www.ohiolumex.com

OHIO LUMEX

SCR Support Services

Tools to help model, manage, and optimize SCR performance

Ohio Lumex &
W.S. Hinton & Associates.

Joint Service Offering

OHIO LUMEX

your partners for environmental solutions

Who We Are

OHIO LUMEX provides environmental testing and support services. Our mission is to help our clients at every level – from plant technicians to corporate leadership – in their efforts to understand their emissions and to achieve and maintain environmental compliance while operating at optimal levels. We do this by assembling the leading experts in the field and applying their knowledge and experience to all of our customers' unique needs. Our support team includes individuals who have expertise in a wide range of fields including process & chemical engineering, pollution control technologies, environmental regulations, and environmental monitoring & analysis.

W. S. HINTON & ASSOCIATES is an engineering research and consulting firm specializing in environmental controls for commercial coal-fired boilers, as well as controls for other combustion processes and fuels. A wide variety of environmental controls are supported, especially those related to catalytic and adsorptive processes, and in particular SCR and mercury control. Each of our clients has specialized needs. We are committed to meeting these needs with practical, common sense approaches while minimizing costs and providing quality services. We understand that to meet this commitment we must have the right technical expertise. We maintain close working relationships with many other research and testing firms, as well as research consortiums — allowing us to assemble a project team that has the most qualified expertise to address your needs.

Joseph Siperstein, M.S. is the founder and President of Ohio Lumex. He has over 30 years of experience in applications related to industrial scale chemical processes and analytical instrumentation. For the past 15 years, Joseph has focused his attention on the power generation industry. In addition to working closely with the EPA to develop some of the flue gas measurement methods and techniques used today, his innovations in analytical instrumentation have provided much-needed solutions to the challenges facing coal-burning sources. Throughout Joseph's career and wide array of experiences in the field of chemical engineering, his philosophy has always remained to take the most practical approach to the task at hand. This common-sense strategy continues to produce real-world results for our customers and industry partners.

Andrew Mertz is the Lead Project Engineer at Ohio Lumex. He has been instrumental in the successful implementation of the company's innovative environmental monitoring technology and techniques. Andrew leads a team of Project Managers and Field Services Engineers and has been involved in over 100 projects including baseline operation studies, control technology evaluations, tuning/optimization of pollution control systems, and compliance monitoring. The variety and quantity of his experience over the last several years with different source conditions, control strategies, and control technology vendors is unrivaled in the industry.

W. Scott Hinton, Ph.D, P.E. leads W.S. Hinton & Associates and holds Ph.D. and B.S. degrees in Chemical Engineering from the University of Alabama. He is a registered Professional Engineer in the state of Florida, with more than 25 years of experience in air pollution control processes, especially Selective Catalytic Reduction (SCR) technology. Dr. Hinton's academic background focused on heterogeneous catalysis. He has applied that background to his career in air pollution control – examining advanced environmental control processes, flue-gas chemistry, flue-gas monitoring, and adsorptive processes. He has considerable experience in research project management. As a former employee of the Southern Company, Inc., he managed their DOE Clean Coal Technology Demonstration Project, examining the application of SCR to coal-fired boilers. This provided Dr. Hinton extensive experience related to flue gas monitoring, testing, and the application of SCR technology to flue gases in general. Subsequent work in numerous research areas has included mercury control options for coal-fired boilers, effects of chlorine and bromine on mercury oxidation and capture, scrubber performance including mercury control, SCR system design, maintenance, and optimization, SCR catalyst regeneration, cleaning, and disposal, ammonia adsorption on fly ash, gas-phase ammonia and sulfur trioxide reactions, advanced catalysts for NOx control, development of new gas monitoring techniques, desorption mechanisms of ammonia-contaminated fly ash and amelioration methods, and other projects related to environmental aspects of fossil-fuel energy.

