REINHOLD ENVIRONMENTAL Ltd.

2017 APC & Wastewater Round Table & Expo Presentation

July 17 & 18, 2017 in Charlotte, NC / Hosted by Duke Energy

UNITED CONVEYOR CORPORATION

Industry Update: Wet-to-Dry Ash Conversions & Review of Recent Case Studies

Prepared for: 2017 APC-Wastewater/PCUG Conference

Presented By: Gerald Long

17 July 2017

Discussion Overview

- Regulatory Update & Implications
- Technology Selection Criteria & Summary of Recent Ash Conversion Activity
- PAX Dry Bottom Ash Technology Review
- (3) Recent Wet-to-Dry Conversion Case Studies

Discussion Overview

- **Regulatory Update & Implications**
- Technology Selection Criteria & Summary of Recent Ash Conversion Activity
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Safety Moment

Key Regulatory Actions

Coal Combustion Residuals (CCR)

- Issued December 19, 2014
- CFR Publication: April 17, 2015
- Goals
  - ✓ Groundwater Protection Benefits
  - ✓ Preventing Future CCR Impoundment Catastrophic Failures

Effluent Limitations Guidelines (ELG)

- Proposed Rules Issued April 2013
- CFR Publication: November 03, 2015
- Goals
  - ✓ Strengthen Steam Electric Power Plant Discharge Controls
  - ✓ Reduce Surface Water Pollutant Discharges

Effluent Limitations Guidelines (ELG)

Proposed Rules: Issued April 2013

CFR Publication: November 03, 2015

Compliance Date: 2018-2023

Depending on NPDES permit renewal dates

Goals:

- ✓ Strengthen the controls on discharges from certain steam electric power plants by revising technology-based effluent limitations guidelines and standards for the steam electric power generating point source category

- ✓ Reduce the amount of toxic metals and other pollutants discharged from power plants to surface waters (direct discharges) and publicly owned treatment works (indirect discharges to POTWs)

ELG Update

ELG Final Rule Background

- On November 3, 2015, the EPA issued a Final Rule amending 40 CFR part 423, the Effluent Limitations Guidelines and Standards for the Steam Electric Power Generating Point Source Category, under various sections of Clean Water ACT (CWA).

- The Rule addressed and contained limitations and standards on various wastestreams at steam electric power plants:
  - Flue Gas Desulfurization (FGD) Wastewater
  - Fly Ash & Bottom Ash Transport Water
  - Flue Gas Mercury Control Wastewater
  - Non-Chemical Metal Cleaning Wastes
  - Gasification Wastewater
  - Combustion Residual Leachate

ELG Ruling

Final Rule Basis

Wastestreams	Technology Basis
FGD Wastewater	Chemical Precipitation + Biological Treatment
Fly Ash Transport Water	**Dry Handling / Closed-loop for units >50W; Impoundment (equal to BPT) for units <50MW**
Bottom Ash Transport Water	**Dry Handling / Closed-loop for units >50W; Impoundment (equal to BPT) for units <50MW**
Combustion Residual Leachate	Impoundment (equal to BPT)
FGMC Wastewater	Dry Handling
Gasification Wastewater	Evaporation
Nonchemical Metal Cleaning Wastes	Chemical Precipitation

ELG Ruling

Specialized Definitions

- **Transport Water**
  - Any wastewater that is used to convey fly ash, bottom ash, or economizer ash from the ash collection or storage equipment, or boiler, and has direct contact with the ash.
  - 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).
- **Low Volume Waste Sources include:**
  - Boiler blowdown
  - Floor drains
  - Recirculating house service water systems

Petitions to the ELG Final Rule

- After the ELG Final Rule was published, The EPA received seven (7) petitions for review of the Rule. The United States Judicial Panel on Multi-District Litigation issued an order on December 8, 2015, consolidating all of the petitions in the U.S. Court of Appeals for the Fifth Circuit. Litigation is ongoing and the EPA's brief is currently due by May 4, 2017.
- March 24, 2017: The Utility Water Act Group (UWAG) submitted a petition for reconsideration of the Rule and requested that the EPA suspend the Rule's approaching deadlines.
- April 5, 2017: The Small Business Administration Office of Advocacy petitioned the EPA for reconsideration of the Rule.
- The 2017 petitions raised several objections to the Rule, some of which are consistent with the claims in the ongoing litigation.

U.S. EPA Response to the 2017 ELG Petitions

Date: April 12, 2017

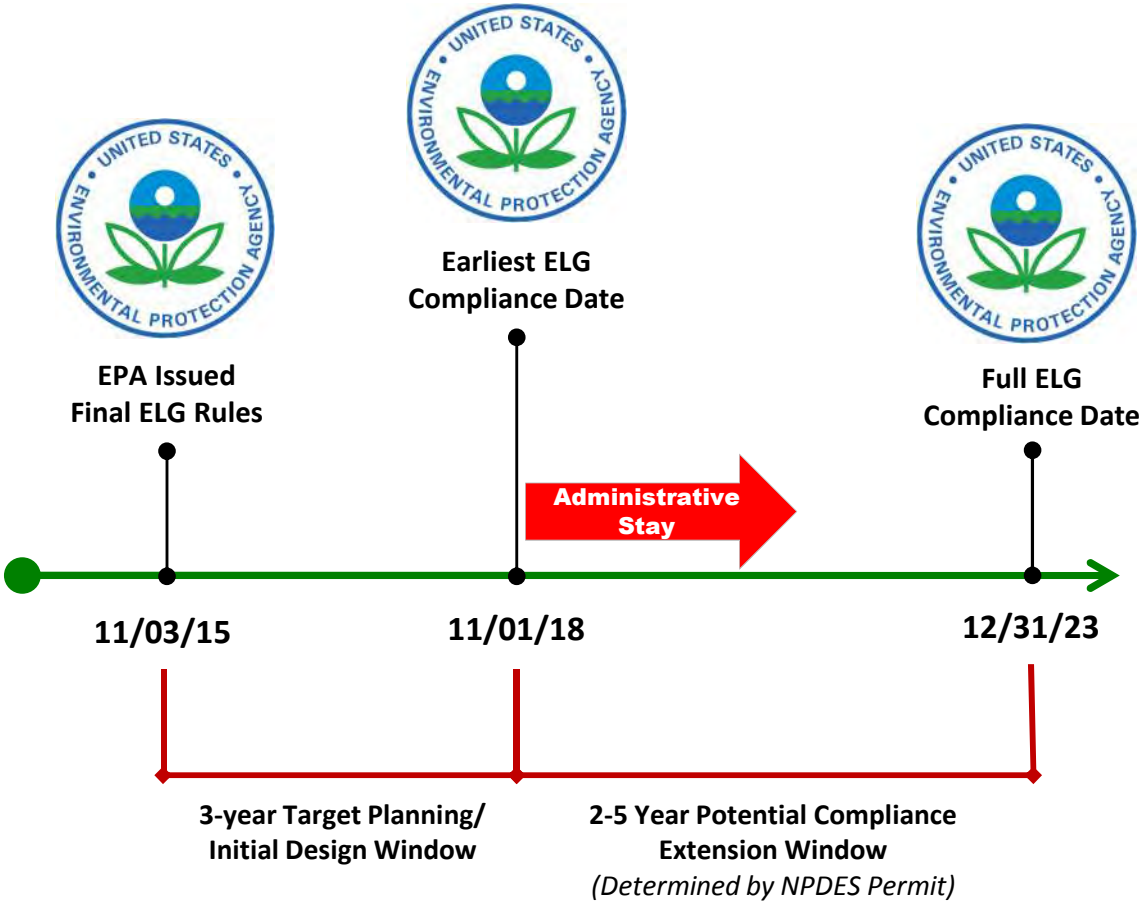
Subject: Stay of Certain Compliance Deadlines for the Final Rule Entitled "Effluent Limitations Guidelines and Standards for the Steam Electric Power Generating Point Source Category" Published by the Environmental Protection Agency on November 3, 2015.

ACTION:

- The U.S. EPA decided that it is appropriate and in the public interest to **RECONSIDER THE FINAL RULE.**
- The U.S. EPA issued an **ADMINISTRATIVE STAY OF THE COMPLIANCE DATES** that have not yet passed, pending judicial review.
- The EPA also intends to request that the U.S. Court of Appeals for the Fifth Circuit **STAY THE PENDING LITIGATION OF THE RULE FOR 120 DAYS** (until September 12, 2017) by which time the EPA will inform the court of the portions of the Rule, if any, that it seeks to have remanded to the agency for further rulemaking.
- During this reconsideration, EPA intends to **CONDUCT NOTICE AND COMMENT RULEMAKING** with respect to staying the effective dates and/or the compliance dates of the rule.

Issuance of a Stay and Delay of Compliance Dates:

"The EPA hereby issues an administrative stay of the compliance dates that have not yet passed contained in the Effluent Guidelines and Standards for the Steam Electric Power Generating Point Source Category under Section 705 of the APA. The compliance dates of the Rule specified at 40 CFR §§ 423.11(t), 423.13(g)(1)(i), 423.13(h)(1)(i), 423.13(i)(1)(i), 423.13(j)(1)(i), and 423.13(k)(1)(i), and 40 CFR §§ 423.16(e), 423.16(f) 423.16(g) 423.16(h) 423.16(i), published at 80 FR 67838 (Nov. 3, 2015), are stayed pending judicial review."



ELG Update

EPA Response to Petitions

EPA's response to the 2017 Petitions Regarding Wastestreams:

"The stay will preserve the regulatory status quo with respect to wastestreams subject to the Rule's new, and more stringent, limitations and standards, while the litigation is pending and the reconsideration is underway."

