more in response to proposed emission regulations.[1] The reliability of these technologies plays an important role in influencing: 1) the ability of these technologies to achieve the necessary reduction in pollution emissions, and 2) the cost of achieving the necessary reduction in pollution emissions. Articles by others have raised questions about the reliability of SCR systems in providing high levels of NOx control, i.e., approaching 90% NOx removal.[2] Reference 2 explored reliability of operational SCR systems through an analysis of continuous emission monitoring system (CEMS) data. However, Reference 2 acknowledges that various plant operations – such as unit start up or shut down - can introduce artifacts in CEMS data that will affect the inferred level of NOx reduction. Reference 2 describes the filtering techniques used by the authors in an effort to compensate for these artifacts.

In this effort, we explore some of the important considerations for estimating effectiveness of control equipment through a review of CEMS data. Examples are used to provide insight on how to best screen and interpret this data.

A major part of this effort, however, was associated with collecting and evaluating input from facility operators. Information on the operating approaches they use and their experience with reliability of SCR and FGD systems were of interest. Questionnaires were prepared and sent to many utility companies. Some companies chose not to participate, but several did choose to participate. Data was collected for 23 SCR systems and 14 FGD systems. These represent a fraction of the total installations in the US, and may not be statistically representative. But, certain trends can be observed from the data.

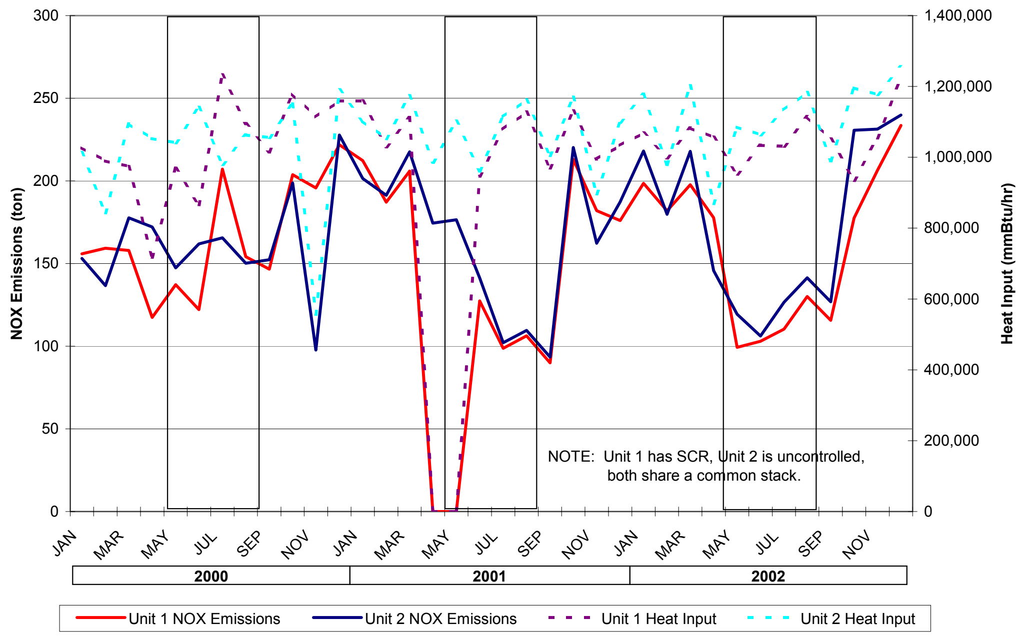
REVIEW OF CEMS DATA

The Clean Air Markets Division of the US Environmental Protection Agency (EPA) collects hourly air emissions data from sources subject to reporting requirements of Part 75 under programs such as the Acid Rain Program. This hourly data, along with unit characteristics is made available to the public via the EPA website.[3] Although EPA provides this data for use by the public, certain operational characteristics such as the efficiency of add-on control devices is difficult to derive from this data alone. For example, facilities often monitor emissions at common stacks for multiple units where emissions from uncontrolled and controlled units are monitored together. In such cases distinguishing the contribution of emissions of the controlled unit from those of the uncontrolled unit may not be possible.

Figure 1 provides the NO_X emissions over a three-year period for a facility in the eastern United States where two tangential coal-fired units of similar size share a common stack with a single CEMS monitoring the common stack. As shown in Figure 1, the reported NO_X emissions for both units follow a very close pattern, even though one unit has an operational SCR and actually has much lower NOx emissions during the ozone season (May 1 – September 30). An SCR was installed on Unit 1 in June 2001 and is operated during the ozone season. Unit 2 does not have an add-on NO_X emissions control device. The incorrect representation of NOx emissions results from the methodology used by the CEMS in allocating emissions between the units. Total NOx emissions from the common stack are allocated to the individual units on the basis of heat input without consideration to the actual emissions from each unit – only the total is measured. As a result, the hourly data from the CEMS at this plant cannot be used to determine SCR characteristic information for the unit with the SCR.

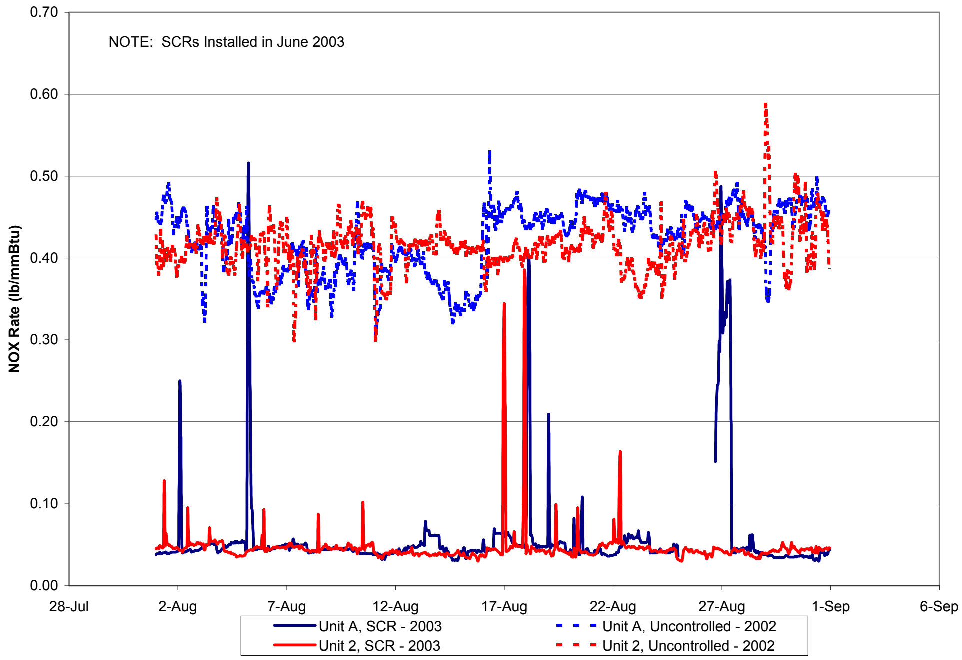
In addition to common stack issues, hourly data may not always be from CEMS as certain sources may use alternative Part 75 methods to develop hourly emissions. For example, during periods of CEMS downtime units may use acceptable substitute data. Also, a limited number of units do not need to install CEMS and may use other methods to determine hourly emission such as default emission rates. Finally, units that install add-on control devices, such as an SCR, under Part 75 requirements are installing the device to meet NO_X allowance demands. That is to say that these units have an emissions “cap” that they are required to meet and can reduce emissions to meet their “cap” by using add-on controls or by purchasing additional allowances. Economics is a powerful driver in this type of compliance system, and facilities that have add-on controls rarely use these controls to their maximum capacity unless there is an economic incentive to do so. Therefore, use of EPA hourly data from sources subject to Part 75 reporting requirements should not be used to characterize add-on control efficiencies without carefully analyzing how the data are derived and what they represent.

