Continuous Fly Ash Transfer System or A2PTM at JEC

Robert Youells1, Dave Spacek2

1FL Smidth Inc. Pneumatic Transport, 2040 Avenue C, Bethlehem, PA 18017; 2Jeffrey Energy Center, 25905 Jeffrey Rd., Saint Marys, KS 66536

In October 2006, the new Airslide® to Fuller-Kinyon™ Pump (A2PTM) fly ash transfer system began commercial operation on Unit 1 of the Westar Energy Jeffrey Energy Center (JEC). The coal-fired plant’s three units have used traditional fly ash removal and transfer systems since it went online in the late 1970s.

Fly ash removal and transfer is a very important process of all coal fired power plants and is most familiar to plant engineers, operators, and maintenance personnel. Fly ash is a continuous byproduct of coal combustion, so plants depend on their ash transfer systems and equipment to reliably remove their ash. Fly ash transfer systems which are not operating properly or systems that require constant maintenance with an excess of down time may not be able to keep up with the plant’s fly ash production rate. This is a serious problem. A plant’s electricity production is commensurate with its coal combustion rate which is commensurate with its fly ash production rate.

Plant personnel usually attempt to remedy ash system failures on the fly by temporarily deactivating the affected portion of the system while continuing to generate power and ash. This involves allowing the ash overages to build-up in the precipitator collection hoppers while hurriedly trying to replace or repair the inoperable equipment. Under extreme situations where the ash equipment cannot be repaired and system brought back on line promptly, a decision must be made to unload the ash on the floor of the precipitator and deploy vacuum trucks for ash clean up, or shut down the boiler. System maintenance, ash dumps, and unit shut downs are all costly endeavors for a power plant.

Due to availability or economics, power plants may elect to change the type of coal or vary the recipe of the types of coal that they burn. This alters the chemical composition of the ash and can increase the amount of ash being produced per megawatt of electricity. Both ash composition and increased ash production rate coupled with aged, high maintenance equipment can negatively affect an ash system by reducing its removal effectiveness and inherent safety factor, causing the system to become very problematic.

All coal fired power plants in the U.S. employ an electrostatic precipitator or bag house that effectively filters out the very fine fly ash particulate entrained within the flue gas stream. The ash accumulates on large electrodes or filter bags and falls into a field of collection hoppers directly below. Pneumatic conveying systems are commonly installed under an electrostatic precipitator or bag house collection hoppers to handle the ash. These conveying systems take in the fly ash from the precipitator collection hoppers and transfer it via a pipeline by means of vacuum or positive pressure to an ash storage silo.

The traditional types of pneumatic conveying systems utilize numerous moving components such as ash intake valves, swinging or sliding disc valves, butterfly valves, double dump valves, and pressure tanks. These systems also require a moderately sophisticated control system which necessitates a large amount of discrete input/output signals. The systems utilize pressure transmitters, timing devices, and level switches to
monitor/control the conveying system’s operational sequence. All of these devices must function reliably and repeatedly for the system to operate effectively.

FLSmidth Inc. (Formerly Fuller Company) has been providing pneumatic fly ash transfer systems for over thirty years and is very aware of the issues that plant personnel confront with maintaining their fly ash systems and the dollars that are spent doing so. This launched the move for FLS to formulate and market a nearly maintenance free ash transfer system. The objectives were to reduce operation, maintenance & capital costs, improve system availability, and utilize proven FLS product technologies. FLS has branded this ash system Airslide® to Fuller-Kinyon™ Pump, or A2P™.

The A2P system is only new in name and concept. The system’s ash removal approach combines two well proven ash handling technologies. This system stores no ash in the precipitator’s collection hopper like traditional ash systems do. As soon as the ash falls into the collection hoppers, it is funneled into the Airslide network that slopes on a slight angle toward an F-K Pump. All of the hoppers feed the Airslide network continuously and simultaneously for nonstop ash removal. The ash residence time from precipitator to storage silo is only a few seconds.

