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Topics:
Biological fouling
Biofouling control
Condensers—performance
Cooling systems—reliability
Power plants—condensers
Meetings

EPRI CS-4399
Project 2300-2
Proceedings
January 1986

Proceedings: Condenser Biofouling Control R&D Workshop

Prepared by
Stone & Webster Engineering Corporation
Boston, Massachusetts

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CS-4399
Research Project 2300-2

Proceedings, January 1986

Lake Buena Vista, Florida
June 21, 1985

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Prepared by
Stone & Webster Engineering Corporation
Boston, Massachusetts

REPORT SUMMARY

SUBJECTS: Water quality control / Steam turbines and related auxiliaries / Major components

TOPICS:
- Biological fouling
- Biofouling control
- Condensers—performance
- Cooling systems—reliability
- Power plants—condensers
- Meetings

AUDIENCE: Environmental managers, engineers, and scientists / Generation managers and engineers

Proceedings: Condenser Biofouling Control R&D Workshop

Condenser biofouling can have a tremendous effect on the cost of electricity generation from conventional steam-electric plants. This workshop contributed valuable input to EPRI's R&D planning for improving condenser performance and reliability by identifying three critical research areas.

BACKGROUND: Biofouling is a major cause of reduced condenser heat transfer, leading to diminished plant performance and availability. With regulatory constraints imposed on the use of chlorine, utilities are seeking new ways to maintain clean condensers, including developing new technologies for using chlorine more effectively, using other chemicals, and applying mechanical control methods. However, inadequate documentation, limited applications, and insufficient performance data have precluded consideration of these alternatives.

OBJECTIVES:
- To discuss electric utility experiences and practices of various biofouling control technologies and to explore new, innovative technological improvements.
- To identify industry research needs and define specific recommendations for new EPRI R&D projects.

APPROACH: Following the EPRI Condenser Biofouling Control Symposium in June 1985, 31 people representing EPRI member utilities, contractors, and consultants gathered to discuss biofouling control technologies. They formed four work groups aimed at addressing the following technological areas: monitoring techniques and chemical, mechanical, and alternative controls. These topics corresponded with those discussed at the symposium. The workshop concluded with a joint session to discuss individual group R&D recommendations and priorities and to develop an overall consensus on future research needs.

KEY POINTS: The proceedings summarize the workshop discussions, presenting the important issues related to controlling condenser biofouling in U.S. electric utilities. The participants suggested about 60 individual research projects for future R&D, ranking them according to industry importance, cost-benefits,

and timing of the research products' availability. During the workshop they pinpointed three themes as critical issues: (1) the capability on the part of industry to detect and measure biofouling in condensers, (2) a knowledge of the capabilities, limitations, and performance of various control alternatives, and (3) a decision methodology for evaluating these alternatives.

EPRI PERSPECTIVE

Part of an ongoing EPRI research program on condenser biofouling control, this workshop was designed to complement the preceding symposium. Thus the symposium proceedings (EPRI report CS-4339) serve as an important companion to this report. The information in these workshop proceedings will help utility researchers, environmental scientists, consultants, and academic institutions focus on the present and future R&D needs of the electric utility industry. Another phase of this ongoing program is to develop innovative methods for utilities to continue the use of chlorine for biofouling control.

The ultimate goal of EPRI's overall research program on biofouling control is to define the capabilities and limitations of current techniques to monitor and control biological growth in plant cooling systems; to develop new, low-cost condenser cleaning approaches; and to produce guidelines for evaluating and selecting the optimal treatment strategies to ensure condenser cleanliness, thus maximizing performance.The R&D recommendations from this workshop will be incorporated in EPRI's program-planning activities for future project development.

PROJECT

RP2300-2
EPRI Project Manager: Winston Chow
Coal Combustion Systems Division
Contractor: Stone & Webster Engineering Corporation

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ABSTRACT

Condenser biofouling is a major source of problems causing poor power plant availability and efficiency. An R&D workshop on condenser biofouling control technologies was sponsored by the Electric Power Research Institute (EPRI) on June 21, 1985, in Lake Buena Vista, Florida which followed EPRI's Condenser Biofouling Control Symposium. The workshop was attended by 31 engineers and scientists representing EPRI-member utilities and EPRI consultants.