Figure 1. Combined NO_X Emissions from a unit with SCR and a unit without SCR



Although care must be taken to assure CEMS hourly data accurately reflects the operations of a unit, it is possible to estimate add-on control performance for carefully screened data sets. For example, Figure 2 provides a comparison of hourly NO_X emission rates of two coal-fired units (each from a different facility) which installed SCR prior to the ozone season of 2003. As shown in this figure, the NOx emission rates during the month of August 2002 for each unit were approximately 0.42 lb/MMBtu prior to SCR installation (dashed lines). The NOx emission rates during the month of August 2003 for each unit were approximately 0.04 lb/ MMBtu after SCR installation and optimization (solid lines). Both units averaged a percent reduction of approximately 89% in NOx emission rates after SCR installation. Similar data analysis for other CEMS-monitored units has demonstrated NOx achievable emission rates of 0.04 lb/ MMBtu with SCR.

Figure 2. Example of NO_X Emission Reductions with SCR Installation



A screen of all CEMS monitored (under Part 75) coal fired units equipped with SCR that were operating in the third quarter of 2003 resulted in 22 units with NO_X rates equal to or less than 0.07 lb/MMBtu. These 22 units included only coal-fired boilers that either had single stacks or shared a common stack or multiple stacks with other coal-fired boilers also equipped with SCR control devices. The average emissions rate of the 22 units during the third quarter of 2003 is 0.058 lb/MMBtu with a standard deviation of 0.010 lb/MMBtu. Of these 22 units, 15 units had emission rates from 0.04 to 0.06 lb/MMBtu. Without information on the value of the SCR inlet NO_X level, it is not possible to estimate the percent reduction resulting from SCR. But, if the average emission rate into the SCR were assumed to be 0.50 for the 22 units, the average NOx reduction level for these units would be approximately 88 percent. For the 15 units with 0.06 lb/MMBtu or lower emissions, the average NOx reduction level would be approximately 90 percent.

As mentioned earlier, CEMS data may not reflect the maximum capabilities of the SCR installations. In some cases, the operating decisions may have an impact on the SCR NOx removal rates estimated from such data. For example, due to operating or economic reasons, operators might choose to get less NO_X removal than is possible from their SCR systems. To better understand plant specific situations, facility owners were surveyed.

RESPONSES TO SCR QUESTIONS

Because the focus of this effort was to evaluate reliability of high efficiency SCR's, the discussion will initially focus on high NOx reduction SCRs (85% or greater NOx reduction). Subsequently, results from such SCRs will be compared with results from older SCRs built for lower removal efficiencies. Data was collected on 23 high efficiency SCRs (85% removal or higher) and from owners of two older SCRs that are not designed for high removal efficiencies.

Of the high removal efficiency SCRs, the average unit size was 814 MW, the largest unit was 1300 MW, the smallest unit was 349 MW and the standard deviation in size was 265 MW. Fuels fired included bituminous coals, subbituminous coals (Powder River Basin, PRB) and bituminous/subbituminous coal blends.

OPERATION

Although most of the high removal efficiency facilities must meet total mass emission requirements over a period of time, about half of the facilities responded that they control to specific emission rates rather than tonnage over a period of time. 52% of the respondents indicated that they control to a specific emissions rate and the remainder (48%) reported that they control to a total tonnage level. Since a review of state permits for each unit was outside the scope of this work, it is not possible to determine whether the state or local requirements differed from the SIP Call requirements. But, it is most likely that units that are controlled to specific levels are operated in this manner with the intent of targeting a cumulative mass emission for the period. However, this could not be confirmed.

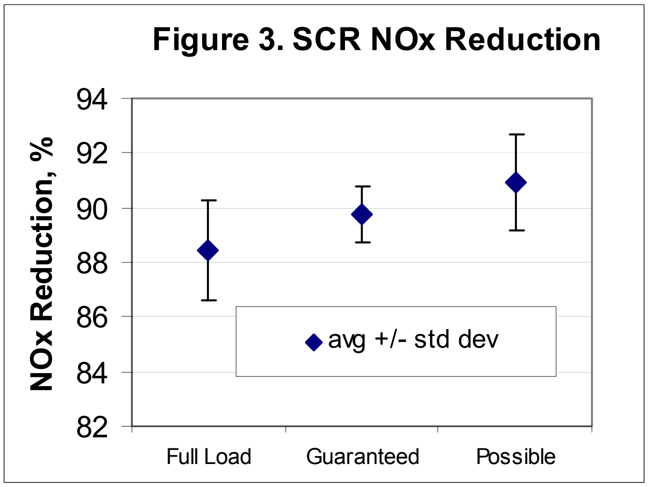
Most of these SCRs were designed to achieve an emissions rate for a particular coal and firing condition. The impact is that if the NOx emissions from the boiler are less than the design basis, the percent reduction will likely be less than the design or guaranteed rate.

The average operating hours for these high removal efficiency units was about 5,300 hours, which is within the warranty period in most cases. The unit with the most operating hours was 10,000 hours and the unit with the least had only 1,500. Standard deviation of the operating hours was 2,475 hours. So, it could be argued that these responses may reflect initial operating experience and it will be necessary to wait for long-term experience. In a later section these results are compared to units with longer operating experience but lower NOx removal.