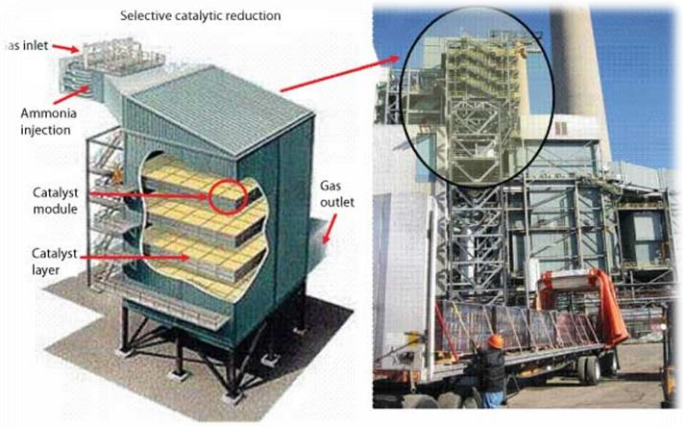
How We Can Help

Ohio Lumex and W.S. Hinton & Assoc. offer a joint service to help utilities manage and optimize SCR performance by using in-situ measurements to perform a direct and comprehensive assessment and characterization of the SCR. The initial benchmarking is incorporated into the latest modeling techniques to provide the tools necessary to effectively and holistically operate and manage the SCR. Additional benefits include the ability to predict the impacts of fuel and operational factors on $deNO_x$ and mercury oxidation as well as the effects of ammonia slip, HBr, and SO_3 on downstream equipment.

Direct In-Situ Measurements

Inlet, outlet, interlayer

- **Use of state of the art instrumentation and proprietary techniques to measure:**
  - **NH_3**
  - **Mercury Oxidation**
  - **SO_3**
  - **NOx**
  - **As**
  - **Se**
  - **Hydrogen Halides (HCl, HBr, etc.)**



SCR Management

- **Latest modeling techniques**
- **OEM, advanced, and regenerated catalysts**
- **Predictions of fuel and operational impacts on $deNO_x$ and Mercury Oxidation**
- **Effects of ammonia slip and SO_3 on downstream equipment**

Key Factors

- **Independent providers of technical expertise, testing, modeling, and consulting**
- **Joint effort between industry leaders in respective fields**
- **Fast, complete, direct assessment of SCR performance**
- **Use of state-of-the-art non-extractive measurement techniques**

Ohio Lumex Co.
30350 Bruce Industrial Pkwy
Solon, OH 44139
Tel: 440-264-2500
Fax: 440-264-2501
www.ohiolumex.com

Introduction

Our team offers independent support services designed to give SCR operators the tools and unbiased technical expertise to make optimal operational and management decisions concerning their SCRs. Ohio Lumex's unique testing capabilities in collaboration with W.S. Hinton & Associates' subject-matter expertise allows for field measurements to be combined with laboratory data and engineering assessments in a cost-effective manner to develop a comprehensive and realistic assessment of SCR performance. Merging this with our wide-ranging experience and knowledge of the best available technologies and relevant vendors adds a critical resource to our customers' SCR management strategy.

The process starts with the collection of available plant data and discussion to identify unique concerns and goals. This is followed by an initial direct field assessment (benchmark) that is then incorporated into the long-term SCR management program. Additional periodic field performance testing is recommended to fine tune the program and provide ongoing insight into the actual performance of the SCR. This holistic approach is completely independent of other equipment or service providers, ensuring that the utility receives the most cost-effective and technically optimal options available.

Benchmarking

Benchmarking centers around the benchmark test plan, a one-time initial performance characterization of the SCR. The test plan is designed to establish the baseline SCR performance for a number of parameters, including;

- DeNOx Performance (ammonia slip)
- SO_2 Conversion
- Mercury Oxidation

Each of the above performance characterizations utilize Ohio Lumex trap technology to establish the primary parameters of interest, such as ammonia slip level, SO_3 level, and speciated mercury, at various locations around the SCR. Complimentary unit operational data will be acquired using plant instrumentation to provide a complete performance picture of the SCR. Once a baseline has been established, various models may be utilized to predict performance as a function of catalyst aging, catalyst management events, changes in operational conditions, changes in fuels, etc.