Wastestreams	Technology Basis
FGD Wastewater	Chemical Precipitation + Biological Treatment
Fly Ash Transport Water	**Dry Handling / Closed-loop for units >50W; Impoundment (equal to BPT) for units <50MW**
Bottom Ash Transport Water	**Dry Handling / Closed-loop for units >50W; Impoundment (equal to BPT) for units <50MW**
Combustion Residual Leachate	Impoundment (equal to BPT)
FGMC Wastewater	Dry Handling
Gasification Wastewater	Evaporation
Nonchemical Metal Cleaning Wastes	Chemical Precipitation

Coal Combustion Residuals (CCR) Ruling

Overview

- **Pre-Publication Rule Issue: 19 December 2014**
- **Formal CFR Issue: April 2015**
- **RCRA Subtitle D Classification (Non-Hazardous)**
- **Finalizes National Minimum Criteria for:**
  - Existing and New CCR landfills
  - Existing and New CCR surface impoundments
  - All Lateral Expansions of Existing CCR Units
- **CCR Rule Targeted Benefits:**
  - Groundwater Protection Benefits
  - Prevention of CCR Impoundment Catastrophic Failures

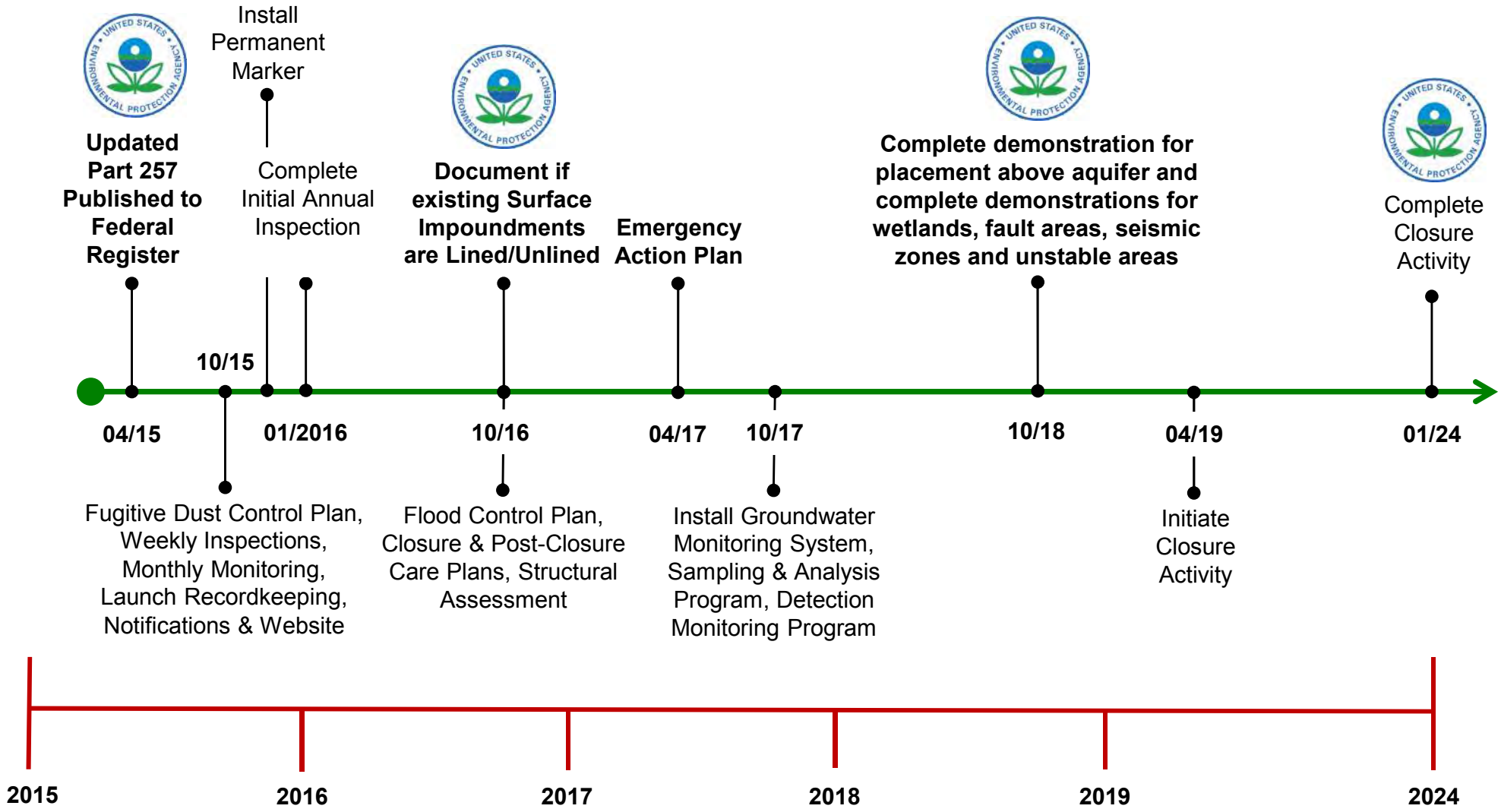
Coal Combustion Residuals (CCR) Ruling

Overview

- **Regulation Focus Areas:**
  - Location Restrictions: Aquifer, Wetlands, Fault Zones, Seismic Zones, Unstable Areas
  - Design Criteria: Lined/Unlined, Leaking/Not Leaking, Structural Integrity
  - Operating Criteria: Flood Control, Fugitive Dust Control, Inspections (Weekly/Monthly/Annual)
  - Groundwater Monitoring and Corrective Action
  - Closure Requirements and Post-closure Care
  - Recordkeeping, Notification, and Internet Posting

Coal Combustion Residuals (CCR) Ruling

Regulatory Timeline – Existing CCR Surface Impoundments



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Discussion Overview

- Regulatory Update & Implications
- **Technology Selection Criteria & Summary of Recent Ash Conversion Activity**
- PAX Dry Bottom Ash Technology Review
- (3) Recent Wet-to-Dry Conversion Case Studies

Bottom Ash Wet-To-Dry Conversions

Technical Alternatives

Submerged Flight Conveyor – SFC™

- Long-Term Economical Choice (Low O&M Costs)
- Simple Solution if Space Under Boiler is Available

Re-Circulating Hydraulic System (3 Options)

- No Changes Under Boiler, Uses Existing Hopper
- Minimizes Outage Requirements

Clarifying Hydraulic System

- No Changes Under Boiler, Uses Existing Hopper
- Minimizes Outage Requirements
- Allows for Water Reuse (FGD Makeup per ELG)

Dry Hopper Pneumatic Conveying – PAX™ & DAX™

- No Water, Returns Heat Back to Boiler
- Elimination of Long-term Environmental Wastewater Risk

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Technical Design Considerations

Wet-To-Dry Ash Conversion Project Design Criteria	
Budget	Plant Water Balance Considerations
Outage Requirements	Ash Conveying Capacities
Physical Parameters	Conveying Distance Considerations
Site Environmental Considerations	Operations & Maintenance Issues
Ash Characteristics	Multiple Unit Synergies
Ash Marketability/Beneficiation	Unburned Carbon Concerns

- Evaluate Criteria Against Multiple Alternatives
- Determine Optimal Solution for each Plant
- “One Size Does Not Fit All”

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- **PAX Dry Bottom Ash Technology Review**
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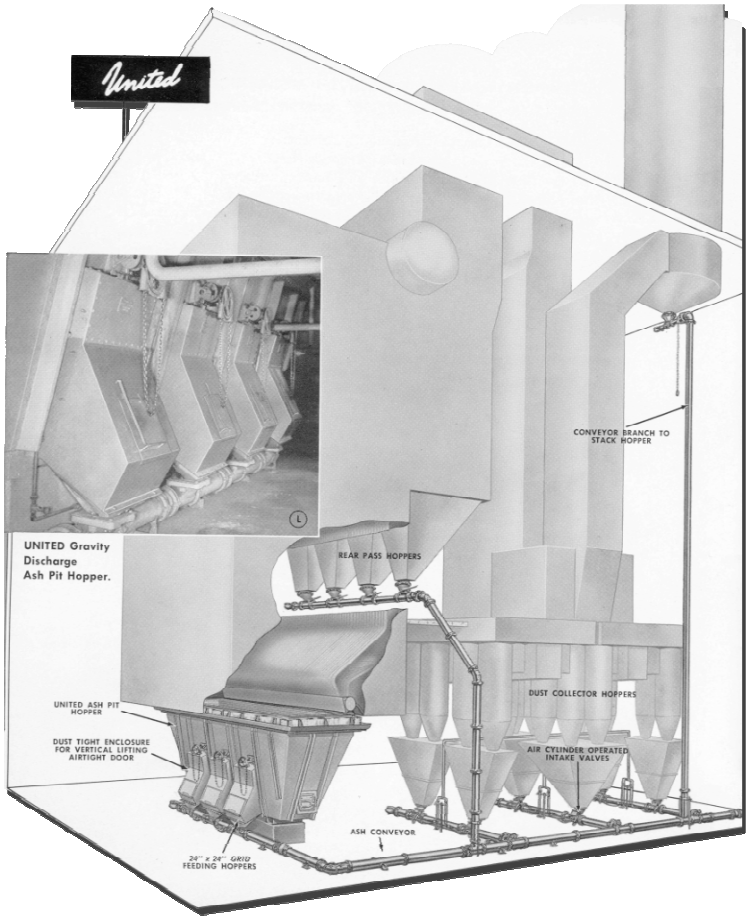
Pneumatic Ash Extractor (PAX) System

PAX Bottom Ash System Overview

Pneumatic Ash Extractor (PAX)



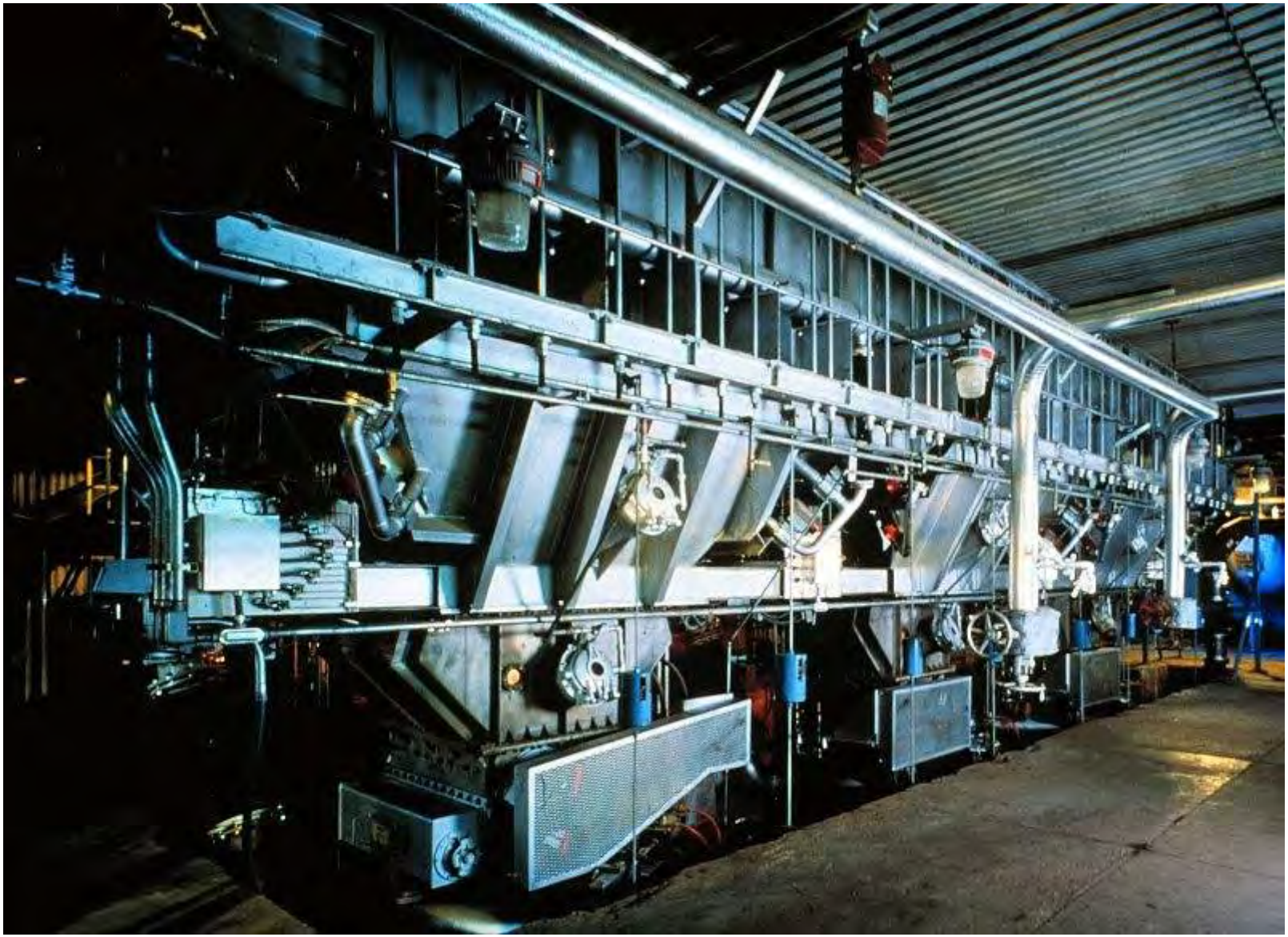
Rendition of a UCC NUVEYOR system for a utility boiler, including gravity discharge ash pit hopper.