NOx REDUCTION

The operators were asked to provide the typical full-load NOx reduction, the designed or guaranteed NOx reduction, and an estimate of the best removal rate they thought the system could achieve on a regular basis if they had a reason to operate it at higher removal rates.

As shown on Figure 3, the SCRs, on average are currently providing between 88% and 89% NOx reduction (This is consistent with the results of Reference 2). The error bars show plus and minus one standard deviation. The guaranteed reduction on average is nearly 90% NOx reduction, with a narrower deviation than the actual operating reduction. And, if necessary, these units could provide, on average, close to 91% NOx reduction on a regular basis. The highest NOx reduction reported was 93%, by five units, or over 20% of those responding. In



every case the highest regular reduction estimated to be possible was equal to or greater than the guaranteed NOx reduction. Therefore, all of the operators are confident of the SCR's ability to achieve the guaranteed reduction on a regular basis. The fact that the operating full-load NOx reduction rates are slightly less than the guaranteed rates is likely because the NOx levels into the SCR are probably less than the maximum expected for the design conditions. If the units are being operated to maintain a particular outlet NOx emissions rate, as many are, then the operating NOx removal rate is going to be lower than the design or guaranteed rate. Thus, if SCR NOx reduction performance were inferred from CEMS data, this could cause an artifact suggesting poorer NOx reduction than is actually possible.

All of the high removal efficiency units responded that initial performance tests were performed and on all of the units the initial performance tests were passed.

All of the units responded that the SCR is operated at part load conditions and about one third of them responded that they operate during start up or shut down, but only while gas temperature is adequate for SCR operation. During start up or shut down the gas temperature can drop below the necessary gas temperature for SCR operation. As a result, if the unit is being shut down for start up, the outlet emissions rate may indicate higher than normal on the CEMS. Thus, if SCR NOx reduction performance were inferred from CEMS data, this could introduce an artifact suggesting poorer NOx reduction than is actually occurring during normal SCR operation.

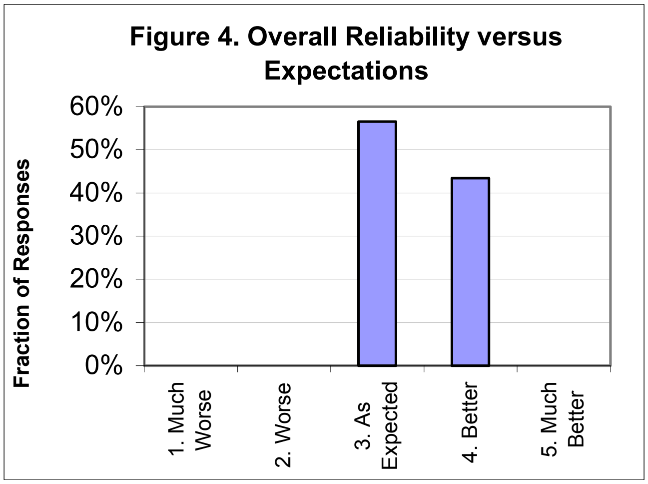
RELIABILITY RELATIVE TO EXPECTATIONS

The survey also polled the reliability of the SCR and its components versus expectations. The following categories were evaluated:

- Performance in general
- Reagent Storage/Handling
- Ammonia Injection
- Instrumentation and Controls
- Catalyst Activity
- Ash Depostion/Pluggage
- SCR Reactor and Structural
- Dampers and Ductwork

Respondents could indicate one of the following for each category:

1. Much worse than expectations
2. Worse than expectations
3. Met expectations
4. Better than expected
5. Much better than expected



As shown on Figure 4, all of the high removal SCRs generally performed as expected or better than expected (either 3 or 4). Responses for SCR components varied.

In the following paragraphs we will examine the reliability of SCR components.

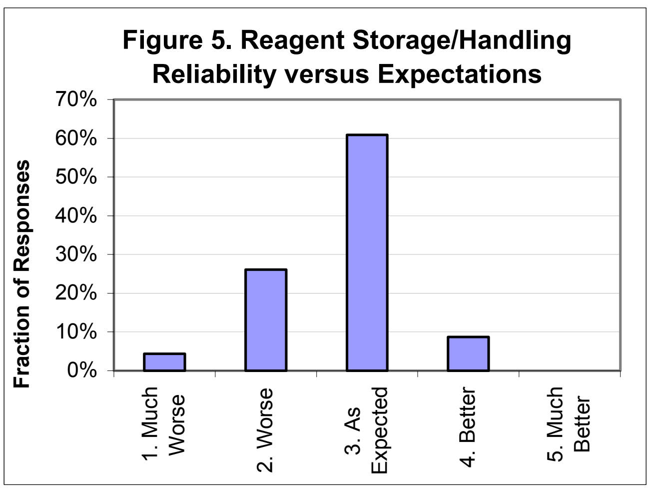


Figure 5. shows the distribution of responses regarding Reagent Storage and Handling. Ammonia or Urea storage and Handling was very problematic for some respondents. Fortunately, all of those respondents that indicated a performance shortcoming in this system (answered 1 or 2) also indicated that the problem was short term and correctable. Some indicated separately that the long-term reliability of some urea conversion systems remains a question.

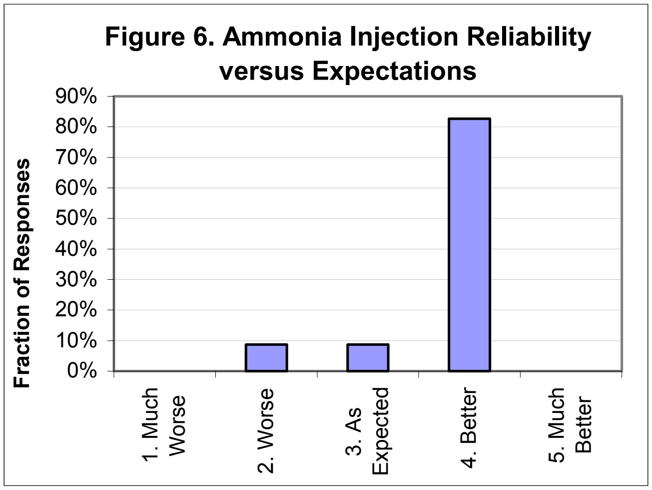
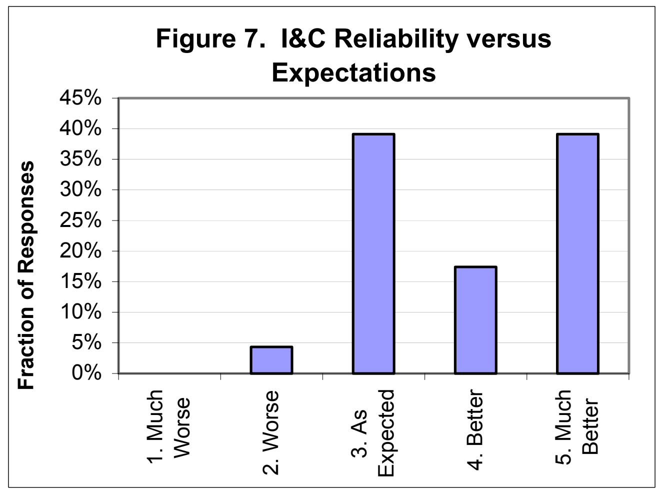


