ADDITIONAL FLY ASH STORAGE – DEWATERING BINS CONVERSION PROJECT AT INDIANAPOLIS POWER & LIGHT PETERSBURG GENERATING STATION

By

Christopher J. Brooks, P.E.

December 2017

Submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree

Master of Science in Industrial Management in the Department of Engineering

of the Pott College of Science and Engineering at the

University of Southern Indiana

December 2017

Accepted by the Graduate Faculty of the University of Southern Indiana,

in partial fulfillment of the degree of

Master of Science in Industrial Management

Dr. Thomas N McDonald

Associate Professor

Director, MS Industrial Management

University of Southern Indiana

Dr. Marco Lara Gracia

Associate Professor of Engineering

University of Southern Indiana

Jason R. Deadmond, P.E.

Long Term Planning Leader – Central Complex

Indianapolis Power & Light Company

ABSTRACT

Brooks, Christopher J. Master of Science in Industrial Management, University of Southern Indiana, December, 2017. Additional Fly Ash Storage – Dewatering Bins Conversion Project at Indianapolis Power & Light Petersburg Generating Station. Major Professor: David E. Schultz, Ph.D, P.E.

The objective of this thesis is to complete a project in order to create additional ash storage capacity and system reliability for our Petersburg Generating Facility. Specifically, an economical solution for fly ash storage and disposal is required in order to meet evolving environmental emissions regulations required at the coal fired power plant.

First, the additional storage space required will allow both outage maintenance on existing fly ash storage locations and add extra capacity for use during full capacity generation. Second, creating this additional place for disposal will allow for operations to continue generation during any issues with the existing disposal locations. Operational and financial impacts determined that a project centered on the conversion of existing bottom ash handling tanks provides the greatest benefit. Current and future operations is impacted and internal planning and coordination helps change once open topped dewatering bins to closed fly ash handling tanks.

TABLE OF CONTENTS

Page

ACKNOWLEDGEMENTS

I would personally like to thank Dr. David E. Schultz for providing myself and others the opportunity to advance both my education and experiences while completing the journey of finishing this project.

"It always seems impossible until it's done."

- Nelson Mandela

LIST OF FIGURES

1. INTRODUCTION

A tremendous amount of organization and collaboration is necessary in order to operate and maintain a coal fired power plant. There are hundreds of complex machines and thousands of feet of mechanical process piping and electrical power and control cables to operate this functional system. At the Petersburg Generating Station there are four coal powered units. Approximately one thousand and seven hundred tons of coal is used at full capacity per day between these four units. In the simplest form, the coal is pulverized and fluidized by conveying air into the boiler where it is ignited and burned for its stored heat energy. The boiler is lined with hundreds of lineal feet of boiler tubing/piping. The heat from the combustion transfers into the pipe and into the water inside. The water inside the tubes heats into a high pressure steam that is used to spin a steam generator that produces electricity as an output. This facility contains over three hundred employees that facilitate keeping the power units online and generating.

In today's industry more and more environmental regulations of compliance add even more challenges to the day-to-day processes. The Environmental Protection Agency (EPA) has added many beneficial laws and regulations since their inception in 1970. Their main focus is providing clean air and water to all individuals within the United States. Over the past few decades, many regulations have been passed in order to minimize the environmental impact of coal plants including emissions limitations, water regulations and waste management regulations. Though a shift for cleaner energy is currently ongoing, coal generation is still the most reliable and cost effective source in today's energy market. Thus, the industry has evolved to incorporate new technologies and equipment in order to meet these regulations while still providing a low cost product to the consumers. One of the largest by-products of burning coal is the ash generated inside of the boiler. In general, there are two separate types of ash: heavier bottom ash and lighter fly ash. The heavier bottom ash settles within the confines of the boiler proper while the fly ash follows the pathway of air and smoke towards the exhaust chimney. Fly ash has the consistency of a very fine powder and is easily made airborne by even the slightest disturbance. Throughout this journey, various other environmental control systems allow this ash to settle out and become trapped in ductwork hoppers. The hoppers act like funnels and allow for the ash to be conveyed inside of piping via air into our current onsite storage facility for disposal.

The disposal of the ash is governed by the EPA and contains stringent guidelines. In December 2014, the EPA signed the Disposal of Coal Combustion Residuals (CCRs) from Electric Utilities final rule. This rule finalized regulations to provide a comprehensive set of requirements for the safe disposal of CCRs from coal-fired plants. These regulations address the risks from coal ash disposal including leaking of contaminants into ground water, blowing of contaminants into the air as dust and the catastrophic failure of coal ash surface impoundments. Additional regulations include the National Pollutant Discharge Elimination System (NPDES) and Mercury and Air Toxic Standards (MATS) that create additional processes and equipment required to comply. These regulations place immediate concern and require action for any circumstance during operations that would not allow for proper disposal of the ash.

Petersburg previously managed fly ash removal and transportation by storing it in two concrete silos or by wet sluicing the fly ash to the existing ash ponds. As of the end of 2017, wet sluicing has been discontinued due to new CCR regulatory changes within the NPDES water discharge permit. Due to this, all fly ash disposal is now conveyed via air inside of piping into two existing fly ash concrete silos. As shown below in Figure 1, these silos are located approximately three thousand feet away from the power house in an isolated location that is named Integral Utility Conversion Systems (IUCS). Even though it is remote, this fly ash storage and disposal system must operate at all times that the facility is generating in order to remove the ash from the power house.

Figure 1 - Petersburg Generating Facility Aerial Photo

Each silo is 45 feet in diameter and 75 feet tall, which totals slightly over 100,000 cubic feet of storage per silo. Assuming a conservative bulk density of 50 pounds per cubic feet of fly ash, each silo yields a storage capacity of approximately 2,500 tons. The four units at Petersburg can burn coal and yield an estimated 1,200 tons per day of fly ash. With these calculations and normal operation, we know that one single concrete silo can be utilized for all fly ash storage and disposal operations.

Disposal from the concrete silos is done via semi-trucks which haul contained tanker style trailers through a drive path that is located at the ground level underneath the silos. The ash is fluidized similar to a table hockey game via warmed, dry air. Spouts within the silo are then lowered into the tops of tankers and fly ash is loaded into the trucks for off-site removal. A weigh scale located underneath the silo allows the truck to generate a weighed product of removal. The silo is additionally equipped with level sensors in the top that monitor the ash levels inside of the silo.

The constant challenge that the Petersburg Operations and Maintenance teams fight is the reliability of these two concrete silos for disposal operations. The fluidized fly ash piping is transported within the confines of onsite plant trenches. Due to improper drainage, there could be times, especially during rain events, that sections of this trench could submerge the pipes in water. When the blowers are shut down and the positive pressure is removed from the piping, this water could seep into the pipeline. During startup, a blow-down, which would typically remove this water, may fall short of drying the line out completely. The residual water would then mix with the fly ash and all would be conveyed to the silo. This mixture causes a much larger problem because the fly ash will begin to harden into a concrete-like rock.

A search of plant maintenance records found six events where a single fly ash silo was taken out of service due to moisture intrusion over the last ten years. These outages lasted as few as four weeks and as many as ten weeks in order to remove the hardened fly ash material. Luckily, no event between the two silos had overlapped. However, should this instance occur, the power generation would have to be halted due to improper collection and disposal setup for fly ash. Our company and plant would have a full loss in revenue resulting in a dramatic financial loss.

Due to limitations of redundancy and additional measures within the CCR regulations, additional fly ash storage capacity and disposal methods are required at the Petersburg operating facility. This project will utilize the Project Management Institutes methodology to complete a project that has met all necessary requirements. The project will review two conceptual ideas and choose the smartest and most economical model to construct.

2. PLANNING

A project of this magnitude requires significant upfront review and brainstorming. In order to minimize cost and operational impact, there will be a lot of coordination over the solution chosen for this upgrade. Meetings with operation included a multitude of standard daily activities that the current fly ash storage and unloading silos facilitate. Additionally, the maintenance team was consulted to review their constant struggles and understand their necessity for ease of repair and maintainability. Throughout all of the meetings, it is largely noted that the fly ash storage and disposal is currently handled away from the plant at the remote location, IUCS. Thus, it was determined that our project would need to include a disposal location near the existing facility.

Operationally, the Petersburg facility contains two fly ash silos and other various coal burning by-products removal systems at the IUCS area as shown in Figure 2. The operators for this area continually monitor remote computers showing the silo elevations for fly ash content. They then plan the disposal of fly ash accordingly by coordinating with a third-party trucking contractor that disposes of the ash either at approved off-site locations or at our onsite owned and operated landfill. They are able to direct the fly ash from the four separate sources at the power plant into the two fly ash silos utilizing a piping and valve matrix that allows for any unit to reach any silo. This utilizes interdependent redundancy and grants the IUCS operators the ability to control their systems remotely. However, one operational control that the operators have zero charge over is how much and when fly ash is delivered to the silos. The amount and timing is dictated by the power plant and the standard power generation operations. Understanding this operation is critical in choosing a new location for storage and disposal.

