ZERO LIQUID DISCHARGE: BOTTOM ASH TRANSPORT WATER

White Paper

Abstract | *One of the major compliance hurdles introduced by the recently-finalized Effluent Limitations Guidelines (ELGs) is the establishment of a zero liquid discharge (ZLD) configuration for existing bottom ash systems. Bottom ash management systems vary widely from station to station, but they generally include some or all of the following eight components: source water supply; ash sluice pumps; boiler hopper; clinker grinder; hydrobins/dewatering bins; ash filter ponds; surge/equalization tanks; and recirculation pumps. This white paper, authored by David Weakley II, PE, Assistant Engineering Manager at GAI Consultants, outlines nine steps to serve as a starting point for stations gearing up for ELG compliance. The steps include creating and verifying the station water balance; isolating the ash sluice system; determining a make-up water source to the bottom ash system; completing a hydraulic analysis; eliminating uncontrolled influent flows into the closed loop system; understanding chemistry issues of a closed-loop system; identifying opportunities for ELG compliant blowdown of the bottom ash system; removing fines; and implementing operator and control changes.*

Introduction

Many coal-fired power stations were designed decades before the scientific community became aware of the negative environmental impacts that ash sluice water can have on receiving bodies of water. Previously, station engineering and design would often incorporate reuse of sluice water in other plant processes, including use as make-up water for Flue Gas Desulfurization (FGD) scrubber systems. While this concept may still be maintained, the ELGs will require stations to take a close look at their bottom ash systems and determine additional options for eliminating all associated liquid discharges. The steps outlined below serve as a starting point for stations gearing up for ELG compliance.

Step 1: Create and Verify the Station Water Balance

Priority number one for ELG compliance is to create and verify the power station water balance. Please refer to our previous installment for more discussion on the benefits of having an accurate, up-to-date station water balance. If a working water balance has already been developed, further steps may be taken to improve its accuracy and completeness. Helpful additions to the water balance include minimum, average, and peak flowrates through pump stations and pipelines. Historical flow data should be verified periodically to ensure that operating conditions are represented accurately. Additional details should also be included for standard operation, partial outage, and full outage conditions. Each of these scenarios may have dramatically different water consumption patterns, and all possible operating configurations should be evaluated.

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Step 2: Isolate the Ash Sluice System

Isolate the ash sluice system and identify all influent and effluent sources of water. Drawing a theoretical "box" around the existing bottom ash system will allow the

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station to establish the boundaries of the required ZLD system. Particular attention should be paid to stormwater entering the system via surface runoff into ash filter ponds. Once stormwater comes into contact with ash material, it becomes part of the bottom ash system and must be managed accordingly. Preventing stormwater runoff from entering the system can drastically reduce the amount of water that the station must manage in order to meet the requirements established by the ELGs. Another critical area of concern is the establishment of appropriate discharge locations for bottom ash system overflows. Currently, many bottom ash system overflows are diverted to stormwater collection systems or to the station's industrial water treatment system. Under the ELGs, these strategies will no longer be considered viable options for overflow management, since each will ultimately result in discharge of bottom ash water.

Step 3: Determine a Make-Up Water Source to the Bottom Ash System

The next step in developing a ZLD bottom ash system is controlling the influent water supply. Potential source water options for make-up water supply to the bottom ash system include the following:

- Cooling tower circulating water (blowdown)
- Raw surface water (e.g., streams, rivers, and lakes)
- Groundwater
- Industrial water treatment effluent
- Treated ash leachate
- Captured stormwater
- Reclaimed municipal wastewater

Where available, reclaimed municipal wastewater may be an economically attractive source of make-up water since municipalities may offer a financial incentive for its usage. Regardless of the make-up water source or sources selected, a reliable water supply that can be accessed on an as-needed basis is preferable to the use of a constant source of fresh water for continuous sluicing. Water sources with irregular flow patterns may be controlled by a surge/equalization tank or sump level controller within the ZLD system to ensure that water is always available when needed.

Step 4: Complete a Hydraulic Analysis

Performing a hydraulic analysis of the station's bottom ash management system will allow for determination of the station's current ash sluicing needs, including the following:

- Ash sluice water volume requirements
- Average and peak sluicing flowrates
- Typical duration of ash sluicing
- Frequency of ash sluicing events

It is important to consider all of the station's operating conditions, including the following:

- Full operation, full load
- Full operation, reduced load
- Partial outage, full load
- Partial outage, reduced load
- Full outage

Regardless of the make-up water source or sources selected, a reliable water supply that can be accessed on an as-needed basis is preferable to the use of a constant source of fresh water for continuous sluicing.

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Although ash sluicing does not occur during full outage scenarios, stations must be prepared to manage the water residing within the ZLD bottom ash system during these periods. With this information, the station may determine the size, number, and capacity of recycle pumps and surge tanks necessary to accommodate its water supply needs.

