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Project Summary

Lime/Limestone Flue Gas Desulfurization Inspection and Performance Evaluation Manual

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This manual on wet nonregenerable lime/limestone flue gas desulfurization (FGD) systems is intended to guide Federal and State regulatory personnel concerned with the inspection and permitting of FGD systems for coal-fired steam electric generators in the U.S. The manual is structured as a "working document" for someone who periodically inspects power plants to ensure compliance with emission standards. Orientation material in the manual on the design, operating, and performance characteristics of FGD systems may also be useful to the environmental regulatory agency permitter. With its goal of facilitating the systematic inspection of an FGD system to determine the system's present and probable future compliance status, the manual limits process theory to a necessary minimum and makes ample use of charts, checklists, and simplified diagrams in providing important guidelines and recommendations.

Following the introductory section defining its purpose, approach, and scope, the manual contains sections on lime/limestone technology, performance monitoring, inspection methods and procedures, performance evaluation and problem diagnosis/correction, operation and maintenance, and safety. Appendices provide supplementary reference material, definitions of FGD terms, calculation sheets, and example checklists, the latter two for use by someone inspecting a plant.

This Project Summary was developed by EPA's Air and Energy Engineering Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Purpose

The purpose of the manual is to guide Federal and State environmental regulatory personnel involved in the inspection and permitting of flue gas desulfurization (FGD) systems for electric utility coal-fired steam generators (boilers) in the U.S.

The primary intended audience of the manual is the field inspector directly involved in the inspection of operational, FGD-equipped, coal-fired, utility boilers. For the purposes of the manual, the field inspector is defined as the individual who periodically inspects power plants to ensure compliance with emission standards. The scope of the inspector's responsibility ranges from confirmation of existing status reports to anticipation of future compliance status (i.e., avoidance of potential noncompliance episodes).

A secondary intended audience of the manual is the environmental regulatory agency permitter, the individual who reviews permit applications for new capacity in accordance with adherence to environmental regulations and emission standards. Although the permitter is not specifically "targeted" in the manual, pertinent orientation material is presented on the design, operating, and performance characteristics of FGD systems.

Approach

The philosophy adopted for the preparation of this manual is unique in comparison to other FGD technology manuals.

As stated above, the intended audience is environmental regulatory personnel. Other similar manuals generally define their intended audience as the owner/operator utility, architect-engineer, research firm, and/or technology investigator. This manual, for the first time, addresses solely the needs of environmental regulatory agency personnel.

Another unique feature of the manual is its intended use. The manual is structured as a "tool," or working document, which will accompany the inspector on each plant inspection. This contrasts to the use of other similar manuals which are often read and then filed away for possible future reference. To adequately serve as a working document, two major objectives must be met in the organization of the material. First, the document must provide practical information tailored to its intended use; e.g., the systematic inspection of an FGD system to determine present and future compliance status. This requires that information on process theory be limited to a necessary minimum. Secondly, the information must be presented in a "user-friendly" format to encourage its use. This is accomplished by nomographs, checklists, matrices, simplified diagrams, cross-referencing and indexing of textual information, and presenting important guidelines and recommendations in a conspicuous fashion.

A final unique feature of the manual is its use for the interpretation of sulfur dioxide (SO_2) excess emission reports. If an FGD-equipped boiler is a source of frequent SO_2 excess emission reporting, the manual will provide guidelines to determine the cause and to evaluate the remedial actions taken by the plant operator. If an FGD-equipped boiler is a source of infrequent SO_2 excess emission reporting, the manual will provide guidelines to identify the contributing factors that are associated with this situation.

Scope and Content

FGD systems are generally the last pieces of equipment to handle the boiler flue gas before it reaches the stack. In lime/limestone slurry processes, SO_2 in the flue gas stream is removed with the aid of dilute limestone or lime slurries. The treated flue gas is cooled and saturated with moisture in the process. A thorough description of the processes is presented in Section 2 of the manual.

