



Multi-faceted Inspection and Retrofit Project Improves Performance and Reduces Emissions at El Segundo

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The recent California power crisis forced many power generation companies to achieve high capacity levels from power plants with equipment up to 50 years old. Unfortunately, California's restrictive air permits also challenged many generators to maintain total annual emissions at the previous year's levels. Furthermore, equipment life forecasts showed uncertain viability for older units, thus creating risks for any capital expenditures that might be required.



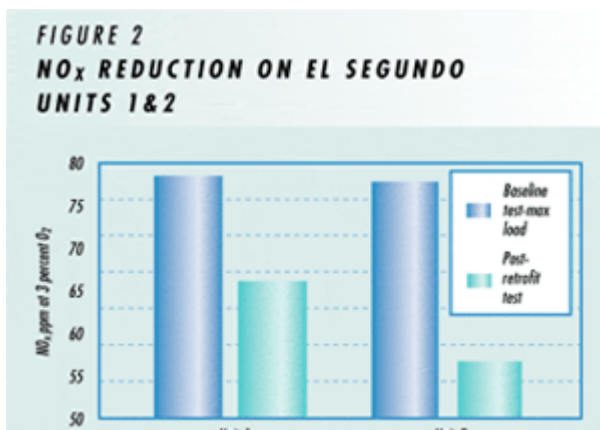
El Segundo Power, LLC awarded John Zink Company, LLC and Source California a contract to evaluate ways of reducing emissions from Units 1 and 2 at the El Segundo power station. Although the mandate was to reduce emission levels with as little capital investment as possible, time was still of the essence.

The team set two goals:

- Decrease NO_x emissions by at least 12 percent without any increase in CO or loss of generating capacity.
- Improve overall performance.

Plant Characteristics

El Segundo Units 1 and 2, Figure 1, constructed in 1953, have balanced draft Babcock & Wilcox (B&W) radiant type, single steam drum, bent tube boilers. Each boiler has a continuous rated steam generating capacity of 1,140,000 lb/hr with superheater outlet conditions of 1,990 psig and 1,000 F and a reheat temperature of 1,000 F.



The boilers each have 16 B&W natural gas burners arranged in four rows of four burners on a single wall. At the time of the project, the boilers had four over-fire air (OFA) ports located above the top row of burners; however, the OFA had not been used for some years and the ports were closed.

Both boilers have two counterflow regenerative parallel, horizontally mounted, Ljungstrom-type air pre-heaters, two forced draft (FD) fans and two induced draft (ID) fans. Hot combustion air is delivered to the burners and the OFA ports through a common windbox. Flue gas recirculation, used primarily for steam temperature control, is delivered to the base of the combustion zone opposite to the burners.

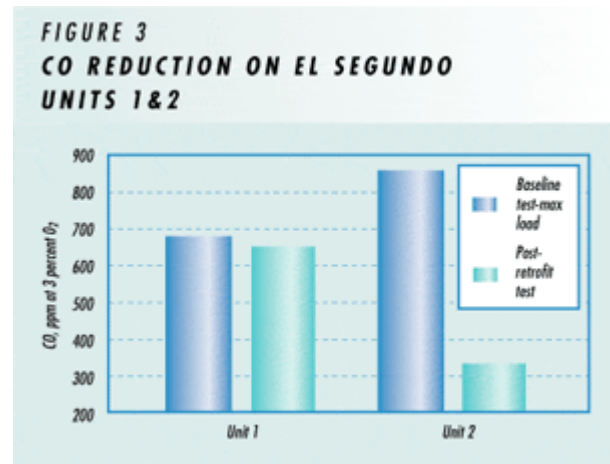
The units also have a single tandem compound GE steam turbine-generator. Although each unit's original predicted net output was 172 MW, baseline tests conducted on the two units prior to the upgrade indicated the maximum attainable net loads achievable were 159.5 MW for Unit 1 and 151 MW for Unit 2.

Rectifying Operating Problems

A major area of concern was the apparent capacity loss resulting from limitations of the ID fans. Although the ID fan dampers were operating at 100 percent, the actual boiler draft pressure was just able to maintain set point within the draft control system. Because of the equipment's age and the condition of the expansion joints and the ductwork upstream of the ID fan, the fans were required to work harder at baseline levels of output.

During the upgrade the ID fan inlet ducts were patched and all of the failed expansion joints were replaced with high temperature cloth joints. To protect the new fabric joints from abrasion, a protective layer of material was installed over the existing metal accordion-type joints. The cloth expansion joints are installed over the old joints and are secured by flanges welded to the ductwork.

Inspection of the air pre-heater revealed that the original basket metal plates had at some time been replaced with plates with a higher surface area pattern. By design, the increased surface area increased the pressure drop across the air pre-heater, thus causing a higher pressure drop than the original design.



