bulk solids handling Volume 2, Number 3, September 1982

A Large Coal Storage and Blending Facility at the Monroe Power Plant

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Summary

The new coal handling facility for Detroit Edison's Monroe Plant is nearing completion. The capability to blend high and low sulfur coals will enable the plant operators to comply with increasingly stringent sulfur dioxide emission standards. The facility will also permit the company to achieve a high level of overall power plant availability, thus contributing in a very positive manner to providing power to their customers at a reasonable cost.

1. Introduction

Historically, in the eastern and mid-west regions of North America, coal-fired power plants were constructed to bum high sulfur, bituminous coal. This type of coal contains sulfur in the 2 % to 5 % range, and has a heating value above 12,000 Btu/lb. High sulfur, bituminous coal supply, in the United States, comes primarily from the Appalachian region and the Illinois area.

The Monroe Power Plant of Detroit Edison Company, located on Lake Erie at Monroe, Michigan, has four 750 MW turbine generators, powered by four 3,600 psig steam generators, each rated at 5.7 million lb/h. When the plant was conceived in the mid-sixties, the logical choice was to fuel the steam generators with Appalachian high sulfur coal delivered by unit trains.

By the time the plant was completed and the fourth turbine came on line in late 1973, environmental concerns began to take on added importance to society, and to state agencies and power utilities in particular. In 1976, faced with the task of meeting increasingly stringent sulfur dioxide emission standards, Detroit Edison, by agreement with the Michigan Air Pollution Control Commission, decided to burn increasing proportions of low sulfur coal, blended with high sulfur coal, as the primary means of reducing the SO_2 emission to 3.68 lb/million Btu by 1980 and to 1.6 lb/million Btu by 1985.

Low sulfur, bituminous coal with 0.8 % sulfur and 12,000 Btu/lb heating value was available from eastern suppliers at premium cost. Low sulfur, sub-bituminous coal with 0.4 % to 0.8 % sulfur and 8,000 to 9,500 Btu/lb heating value was also available from western mines via the Burlington Northern Railroad and Great Lakes vessels. Blending an increasing percentage of the western coal with eastern high and low sulfur coals offered economic advantages in spite of its low heating value. Consequently, Detroit Edison decided to construct a new coal handling facility integrated with the existing system, to receive coal by ship and by rail, and to stockpile, reclaim and blend the three types of coal in the proportions required to feed approximately 10 million tons per year to the plant.

Following initial conceptual studies, Bechtel was engaged to perform engineering, procurement and construction management services for the project.

This article covers features and concepts incorporated in the design directed towards achieving high availability through system flexibility, maintainability, simplicity, and application of proven features of modern bulk materials handling technology.

2. Design Objectives

Key objectives established by Detroit Edison for the design of the facility were:

- Coal handling system availability above 99 %.
- Simultaneous receiving, stockpiling, blending of rail and ship delivered coal.
- System flexibility to vary the capacity of live and compacted storage piles and the ratio of tonnage reclaimed amongst the three types of coal.
- System redundancy and quality components.
- System simplicity and maintainability through component standardization, with provision for adequate

