BEST PRACTICES: THE ENGINEERING APPROACH FOR INDUSTRIAL BOILERS

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Presented at the Twenty-Third National Industrial Energy Technology Conference, Houston, Texas, May 1-4, 2001

ABSTRACT

A plant's boilers represent a large capital investment, as well as a crucial portion of overall plant operations, regardless of the industry our customers are in. It is important to have systems and procedures in place to protect this investment, as well as plant profitability. Boiler Best Practices represent The Engineering Approach for Boilers—a way to examine mechanical, operational and chemical aspects of the systems (pretreatment through condensate) to ensure reliable boiler operations with no surprises.

INTRODUCTION

All industrial plants have boilers of one type or another, often more than one type. Whether the plant in question has one small boiler, or many large ones, the boilers are an essential element of every plant, regardless of plant size or of product produced. With skyrocketing fuel and energy costs, maintaining both boiler reliability and consistent system performance while minimizing energy costs can be a challenge and an opportunity for any utility operation. The Engineering Approach provides a framework to examine all aspects of Boiler Best Practices to optimize system performance, and Total Cost of Operations.

Implementing the Engineering Approach assists in gathering information to measure and track progress, to initiate further improvements, and to allow benchmarking and norming of systems across corporations, within industries, and so forth.

There are several steps in the effective implementation of the Engineering Approach, or Best Practices for Boilers. This paper will discuss the philosophy of the Engineering Approach, as well as examples of its implementation, and the benefits received from it both in terms of system operation, and in terms of Total Cost of Operations.

WHAT IS THE ENGINEERING APPROACH?

The Engineering Approach represents the formalization of ONDEO Nalco's approach to serving our customers. It is fundamentally a customer-centric method of doing business that permits the management of knowledge of the customer's water system, and knowledge of the impact that water systems can have on process operations, environmental performance, and overall costs. This engineering knowledge is used to significantly build value for the customer.

The fundamental elements of the Engineering Approach are Mechanical (M), Operational (O) and Chemical (C) considerations. This provides a system that

- is independent of personnel movement to new assignments (customer or consultant)
- focuses on results
- is proactive in the prevention of problems
- identifies opportunities to reduce total cost of operation (TCO) for the plant

The Engineering Approach represents best practices for boilers in that it provides a benchmark for continuous improvement of our customers' systems. With the Engineering Approach we provide recommendations for optimizing Total Cost of Operations (TOC) by considering <u>all</u> relevant factors.

WHY IMPLEMENT THE ENGINEERING APPROACH?

Individual plant management is increasingly being asked by their corporate offices to consider financial results, TCO, quality, environmental health and safety, and manpower effectiveness. The order of importance may have changed over the past few years, and may be different from industry to industry, but all plants are focussing more and more on the environment, safety, budgets, and performance.

Water treatment can have an impact on all areas of a utility budget. Actual water treatment costs, however, usually only represent 2-3% of overall costs, as seen in Figure 1. Although water treatment chemicals represent a small portion of the utility budget, they have a major impact on all areas of a utility budget. Water touches most if not all of the key process units, and can have a major impact on production rates, maintenance costs, and overall plant profitability.

Unexpected boiler outages will limit, or even stop, production. Poorly run boiler systems will be very energy inefficient, and may even result in environmental problems with emissions.

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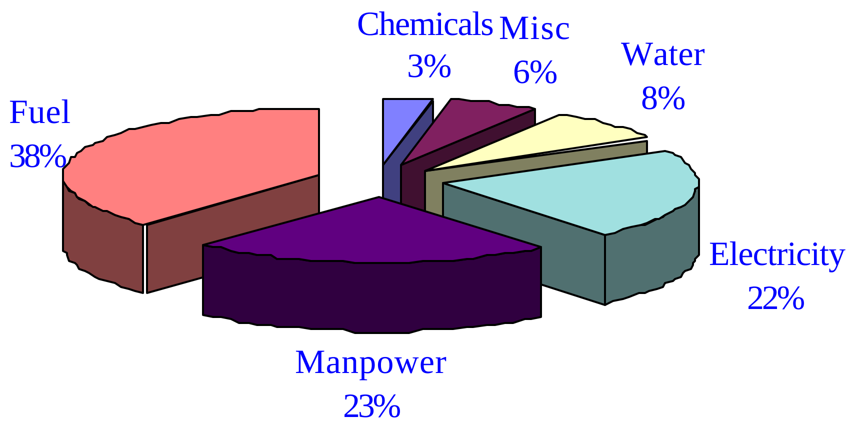

Figure 1. Typical Cost Distribution in the Utility Area

Additionally, running ineffectively may actually shorten boiler life, or at a minimum increase maintenance costs. In any case, plant profitability suffers, and both short- and long-term viability may be brought into question.

All is not lost, however! ONDEO Nalco's strategy is to become part of the solution, the Total Cost Reduction Solution, partnering with our customers to become a generator of profit and a reducer of total costs. Best Practices, the Engineering Approach, provide the means as well as the tools to bring this about.