Figure 6 shows the distribution of responses regarding ammonia injection equipment. Fortunately, most respondents found this equipment to meet or exceed expectations. Furthermore, in the small number of cases where reliability of ammonia injection equipment was worse than expected, the problems were short term and correctable. So, these problems should not adversely affect reliability in the long term.

Figure 7 shows the distribution of responses regarding instrumentation and controls. Fortunately, most respondents found this equipment to meet or exceed expectations – in several cases much better than expectations. Furthermore, in the small number of cases where reliability of instrumentation and controls was worse than expected, the problems were short term and correctable. So, these problems should not adversely affect reliability in the long term.



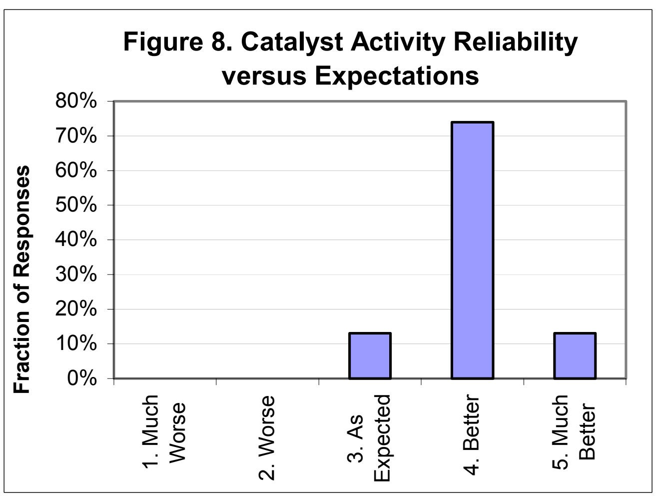


Figure 8 shows the distribution of responses regarding catalyst activity. All respondents found catalyst activity meeting or exceeding expectations – in some cases much better than expectations. However, it is important to note that since most of these units had only a few thousand operating hours, these responses may not be indicative of long-term catalyst performance. Long-term catalyst behavior can only be determined with more time.

Figure 9 shows the distribution of responses regarding ash deposition and plugging. Although most respondents found ash deposition and plugging meeting or exceeding expectations, a significant number of respondents found ash deposition and plugging to be much worse than expectations. Moreover, all of those responding that ash deposition and plugging were much worse than expected also indicated that this is expected to be a long-term problem. Therefore, this is likely to impact future reliability and a solution to this problem would be very desirable.

Figure 9. Ash Deposition/Pluggage versus Expectations

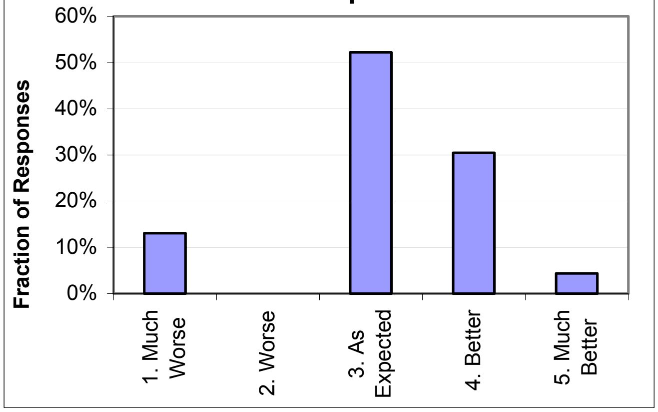


Figure 10. SCR Reactor/Structural Reliability versus Expectations

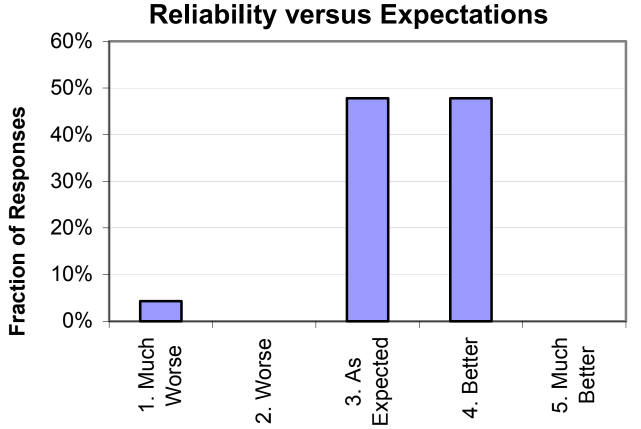
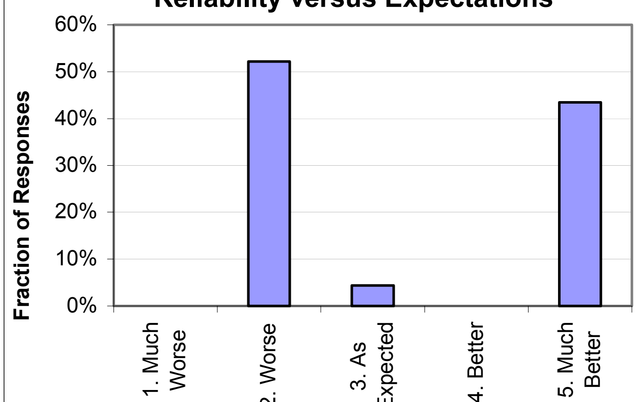


Figure 10 shows the distribution of responses regarding the reliability of the SCR reactor and other structural components. Most respondents found the reliability of this equipment to meet or exceed expectations. Furthermore, in the small number of cases where reliability of the SCR reactor or other structural components was much worse than expected, the problems were short term and correctable. So, these problems should not adversely affect reliability in the long term.