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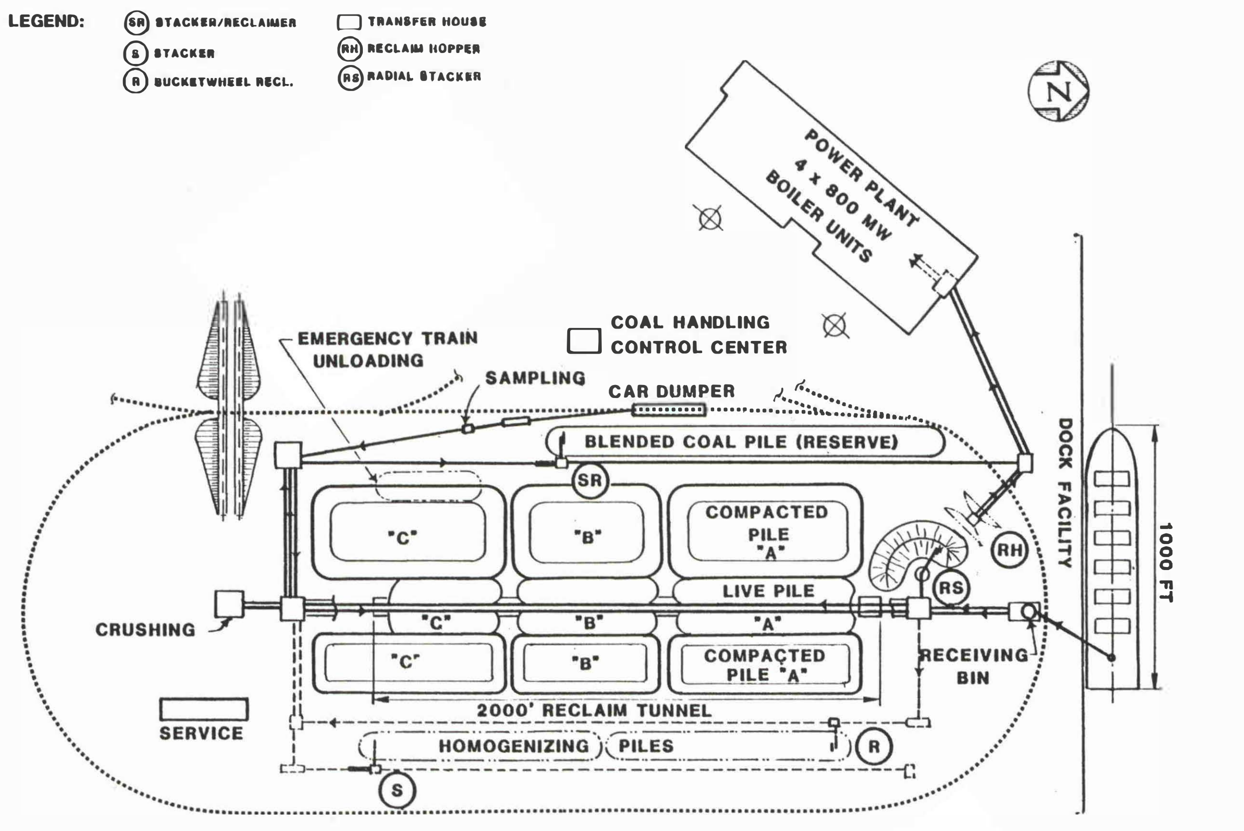

Fig. 1: Storage and blending system, Monroe Power Plant, Monroe, Michigan, USA

access to components without having to move adjacent equipment.

- System design for cold weather operation with particular accent on coal behaviour at freezing and thawing temperatures.
- Provisions to cope with the large fluctuation of sulfur content in the eastern high sulfur coal by homogenizing or by continuous monitoring of sulfur content in the blended coal, and adjustment of the blend ratios.
- Dust control to minimize escape of fugitive dust to the environment and coal dust accumulation inside buildings.
- Provision for an interim coal blending facility to meet the 1980 SO_2 emission level commitment.

3. System Description

3.1 General

The coal handling system is shown in Figs. 1 and 2. The major elements consist of 48 inch and 72 inch wide belt conveyors with a total length of approximately 35,000 ft; belt feeders of 60 inch to 84 inch widths; rail mounted trippers; rotary plow discharge machines; and ring type impact crushers for reducing minus 2″ coal to minus 3/4″ for pulverizer feed.

Auxiliary equipment consists of sampling systems and precision scales for the "as received" and "as fired" coal, tramp iron magnets, and metal detectors.

Services provided include heating, ventilating and air conditioning, fire protection, compressed air and service water systems, and maintenance facilities.

3.2 Ship Unloading

A new dock was constructed, currently capable of berthing up to 30,000 ton capacity Great Lakes type, self-unloading vessels. When the channel is dredged to 27 ft depth in the future, the system will be able to handle the newer 1,000 ft long, 63,000 ton capacity vessels.

The system is designed to receive coal at up to 10,000 t/h via a 560 ton capacity covered receiving bin located in the vicinity of the dock. A hood enclosure, fitted with motorized doors and dust curtains, and maintained under negative pressure, is provided on the top of the bin. During unloading operations, the discharge end of the ship's boom is set inside the hood enclosure and the door and curtains closed around the boom. The hood enclosure prevents dusting due to wind action, and adjustment of doors and dust curtains reduces the open area around the ship's boom structure. The dusty air is drawn from the top of the hood to two 45,000 ft^3/min baghouse type dust collectors. This design has been effective in preventing dust escape during ship unloading at Detroit Edison's other similar installations. Variable speed belt feeders regulate the flow of coal from the bin to the stockpiling system.