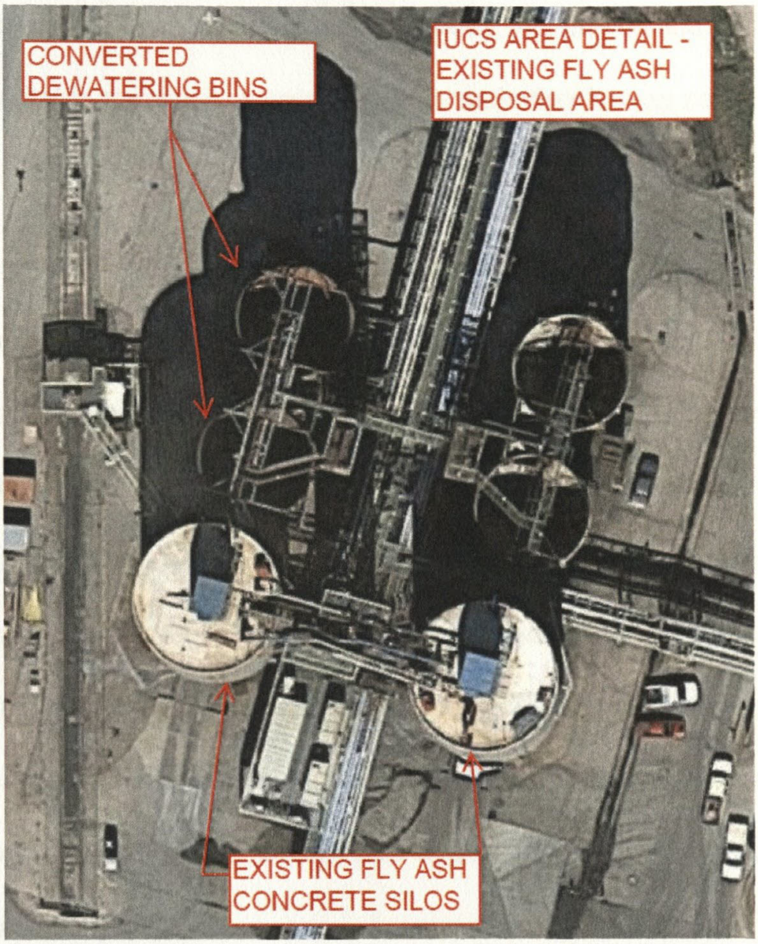


Figure 2 - IUCS Area Aerial Photo

As critical as this system is, being able to maintain and repair any issues that arise is just as important as the operational inputs. Two large factors for maintenance that will allow for more reliable operations are ease and convenience. Understanding that it makes a much larger impact for our parts, pieces and components to be interchangeable is critical for maintainability. Being competent on one part is much easier than attempting to train on various manufacturers. For this reason, the new construction will require the same or similar components. Additionally, the physical location of the parts is critical to the long term impacts for the facility. It is essential to have proper access to each part which could potentially need service in the future. Taking this into consideration will depend on having suitable stairways, access platforms, and other human occupancy requirements.

Most of the current onsite ash handling facilities have been designed and procured through a competent vendor, United Conveyor Corporation. Their designs keep being utilized from the initial power plant construction up to and including the present day operations. With their current designs and equipment onsite, it was important to include them in the selection and design process for our generating facility. Their involvement, maintenance, and operations feedback concluded that there were two concepts that would satisfy our requirements and supply the best benefits for our facility. These two conceptual designs include the conversion of existing non-utilized storage bins and the construction of a new concrete fly ash storage silo. Each of which contain their own unique challenges and benefits.

In the late 1980s, the IUCS facility took shape with the construction of the fly ash storage silo and adjacent bottom ash dewatering bins. These bins were designed by UCC and made to send water sluiced bottom ash from the power plant into the opened-top bins. The water would then be removed and treated while the bottom ash solids would be stored and disposed similar to the fly ash. Due to the functionality and other disposal methods, these bins were never fully utilized at the Petersburg facility after construction and have been left empty since their construction.

UCC has experience with this type of storage conversion and their initial conception could be facilitated at Petersburg. Each bin could be converted into a closed top tank with a fly ash capacity of approximately 600 tons or half of the total daily generation at the power plant. Due to their proximity, the first design idea would convert two of these bins in order to maintain our daily operation functions and keep the power plant generating at full capacity. Two bins would address the issue with the existing fly ash silos while still operating a storage and disposal system for the ash. The budgetary cost for engineering design, equipment supply and materials required for this type of conversion was an estimated $850,000. Without physical estimates and an assumption that this would be approximately 25% and an additional 5% contingency for the total installation cost, the concepts budget for completion was $3.1 million.

The second option included the design and construction of a new concrete silo. This would satisfy many of the redundancy and operational requirements. It would also allow for a larger storage location for the ash supplying even more redundancy. However, due to the facilities location and layout, a suitable site for this new silo may be difficult to locate without demolition of the aforementioned dewatering bins. Based upon previous project histories at other facilities, a new concrete silo with all of the required mechanical equipment and foundations would cost between 6 million to 8 million dollars.

Due to the complexities and cost of a new concrete silo, the conversion of our existing dewatering bins will be explored as a solution for our issue. UCC will supply the engineering design and conversion materials while additional contractors will be utilized for the additional engineering requirements and construction operations. In lieu of a construction general contractor, I will also facilitate coordination efforts throughout in order to minimize the cost impacts for the construction.

Within our organization, in order to complete a project of this magnitude, it must be fully accepted by the Capital Projects approval process. The instrument utilized to justify the requested expenditure is called the Project Authorization, Scoring & Evaluation Tool or PASE tool. An excel file is used to provide all details for the project including the business justification behind the project, the reason for the chosen path of construction, and the economics used to justify the large scale setup for the project. This spread sheet contains operational data including various calculations used to derive the Financial Cost Savings and Impacts in the event of the project is not completed. Utilizing a 20% chance that both fly ash units will cause the generation of our plant to stop for up to thirty days in one calendar year will cause over $3.5 million in lost generation revenue and an additional $0.14 million in startup savings cost. Appendix A shows an example of this PASE tool spreadsheet and how it is shared internally. As shown in this justification document, funding was approved in order to save on the potential loss of revenue allowing the project to move forward.

Converting two open top tanks that have sat vacant for decades into closed top fly ash storage silos is quite an endeavor. There are many unknowns walking into the project and various other concerns with the conversion. The existing bins are rust laden and nearly 30 feet above the finished roadway underneath. Throughout their journey we had to ensure that they were structurally sound and able to handle the newly acquired loading with fly ash and equipment.

UCC's proposal included all of the structural rework to the existing dewatering bins including the modifications required to the create a flat bottom on the existing silos and the installation of a new roof for enclosing the bin similar to a flat-top tank. Figure 3 shows a depiction of this modification. This alteration included all work in regards to the structural integrity to the dewatering bins. To ensure the bin walls and supporting structure were not jeopardized from rust, a metal thickness gauge was used to test a pattern around the four quadrants of each shell in various heights around the perimeter walls internally. The original tank design included 3/8" thick steel plate at the bottom cone and above the middle support section while ½" steel plate was used for the main support ribbed area. The samples concluded a degradation of nearly 1/8" on the entire north tank. This was noted to UCC and due to less loading from fly ash, there was no concern moving forward with the upgrade.

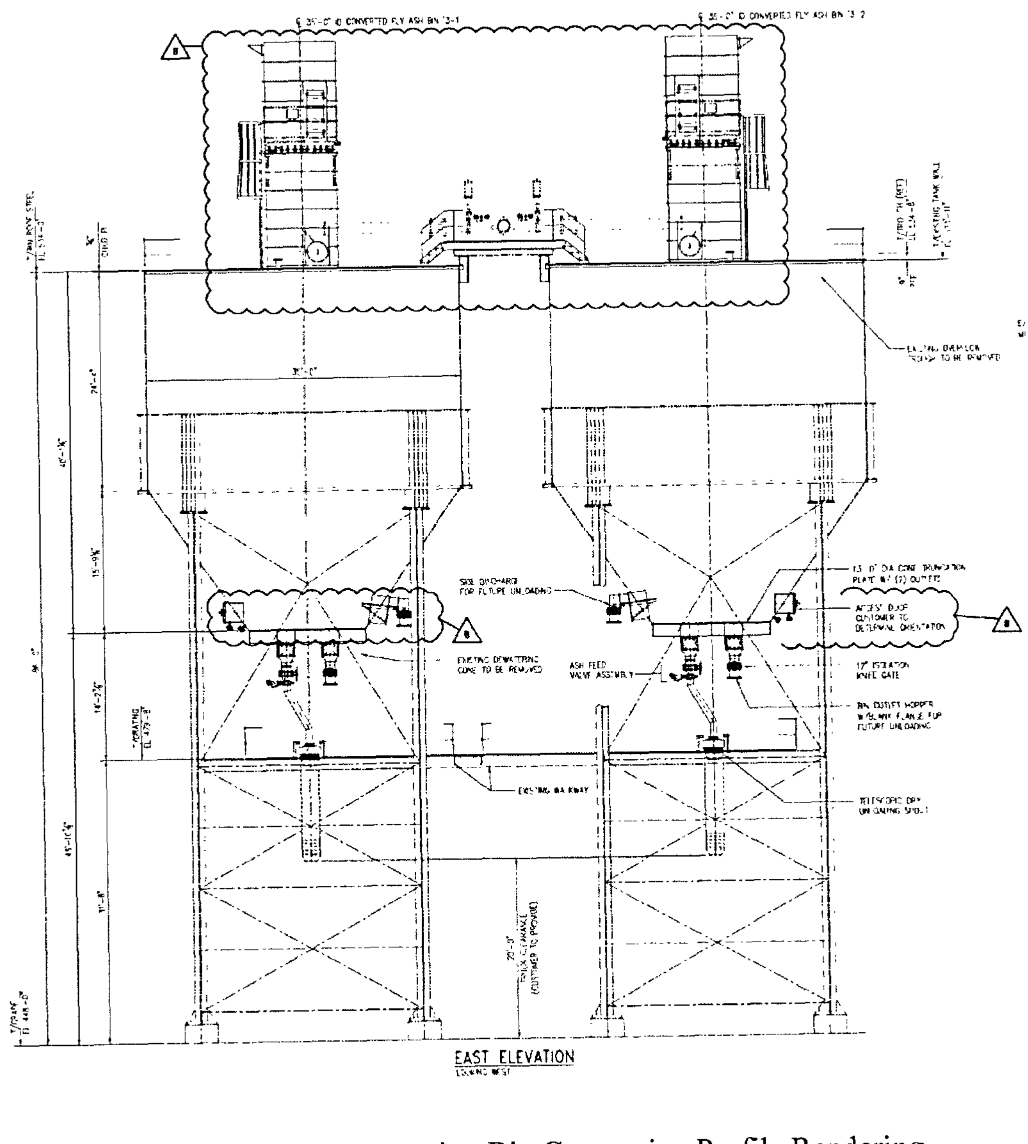


Figure 3 - UCC Dewatering Bin Conversion Profile Rendering

The new flat-top tank would receive a handrail around its perimeter. Since there was an existing catwalk system across the top, the existing stair towers and catwalks would be reused and modified in order to accommodate access on this new roof. The roof will provide our operations and maintenance teams an easily accessible location for all of the major roof top equipment.

