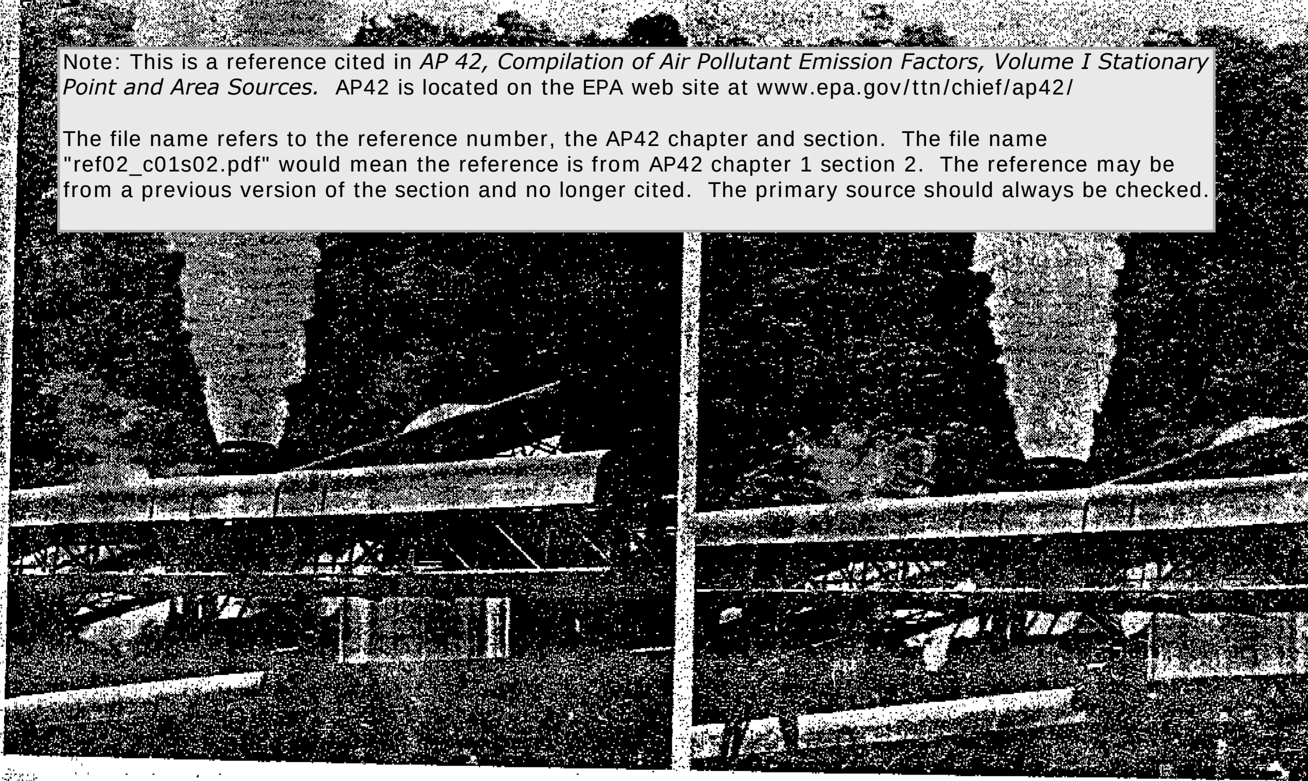
Dust Abatement at Bird Coal



Dust emission at the Riverside preparation plant of Bird Coal Co. is believed to be lower than at any coal cleaning plant in the United States. To achieve this, the company spent about $400,000 beyond the cost of the original plant

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DUE to the physical location of its Riverside preparation plant, Bird Coal Co. initiated a program of air pollution abatement that has resulted in emission levels much lower than are typical within the coal industry. Several modifications to the original flowsheet, as well as the installation of additional equipment, were necessary to complete the program.

Located near Johnstown, Pa., the plant was built by Bird's parent, Maust Coal & Coke Corp., with engineering and design assistance of Heyl & Patterson, Inc. The preparation plant was designed to handle coal from the B seam in the #3 Mine and the C prime seam in the #2 Mine. The flowsheet of the Riverside cleaning plant in its original form is shown in figure 1 and is described below and on the following page.