This workshop provided a forum to discuss utilities' needs and identify Research & Development activities for the utility industry. Suggested R&D elements were ranked and described in detail.

The workshop was divided into the following sessions for topical discussions: monitoring techniques, chemical controls, mechanical controls, and alternate controls. A joint wrap-up session which included all workshop attendees allowed consensus agreement on the type, scope, and priorities of recommended future R&D activities.

This report documents the proceedings of the workshop and contains summaries of topics discussed and research and development recommendations.

PREFACE

On June 21, 1985, EPRI sponsored an R&D planning workshop on condenser biofouling control technologies. The workshop provided a forum to discuss utilities' needs and explore future Research & Development programs for the electric utility industry.

There were 31 individuals in attendance at the workshop. These participants were engineers and scientists representing EPRI-member utilities and EPRI consultants. This document contains the proceedings of the workshop which present summaries of the numerous topics discussed and the Research & Development activities recommended by the participants.

To help focus on specific technical issues, facilitate exchange of ideas, and encourage active discussions, the workshop was divided into five sessions. They covered Monitoring Techniques, Chemical Controls, Mechanical Controls, Alternate Controls, and finally a joint wrap-up session.

It is our intention that this document will further intimate industry's experiences in the control of condenser biofouling and transfer practical knowledge to those who operate and maintain steam surface condensers. Moreover, the R&D recommendations identified at this workshop are intended to direct utility researchers, scientists, and R&D institutions towards priority needs of the electric utility industry. In all, some 60 different R&D suggestions were developed. They, when coordinated with current program elements and needs, will form the basis for guiding future EPRI research.

Winston Chow, Project Manager
Coal Combustion Systems Division

ACKNOWLEDGMENTS

The success of this workshop on condenser biofouling control could not have been accomplished without the interest and cooperation of the utilities, organizations, and individuals listed below. The Electric Power Research Institute (EPRI) and Stone & Webster Engineering Corporation (SWEC) wish to acknowledge the excellent cooperation afforded us throughout the industry.

For their generous contribution of time and valuable comments during session meetings or in review of the report, we are especially grateful to the following individuals and organizations:

MONITORING TECHNIQUES SESSION

John Garey - Moderator	Marine Biocontrol Corporation
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Section 1

INTRODUCTION

Fouling of steam surface condensers is a major source of poor power plant availability and efficiency.

Microbiological fouling represents 70 percent of those power plant units which experienced biofouling of one form or another (1). Sixty percent of the biofouling problems are detected in the condenser tubes themselves. Microbiological fouling results in corrosion, erosion and pitting, and in loss of condenser heat transfer performance. The penalties and costs associated with impaired condenser operations are substantial. They include increased fuel consumption, replacement power costs, condenser cleaning costs, and loss of availability. Typically, an increase in back pressure of 0.7 in. at a 600 MW(e) coal-fired plant can cost $500,000 annually and, for a 1150 MW(e) nuclear plant, about $2.0 million (1).

On June 21, 1985, the Electric Power Research Institute (EPRI) sponsored a workshop on condenser biofouling control technologies following their Condenser Biofouling Control Symposium.

WORKSHOP OBJECTIVES

The workshop was designed to address the following objectives:

- To discuss electric utility experiences and practices of various technologies and to explore new and innovative technological improvements
- To identify industry research needs to effectively control biofouling and improve condenser availability and performance
- To define specific recommendations for proposed EPRI Research and Development Projects

WORKSHOP SESSIONS

The workshop was organized into sessions that covered the following categories:

- Monitoring Techniques
- Chemical Controls

- Mechanical Controls
- Alternate Controls
- And a Joint Wrap-up session that incorporated all session discussions

Monitoring Techniques

This workshop session explored performance monitoring, early detection monitoring, corrosion monitoring, and the need for better interpretation of monitoring results. Potential Research Projects were also discussed.

Greater detail of this workshop can be found in Section 2.

Chemical Controls

This workshop session discussed problem elements of chemical controls, targeted chlorination, targeted ozonation, chlorine minimization, manganese dioxide control, biofilm formation/destruction modeling, analytical measurement techniques, toxicity testing, and subsystem biofouling control. Potential Research Projects were also discussed.

Greater detail of this workshop can be found in Section 3.