The FGD technology addressed in this manual is limited to tail-end, "wet" lime/limestone slurry processes, excluding:

- all tail-end processes that do not use calcium-based (lime/limestone) additives as the SO_2 reactant (e.g., sodium/calcium [dual or double alkali]), sodium/thermal regeneration [Wellman-Lord], magnesium oxide [Mag-Ox], and sodium [once-through soda ash, sodium hydroxide, trona, nahcolite]).
- all tail-end processes that do not completely saturate the flue gas during treatment, known as "dry scrubbing" (spray drying, dry sorbent injection).
- precombustion and in-situ (combustion) SO_2 control techniques which may involve the use of calcium alkali additives (e.g., limestone injection multistage burner [LIMB], lime furnace injection).

The rationale for emphasizing lime/limestone slurry processes is based on their widespread use in the power industry due to their level of process development and economics. Since the early application of FGD to control SO_2 emissions from boiler flue gas, there has been pronounced preference for lime/limestone slurry processes. Presently, plants equipped with FGD systems using lime or limestone slurry represent over 80 percent of the electric generating capacity with emissions controlled by FGD. A perspective of the historical and projected future application of lime/limestone slurry processes is illustrated in Figure 1 which shows the installed capacity controlled by lime/limestone

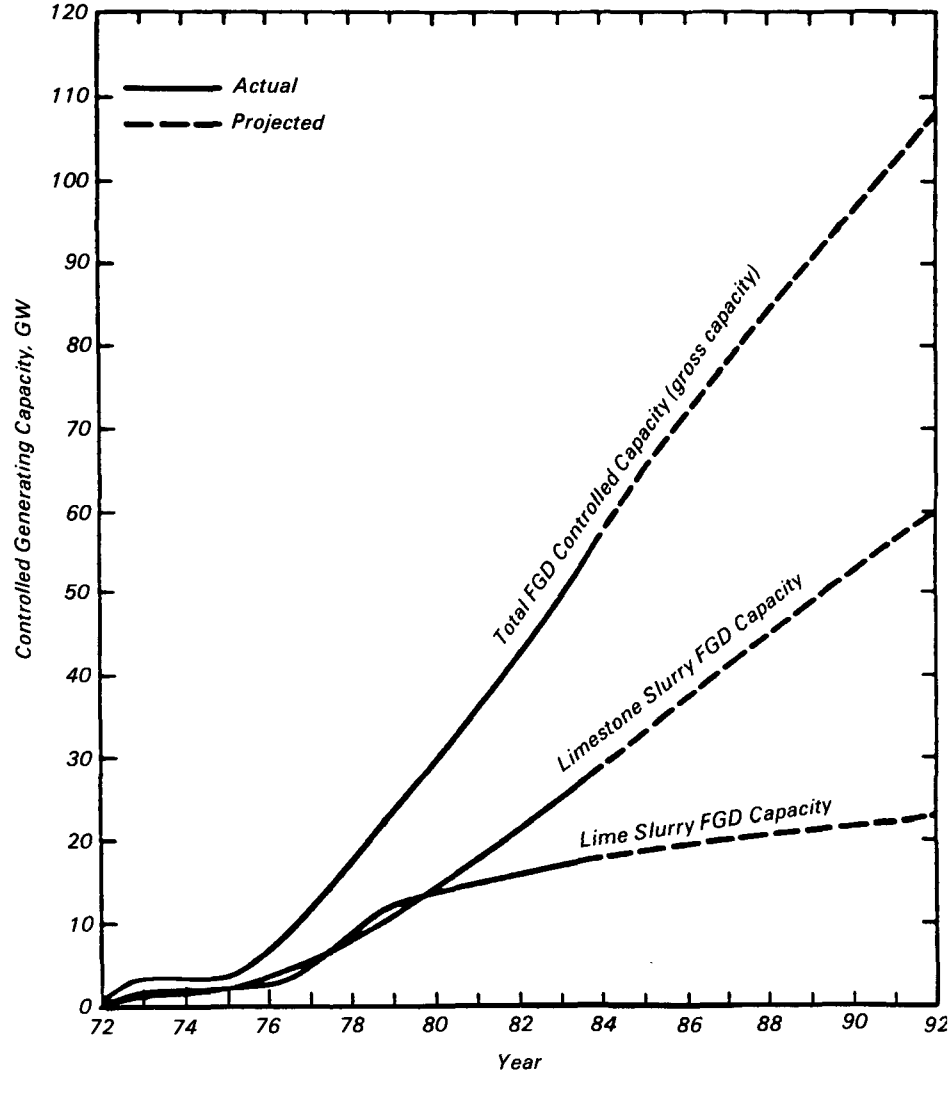

Figure 1. Lime/limestone FGD capacity and total FGD-controlled capacity through 1992 (totals reflect end-of-year values).

slurry processes as a function of the capacity controlled by all processes.

Detailed cost studies indicate that both the capital and the annual costs are *generally* less than those of other FGD processes. Additionally, the on-line experience of commercial systems at utility plants has generated a wealth of operational data which are being used to enhance system reliability. Advances in waste disposal technology (e.g., forced oxidation to produce more easily dewatered calcium sulfate) have enabled utility operators to reduce the volume of waste for disposal as well as improving its handling and disposal properties. Advances in process chemistry (e.g., magnesium salts and organic acid additives) have enabled operators to improve performance with respect to SO_2 removal, process chemistry, service time, and cost effectiveness. With continuing technological advances and increasingly wider utilization, lime/limestone slurry processes are considered the major means of compliance with New Source Performance Standards promulgated by the USEPA for control of SO_2 emissions from power plants.

The scope of the manual is the complete battery limits of the entire FGD process, from the inlet gas stream to the final waste disposal site. All operations in between are examined, including: gas handling and treatment, reagent preparation and feed, and waste solids handling and disposal. Moreover, operations and factors that influence the FGD process envelope are considered, including: coal characteristics and consumption, boiler design and operation, and particulate emissions control and operation.

