LG&E/KU – Mill Creek Station

Phase II Air Quality Control Study

Fly Ash Handling

March 9, 2011
Revision B – Issued For Client Review

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1.0 Introduction

The amount of particulate matter collected from the exhaust gas from all four units at the Mill Creek Station will be increased by the additions and modifications proposed by the Phase II Air Quality Control (AQC) Study. This in turn requires the existing fly ash handling system that collects and transports this particulate to be investigated to confirm acceptability under the new operating conditions. The purpose of this report is to describe the existing fly ash handling system and its operating capacity, quantify the impacts to the system due to the AQC modifications proposed, and confirm its acceptability or identify any modifications required to allow proper operation.

2.0 System Description and Evaluation

All four units at Mill Creek currently include an electrostatic precipitator (ESP) for collection of particulate matter from each unit's flue gas stream. As part of the AQC modifications, the existing ESPs will be replaced (Units 1 and 2) or supplemented (Units 3 and 4) by pulse jet fabric filters (PJFFs) to collect fly ash prior to the exhaust gas reaching the wet scrubbers. In addition, the project includes the injection of sorbent (lime/trona) for sulfuric acid (SO_3) control and powdered activated carbon (PAC) for mercury (Hg) control. The injected reagents must also be removed from the exhaust stream by the PJFF.

For purposes of this study all particulate removed from the PJFF will be covered under the term "fly ash." Considering the improved efficiency of the proposed PJFFs over the existing ESPs and the addition of injected reagents that must be removed from the flue gas stream, the amount of total fly ash that must be handled will be higher at each unit than that currently processed through the existing system. This increased load on the existing fly ash handling system must be evaluated and any recommended modifications or operating conditions identified.

2.1 Description and Capacity of Existing Systems

Fly ash from the ESPs at all four units is currently being collected and transferred as dry material. Fly ash collected by the fields in the ESPs falls to collection hoppers at the bottom of the ESP. Mechanical exhausters are used to create a vacuum in piping connected to the hopper bottoms. Collected ash is transferred under vacuum from the hoppers to a separator where the collected ash is placed in a transfer tank for temporary storage. The temporarily stored ash is then transferred by a pressurized pneumatic blower system that forwards the ash to the ash storage loadout silos near the dewatering facility south of the units. Ash is unloaded from the silos to trucks for transfer to beneficial reuse or landfilling operations.

Each unit is provided with its own vacuum piping and mechanical exhauster system that transfers ash from the collection hoppers to the appropriate transfer tank. There is a common ash transfer tank serving both Unit 1 and Unit 2 with a common blower and transfer system to the dewatering facility. A separate transfer tank and pressurized pneumatic system is provided at Unit 3 and another separate tank and transfer system at Unit 4.

The vacuum system forwarding ash from the hoppers to the transfer tank is operated on a sequential basis. Vacuum is maintained in the piping system and automatic slide or knife gate valves are opened at each individual hopper to allow ash from that

hopper to be forwarded to the transfer tank. Once a hopper is empty, it is again isolated and the valves at the next hopper activated, allowing each hopper to be emptied in turn. The ash is forwarded to the transfer tank for temporary storage before being forwarded to the station ash loadout silos.

Ash transfer from the transfer tank to the station ash loadout silos is completed on a batch basis by each separate system. Transfer operation is triggered by a timer and each system is operated twice a day for a fixed period to empty the transfer tanks. Collected fly ash drops from the transfer tank into the conveying line via nuva feeders and is blown to the loadout silos. Transfer can occur simultaneously with the fly ash being pulled from the hoppers. Operation of the transfer systems is on a timed basis only; operation is not triggered by ash levels in the transfer tank. It is not currently known if the transfer tanks are full when the transfer operation starts or if there is capacity in the tanks for additional ash.

The common system serving Unit 1 and Unit 2 is operated twice a day for eight hours per operation to empty the transfer tank as it fills. The two systems serving Unit 3 and Unit 4, respectively, are each operated twice a day for six hours each. In these operations, the quantity of ash being transferred by unit is summarized as follows, based on maximum design coal burn, ash content in the coal, ESP efficiency, and portion of fly ash in the total ash expressed as a percentage.

- Unit 1 – 331 tons/day
- Unit 2 – 330 tons/day
- Unit 3 – 445 tons/day
- Unit 4 – 545 tons/day

The existing ash loadout silos have the capacity to store the ash generated in 2.5 days by all four units operating at design load. The operating information presented above was confirmed by Mill Creek Operations and will be considered as the current nominal operating conditions for the existing ash transfer systems. As a worst case assumption, the existing transfer tanks will be assumed full or very nearly full when the transfer process is started; no consideration will be given to any excess capacity that may be available in the tanks when the timed transfer operation begins. Additional fly ash loading resulting from the new AQC equipment will be compared to these “base” conditions.

See Figures 1, 4 and 6 in Appendix A for the existing simplified system schematics for all four units.

2.2 New Fly Ash System

A new PJFF will be installed on each of the four units; each requiring its own fly ash handling system. In addition to ash, the new PJFFs will collect powdered activated carbon (PAC) and sorbent (lime/trona). The new PJFF and fly ash system for each unit will be sized for the total amount of fly ash, PAC and sorbent generated by each boiler for each unit so that the existing ESPs at Units 1 and 2 can be eliminated and the ESPs at Unit 3 and 4 can be retired some time in the future. After the new PJFFs are installed, the existing Unit 3 and 4 ESPs will continue to be operated.

A single vacuum conveying line will be used for Units 1, 2, and 3(each), and two vacuum conveying lines will be used for Unit 4. Single pressure conveying lines will be provided for Units 1, 2 and 3 and two pressure conveying lines will be provided for Unit 4 for the new system, similar to the existing system. Cross ties will be provided at branch line locations at the PJFFs to provide redundancy in the system. Note that two silo destinations are provided for each system. Single point failures that cause a unit shutdown are not acceptable.

In general, the systems will include the following major components. The arrangement and scope of supply is summarized in Tables 2-1 and 2-2 below.