3.3 Unit Train Unloading

The existing rotary car dumper facilities are integrated, via a new conveyor line, into the new system. The car dumper and

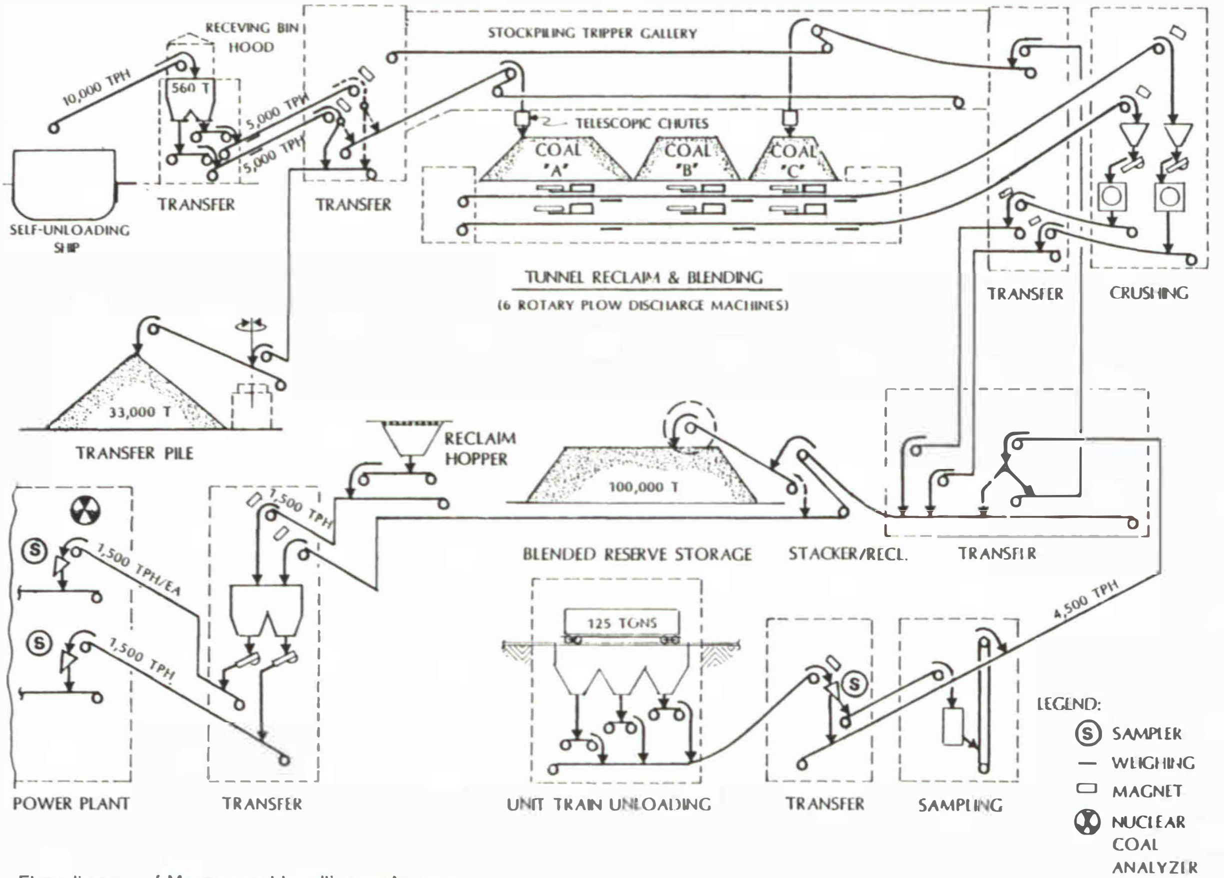

Fig. 2: Flow diagram of Monroe coal handling system

the new handling facilities are designed to unload unit trains at 4,500 t/h. Each unit train consists of up to 140 aluminium gondola cars of 125 ton capacity each. The cars enter the rotary dumper under power from the automatic car positioning arm. All cars making up the unit train employ special rotary couplers, making uncoupling unnecessary. The coupling rotates with the car as the dumper cage rolls to a 140° to 160° inversion, and the cars to the front and rear of the rotated car remain stationary. Under normal operating conditions, these features permit unloading an average 30 cars per hour or a unit train in four and one-half hours.

