Proceedings of ASME Power:
ASME Power
April 5 -7, 2005, Chicago, Illinois

PWR2005-50203

ASH MEASUREMENT AT NRG HUNTLEY USING HIGH TEMPERATURE STRAIN GAUGES

Charlie Breeding/Clyde Bergemann

Joe Schmitt/NRG Huntley

Huiying Zhuang/ Clyde Bergemann

ABSTRACT

The paper presents the results of a unique method of ash measurement at the NRG Huntley station. High Temperature strain gauges were installed in the boiler penthouse. The gauges were located on rods that support the superheater pendants. Output from the gages measure ash accumulation and soot blower effectiveness. Output from the system is utilized in the soot blower control system to optimize blower operation. The system will allow less steam to be used for soot blowing while keeping the superheater clean at all times. This is valuable to the plant as a switch to 100% PRB coal is made. The paper will present details of the installation.

INTRODUCTION

Boiler walls and internal components are suspended from hanger rods that are attached to the steel structure above the boiler. This structure is used for support of the steam generating pendants that hang inside the upper section of the boiler. These pendants super heat the steam or reheat steam before it is directed to the steam turbine. Coal combustion in the boiler results in an ash residue that can foul the steam generating sections of the boiler. This fouling results in loss of steam capacity, and loss of boiler efficiency. To keep the steam generating section clean, soot blowing equipment is employed. In the convection pass of boilers, this equipment is typically retractable steam or air blowers. Traditional control of these blowers is done by monitoring steam conditions, and blowing when temperatures drop below acceptable levels. Often the blowers are operated in "sequential" type groups. Thus, all the blowers associated with the superheater pendants would be operated sequentially to clean this section.

The blowers are often operated based on a time schedule or in response to reductions in steam temperatures as noted by the unit operator. The time based operation can result in blowing when it is not necessary. This results in a waste of blowing steam and may erode tubes. When steam temperature drops are used as a trigger for operation, there is a loss of proper steam conditions before the blowers can restore the proper steam temperatures, and there may be sudden changes in steam conditions which can have negative effects on the steam turbine and other steam cycle components.

Clyde Bergemann and International Paper have pioneered the use of strain gages to measure the ash accumulation on the pendant surfaces. Installation of strain gages to measure the amount of ash deposited on the pendants can result in better control of the soot blowing equipment. Weight information from the gages indicates the location and amount of ash accumulated on the heat transfer surface. When the soot blower is operated the weight measurement indicates the amount of ash removed. This can be used to determine the effectiveness of each blower. Better control of steam conditions, less erosion of tubes, and better boiler efficiency are all results of improved soot blowing.

The NRG Huntley 67 boiler is a Combustion Engineering design. It is a twin furnace design, which has two separate furnaces and convection sections. Capacity of the plant is 200 MW. The boiler design has a support structure built into the roof of the penthouse that supports the pendants with hanger rods. Thus there are no hanger rods outside the boiler. The roof of the boiler is shown in the photo 1. This created a special problem for the installation of stain gages. Previous papers have described strain gage installations to measure pendant weight by installation of strain gages on the pendant hanger rods. These installations have used rods that exited the penthouse region and were in a relatively ambient environment.

Thus traditional strain gages could be used to measure the change in weight due to ash build up.

For the Huntley installation strain gages that could survive the high temperature were used. Photo 2 shows the hanger rods inside the penthouse area. The temperature inside the boiler penthouse can approach 1000 ^{o}F as the steam pipes inside this area are not insulated. Also, the traditional strain gages had been attached to the hanger rods using adhesive. This could not be used in the high temperature environment, so the gages were installed using a spot welding technique. Photo 3 shows a gage installed on a hanger rod with spot welds.

NOMENCLATURE

S = Stress in pounds per square inch
E = Modulus of elasticity ($30x10^6$ for steel)
ε = Strain in micro inches per inch.

Operational Theory

Data from each gage is converted to weight using the stress strain relationship:

$$S = E\varepsilon$$

Using the diameter of the rod a cross sectional area can be calculated, and the stress is multiplied by the area of the rod to arrive at weight. The weight measurement can be started at any time within the process and any subsequent readings indicate the change in weight from starting conditions. Thus it is not necessary to start from a totally unloaded rod.