Table 2-1 – Plans for the Existing Fly Ash ESP Conveying System

Description	Unit 1	Unit 2	Unit 3	Unit 4	Remarks
Transfer tank	Remains in service - modified for Unit 1 service only	n/a	Remains in service	Remains in service	See Note 1
Filter separators	Remains in service but used for PJFFs	n/a	Remain in service	Remain in service	Add cross-tie piping and valves between Unit 1 & 2 separators
Exhausters	Remains in service but used for PJFFs	n/a	Remain in service	Remain in service	
Pressure feeders	Remains in service but used for PJFFs	n/a	Remains in service (4)	Remains in service (8)	
Pressure blower	Remains in service but used for PJFFs	n/a	Remains in service (1)	Remains in service (2)	
Piping from ESP hoppers to transfer tank	Remove	Remove	Remains in service	Remains in service	Units 1, 2, & 3 have single pipe run, Unit 4 dual pipe run to silo.
Piping from transfer tank to silo	Remains in service but used for PJFFs	n/a	Remains in service	Remains in service	Units 1, 2, & 3 have single pipe run, Unit 4 dual pipe run to silo.
Conveying system silo connections	n/a - no ESP hoppers	n/a - no ESP hoppers	1. East silo (existing – default destination) 2. West silo (existing – use only if East silo is unavailable)	1. East silo (existing – default destination) 2. West silo (existing – use only if East silo is unavailable)	Units 1, 2, & 3 have single pipe run, Unit 4 dual pipe run to silo.
Notes:	1) Units 1 and 2 existing systems have a common transfer tank and pneumatic pressure system to transfer fly ash to both the existing east and west silos. 2) The existing fly ash system for Units 3 and 4 transports ash to either the existing east or west silo.				

Table 2-2 - New Fly Ash System Equipment for PJFF

Description	Unit 1	Unit 2	Unit 3	Unit 4	Remarks
PJFF	New (10 hoppers)	New (10 hoppers)	New (12 hoppers)	New (16 hoppers)	
Piping from PJFF to transfer tank	New, (single line)	New, (single line)	New, (single line)	New, (dual line)	
Transfer tank	Use existing	New	New	New	
Filter separator	Use existing	New (2)	New (2)	New (2)	
Exhausters	Use existing	New (2)	New (2)	New (2)	
Pressure feeders	Use existing	New (2)	New (2)	New (2)	
Pressure blower	Use existing	New (2)	New (2)	New (2)	
Piping from transfer tank to silo	Use existing	New, single line with	New, single line with	New, dual line	
New conveying system silo connections	1. East silo (existing – lock out while Units 3 and 4 ESPs are in use) 2. West silo (existing) 3. New silo (new)	1. West silo (new) 2. New silo (new)	1. East silo (new) 2. New silo (new)	1. West silo (new) 2. New silo (new)	Includes provisions to add conveying line branches to the east silo after U3 & U4 ESPs are abandoned.

See Figures 2, 3, 5 and 7 in Appendix A for the new simplified system schematic for all four units.

The existing AQC system has electrostatic precipitators (ESPs) and wet scrubbers on all four generating units. It is the intent of this scope document to use as much of the existing system as practical while addressing the requirements of the new PJFFs. The existing conveying systems have operated successfully over many years and will be utilized to convey ash for the new Unit 1 PJFF and existing Units 3 and 4 ESPs as described above. Ash collection systems are not required for Units 1 and 2 ESP hoppers since these ESPs will no longer be in service and will be replaced with new ductwork. The existing Units 3 and 4 ESPs will continue to operate for the foreseeable future collecting an assumed 75% of the ash which will be segregated from the remaining ash to allow beneficial reuse. Units 3 and 4 ESPs will likely be abandoned-in-place when their useful life is complete. If abandoned-in-place and not replaced with new ductwork, the UCC conveying systems will continue to collect accumulated ash in these hoppers. From prior UCC experience on other units, up to 50% of the ash from the boiler will accumulate in the abandoned hoppers.

The existing east and west ash loadout silos will continue to be used in the new arrangement. It is proposed that one of the existing east or west silos be designated for saleable ash and the other silo utilized for waste ash along with a new silo to raise the plant storage capacity to 4 days of ash at MCR operating conditions. The existing ESP conveying systems currently convey ash to these silos. The east silo provides enough inventory for up to 2.8 days saleable fly ash. The west silo and a new silo together will have enough capacity for up to 4 days of waste ash during ESP operation. Total site storage capacity with all three silos will be 7,780 tons which is sufficient to store 4 days production of all fly ash and byproducts for all four units, including the saleable ash. The proposed location of the new silo is north of the existing east and west silos and adjacent to the pipe rack. If one of the existing silos requires maintenance on the fluidizing system due to poor discharge performance, this may be accomplished when the new silo is operational or during an outage. Modifications required to refurbish the silo fluidizing systems should be investigated further in the future if this project is pursued further.

A new PJFF will be installed on each of the four units; each requiring its own fly ash handling system. In addition to ash, the new PJFFs will collect powdered activated carbon (PAC) and reacted and un-reacted sorbent (trona/lime). The new PJFF and fly ash system for each unit will be sized for the total amount of fly ash, PAC and sorbent generated by each boiler unit so the existing ESPs at Units 1 and 2 can be eliminated as a part of this project and the ESPs at Units 3 and 4 can be retired in the future.

2.2.1 Capacity of New System

Table 2-3 - Fly Ash and Byproduct Mass Flow Rates (lb/hr)					
Description	**Unit 1**	**Unit 2**	**Unit 3**	**Unit 4**	**Remarks**
Total fly ash	28,165	28,925	36,812	44,797	
Ash removed by ESP	0	0	27,609	33,598	See Note 1
Ash removed by PJFF	28,165	28,925	9,161	11,148	
PAC	783	818	982	1,196	See Note 2
Unreacted sorbent	2756	2831	3598	4379	Lime used as reagent
CaSO4	1233	1267	1610	1960	Lime used as reagent
Total byproducts with lime as sorbent (worst case)	32,937	33,841	43,002	52,332	See Notes 3 and 4
Design fly ash removal rate for new fly ash system with PJFF	*66,000*	*68,000*	*86,000*	*105,000*	*Sized for total byproduct rate x 2*
Notes:	1) Represents 75% removal of total ash removed by ESP for Units 3 & 4. Units 1 and 2 ESPs will be retired. 2) PAC injected upstream of PJFF 3) Lime used as sorbent for SO3 removal (worst case for amount of byproducts generated). 4) Total byproducts include fly ash, PAC for mercury removal, unreacted lime and CaSO4 as dry scrubber byproducts.				

2.2.2 Silo Capacity Design Basis and Operation Summary

The existing east and west silos each hold 2,081 tons. The new silo is sized at 3,620 tons to achieve total silo capacity of four days operation with the use of existing east and west silos and only new PJFFs in service. Units 3 and 4 ESPs saleable fly ash with a combined rate of 734 tons per day will be sent to the existing east silo under normal operation at 2.8 days total capacity or it will be sent to existing west silo or new silo as waste for backup operation if the east silo is out of service.