3.4 Stockpiling, Reclaiming and Blending

Both ship and rail delivered coals are stockpiled to live storage by travelling trippers installed in the enclosed twin tripper gallery shown in Fig. 3. To minimize fugitive dusting, telescopic chutes mounted separately from the trippers are synchronized to travel as "slaves" with the trippers.

The ground storage facilities include:

- Three separate live storage piles for the high and low sulfur coals, totalling 110,000 tons.
- Compacted coal storage, totalling 1.7 million tons, which allows for fifty days reserve for rail delivered eastern high sulfur coal and five months reserve for the ship delivered low sulfur coal.
- Emergency train unloading pile with 17,000 ton capacity.
- Emergency ship unloading and transfer pile with 33,000 ton capacity.
- Emergency blended coal storage pile with 100,000 ton capacity.

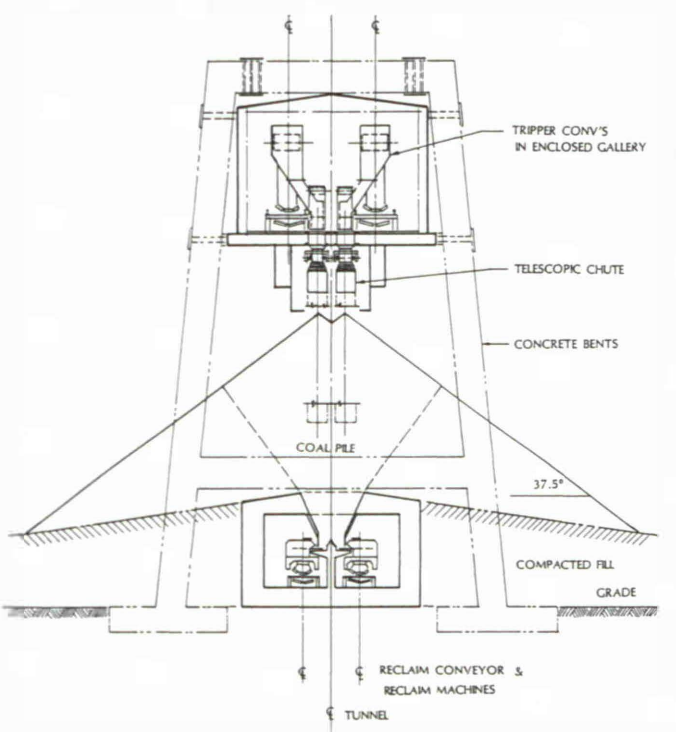

Fig. 3: Tripper gallery and reclaim tunnel section

Stockpiling to the emergency ship unloading pile is carried out by a luffing and slewing radial stacker, and stockpiling to the emergency train unloading and blended coal storage is accomplished by an existing rail mounted stacker-reclaimer.

Reclaiming from the live storage piles is accomplished by six rotary plow reclaim machines and two 48 inch belt conveyors located in a 2,000 ft long concrete tunnel. The system permits simultaneous reclaiming of three different types of coal by layering the coal from different piles onto the tunnel belt conveyors. The reclaim rate of each rotary plow can be adjusted remotely to provide the required coal blend.

3.5 Plant Feed System

The plant feed system is capable of delivering 3,000 t/h of blended coal to the 28 existing silos in the power plant from either the live storage piles via the tunnel reclaiming system, or the emergency blended storage via the rail mounted stacker-reclaimer and feed conveyors, or the interim coal blending facility.

An interim coal blending facility was provided to meet the January 1, 1980 SO_2 compliance milestone, comprising two below-grade reclaim hoppers, variable speed belt feeders and reclaim conveyors discharging to the plant feed conveyor line.

3.6 On-Stream Analysis of Blended Coal

The design initially considered facilities for homogenization of eastern high sulfur coal to cope with the large fluctuations in sulfur content. Development of continuous on-stream nuclear coal analysis technology by the Energy Research Development Agency Laboratories in Morgantown, Pennsylvania, offered a more economical alternative. Detroit Edison has pioneered by incorporating this technology in the Monroe system to monitor the content of sulfur, moisture, and other elements in the blended coal.