Figure 11 shows the distribution of responses regarding the reliability of the SCR dampers and ductwork. Included in this is experience with expansion joints. Experience was mostly either very good or bad – little in between. Fortunately, for the facilities that reported that reliability of the SCR dampers or ductwork or expansion joints was worse than expected, the large majority of them reported that the problems were short term and/or correctable. So, in some cases there will be a long-term impact on reliability. But, these are likely to be the minority of cases.

Figure 11. Dampers and Ductwork Reliability versus Expectations



In summary, all high NOx reduction SCR respondents found that their systems met or exceeded expectations overall. Where shortcomings in performance were noted, in most cases the shortcomings were short term or correctable. However, ash plugging and dampers and ductwork may be an ongoing reliability problem. And, the long-term reliability of urea conversion systems may also be a question.

Comparisons with Lower Removal Units

Although the focus of this effort was evaluating the performance of high NOx removal SCRs, in the process of collecting information, information was received from two facilities designed to achieve lower removal rates than what has been achieved from the retrofit units that were discussed so far. These two units also have been in operation for several years, unlike most of the high removal rate retrofit units that were retrofit onto existing units in recent years.

Figure 12 shows the results of overall reliability for all respondents as a function of the NOx reduction that they are actually delivering. Note that some of the data points represent more than one response. The only unit that was rated below expectations (1 or 2) provides 75% reduction (which is also higher than the design NOx reduction for that unit). So, there's no apparent trend that higher reduction results in worse reliability, except possibly if you operate significantly above the design removal rate.

Figure 12. SCR Overall Reliability

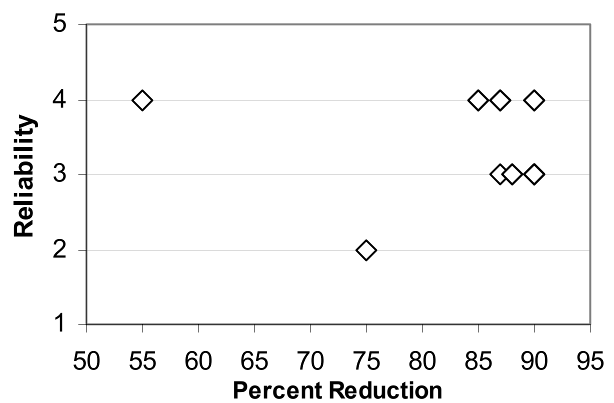
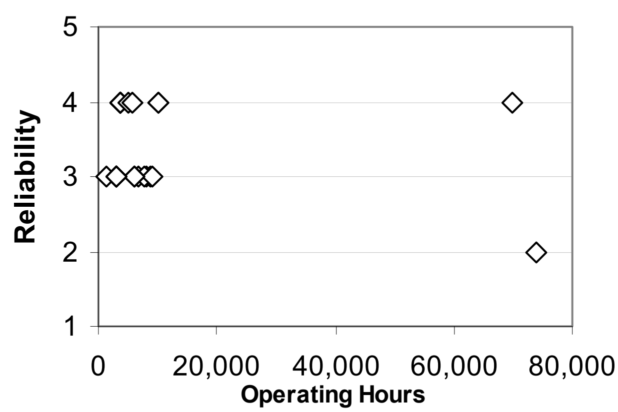


Figure 13 shows the results of overall reliability for all respondents as a function of the operating hours. The higher NOx reduction units have fewer operating hours. As in Figure 10, there is not a clear trend toward poorer reliability over time. Of course, there are only a few data points at higher operating hours and it would be better to have more data. Of possible significance is the fact that the two units with high operating hours were among the first SCR installations on coal-fired boilers in the United States. So, there could be "first of a kind" issues with these two units, especially the one with more hours that showed reliability below the operator's expectations (and is also operated well above its designed NOx removal rate). In this one installation some issues have been corrected, but efforts continue to address others.

Figure 13. SCR Overall Reliability



Summary on SCR Reliability
In this effort, responses were received for 25 SCR systems – 23 of them high NOx removal systems of 85% removal or better. Based upon operation of a few thousand hours, all are capable of achieving their design NOx removal rate if necessary and all are meeting or exceeding expectations for reliability. Some units have had reliability issues with specific components of the SCR system. But, overall reliability is satisfactory. Because these high removal SCRs have generally operated for a few years or less, these results should be considered representative for initial operation. Longer operation may reveal other issues. Comparison against two lower removal systems that have been operating for several years showed no clear trend in reliability as a function of removal efficiency or operating hours. Of course, since there are only a few data points for longer operating hours or lower efficiency, it is difficult to reach any firm conclusions.

RESPONSES TO FGD QUESTIONS

In this effort information was gathered on reliability of FGD systems. There are three basic types of FGD systems that were evaluated: 1) Limestone-based wet FGD; 2) Lime-based wet FGD, and ; 3) Lime-based Spray Dryer Absorber (SDA). Unfortunately, it was not possible to collect as many responses for FGD technology as for SCR technology. This is partly because many FGD systems were installed much earlier than SCR systems. So, while most SCR systems in the United States reflect the current state-of-the-art, most FGD systems were installed many years ago when technology was less advanced than today's state-of-the-art and also when prevailing regulations did not require or encourage higher SO_2 removal efficiencies. Nevertheless, information was obtained on Limestone-based wet FGD systems serving five boilers (some with multiple boilers served by a single FGD tower), on seven different Lime-based wet FGD systems serving seven boilers (some serving only a portion of a boiler's flue gas), and on only two Lime-based Spray Drier Absorbers serving two boilers.

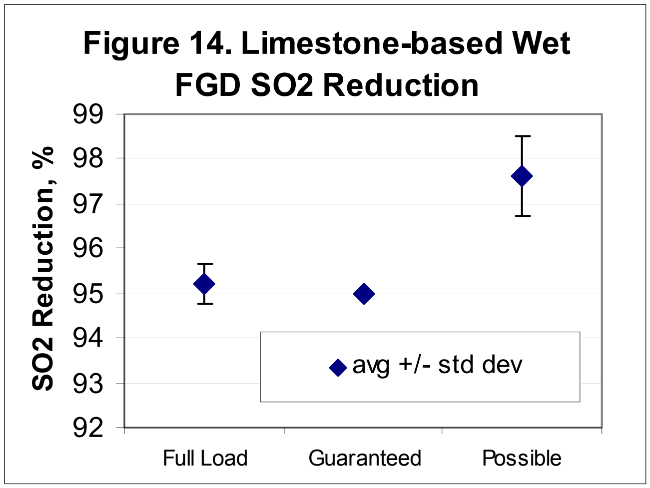
The largest boiler reviewed of all of the FGD systems was 750 MW, the smallest was 80 MW. In one case a single limestone FGD system served multiple boilers. In another case a lime wet FGD system scrubbed only a portion of the boiler gases.