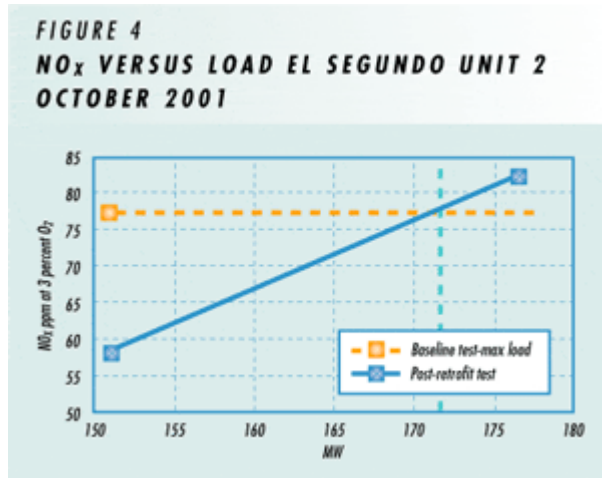
During initial equipment condition assessment testing, the project team found that some sections of the air pre-heater had deteriorated and needed repair. Prior to the repairs the plant had experienced dramatic furnace pressure swings even when the furnace draft, FD fan and fuel gas valve controls were placed in manual operation. Additionally, every time the furnace pressure swung to a positive pressure, the boiler would produce a low frequency audible rumbling noise for about 10 seconds. Inspection revealed the 10-second rumble coincided with the rotation of the air pre-heater shaft.

After completing the air pre-heater inspection the engineers decided to remove the most deteriorated hot baskets and clean the remainder. However, due the project schedule and capital constraints, the engineers later elected to clean all of the baskets rather than fabricating and installing less restrictive baskets. When the air pre-heater was returned to service, the 10-second boiler-rumbling problem disappeared.

Prior to the modifications, an important contribution to NO_x production was the condition of the aging

boiler and its casing. The old B&W boilers utilized a "soft" casing design to minimize the flow of atmospheric ambient air into the combustion and convection zones. In a soft casing design the gaps between the tubes are covered, which minimizes the air flow. Damage to some parts of the boiler's soft casing was repaired. However, casing from just above the windbox to the furnace outlet duct was replaced. In addition, the penthouse floor and the vestibule where the superheaters are located were resealed.

The control devices responsible for the delivery of fuel and air to the boiler play a significant role in stable combustion within the furnace. Therefore, a key strategy of the upgrade was to return the generating units back to fully functional, automatic control. The project team performed an extensive test on every loop of the 1956 vintage Bailey pneumatic control system.



Testing involved calibration of the field instruments followed by pressure testing of all the sensing and pneumatic tubing lines. All the related relays, standatrols, regulators, and hand/auto control stations were checked and returned to the best condition possible.

The final control element drives were also re-built to restore them to their original design performance. During inspection of the combustion air fans, the engineers found the airflow control of the inlet regulating dampers was restricted. To improve their operation the inlet vanes were re-built.

Improving Combustion

An internal inspection of the burners from the windbox area and furnace front wall area revealed a variety of problems. A number of the burner diffusers, which impart a swirl to a portion of the combustion air as it enters the furnace and mixes with the fuel, needed repairing and/or replacing. Similarly, the burner tip gas orifices, especially those on the lower row of burners, were severely plugged. To correct these problems, the diffusers were repaired and/or replaced and the burner tip orifices cleaned.

Another problem involved the condition of the burner air registers that regulate the airflow to the burners. Many of the air registers had less than optimum operability, creating a potential for airflow imbalances between the burners. Repair to these air registers resulted in improved operation.

After baseline testing, assessment and analysis of the units, the engineers concluded the combustion performance could be dramatically improved, and emissions significantly reduced, by redesigning the OFA ports. This has eliminated the airflow imbalances between the OFA ports. These imbalances were caused by the original design of the combustion air windbox and ductwork.

Using physical modeling the engineers were able to design cost-effective retrofits of the OFA ports. A physical model was used to design the baffles and turning vanes. The baffles and vanes, installed in the windboxes and ductwork, correct the airflow distribution, thus allowing the existing OFA ports to be more effective.

The modeling process revealed two reasons why the OFA ports had not been used. First, the dampers

that regulated the airflow to the OFA ports were undersized, which resulted in low velocities and poor furnace penetration. Second, the air trajectory through the OFA ports was at a 45 degree upward angle so that the air entering the furnace stayed close to the front wall, thus causing it to leave the furnace without sufficiently completing the combustion process.

To correct these problems, and to allow sufficient airflow to the ports, new larger dampers were designed and installed. Baffles and turning vanes were also installed to ensure proper air trajectories from the OFA ports into the furnace.

Results

Due to the extensive testing and improvements made to the old control system the startup of the units went smoothly. Only a minimal amount of tuning was required to stabilize process parameters. The boilers are now capable of fully automatic operation from 15 MW to full load.

The repairs and maintenance to correct the swinging draft pressure problem significantly improved the airflow control. Similarly, the rebuilt pneumatic control system responded well to airflow demand changes, resulting in smoother air-to-fuel control.

As a result of the improvements to the burners and combustion air system, NO_x emissions on both units have been reduced by an average of 22 percent, Figure 2, compared to the baseline (pre-retrofit) testing rates. The CO levels in the post-retrofit tests were also lower than the baseline tests. Unit 1 had a 5 percent CO reduction and Unit 2 a 65 percent CO reduction, Figure 3. The post-retrofit test also demonstrated a 26 MW increase in capacity on Unit 2 with a slight increase in NO_x, Figure 4. However, due to time constraints, Unit 1 was not tested.

The work conducted on the two units has provided NO_x reductions of almost double the guaranteed level, reduced CO emissions and increased the plant's capacity by 15 to 25 MW. As a result of the upgrade, El Segundo was able to successfully respond to California's power needs during the recent energy crisis.

Authors -

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