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WORLD'S CLEANEST
THERMAL PLANT RESULTS

EMISSION ABATEMENT REPORT FOR

HUNTINGTON BEACH GENERATING STATION
UNITS 3 AND 4

Huntington Beach Emission Results

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WORLD'S CLEANEST THERMAL PLANT RESULTS

Huntington Beach Generating Station - The Plant That Sets the Emission Control Standards in California and the World

General

The selection of PMSI/ESA as General Contractor and Engineer occurred in the fall of 2000 to completely design, furnish, rebuild and upgrade two 225-megawatt generating plants, along with adding state-of-the-art pollution control equipment.

The major tasks were to redesign and replace two 225-megawatt super-critical steam generators with a superheater outlet steam flow of 1,638,000 lb/hr at 2,450 psig and 1,050 degrees Fahrenheit. Part of the assignment was to rebuild two 225-megawatt cross-compound 3,600-RPM high-pressure and 1,800-RPM low-pressure turbine generator units. The plant was upgraded with a new electrical and plant distribution system, including new steam turbine generator controls. We designed and installed a new condensate polishing system and instrument air system. A key task was the removal, redesign, fabrication and reinstallation of approximately 50,000 lineal feet of pipe ranging from A-106 Grade B standard up to A-335, P-11, and P-22 up to 3-inch wall thickness, and rebuilding and/or purchasing approximately 1,000 control and manual valves.

All of the auxiliary equipment and systems were upgraded or replaced with the latest process technology. Modifications or changes were made to the original design to improve and optimize performance or correct operational difficulties. This work also entailed the demolition and reconstruction of virtually every system in the facility.

In addition, the units were designed with the latest state-of-the-art NOx and CO emission systems to meet or exceed the existing air quality standards in Southern California.

To accomplish this major retrofit and design undertaking, we worked an accelerated 11-month schedule with a work force peak of more than 1,000.

Pollution Control Systems with NOx and CO Reduction Catalyst

The units were designed and retrofitted with some of the highest emission removal systems ever installed on utility boilers.

The burners applied in this modification used combustion air and an ESA design system to induce a flue gas recirculation rate of approximately 10 percent.

Four new ABB Fan Group 1,750 HP forced draft fans, being controlled with new variable frequency drivers, were installed. Each of the forced draft fans were increased in size by 550 HP allowing for the added air flow and pressure to handle the supplementary excess gas recirculation and the extra pressure requirements to manage the additional pressure requirement of the emission removal systems.

Modifications and additions to each B&W boiler were made, including performance

redesign by B&W and its supply of new boiler pressure parts and components. The burner throat opening in the water wall tubes was increased at each of the 48 burner locations to accommodate the installation of 48 new Todd low NOx gas-fired burners for both units. The basis of the design was to develop a stratified flame structure with specific sections of the flame operating fuel-rich and other sections operating fuel-lean. The new burner design provided for internal staging of the flame to achieve reduction of NOx and CO emissions while maintaining a stable flame.

The boiler design capacity rating for each burner was 87 MM Btu/Hr with a unit operating firing rate of 2,088 MM Btu/Hr for each unit.

In addition, each unit's post-combustion control systems were designed and installed with both a selective catalytic reduction catalyst furnished by Cormetech and an Engelhard oxidizing catalyst to further reduce both emissions by an additional 95%. The SCR system provides secondary NOx emission controls utilizing a Cormetech honeycomb catalyst and injection of ammonia up-stream of the catalyst.

The SCR and CO systems were designed to guarantee a reduction in the remaining secondary resultant nitrogen oxide emissions to less than 5 ppm vd at 3% O2, and carbon monoxide emissions of less than 5 ppm vd at 3% O2 at the stack.

The SCR and CO systems designed, installed and guaranteed resulted in the "World's Cleanest Burning Thermal Plant."

To further make the emissions control retrofit environmentally friendly, the ammonia required for the selective catalytic reduction system is generated on site. A new Wahlco process, in which the ammonia is produced utilizing dry urea (fertilizer), was installed. The system generates "on-demand" ammonia use, which eliminates any transportation, handling, and storage of either anhydrous or aqueous ammonia. The urea solution is piped into a reactor for disassociation of urea to approximately 30 percent of ammonia.

Units 3 and 4 at the Huntington Beach Generating station were originally planned to be equipped with SCR systems for removal of NOx only. During the project execution, a CO oxidation catalyst was added to the systems to reduce the CO emission below present regulation requirements. To accommodate the CO catalyst addition, ESA redesigned the SCR systems.

There are differences between gas turbines and utility boilers. The flue gas from the utility boilers may contain more and larger particles (fouling from ductwork material, rust and scale from the boiler). In addition, the distribution of CO concentration and temperature variations in the flue gas of the utility boiler is boiler-specific. An even distribution of velocity, temperature and CO concentration in front of the catalyst layer is important to achieve high removal performance. Although the CO catalyst has been applied for removal of CO from the exhaust gas of many gas turbine installations, we are not aware of any commercial CO catalyst installations on utility boilers.

