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The Marine and Stationary Power Authority

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The County Sanitation Districts of Los Angeles County water treatment plant in Metro Los Angeles have installed Continental Controls Corp. ECV5 air/fuel control valves on five gaseous-fueled engines in an effluent pump station. The five new Waukesha Engine, Vee-configuration, 16-cylinder 9390 VHP units are each rated 1119 kW at 1200 r/min.

Taking Control of Gas Engine Issues

Continental Controls air/fuel ratio control valves help wastewater plant pump station meet emission goals

In an effort to gain maximum engine performance and stay within the local exhaust emission limits over a wide range of engine load and ambient conditions with the least amount of maintenance, operators at the County Sanitation Districts of Los Angeles County's Joint Water Pollution Control Plant wastewater treatment plant, located near downtown Los Angeles, California, U.S.A., have installed Continental Controls Corporation ECV5 air/fuel ratio control valves on five gaseous-fueled engines in an effluent pump station. The engines were installed during a facility upgrade to comply with an EPA-mandated expansion of the facility's secondary treatment process to increase flow.

The additional pumping capacity and expanded secondary treatment process allows the facility to treat 100% of the wastewater that flows into it with both the primary and secondary treatment processes. Before the upgrade, only 60 to 65% of the effluent went through both primary and secondary treatment processes before discharge. The remaining 35 to 40% completed only the primary treatment process. The upgrade has not changed the overall plant capacity; average flow is still about 1.23 billion liters per day.

The engine-driven pumps transfer effluent from the primary treatment facility to the secondary treatment process. During the transfer, the effluent overcomes an elevation gain of approximately 7.62 m from the end of the primary process to the head end of the secondary process.

The engine upgrade consisted of five new Waukesha Engine, Vee configuration, 16-cylinder 9390 VHP units rated 1119 kW at 1200 r/min. The engines are each connected to Flowserve type VCT single-stage vertical mixed-flow pumps. Each pump unit is rated approximately 662 million liters per day at 350 r/min. The pumping facility is designed around the maximum anticipated storm-condition flow (when water leaking into the wastewater sewers through holes in manhole covers and other means substantially increases the flow through the sewers and into the wastewater treatment plant) of approximately 2.65 billion liters per day. This can be met by four of the five pumping units running at maximum speed, with one engine/pump system left as a standby.

Each of the new engines burns natural gas as the primary fuel while propane is used as a backup. The previous engines used digester gas as the primary fuel — the change to natural gas was made in the interest of lowering exhaust emissions. Each engine is equipped with two separate fuel systems.

"The main reason for the dual systems is that the operators wanted no potential downtime related to fuel supply," said Glenn Fultz of Emission Compliant Controls Corporation. "This configuration allows the engines to continue operating even if there is a natural gas fuel supply problem. The engines simply must keep running or the secondary treatment process would not be able to operate, which would lead to lower-quality effluent being discharged from the plant."

With the installation of new engines, exhaust emissions regulations became a factor; the new engines had to meet current emissions requirements while the old engines did not. The facility requirements are 10.7 ppm corrected NO_x corrected to 15% O_2 and 70 ppm CO corrected to 15% O_2.

To assist with the process of ensuring these engines meet the regulations while running at peak efficiency,

As part of the fuel system upgrade, 20 Continental Controls Corporation ECV5 air/fuel ratio control valves were installed on the five engines. Here, an engine technician checks O_2 set points on one of the engines via the ECVI display. To the right is one of the Murphy panels that allows technicians to monitor myriad temperatures and pressures for each engine.

County Sanitation Districts of Los Angeles County called on Murrieta, California-based Emission Compliant Controls Corporation (ECC). ECC assists engine operators in the area of emissions compliance with Air Quality Management District (AQMD) in the state of California. The AQMD has been tightening the levels for VOCs, CO and NO_x.

"As these ranges get tighter, engine operators are finding it harder to keep up with the changes and the sophistication of the new engine management facilities," said Fultz. "We provide everything that has to do with the fuel controls and emissions reduction devices, such as catalysts. We have been using these types of products regularly to bring engines into compliance."

After the engines were installed at the plant, the operators had difficulty effectively controlling their operation on the propane fuel. Analysis revealed that the Btu value of the propane fuel was higher than the natural gas and that the original fuel control systems could not compensate with enough range, quickly enough for smooth engine operation within the emissions regulations on either of the two fuels.

To compensate for the difference in Btu value, the original fuel system allowed the propane fuel to pass through a mixer where ambient air was added. This diluted the mixture, lowering the Btu content of the propane fuel to more closely match the natural gas. However, with this mixing system, the Btu value of the propane became inconsistent causing the engine to surge under loads.