100 % Dry Bottom Ash Conveying UCC History

1940's-1950's:
UCC develops dry bottom ash conveying with NUVEYOR® pneumatic ash conveying systems, gravity discharge ash pit hoppers.

PAX Bottom Ash System Overview

Pneumatic Ash Extractor (PAX)



PAX Bottom Ash System Overview

Pneumatic Ash Extractor (PAX)

- **Easily Retrofitted Around Structural Barriers**
- **Provides Improved Heat Recovery and Boiler Efficiency**
- **Does Not Require Water**

PAX Bottom Ash System Overview

Pneumatic Ash Extractor (PAX)

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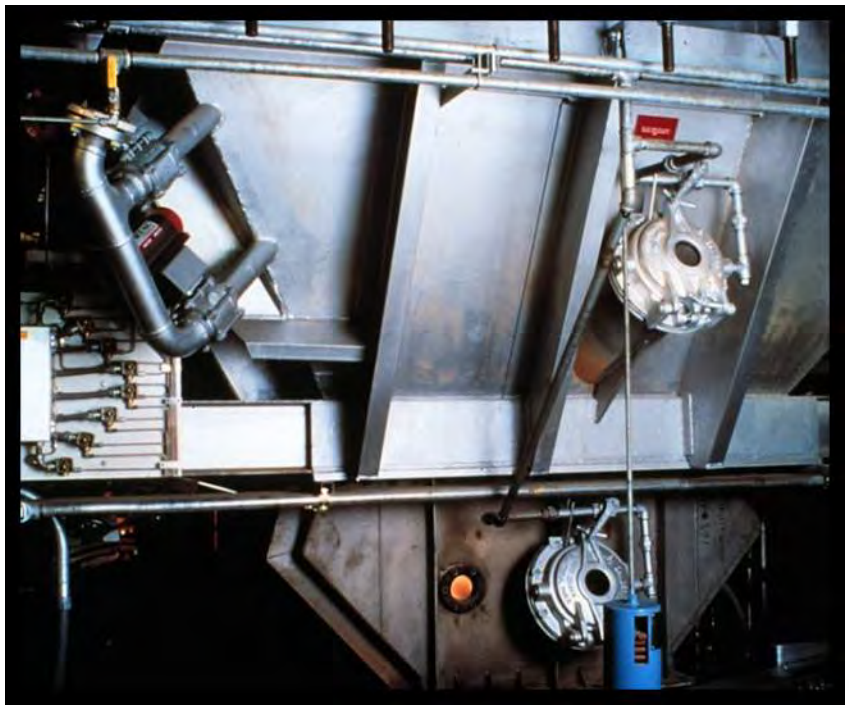
PAX Bottom Ash System Overview

Pneumatic Ash Extractor (PAX)

PAX Bottom Ash System Overview

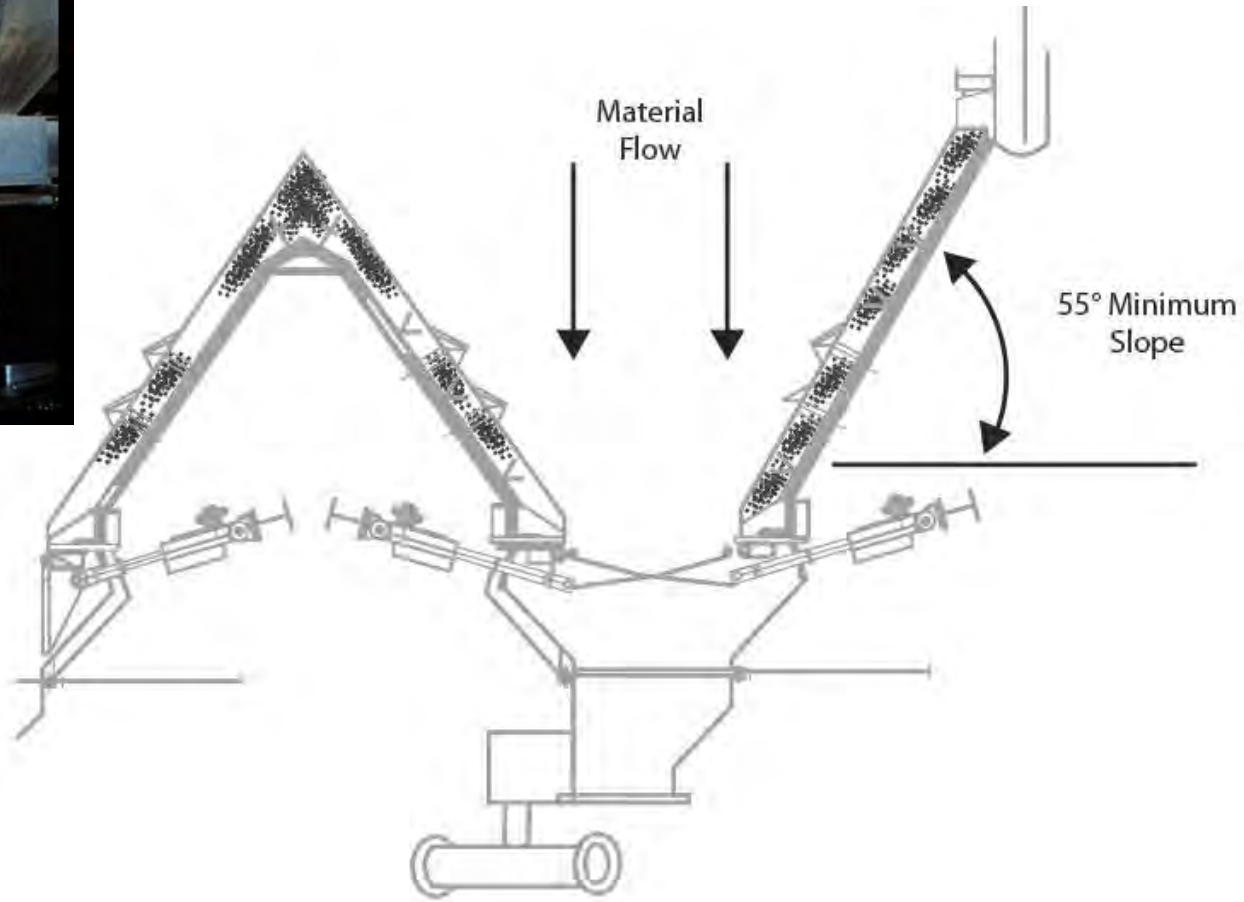
Pneumatic Ash Extractor (PAX)



Orange glow from boiler visible from window below doors

UCC PAX System

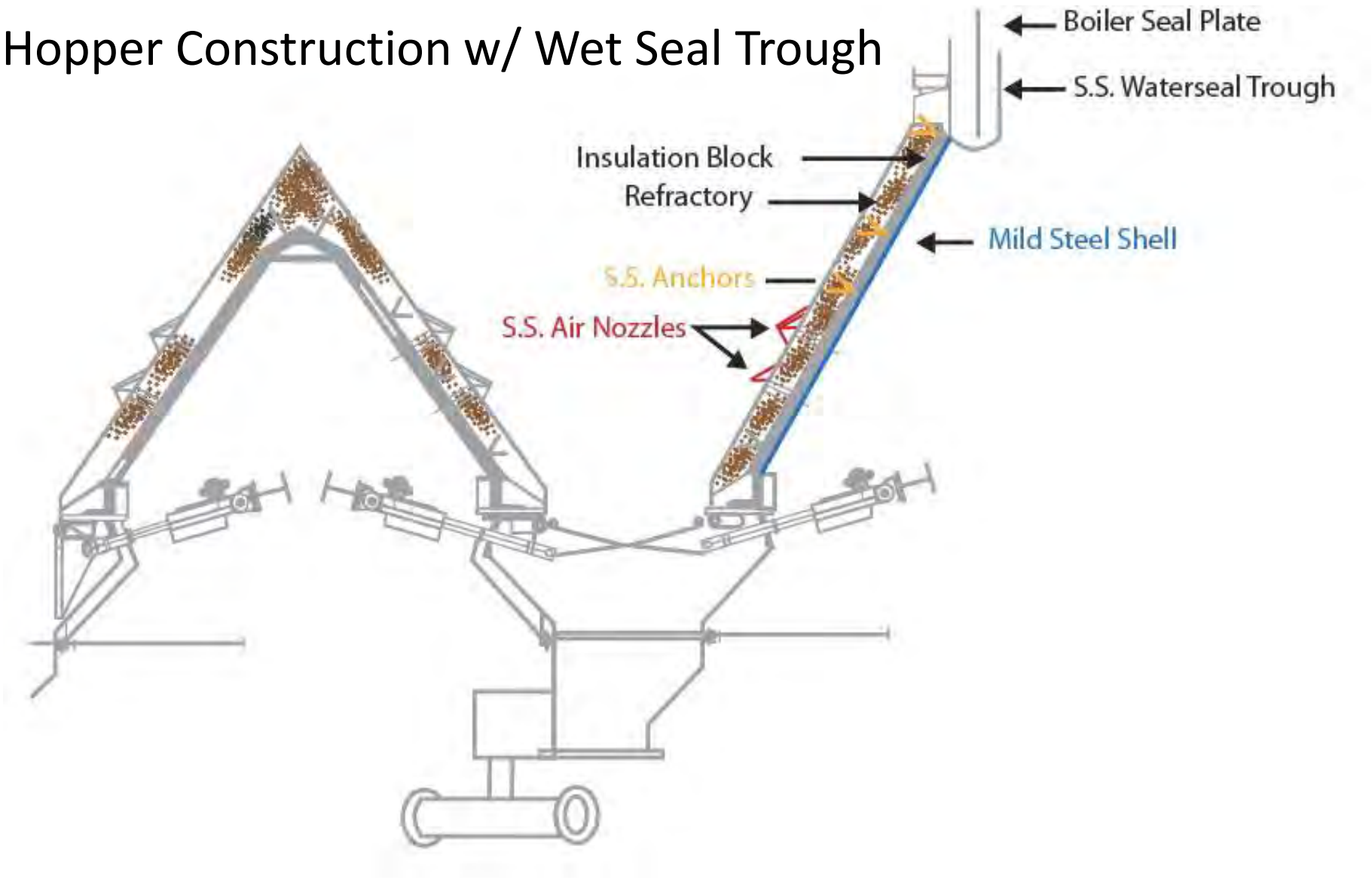
- Hopper Design



PAX Bottom Ash System Overview

Pneumatic Ash Extractor (PAX)