Units 1, 2, 3 and 4 PJFF waste fly ash with a combined total rate of 1,212 tons per day will be sent to the existing west silo and to the new silo under normal operation. The west silo and the new silo capacity combined are 5,701 tons and 4.7 days, with Unit 3 and 4 ESP ash being sent to the east silo as indicated above.

Total combined silo capacity of the existing east and west silos and the new silo is 7,782 tons and 4.0 days, with a total fly ash loading of Units 1, 2, 3 and 4 PJFFs combined of 1,945 tons per day and the Units 3 and 4 ESPs out of service. Note, all fly ash quantities in above summary include PAC and sorbent per Table 2-3 above.

The fly ash handling system will include all equipment as indicated above for a complete operating system including, but not limited to, a new silo and truck unloading

enclosure under the silo, platforms, stairs and ladders for access to all fly ash handling equipment including the silo, electric motors, control devices, and controls.

3.0 Unit Descriptions and Evaluations

3.1 Unit 1

3.1.1 Existing System for Unit 1

The existing ESP will be demolished and replaced with new ductwork that eliminates the hoppers. Fly ash and byproducts will be collected by the new PJFF. Ash is transported from the hoppers to a transfer tank via a vacuum pneumatic system with filter separators and exhausters to deposit ash in a transfer tank. Units 1 and 2 share a common transfer tank and a common pressure pneumatic conveying system with a single conveying line to one of two silos (east and west).

3.1.2 New Equipment for Unit 1

1. PJFF
2. Pneumatic vacuum system from the PJFF hoppers to the transfer tank. Components of the existing transporting system should be utilized to the greatest extent possible.

See Figure 2 in Appendix A for simplified system schematic for the new equipment.

3.1.3 Existing Equipment to be used with PJFFs for Unit 1

1. Unit 1 and 2 transfer tank
2. Filter separators
3. Exhausters
4. Pressure blower
5. Conveying piping and valves to the existing east and west silos shall be re-used for the purpose to convey the PJFF ash to the existing east and west silos. However, the existing Unit 1 and 2 transfer tank and associated equipment indicated above will only be used for unit transport of PJFF ash from Unit 1.

3.1.4 Unit 1 Ash Destinations

Ash will flow from PJFF hoppers to the west and new silos, with the east silo as a back up only. Flow from Unit 1 to the east (saleable) silo will normally be isolated and prevented until Units 3 and 4 ESPs are retired.

3.2 Unit 2

3.2.1 Existing System for Unit 2

The existing ESP will be demolished and replaced with new ductwork that eliminates the hoppers. Fly ash and byproducts will be collected by the new PJFF. There will be no existing equipment reused for Unit 2.

3.2.2 New Equipment for Unit 2

1. Unit 2 transfer tank
2. Vacuum product valves
3. Vacuum conveying lines and in-line devices
4. Vacuum breaker
5. Filter separators
6. Exhausters
7. Pressure blowers
8. Pressure conveying lines and in-line devices

See Figure 3 in Appendix A for the simplified system schematic for the new equipment.

3.2.3 Unit 2 Ash Destinations

Ash will flow from PJFF hoppers to the west and new silos, with the east silo as a back up only. Flow from Unit 2 to the east (saleable) silo will normally be isolated and prevented until Units 3 and 4 ESPs are retired.

3.3 Unit 3

3.3.1 Existing System for Unit 3

The existing Unit 3 ESP and its associated fly ash conveying system will be utilized to collect sellable ash and to transport it to the destinations as shown in Figure 4 in Appendix A. There will be no existing equipment used for the new PJFF equipment for Unit 3. However, the existing fly ash system used for Unit 3 ESP ash will continue to be utilized.

3.3.2 New Equipment for Unit 3

1. Unit 3 transfer tank to service Unit 3 PJFF
2. Vacuum product valves
3. Vacuum conveying lines and in-line devices
4. Vacuum breaker
5. Filter separators
6. Exhausters
7. Pressure blowers
8. Pressure conveying lines and in-line devices
9. New bin vent for west silo to handle additional airflows from PJFF systems
10. New silo vacuum / pressure relief valve for west silo
11. New fly ash waste silo
12. (2) ash conditioner assemblies for new silo
13. (1) dry spout assembly for new silo
14. (1) new silo bin vent

See Figure 5 in Appendix A for the simplified system schematic for the new equipment.

3.3.3 Unit 3 Ash Destinations

Ash from Unit 3 will flow from ESP hoppers to the east silo, with the west silo used as backup only. Ash will also flow from the new PJFF hoppers to the west silo and the new silo.

3.4 Unit 4

3.4.1 Existing System for Unit 4

There will be no existing equipment used for the new PJFF equipment for Unit 4. The existing Unit 4 ESP and its associated fly ash conveying system will be utilized to collect saleable ash and convey it to the destinations below.

3.4.2 New Equipment for Unit 4

1. Unit 4 transfer tank to service Unit 4 PJFF
2. Vacuum product valves
3. Vacuum conveying lines and in-line devices
4. Vacuum breaker
5. Filter separators
6. Exhausters
7. Pressure blowers

8. Pressure conveying lines and in-line devices
9. The following equipment is listed for Unit 3 but is common to the station: new bin vent for the west silo, new silo vacuum / pressure relief valve for the west silo, new fly ash waste silo, (2) ash conditioner assemblies for new silo, (1) dry spout assembly for new silo, and (1) new silo bin vent

