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Dry Ash Conversions

BY KEVIN L. MCDONOUGH

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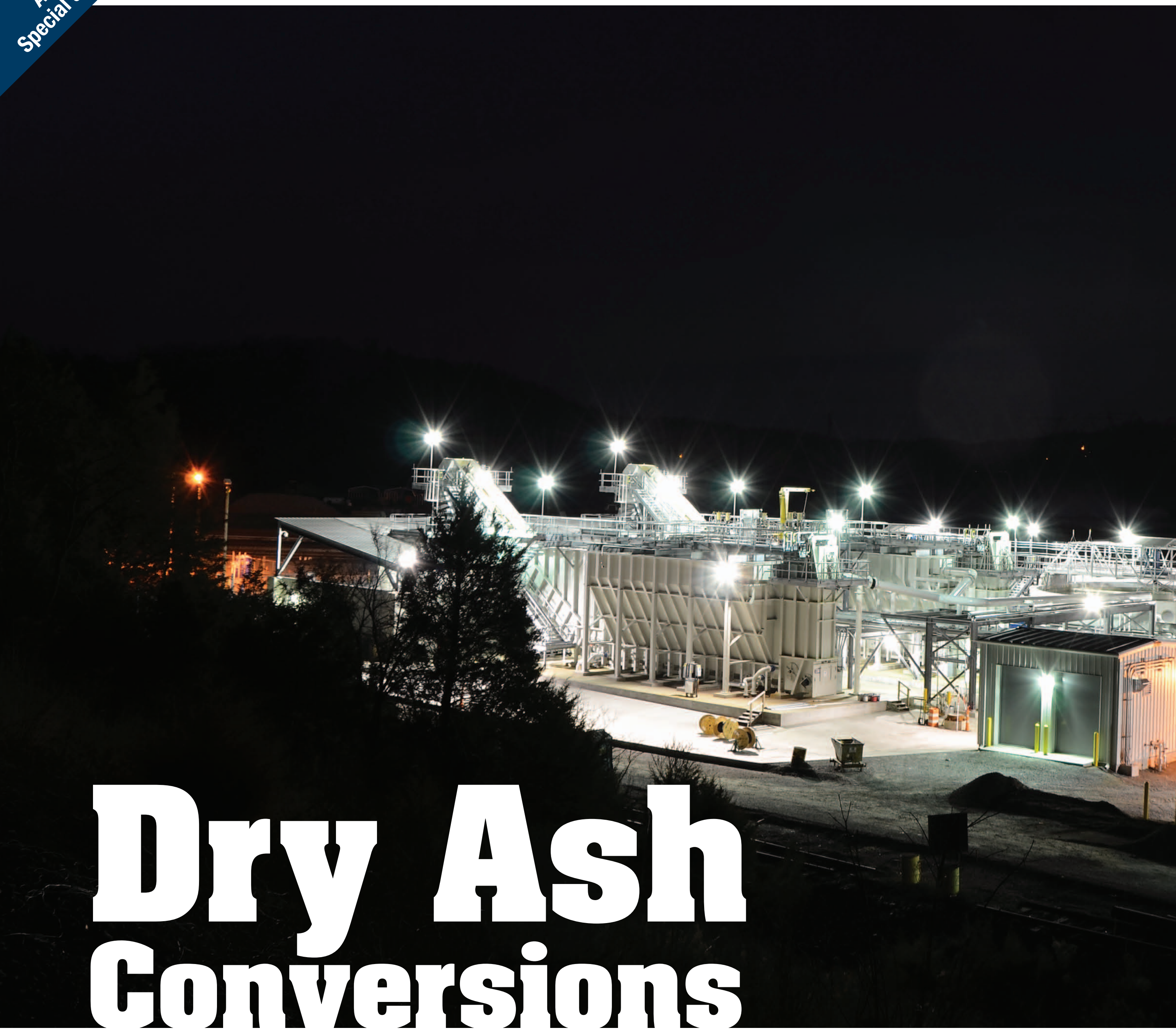

Dry Ash Conversions

Implications, Options and Technical Considerations for CCR & ELG Compliance

BY KEVIN L. MCDONOUGH

With the final issue of the Environmental Protection Agency (EPA) Coal Combustion Residual (CCR) rules on April 17, 2015 and the Steam Electric Power Effluent Limitations Guidelines (ELG) on Nov. 3, 2015, utilities now have defined compliance requirements for post-combustion solid waste management, groundwater and surface water and wastewater management.