The UCC proposal also included the mechanical conversion which consisted of the interception of the fly ash conveying piping from a below existing pipe rack and into the new closed top tanks. Figure 4 helps depict the physical location of these bins with adjacent pipe rack. A new 14" line would intercept and run fly ash up the same path as the previous system. To achieve this, additional isolation valves are required to divert the normal flow of conveyed ash into the newly converted bins will allow for easy control of the systems flow. Since the existing system contained supports for the same size pipe and loads, no major modifications were required.

Lastly, the proposal included all of the necessary equipment required to be installed onto the converted bins for normal operations. This included, but was not limited to, level indicators, pressure relief systems, bag houses for dust collection, and unloading equipment. For redundancy and familiarity, UCC was able to design these systems to mimic the same setup as the existing fly ash silos.

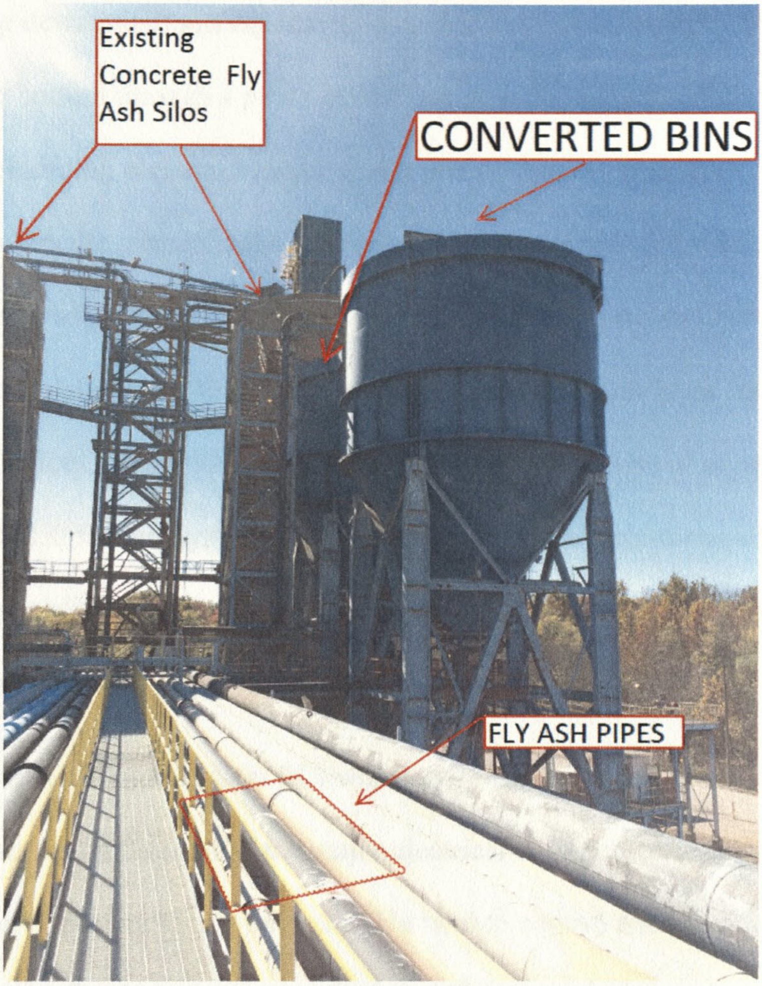


Figure 4 - Photo Looking South at Converted Dewatering Bins

Outside of the major UCC proposal, additional engineering is required in order to create an operational system for the plant to utilize. The largest of these include electrical conversion, electrical power and controls design, and accessibility concerns. An engineering firm familiar with our plant, PCI, provided a proposal to engineer and procure the necessary electrical power feeds and new controls system housed in a new Programmable Logic Controller (PLC). Lastly, a third engineering firm, Project Associates Inc. (PAI), was utilized for ancillary mechanical piping design and accessibility concerns.

The existing dewatering bins equipment contained hydraulic equipment that fed from the tops to the bottom through a pump system setup in an unloading building at ground level. This building contained minor power and control but had all of the hydraulic pumps, hydraulic storage tanks, and minor electrical controls feeding the existing bins. In order to provide necessary power and control to our new converted bins and equipment, it was determined that this building location would be ideal for housing the new electrical devices. Many visits to the plant site and a few days of experimental wire tracing was needed for this system's plan for demolition and reconstruction. This new unloading station also contained windows which would provide all operational needs for unloading of the new bins.

The new electrical upgrade from PCI will require a newly designed PLC that is similar to a computer that houses all of the major electrical communications and controls for an entire system. Utilizing such would concede remote control and provide an operator interface point for the new system. Existing PLC screens were mimicked and allow for ease of use. Figure 5 shows the complex setup that this conversion will require. Four major control valves, circled in red in the figure, will operate based upon the selection from the buttons at the bottom of the screen and allow operators to select which silo or bin is receiving ash. Additionally, the bag house vent relief box is utilized to maintain a constant pressure inside of the tank while fly ash is being pressurized and blown into the tanks with air.

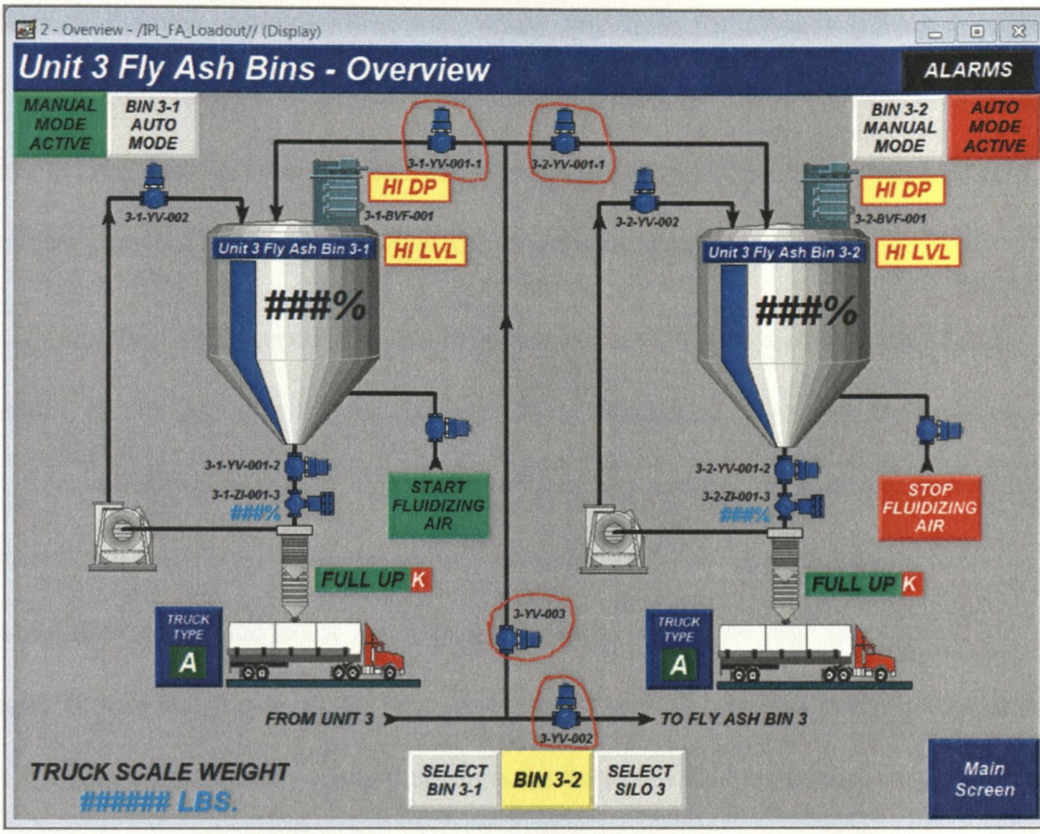


Figure 5 - New PLC Display Screen for Operations

Each bin contains a startup sequence program that is designed into the PLC based upon conditions of the system. Once the telescopic unloading spout is lowered from a "FULL UP" or raised position, the system will start its unloading sequence. This sequence will turn on various pieces of equipment including the fluidizing air inside the silo and a vacuum capture system on the telescopic spout to eliminate dust exposure. In order for operators and their corresponding truck driver to be sure of how much ash is inside of each closed tanker, a truck scale would be necessary. The existing fly ash silo adjacent to this setup already contains a short scale. After discussion with the manufacturer, it was determined that at a scale extension would be able to be completed underneath the new converted bins and imitate operations for unloading from the silos. The new configuration is displayed in the bottom left on the same PLC screen in Figure 5 giving the operator an idea of total load. Weight displays at the truck drivers height would be mounted to an existing structure to show total capacity as well.

The third engineering firm PAI helped connect the missing mechanical and structural pieces that unfolded as the systems were designed. One such major component was mechanical pipe supports. Fluidizing air was run through the existing concrete silo overhead and across to an unloading mezzanine beneath the silos. Supports were required throughout due to the line sizing in order to ensure the pipe met the manufacturer's maximum piping span distance between supports allotted. Additionally, a UCC designed access door was placed on the bottom elevation of each bin. This door would allow an accessible entrance into the silo for any work required. This overhead access also required a structural access platform design by PAI.

As with any major project, communication between all parties is critical to the success of a project. The three proposals for design have many essential interfaces and interactions that are necessary to complete these scopes. Critical data including power supply for equipment, operational manuals and operation, and maintenance input were crucial to the success of the project. Once UCC had supplied its design package and approvals, PAI and PCI were able to harness this data into finalizing construction packages for installation. In order to coordinate these efforts, many project management tactics were utilized including project status meetings with shared minutes, a Primavera Schedule and an Action Item List. An example schedule can be found in Appendix B.