Step 5: Eliminate Uncontrolled Influent Flows into the Closed-Loop System

After the bottom ash system has been isolated and a ZLD configuration has been proposed, all other uncontrolled influent streams into the bottom ash system will need to be eliminated or managed effectively. One of the largest potential uncontrolled contributors of water to the ZLD system is stormwater runoff collected by ash ponds. Sites may need to be regraded and storm drains may need to be plugged or rerouted in order to address this issue. Other sources of water that may enter the ZLD system could be effectively managed if the volumes are low enough. Examples of these low-volume water sources include demineralizer or reverse osmosis reject wastewaters. All extraneous and uncontrolled sources of water into the ZLD bottom ash system will need to be removed in order to allow for complete operator control of system influents, unless that source was determined to be a suitable make-up water source to the bottom ash system.

Stormwater runoff is one of the largest potential uncontrolled contributors of water to the ZLD system

Step 6: Understand Chemistry Issues of a Closed-Loop System

Bottom ash water is hot and is prone to evaporation once it reaches the hydrobins and ash ponds. As the heated bottom ash water evaporates, dissolved solids such as calcium, magnesium, and chlorides are left behind to further concentrate, creating water chemistry issues that are very similar to those observed in cooling towers. Conversion of the bottom ash system to a ZLD configuration will further increase the amount of dissolved substances that accumulate as sources of solids removal are eliminated. Over time, scale and corrosion caused by elevated dissolved solids concentrations can ravage a piping and pumping system, leading to costly repairs and potential outages. It is imperative that stations control the cycles of concentration inside the ZLD bottom ash system to prevent these avoidable catastrophic failures. Stations will need to become familiar with the water chemistry associated with their system in order to develop effective strategies for control. Different sources of coal can introduce differing chemical constituents into the system, and laboratory analysis will be necessary in order to develop a full understanding of each individual system's unique internal chemistry.

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Step 7: Identify Opportunities for ELG Compliant Blowdown of the Bottom Ash System

Under the new ELG rule, bottom ash sluice water may be used for FGD scrubber make-up. This allowance can address two major issues with the station's water balance:

- Supplying the FGD scrubber with wastewater in lieu of fresh water, decreasing water withdrawals
- Allowing the bottom ash system to blowdown to the FGD scrubber, maintaining the water chemistry within the ZLD system

If the station does not have a wet FGD scrubber system, it must rely on the entrained moisture in the dewatered bottom ash to serve as a form of blowdown. In many cases, this may not be sufficient to maintain chemistry within the ZLD system. Chemical additives such as corrosion inhibitors, flocculants, and acids/caustics for pH adjustment may be required to mitigate the negative impacts of dissolved chemical constituents within the system.

Step 8: Remove Fines

Hydrobins and ash filter ponds are capable of removing the majority of insoluble bottom ash material from the sluice water. However, bottom ash water also contains very small colloidal particles that do not settle out of solution under normal operating conditions. These particles are known as "fines," and they will need to be removed from the system in order to curtail potential corrosion issues that they may introduce. Fines are abrasive, and over time they will wear on pump impellers, valves, and pipe elbows if they are not removed. Options for fines removal can be chemical, such as the addition of polymeric flocculants, or physical, such as occasional removal using a rented vacuum truck. Stations will need to evaluate various options for fines removal in order to ensure that their bottom ash system equipment is protected.

Step 9: Implement Operator and Control Changes

A compliant ZLD bottom ash system will need to be operated with more care and attention than standard bottom ash systems. Typically the overflows of tanks and ponds can comingle bottom ash waters with stormwater or other systems, but in the future this would lead to potential ELG violations. It is recommend that new instrumentation and controls be included within the retrofitted bottom ash system in order to give station personnel a better handle on their system's current operational conditions to prevent this. Examples of instrumentation and controls to consider include level controls for tanks and vessels and in-line analytical instruments for real-time evaluation of system water chemistry. Operator training and system safeguards such as locked valves and blind flanges will decrease the opportunity for violations.

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Conclusion

Through evaluation of the existing system's overarching water balance and chemistries, cost-effective and innovative solutions can be engineered to protect the power station from potential violations as these new ELGs become effective. Closed-loop bottom ash water systems can and should be implemented with considerations to maximize the system's efficiency and effectiveness. By following these nine steps, power stations will be better positioned to comply with the ELG requirements while maintaining, if not improving, the power station's overall operations.

For more information on the ELGs and what they mean for the coal power industry, download this guideline document outlining the new contaminant concentrations that stations must meet and the proposed timelines for compliance.

For questions or additional information on developing a ZLD bottom ash system and ELG compliance, contact Senior Engineering Manager Arica DiTullio at 412.399.5455.