Further, it was found that the constantly changing ambient parameters of the application: temperature, humidity, load and natural gas fuel quality also had an effect on engine operation. Consequently, the engines were still not running at peak performance even on the primary natural gas fuel. This also caused the CO exhaust emissions to surge and spike along with exhaust temperatures, as well as catalyst temperatures.

To correct this situation, the operator was constantly making adjustments to O_2 set points to keep the engine running at peak efficiency, while staying within the range of emissions regulations, according to Bob Jackson of ECC.

In an attempt to find a solution, the CCC ECV5 air/fuel ratio valves and controllers were initially installed on the propane fuel systems of the engines. The Continental ECV5 system is able to adjust quickly enough to go with the condition differences. These systems corrected the problem and the operators found the interface much simpler to use, so it was decided to add the Continental systems to the natural gas fuel systems as well.

There are now a total of 20 ECV5 air/fuel ratio control valves installed on the five engines. Each engine is also equipped with a display and interface module that allows the operator to monitor exhaust oxygen concentration and fuel valve operating pressure, and also to make any necessary changes to the controllers, which are integral to each valve. In essence, the air/fuel ratio controllers are set up to run each engine as if they were two eight-cylinder engines — one controls each cylinder bank.

According to the operators and Fultz, continuous adjustment of the set points is a thing of the past, and the new control system requires very few, if any, adjustments at all. However, since the monitoring of CO began, operators have reported that every week or so, there is at least one engine that needs to have its O_2 set point slightly adjusted. In contrast, this is down from almost daily adjustments.

In this region of California, all new engine installations that are over 745 kW must have a continuous emissions monitoring system (CEMS). The system is required by the South Coast Air Quality Management District (SCAQMD) and is designed to make sure that every installation is in compliance. It is a self-monitoring system and operators are required to keep logs of operation. SCAQMD inspectors periodically perform spot checks of engine emissions and review records.

The CEMS does not include a CO analyzer so the operator never really knew what the CO emissions were. Recently, the operator purchased a portable emissions analyzer that can analyze the engine exhaust for NO_x, CO and O_2 concentrations to ensure compliance.

Each engine is monitored on-site or remotely via a Murphy gauge panel. The monitored parameters include such things as intake manifold vacuum, lube oil pressure and temperature, jacket water pressure and temperature, auxiliary water pressure and temperature, main bearing and cylinder head temperatures, pre- and post-catalyst temperatures and exhaust manifold temperatures. The panel provides shutdown protection for the engines if specific preprogrammed parameters are exceeded.

The engine also uses a Waukesha air filtration system. The exhaust silencers are 304 stainless-steel units from GT Exhaust System Inc. rated at 33 to 40 dB attenuation. The catalysts are Johnson-Matthey BX90 elements, two per engine. Each element is sized optimally to bring engine emissions down to permit levels. The oxygen sensors — two per engine, one on each cylinder bank — are from Bosch.

The hard pipe of the exhaust system is insulated by approximately 10 cm of calcium silicate covered by an aluminum jacket. The flanges, expansion joints and catalyst housings are insulated by two layers of Kaowool-type ceramic blanket material covered by a silicone cloth.

The remote-mounted oil filter housing contains cleanable cartridge-type filter elements that filter 100% of the engine's oil flow. The housing includes an internal bypass valve that will open in the event of high differential pressure across the filter. In addition, a Waukesha Engine Microspin oil flow-driven centrifuge that develops approximately 2000 times the force of gravity takes a portion of the oil flow and separates out particulates down to 0.5 microns. The unit uses a disposable paper insert for easy maintenance.

Jacket water cooling is done via FLAT-ROUND mechanical bond radiators from Young Touchstone. These are horizontal core, vertical fan air discharge remote radiators.

Each pumping unit is equipped with an external flywheel that weighs approximately 4536 kg. It is driven by the engine output driveshaft and, in turn, is connected to the input shaft of the right angle gearbox for the pump. The purpose of the flywheel is to prevent a surge of flow backward through the pumps' discharge pipe in the event that one or more of the pumps trip.

Start and stop of the engines is done manually, while speed control and shutdown monitoring is done automatically. The air/fuel ratio control is also done automatically with the newly installed Continental Controls Corporation ECV5 controllers.

The new engines had a staged installation, the first two coming online in 2002. The first two engines were installed in empty engine bays that were part of the original facility design to accommodate future expansion. The second phase was completed with the final three engines installed one at a time in place of three of the original engines. At the time of this writing, the last engine has been installed. However, it has not been officially commissioned and remains offline.

These new engines also allow the use of higher flow pumps and consequently four engine/pump sets are all that is needed to meet any flow requirements for total plant capacity. The fifth engine/pump set is intended as a backup.

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