After nearly five years of data collection, technology and cost evaluations, draft rulemaking, public comment and industry commentary, utilities now have the regulatory clarity necessary for compliance strategy development, technology selection, budgeting, permitting, scheduling and ultimately project implementation. As a result, numerous utilities are now moving forward with project planning and execution in accordance with the compliance requirements and deadlines. Project activity presently includes existing

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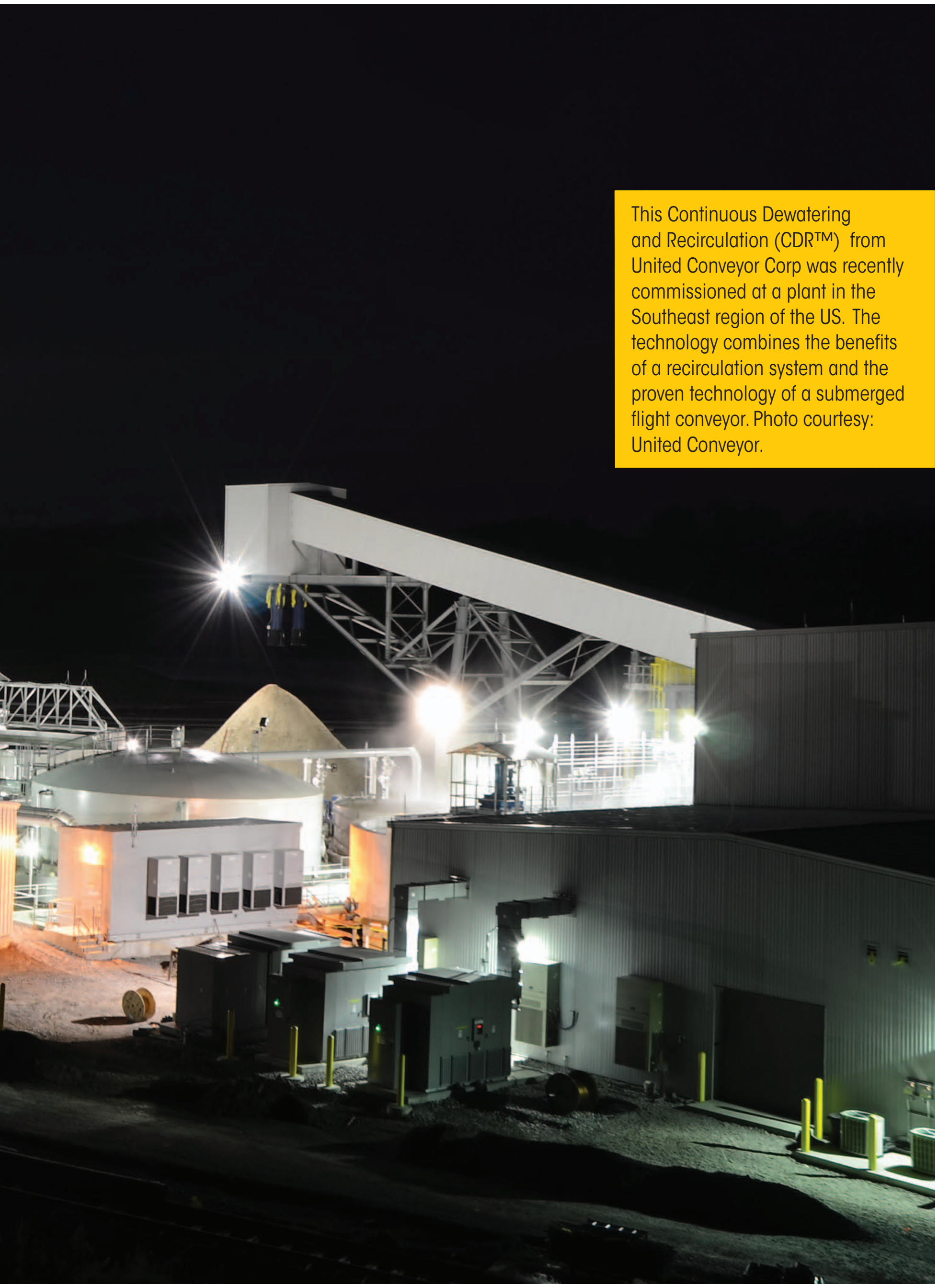