The test plan involves ammonia, speciated mercury, and SO_3 testing at multiple locations to ensure that stratification does not adversely affect the test results. Simultaneous inlet/outlet measurements are performed for SO_3 and speciated mercury determinations. HCl/HBr measurements are also performed.

DeNOx Performance

Historically, SCR performance has been tracked by periodic field testing/tuning, with catalyst performance (measured primarily as catalyst activity) being measured in bench-scale laboratory test reactors using representative samples. Ultimately, the parameter of interest for an operating unit is the ammonia slip actually produced by the reactor, as a function of the deNOx set point and operating conditions. As such, catalyst activity measurements (from laboratory measurements) are used to infer/predict slip based on measured or assumed operating conditions (especially NH_3/NOx and flow distributions) using deNOx models. This approach has historically been taken due to the difficulty in directly measuring ammonia slip. However, using Ohio Lumex' ammonia measurement capabilities, the entire approach can be changed. In other words, ammonia slip, the primary parameter of interest, can be measured DIRECTLY. This approach provides a much more direct and comprehensive evaluation of the SCR performance. The approach also allows for a near real-time performance assessment, where current bench scale catalyst testing has significant delay, resulting in valuable planning time being lost. This immediate feedback helps to avoid significant costs associated with poor SCR performance.

With our field testing capabilities, DeNOx performance for the unit is determined by directly measuring the ammonia slip using Ohio Lumex trap technology and instrumentation. This data is complemented by unit operational data, including NOx levels around the SCR. These data are then evaluated to develop a performance assessment of the SCR's deNOx capability. If available, this information can be compared with laboratory deNOx activity information to further assess the condition and performance of the SCR. Stratification of ammonia slip is a major consideration for testing. As a result, multiple locations are required for

ammonia slip determinations, and the locations are carefully selected to provide the most representative evaluation possible. Known reactor fouling characteristics are taken into account when selecting testing locations, and prior tuning information, etc. may be referenced, when available. Using the available information, proprietary deNOx models can be utilized to support catalyst management, reactor tuning, and the determination of effects of operational changes, etc. to assist the utility in ensuring that NOx emissions targets are met in the most efficient and cost-effective manner. In addition, the information can be utilized to evaluate the impact of the unit's ammonia slip performance on downstream equipment, such as the air preheater, ESP, baghouse, etc.

SO_2 Conversion Performance

Another primary catalyst performance parameter of interest is SO_2 conversion. Coal-fired units will limit catalyst SO_2 conversion to some maximum based on fuel, equipment design, and operating conditions. Historically, field SO_2 conversion has been assessed by measuring SO_3 levels around the reactor using the controlled-condensation procedure. This field measurement is difficult and in many cases provides inconclusive results. As a result, utilities often rely on bench-scale SO_2 conversion testing as the bench-mark for determining field SO_2 conversion. Obviously, this is an indirect approach to determining the actual field performance. A simplified measurement for SO_3 (i.e. Ohio Lumex trap technology) provides much greater ease in field testing and gives more confidence in determining the actual field performance. In addition, this alleviates the delay associated with bench-scale testing, as discussed above.

The field determination of reactor SO_2 conversion must be evaluated using simultaneous reactor inlet and outlet SO_3 determinations using Ohio Lumex trap technology. Testing locations are carefully selected, and multiple locations may be tested depending on the overall test plan and project goals. As with the deNOx evaluation, laboratory determinations of SO_2 conversion may be utilized for comparison purposes to develop a more complete assessment of SO_2 conversion performance. Note that single-layer performance can be evaluated if this information is critical, such as for guarantee purposes, etc. Using proprietary SO_2 conversion models, SO_2 conversion can be predicted for other operating conditions, especially as a function of catalyst aging, fouling, etc. In addition, the effects of SO_3 on downstream equipment can be evaluated.