Having an in-depth understanding of the mechanical components of the water systems, and specifically the boilers, provides a good starting point. The mechanical survey is then followed by statistical analysis of operational control capability, so that we have a statistical understanding of the actual control capability of the system. Finally, having a thorough understanding of the real stresses on the water chemistry of the system completes the picture.

Completing surveys of the plant, and specifically of the boiler operations, with the MOC approach often leads to a new perspective on the system. Results of surveys, statistical analysis, and water chemistry modeling provide an impartial framework to evaluate and improve the overall system operation and cost.

Some examples of mechanical system aspects are heat flux, determining thermal limits, identifying problem areas. Operational factors include examining control charts, and process capability, identifying control problems, and looking at automation. Chemical aspects of the system involve looking at modeling (water chemistry, treatment chemicals, and so on), determining control limits for the system, and examining treatment alternatives.

The current approach in some plants may be to skip the mechanical and operational steps, and just focus on chemical solutions. Standard performance, basic control needs of the water chemistry, and chemical cost are what are considered. But you then have to ask whether you have total system management and whether there is reliability in the mechanical operations and recommendations. What assurances are there that chemical program success can be predicted—are key performance factors being considered and tracked? Can total costs (and possible reductions) be calculated, or just costs associated with chemical treatment?

The Engineering Approach uses a variety of databases for data analysis. Information gathered about the system from surveys is input into the database, and is continually updated. This helps provide system management, reliability, predictability, and TCO reduction. It also allows us to benchmark and norm against other plants, other industries, and so forth.

How and what was your system designed to do? Mechanically: piping, blowdown tanks, economizer; operationally: is your system CAPABLE of operating the way you want?; and chemically: how and what was your current treatment program DESIGNED to do? The Engineering Approach goes beyond MOC, however. Data with their financial implications are compiled so that real value is addressed.

The complete MOC approach provides an objective look at the system with information, which then helps to facilitate decisions at all levels in the plant. Choices for change are clear and documented, whether for mechanical, operational, or chemical segment of the operations. In addition, each choice has a cost and a return associated with it, allowing for project prioritization and tracking. Plant management can truly answer the questions of "how much," "how sure," and "how soon" the savings can be realized.

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Probably the best way to explain the power of the Engineering Approach is to relate some real life experiences in applying the approach in our customers' plants, with plant personnel, of course.

EXAMPLES OF BEST PRACTICES – THE ENGINEERING APPROACH FOR BOILERS

Boiler Water Chemistry out of the Control Box

A plant was experiencing continual out of specification readings for their coordinated phosphate boiler program, that is they were frequently "out of the box" with respect to their control range. There was no immediately obvious reason for the lack of control, and it resulted in the operators making manual adjustments to the blowdown to try to improve their control. This in turn resulted in periodic energy and water loss through excessive blowdown, and variation in cycles of concentration.

As there was no clear reason, and it appeared to be related to boiler cycles, plant personnel started to talk about hideout. This is a serious concern, and was important to determine the real reason for the lack of control.

The Engineering Approach, looking at best practices, was chosen for problem solving. The first thing done was to complete a mechanical survey of the boiler system, focussing on everything that could be influencing the boiler reading. The feedwater system was examined, including raw water treatment, demineralization, the demineralized water storage tanks, the condensate system, and the boiler itself. The goal was to determine if there were additional, unauthorized, water streams being brought into the system, whether proper pretreatment was occurring, whether there was unexpected contamination, and its source and so forth.

Following the mechanical survey, an operational survey was performed. This involved statistical analysis of the plant's control capability in critical control parameters such as pH, cycles, phosphate, chemical feed, conductivity, etc. This will help to understand why there is a control problem in this boiler system.

The parameters tested daily by the operators for feedwater, condensate, and boiler water were examined. The historical deaerator operation was looked at, as well as its maintenance logs. Historical data on condensate return and contaminant concentration were analyzed, as were resin replacement history, and regeneration practices.

All laboratory testing methods were reviewed-frequency, adherence to procedures, instrumentation, calibrations, test methods chosen, sample gathering, and so forth. This was done to make sure that the data being analyzed statistically was accurate, and that correct conclusions would be drawn.

Both ONDEO Nalco and plant personnel did the mechanical and operational surveys. This made sure that the systems were properly surveyed, and nothing was overlooked.

Finally, a chemical audit was done for the system to examine both the program choice, as well as the program application. This included feed location, sampling location, injection methods, etc. This data was examined separately, and in conjunction with the mechanical and operational survey results.

After examining all the data gathered from the various surveys, the conclusion was that there were no mechanical issues that were affecting the lack of control of the internal treatment. The chemical program being used was the technically correct choice given the feedwater pretreatment and water quality. Furthermore, if operated properly, the system was in fact capable of being in control a much larger percentage of the time than was being experienced (<50%). The operators were not taking the holding time of the boiler into account when making blowdown adjustments, and were often "chasing their tail" when trying to move the boiler parameters "into the box." In fact, most of the problems were caused by the operators overreacting to changes in test results from the boiler water chemistry.