The collaborated design for this project was an overall success. I was able to utilize a subject matter expertise in nearly all realms of the scopes. UCC was able to provide an economical solution to an onsite problem with similar equipment and minimal impacts. PCI was able to use their onsite electrical history and knowledge to develop a system that provide all necessary capabilities to our operations and maintenance team. Finally, PAI was able to help introduce final systems for ease of use. Utilizing these scopes we were able to perform construction bid packages and allow contractors to estimate the cheapest total install based upon these packages. Upon completion of the bid events, our site chose the onsite maintenance contractor BMWC to perform the major construction scopes with this project.

3. CONSTRUCTION

Introducing safety in any construction profession is critical to both the project's success, but also the lasting impact for the future. One of the best ways to introduce safety is to ensure the project construction contains a proficient plan of attack and competent personnel performing the work. Within this project, as similar to most retrofit projects, demolition activities will be the largest portion of construction work encountered on the project. Experienced persons running the project is crucial during these operations. The contractor also performs a Job Hazard Analysis that sets out the largest and most hazardous steps in the project allowing all to share their thoughts and concerns and before discerning how to mitigate the dangers.

After all mechanical and electrical systems are isolated via the Petersburg Safety Lock Out and Tag Out procedures, the demolition plans can commence. The first stage of demolition included the removal of all platforms and catwalks from the tops of the old dewatering bins. Inclusive in this stage were critical lift picks that took larger sections of platform down from atop the bins. A critical lift form was utilized because the weight of the pick exceeded 70% of the crane's rigging capacity. Figure 6 shows an image of the top of the bins before the demolition and Figure 7 shows the bins with the above catwalk sections being removed.

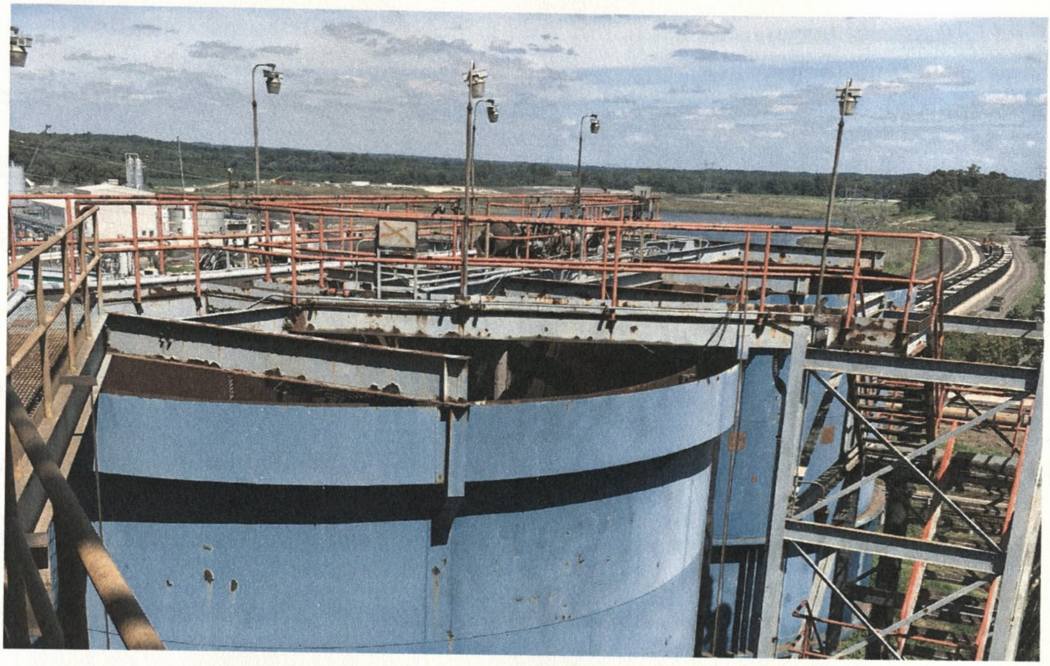


Figure 6 - Top of Existing Dewatering Bins Prior to Demolition

Figure 7 - Existing Dewatering Bins During Demolition of Platforms

The tops of the existing dewatering bins contained an external trough and an internal baffle that were components on the original design of the tanks. Initially, it was determind that the external trough would not need removed as the new lid would sit inside of this ring; however, due to access needed to complete the seal weld detail for the new lid a portion of this ring was removed. Additionally, during removal of the internal trough, a major structural discovery was made. As mentioned previously, the age and conditions of these tanks were of concern. On the most worn tank, the wall of the bin had major signs of deterioration including large holes. Figure 8 shows an example of this issue. Throughout the years, the external trough had collected rain and snow and was eaten from the outside in through the steel plate of the bin. This finding posed a major structural concern for the integrity of the steel walls on the tank.

Figure 8 - Internal Picture of Hole in Tank Wall Due to Weather Exposure

Additional Engineering support from PAI was necessary to help develop a path forward for this repair. Two options were explored as possible solutions to the issue. The first option was to remove the damaged tank wall and continue installation while creating a shorter tank. This, however, would lower the capacity of the tank and cause additional rework of materials during the rebuild. It would also create an access platform issue as the new tank would require additional stairs for access. The second option that was explored was to remove the damaged tank wall and replace with new steel materials. Referencing American Petroleum Institute (API) Standards section 9-5 Tank Inspection, Repair, Alteration, and Reconstruction, it was determined that this repair would be acceptable. Due to the circumstances and effects on the project, this repair was setup for completion. Approximately four feet of steel wall was removed from the top of the northern most bin during the demolition phase of the project.

The bottom of the tanks were stationed on an unloading level of grating above the driveway path for the old unloading design. This equipment was full of hydraulic operating cylinders, valves and electrical devices in order to operate. These systems were all obsolete and part of the removal plan. Due to their physical location and weight, extra care was taken for removal and lowered to the ground. Figure 9 shows the physical aspect of this old cone section. The demolition point for install of the new flat bottomed tank system can be found depicted in Figure 3.

Figure 9 - Existing Dewatering Bin Unloading Cone and Equipment

Another large demolition activity required on the existing system for the future installation was the removal of all mechanical process piping. As previously stated, an existing influent riser pipe was attached to the existing stair tower adjacent to these bins. This larger diameter piping and its valves on top of the bins posed a slight challenge. The crane shown in Figure 7 was necessary due to the heights and access issues for removal. Additionally, the old hydraulic system spanned from the ground floor all the way to the tops of these bins, and due to it being obsolete was removed. Figure 9 shows this hydraulic piping and other water lines that are not necessary in the new design.

The last major demolition activity included the removal of all the existing electrical components. Special care was needed for removal of existing conduits and wiring due to other operations being electrically charged in the area. Special isolation techniques were required. Each wire, prior to being cut, was specially metered for load to determine if it had been properly isolated, allowing for safe removal. Moreover, demolition of the existing electrical cabinets and controls within the unloading building on the ground required careful planning and execution. Electricity was fed into two major control panels and was distributed to the equipment on the bins. Two separate control panels that fed the hydraulic actuators and operations on the existing bins were adjacent to these panels. All components from this point out to the respective bin equipment were within the demolition scopes of work on the project. This included multiple conduit chases that split out amongst the bins.

As with any construction project after demolition, cleanliness of a jobsite can create a world of difference to the safety aspects. Removing any sort of tripping hazard will eliminate many potential injuries. Specifically, this project requires a lot of working at heights and fall protection measures to protect all individuals. Finally, once all structural, mechanical, and electrical demolition were complete, the path forward for the dewatering bins conversion construction could commence.

The first step in order to create a structure that is able to store fly ash dust is to encapsulate the entire structure and eliminate any leaks. UCC's structural design coupled with the ACI tank repair procedure will generate two new fly ash storage tanks. This retrofit will add additional structure members and a roof while also installing a new flat-bottomed deck for the tank's unloading level as depicted in Figure 3. Installing a new lid and bottom will allow for the mechanical and electrical equipment to be put in on the new tanks. All of this work is done nearly 100 feet from the ground level. In order to accommodate workers with the amount of welding necessary for accomplishing this task, an onsite scaffold contractor constructed an internal scaffold around the entire area of this 45 foot diameter tank. This allowed for proper access and egress to and from the tops of these tanks. A structural erection drawing set was supplied by UCC detailing the welded installation details and parts lists of materials.

Installing the new four foot ring of steel atop the northern most tank, per the ACI structural repair procedure, was quite a challenge. The weathered steel below needed careful prepping in order to properly receive the weld required to join to the new steel. The new roof system is designed to provide new attachment lugs to the exterior wall in order to insert and fasten these new beams which provide the support the new roof its ancillary equipment, piping and electrical requirements. For obvious reasons, this installation is critical due to the sheer weight magnitude this new material will transfer onto the tanks walls and supports. Figure 10 shows the new UCC design for structural members to be installed on the new roof. All weld locations were buffed down to clean metal to eliminate all rust and contaminants and provide suitable connections.

