

Recirculating Cooling Water System at Gas Fired Power Station



BACKGROUND

In the middle of 2009, controlled trials of the application of chlorine dioxide as an alternative cooling water biocide was undertaken at a gas fired power station in the United Kingdom.

The 1420 MWe gas fired power station combusts natural gas in four combined cycle gas turbine (CCGT) units (Units 1 - 4). The station has a recirculating hybrid tower cooling system, with estuarine water abstracted from the local river as circuit make-up.

The estuary up to the site is designated as a Site of Special Scientific Interest, notified under the Wildlife and Countryside Act 1981, a Wetland of International Importance under the Ramsar Convention and a Special Protection Area under the EC Conservation of Wild Birds Directive. These designations stem from the international importance of this estuary for migratory wildfowl and wading birds.

These large bird populations use the productive mudflat and salt-marsh areas for feeding and roosting sites. The estuary also acts as a nursery area for several species of fish, and has been designated as a bass nursery area. Any adverse effects on the invertebrate populations living in the mudflat areas would be of considerable significance for these bird and fish populations.

PROJECT

The cooling water is circulated through low-level hybrid cooling towers with wet and dry sections, where the heat is rejected to atmosphere via conduction, convection and primarily evaporation.

Each of the four cooling towers comprise a total of ten cells arranged in two independent banks of five. These banks are designated as Tower A and Tower B, with each bank servicing one side of the unit condenser. The towers are of induced draft type, with top horizontally mounted fans. The lower section of the tower acts as a conventional evaporative tower with plastic film packing. The top section has dry air cooled finned tube heat exchangers to provide alternative cooling for plume control during cold winter periods.

Biofouling control in the cooling system with the existing sodium hypochlorite dosing system has not been effective. This is due in part to environmental restrictions on dosing. This has resulted in the formation of microbial slimes and silt deposition in the cooling system, reducing unit efficiency and compromising cooling tower integrity.

Hypochlorite dosing has resulted in the formation of unwanted disinfection by-products. As a result of these problems, alternative

biocides have been investigated that could potentially provide improved biofouling control and environmental performance at the station by comparison to hypochlorite. Chlorine dioxide was then selected for site trial in consultation with the Environment Agency. The trial was carried out for four months using a turnkey ClO₂ generation system, based on the Purate™ technology.

Generating Unit 4 was designated as being the most suitable unit to perform the trials. One stream (Tower A) was dosed with chlorine dioxide; the other stream (Tower B) was undosed to provide a performance benchmark. The existing hypochlorite dosing system was not in service during the trial.

EFFICACY OF CHLORINE DIOXIDE

Biological monitoring during the trial clearly demonstrated both the efficacy of chlorine dioxide as a biocide for cooling water and, importantly, the ability to control biofilms from fouled surfaces.

By the end of the trial, biofouling plates installed under the tower pack were almost completely clean in the dosed circuit. By contrast, plates in the undosed circuit exhibited significant fouling and microbiological slimes. This clearly demonstrated that a significant improvement in tower pack condition could be achieved with chlorine dioxide such that the frequency of tower pack replacement would be much reduced and tower integrity improved.

This trial shows chlorine dioxide can offer the following potential advantages:

- Halogenated organic disinfection by-products, such as chloroform and other trihalomethanes were not detected.
- Organobromine compounds were not detected.
- Chloramines were not detected.
- Less of the chlorine dioxide needs to be dosed for effective biofouling control.
- It is efficient over a wide pH range (5.0 to 9.5).
- It can control biofilm.
- Chlorine dioxide is very reactive and any residual is short lived in natural waters.

IMPROVEMENTS IN STATION PERFORMANCE

Unit 4 ran almost continuously throughout the four months of the chlorine dioxide trial with only an overnight reduction in load, therefore providing the best chance for an accurate evaluation. As a rule, the unit fluctuated in generation only between the Stable Export Limit (SEL) at 230 MW production and the Maximum Export Limit (MEL) of 345 MW to meet demand.

The control of biofilms and deposits within the cooling system through chlorine dioxide dosing resulted in a significant improvement in each and every performance parameter in Tower A by comparison to Tower B:

- A relative decrease of 0.9°C (1.6°F) in pond temperature and 0.5 to 1.5°C (0.9 to 2.7°F) in condenser cooling water inlet temperature
- A gradual decrease in Tower A cooling water pump pressure of 0.2 bar (12.9 psi), equating to a 6% overall reduction. This would have had the effect of increasing circulating cooling water flow by around 1,000 tonnes per hour (4,400 gpm) relative to a normal flow of between 7,000 and 9,000 tonnes per hour (30,900 and 39,600 gpm). This represents a significant increase in capacity to reject heat from the water. By comparison, the Tower B pump pressure remained steady.
- It is estimated that chlorine dioxide dosing would increase overall unit efficiency by a conservative figure of 0.11% by reducing the cooling water temperature by 1°C (1.8°F). In practice, the improvements observed in all cooling system performance indicators during the trial suggest that a larger improvement may be possible.

The results of the trial improvements from chlorine dioxide dosing at the station include:

- A generating unit efficiency increase of 0.11% as a result of significantly improved heat transfer from the control of biofilms and associated deposits from cooling system surfaces.
- This efficiency increase equates to a projected annual carbon dioxide emissions of 2,235 tonnes per unit or 8,950 tonnes for the station
- A significant reduction in waste generated on site due to much reduced frequency of tower pack replacement, if required at all
- Chemical use would be expected to decrease once the cooling system is clean
- The chlorine dioxide residual is very short lived and decay is rapid in estuarine water. Therefore, chlorine dioxide concentrations are expected to be negligible in the final station discharge, particularly given the additional residence time provided by the purge pond.

NET COST SAVINGS FOR THE STATION

To provide an indication of the level of performance improvement expected from chlorine dioxide dosing, it was hypothesised at the start of the trial that by dosing the Tower A cooling water system, a decrease of 0.5 - 1.0°C (0.9 - 1.8°F) in pond temperature would be realised in comparison to the undosed Tower B due to the removal of biofilms and deposits of low thermal conductivity from heat transfer surfaces within the Tower A system, thereby providing a direct increase in plant thermal efficiency.

Based on a conservative temperature improvement of 0.9°C (1.6°F), the permanent installation of chlorine dioxide dosing is expected to result in annual net cost savings of between \$970,000 - \$2,587,000 for the station from efficiency improvements and reduced frequency of tower pack replacement. If, as expected, an improvement of 1.5°C (2.7°F) is realized, the net annual saving

will be between \$2,280,000 and \$4,270,000.

It must be noted that the cooling water temperature decrease of 0.9°C (1.6°F) represents a conservative estimate from data evaluation. Furthermore, the reduction in circulating water pump pressure showed no indication of leveling out. Therefore, the efficiency benefits from a permanent installation are likely to be greater than those estimated from the results of the trial alone.

RECOMMENDATION OF CUSTOMER'S ENGINEERING

Overall, the cost benefits from implementing chlorine dioxide dosing are considered to be significant. Based on this finding, permanent installation was recommended.

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