Two proven ash handling technologies incorporated into A2P:

1. Airslides, developed by Fuller Company in 1945, are utilized as the fly ash gathering system which continuously and simultaneously removes ash from all of the precipitator or bag house collection hoppers. The Airslide has no moving parts within the ash flow stream and conveys fluidized ash via gravity through a fabricated sloped trough. The trough is separated by a proprietary porous membrane in which ash is conveyed atop of the membrane as low pressure air is supplied below the membrane from a fan or blower package. The low pressure air permeates through the membrane entraining the ash with air which eliminates friction between each ash particle and the fabric membrane. Ash will then glide across the membrane in the direction of the sloped trough (fig. 1). FLS has installed well over 10,000 Airslide systems handling a multitude of bulk powders, many of them abrasive and hot.
2. The Fuller-Kinyon Pump is utilized as the mechanical line charging device which injects the fly ash into the pressurized conveying pipe while acting as an airlock between the conditions in the low pressure Airslide and the higher pressure conveying pipe. The F-K Pump employs a variable pitched screw which continuously compresses the ash to form a material seal or airlock. The rotating screw advances the ash into the pump’s conveying chamber, then into the conveying line (fig. 2). A PD blower or compressor package will deliver the required motive air to pneumatically convey the fly ash from the F-K Pump discharge to the system’s destination silo. FLS has well over 25,000 installations since the F-K’s original inception in 1926. Today, modern advances make the F-K pump a reliable, rugged, and maintenance friendly piece of equipment. Many of the bulk materials that F-K manages are also abrasive and hot.
In summary, the A2P system delivers several advantages compared to traditional ash conveying. Advantages are as follows:

- “All hoppers empty all the time.” There is no storage of ash in collection hoppers. Hoppers act like funnels that dispense ash into the Airslide network.
- No cycling ash intake valves at collection hopper outlets.
- No pressure tanks (eliminating multiple inlet valves, outlet valves, vent valves, level detection, pressure transmitters, and tank/hopper aeration).
- Only two moving parts between collection hoppers and ash storage silo. F-K Pump and rotary flow control valve.
- Less wear of pneumatic transfer pipe utilizing medium phase conveying.
- Low I/O count with simplified control system
- High capacity of ash transfer rate over long distances using dilute or mixed phase conveying.
- Standard schedule 40 pipe can be used in lieu of costly spun cast pipe.

A2P is versatile in that each system can be custom-designed for any ordinary or unique application. It can be designed for a new precipitator installation or retro-fit an outmoded ash system. A2P can service precipitators and bag houses with any number hoppers in any orientation, and can accommodate ash conveying rates varying from 5 to over 300 standard tons per hour.

**A2P at JEC**

FLSmidth’s Pneumatic Transport Department signed a contract with Westar Energy of Topeka, Kansas for the design and supply of the first FLSmidth Airslide to Fuller-Kinyon Pump (A2P) ash handling system for Unit 1 at Jeffrey Energy Center (JEC) located in St. Marys Kansas. Jeffrey Energy Center has three coal fired power generation units that produce 2400 megawatts of electricity. The new A2P ash transfer system commenced commercial operation in October of 2006.

**Justification for JEC**

JEC’s unit 1, 2, & 3 original ash conveying systems have been exceptionally problematic for Westar Energy since commercial operation began in 1978. The three vacuum systems were never able to remove and transfer the ash from the precipitator hoppers at a rate that ash was being produced. This condition worsened when all of the units increased production and yielded an increased ash make rate of 27 STPH per unit from 23.4 STPH. High maintenance costs also ensued on the existing vacuum system which was constantly operating at its full capacity. The total yearly cost to keep the unit 1 fly ash transfer system operational was nearly $235,000.

The pneumatic conveying characteristics of Powder River Basin (PRB) coal ash, with its high calcium content, were not well known back in the mid 1970’s when the three
vacuum systems were designed. The systems were probably designed to convey a bituminous coal ash which would require a less robust system.

It became routine practice to dump full collection hoppers of ash on the precipitator floor to alleviate the high volumes of ash that built up. This high volume condition, if high enough, could arrest the operation of the precipitator, and eventually halt boiler operation. The ash dumping resulted in extensive building and grounds cleanup costs and system oversight. Attempting to combat their predicament, Westar Energy employed two full-time maintenance personnel at JEC to oversee the ash systems to troubleshoot, repair, and to maximize the ash conveying rate. Some of the repairs became an exhausting and potentially dangerous assignment because some of the vacuum system’s equipment was installed atop of the 100’ high ash storage silo with only one means of access - a spiral staircase. Through the years, problems were found and improvements were made, but nothing to dramatically increase the conveying rate or reduce the operational costs.

The vacuum system’s 52 sequentially actuating ash intake and gate valves, filter separators, and the vacuum pumps were all high maintenance items which caused 177 emergency failures for JEC in 2003. JEC personnel thought the plant would benefit from the new A2P technology and the advantages the system had to offer, consisting of only 14 moving low maintenance components.