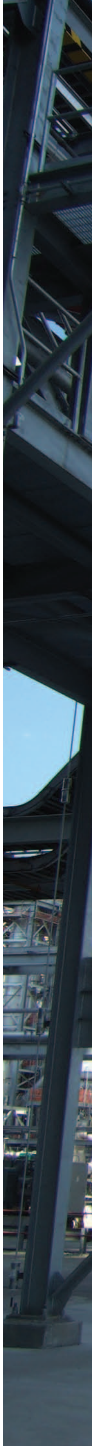
This Continuous Dewatering and Recirculation (CDR™) from United Conveyor Corp was recently commissioned at a plant in the Southeast region of the US. The technology combines the benefits of a recirculation system and the proven technology of a submerged flight conveyor. Photo courtesy: United Conveyor.

CCR impoundment stabilization, dry landfill expansion/construction, groundwater monitoring, fly ash and/or bottom ash wet-to-dry conversions, gypsum dewatering, wastewater treatment and overall plant water balance management. This activity is expected to continue in earnest for the immediate three to five years and largely conclude in 2023 at the close of the ELG compliance window.

The CCR rules target benefits such as ground water protection and the prevention of CCR impoundment catastrophic failures. As opposed to the initial draft rule, which was more focused on the closure of surface impoundments, the final rule was issued with a more defined set of criteria by which coal unit operators could continue to utilize surface impoundments as an alternative to complete wet-to-dry conversions. Its focus is based on the following implementation timeframes from the publication of the rule: a) location restrictions (aquifer, wetlands, fault zones, seismic zones and unstable areas): 42 months; b) design criteria (lined/unlined, leaking/not leaking, structural integrity): 18 months; c) operating criteria (flood control, fugitive dust control, inspections): six to 18 months; d) groundwater monitoring and corrective action: 30 months; e) closure requirements and post-closure care: 36 to 162 months; and f) recordkeeping, notification and internet posting: 6 months.

The ELG rule seeks to strengthen the controls on discharges from steam electric power plants by revising technology-based effluent limitations guidelines and standards for the steam electric power generation industry. It also seeks to reduce the amount of potentially harmful metals and other pollutants discharged to surface water (direct discharges) and publicly owned treatment works (indirect discharges to POTWs). Targeted wastewater streams include Flue Gas Desulfurization (FGD) Wastewater, Fly Ash and Bottom Ash Wastewater, Flue Gas Mercury Control (FGMC) Wastewater, Combustion Residual Leachate from Landfills and Surface Impoundments, Nonchemical Metal Cleaning Wastes and Coal and Pet Coke Gasification Wastewater. According to the EPA, Best Available Technology (BAT) compliance technologies include chemical precipitation, biological treatment, evaporation, dry handling and properly designed surface impoundments for the differing waste streams. For fly ash and bottom ash, however, the technology basis for compliance is dry handling or closed-loop zero liquid discharge (ZLD) systems for all units >50MW, with the exception that fly ash and bottom ash transport waters can be used as a source of FGD process water. For generating units <50MW, the ash systems must meet Best Practicable

This Continuous Dewatering and Recirculation (CDR™) system from United Conveyor Corporation is installed at a plant in South Carolina. The technology was the preferred wet-to-dry conversion option due to physical limitations underneath the boiler. Photo courtesy: United Conveyor.



Technology (BPT) requirements that include Total Suspended Solid and Oil/Grease limitations in the ash effluent wastewater streams. The rule mandates a compliance timeframe that is "as soon as possible beginning November 1, 2018, but no later than December 31, 2023". Under the implementation approach, each state (permitting authority) shall confirm the required compliance date within the defined window with particular consideration for existing National Pollutant Discharge Elimination System (NPDES) permit validity dates and sufficient timelines for implementation. The combination of the CCR and ELG requirements will likely drive dozens of wet-to-dry conversions, pond closures, along with dry landfill and wastewater treatment projects. In fact, numerous projects are currently underway.