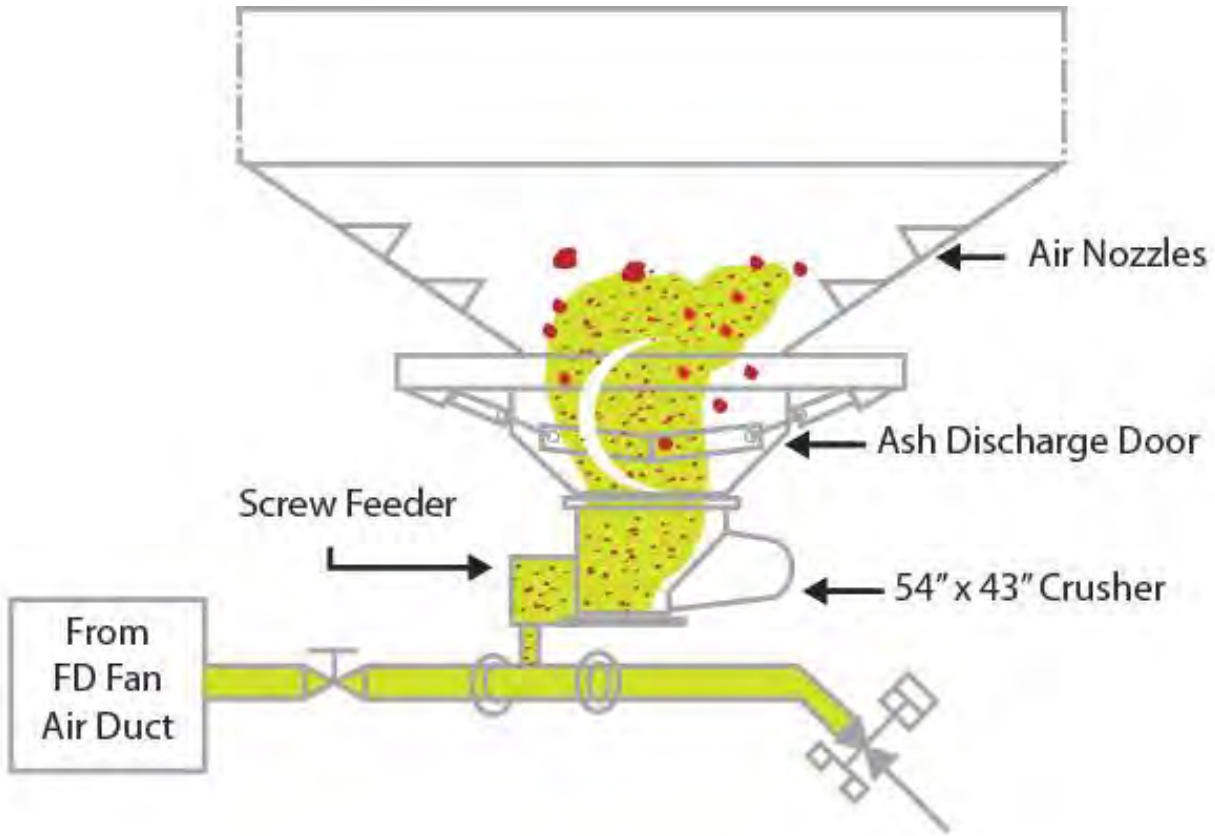
- Hopper Construction w/ Wet Seal Trough



PAX Bottom Ash System Overview

Pneumatic Ash Extractor (PAX)

- Unique Cooling & Combusting Using FD Fan Air
  - Cools Feeder and Crusher
  - Cools Fine Ash
  - Promotes Continued Combustion of Coarse Ash



PAX Bottom Ash System Overview

Pneumatic Ash Extractor (PAX)

- Large Grid Doors Handle Large Clinkers

New doors shown prior to installation

Doors after 1.5 years of Service

Hopper Grid Doors Shown in Open and Closed Positions
PAX System Installed at Crystal River Station

PAX Bottom Ash System Overview

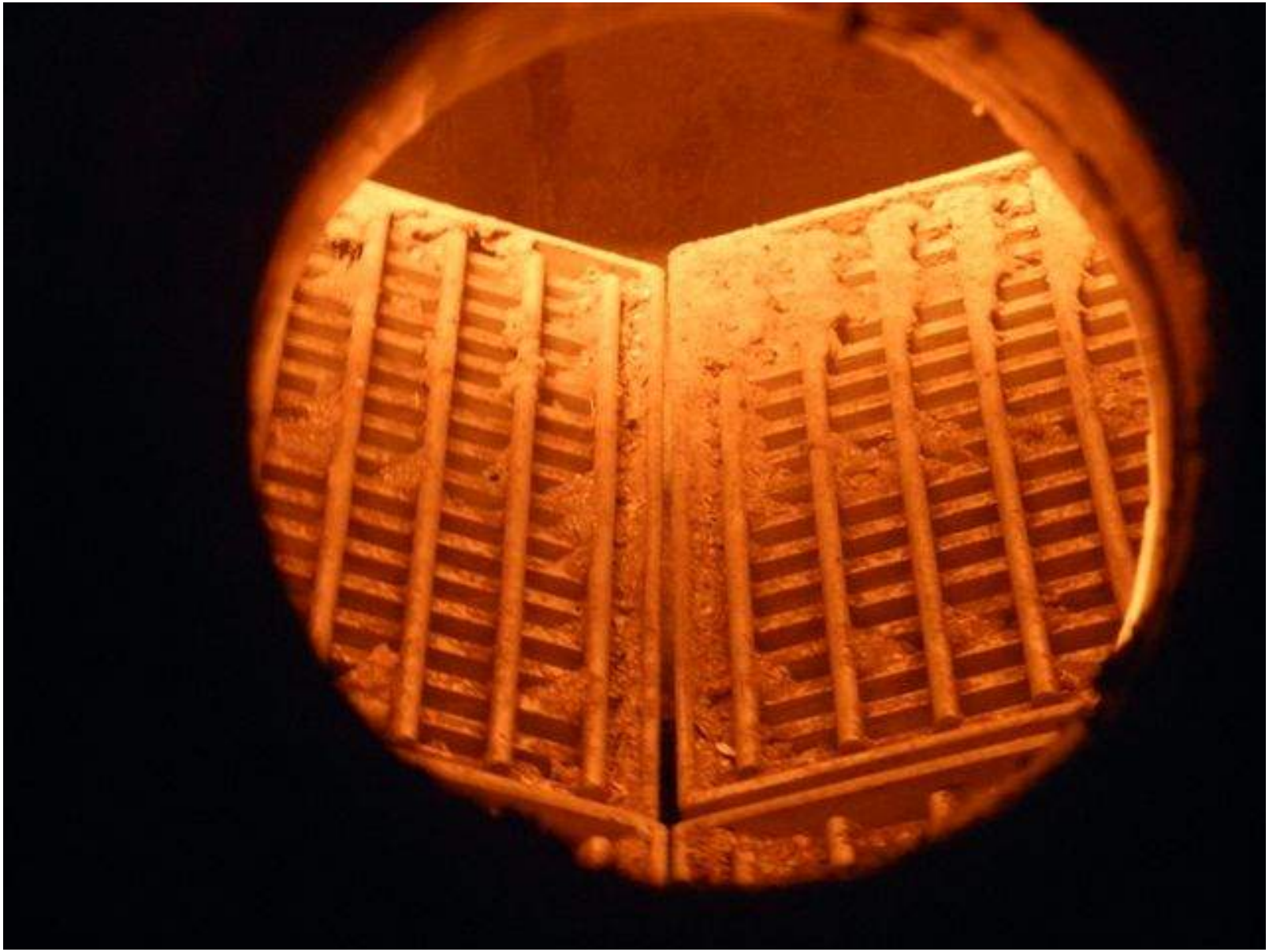
Pneumatic Ash Extractor (PAX)

Grid holds back large particles which then hold back fines while still allowing airflow upwards