A recommendation to replace the conventional vacuum ash removal system with an Airslide to F-K Pump system was presented to Westar Energy management at two meetings. The operation and maintenance difficulties with the old system, in terms of both man-hours and costs, were detailed. In addition, it was demoralizing to personnel to have to dump ash hoppers to the floor and work in the resulting mess. The discussion proceeded to the operation of an Airslide ash conveying system, the absence of so many moving parts and the concept of continuous ash removal. Two trips were made to Black Hills Power, Inc. (Neil Simpson Station) and E.ON Louisville Gas & Electric (Rova Station) where similar systems were operating. Both of these plants were using Airslides in recirculating dry scrubber applications designed and supplied by FLSmidth. These Airslide installations were handling large amounts of material (up to 250 STPH), and plant personnel said the Airslide systems had worked well during their 10 years of operation.

Members of management asked many questions during these meetings. Employing an Airslide type conveying system for ash removal is a relatively new application in the power industry. Airslides have been used in other industries for more than 50 years. All attendees went away from these meetings convinced that Airslides and F-K Pumps would work in the Jeffrey Energy Center application.

**A2P Design**

Prior to any engineering of the new A2P ash transfer system, fly ash produced at JEC was thoroughly tested at the FLS-PT R&D lab. Several 55 gallon drums of ash were collected
from multiple hoppers throughout the Unit 1 precipitators and the ash storage silo. These samples gave FLS a good cross section of the fly ash produced at JEC. The ash went through Airslide testing, which established the design angle that the Airslide had to be pitched and the aeration requirements to optimize the conveying rate. An ash chemistry analysis and a particle size distribution were also performed to determine the pneumatic conveying characteristics of the ash.

The JEC A2P system was designed around the following data:

**Fly Ash Data – PRB Coal**

- Fly ash bulk density (loose poured) 72 lb/ft$^3$
- Fly ash temperature 250°F max
- Fly ash Chemical Analysis:
  - SiO$_2$ 29.71 %
  - Al$_2$O$_3$ 17.66 %
  - Fe$_2$O$_3$ 5.78 %
  - CaO 29.01 %
  - MgO 7.11 %
  - SO$_3$ 2.76 %
  - Others 7.97 %

**Climatic Data**

- Jeffrey Energy Center Saint Marys, KS
- Site Elevation 1300 ft ASL
- Ambient Temperature -10 to 100°F

**Performance Data**

- Unit 1 employs (2) precipitators (A & B)
- (32) ash collection hoppers total
- (2) 4X4 hopper configurations
- Ash production rate per precipitator: 27,000 lb/hr (13.5 STPH)
- Conveying system design rate per precipitator: 60,000 lb/hr (30 STPH)
- Precipitator vacuum -27” WG
- Conveying System Pipeline:
  - Horizontal distance: 580 ft
  - Vertical distance: 110 ft
  - Elbows: (10) bends
  - Size: (2) 8” dia. cast iron
  - (1) per precipitator
- Precipitator hopper thermal expansion: 3/8” to 1 ¼”
Airslide Design

Each of the two JEC precipitators were designed to have a fly ash removal rate of 30 standard tons per hour. Under normal precipitator operating conditions, approximately 80% of the fly ash is collected in the first hopper fields, 10% of the ash is collected in the second fields, and 10% is collected in the third and fourth fields within the two 4X4 hopper configurations. This yields a maximum ash discharge rate from any one hopper to be only 6 STPH. Due to this very low rate, FLS applied a common width Airslide conveyor from all 32 hopper outlets (fig 3). These Airslides direct the ash into the primary Airslide collection manifolds that transfer the ash collected from the collection hopper network to the A2P system rotary metering valve located just upstream of each F-K Pump. All system Airslide sections were furnished with polyester fabric (membrane) which has a max operating temperature of 350 degrees F.

Since 90% of the precipitator ash is collected in the first two hopper fields of the precipitator, the decision was made to update each precipitator’s collection hopper fluidization system. These systems were comprised of 10 hp PD blower packages capable of 320 CFM, 35 kW air heaters, and 12” square fluidizing air pads located approximately 8’ up the hopper side walls. It was concluded that the fluidizing pads, as located, were not effectively aerating the ash at the hopper discharge where ash bridging or plugging is most likely to occur. These fluidizing pads were removed and replaced with open type Airslides 4’ long (two per hopper) near the hopper outlets. The existing PD blowers and Air heaters were re-piped to complete the aeration systems. These
fluidizing systems will only be required to operate during an upset condition or after system maintenance when the ash accumulates in the collection hoppers. During normal A2P system operation, all of the ash will continuously fall from the hoppers entering the conveying system, without the use of the fluidization systems.