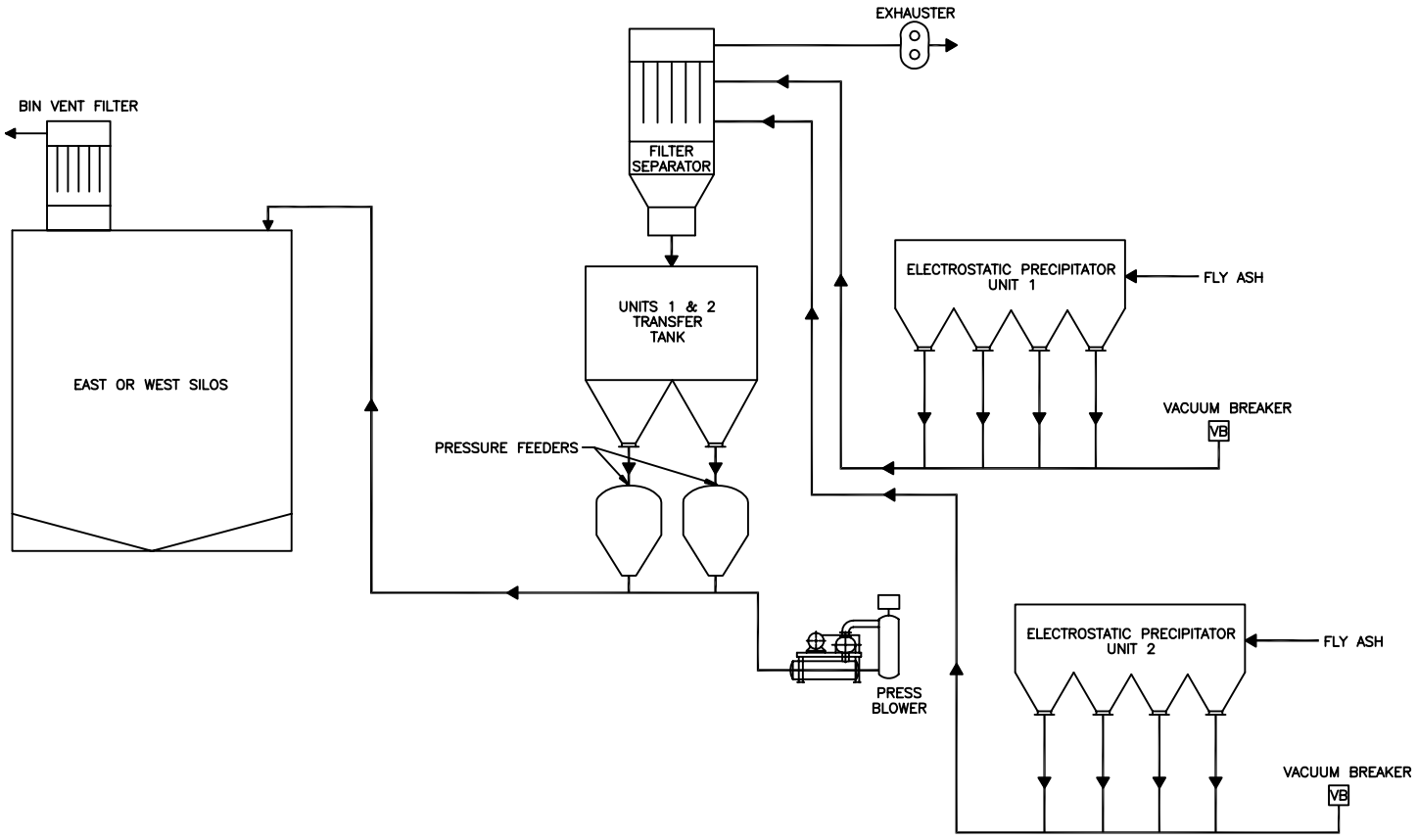
See Figure 7 in Appendix A for the simplified system schematic for the new equipment.

3.4.3 Unit 4 Ash Destinations

The saleable ash from unit 4 will flow from ESP hoppers to the east silo, with the west silo as backup only. The waste ash will also flow from the new PJFF hoppers to the west silo and the new silo.

Appendix A
Fly Ash Handling System Schematics

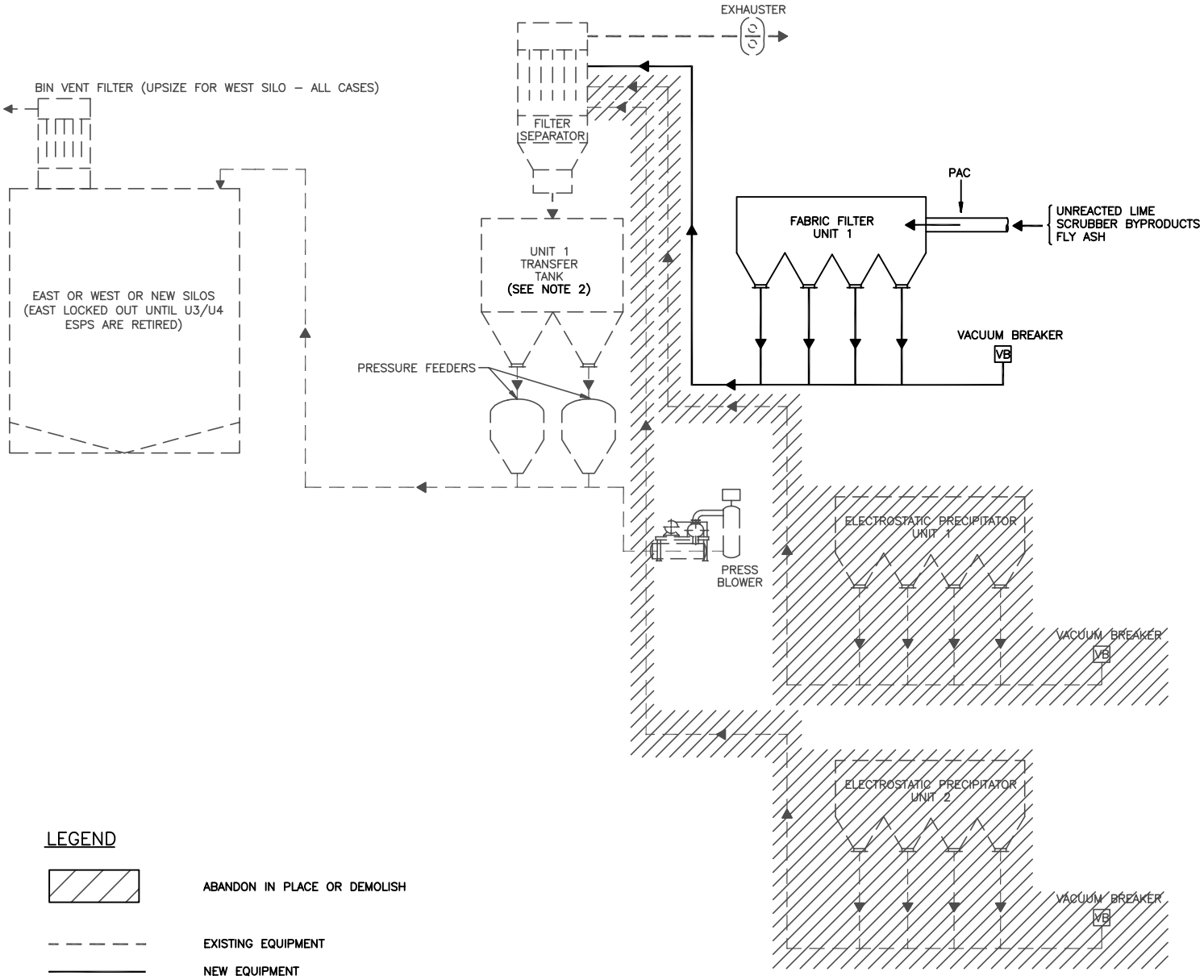
LOUISVILLE GAS AND ELECTRIC, MILL CREEK STATION
UNITS 1 & 2 EXISTING
FLY ASH HANDLING SIMPLIFIED SYSTEM SCHEMATIC