Grid Doors Installed at SCE&G McMeekin Station

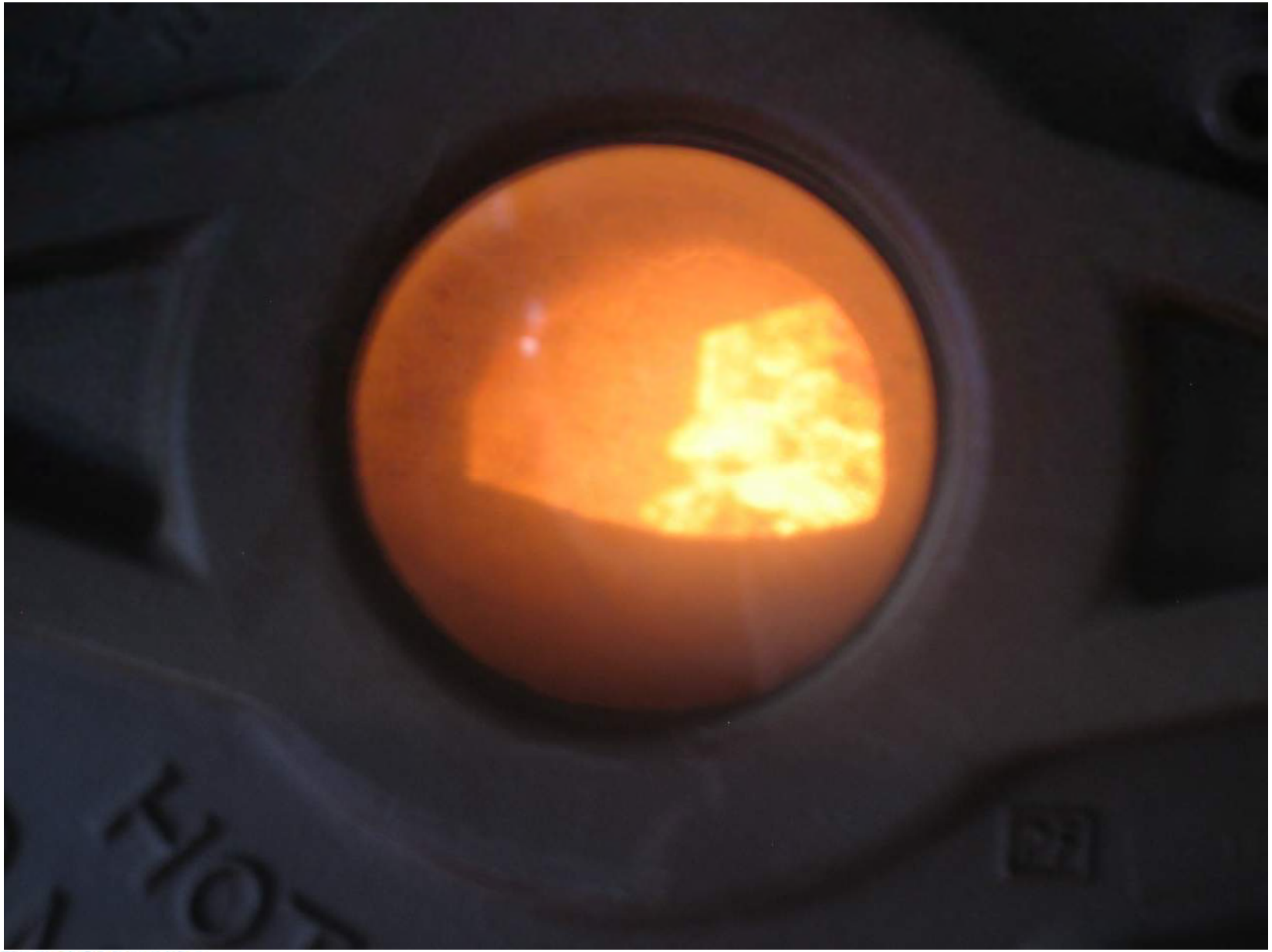
PAX Bottom Ash System Overview

Pneumatic Ash Extractor (PAX)



PAX Bottom Ash System Overview

Pneumatic Ash Extractor (PAX)



PAX Bottom Ash System Overview

Pneumatic Ash Extractor (PAX)

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PAX Bottom Ash System Overview

Pneumatic Ash Extractor (PAX)

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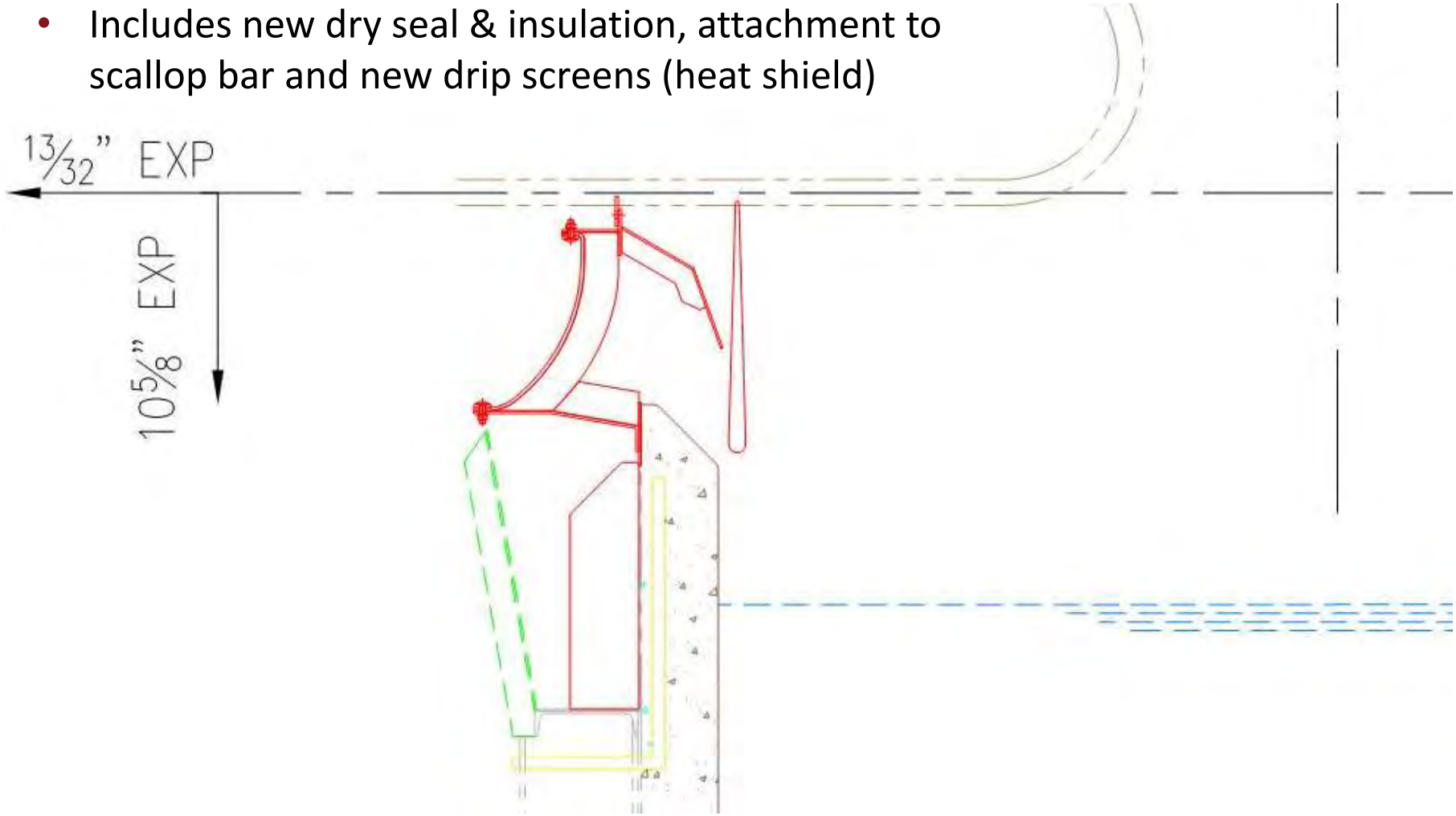
PAX Bottom Ash System Overview

Dry Boiler Seal

- **Dry Seal Option**
  - Includes new dry seal & insulation, attachment to scallop bar and new drip screens (heat shield)



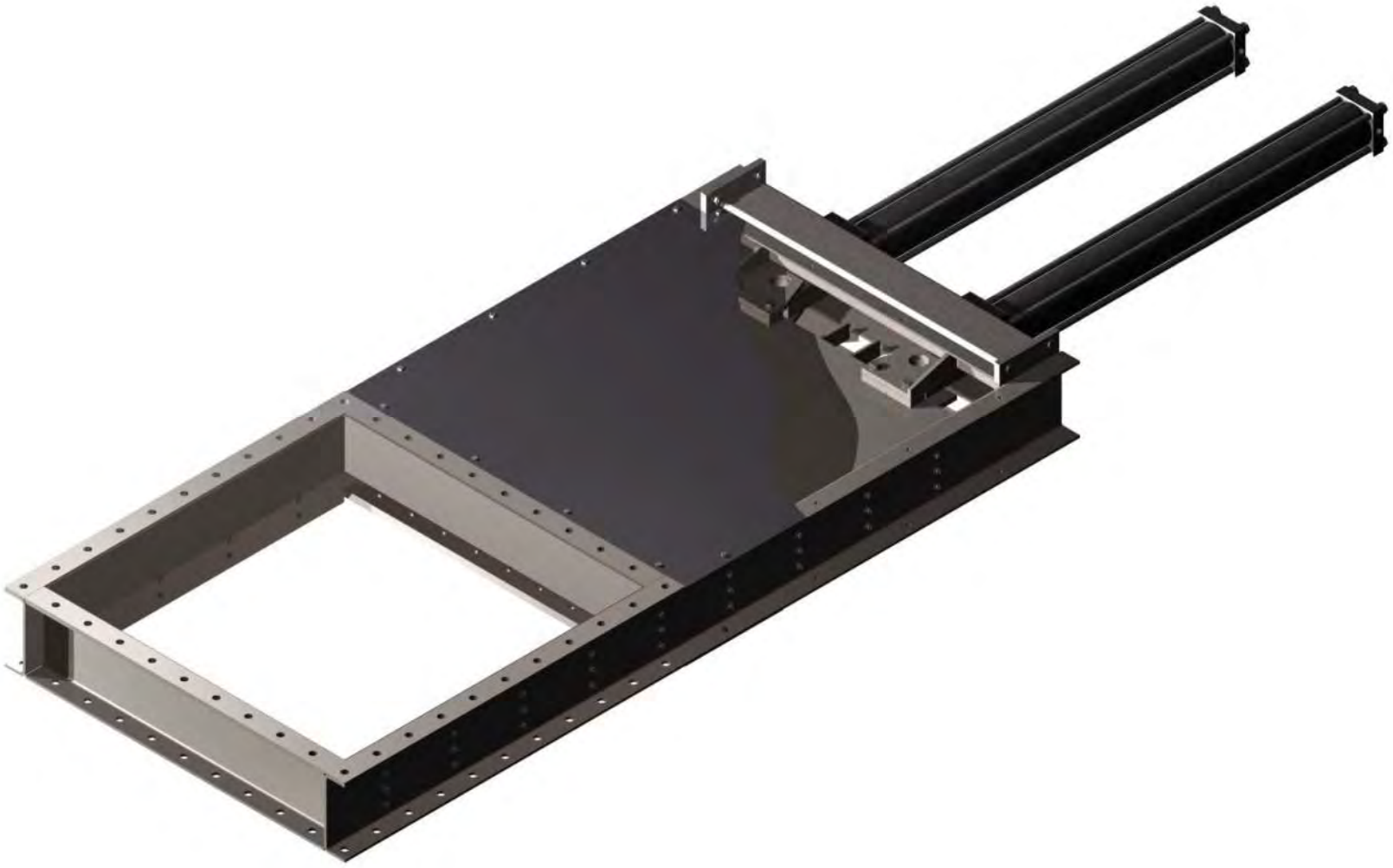
PAX Bottom Ash System Overview

Dry Boiler Seal

- **Dry Seal Option**
  - Multi-layer seal, including wire mesh, insulating woven glass fabric, PTFE gas tight membranes and outer fabric with wire mesh protection
  - Insulation composed of high density glass wool encapsulated with fabric and wire mesh
  - Still need drip screens (heat shield)