All precipitator collection hoppers were supplied with a manual knife gate valve and an expansion joint. The valves will discontinue ash flow to the A2P system if any unusual maintenance issues arise and expansion joints were built to accommodate the precipitator’s thermal movements and high vacuum of 27” WG. Special Airslide inlet sections, located under each collection hopper, were designed with 2” x 4” wide grating to trap falling precipitator hammers, large conglomerates of ash, etc., and a retrieval door to retrieve the fallen debris (fig. 4). This design also prevents these items from entering the A2P system and also it protects the Airslide’s fabric membrane directly under the hopper outlet.

Two operating centrifugal fans, one dedicated to each precipitator and each with a standby, were sized to deliver the necessary amount of fluidizing air to the Airslide conveyors to achieve the optimal ash transfer rate within the Airslide network (fig. 5). Manual butterfly valves equipped with limit switches were located within the Airslide air supply pipeline to isolate the selected (in service) fan blowers from the standby packages. Airslide aeration air requirements are usually measured in ratio form (cubic ft per minute of fluidizing air CFM/square ft of system Airslide fabric). After reviewing the Airslide R&D data, FLS established an optimal conveyor slope coupled with 1450 CFM fans powered to deliver a pressure of 80” WG would have the safety factor to achieve the design conveying rate. This design basis would cover all of the possible Airslide worst case operational conditions that may occur in the field such as: re-aerating stagnant ash that could become compacted in the Airslides during upset conditions or unexpected maintenance, future variances in ash conveyability due to changes in plant fuel and ash composition, and varying ash temperatures and site conditions.

Two circulation style electric air heaters are being utilized to heat the Airslide fluidizing air (fig. 6). One heater is committed to each precipitator’s Airslide and is installed between the fan blower outlet and the Airslide sections. The heaters will heat the incoming ambient fluidizing air, eliminating the risk of condensation that can be created from cool air reacting with the hot flue gases that may still be entrained in the fly ash. These heaters were sized to increase the fluidizing air from the lowest design ambient (-10 degrees F) to the maximum ash temperature (250 degrees F).

It is recommended that all Airslides conveying a hot ash along with all air supply piping downstream of the circulation air heaters be insulated and sheathed for personal protection and heat retainage.
Injecting the fly the ash from the Airslide network terminal point into the pressurized conveying pipe is accomplished by only two components. These components contain the only moving parts that come in contact with the fly ash. These components are the modulating aperture of the rotary metering valve located just up-stream of each F-K Pump and the rotating screw of the F-K Pump.

The rotary flow control valve (fig. 7), which works in conjunction with a pipeline pressure transmitter, receives the 4-20mA that meters the ash into the pumps intake hopper at a controlled rate. The pressure transmitter constantly monitors the conveying pipe pressure. The analog signal being sent to the metering valve will dampen the ash flow during a high pipeline pressure condition. (A pneumatic conveying system’s pipeline pressure is directly related to the rate of material that is being charged in the conveying pipeline). This metering system is the scheme to keep the F-K Pump from overloading the conveying pipe during an upset condition, where an excessive flow ash can discharge from the collection hoppers into the Airslide network. In reality, the F-K
Pumps and the conveying systems are designed to easily handle the free flow of ash from the Airslides during steady state ash production and when the A2P system is operating within its design conditions. During these conditions, the rotary metering valve is operating at 100% open allowing the free flowing ash to enter the F-K Pump hopper, then into the conveying pipeline.

To sustain the conveying rate that is commensurate with the system design, four operating 150M F-K Pumps were installed under the precipitators in optimal locations where an equal amount of ash could be supplied to each F-K from the Airslide network. Two Operating F-K Pumps are dedicated to each precipitator along with standby F-Ks (fig. 8). One set of two operating F-K Pumps is charging one conveying pipe with ash, while the other set of two F-Ks charges the second conveying pipe. These two pipe lines run in parallel from the precipitators to the ash storage silo and were salvaged from the removal of the old vacuum system. These 8” pipelines were a suitable fit for the conveying system and able to be utilized for the new A2P system.