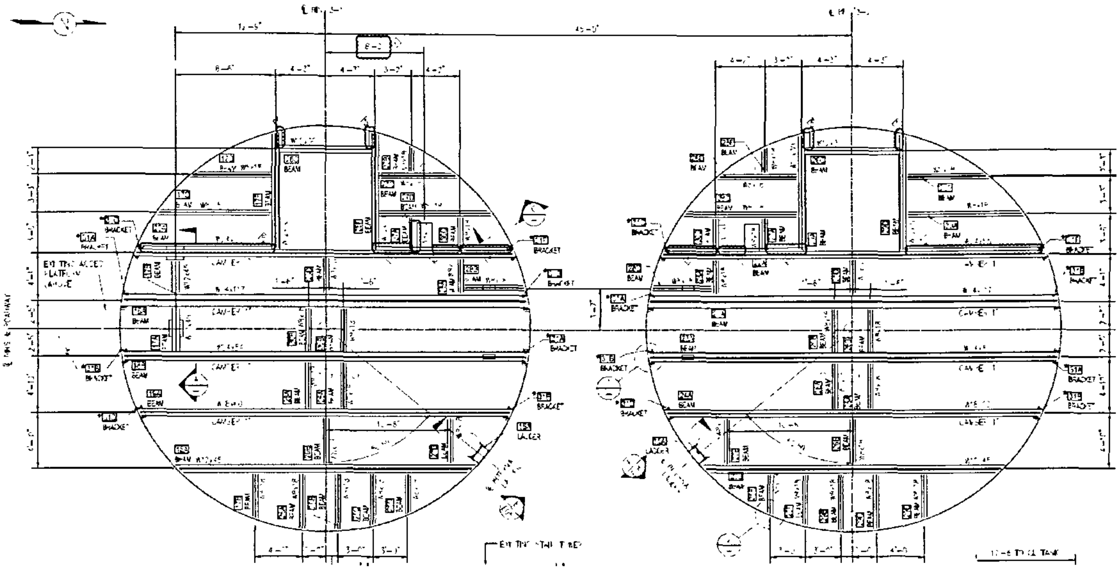


Figure 10 - New Bin Roof Structural Framing Plan

Upon completion of the roof support beams, a checkered steel deck is installed to act as the roof. Then, seam welding is done to provide a fully welded encased tank. External rolled angle is attached to the walls for perimeter support while the new beams allow the checkered decking to rest atop the welded assembly. These two new roofs allow the connection of the two access platform installs from the existing stair towers to the south tank and the new cross-over platform between the tanks to create access to the north tank. It also concedes the installation of equipment and then process piping. Figure 11 shows a photo during construction of the newly placed roofs atop the dewatering bins.

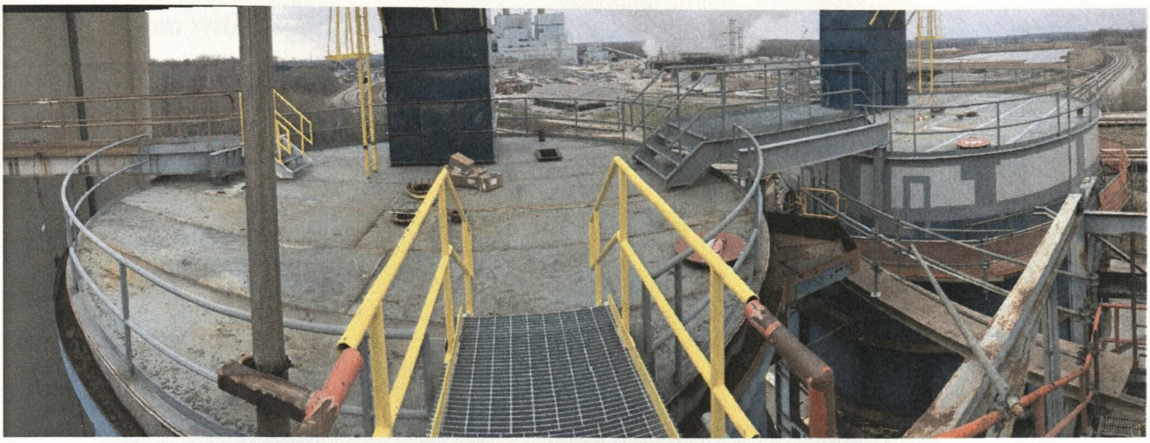


Figure 11 - New Roofs and Accesses During Construction Atop Bins

The other major structural conversion component to the dewatering bins is the installation of a newer flat bottom. This flat bottom would make way for the installation of the fluidizing air and unloading systems. From Figure 9, the new tank bottom is much higher than the other unloading equipment shown. The new bottom is 13 feet 2 inches in diameter and is composed of much thicker, external support beams. This bottom will hold all of the internal weight of the fly ash introduced into the tanks. It will also support most of the unloading equipment for the new fly ash system. Similar to the roof, special quality control and weld inspections are required in creating a new ACI standard tank. Again, seam welding a new 1" thick bottom plate creates the enclosed system for fly ash storage. Additionally, for internal access into the bottom of the tank, a round access door is cut and welded into the bottom side wall of the tank. This access door is just above the new bottom and is fitted with an industrial vacuum connection for additional fly ash removal methods should the unloading equipment or bottom of bins become clogged or damaged. This is a fairly standard component to fly ash storage systems due to their finicky nature and constant need for repair. This and the completed retrofit installation of a new bottom with support steel and parts of the unloading hoppers of the final product is shown in Figure 12.

Figure 12 - New Tank Bottom Installation During Construction

As shown in Figures 11 and 12, upon completion of the new structure, all mechanical systems can begin their installation. This new structure is utilized to brace and support these pipes.

There are tremendous amounts of mechanical processes involved within the fly ash storage and unloading systems. The four main piping systems include fly ash transmission, unloading system vacuum return, unloading system fluidizing air, and instrument air for the different equipment. The various equipment is composed of many items supplied by UCC as mentioned in the design stage. All of these systems are necessary on both bins and each require input from the others. Installation of the equipment on the new structure is the first step in being able to run the supporting air and electric lines accordingly.

As previously mentioned, fly ash is fluidized with air and transferred from the power houses out to the IUCS island for disposal via large diameter pipes and conveying blowers. Due to fly ash constantly being created and transferred through this line, the installation of a tie-in "Y" and diversion valves that would move the fly ash into the new bins was scheduled to be placed during a unit outage. This required input from the unit operators and a thorough plan for completion to be done on schedule. To save installation time, the tie-in was preassembled on the ground and flown into its final position during the outage window available on the line. Figure 13 shows the final installation of this branch from the main pipe. Additional support steal was installed to support the loads underneath the piping.

Figure 13 - Fly Ash Transfer Tie-In Piping

New equipment is installed on the new rooftops via flanged-bolted connections that are rising above the lid in Figure 11. The largest component installed is the bag house filter that captures fugitive ash in a dust collection system while keeping the internal pressures of the tank to atmospheric pressure. For bins of this size, an over 24 foot tall filter that is 8 foot by 8 foot in profile is required. Figure 14 shows the interior design of this device. Additional equipment on the rooftop includes a high level rotary device that sends alarm at high levels, a level transmitter that relays back the total height percentage of ash in the bins, and a pressure relief system in the event that the baghouse becomes stuck or plugged. The other penetrations in the roof include connections for the incoming fly ash, the unloading vacuum return system and a manway with access rungs at the edge. Lastly, all of these devices require an instrument air feed that is run up the existing stair tower and branched out to each piece of equipment. Figure 15 shows the final installation with final paid coating from above the two dewatering bins.

Figure 14 - Interior Photo of the New Baghouse Collection Device

Figure 15 - Rooftop Photo of the Newly Converted Bins with Installed Rooftop Equipment

Below the rooftops and at the bottom of the bins is a mezzanine grating level where the unloading equipment is installed. The unloading equipment is vital to the removal of the fly ash from the bins in a controlled and easily operated manner. On the newly attached flat bottom assembly, two holes for chute attachments collect the fly ash from inside the bins for disposal. One opening is for normal operations while a second is installed for plugged systems. Control valves isolate the flow of this ash during a controlled operational sequence discussed later. Next the installation of a discharge pipe which leaves these valves and travels into a telescoping spout. The telescoping spout is lowered from the mezzanine level and down into the unloading trucks below. This spout contains an internal pipe that the ash travels through as well as encompassing external pipe that is under constant vacuum. This constant vacuum is produced by a blower at the mezzanine level that then cycles the captured ash back up and into the top of the silo. The vacuum system allows for a low spill environment and is beneficial for maintenance and operations. Figure 16 below shows the completed installation.

Additionally, isolation and control valves lead the fluidizing air around the mezzanine and up into the bottom of the new bins. This installation also coincides with the new internal plates, called stones, which disperse the air and fluffs the fly ash into a fluid state and allows it to flow. Figure 17 shows an internal picture of these stones installed through the inspection port. Also note the internal rusty environment that these tanks contained. Instrument air to these various components completes the mechanical installation on the converted bins.

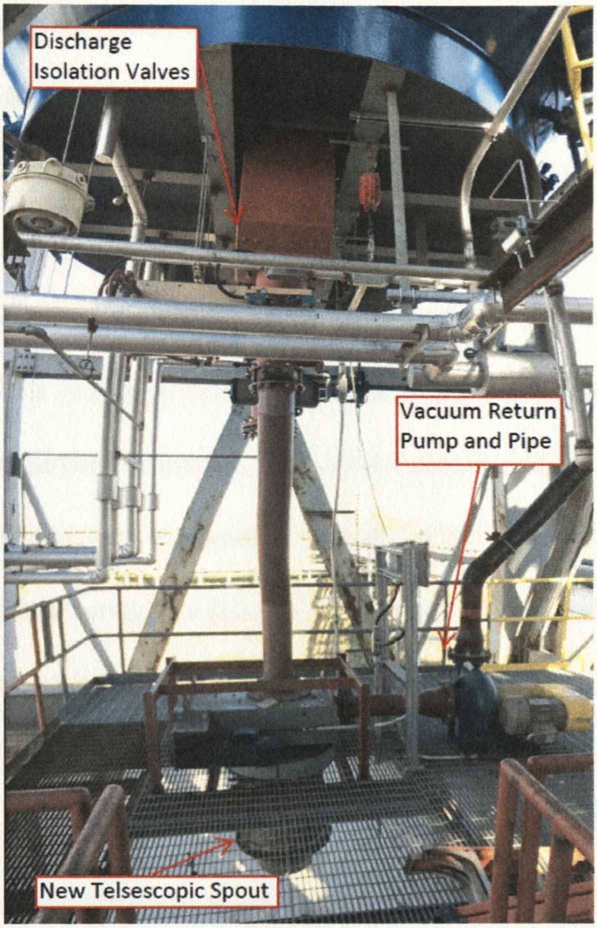


Figure 16 - Mezzanine Level Unloading Equipment

Figure 17 - Installed Fluidizing Stones Inside of Silo on New Flat Bottom

One of the last items to be completed during construction activities was the electrical system due to its dependence on previous installations. Once the mechanical components have been set, running conduits and wiring to the new devices is achievable. Inside the cleared out unloading building, an electrical power panel, called a motor control center (MCC), is installed in place. These devices are similar to residential fuse panels in that they take a supply power feed and distribute it accordingly to the various breakers feeding the external equipment. The newly installed MCC houses eight large breakers, one spare breaker, and one smaller residential fuse panel for the lights and electrical outlets installed throughout the project. Due to its physical size and only a man door of access, it was installed in four separate sections to complete a 7 foot wide, by 7 ½ foot tall, by 20 inch deep cabinet. The PCI design supplied detailed drawings and a detailed cable schedule, shown in Appendix C, that allows for easy field routed conduits and wires. Once complete, the installation of both the supply power and distribution power is finished.