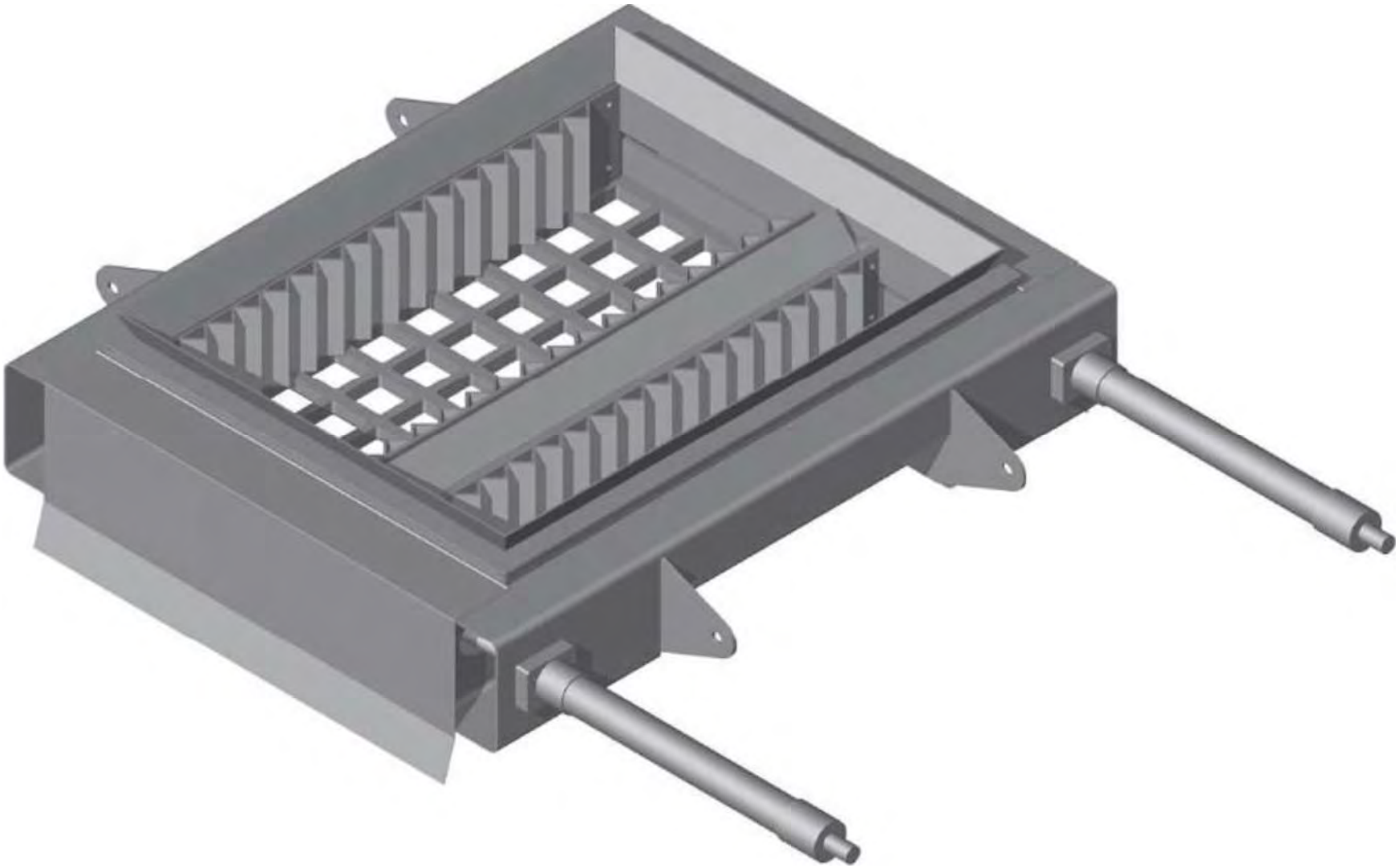
PAX Bottom Ash System Overview

Hydraulic Enclosure Isolation Gate



PAX Bottom Ash System Overview

Pneumatic Ash Extractor (PAX) – Hydraulic Jaw Crusher



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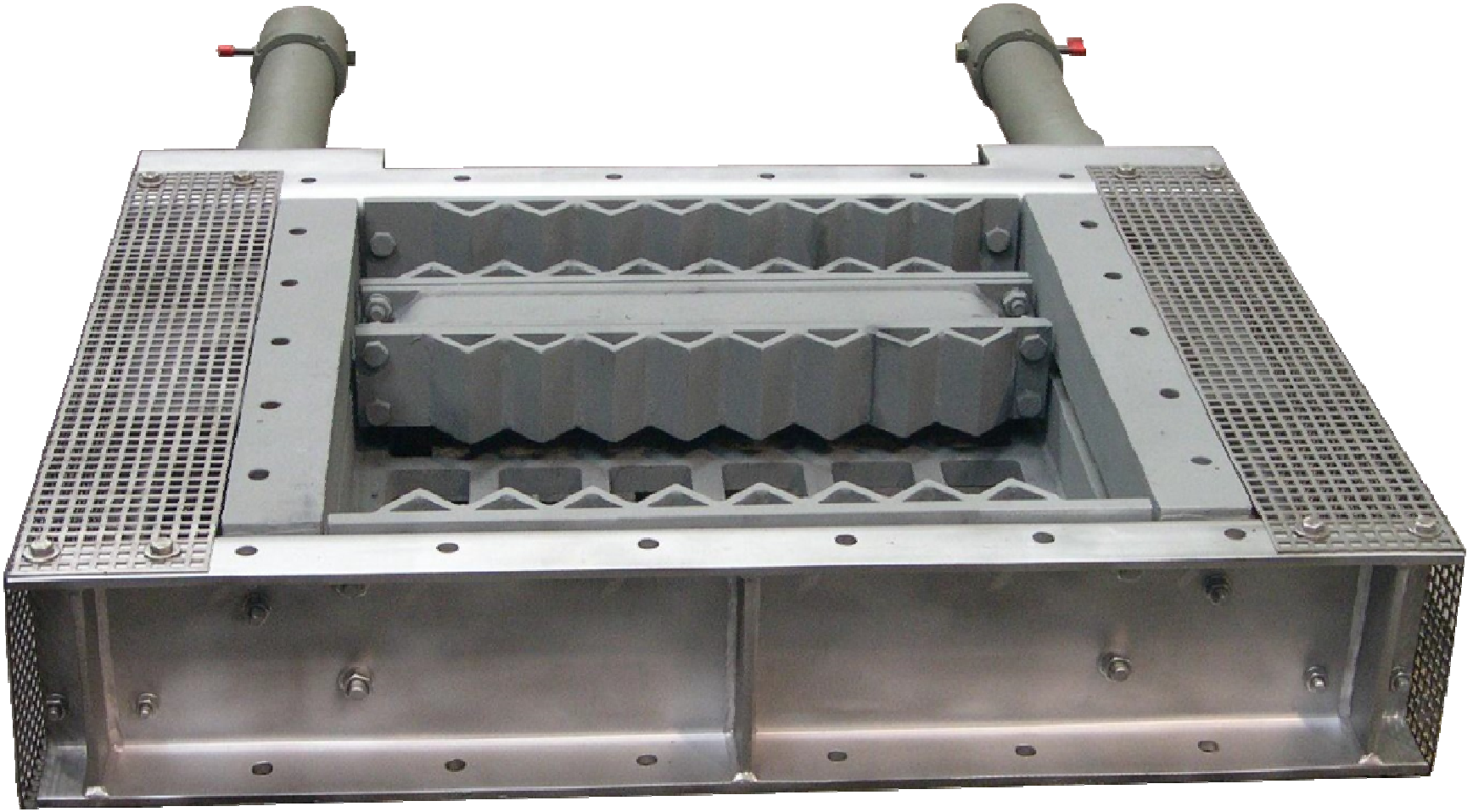
PAX Bottom Ash System Overview

Pneumatic Ash Extractor (PAX) – Hydraulic Jaw Crusher



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- PAX Dry Bottom Ash Technology Review
- **(3) Recent Wet-to-Dry Conversion Case Studies**

Case Study #1

Bottom Ash WTD Conversion Alternatives

Pneumatic Ash Extractor (PAX): Case Study #1

Installation Overview

- Southern Utility
- 4 x 700 MW Base Loaded Plant
- Fuel = 100% Power River Basin (PRB)

Unique Plant Conditions

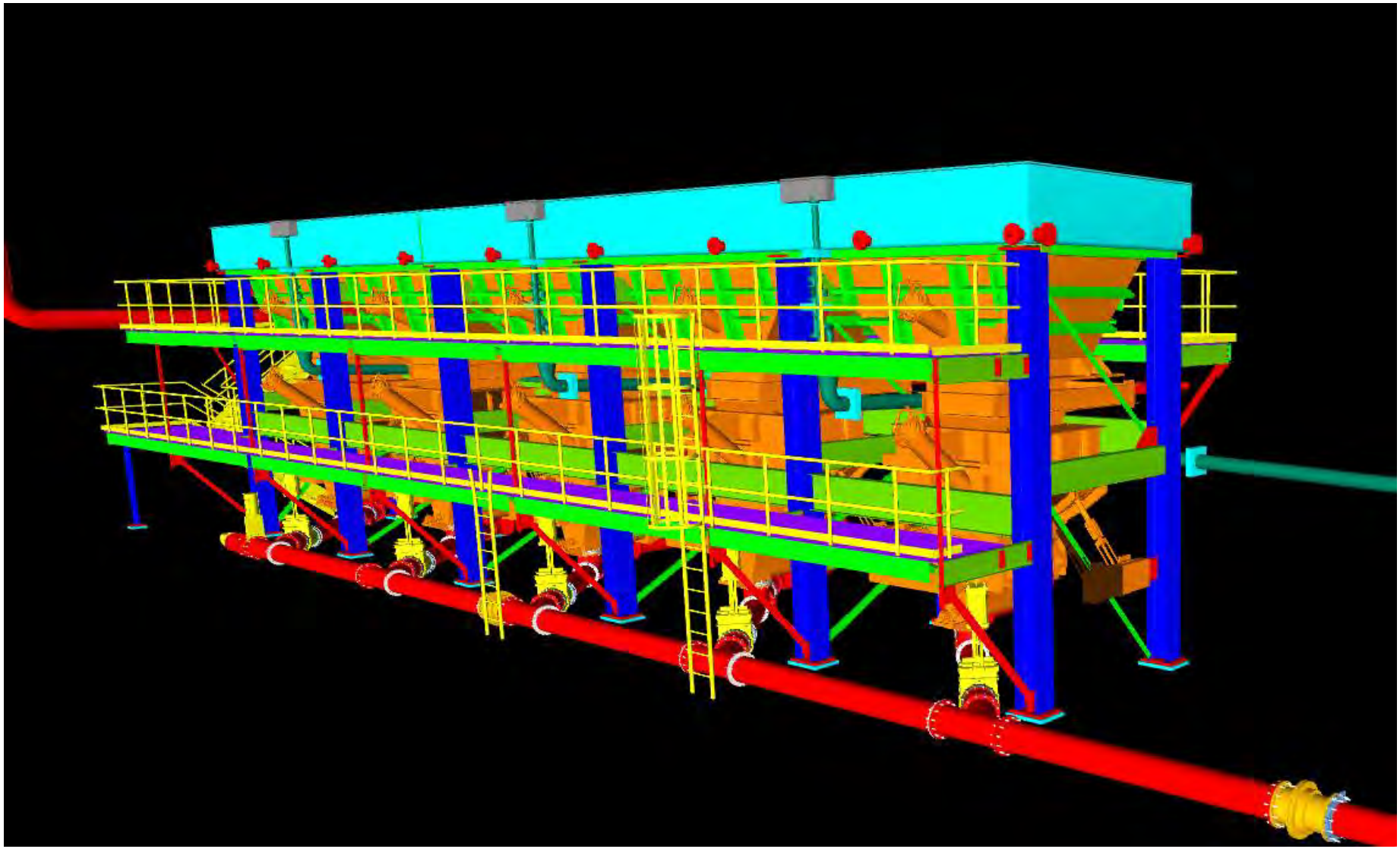
- 4-unit configuration made under-unit SFC option challenging
- Significant O&M costs for existing water impounded Bottom Ash Hoppers and Sluice Conveying Systems
- Physical space available for new Dry Bottom Ash Silos next to powerhouse
- Preference to handle Economizer Ash in dry state
- Potential local market for Dry Bottom Ash beneficial reuse