NOTES:

1. REFER TO EXISTING DRAWINGS FOR NUMBER OF ASH HOPPERS AND NUMBER OF EQUIPMENT COMPONENTS (FILTER SEPARATORS, PRESSURE FEEDERS, SILOS, ETC.)

LOUISVILLE GAS AND ELECTRIC, MILL CREEK STATION
UNIT 1 NEW
FLY ASH HANDLING SIMPLIFIED SYSTEM SCHEMATIC



LEGEND

ABANDON IN PLACE OR DEMOLISH

EXISTING EQUIPMENT

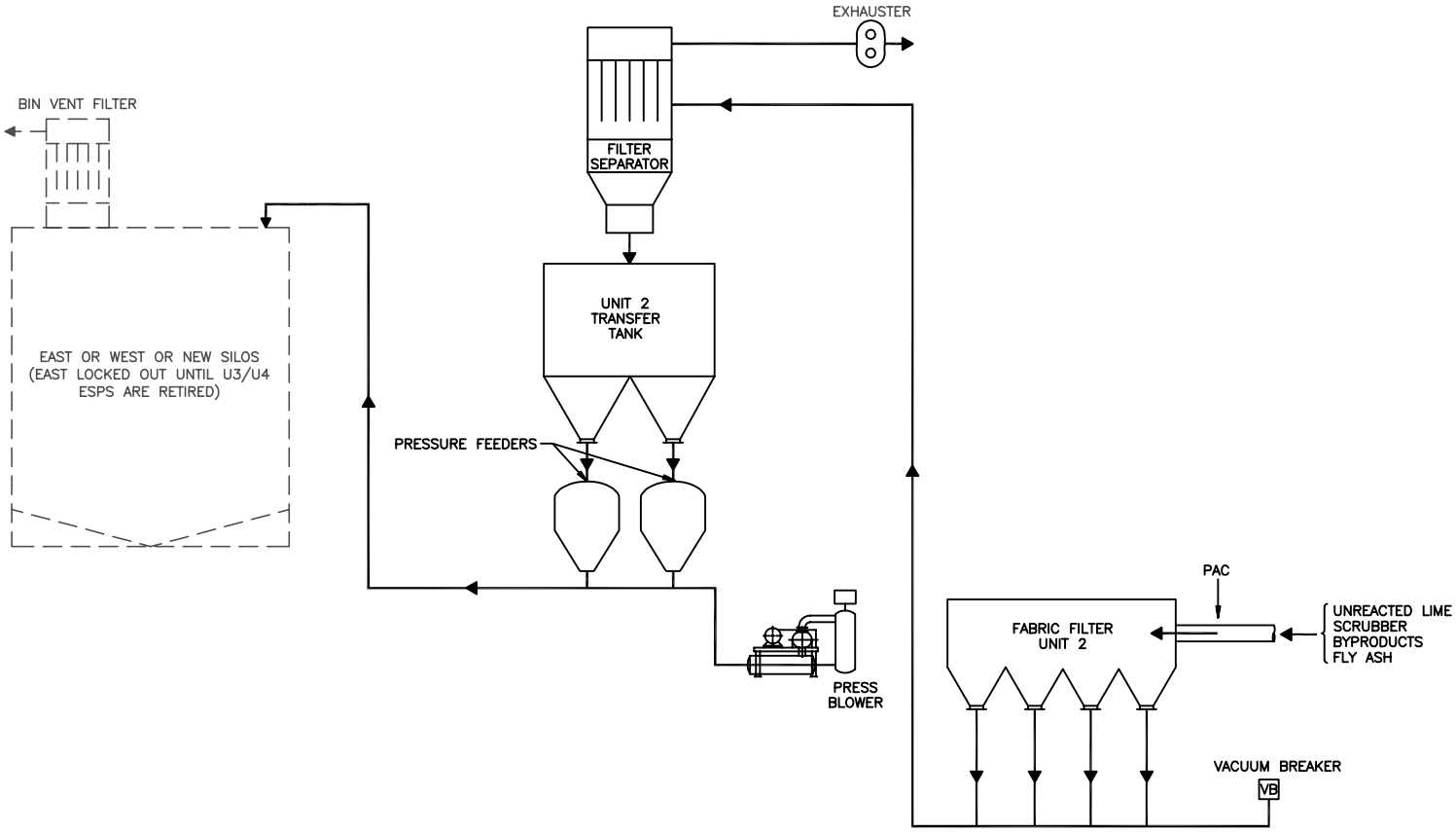
NEW EQUIPMENT

NOTES:

1. REFER TO EXISTING DRAWINGS FOR NUMBER OF ASH HOPPERS AND NUMBER OF EQUIPMENT COMPONENTS (FILTER SEPARATORS, PRESSURE FEEDERS, SILOS, ETC.)
2. EXISTING UNITS 1 & 2 TRANSFER TANK USED FOR UNIT 1 ONLY.