The brains of the entire operation are handled within the design that was created by PCI's electrical team. Onsite meetings and UCC standard operations created a robust system with a new Programmable Logic Controller (PLC) that operates all parameters of the inputs. Attached to the large new PLC cabinet is the display screen utilized for startup shown in Figure 5. This PLC operates and controls all valves and motors based upon the operators inputs. Valves are controlled via solenoids that control the instrument air for their movements. Motors for lowering the spout and turning on the bin vent filters and telescopic spout vacuum returns are controlled on this screen. Also contained within the cable schedule provided is the control cable schedule that slows for these devices to know when and how to operate. Typically run in the same conduits, they connect the PLC to the operating equipment in the field.

Additional control panels for the unloading equipment were supplied by UCC. These are installed in the same unloading room for ease of use. They give the operator control, separate from the PLC, to lower and raise the telescopic spout, open and close the unloading valves ash, and actuate a safety punch stop device. Figure 18 shows the newly constructed control room. All controls and operation can be done from this room alone.

Figure 18 - New Unloading Building Control Room

Construction and conversion of the two dewatering bins was a giant success. With a lot of high hazard activities and coordination, it was completed without any safety accidents. Even with an evolving conversion due to the deterioration of the tanks, it was also completed without any quality incidents. When final construction was complete, a full coat of exterior paint was supplied and the system could begin start up and commissioning.

4. START UP AND COMMISSIONING

The first step in making the conversion operational is to ensure that all the newly installed components function and control properly. Systematically checking more than fifty devices for operation can take time. The first step involves removal of all locked out and tagged isolation devices on the equipment including supply air valves and electrical breakers isolating the new construction. Next, it is important to open all manual isolation valves installed on the new fluidizing air and instrument air system in order to gain control of all pneumatic operations of the plant. Prior to involving a UCC representative, PCI with the help of the construction contractor started system and function testing on the unit. The new PLC would send a signal to the valve, motor or component and radio feedback from an individual item that would validate results seen on the PLC computer. This proved to be quite cumbersome as repair work was necessary on a few valve instruments and trial and error was required on operational set points for this equipment based on the feedback sent to the PLC.

After ensuring all components functioned properly, based upon manual operation at the device and forced control operation via the PLC computer, the system could begin situational operation testing. These tests would mimic normal operational situations and ensure that the systems would function properly based on the logic written by PCI. It is imperative that certain systems operate properly prior to introducing ash into the tanks. This is essential because fluidizing air needs to be on and operating at least thirty minutes prior to allowing unloading operations and valves to open. This is a parameter set by

UCC that ensures no plugging can occur at the unloading chutes. These tests proved beneficial as many holes were found within the logic on the new PLC.

During the latter part of this testing, we deemed it beneficial to have a UCC field representative onsite that had more knowledge on the system as a whole. It was determined that PLC logic was needing rewritten and other set point questions could only be answered by UCC. While onsite, the representative verified the operation on all major UCC supplied equipment. We were able to couple a construction contractor with their representative in order to complete all punch list activities while on site. The representative's knowledge and experience with these systems gave us a level of comfort and helped expand our understanding of how certain situations should be perceived by the PLC. A tremendous amount of work was completed in the days leading up to introducing fly ash into the storage bins. Once all parties were confident in the system, we were able to coordinate with plant operations to redirect fly ash into the converted bins.

After completing all startup and testing responses we were able to use the UCC representative to give our onsite maintenance and operations training for this new system. Each team was given an Operations and Maintenance Binder and taken through the loading and unloading operations experienced during the startup. Extra beneficial questions and answers were provided throughout this process.

5. RESULTS AND DISCUSSION

Inserting fly ash at this point was literally as simple as pushing a button. With the new display shown in Figure 5, we selected Bin 3-1 and watched the fly ash sequence begin. The diversion valves opened and closed accordingly to divert the fly ash conveyance into the selected tank. Both the fluidizing air and bin vent bag house started operation to keep the fly ash fluidized and stable during the filling process. The 3-1 Bin began receiving fly ash through the newly installed 14" pipe.

The new level transmitter read a zero to one hundred percent reading on the new read out screen. We were able to track each percent of raise in this bin during the fill. It took approximately one hour for the first silo to fill up to four percent on the read out screen. This reading confirmed our original data assumption, which stated that each silo can hold approximately one day's worth of fly ash production from the power plant. Though this was a slow and tedious fill process, we were excited to see the results. Throughout the fill, we monitored the equipment at the PLC display as well as out on the bins. After filling to approximately twenty percent full, we selected the 3-2 bin on the computer. Again, the diversion valves opened and closed accordingly as we began filling the second bin with fly ash. While monitoring all of the newly added steel sections and parts, we were able to see that neither bin showed any signs of leaks throughout the fill process.

Upon confirmation that fly ash had entered the new tanks appropriately, we scheduled a tanker truck in order to operate the system for ash removal. The system was tested in manual and automatic states to confirm both capabilities. While in manual, the UCC supplied operated control panels, shown in Figure 18, were utilized. After aligning the truck's opening underneath the telescopic spout, we began manually opening and closing the fill station valves. We were able to track the fill into the tank by monitoring the weight climb on the new scale extension. Additionally, the automatic controls from the new PLC were tested. The program was written to allow operators input a weight set point which allowed the system to load ash into a truck until the scale read a specific limit. At 90% of the set point, the valve controlling the chute would close halfway in order to slow flow until the desired weight was achieved. Both tanks were tested in manual and automatic mode successfully. We emptied both tanks and left operations with two new storage and disposal tanks to use whenever they deemed it necessary.

This project contained varying challenges and complexities with similar learning experiences throughout its duration. Completing the project took nearly 24 months from concept to completion. There were zero safety incidents and zero quality incidents. The only rework required was to replace faulty equipment that was underneath the warranty blanket for the new system. Separate purchase orders were tracked utilizing internal software. Even with the unforeseen tank repairs, we were able to supply a fresh paint to the exterior of the tanks and still come in right on budget.

Although the financial benefit for this project is only correlated to failures of other equipment in the same process, it will still give the operations and maintenance teams flexibility as far as the operational constraints surrounding fly ash disposal are concerned. Our facility is now capable of handling additional fly ash storage and disposal.

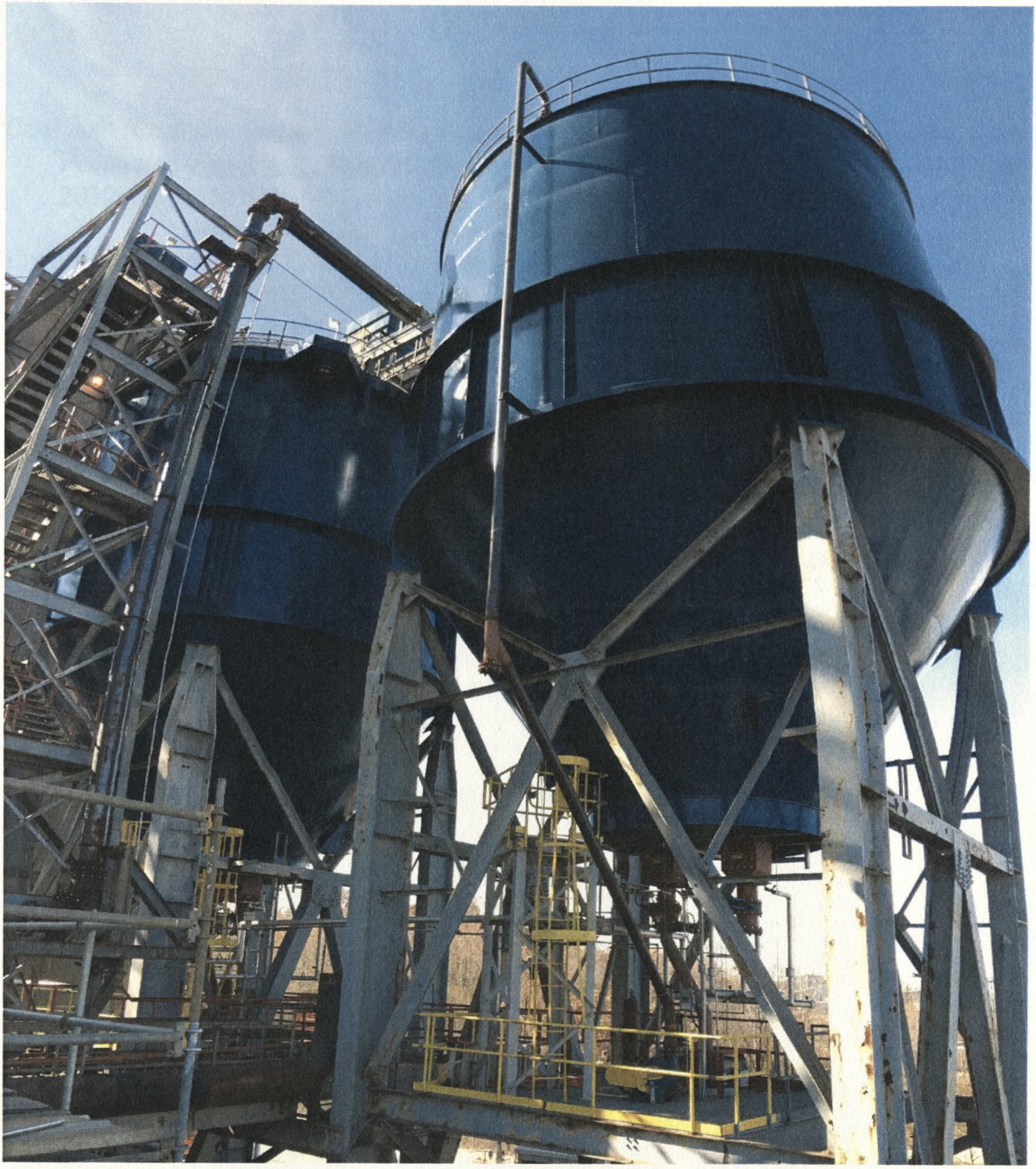


Figure 19 - Converted Dewatering Bins at Completion

REFERENCES

"Coal Ash (Coal Combustion Residuals, or CCR)". *United States Environmental Protection Agency*, 22 Aug. 2017, https://www.epa.gov/coalash , Accessed 7 Sept. 2017.