Four operating PD blower packages, one dedicated to each operating F-K Pump, deliver the required motive air to pneumatically convey the fly ash to the storage silo from the F-K Pump discharge (fig. 9). A fifth common standby blower package is shared between all of the F-Ks. Manual butterfly valves equipped with limit switches located within the motive air supply pipeline isolate the selected (operating) blower package from the standby package.

During steady state ash production, the conveying pipe pressure at the ash injection point hovers at approximately 7 PSIG, which was exactly what was calculated during the conceptual design of this project. It is expected that the conveying pressure will increase to only 13 PSIG at the systems design rate, which is more than 2X the ash production rate. The pneumatic conveying air velocities are consistent for the conveyance of PRB coal ash in this low pressure application.

All F-K Pumps that handle fly ash are factory installed with tungsten carbide conveying screws for additional wear resistance. The implementation of the tungsten carbide screws should extend the life of the rotating screw to three years without maintenance when operating continuously.

The ash-laden conveying air terminates at the ash storage silo. The air is filtered then vented to atmosphere by means of an open bottom dust collector mounted directly onto the silo roof. The dust collector includes an exhaust fan to maintain a negative pressure inside the silo and local cleaning controls with a differential pressure switch to initiate filter cleaning. The dust collector was sized with 1964ft² filter area which services the conveying air from both conveying pipes, any conveying air surges, the silo unloading
aeration system, and the material duty fan that vents the PD trucks during the ash unloading process.

JEC controls the new system with an updated and simplified version of its existing Distributed Control System (DCS) (fig. 10). Since the A2P system has no sequencing valves, I/O count is reduced when compared with the removed vacuum system, thereby further contributing to a low cost and schedule-sensitive system retrofit.
A2P Power Consumption

<table>
<thead>
<tr>
<th>SYSTEM</th>
<th>EQUIPMENT</th>
<th>HP</th>
<th>KW</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIRSLIDE EAST PRECIPITATOR</td>
<td>DUTY FAN - 101</td>
<td>50</td>
<td>37.5</td>
</tr>
<tr>
<td>AIRSLIDE EAST PRECIPITATOR</td>
<td>STANDBY FAN - 102</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AIRSLIDE WEST PRECIPITATOR</td>
<td>DUTY FAN - 103</td>
<td>50</td>
<td>37.5</td>
</tr>
<tr>
<td>AIRSLIDE WEST PRECIPITATOR</td>
<td>STANDBY FAN - 104</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AIRSLIDE EAST PRECIPITATOR</td>
<td>DUTY AIR HEATER</td>
<td>147</td>
<td>110</td>
</tr>
<tr>
<td>AIRSLIDE WEST PRECIPITATOR</td>
<td>DUTY AIR HEATER</td>
<td>147</td>
<td>110</td>
</tr>
<tr>
<td>EAST PRECIPITATOR - FIELD 1&amp;2 F-K PUMPS</td>
<td>DUTY BLOWER 101</td>
<td>100</td>
<td>75</td>
</tr>
<tr>
<td>EAST PRECIPITATOR - FIELD 3&amp;4 F-K PUMPS</td>
<td>DUTY BLOWER 102</td>
<td>100</td>
<td>75</td>
</tr>
<tr>
<td>EAST / WEST PRECIPITATOR</td>
<td>STANDBY BLOWER 103</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WEST PRECIPITATOR - FIELD 1&amp;2 F-K PUMPS</td>
<td>DUTY BLOWER 104</td>
<td>100</td>
<td>75</td>
</tr>
<tr>
<td>WEST PRECIPITATOR - FIELD 3&amp;4 F-K PUMPS</td>
<td>DUTY BLOWER 105</td>
<td>100</td>
<td>75</td>
</tr>
<tr>
<td>EAST PRECIPITATOR - FIELD 1&amp;2</td>
<td>DUTY FK PUMP 101A</td>
<td>50</td>
<td>37.5</td>
</tr>
<tr>
<td>EAST PRECIPITATOR - FIELD 1&amp;2</td>
<td>STANDBY FK PUMP 101B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EAST PRECIPITATOR - FIELD 3&amp;4</td>
<td>DUTY FK PUMP 102A</td>
<td>50</td>
<td>37.5</td>
</tr>
<tr>
<td>EAST PRECIPITATOR - FIELD 3&amp;4</td>
<td>STANDBY FK PUMP 102B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WEST PRECIPITATOR - FIELD 1&amp;2</td>
<td>DUTY FK PUMP 104A</td>
<td>50</td>
<td>37.5</td>
</tr>
<tr>
<td>WEST PRECIPITATOR - FIELD 1&amp;2</td>
<td>STANDBY FK PUMP 104B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WEST PRECIPITATOR - FIELD 3&amp;4</td>
<td>DUTY FK PUMP 105A</td>
<td>50</td>
<td>37.5</td>
</tr>
<tr>
<td>WEST PRECIPITATOR - FIELD 3&amp;4</td>
<td>STANDBY FK PUMP 105B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SILO</td>
<td>DUTY DUST COLLECTOR FAN</td>
<td>15</td>
<td>11.25</td>
</tr>
<tr>
<td><strong>TOTALS</strong></td>
<td></td>
<td>1009</td>
<td>756.25</td>
</tr>
</tbody>
</table>