Mechanical Controls

This workshop session discussed the need for a more coordinated industry effort to effectively disseminate technical information on condenser cleaning systems and performance. Mechanical controls that were discussed were sponge ball cleaning, cleaning with suspended solids, side effects of mechanical cleaning, tube velocity optimization, and tube materials. Potential Research Projects were also discussed.

Greater detail of this workshop can be found in Section 4.

Alternate Controls

This workshop session discussed recent utilities' experiences with various new chemical and mechanical treatments and design considerations that are not covered by the established chemical and mechanical control methods. Also discussed was the need for a portable national test facility to assist in solving problems in condenser related work (particularly cooling water). Potential Research Projects were also discussed.

Greater detail of this workshop can be found in Section 5.

Joint Wrap-up Session

This workshop session was held after the four individual workshops were completed to summarize topics discussed and present proposed Research and Development Projects to the entire group.

Greater detail of this workshop can be found in Section 6.

References

1. Winston Chow, "Condenser Biofouling Control: The State of the Art," Proceedings of the Condenser Biofouling Control Symposium, Lake Buena Vista, FL, June 18-20, 1985.

Section 2

MONITORING TECHNIQUES

WORKSHOP DISCUSSION

During the workshop session on monitoring techniques, discussions took place that explored performance monitoring, early detection monitoring, corrosion monitoring, and the need for better interpretation of the results of monitoring. Research projects were proposed to improve thermal performance monitoring techniques and problem diagnosis and to determine the severity of microbiologically induced corrosion (MIC) and the merit of early detection monitoring.

The discussion began with consideration of the best techniques to be used for monitoring condenser fouling. Three basic techniques were proposed: simple fouling detection, thermal performance monitoring, and side stream monitoring.

SIMPLE FOULING DETECTION

The first technique involves a simple fouling detector which would indicate whether fouling was present or not. This could be as simple as a piece of transparent tubing which could be visually examined to determine whether any fouling was present at all. Its main advantages were stated to be its propensity for early detection of fouling and its simplicity. The main disadvantage stated was that quantifying the effect of fouling on heat transfer efficiency and on plant heat rate was essential before serious corrective action would be undertaken.

THERMAL PERFORMANCE MONITORING

The second technique involves thermal performance monitoring in the main condenser. The main advantages were stated to be that results would be more credible and directly applicable if they were obtained on the main condenser, and that only additional instrumentation would be needed, rather than separate devices such as external fouling monitors or side stream condensers. The main disadvantage stated was the difficulty of making outlet temperature and flow measurements. Determining cooling outlet temperature is difficult because of the high accuracy required in conjunction with the irregular temperature distribution frequently experienced.

Flow measurement is difficult due to the large diameter pipes present and the poor piping arrangements which prevent development of uniform flow patterns. Dye techniques and ultrasonic techniques were mentioned as possible improvements.

The participants indicated that there was no consensus on which parameters should be measured and calculated. It would be desirable to monitor parameters that reduced the effects of load and other externally imposed variables. It would also be desirable to monitor parameters that would segregate effects such as air removal problems from tube fouling.

It was proposed that research be undertaken to determine the best parameters to monitor and the measurements to be made in order to monitor them. It was further proposed that research be undertaken into the best measurement apparatus to be installed on condensers. It was stated that the problem involved more than the selection of instruments, but included the proper location, arrangement, and installation.

SIDE-STREAM MONITORING

The third technique involves side stream monitoring. The main advantage stated for side stream monitoring is the ability to test cleaning techniques, different tube materials, etc., in a controlled environment, with great testing flexibility, that is reasonably representative of the actual condenser and of site specific conditions. The main disadvantages were cost, space requirements in some plants, and acceptance by station personnel. The consensus of opinion was that side stream devices were useful in testing new cleaning programs, but that instrumenting the main condenser would be preferable for routine monitoring.

There was agreement that information should be developed as to determining the correlation of side-stream units to operating units, and further as to the use of side-stream units together with improved condenser performance monitoring to provide a prediction capability in isolating condenser performance problems.

CONDENSER FOULING DIAGNOSTICS

Concern was expressed about the lack of systematic information correlating the visual appearance of condenser tubes with the fouling and corrosion mechanisms taking place. It was pointed out that boiler tube manufacturers have published manuals with color photographs of typical tube deposits and corrosion. The