The boiler was experiencing frequent load swings due to plant operation. These load swings could not be evened out due to plant configuration and requirements. Surveys also showed that the manual control of the feedwater treatment products was exacerbating the problems as manual adjustments made as the load was swinging were not necessarily timely.

Actions taken to improve the situation included operator training. Training on holding time, and the length of time it would take to have a change be seen led to better understanding for the operators as to what was going on in the boiler system. It was agreed

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with management and the operators that, except in case of emergency, blowdown rate changes would only be made on the day shift. This allowed the plant to stop exaggerating the changes.

The feedwater treatment was automated, providing more consistent feedwater treatment, even through large load swings for the boiler.

Results from this relatively simple “MOC” study were very positive. The percent of time the boiler spent “in the box” increased from <50% to >90%, and a project is in place to study whether it is possible to improve this further (is present system capable?).

With the training, the operators understood the overall system much better. They were able to reduce the amount of reacting they did, and were much happier on the job. It also freed operators’ time for more value-added proactive projects.

Automation improved overall system operation, and resulted in feed optimization, even with fairly large swings in steam load. This in turn allowed a minimization of feed—no “overfeed” was required to ensure system protection.

Additional savings were realized by the plant through optimized blowdown. This reduced both water and energy usage resulting in reduction of Total Cost of Operation for the Utility Department, and improved boiler operations through consistent cycles of concentration.

Through the use of the Best Practices Engineering Approach (Mechanical – Operational – Chemical), the plant saw good returns with a small investment in time and money. The investment was for surveys and data analysis and some automation equipment. The plant was able to eliminate hideout as a possible cause for the problem, improve overall operations, and reduce overall cost of the operation through optimization of their existing systems, not through a reduction in chemical price/pound. There was no quantification of what the plant saved through increased reliability and extended lifetime for the boiler.

By looking at the overall operations rather than just looking for a quick band-aid, the plant was able to quickly optimize operations and save money. This resulted in a very happy customer, an optimized system, and a better partnership between the customer and ONDEO Nalco. We were seen to provide a value-added service through our on-site technical representative acting as a consultant to the customer and using our best practices—The Engineering Approach.

<u>Iron and Copper Corrosion in a Condensate System</u>

A plant on the West Coast was experiencing corrosion in their condensate system. The system is primarily mild steel, although there are copper containing portions. Due to plant operation, there are constant steam load swings resulting in pH swings in the condensate system. Both copper and mild steel corrosion were detected.

The operators adjusted the condensate treatment (neutralizing amine) to maintain acceptable pH to minimize corrosion, with the focus on mild steel.

Again, a mechanical survey was done of the condensate system, followed by looking at all the data. Steam load swings were correlated with pH swings and corrosion results. A chemical survey was also performed which looked at the particular neutralizing amine chosen, its application point, the average dosage, and the frequency of changes in dosage to maintain minimized mild steel corrosion (optimized pH). The historical copper and iron levels in the condensate were also analyzed.

The surveys indicated that no mechanical changes were needed, and that all testing procedures, equipment, calibrations, and frequency of testing were all acceptable.

When system operation was analyzed, it became apparent that the pH swings that were causing the problem would continue, and the system would continue to have sections that were at low pH (5.5-7). More neutralizing amine could not simply be added to increase the pH as this would unacceptably raise the pH elsewhere in the boiler system. This restriction needed to be taken into account in examination of the system. The chemical program chosen was not capable of properly protecting the system under the given conditions. As the operation could not change, changes to the chemical program were considered.

After careful examination of a variety of neutralizing amines (different blends, different neutralizing ability), a supplemental program was suggested. The original neutralizing amine was retained, and a new non-amine film former was chosen as a supplement in the low pH areas of the system. The product works in the pH range of 5-7, which will

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meet the system's mild steel protection needs in the low pH regions, but will not raise pH in other areas of the system, protecting the copper areas.

Within twenty-four hours of implementing the chemical program, both iron and copper levels in the condensate dropped dramatically. In fact plant personnel commented on the Millipore pads, and how clean they looked through the first day, from almost black to grey to almost clean!

Again, through a careful examination of all potential factors, a solution was arrived at that met the needs of the plant, with good results. If the operational information had not been analyzed, it is possible that the chosen solution might have been just to feed more neutralizing amine, definitely the wrong long-term overall solution.

SUMMARY

There are many opportunities to improve overall plant as well as boiler system performance, efficiency, and safety while reducing the total cost of operations. Boiler Best Practices and the Engineering Approach provide useful tools to achieve these goals, and make sure that no stone is left unturned in making the system reliable. By looking at Mechanical, Operational, and Chemical aspects of the systems, all potential problems and opportunities for improvement can be identified, whether in performance, total cost of operation, profitability, or safety.

Incorporating all aspects of the system provides a comprehensive approach. Regardless of the source of the problem, they can be solved/prevented without creating others in other parts of the system. In fact, often starting with a Mechanical survey, followed by statistical analysis of Operational data, will eliminate problems that may be masking issues with the chemical treatment. Costs associated with improvements (chemical, capital, operational) can then be determined/justified, and agreement obtained from management to prioritize projects, and then track and complete them.

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