The original vacuum system was comprised of one operating water recycle pump and one standby. The recycle pump created the system’s vacuum by pumping treated water through a recirculation loop of exhauster nozzles and air/water separators. The operating vacuum exhauster was powered by a 1000 HP 6600V motor and the standby exhauster by an 800 HP motor.
Comparing the A2P to the vacuum system, the installed power of the operating equipment is very similar (756kW for the A2P vs. 750kW for the vacuum system). But the true efficiency of the A2P system comes to light by evaluating its consumed power usage. Although the JEC A2P was built with a 2X design conveying rate over the normal ash production rate and devised for any upset condition, the DCS readings indicate its consumed power is incredibly low. When the precipitator hoppers are collecting ash at the normal ash production rates of 13.5 SPTH per precipitator, the Airslide fan motors, PD blower motors for conveying air, and the F-K Pump motors operate with very little resistance.

- Airslide fluidizing fan dampers set overcome low pressures to aerate only a shallow bed of ash in Airslide.
- PD blowers only produce 7 PSIG of conveying air.
- F-K Pumps screw only advance 6.75 STPH of ash and inject it into a low 7 PSIG conveying pipe.
- Air heater consumed power calculated at yearly average ambient temperatures.

<table>
<thead>
<tr>
<th>OPERATING EQUIPMENT</th>
<th>OPERATING CONDITIONS</th>
<th>BHP ea</th>
<th>KW ea</th>
</tr>
</thead>
<tbody>
<tr>
<td>(2) DUTY FANS</td>
<td>80&quot; WG</td>
<td>40</td>
<td>30</td>
</tr>
<tr>
<td>(2) DUTY AIR HEATERS</td>
<td>55 DEGREE F AMBIENT</td>
<td>96</td>
<td>72</td>
</tr>
<tr>
<td>(4) DUTY BLOWERS</td>
<td>7 PSIG</td>
<td>39</td>
<td>29.25</td>
</tr>
<tr>
<td>(4) DUTY F-K PUMPS</td>
<td>6.75 STPH @ 7 PSIG</td>
<td>17</td>
<td>12.75</td>
</tr>
<tr>
<td>(1) DUST COLLECTOR FAN</td>
<td>6&quot; WG</td>
<td>10</td>
<td>7.5</td>
</tr>
<tr>
<td><strong>TOTALS</strong></td>
<td></td>
<td>506</td>
<td>379.5</td>
</tr>
</tbody>
</table>

Future testing will be conducted by FLS to determine if the A2P system air heaters that heat the Airslide air could possibly be shut off during normal conveying conditions, decreasing system consumed power even further. Potentially, the A2P system Airslide fan blowers could create enough positive pressure below each collection hopper which could prevent the likelihood of the hot flue gasses descending into the Airslide network and condensing in the ambient fluidizing air. Furthermore, testing will also be done on the effect ambient fluidizing air has on the hot ash along with the low residence time that the ash has in the Airslide network. The presumption is that the adiabatic temperature does not drop below 180 degrees F, which is an average dew point of flue gas.
Air heaters must still be present within the A2P system and ready to be activated upon signal. There are infrequent circumstances in which these components are essential to system performance.