While the ELG does mandate ZLD requirements for both Fly Ash and Bottom Ash transport water, it is worth noting that the EPA has attempted to incorporate some operational flexibility to account for typical plant operating conditions and maintenance activities. Specifically, the ELG notes that "transport water does not include low volume, short duration discharges of wastewater from minor leaks (e.g. leaks from valve packing, pipe flanges, or piping) or minor maintenance events (e.g., replacement of valves or pipe sections)."

The overwhelming majority of utility installations currently utilize dry handling systems for fly ash (>85%). These positive and negative pressure pneumatic systems in various dilute and dense phase conveying regimes, have been proven to be highly reliable systems if properly designed, operated and maintained consistent with fuel/ash characteristics and plant operating conditions. The new ELG requirements will likely result in dry ash conversions for any remaining wet handling systems, along with the decommissioning of existing wet back-up systems. Utility operators may elect to install additional redundancy for primary dry systems that currently utilize wet back-up systems.

In contrast to fly ash, many installations presently utilize wet sluicing systems to transport bottom ash from the operating units to surface impoundments. Due to the traditional coal unit boiler and associated bottom ash hopper designs, wet-to-dry conversions pose numerous unique design considerations, such as boiler operating seal requirements, spatial limitations both under the boiler and

The patented 100% Dry Pneumatic Ash Extractor (PAX™) from United Conveyor is installed at a plant in the Eastern US, as they preferred a conversion solution that removed water as a conveying medium. Photo courtesy: United Conveyor.

beyond the walls of the powerhouse, water balance requirements, as well as unit outage considerations.

Although the technical and economic criteria is unique to a given plant, consideration must be given to a multitude of variables in order to determine the optimal solution for compliance. Accordingly, a single technical solution does not necessarily translate to all bottom ash applications (i.e. "one size does not fit all"). Therefore, selecting the most appropriate technical alternative requires careful evaluation of a combination of factors including: schedule requirements, site impacts, spatial constraints, budget, outage requirements, site environmental considerations, ash conveying capacities and distance, ash marketability/beneficiation, unburned carbon concerns, ash characteristics, physical parameters, multiple unit synergies, plant water balance and maintenance requirements. Due to the extent and complexity of the project variables, it is also critical to select a technology provider with sufficient experience, proven reference installations and execution capacity to meet the needs of the plant within a defined timeframe.

Relative to the survey of Best Available Technologies (BAT) noted in the ELG, UCC has implemented various technologies throughout the U.S. utility coal fleet, which are summarized below.

UNDER BOILER SUBMERGED FLIGHT CONVEYOR (SFC) SYSTEM

System Overview:

The SFC collects bottom ash from the boiler into a water-filled trough where it quenches and cools the ash. Horizontal flights move the ash continuously through the trough and up a dewatering ramp where it is then discharged into a load-out bunker or secondary transfer conveyor. Bottom ash is typically allowed to dewater in the bunker to 15 percent or 20 percent moisture, which is ideal for fugitive dust emission control and landfill compaction. In addition, the SFC produces a dewatered product with a consistent particle size distribution suitable for beneficial reuse. Overflow water from the SFC trough is commonly captured, cooled and recirculated to complete a zero liquid discharge system, although the final ELG allows some flexibility for the management of cooling water overflows. The under boiler SFC has been the industry standard on new units for the past few decades. In addition, numerous utilities have successfully retrofitted SFCs on existing units. The SFC is a proven bottom ash system and a cost-effective solution when long-term life cycle costs are a major decision factor and when existing bottom ash hoppers may be in need of repair. Feedback from existing reference installations has indicated that maintenance costs for an SFC System are only 1/3 that of a conventional water-impounded bottom ash hopper and sluice conveying system.

This under-the-boiler Submerged Flight Conveyor (SFC™) by United Conveyor is installed at a plant in Midwest. Numerous utilities have successfully implemented the SFC technology which has been the industry standard on new units for the past few decades. Photo courtesy: United Conveyor.