System Design

The system for Huntley unit 67 uses high temperature strain gages which are designed for temperatures above 1000 ^{o}F. The gages are self-temperature compensated and fabricated on a stainless steel shim. The gages are compensated for the steel hanger rods. The shim is curved to fit the hanger rod. Attachment of the gage to the hanger rod is done with a spot welder. High temperature lead out wire is used to get the signal out of the pent house area.

A small hole was drilled into the roof of the penthouse and a section of tubing was installed to act as a conduit for the gage lead out wires. Above the roof the lead out wires were connected to a cable which led to the data acquisition cabinet located beside the boiler roof. The attached sketch shows the installation of the gages inside the penthouse, the penetration through the roof, and the cable that leads to the data acquisition system.

A data acquisition system is located in a cabinet on the side of the boiler. This equipment provides excitation to the gages, and measures the output from each gage. The data acquisition system is connected to a computer in the control room by Ethernet cable.

Installation of the gages was made in October 2004 during a planned outage. The unit was being upgraded in preparation for the switch of fuel to 100% Power River Basin (PRB) coal. 20 gages were installed, 10 in the super heat furnace and 10 in the re-heat furnace. Figure 1 shows the location of rods in the Huntley 67 boiler. Gages were installed on the "K" line of support rods

System Operation

The system has successfully monitored the weight of the superheater and reheater pendants. Data from the gages is plotted with the unit load in the graphs. As unit load is reduced the gages indicate lower weight due to the change in density of the steam and the change in the structural load carried by the rods. Loss of ash weight can be seen when the unit is returned to full load. This is a typical reaction to load drops. Ash tends to fall off the pendants during a load drop, as the ash solidifies in the cooler gas temperatures.

Conclusions

The installation of high temperature gages at Huntley 67 has demonstrated that it is possible to install strain gages inside the penthouse region of a power boiler. The high temperature gages have demonstrated an ability to measure and monitor the weight of the pendants at Huntley 67. Weight change with load changes can be measured. Further testing is being conducted to determine the reaction of the gages to soot blower operation. Also, the gages are being monitored to determine their long term reliability.

ACKNOWLEDGMENTS

The staff of the Huntley station has supported this work during the installation of the gages, with data from daily operation, and with overall open communication.