The nuclear analyzer, shown in Fig. 4, uses the technique of prompt gamma neutron activation analysis by bombarding the coal sample with fast neutrons. Some of the neutrons are absorbed in the various elemental components of the coal. Each element then emits gamma rays, the wavelength of which is uniquely characteristic of the element, and the intensity of which is proportional to the elemental percentage in the coal. The gamma ray signals are processed and fed to a microcomputer, which calculates the percentage of sulfur within minutes. The values are displayed and printed at a local panel, and transmitted to the central control room.

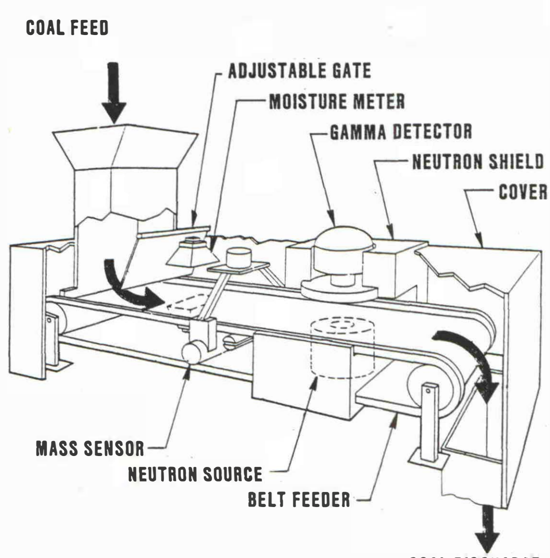

Fig. 4: Nuclear coal analyzer (schematic)

The coal is blended to a fixed ratio for each plant fill cycle, approximately six per day. The average sulfur content reading of the coal during the feed cycle is used by plant operations and fuel supply personnel to set the subsequent fill cycles' blend ratios, to meet the twenty-four hour average SO_2 emission level.

The on-stream nuclear analyzer provides immediate elemental analysis for fine tuning of the coal blend ratio, thus permitting maximum use of the lower cost, high sulfur coal. The development of this equipment has made it unnecessary to provide the homogenizing capability at this time.

3.7 Control and Instrumentation

All equipment functions within the facility are controlled through a programmable controller (PC) system. This system provides fully automatic control of coal routes and equipment, analog signals processing, as well as self-supervision for system failures.

Four control modes of operation were established for the coal handling and blending facility. The "local" and "test" modes utilize a hardwired system located in the vicinity of the drives; the "auto" and "manual" modes utilize the PC system and provide plant control from a central control room. In the "manual" mode, the operator selects individual equipment and operates them in sequence to provide a coal transfer route. In the "auto" mode, the operator identifies the desired coal transfer route by its number, then checks the availability of the selected route prior to starting. The selection of the mode of operation is made manually by a key operated selector switch located in the central control room.

The PC system consists of two Modicon 1084 main control units, one which is "online" while the other is "standby", located in the central control room. Modicon 384'B data processing units are also part of the PC system and are utilized as remote data processing units. These are located in various plant areas and convert signals from/to plant equipment into analog or logic voltage levels for transmission to the main control units via data link cables.

Installation of the PC system for the Monroe coal handling and blending facility provides simplicity in operation, self-supervision and annunciation of problem areas. It also eliminates costly cable runs normally associated with hardwired systems for a coal handling facility of this size.

4. Design Features

The coal handling facility was developed to provide flexibility in methods of delivery and handling of the coal within the plant, and also to provide protection to maintenance personnel and equipment during cold weather operation throughout the system. This was achieved by stockpiling of ship and rail delivered coal using travelling trippers in enclosed galleries; reclaiming and blending from three different live storage piles through a twin reclaim tunnel system using rotary plow discharge machines; and full enclosure of all buildings and elevated conveyors. These features also provide flexibility in live and compacted storage pile capacity and location irrespective of the method of coal delivery and, in turn, provide opportunities for the utility to minimize fuel cost and to obtain greater security in coal supply.

The stockpiling system makes use of an elevated tripper gallery to form live storage piles centrally located between the compacted storage piles. The gallery is supported on widely spaced concrete bents permitting a cost effective dozer and scraper operation for moving coal from live storage to compacted piles and vice versa.