System Design Considerations:

The key variables that determine viability for an SFC retrofit include available physical space and planned outage schedules. Many existing boilers do not possess the physical space to accommodate an SFC retrofit due to limited headroom between the boiler throat and grade, deep bottom ash hopper pits, structural steel interferences, equipment/ductwork interferences around the bottom ash hopper or limited space outside the powerhouse wall for storage, truck traffic or ash transfer. In addition, this retrofit will require removal of the existing bottom ash hopper and associated equipment. As such, the retrofit typically requires a 6-8 week outage for successful project execution. If the SFC cooling water overflows are captured in a closed-loop system, the system must be designed to ensure that the water temperatures are maintained at appropriate levels, often requiring some form of heat exchanger in the hydraulic system.

DEWATERING BIN SYSTEM

System Overview:

Conventional dewatering bin systems, often with associated settling and surge tanks, have been implemented throughout the U.S fleet since the 1960s and represent the traditional approach to bottom ash closed-loop design. Dozens of these systems are currently in operation, although performance issues related to maintainability and operability have been noted for these prior generation dewatering solutions. Recent design enhancements, including improved dewatering elements, valves and operational sequencing, have addressed many of the performance concerns. If designed, operated and maintained properly, this technology still represents a viable wet-to-dry conversion solution, and particularly if a plant currently has existing dewatering bins installed as a means of coarse particulate separation with overflows directed to an operating surface impoundment. In this scenario, the system can be retrofitted to a closed-loop system with the addition of settling and surge tanks and associated return water pumps, valves and piping. Several units have recently been converted using this approach and are in compliance with the ELG zero liquid discharge requirements.

System Design Considerations:

Due to the scope of the system – including multiple tanks, overflow piping, underflow piping, valves, pumps, etc. – system controls and associated operation can be complex. Redundancies must also be balanced with added complexity. In addition, these systems can retain ash in solution for extended periods of time, often numerous days and even longer in certain circumstances. In these cases, additional consideration has to be given for the water quality/chemistry in a closed-loop system, particularly relative to the zero liquid discharge requirements of ELG. Plants must determine and specify their desired approach for water sampling and analysis for ongoing water quality management, which can be accomplished via additional system instrumentation and continuous monitoring or intermittent sampling and analysis. To manage unanticipated excursions in water quality, the system can also be designed with blowdown provisions; in particular, bottom ash sluice water can be used as a FGD system makeup water source or as a dry fly ash conditioning water source.

CONTINUOUS DEWATERING AND RECIRCULATION (CDR) SYSTEM

System Overview:

The Continuous Dewatering and Recirculation (CDR) system with Remote Submerged Flight Conveyors (R-SFC) is a preferred wet-to-dry conversion option for installations that have physical limitations underneath the boilers and seek to minimize costly outage-related activity, while also realizing the benefits of the SFC, which produces a highly consistent dewatered bottom ash product.

The CDR system is designed to receive existing sluice conveying lines and divert the bottom ash slurry to a remote dewatering conveyor located outside of the powerhouse. Material is collected, dewatered and then discharged into a load-out bunker or secondary transfer conveyor to a condition that is favorable for transport to and compaction in a dry landfill. In addition, the CDR system can be readily designed to ensure that beneficial reuse products can be separated.

After completing a fine particulate settling phase, the sluice water is then pumped back to the boiler house to complete a closed-loop, zero-liquid discharge system. The CDR system has been designed to address the complexities of a bottom ash water balance, considering multiple flow sources, intermittent conveying cycles and variable flow rates. The conversion option is highly favorable when considering physical space limitations underneath the boiler and maintaining plant availability, as this can be implemented with little to no outage requirements if commissioning is planned and executed properly.

System Design Considerations:

For CDR systems, R-SFC location, conveying distance and hydraulic profile are key variables in the proper design of the closed-loop system. Accordingly, pump selection, sizing and quantity are key factors in the system design. Experience is essential to properly select pumps that balance the flow and pressure requirements with the anticipated water quality.

As with the dewatering bin system, additional consideration has to be given for the water quality/chemistry in a closed-loop system, particularly relative to the zero liquid discharge requirements of ELG. Plants will need to monitor water quality in the closed-loop system.

Should an installation have a particle size distribution that has an increased concentration of fines in the bottom ash water recirculation system (e.g. finer bottom ash, economizer ash, etc.), the CDR system can also be scaled to provide for additional settling area, additional mechanical particulate separation and/or polymer addition to reduce TSS concentrations in the recirculating water.

