ASSISTANCE FOR AVAILABILITY — BOILER INSPECTIONS

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INTRODUCTION

The job of the Plant Engineer in industry is a very difficult one. He is responsible for the installation, maintenance and upgrading of the process equipment, office and manufacturing facilities and the boiler plant. In some cases the maintenance and upgrading of the boiler plant has been given minimal attention or priority because it was not considered as a direct cost of the finished product. Since the Arab oil embargo, the cost of energy and fuel for the boiler plant has risen rapidly. These increased costs and the recessionary economic climate have caused upper management to focus on the boiler plant and attempt to reduce its operating costs.

The Plant Engineer, as "The Technical Expert," is usually given the task of determining how to reduce the operating costs in the boiler plant. He may do the study himself, assign it to one of his staff, or go to outside sources. The list of ways to reduce operating costs can be endless. They range from fine tuning the existing equipment and operating more efficiently, to replacing the entire boiler plant with new equipment. There is no single answer, as all boiler plants are not alike and the answer may be one or a combination of alternatives.

BOILER CONVERSIONS

Boilers which are equipped with burners capable of burning multiple fuels can change to the least expensive fuel available. Some plants are swapping between fuels to take advantage of the spot market and off-season fuel rates. Boilers which were originally designed for coal firing are the most flexible when it comes to fuel conversions as their furnaces are sized with conservative heat releases, and are equipped with ash hoppers and soot removal equipment. Many of these boilers were converted to oil and gas firing in the 50's and 60's, and today they are being considered for conversion back to coal or some type of waste fuel (RDF, wood chips, sludge, process wastes or byproducts). In some cases this re-conversion will require a large investment to refurbish the coal handling equipment or add back end clean-up equipment to meet today's stringent environmental codes. These costs may exceed the book value of the boiler and could exceed its original cost.

It does not make sense to convert a boiler if it will not last to or beyond the end of the payback period or its availability will be poor. This does not mean that a thirty-or forty-year old boiler should not be considered for conversion, as the boiler may be in good condition and have many years of useful life remaining. A thorough boiler inspection program can be used to determine the physical condition of a boiler and test data can be taken to estimate its remaining useful life.

INSPECTION SERVICES

There are a number of companies and organizations which provide boiler inspection services. Some states and municipalities require yearly inspections by an authorized inspector to determine that the equipment is in safe operating condition. There are other inspection services which are meant to supplement these yearly inspections. These other inspection services will determine that the equipment is in safe operating condition, but they also look at ways to improve the availability and efficiency of the equipment. This type of boiler inspection can be of great assistance to the Plant Engineer who is considering a fuel conversion of an older boiler.

The services we suggest are a customized in-depth mechanical inspection and analysis of a boiler and its auxiliary equipment by a team of experts: Boiler Designers, Stress Analysts, Fuel System Engineers, Service Engineers, Metallurgists and Construction Specialists.

Drums and Drum Internals

On an older boiler being considered for conversion, we suggest a thorough inspection of the drums and drum internals. A visual inspection and magnetic particle inspection of the drums would determine if there are any cracks in the ligaments between the tube holes. Ultrasonic thickness measurements would be made of the drum shell and heads. The thickness measurements are used to determine the maximum allowable working pressure of the drums, utilizing the appropriate formulas from the ASME Code edition which was effective when the drums were fabricated. If sufficient data is available, an average annual depletion rate (AADR) will be determined from drum metal wastage due to corrosion. Normally the actual original thickness of the drums is not known and the nominal thickness from the manufacturer's data sheet must be used. The AADR is calculated as follows:

$$\text{AADR} = \frac{\text{Orig. Thickness} - \text{Pres. Thickness}}{\text{Years in Service}}$$

The depletion rate can be used to predict when in the future the maximum allowable working pressure must be reduced. It can also be used to estimate the remaining useful life of the boiler. If the drum thickness is near the value at which the maximum allowable working pressure must be reduced, it is advisable to measure the drum thickness again in a couple of years to confirm the calculated depletion rate.

The headers will be inspected internally and externally and ultrasonic thickness measurements will be taken. The maximum allowable working pressure can be calculated for each header by using the appropriate formulas from the ASME Code. On older boilers where the tubes were rolled into the headers, the header thickness required for tube rolling is usually greater than the thickness required by the operating pressure.

Furnace

A complete visual inspection of the fire side of the boiler will be performed. The amount and location of slag deposits is noted to evaluate the effectiveness of existing sootblowers or the need for additional ones. The tubes will be checked for proper alignment, spacing, any signs of overheating, corrosion or erosion. Ultrasonic thickness measurements will be taken of tubes throughout the boiler, especially in areas of expected high wear. The exact location and quantity of the measurements will be based on the visual inspection and the experience of the inspection team on similar boilers.

The tube thickness readings are reviewed and the minimum thickness at each furnace wall and elevation is noted. These minimum thicknesses are then used in the appropriate ASME Code formula to determine the maximum allowable operating pressure. This is one point of reference that may be used for determining the tube average annual depletion rate as was done with the drum thickness measurements. Tubes are selected for removal for metallurgical analysis on the basis of visual observations and ultrasonic thickness readings. The tubes selected include tubes which show signs of deterioration as well as tubes that do not. The metallurgical analysis determines degradation of the material microstructure, plus the thickness of internal and external scale or deposits. If significant amounts of internal deposits are present, they will be chemically analyzed if

they show signs of attacking the tube surface.

The tube supports and other attachments to the tubes are inspected for structural soundness. One of the critical areas is the weld between dissimilar metals with different coefficients of thermal expansion. These areas are subject to cracking if care has not been taken to use the proper weld rod material and make a smooth fillet.