The live piles are formed directly over the reclaim tunnel. The concept of a tunnel reclaim and blending system, combined with the use of rotary plow discharge machines, offers the following additional advantages over alternative reclaiming and blending methods that were considered for the Monroe site:

- Discharge machines and reclaim conveyors are enclosed inside the tunnel, thus preventing dust escape to the atmosphere.
- The machines operate automatically at variable discharge rates on the gravity flow concept, thus require less power than any other type of reclaiming equipment.
- The machines provide simplicity and flexibility of operation. An installed spare unit is located in the tunnel maintenance area, permitting easy replacement when major maintenance of an operating unit is required.

Active redundancy is provided through dual conveyor lines for ship unloading, stockpiling, reclaiming, and plant feed. Should one system fail, the other active conveyor line is still capable of unloading a ship, although at a lesser rate. Blending and plant feed normally utilizes two conveyor lines intermittently. Should one system fail, full feed rate can be maintained by near continuous operation of the other line.

A high level of component standardization is provided throughout the system to facilitate maintenance and reduce spares inventories. The fourteen conveyors in the system are designed to use only two belt widths, 48 inches and 72 inches, with steel cord belts all of the same construction. Twenty-four drives are standardized into three size groups, namely 250, 350 and 500 horsepower. Pulley assemblies, idlers, and accessory equipment such as service hoists, are also standardized.

To further enhance the overall system availability, the design includes heavy duty, high quality components, and incorporates modern features of coal handling technology such as:

- Transfer points designed to eliminate chute plugging and spillage by the use of 55° to 60° deep trough catenary impact idlers, steep sloped transfer chutes with adjustable baffle boards and sloping skirtboards which center the material on the belt.
- Shuttle head frames for multiple choices of routing the coal flow; this approach eliminates the need for bifurcated chutes with diverter gates which may jam or freeze up in cold weather.
- Compact shaft mounted drives with wound rotor motors and step resistor acceleration torque control on drives of 250 horsepower and over.
- Primary and secondary drives which facilitate standardization of gear reducers, motors, drive pulleys and belting, and allow operation of conveyor lines at reduced capacity, in case of failure of a drive unit in the system.
- Motorized belt take-up devices on all steel cord belt conveyors to minimize drive pulley lagging wear due to belt slip, and to assure a positive conveyor start and stop even under cold weather conditions.
- Dust collector baghouses, combined with wet-water spray system, to control dust escape at transfer points. The recently developed foam spray technology has been installed at two selected transfer points and has proven superior to wet-water dust suppression in trial operations. It is particularly beneficial at sub-freezing temperatures when wet-water sprays cannot be used. Test measurements indicate a requirement of approximately 0.03 gallons to 0.07 gallons of foam per ton of coal treated.

Dribble accumulation on floors and components, originating from return belts running over pulleys and idlers, and coal spillage from the carrying side of conveyor belts can be a major source of problems unless adequate preventive measures are included in the design. At Monroe, in addition to the deep trough catenary impact idlers at transfer points mentioned earlier, preventive measures include:

- Elimination of snub and bend pulleys wherever possible, and rubber lagging of all pulleys in direct contact with the "dirty" side of belt. Rubber lagging minimizes dribble build-up on pulley faces, belt misalignment and subsequent coal spills.
- Conveyor slopes at loading points are at zero to eight degrees to enhance material acceleration thus avoiding chute plugging; elsewhere slopes do not exceed fifteen degrees to avoid frozen coal backslides on icy belts.
- Belt conveyor drives are fitted with brakes to control coasting time and thereby prevent coal accumulation in the transfer chutes in the event of emergency shut down of the system.
- All belt conveyors are designed to take 10 % continuous overload and instantaneous peak surges according to the source of belt loading.
- All belt conveyors are installed with dual belt scrapers equipped with tungsten carbide blades, instead of rubber blades, which lose their elasticity in cold weather, freeze up with dribble and wear out rapidly.
- In the event that spillage does occur, clean-up is facilitated by the use of smooth concrete floors in transfer houses and galleries, adequate clearances beneath conveyors and provision of washdown facilities.

These measures will reduce the effort and cost of plant house-keeping and minimize the hazards of spontaneous combustion of spilled coal, and most important, will also reduce dust accumulation which are potential sources of fire and explosion.

Acknowledgements

The authors wish to offer sincere thanks to the management of the Detroit Edison Company for their full support and innovation approach in applying advanced technology to this project, and for their permission to publish this paper.

We also wish to acknowledge the encouragement and support of Messrs. Howard Wahl and John Trommershausser of Bechtel's Ann Arbor Power Division.