Bottom Ash WTD Conversion Alternatives

Pneumatic Ash Extractor (PAX): Case Study #1

Bottom Ash WTD Conversion Alternatives

Pneumatic Ash Extractor (PAX): Case Study #1



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Bottom Ash WTD Conversion Alternatives

Pneumatic Ash Extractor (PAX): Case Study #1

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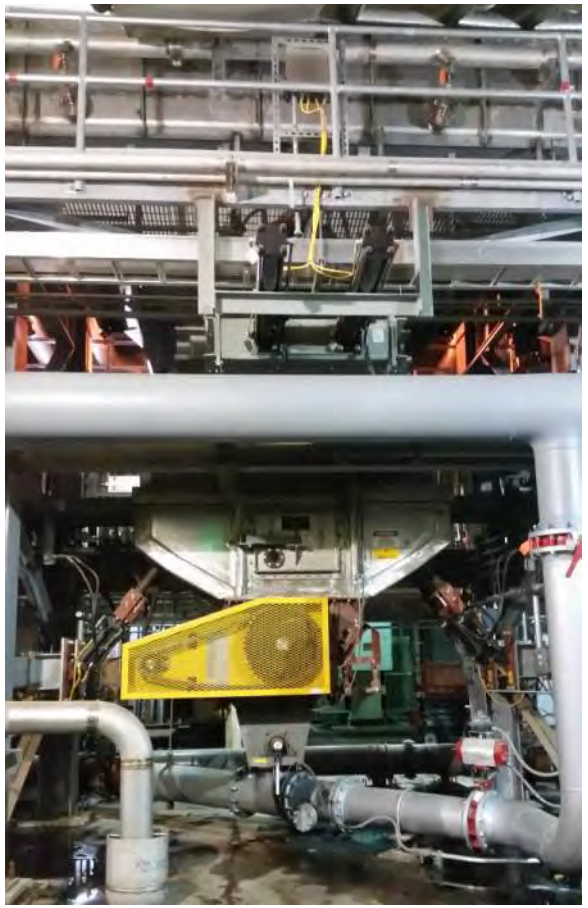
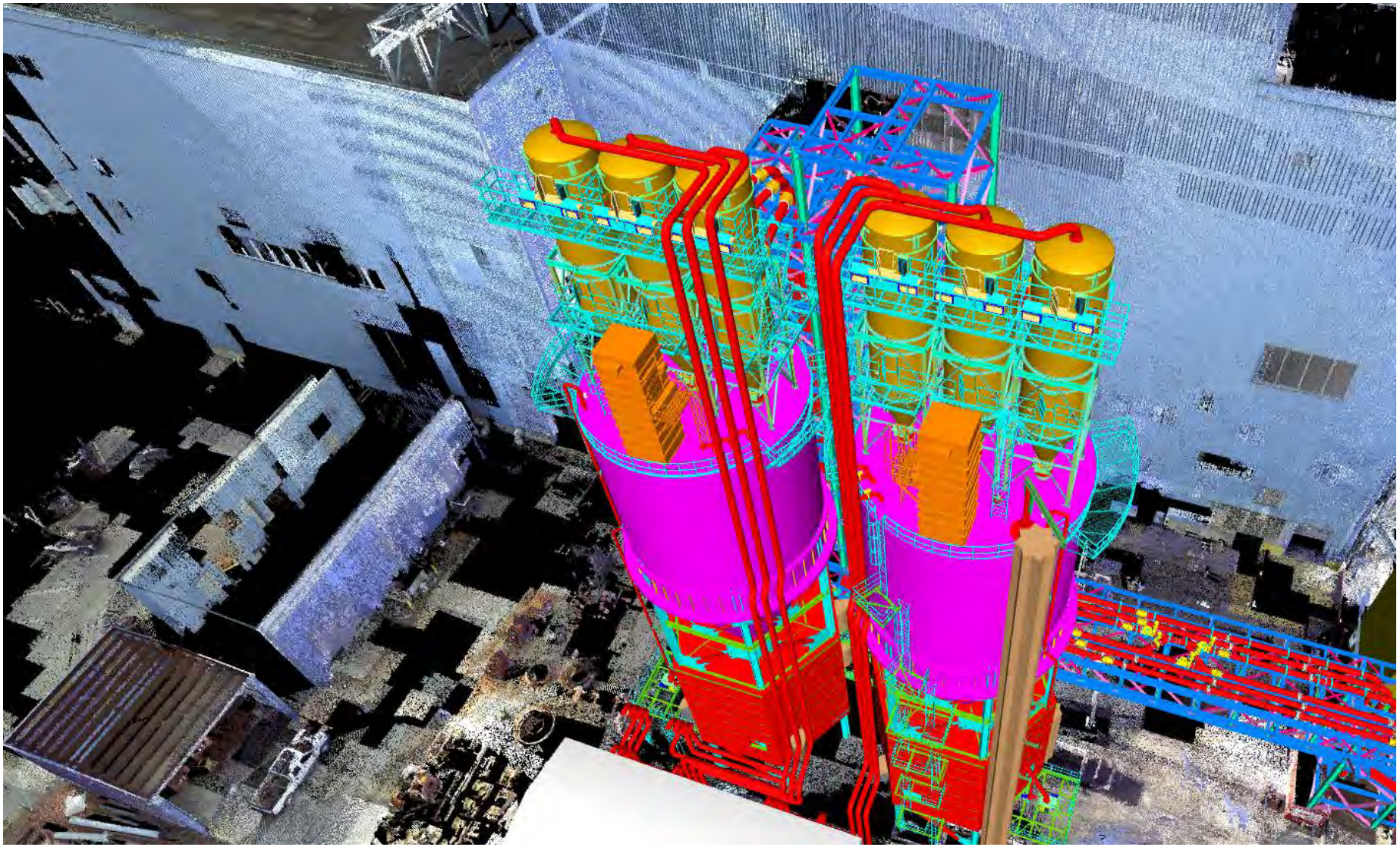


Bottom Ash WTD Conversion Alternatives

Pneumatic Ash Extractor (PAX): Case Study #1



Bottom Ash WTD Conversion Alternatives

Pneumatic Ash Extractor (PAX): Case Study #1

Bottom Ash WTD Conversion Alternatives

Pneumatic Ash Extractor (PAX): Case Study #1

Technology Selection

- (4) UCC PAX Systems to (2) collocated Dry Bottom Ash Silos

Key Decision Criteria

- Lowest Cost technology selection when considering 20-year plant lifecycle cost (lowest cost at Year 6 and beyond)
- Elimination of water from Bottom Ash Handling Systems, which reduced O&M Costs and longer-term environmental risk
- Readily incorporated Economizer Ash into Bottom Ash pneumatic systems, which preserved Fly Ash sales
- Potential local market for Dry Bottom Ash beneficial reuse
- Status: Unit 3 PAX Bottom Ash Hopper now operational; balance of units to follow with outage schedules

Case Study #2

Bottom Ash WTD Conversion Alternatives

Pneumatic Ash Extractor (PAX): Case Study #2

Installation Overview

- Midwestern Utility
- 1 x 300 MW Base Loaded Plant
- Fuel = 100% Power River Basin (PRB)

Unique Plant Conditions

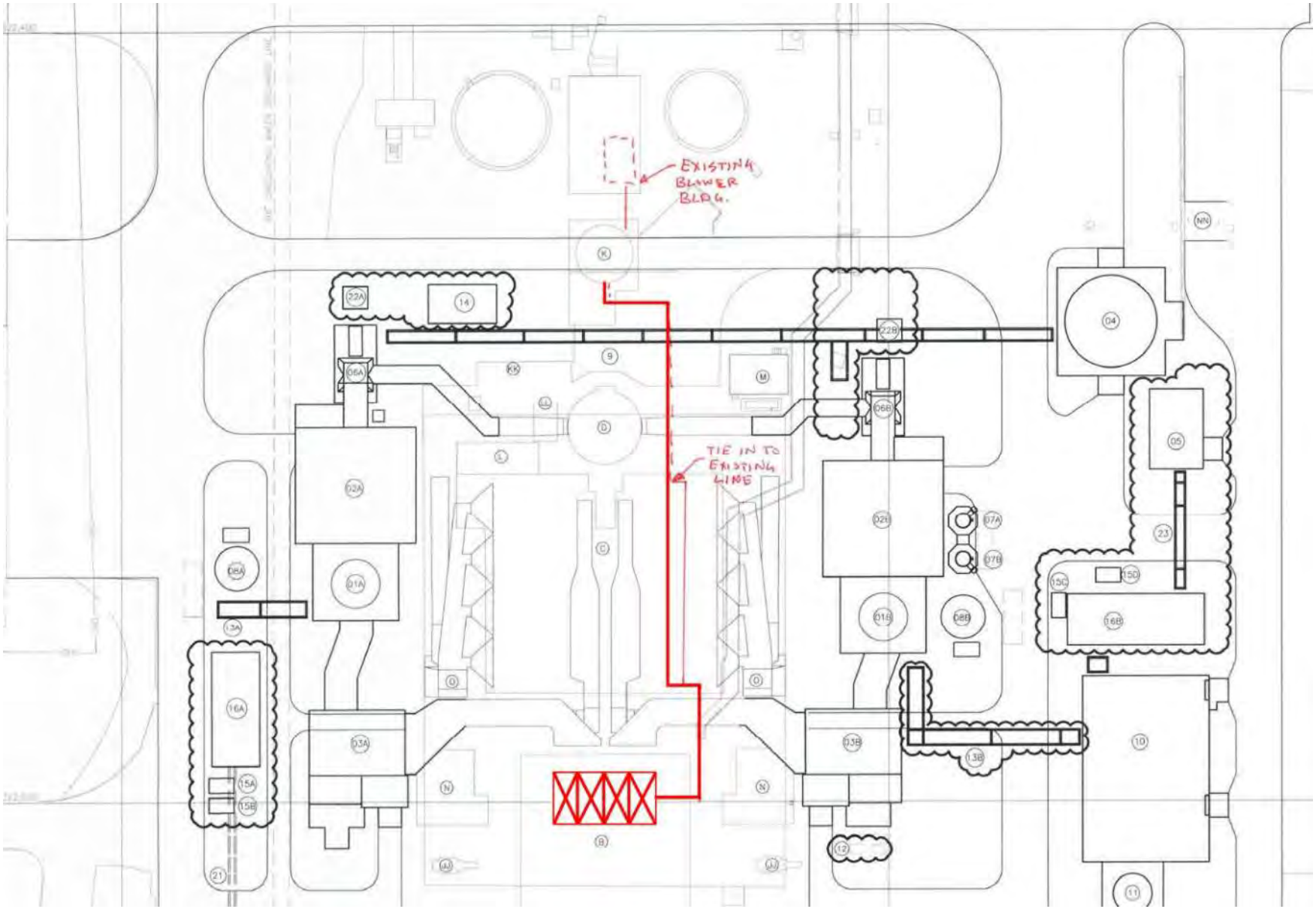
- Unit configuration made under-unit SFC option challenging (w/interferences on each end of boiler)
- Previously decommissioned Fly Ash Silo available for potential retrofit/reuse for Dry Bottom Ash Silo (including idle Mechanical Exhausters)
- Potential local market for Dry Bottom Ash beneficial reuse