**A2P Installation**

The FLSmidth Inc. Pneumatic Transport Department designed the A2P conveying system consisting of the Airslides, F-K Pumps, motive air PD blowers and fans, silo vent filter, material duty valves and ancillary conveying components. Under separate contract with Westar, the Burns and McDonnell Consulting Engineering Co. of Kansas City designed of the air piping, their supports, and placement of the air supply equipment. The mechanical design involved the correct placement of five conveying blowers, four fluidizing Airslide fans, two air heaters, all necessary piping, supports, ash storage silo vent filter placement and the accompanying fan ductwork on top of the fly ash silo. JEC designed the electrical power requirements. It involved the installation of a motor control center, securing a contractor to install cables and tray from the source in the plant to the motor control center, creation and programming of a new control system and installation of cables from the motor control center to the individual components.

A bid specification was prepared for the labor and installation of the new fly ash in late July. An award was made the week of August 12, 2006. The contractor arrived on site August 21 to commence the work. Due to the nature of the work, much of the installation was to be done while Unit 1 was in service and the final tie in connections made after shutdown. Unfortunately, it did not work out this way. The contractor had approximately four weeks before the scheduled shutdown to install equipment. Approximately 50% of the installation of the new A2P system was completed before the Unit 1 shutdown. However, the goal of completing 80% of the equipment installation in the precipitator ash hopper area was not achieved. This will be the goal for future A2P system replacements in Units 2 and 3.

The installation of the air piping presented one of the largest challenges. The piping had to be designed to avoid inhibiting the movement of people and equipment in the area (fig 11). This caused some of the pipe runs to interfere with existing electrical work, structural members, and other piping. These issues were worked out with the contractor as they were discovered. These issues also were a reflection of the fast-paced installation.

The Jeffrey Energy Center employed a field service representative from FLSmidth Inc. to provide technical assistance during the installation and start up phase of the A2P project. The installation of Airslides was new for almost everyone in the construction crew. As the Airslides were installed, FLS’s field service representative provided guidance and support as necessary to install the Airslides at the correct decline angle in order to insure proper operation. Perhaps the biggest challenge with the installation of the Airslides occurred when it came time to bolt the Airslide inlet sections to the knife gate valves at
each collection hopper outlet. Some difficulty was encountered in aligning the Airslide flanges to provide a proper connection to the next adjoining Airslide. One of the JEC mechanical maintenance supervisors suggested utilizing the existing three piece flange clamps at the collection hopper outlets to fit the Airslide up to the knife gate valve. Doing this allowed the Airslide inlet sections to swivel and be adjusted as necessary to insure a correct fit to the next Airslide (fig 12).

Another challenge during the construction involved the salvaged conveying pipelines from the precipitator area to the fly ash storage silo. The pipelines are hardened twenty-foot steel pipe sections that are connected with pipe couplings. After completion of the piping construction, the pipes were required to hold 20 psig of air without leaking. Several unsuccessful attempts were made to do this. It was discovered that nearly all 60 of the old existing pipe couplings were leaking. Luckily the couplings were located air freighted in so the contractor could install them. The quick response from the supplier and the contractor resolved a situation that could have caused an extension of the maintenance outage in three days.

Many tasks had to be completed on top of the fly ash storage silo. Before the outage began, a 20-ton track crane with a 140-foot boom was leased for use. One of the members of the contract crew operated the crane. The silo has a weather cover over the top of it and an access hole was cut in the roof. This hole was large enough to allow the removal of all old vacuum system equipment on top of the silo (primary and secondary separators, bag tanks, etc.) All of this equipment was replaced with one silo vent filter and a fan (fig 13). This work went very well. At the same time, the pipelines carrying fly ash to the top of silo were shortened by about 10 feet, conveying target boxes installed (Fig 14), and new supports for the ash conveying pipes. Much of this pipe work was done from a man-lift with a 120-foot reach.
A2P Start-up and Operation

The FLSmidth field representative, working closely with Westar Energy electrical maintenance, predictive maintenance, and operations personnel, prepared a plan for check out and start up of the A2P system. All the rotating equipment was started and checked for rotation and proper operation. The Airslides were checked for leaks and the control system was checked for proper operation as well. The system was ready to go before the start up of the generating unit.

Unit 1 Boiler was started up on #2 Fuel Oil. As the boiler was brought up to pressure, coal mills were brought into service gradually. The unit 1 fly ash system was placed into service and was ready for ash before the boiler start up began. The start up of the boiler was longer than normal and therefore more fuel oil than normal was burned in the boiler. This created some issues with ash collection and removal. The ash collected from the first two days after startup had some oil soot in it, making it somewhat sticky and difficult to convey. After the first two days when the boiler was burning 100% coal, the problem went away and the ash began to convey as expected. Throughout this time,
adjustments continued in the air flow to the Airslides and the ash feed rate to the F-K Pumps.