168908–FIGURE 2

LOUISVILLE GAS AND ELECTRIC, MILL CREEK STATION
UNIT 2 NEW
FLY ASH HANDLING SIMPLIFIED SYSTEM SCHEMATIC



LEGEND

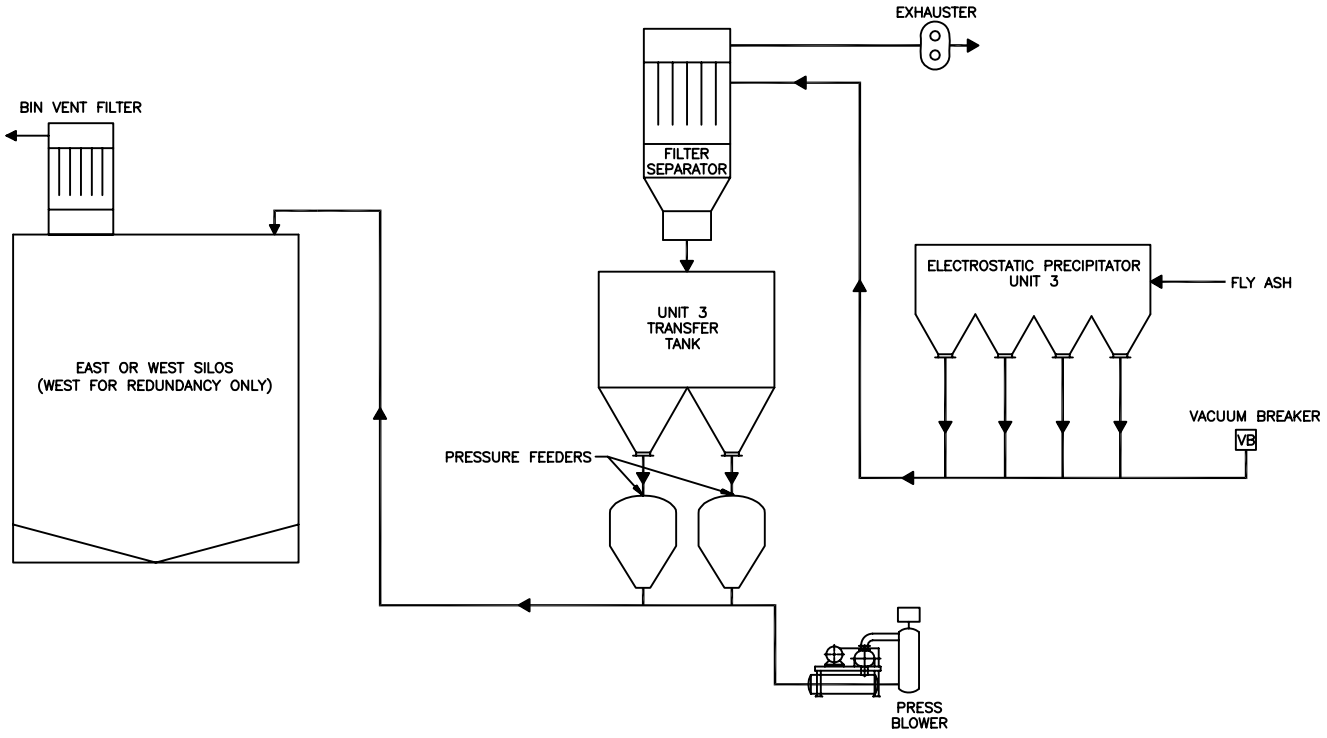
- – – – – EXISTING EQUIPMENT
- ———— NEW EQUIPMENT

NOTES:

1. REDUNDANT EQUIPMENT NOT SHOWN (PRESSURE BLOWERS, FILTER SEPARATORS, PRESSURE FEEDERS, ETC.)

168908–FIGURE 3

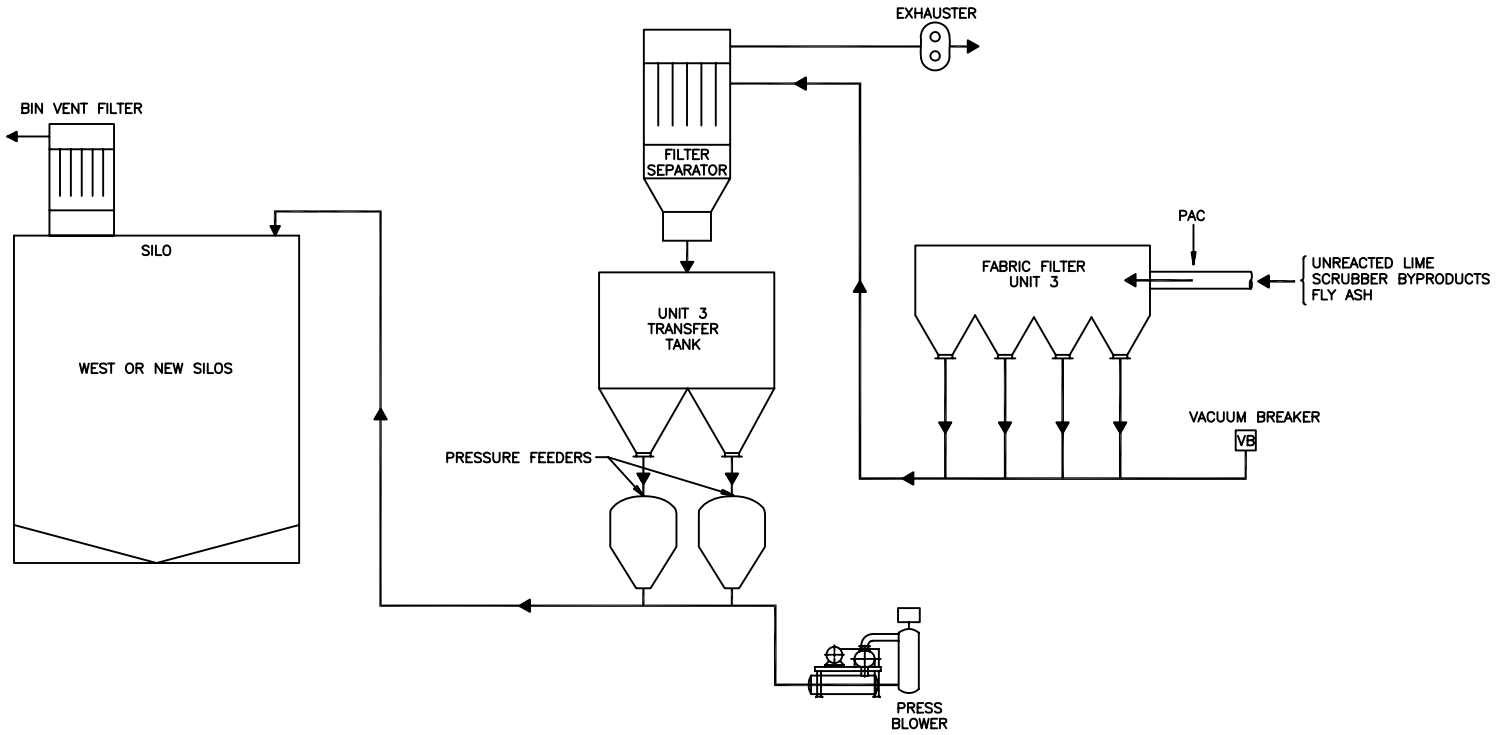
LOUISVILLE GAS AND ELECTRIC, MILL CREEK STATION
UNIT 3 EXISTING
FLY ASH HANDLING SIMPLIFIED SYSTEM SCHEMATIC