CDR SYSTEM WITH CLARIFIER

System Overview:

The CDR System with clarifier matches the system described above, but with an additional clarification phase that reduces the Total Suspended Solids (TSS) concentration in the bottom ash transport water. The additional clarification phase is provided by means of a thickener/clarifier located downstream of the remote submerged flight conveyor (R-SFC) with polymer addition. This technology selection is suitable for installations that anticipate a higher concentration of fines in the ash particulate or require lower TSS levels suitable for certain types of recirculation pumps.

System Design Considerations:

If the plant desires to keep existing high pressure "clean water" slurry pumps in operation, the CDR System with clarifier is highly effective in producing water quality (TSS) suitable for these types of pumps. In addition, this system, while likely higher in both capital and operating cost, will provide greater control in water quality should the bottom ash sluice water be needed as a source for FGD makeup or dry fly ash conditioning water.

PNEUMATIC ASH EXTRACTOR (PAX) SYSTEM

System Overview:

The patented UCC PAX Pneumatic Ash Extractor is a preferred wet-to-dry conversion alternative when a plant desires to convert from the traditional water-impounded hopper design and eliminate water usage for the bottom ash systems. As a 100% dry solution, the PAX system is particularly ideal for installations that have physical limitations under the boiler. For this technical alternative, bottom ash is collected dry in a refractory-lined hopper under the boiler. Percolating air cools the ash to help complete combustion of unburned material and protection of ancillary equipment. As the ash cools, it is crushed then fed into a pneumatic vacuum conveying line and transported to a storage silo or transfer station for dry bottom ash unloading.

System Design Considerations:

One of the important design features of the PAX system is the design of the dry, refractory-lined hopper. Similar to traditional systems, this multi-V hopper provides for system redundancy and operational flexibility during upset conditions. The system can also be designed with additional boiler isolation features that provide improved reliability.

For PAX systems, vacuum conveying distance and Dry Bottom Ash Silo location are key variables in the proper design of the conveying system. In addition, ash characteristics (specific gravity, density, chemical constituents, etc.) and generation rates are also of essential importance in system sizing and equipment selection.

Several utility clients have recently selected PAX as their preferred bottom ash compliance technology and several others are actively investigating its potential application. Utility feedback indicates that the condition of the existing bottom ash hoppers, long-term life cycle cost analysis and environmental risk analysis are key factors in the PAX system evaluation. Based on favorable field data from operating references on O&M costs, the PAX option may be ideal if existing bottom ash hoppers need to be significantly repaired/replaced and/or an owner wants to remove bottom ash sluice water from their environmental risk profile to address current ELG requirement and longer term regulatory exposure.

ECONOMIZER ASH IMPLICATIONS

The new rules made no new distinction for economizer ash. As presently defined, economizer ash is considered fly ash when "it is collected with the fly ash systems" and bottom ash when "it is collected with the bottom ash systems." With this apparent regulatory flexibility, plants will have the option to manage economizer ash as is deemed most appropriate relative to key variables including existing system operation, fly ash and bottom ash beneficial reuse and cost. In any case, economizer ash can be incorporated into the dry fly ash or dry bottom ash systems with proper consideration for generation rates, particle size distribution and unique material characteristics.

> "Economizer ash can be incorporated into the dry fly ash or dry bottom ash systems with proper consideration for generation rates, particle size distribution and unique material characteristics."

MILL REJECTS (PYRITES) IMPLICATIONS

The CCR and ELG rules made no new distinctions for mill rejects, as these are not included in the definition of coal combustion residuals.. The majority of existing Mill Reject (Pyrites) removal systems currently use sluice conveying systems for removal and most are connected in some manner to the existing bottom ash sluice conveying systems and discharged to surface impoundments. In any case, the Mill Reject systems can be readily tied into SFC, CDR or Dewatering Bin Systems or can be segregated via independent systems to allow for bottom ash separation and beneficial reuse.

CONCLUSION

While the final Coal Combustion Residual and Effluent Limitations Guidelines present challenging regulatory requirements for new and existing coal unit installations, numerous options are available to achieve compliance, and in many cases improve system operations with newer technologies. A careful evaluation of multiple alternatives, with consideration for each unique set of plant operating and design criteria can result in an optimal selection of a safe, reliable and cost-effective compliance solution for fly and bottom ash handling. pe