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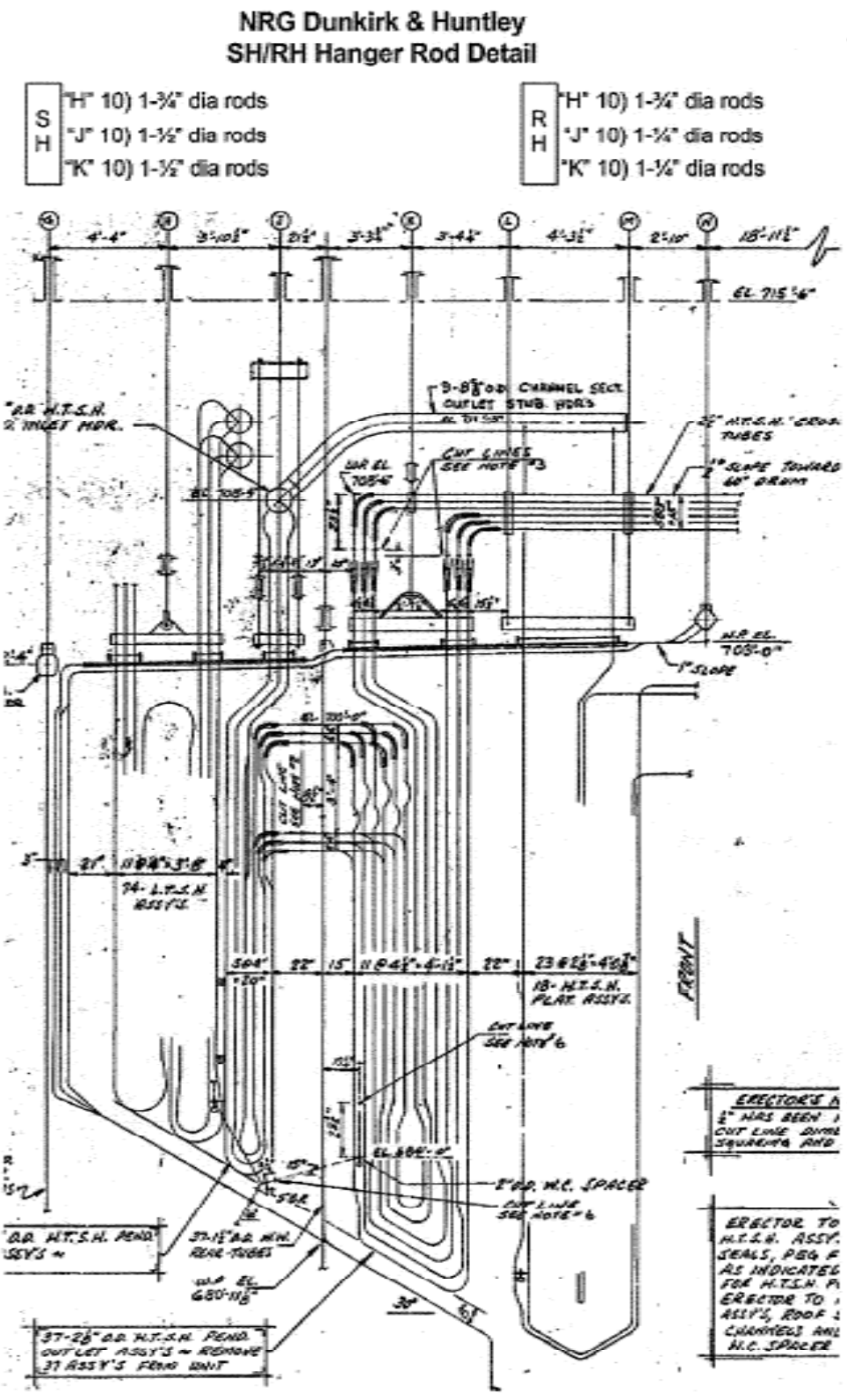
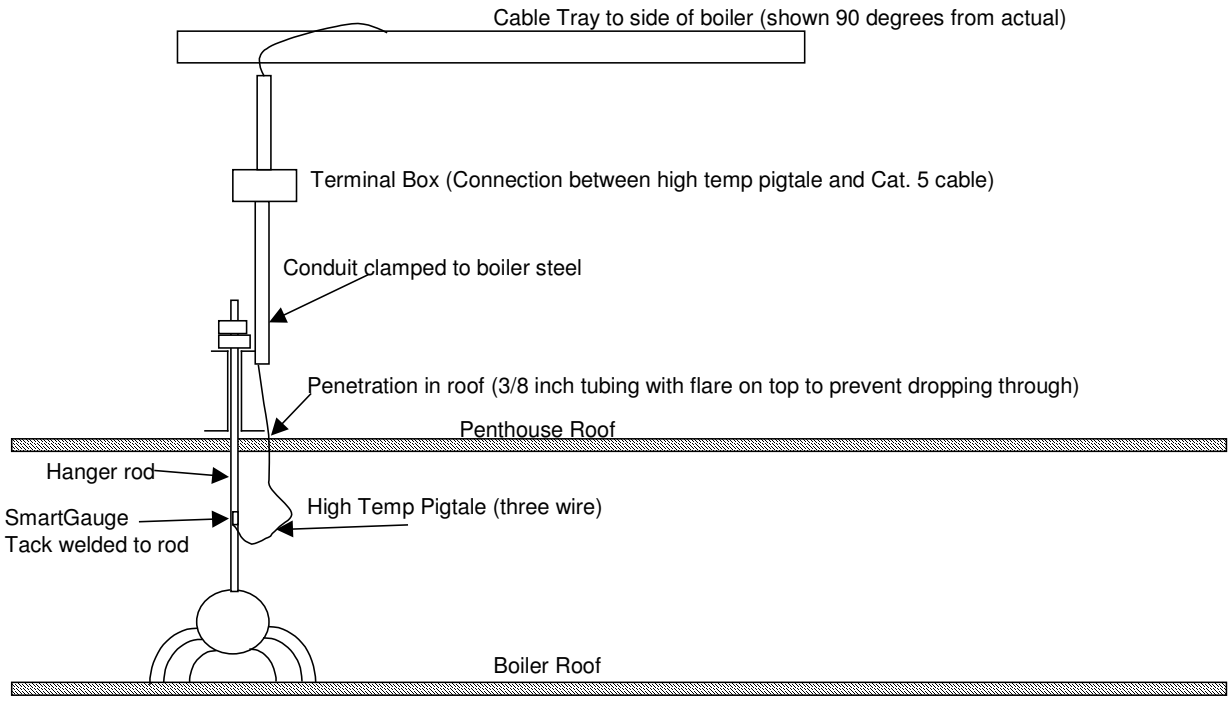