The seals at tube penetrations through roofs and walls are examined for deterioration and leakage. Hot gases or flyash leaking through these seals can cause severe damage to penthouse and boiler casing.

The baffles are inspected for proper sealing and channeling of hot gases to the proper areas. Bypassing of the hot gases through baffles or around boiler sections can cause areas where tubing can get too hot and other areas where there is insufficient hot gas for proper heat transfer. There are two undesirable effects from leaking baffles. The first is reduced boiler efficiency and the second is damage to boiler components from overheating. The condition of the tile and refractory in the boiler is also determined.

On the exterior of the boiler, the setting is inspected for leakage and hot spots. Hot spots on the setting are an indication of deterioration of the insulation and can be a personnel hazard even though most of the field-erected industrial boilers are balanced draft units. Usually the leakage through the setting of a balanced draft boiler will be into the boiler. However, during operation there are occasions when a boiler gas pressure will become positive and force hot gases and flyash out of the boiler. Leakage into the boiler can reduce its efficiency and increase the loading on the induced draft fan. Positive pressure or gases leaking out of the boiler can be an indication of potential problems.

Fans and Fan Controls

The fan controls may need adjustment. The induced draft fan may be marginal in its performace due to wear or the boiler gas passes may have a blockage due to flyash or slag. A visual inspection can detect the blockage and monitoring operations can indicate needed controls adjustment. If the fan is marginal in its performance it may be time to make a repair or replacement. The amount of flue gas to the induced draft fan is a function of the fuel being burned and level of excess air being maintained. For a pulverized coal-fired boiler the amount of flue gas to the induced draft fan is 10 to 15 % greater than the same boiler firing gas or oil at recommended excess air levels. On a stoker-fired boiler this percentage could be as high as 25% because of the higher excess air associated with stoker firing. If a boiler is converted back to coal firing and the boiler setting is not refurbished to minimize air infiltration, the induced draft fan can become overloaded and full boiler load will not be attained.

Fuel Burning Equipment

An important part of the inspection of a boiler being considered for a conversion back to coal is the existing fuel burning equipment. In many cases when a boiler was converted to gas or oil, the coal preparation and fuel burning equipment was either stored with little or no preparation for long term storage, or scrapped. The stored equipment will have to be closely inspected to determine its condition and what refurbishment will have to be performed to return it to good operating condition. Recommendations can also be made to upgrade the equipment to the latest standards. Upgrading may be required to handle the proposed coal as it may be quite different from the coal that was originally burned. In many plants the maintenance personnel who knew the coal preparation and fuel burning equipment have retired. Training and assistance may be provided for the new personnel to give the the skills for the proper maintenance and adjustment of the equipment.

On boilers where a new fuel is to be added, an assessment can be made on whether or not it can be fired with the existing equipment. If it can not, a study may be made to determine the location and type of new equipment to be added.

Air Preheaters

A test for tube leakage is not normally run as part of the inspection, but can be if specified. On a regenerative-type air heater, the housing and structural members are inspected for integrity, corrosion and

erosion. The heat transfer elements (baskets) are inspected for integrity, plugging and corrosion. The condition and adjustment of the seals between the sectors is determined as it effects the amount of air and flyash leakage from the flue gas side to the hot air side.

Pulverized coal-fired boilers and boilers which were designed to fire a cellulose fuel on a grate are usually equipped with some type of air preheater. The tubular airheater was the most common type used on industrial boilers, but recently regenerative-type (Ljungstrom) airheaters have gained greater usage. The inspection of a tubular air heater includes the visual inspection of the casing and tube sheets for signs of leakage or corrosion. The baffles on the air side are checked to see that they are in place and intact. On the gas side the tubes are inspected for erosion at the inlet end, corrosion at the outlet end, and plugging of the tubes with ash. The number of tubes that are plugged because of air leakage are noted and a determination is made to run the unit with the tubes plugged or to replace them.

Auxiliary Equipment

The remainder of the auxiliary equipment normally furnished with the boiler is also inspected. The forced and induced draft fan housings and rotors are inspected for integrity, erosion and corrosion. The sootblower lances are inspected in place and their cleaning effectiveness evaluated. The mechanical dust collector is inspected for integrity and erosion. The ducts, breeching, dampers and expansion joints are inspected for structural integrity, corrosion and leakage.

The foundations and structural supports for all the boiler-related equipment are inspected. On bottom-supported boilers the exposed portions of the foundations are inspected for signs of deterioration and settling. For top-supported boilers the structural support steel and hanger rods are inspected for integrity and any signs of corrosion or deterioration. This is especially important on outdoor or partially-enclosed boilers where the support structure is exposed to the elements.

RESULTS OF INSPECTION

At the completion of the inspection, the inspection team should meet with the Plant Engineer and Manager to discuss the inspection findings and make recommendations for immediate repairs and maintenance before the boiler is returned to service. Recommendations will also be made for long term maintenance items and modifications to improve the efficiency and availability of the equipment. A copy of the handwritten field notes is left with the Plant Engineer and Manager as a preliminary inspection report. A final report is prepared including the lab analyses, reviews and analyses by team members, photographs taken during the inspection, conclusions on the condition of the equipment and recommendations on long-term repairs and modifications. This document is of assistance to the Plant Engineer and his management in making decisions on the future use and maintenance of the boiler.

A thorough inspection and report is invaluable to the Plant Engineer in helping him to schedule repairs, set up maintenance budgets and improve the availability of his steam boilers.