OPERATION
Almost all of the FGD systems are operated with the intention of maintaining a particular emissions rate or percent reduction. Since a review of the state permits for each unit was outside the scope of this work, it is not possible to determine whether the state or local requirements differed from the Federal requirements. Because all or most of these units are Title IV affected units, it is likely units are controlled to specific levels with the intent of targeting a cumulative mass emission for the period. However, this was not confirmed.

Unlike the high NOx reduction SCRs, most of these FGD systems have been in operation for at least a few years. The average operating history of Limestone-based FGD systems was 44,000 operating hours, the maximum was 60,000 operating hours and the minimum was 40,000 operating hours. The average operating history of Lime-based FGD systems was 114,000 operating hours, the maximum was 254,000 operating hours and the minimum was estimated 20,000 operating hours. The two SDA systems had about 70,000 to 80,000 operating hours.

SO_2 REDUCTION

All of the Limestone wet FGD systems are designed and guaranteed for 95% SO_2 reduction, and all operate at or better than that level of SO_2 removal. Respondents indicated that some of the systems could operate at higher SO_2 removal efficiencies, as indicated in Figure 14. Not all systems had acceptance tests upon commissioning. But, those that had, passed the acceptance test.



For the lime-based wet FGD systems, of the seven systems that responded, only three of them were designed to achieve 90% or more SO_2 removal for the flue gas they treated.[1] The other facilities were older facilities that were designed for lower SO_2 removal rates – on the order of 70-80% removal. As shown in Figure 15, which shows full load SO_2 reduction of lime-based wet FGD plotted against operating hours, more recently installed systems operate at much higher flue gas SO_2 removal rates than previously installed systems.

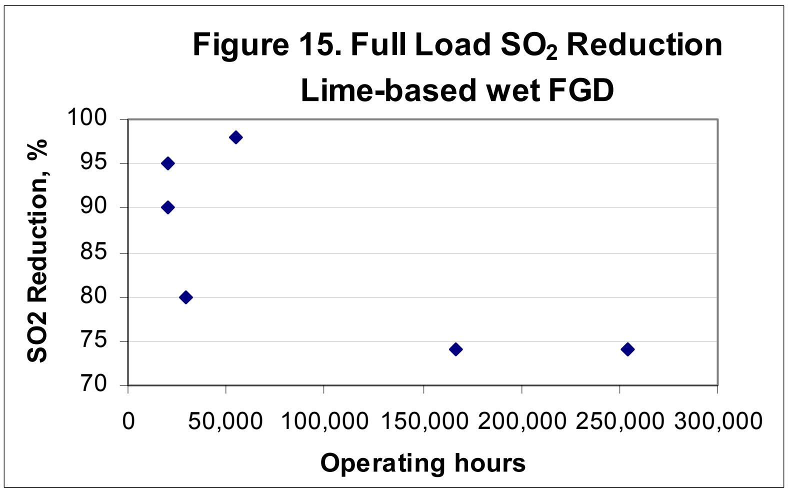
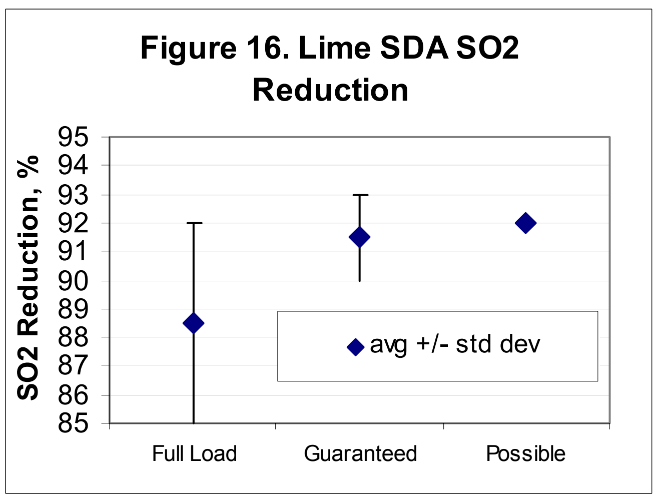


Figure 16 shows the SO_2 removal efficiencies reported for the two SDA-equipped facilities. As shown, both systems normally operate at removal efficiencies in the range of 85% to over 90% removal efficiency. Both were designed for guaranteed SO_2 removal efficiencies of somewhat over 90% removal and facility operators project that about 92% removal is achievable on a regular basis with these systems if necessary.



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1 One of the systems treated a fraction of the total flue gas for the boiler. We consider the percent reduction for the flue gas treated here. Also, two installations have same percent reduction and operating hours, which explains why there are apparently only six points displayed on Figure 13.

RELIABILITY RELATIVE TO EXPECTATIONS

The survey also polled the reliability of the FGD and its components versus expectations. The following categories were evaluated:

- Performance in general
- Reagent Storage/Handling
- Slurry Injection/Atomization
- Instrumentation and Controls
- Pumps, Tanks, chemical hardware
- Corrosion or scale build up
- Waste disposal or handling
- FGD reactor vessel or structural
- Dampers or Ductwork
- Fabric Filter, for SDA

Respondents could indicate one of the following for each category:

1. Much worse than expectations
2. Worse than expectations
3. Met expectations
4. Better than expected
5. Much better than expected

Because for each SO_2 control technology – Limestone-based wet FGD, Lime-based wet FGD, and Spray Drier Absorber (SDA) technology – there are a limited number of responses, the results of this analysis will be presented in a different way than for the SCR analysis.

Figure 17 shows the results of responses to questions regarding reliability versus expectations – in general and for specific components - for the limestone-based wet FGD. As shown, for all cases the reliability in general met or exceeded expectations. Only in the case of waste disposal and handling did reliability fail to meet expectations. Fortunately, in every case the reliability shortcoming was short term and correctable.

Figure 18 shows the results of responses to questions regarding reliability versus expectations – in general and for specific components - for the lime-based wet FGD. As shown, for all cases the reliability in general met or exceeded expectations. As in the case of limestone wet FGD, waste disposal and handling did not exhibit reliability meeting expectations. In some cases dampers and ductwork failed to meet expectations. In this case it was unclear to the respondents whether or not the reliability shortcomings are a short-term or long-term problem.