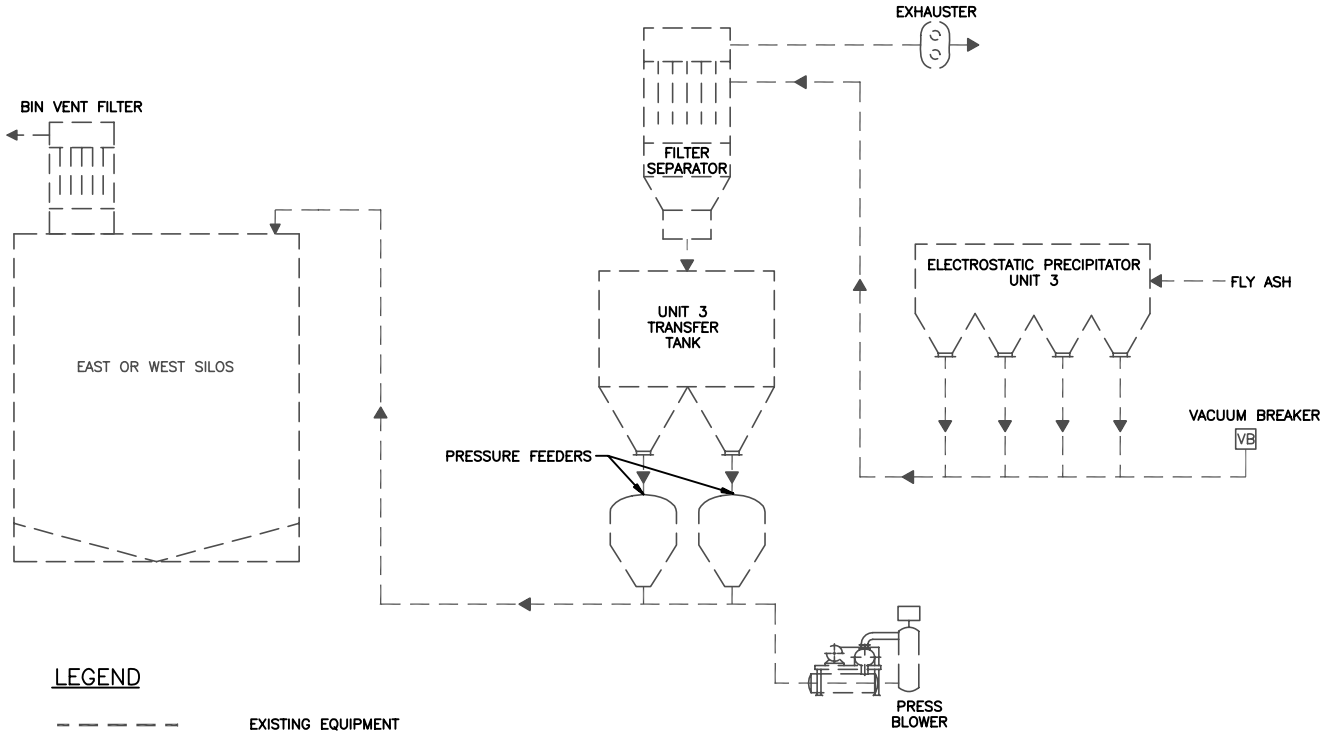


NOTES:

1. REFER TO EXISTING DRAWINGS FOR NUMBER OF ASH HOPPERS AND NUMBER OF EQUIPMENT COMPONENTS (FILTER SEPARATORS, PRESSURE FEEDERS, SILOS, ETC.)

LOUISVILLE GAS AND ELECTRIC, MILL CREEK STATION
UNIT 3 NEW
FLY ASH HANDLING SIMPLIFIED SYSTEM SCHEMATIC





LEGEND

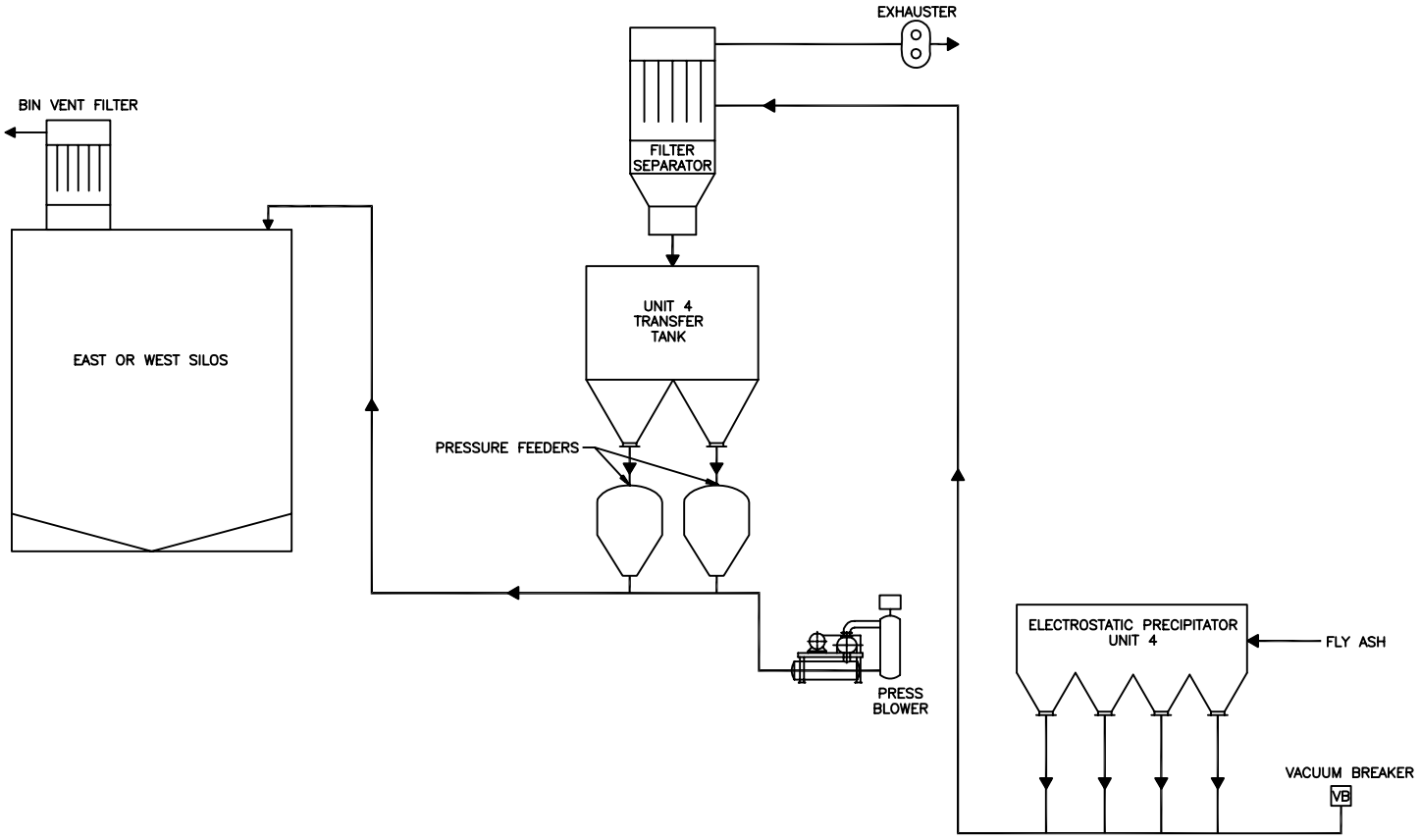
- – – – – EXISTING EQUIPMENT
- ——— NEW EQUIPMENT