Organization of the Manual

The manual is structured to be a constant companion to the environmental regulatory agency inspector of FGD-equipped, coal-fired, utility boilers. Section 1 follows the format of this Summary.

Section 2, Lime/Limestone FGD Technology, discusses: (1) pertinent environmental regulations; (2) coal properties and flue gas characteristics; (3) basic principles of lime/limestone slurry processes; (4) design configurations; and (5) operation and maintenance (O&M) considerations.

Section 3, Performance Monitoring, discusses a major element in the O&M activities of every lime/limestone slurry FGD system. Monitoring the FGD system is required to demonstrate compliance with applicable standards and that the system meets the vendor performance guarantees. Additionally, routine monitoring can identify potential operating problems before they significantly impact the performance of the system and/or the generating unit. This section is devoted to lime/limestone slurry FGD system performance indicators and their measurement. Addressed in this section are the instrumentation systems that measure process parameters, manual testing and continuous emission monitoring methods used for emission measurements, and recordkeeping practices of the operator utility. This information is presented from the perspective of the agency inspector; e.g., what monitoring techniques will yield what kinds of data, how are these data recorded and logged, and how to interpret these data in terms of SO_2 compliance status.

Section 4, Inspection Methods and Procedures, gives detailed procedures and guidelines for the inspection of lime/limestone slurry FGD systems. The objective of this section is to assist the agency inspector in examining the FGD system, looking first for telltale signs that might suggest misrepresentations of emissions such as faulty monitors or leakage in or out of ducts, and looking secondly for factors in addition to SO_2 removal efficiency that suggest poor reliability of the FGD system. If excess emissions are reported, this section guides the inspector in collecting information for the determination of causes for the problem and the assessment of remedial action(s) taken by the utility. When no excess emissions are reported, suggested procedures allow the inspector to assess the preventive actions taken by the utility. It is important that the inspector make specific observations and record pertinent data in order to make intelligent decisions for resolving compliance problems or processing variance requests.

The information in this section is presented in a practical fashion that facilitates comprehension by regional/state agency personnel; theoretical principles underlying the inspection procedures are not discussed.