Mercury Oxidation Performance

The ability of SCR catalysts to oxidize mercury is increasingly important to the coal-fired utility industry. Virtually all units benefit from SCR mercury oxidation, even if the SCR is not a principal part of the overall mercury control strategy. For units relying solely on co-benefits, SCR mercury oxidation is paramount to the control strategy and catalyst may be managed principally for mercury oxidation, with deNOx conversion being a secondary consideration. From an operational standpoint, predicting mercury oxidation as a function of operating conditions (fuel, load, temperature, etc.) is critical. From a catalyst management standpoint, current modeling efforts utilize deNOx activity as an indicator of mercury oxidation activity, from which mercury oxidation behavior can be predicted. Halogen levels are also extremely important, and the benchmark mercury oxidation measurement requires a simultaneous measurement of flue gas chlorine (bromine may also be required if bromine injection is utilized). The use of Ohio Lumex halogen traps, in conjunction with speciated mercury measurements and unit operational data, would provide all of the information necessary to benchmark the unit.

Mercury oxidation performance for the reactor is determined by the simultaneous measurement of the SCR inlet and outlet mercury speciation using Ohio Lumex mercury speciation traps. From these data, the mercury oxidation rate for the reactor can be determined. Proprietary models can then be utilized to predict mercury oxidation for the reactor as a function of catalyst aging, fouling, and catalyst management events. In addition, the data can be used to determine the expected mercury oxidation rate for other operating conditions, including load changes, and fuel changes/variability. If desired, the effects of bromine or chlorine supplementation can be evaluated.

Catalyst Management

The catalyst management services are based on several sources of input information; including laboratory bench-reactor activity and SO_2 conversion assessments, field data acquired by Ohio Lumex, long-term continuous operational data acquired using the unit's process instrumentation, and reactor field inspection reports. Long-term catalyst management scenarios can then be developed based upon required unit deNOx, slip limitations, expected unit capacity factor, etc. Proprietary deNOx models allow for the various operational scenarios to be examined ensuring that long-term deNOx requirements are met with minimum adverse impacts on downstream equipment, and at a minimum economic impact. The use of regenerated catalysts, as well as the use of different catalyst formulations and catalyst suppliers can be investigated.

Catalyst management may also include evaluations of mercury oxidation in tandem with the deNOx evaluations. Management scenarios can be developed which will ensure a minimum level of mercury oxidation, and this minimum may control the overall management plan, as required by the utility. No special laboratory testing is required for the mercury oxidation evaluations, since robust models are utilized to predict mercury oxidation as a function of catalyst deactivation for deNOx. These predictions vary as a function of the exact operating conditions, and various management scenarios can be evaluated based on predicted future operational conditions, including changes in fuels, etc.

SCR Management

SCR management includes evaluations of the effects of fouling, maldistributions in flow, NOx, temperature, and NH_3, soot blowing methods and procedures, etc. All of these factors affect the operational status of the SCR and are important considerations for effective management of the SCR over the long-term. These factors must be evaluated in tandem with catalyst management, described above, to effectively manage the SCR holistically. This global management approach ensures that the SCR operates in the most cost-effective and technically efficient manner possible.

In particular, robust models for deNOx, SO_2 conversion, and mercury oxidation will be utilized to evaluate the impact of various operating scenarios. The effects of load changes, fuel changes, catalyst deactivation, catalyst additions or exchanges, halogen injection, etc. can all be investigated in detail.

Long-Term Performance Confirmations

Periodic performance confirmations will be performed using field testing to ensure that the SCR is performing as predicted, and to fine-tune the models to more accurately predict SCR performance. These periodic field tests provide a much-needed link between theoretical performance (based on laboratory measurements, for instance), and the actual performance of the SCR in the field. Ohio Lumex' unique testing technology makes this approach much more cost-effectively than has historically been the case.

Additional Available Services

- Field measurements throughout the plant (stack, FGD, etc.)
- Continuous mercury monitoring with portable CEMs
- AIG Tuning
- Onsite or laboratory analysis of coal, ash, FGD slurry, and effluent (Se, As, Hg, etc.)
- Consulting services based on holistic approach to plant operations

Ohio Lumex Co.
30350 Bruce Industrial Pkwy
Solon, OH 44139
Tel: 440-264-2500
Fax: 440-264-2501
www.ohiolumex.com