However, an Engelhard CO catalyst was designed and applied on Units 3 and 4 at Huntington Beach based on experience available on gas turbine applications. In addition, we had considered measures in the system arrangement and catalyst selection to minimize the differences between the operating conditions at the Huntington Beach Units versus those in gas

turbine applications.

Nevertheless, there were uncertainties ESA had to consider in its design approach due to the lack of operating experience with the CO catalyst on utility boilers, especially with the required CO removal efficiency of 95% at 3% O2.

The SCR system including the CO oxidization catalyst was designed to achieve the performance requirements shown in Table 1.

TABLE 1

SCR System Including The CO Oxidization Catalyst Performance Requirements

SCR System	
NOx emission:	**5 ppm vd at 3% O2 (95 % reduction)**
NH3 slip:	**5 ppm vd at 3% O2**
Lifetime:	**24,000 operating hours**
CO Catalyst	
CO reduction:	**5 ppm vd at 3% O2 (95% reduction)**
Catalyst lifetime:	**24,000 operating hours**

The required performance for both NOx and CO reduction was challenging considering that there were no operating utility boilers in the world equipped with this significantly high level of air emission pollution removal controls. Therefore, the SCR system, including the CO catalyst at the Huntington Beach unit 3 and 4 generating station, was the first, and set a new level in achievable emission performance in Southern California and in the air pollution control industry.

System Performance

AQMD's New Source Review rules require the use of Best Available Control Technology (LAER for major sources) for any new sources of non-attainment air pollutants and ammonia emissions, which applied to the Huntington Beach facility.

To satisfy the South Coast Air Quality Management District permit requirements, Units 3 and 4 at Huntington Beach Generation Station were refurbished and retrofitted with emission control systems limiting the NOx and CO emission beyond the permit restriction imposed by the Air Quality Management District at the start of the project in the fall of 2001, as noted in Table 2.

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TABLE 2
AQMD 2001 Regulations for Thermal Boiler Electric Facility at 3% O2
at the Start of the Huntington Beach Unit 3 and 4 Projects

NOx Limits For 1 Hour	**7.0 ppmvd at 3% O2**
CO Limits For 1 Hour	**100.0 ppmvd at 3% O2** With No Oxidation Catalyst Control Requirement
NH3 Limits For 1 Hour	**5.0 ppmvd at 3% O2**

The emission control measures undertaken for Units 3 and 4 at Huntington Beach Generation Station consisted of replacement of all the burners, installation of the induced flue gas recirculation system and the installation of an SCR system with a dilution air and mixer system to induce an on-demand ammonia supply by the disassociation of urea and an oxidation catalyst for conversion of CO into CO2.

The induced flue gas recirculation system's recirculation rate of approximately 10 percent provided sufficient NOx reduction enabling the newly installed low NOx burners to provide a NOx emission limit guarantee of 90 ppm vd at 3% O2 and a guaranteed CO emission limit of 100 ppm vd at 3% O2.

The catalytic reduction systems of NOx and CO2 downstream of the economizer are designed to reduce the CO emission from 100 to 5 ppm vd at 3% O2, and the NOx emission from 90 ppm vd at 3% O2 to 5 ppm vd at 3% O2 with a maximum ammonia slip of 5 ppm vd at 3% O2.

The catalyst systems had been designed to guarantee the emission mentioned above under an off-design case operating condition, which was a 100 ppm NOx and a 110 ppm CO inlet to the catalytic system. The air emission results were expected to be less than guaranteed air emission due to actual operating conditions, which may be better than the conditions assumed during the design phase.

Since the ammonia to NOx ratio determines the performance of the SCR system and the amount of ammonia slip, the expected ammonia slip limitations were designed to achieve lower than 5 ppm based on the advanced and optimum design of the ammonia injection grid system.

The Units 3 and 4 Huntington Beach Generation Station Compliance Test Plant Emission Summary Levels operating results and achieved improvement regulation comparisons are shown in Table 3.

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TABLE 3

Summary of Emission Levels Achieved at Huntington Beach Unit 3
Compliance Test August 2002 as Witness by Representatives of the SCAQMD

NOx Limits for 1 Hour	**3.41 ppmvd at 3% O2** is a ***105 % Improvement*** over the original 2001 AQMD Thermal Boiler Regulation, and when compared to the present New AQMD Gas Turbine Regulation, results in a ***120 % Improvement***.
CO Limits for 1 Hour	**< 1.0 ppmvd at 3% O2** is a ***9900 % Improvement*** over the original 2001 AQMD Thermal Boiler Regulation, and when compared to the present New AQMD Gas Turbine Regulation, results in a ***1700 % Improvement***.
NH3 Limits for 1 Hour	**2.96 ppmvd at 3% O2** is a ***68 % Improvement*** over the original 2001 AQMD Thermal Boiler Regulation, and when compared to the present New AQMD Gas Turbine Regulation, results in a ***406 % Improvement***.

The success of this major accomplishment to install the ***"WORLD'S CLEANEST THERMAL PLANT"*** is based on our optimum design, the philosophy of teamwork, hard work, and the management and expertise of principal Michael Medock along with Farrokh Ghoreishi.