Bottom Ash WTD Conversion Alternatives

Pneumatic Ash Extractor (PAX): Case Study #2

Bottom Ash WTD Conversion Alternatives

Pneumatic Ash Extractor (PAX): Case Study #2



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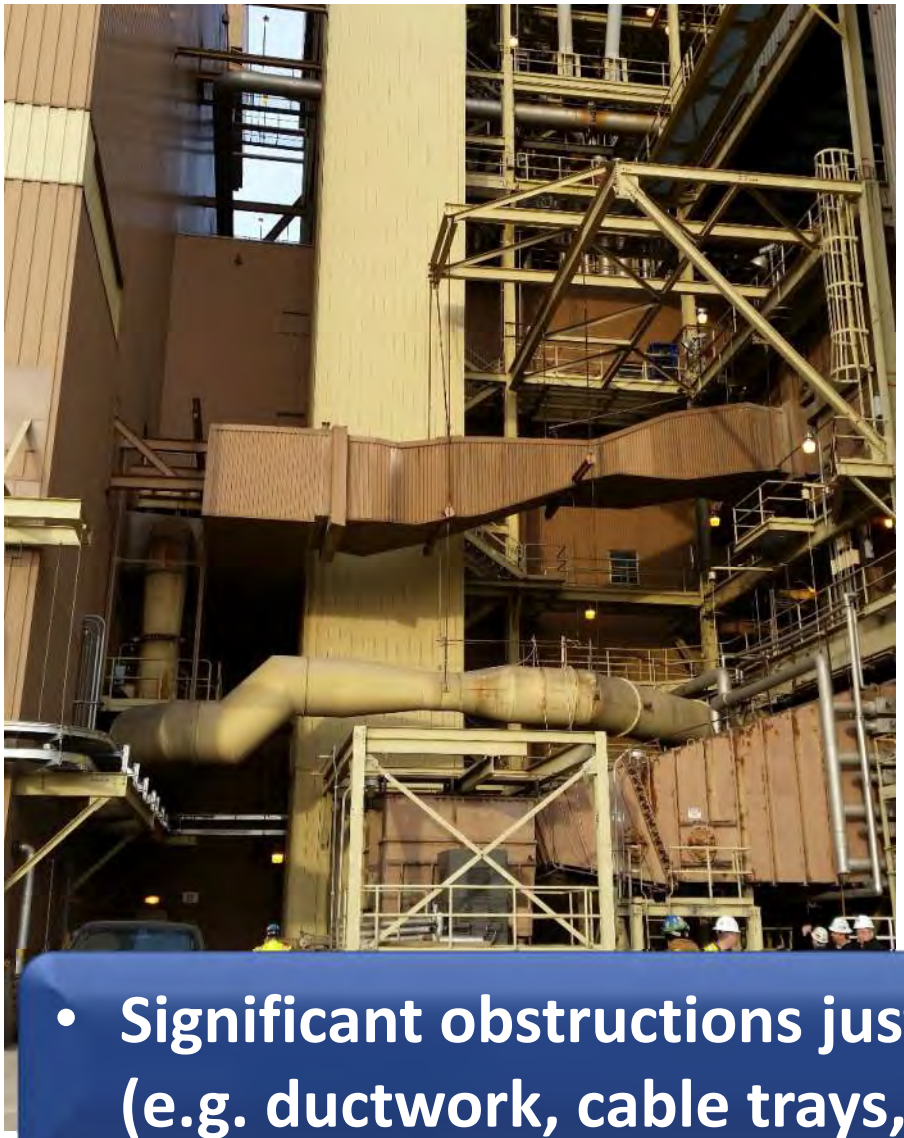
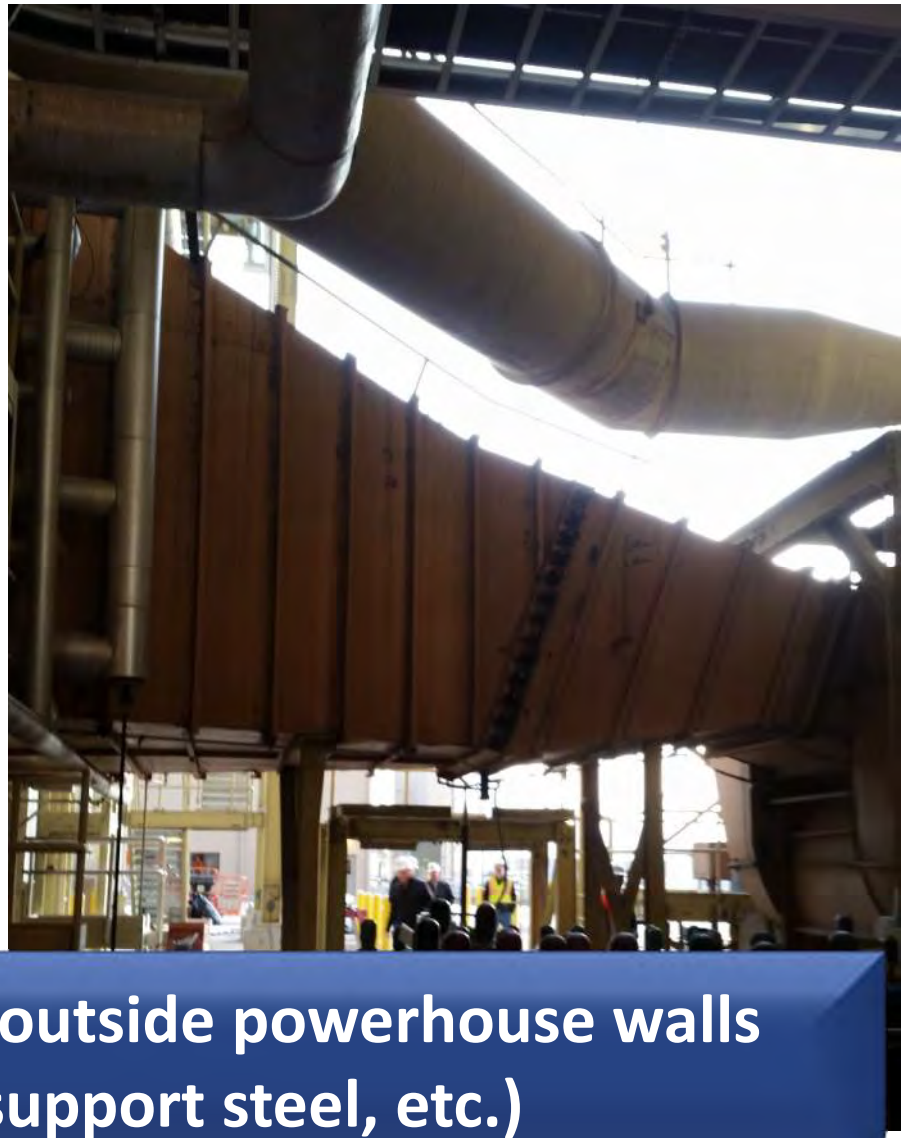
Bottom Ash WTD Conversion Alternatives

Pneumatic Ash Extractor (PAX): Case Study #2





- **Significant obstructions just outside powerhouse walls (e.g. ductwork, cable trays, support steel, etc.)**

Bottom Ash WTD Conversion Alternatives

Pneumatic Ash Extractor (PAX): Case Study #2

- **Ability to reuse decommissioned Fly Ash Silo base/stairtower, Mechanical Exhausters, Exhauster Building & Piping Corridor**

Bottom Ash WTD Conversion Alternatives

Pneumatic Ash Extractor (PAX): Case Study #2

Technology Selection

- (1) UCC PAX System to repurposed Dry Fly Ash Silo

Key Decision Criteria

- Significant cost savings by reusing portions of decommissioned Fly Ash Handling System (silo base, piping corridor, exhausters, building)
- Elimination of water from Bottom Ash Handling Systems, which reduced O&M Costs and longer-term environmental risk
- Potential local market for Dry Bottom Ash beneficial reuse
- Status: Engineering Phase, Operational Summer 2018

Case Study #3

Bottom Ash WTD Conversion Alternatives

Pneumatic Ash Extractor (PAX): Case Study #3

Installation Overview

- Midwestern Utility
- 4 Unit Base-Loaded Plant (550 MW, 450 MW, 2x350 MW)
- Fuel = Blend of Illinois Basin and Eastern Appalachian

Unique Plant Conditions

- 4-unit configuration and below-grade pits made under-unit SFC option challenging
- Significant O&M costs for existing water impounded Bottom Ash Hoppers and Sluice Conveying Systems
- Physical space available for new Dry Bottom Ash Silos next to powerhouse
- Concerns about long-term transport water recycling
- Preference to handle Economizer Ash in dry state

Bottom Ash WTD Conversion Alternatives

Pneumatic Ash Extractor (PAX): Case Study #3

Bottom Ash WTD Conversion Alternatives

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Bottom Ash WTD Conversion Alternatives

Pneumatic Ash Extractor (PAX): Case Study #3

Technology Selection

- (4) UCC PAX Systems to (2) collocated Dry Bottom Ash Silos

Key Decision Criteria

- Lowest Cost technology selection when considering longer term plant lifecycle costs
- Elimination of water from Bottom Ash Handling Systems, which reduced O&M Costs and longer-term environmental risk
- Readily incorporated Economizer Ash into Bottom Ash pneumatic systems, which helped preserve Fly Ash sales
- Potential local market for Dry Bottom Ash beneficial reuse
- Status: Engineering 50% Complete, Concrete Silos under construction, Unit 2 operational Spring 2018

Wet-to-Dry Ash Conversions

Challenges & Considerations

Understand Regulatory Requirements & Implications

Define Criteria As Early As Possible

Evaluate Criteria Against Multiple Alternatives

Determine Optimal Solution for each Plant

“One Size Does Not Fit All”

Evaluate Potential Fleetwide Synergies

Begin Schedule Planning ASAP

Questions ?

Wet-to-Dry Ash Conversions

Challenges & Considerations