Figure 19 shows the results of responses to questions regarding reliability versus expectations – in general and for specific components - for the lime-based Spray Drier Absorber technology. Only two facilities responded in this case. As shown, in one case the reliability in general and for all components met reliability expectations. In the other case, the facility operator reported that performance in general failed to meet expectations. And the same user also reported that several components of the SDA system failed to be as reliable as expected. This user also reported that all of the areas where reliability failed to meet expectations were long-term issues, except for corrosion/scale build up and reactor structural which were short-term problems. It should also be noted that with only two facilities responding, it would be very desirable to collect more information in the future from other facilities to compare with these results.

Figure 17. Limestone wet FGD Reliability Versus Expectations

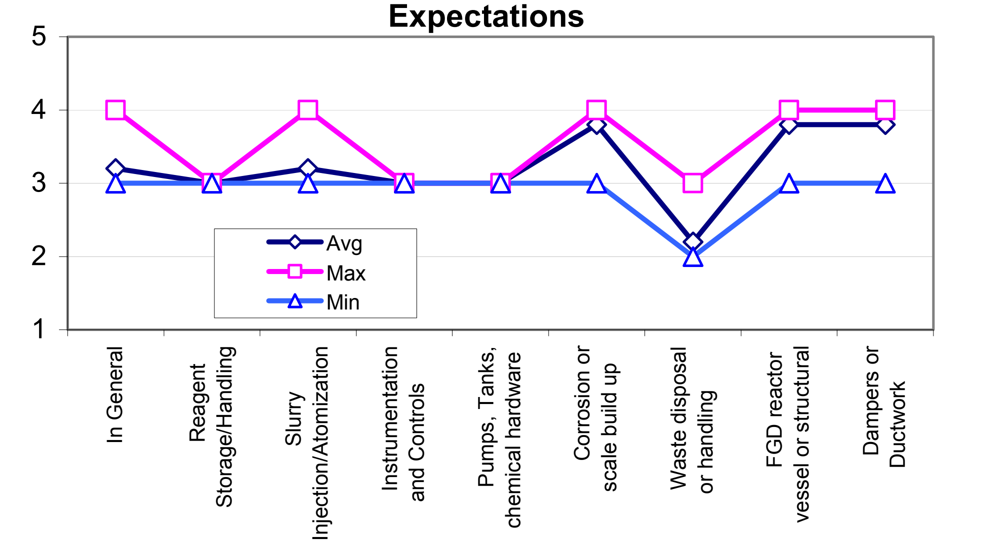
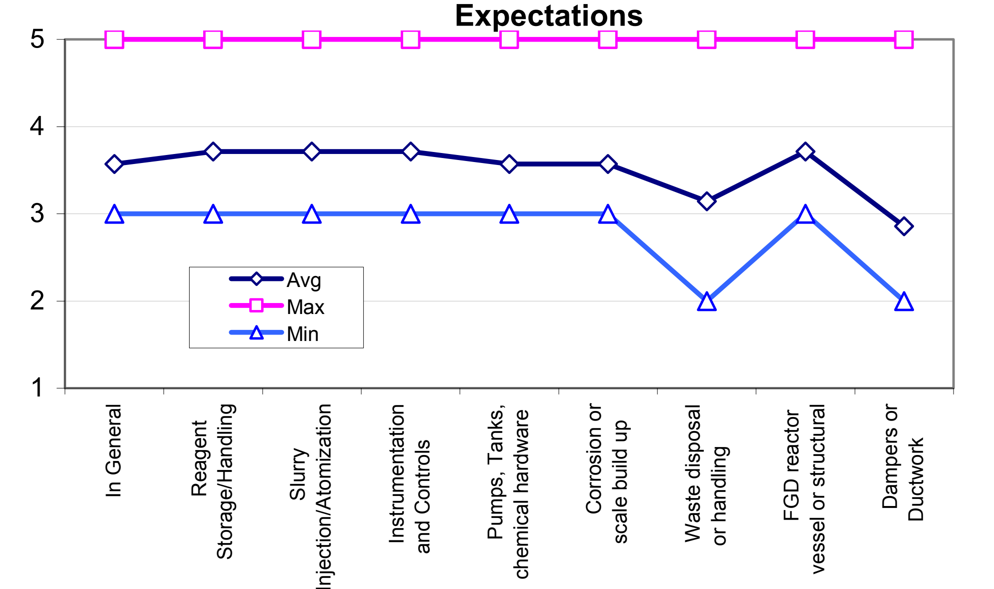
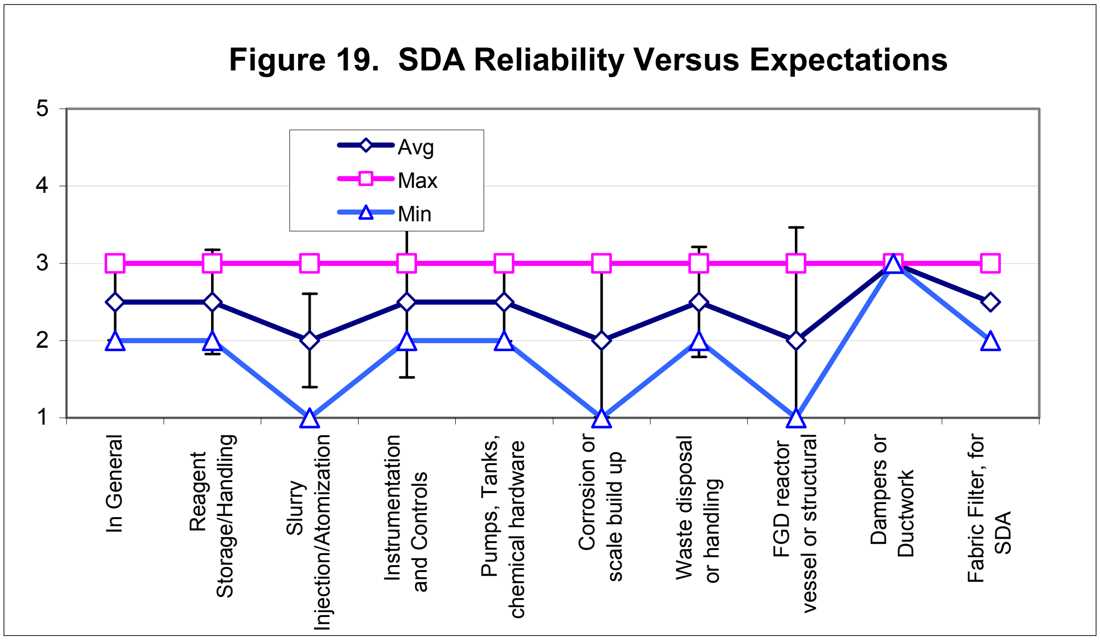