"Final Rule: Disposal of Coal Combustion Residuals from Electric Utilities". *United States Environmental Protection Agency,* 7 Mar. 2017, https://www.epa.gov/coalash/coal-ash-rule , Accessed 7 Sept. 2017.

"National Pollutant Discharge Elimination System (NPDES)". *United States Environmental Protection Agency,* 7 Nov. 2017, https://www.epa.gov/npdes , Accessed 20 Nov. 2017.

"Mercury and Air Toxics Standards (MATS)". *United States Environmental Protection Agency,* 12 Sept. 2017, https://www.epa.gov/mats , Accessed 2 Oct. 2017.

American Petroleum Institute. (2014). *API 653 Standard entitled: Tank Inspection, Repair, Alteration, and Reconstruction*. Copyrighted Material licensed to Tom Minsterketter.

APPENDICES

APPENDIX A – COST JUSTIFICATION SHEETS (PASE TOOL)

Project Cost Information: *All Project Costs should be entered in 100% dollars (not share)

Material	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	TOTAL
UCC Proposal	$ 800,000										$ 800,000
Electrical Conversion		$ 300,000									$ 300,000
IT Hardware	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
IT Software	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Spare Parts											
Spare Parts		$ 100,000									$ 100,000
Grand Total Material	$ 800,000	$ 400,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 1,200,000

Raw Labor (Internal)	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	TOTAL
Field engineering	$ 10,000	$ 10,000									$ 20,000
(Other)											$ -
IT Internal Labor	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
IT Business Labor	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Overheads	Calculated below										

Raw Labor (External)	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	TOTAL
Engineering Study, Design, DCS Logic, etc.	$ 80,000	$ 20,000									$ 100,000
Installation Field Labor	$ 1,120,000	$ 560,000									$ 1,680,000
Consultant/External IT Labor	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Grand Total Labor	$ 1,210,000	$ 590,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 1,800,000

Cost of Removal	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	
Removal Costs	$ 100,000										$ 100,000

Salvage Value($)	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	TOTAL
Salvage	$ -										$ -

Contingency (%)	5.0%	Reason for Contingency:
Calculated Contingency ($)	$ 145,000	

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	TOTAL
Total Capital Project Cost	$ 2,010,000	$ 890,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 2,900,000
Capitalized Cost of Removal	$ 100,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 100,000
Contingency	$ 100,500	$ 44,500	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 145,000
Overheads*	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
☐ *Check box to add overheads	$ 2,210,500	$ 934,500	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 3,145,000
Total Project O&M / Expense	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -

Project Benefit Information: *All Project Benefits/ Avoided Costs should be entered in 100% dollars (not share)

Forced Outage Avoidance ($) = # days * 24 hrs * # outages * MW Unit Load * $/MWh * Capacity Factor * Probability %

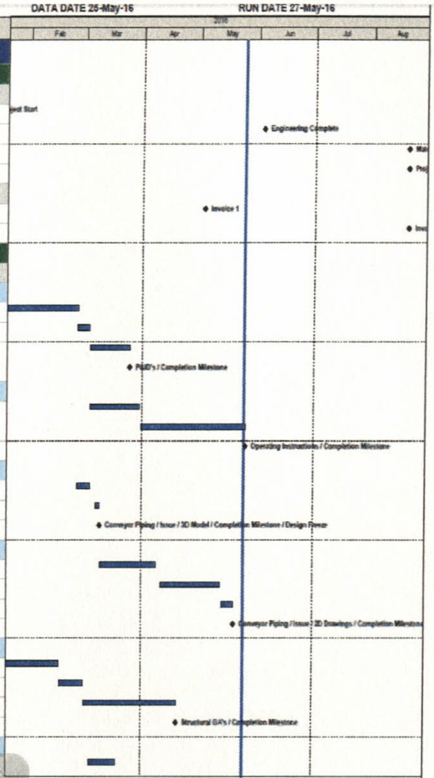
Financial - Cost Saving

Generation (Lost Margin)	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Outages due to Bins Plugged (20% chance)	$ 3,579,389									
Startup Costs	$ 137,600									

APPENDIX B – EXAMPLE PRIMAVERA SCHEDULE

UCC / 54674-26 IPL DEWATERING BIN MODIFICATIONS — **DETAIL SCHEDULE** — **DATA DATE 25-May-16** — **RUN DATE 27-May-16**

Activity ID	Responsible Department	Activity Name	Original Duration	Activity % Complete	Start	Finish
UCC / [54674-26] / IPL Petersburg / Dewatering Bin Modifications			160		12-Jan-16 A	19-Aug-16
*** PROJECT MILESTONES**			157		12-Jan-16 A	19-Aug-16
Contract Award			157		12-Jan-16 A	19-Aug-16
UCC0100	100	Project Start	0	100%	12-Jan-16 A	
UCC0540	100	Engineering Complete	0	0%		03-Jun-16
UCC1100	100	Material Shipped Complete	0	0%		19-Aug-16
UCC1200	100	Project Complete	0	0%		19-Aug-16
Invoice Milestone			76		03-May-16 A	19-Aug-16
UCC1110	100	Invoice 1	0	100%		03-May-16 A
UCC1120	100	Invoice 2	0	0%		19-Aug-16
*** ENGINEERING / DESIGN**			103		12-Jan-16 A	03-Jun-16
Dewatering Bin Modifications			103		12-Jan-16 A	03-Jun-16
P&ID's			53		12-Jan-16 A	25-Mar-16 A
UCC110	102	Prepare & Submit / P&ID's	32	100%	12-Jan-16 A	26-Feb-16 A
UCC120	102	Customer Review and Return Comments / P&ID's	10	100%	26-Feb-16 A	03-Mar-16 A
UCC130	102	Incorporate Comments & Submit Final / P&ID's	10	100%	04-Mar-16 A	25-Mar-16 A
UCC140	102	P&ID's / Completion Milestone	0	100%		25-Mar-16 A
Operating Instructions			59		04-Mar-16 A	25-May-16 A
UCC160	102	Prepare & Submit / Operating Instructions	10	100%	04-Mar-16 A	30-Mar-16 A
UCC170	102	Customer Review and Return Comments / Operating Instructions	10	100%	31-Mar-16 A	25-May-16 A
UCC190	102	Operating Instructions / Completion Milestone	0	100%		25-May-16 A
Conveyor Piping / 3D Model			16		26-Feb-16 A	09-Mar-16 A
UCC210	102	Conveyor Piping First Submittal / 3D Model	7	100%	26-Feb-16 A	04-Mar-16 A
UCC220	102	Conveyor Piping / Customer Review and Comment / First Submittal / 3D Model	34	100%	07-Mar-16 A	09-Mar-16 A
UCC240	102	Conveyor Piping / Issue / 3D Model / Completion Milestone / Design Freeze	0	100%		09-Mar-16 A
Conveyor Piping / 2D Drawings			45		10-Mar-16 A	19-May-16 A
UCC260	102	Conveyor Piping / Prepare & Submit / 2D Drawings with BOM	15	100%	10-Mar-16 A	08-Apr-16 A
UCC270	102	Conveyor Piping / Customer Review and Comment / 2D Drawings	10	100%	11-Apr-16 A	12-May-16 A
UCC280	102	Conveyor Piping / Incorporate Comments / Final Submittal / 2D Drawings	10	100%	13-May-16 A	19-May-16 A
UCC290	102	Conveyor Piping / Issue / 2D Drawings / Completion Milestone	0	100%		19-May-16 A
Structural GA's			71		12-Jan-16 A	19-Apr-16 A
UCC310	090	Prepare & Submit / Structural GA's	20	100%	12-Jan-16 A	16-Feb-16 A
UCC320	090	Customer Review and Return Comments / Structural GA's	10	100%	17-Feb-16 A	29-Feb-16 A
UCC330	090	Incorporate Comments & Submit Final / Structural GA's	11	100%	01-Mar-16 A	19-Apr-16 A
UCC340	090	Structural GA's / Completion Milestone	0	100%		19-Apr-16 A
Structural Design Drawings			33		04-Mar-16 A	19-Apr-16 A
UCC360	090	Prepare & Submit / Structural Design Drawings	11	100%	04-Mar-16 A	18-Mar-16 A



Actual Work — Critical Remaining Work — Remaining Work — ◆ Milestone

APPENDIX C – CABLE INSTALLATION SCHEDULE (EXCEL)