Plant handles 250 tph

Coal from the two seams is kept separated in 2000-ton capacity concrete silos and is processed as two independent feeds at approximately 250 tph. From the silos, the raw coal goes to the screen house, containing two 8 × 20-ft vibrating screens. Plus ¼-in. from the screen house is moved by belt conveyor to the wet cleaning plant and minus ¼-in. product is fed to a Heyl & Patterson fluid bed classifier.

In the wet cleaning plant, material follows a more or less conventional heavy media flowsheet. Plus ¼-in. coal goes first to a pre-wet screen where it is wetted and any fines are rinsed away. The coal is then fed into a primary DMS vessel, float material from which is sized at ¾-in., suitably drained and rinsed. Minus ¾-in. material is fed to a fluid bed thermal dryer, and plus ¾-in. product is crushed to minus ¾-in. and joins the dried coal for loading into railroad cars.

Plus ¼-in. sink material from the primary DMS vessel goes to a secondary DMS unit operating at a higher gravity. Plus ¼-in. float from this secondary vessel is crushed to minus ¾-in. and goes to loading for utility coal. Sink material from the secondary DMS vessel is refuse and is conveyed by belt to a disposal area where it is spread and compacted by bulldozers.

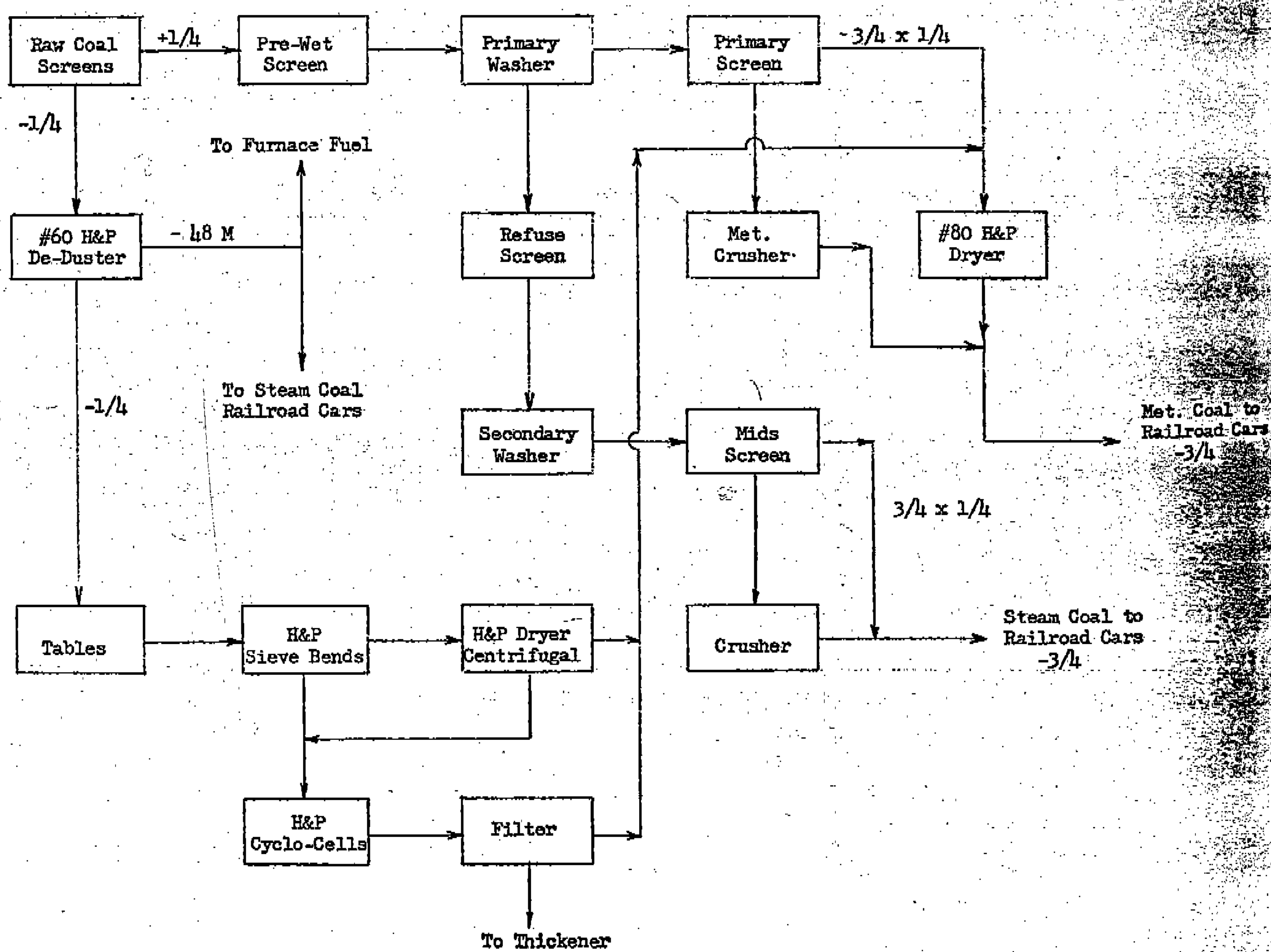
In the fluid-bed classifier, minus ¼-in. raw coal is separated pneumatically at approximately 48 mesh. Minus ¼-in. plus 48-mesh material goes to a battery of double-deck tables. After passing over the tables, the minus ¼ in. plus 48 mesh is sent to Sieve Bends so that any minus 48-mesh material is removed and fed to Cyclocell flotation units. The ¼-in. x 48-mesh material is dewatered in centrifugal dryers to remove extraneous surface moisture. Clean coal from the froth cells is dewatered on an 8-ft 10-in., six-disc filter. This material along with the ¼-in. x 48-mesh clean coal product is mixed with the plus ¼-in. float from the primary DMS vessel before going to the fluid bed dryer.