Figure 18. Lime Wet FGD Performance Versus Expectations

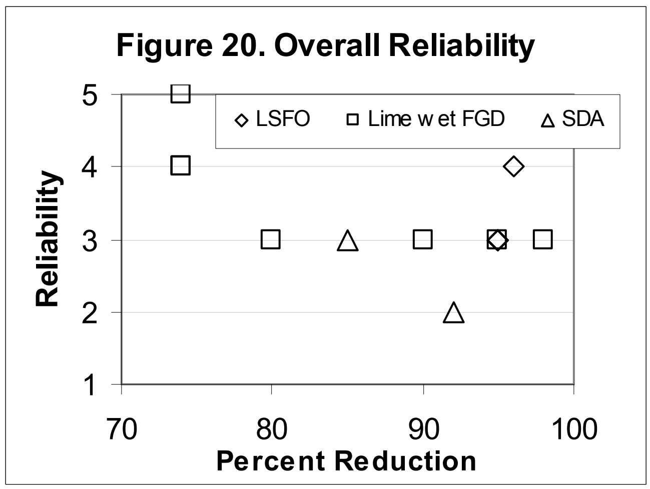


Reliability Key
5 = Much Better Than Expected
4 = Better Than Expected
3 = As Expected
2 = Worse Than Expected
1 = Much Worse Than Expected



Summary on FGD Reliability

Figure 20 is a plot of overall reliability reported against reported full-load SO_2 reduction. With one exception – an SDA system – all systems met or exceeded expectations regarding reliability. In some cases there were individual components that failed to meet expectations regarding reliability, but overall reliability met expectations.

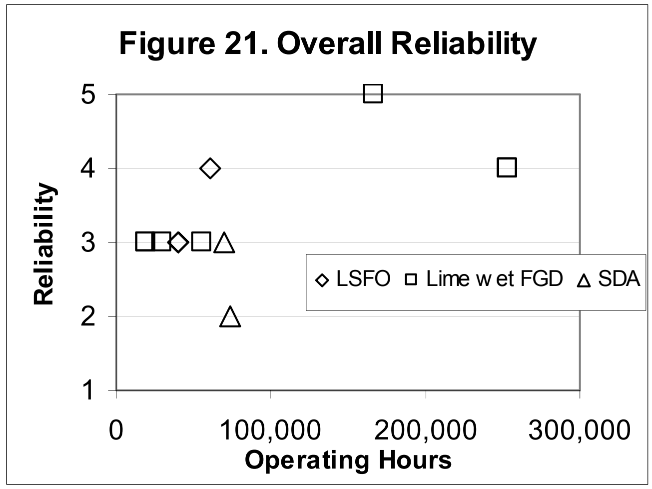


As shown on Figure 20, reliability for systems with under 80 percent reduction were reported to exceed expectations. For those systems operating above 80 percent, all but one were reported to have met or exceeded expectations for reliability. One of the two SDA systems that we received information on reported reliability that was below expectations. But, in both cases the responses showed that over 90% SO_2 removal was possible on a regular basis if necessary. Thus, there is no clear trend toward poor reliability at high SO_2 removals.

Figure 21 shows Overall Reliability for the different technologies reported against Operating Hours. There is no clear trend toward increasing or decreasing reliability versus operating hours.

However, it would be very beneficial to collect more data on FGD systems, especially SDA technology.

CONCLUSIONS



This effort explored the reliability of SCR systems at providing high levels of NOx removal. CEMS data was evaluated. But, while CEMS data provided some useful information regarding the emission rates being achieved, it is not possible to ascertain the actual emissions reductions accurately because of artifacts associated with the way CEMS data is collected and reported. These artifacts are complicated by operating decisions that facility owners make that will affect the data. For this reason, facility owners were contacted for their input on how they operate the facilities.

The results of an effort to collect information from facility operators on the reliability of SCR and FGD systems at providing high levels of NOx and SO_2 reduction are summarized in this paper. It is always desirable to collect information from as many members of a population as possible to ensure that the sample is as representative of the population as possible. To this end, numerous facility owners were contacted. Only a portion of those facility owners chose to participate in this survey. Nevertheless, some very important insights have been garnered from this effort. All of the high NOx reduction SCRs that are represented in this survey met or exceeded expectations regarding reliability in general. Some facilities experienced less-than-expected reliability on some specific SCR system components; however, these were in most cases short term or correctable. And, because other aspects of the SCR exceeded expectations for reliability, reliability in general was viewed by the respondent as meeting or exceeding expectations.

Since the high NOx reduction SCR systems that are represented in this survey generally had only a few thousand operating hours, it could be argued that the results of this survey may not be representative for long-term operation. However, because an SCR has only a limited number of wear parts, it is likely that the experience reflected here can provide useful insights for all of the SCR components except possibly for the SCR catalyst, which is known to degrade over time, or possibly the urea conversion technology, for which there is limited long-term experience. There are high NOx removal facilities in the US with more operating hours. Many of these facilities were invited to participate; however, the facility owners chose not to. Nevertheless, the fact that all of the high NOx removal facilities that responded were operating over 85% reduction regularly, were typically guaranteed for about 90% reduction and all replies indicated that at least guaranteed NOx reductions could be reliably achieved if desired, indicates that 90% NOx reduction is a reasonable estimate to use for the NOx removal that is ***possible*** from SCR. Whether facility owners choose to achieve such removal rates is a business decision that they make.

With regard to FGD, a fewer number of facilities were available to collect information from, particularly with regard to high levels of removal. As shown in Figure 15, high removal systems have only been installed in more recent years. So, removal rates on systems installed 20 or more years ago are not representative of what is possible with current technology. But, the more recently installed wet (lime and limestone) systems were mostly guaranteed at 95% reduction or better with higher reductions in the range of 97-98% reported as being possible on a reliable basis, if needed. Only two dry FGD systems were evaluated, and both of them were reported to be capable of over 90% SO_2 removal, if needed.

With regard to FGD reliability, in every case except for one SDA system, performance overall met or exceeded owner expectations. Therefore, there is reason to believe that the FGD systems will perform as expected (albeit, with some specific components that may perform more or less reliably than other components). That only two responses were received for SDA systems raises the question regarding how representative this sample is for SDA systems. Therefore, there may be some benefit in collecting more information in the future for all three FGD technologies, but especially for SDA technology.

DISCLAIMER

The views and opinions expressed here are those of the author(s) alone and do not necessarily represent the policies of the U.S. Environmental Projection Agency.

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