NOTES:

1. REDUNDANT EQUIPMENT NOT SHOWN (PRESSURE BLOWERS, FILTER SEPARATORS, PRESSURE FEEDERS, ETC.)

168908–FIGURE 5

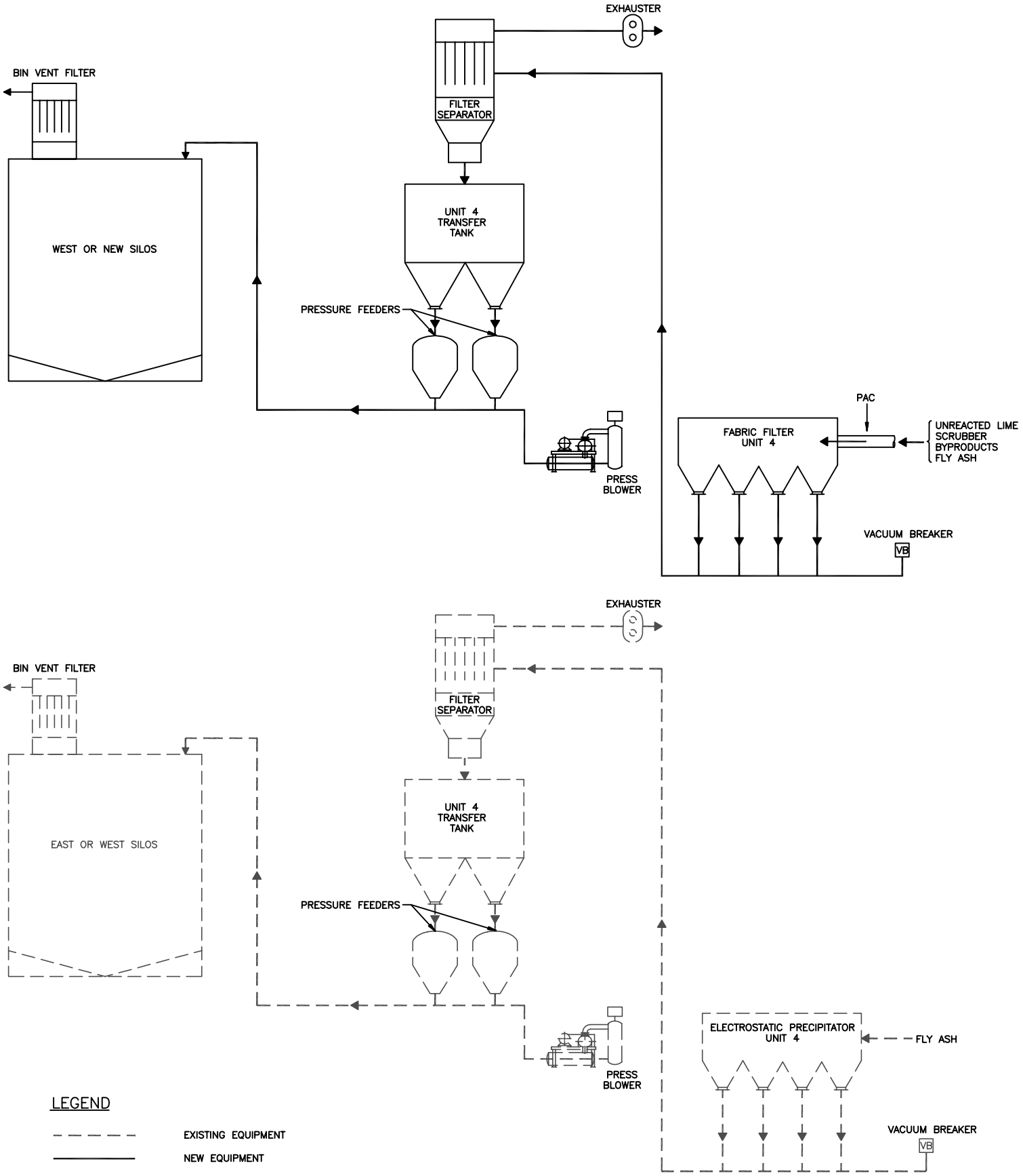
LOUISVILLE GAS AND ELECTRIC, MILL CREEK STATION
UNIT 4 EXISTING
FLY ASH HANDLING SIMPLIFIED SYSTEM SCHEMATIC



NOTES:

1. REFER TO EXISTING DRAWINGS FOR NUMBER OF ASH HOPPERS AND NUMBER OF EQUIPMENT COMPONENTS (FILTER SEPARATORS, PRESSURE FEEDERS, SILOS, ETC.)

LOUISVILLE GAS AND ELECTRIC, MILL CREEK STATION
UNIT 4 NEW
FLY ASH HANDLING SIMPLIFIED SYSTEM SCHEMATIC



LEGEND

- – – – – EXISTING EQUIPMENT
- ——— NEW EQUIPMENT

NOTES:

1. REDUNDANT EQUIPMENT NOT SHOWN (PRESSURE BLOWERS, FILTER SEPARATORS, PRESSURE FEEDERS, ETC.)

168908–FIGURE 7