One operating issue that came up early on was leaking expansion joints between each individual hopper Airslide branch and the main collection Airslides to which they are connected. These expansion joints are simple devices to accommodate collection hopper thermal movement and made of EPDM. The vacuum inside the ash collection hoppers operates at around -27 WG with higher spikes.

The expansion joints were not designed to operate at this high level of vacuum. Some of the clamps holding the expansion joints to the Airslides were also not adequate to properly secure the expansion joints. A new design has been developed between the FLSmidth and Westar Energy personnel. The new joints are made of wire reinforced Teflon and were pressure tested in the FLSmidth R&D lab at -40” WG. At first, only two of the 32 expansion joints were installed to ensure that this design is proved before replacing all 32. After the test joint break in period, it was determined that this design was robust enough to withstand the high vacuum spikes and was implemented throughout the system. Today, all of the new 32 expansion joints are functioning properly.

During initial project discussions, Jeffrey personnel expressed concern regarding what would happen if the A2P system tripped while the generating unit continued to run. After initial operation, the A2P system was put to the test. It was shut down with the unit under full load and ash accumulating in the Airslides and precipitator hoppers. After two to three hours of ash collection, the A2P unit was restarted. The result was that the A2P system restarted flawlessly, cleared all collected ash in 15 to 20 minutes, and came back to normal continuous operation without a problem.

While the system has operated nearly flawlessly since it was started, it did experience one upset. On the evening of January 3, 2007, Unit 1 boiler was taken out of service due to a boiler tube rupture that introduced 600 GPM of water into the flue duct (fig 15). Within an hour after the boiler shutdown, the plant operators went to the A2P fly ash system and found the B side tripped out of service. The B side ash system was restarted and the operators left the area to deal with other issues related to the unplanned outage. At around 10:00 p.m., the F-K Pumps on B side tripped again and less than one hour later the F-K Pumps on the A side system tripped as well. The plant operators never returned to the A2P system that night. The next morning the system was discovered in a state of distress with the F-K Pumps out of service and the relief valves on the conveying blowers lifting. Ash had collected in all of the precipitator collection hoppers during this upset. The B side system suffered more problems than A side. The ash conveying lines from the B side F-K Pumps were plugged with ash. In addition, the F-K Pumps were plugged up with ash and ash had backed up into the motive air supply lines. This ash had to be cleaned out quickly. The A2P system allowed for a quick clean out and was ready for operation by the time the boiler was ready for start up. The system was placed into operation before the unit start up and has operated exceptionally ever since.
A meeting of the JEC Fly Ash group was held a few days after this to analyze the upset and to provide solutions and ideas. The main problem was when the boiler tube ruptured, it initiated the precipitator to go into a clean out mode causing all of its hammers to activate simultaneously. This reaction rapidly filled all of the collection hoppers causing very high ash flow into the A2P system. Probably the most significant solution was to make a change in the control system to make the ash rotary flow control metering valve operate in a more throttled position during a sharp load reduction and also during a shutdown. All involved were confident that this change should allow a more controlled and lower rate of flow into the F-K Pumps during upset conditions when an unusual high flow of ash enters into the system. There has not been a unit outage since this incident. It remains to be seen if the changes implemented will prevent a similar occurrence.

The unit 1 A2P Fly Ash System at JEC is still relatively new and, as mentioned earlier, both operations and maintenance personnel have been trained. The people still have quite a bit to do in order to become familiar with and learn about the new system. However, by and large the system has operated very well and the operations personnel have grown to rely on it for trouble free service. The plan is to install a second A2P system on JEC Unit 2 in October 2007.

(fig 15) ruptured boiler tube
In Summary

Precipitator floor before Airslide to F-K Pump system
Precipitator floor after Airslide to F-K Pump system

The need for a modern fly ash removal and transfer system has produced a well-engineered product with a straightforward operating system for Jeffrey Energy Center and the marketplace. The A2P system compared to traditional ash systems is more advantageous to power plant operations and encompasses improved design features, efficiency, and minimal maintenance. An A2P system will provide a positive return on investment to the end user throughout its operating service.

Authors are:
- Robert Youells is an application engineer for FLSmidth Inc.
- David Spacek is a plant engineer and the Ash Handling System Owner at Westar Energy Jeffrey Energy Center