	A	B	C	D	E	F	G	H	I
1	Rev	Volt	Cable or Conduit	Spec	From Location	From Drawing	To Location	To Drawing	Notes
2		120V	C-3101	5/C #14	REMOTE FA-PLC	E-3AHSRFAPLC-02	3-1-FV-001-2 (3-1 Outlet)	E-3AHSRFAPLC-06	Bot
3		120V	C-3102	5/C #14	REMOTE FA-PLC	E-3AHSRFAPLC-02	3-FV-002 (Transport)	E-3AHSRFAPLC-06	Top
4		120V	C-3103	5/C #14	REMOTE FA-PLC	E-3AHSRFAPLC-02	3-1-FV-001-1 (3-1 Inlet)	E-3AHSRFAPLC-06	Top
5		120V	C-3104	5/C #14	REMOTE FA-PLC	E-3AHSRFAPLC-02	3-1-FV-002 (3-1 Vent)	E-3AHSRFAPLC-06	Top
6		120V	C-3105	3/C #14	REMOTE FA-PLC	E-3AHSRFAPLC-02	3-1-LS-001 (Level Sw)	E-3AHSRFAPLC-06	Top, see E-3114
7	C	120V	C-3106	5/C #14	REMOTE FA-PLC	E-3AHSRFAPLC-02	3-1 Bin Vent Diff Pres & Enable	E-3AHSRFAPLC-06	Increased to 5/C, Top
8		120V	C-3107	3/C #14	REMOTE FA-PLC	E-3AHSRFAPLC-02	3-1-PSL-001 (Inst Air)	E-3AHSRFAPLC-06	Bot
9		120V	C-3108	3/C #14	REMOTE FA-PLC	E-3AHSRFAPLC-02	3-1-ZSC-001-3 (Ash Feed Close)	E-3AHSRFAPLC-06	Bot
10		120V	C-3109	3/C #14	REMOTE FA-PLC	E-3AHSRFAPLC-02	3-1-ZSL-001-1 (Spout Slack)	E-3AHSRFAPLC-06	Bot
11		120V	C-3110	3/C #14	REMOTE FA-PLC	E-3AHSRFAPLC-02	3-1-ZSH-001-1 (Spout Full Up)	E-3AHSRFAPLC-06	Bot
12	C	120V	C-3111	9/C #14	REMOTE FA-PLC	E-3AHSRFAPLC-02	3-1 Spout Control Station	E-3AHSRFAPLC-06	Increased to 9/C
13		120V	C-3112	9/C #14	REMOTE FA-PLC	E-3AHSRFAPLC-02	MCC-34-4-3-02 (Spt Mtr Cntl)	E-3AHSRFAPLC-06	Control Room
14		120V	C-3113	9/C #14	REMOTE FA-PLC	E-3AHSRFAPLC-02	MCC-34-4-3-02 (Vent Mtr Cntl)	E-3AHSRFAPLC-06	Control Room
15		120V	C-3201	5/C #14	REMOTE FA-PLC	E-3AHSRFAPLC-02	3-2-FV-001-2 (3-2 Outlet)	E-3AHSRFAPLC-06	Bot
16		120V	C-3202	5/C #14	REMOTE FA-PLC	E-3AHSRFAPLC-02	3-FV-003 (Crossover)	E-3AHSRFAPLC-06	Top
17		120V	C-3203	5/C #14	REMOTE FA-PLC	E-3AHSRFAPLC-02	3-2-FV-001-1 (3-2 Inlet)	E-3AHSRFAPLC-06	Top
18		120V	C-3204	5/C #14	REMOTE FA-PLC	E-3AHSRFAPLC-02	3-2-FV-002 (3-2 Vent)	E-3AHSRFAPLC-06	Top
19		120V	C-3205	3/C #14	REMOTE FA-PLC	E-3AHSRFAPLC-02	3-2-LS-001 (3-2 Level Sw)	E-3AHSRFAPLC-06	Top, See E-3204
20	C	120V	C-3206	5/C #14	REMOTE FA-PLC	E-3AHSRFAPLC-02	3-2 Bin Vent Diff Pres & Enable	E-3AHSRFAPLC-06	Increased to 5/C, Top
21		120V	C-3207	3/C #14	REMOTE FA-PLC	E-3AHSRFAPLC-02	3-2-PSL-001 (Inst Air)	E-3AHSRFAPLC-06	Bot
22		120V	C-3208	3/C #14	REMOTE FA-PLC	E-3AHSRFAPLC-02	3-2-ZSC-001-3 (Ash Feed Close)	E-3AHSRFAPLC-06	Bot
23		120V	C-3209	3/C #14	REMOTE FA-PLC	E-3AHSRFAPLC-02	3-2-ZSL-001-1 (Spout Slack)	E-3AHSRFAPLC-06	Bot
24		120V	C-3210	3/C #14	REMOTE FA-PLC	E-3AHSRFAPLC-02	3-2-ZSH-001-1 (Spout Full Up)	E-3AHSRFAPLC-06	Bot
25	C	120V	C-3211	9/C #14	REMOTE FA-PLC	E-3AHSRFAPLC-02	3-2 Spout Control Station	E-3AHSRFAPLC-06	Increased to 9/C
26		120V	C-3212	9/C #14	REMOTE FA-PLC	E-3AHSRFAPLC-02	MCC-34-4-3-02 (Spt Mtr Cntl)	E-3AHSRFAPLC-06	Control Room
27		120V	C-3213	9/C #14	REMOTE FA-PLC	E-3AHSRFAPLC-02	MCC-34-4-3-02 (Vent Mtr Cntl)	E-3AHSRFAPLC-06	Control Room
28		120V	E-3101	2 #12, #12G	LP1	E-3AHSSMCC34-4-3-01	2nd Floor Control Room Lights	E-3AHSSMCC34-4-3-01	
29		120V	E-3102	2 #12, #12G	LP1	E-3AHSSMCC34-4-3-01	2nd Floor Control Room Recpts	E-3AHSSMCC34-4-3-01	
30		120V	E-3103	6 #12, #12G	LP1	E-3AHSSMCC34-4-3-01	REMOTE FA-PLC	E-3AHSRFAPLC-02	
31		120V	E-3104	2 #12, #12G	LP1	E-3AHSSMCC34-4-3-01	Ground Floor Lights	E-3AHSSMCC34-4-3-01	
32		120V	E-3105	2 #12, #12G	LP1	E-3AHSSMCC34-4-3-01	Ground Floor Lights	E-3AHSSMCC34-4-3-01	
33	C	120V	E-3106	3 #12, #12G	LP1	E-3AHSSMCC34-4-3-01	3-1 Winterizing Kit, Pulse Timer	E-3AHSSMCC34-4-3-01	Moved Level Detector to it's own conduit
34		480V	E-3107	3 #12, #12G	MCC-34-4-3	E-3AHSSMCC34-4-3-01	3-1 Telescopic Spout Hoist, Motor	E-3AHSSMCC34-4-3-01	
35		480V	E-3108	3 #10, #10G	MCC-34-4-3	E-3AHSSMCC34-4-3-01	3-1 Telescopic Spout Vent Fan Motor	E-3AHSSMCC34-4-3-01	
36		120V	E-3109	2 #12, #12G	LP1	E-3AHSSMCC34-4-3-01	Exterior Receptacle West Wall	E-3AHSSMCC34-4-3-01	
37		480V	E-3110	3 #6, #10G	MCC-34-4-3	E-3AHSSMCC34-4-3-01	Exterior Welding Receptacle West Wall	E-3AHSSMCC34-4-3-01	
38		480V	E-3111	3/C #3/0, #4G	MCC-34-4-1	E-3AHSSMCC34-4-3-02	MCC 34-4-3	E-3AHSSMCC34-4-3-02	
39		480V	E-3112	3/C #3/0, #4G	MCC-34-4-2	E-3AHSSMCC34-4-3-02	MCC 34-4-3	E-3AHSSMCC34-4-3-02	
40		120V	E-3113	2 #12, #12G	LP1	E-3AHSSMCC34-4-3-01	REMOTE FA-PLC	E-3AHSRFAPLC-05	
41	C	120V	E-3114	2 #12, #12G	LP1	E-3AHSSMCC34-4-3-01	3-1-LS-001 (Level Sw) power	E-3AHSSMCC34-4-3-01	new
42	C	120V	E-3201	3 #12, #12G	LP1	E-3AHSSMCC34-4-3-01	3-2 Winterizing Kit, Pulse Timer, Level Detector	E-3AHSSMCC34-4-3-01	Moved Level Detector to it's own conduit
43		120V	E-3202	3 #12, #12G	MCC-34-4-3	E-3AHSSMCC34-4-3-01	3-2 Telescopic Spout Hoist, Motor	E-3AHSSMCC34-4-3-01	
44		120V	E-3203	3 #10, #10G	MCC-34-4-3	E-3AHSSMCC34-4-3-01	3-2 Telescopic Spout Vent Fan Motor	E-3AHSSMCC34-4-3-01	
45	C	120V	E-3204	2#12, #12G	LP1	E-3AHSSMCC34-4-3-01	3-2-LS-001 (Level Sw) power	E-3AHSSMCC34-4-3-01	new
46	C	DC	~~I-3101~~	~~2/C #16 SHLD~~	~~REMOTE FA-PLC~~	~~E-3AHSRFAPLC-02~~	~~3-1-WT Level Transmitter~~	~~E-3AHSRFAPLC-07~~	HOLD, not sure how this is connected.
47		DC	I-3102	2/C #16 SHLD	REMOTE FA-PLC	E-3AHSRFAPLC-02	3-1-LT-001 Level Transmitter	E-3AHSRFAPLC-07	
48		DC	I-3103	2/C #16 SHLD	REMOTE FA-PLC	E-3AHSRFAPLC-02	3-1-ZT-001 Ash Feed Valve	E-3AHSRFAPLC-07	
49	C	DC	I-3201	~~2/C #16 SHLD~~	~~REMOTE FA-PLC~~	~~E-3AHSRFAPLC-02~~	~~3-2-WT Level Transmitter~~	~~E-3AHSRFAPLC-07~~	HOLD, not sure how this is connected.
50		DC	I-3202	2/C #16 SHLD	REMOTE FA-PLC	E-3AHSRFAPLC-02	3-2-LT-001 Level Transmitter	E-3AHSRFAPLC-07	
51		DC	I-3203	2/C #16 SHLD	REMOTE FA-PLC	E-3AHSRFAPLC-02	3-2-ZT-001 Ash Feed Valve Pos	E-3AHSRFAPLC-07	
52		ETH	Z-3001	Cat 6 Ethernet	REMOTE FA-PLC	E-3AHSRFAPLC-02	RR-PLC	E-3AHSRFAPLC-05	
53		ETH	Z-3002	Cat 6 Ethernet	REMOTE FA-PLC	E-3AHSRFAPLC-02	Truck Scale	E-3AHSRFAPLC-05	