Figure 1, Superheater pendant, with rod locations

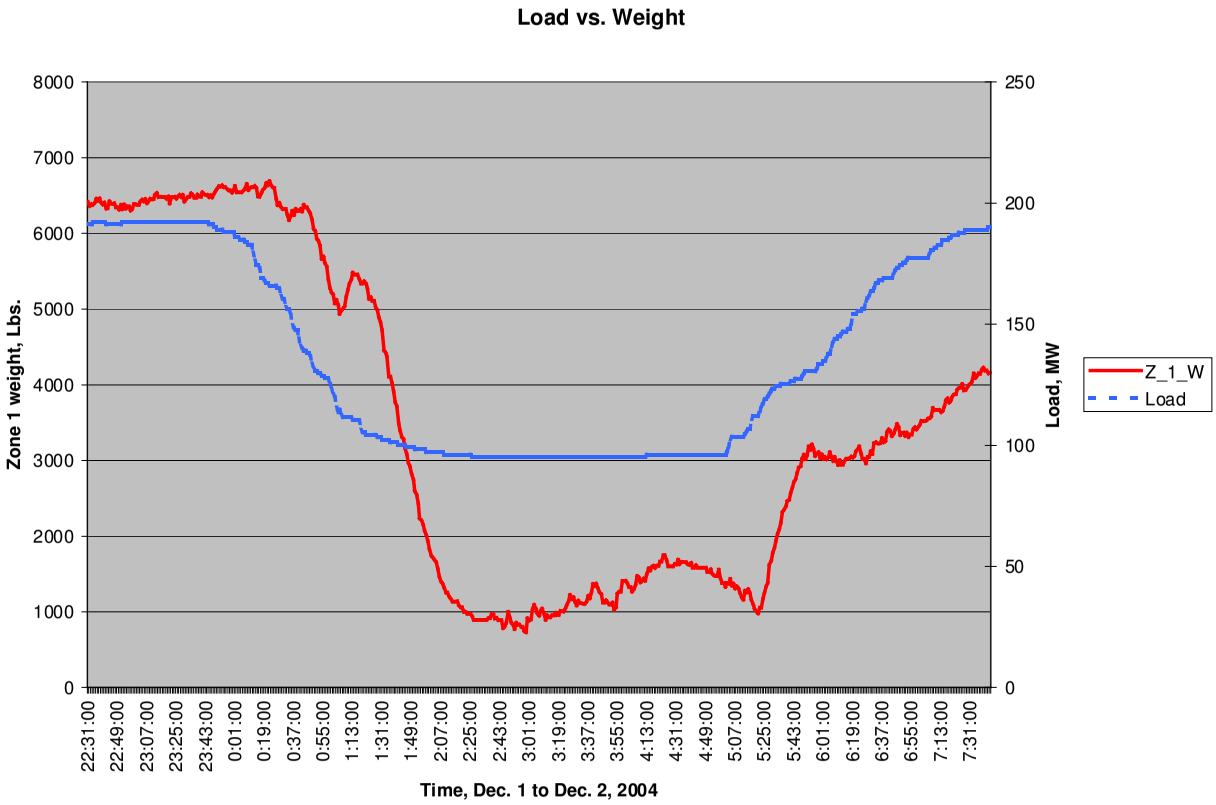
Photo 1, Roof with rod ends visible

Photo 2, Hanger rods inside penthouse

Photo 3, Gage installed on hanger rod



Sketch of hanger rod gage installation



Load compared to strain gage weight for Superheater and Reheater section of the Huntley 67 boiler