The section begins with a brief discussion of inspection procedures for the overall plant, followed by detailed inspection procedures addressed by equipment area and equipment items in the order presented in Section 2. Inspection procedures for each equipment item include an inspection checklist, an illustration (where applicable) showing the relative sizes of the associated components, and brief supporting text. Performance parameters addressed in the equipment inspection checklists are classified under three categories (observation, process, and operation and maintenance) to facilitate the interpretation and evaluation of data obtained during inspections. The various checklists presented in this section are compiled in Appendix C.

Section 5, Performance Evaluation and Problem Diagnosis/Correction, describes guidelines that can be used by the field inspector to interpret FGD system performance data with respect to present and future compliance status. The guidelines presented are "independent" in that they are designed to assist the field inspector irrespective of performance interpretation or "biasing" by the plant operator. The guidelines are designed to be used in both immediate and long-term performance evaluations. The latter consideration is important in that an FGD system may yield performance data indicating compliance at the time of the inspection; however, process data may indicate the existence of problems which will jeopardize future compliance status.

This section is a continuation of Section 3 (which describes lime/limestone slurry FGD performance indicators and their measurement) and Section 4 (which describes lime/limestone slurry FGD inspection methods and procedures). In this section the sources of data available to the field inspector are described, as well as the "form" these sources take. Techniques are described that are available to aid the field inspector in performance evaluation. Cause-and-effect problem relationships and corrective measures are identified using simplified sequence diagrams. Finally, followup procedures are presented that can verify the success of the corrective measures taken.

As in Section 4, the information presented in this section is organized in accordance with the equipment areas and subsystems identified in Section 2.

Section 6, Model O&M Plan, highlights a model O&M plan for lime/limestone slurry FGD systems. This section introduces the field inspector to the elements of an "idealized" O&M plan which the field inspector can use as a benchmark from which to evaluate (compare) actual FGD systems. "Idealized," in this context, refers to practices that are determined to be "preferable" based upon their successful application in specific systems throughout the industry.

This section is a continuation of the material introduced in Sections 2 and 5. It addresses the operator utility's manage-

ment and staff at both the corporate and plant levels. Operating and maintenance manuals are described, complete with suggested outlines. Troubleshooting techniques are described in terms of an organized multiphase program. Necessary spare parts are described for inventories of shelf spares. The work order system is described in terms of its importance for monitoring O&M response. Computerized tracking is discussed as a necessary function to store, retrieve, and analyze the current and projected status of FGD performance.

Section 7, Safety, discusses the safety of agency personnel during field inspections. The field inspector should take adequate precautions to guard against: (1) inhalation of toxic gases; (2) skin irritation and/or chemical burns; and (3) exposure to fugitive dust. In addition, normal industrial safety practices should be followed such as attention to electrical power lines and connections, attention to steam lines and connections, attention to rotating equipment, and protection against falling objects. During an FGD inspection, many of these concerns are simultaneous and can result in potentially serious injuries to the inspection personnel. Familiarization with safety procedures and use of safety equipment can result in inspections being performed safely without risk of injury.

This section discusses many of the potential hazards and addresses proper safety procedures. Further information concerning safety precautions/considerations can be found in specific vendor equipment O&M manuals for the FGD systems and subsystems, Occupational Safety and Health Administration (OSHA) publications, and National Institute for Occupational Safety and Health (NIOSH) publications.

The appendices consist of supplementary reference material: definitions of FGD terminology (Appendix A), calculation sheets (Appendix B), and example checklists (Appendix C) which will be used by the inspector during a plant inspection. The inspector may wish to reproduce and make several copies of the checklists and keep them separate for the purpose of conducting an inspection. The more experienced inspector may be able to tour the facility without carrying the manual.

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The complete report, entitled "Lime/Limestone Flue Gas Desulfurization Inspection and Performance Evaluation Manual," (Order No. PB 86-107 398/AS; Cost: $28.95, subject to change) will be available only from:

National Technical Information Service
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