From the dry classifier, minus 48-mesh raw coal is blended with plus ¼-in. float from the secondary DMS vessel and is loaded into railroad cars as steam coal. A portion of this minus 48-mesh raw coal is utilized as furnace fuel.

Rejects from the tables are mixed with coarse refuse from the secondary DMS vessel for disposal overland. Sink material from the froth flotation cells is dewatered in another filter before joining the coarse refuse for disposal.

Hot gases leaving the fluid bed dryer were cleaned in two Roto-clones, which were guaranteed to meet (and in fact surpassed) the Allegheny County Code for particulate emission. However, after they had been placed in operation, it became apparent that higher degrees of cleaning efficiency might have to be considered

Fig. 1. In the original flowsheet for the Riverside preparation plant, dust found its way into the atmosphere at the raw coal transfer point beneath the screening house, at the railroad car loading belt underneath the fluid bed dryer, at the railroad car loading area, and from the thermal dryer stack



at the plant due to its location and the terrain of the surrounding area.

Dust created in three areas

Realizing the need for stringent control of air pollution, Maust Coal engaged the consulting engineering firm of Robinson & Robinson, Inc. to inspect the plant over a period of several months.

Three areas were found in which dust was being created and finding its way into the atmosphere. One point was at the raw coal transfer point beneath the screening house, where vibrating feeders deliver minus ¼-in. coal onto the classifier feed belt. Especially during periods of start-up, with subsequent flooding, and also shutdown, sufficient turbulence is created to liberate dust into the atmosphere.

A second source of dust emission was at the railroad car loading area. Although there was a car-size hood, when the loaded car was pulled out from under it, dust escaped into the atmosphere. Extreme drying of the fine materials in the fluid bed dryer and the dry, dusty condition of minus 48-mesh material removed by the dryer classifier were responsible for this part of the dust problem.

A third point of dust emission was the railroad car loading belt underneath the fluid bed dryer. Crushed metallurgical coal is first loaded on this belt, then minus ¾-in. material from the heat dryer. This is topped off with the extremely dry cyclone product (primary dust collector) from the thermal dryer.

With regard to a fourth possible source of pollution, the stack from the thermal dryer, a series of tests were performed by representatives for a nearby township, Bird Coal, and the Pennsylvania Air Pollution Commission. These tests averaged 0.326 lb of particulates per thousand lb of gases, or approximately 0.17 grams per cubic foot, which adequately meets the current Allegheny County code.

Although the company was satisfied that the exhaust stack was meeting Allegheny County code, it was realized that the plant would have to exceed any current legislative restrictions on total emissions because of the proximity of residential areas, topography, and the local wind conditions. Therefore, in October 1964, recommendations were made to eliminate, almost completely, three of the possible sources of dust emission.

Raw coal now screened wet

In order to eliminate dusting from the raw coal screening house, it was recommended that the screening process be changed from dry to wet. By judicious utilization of all water, a quantity in excess of 70,000 gph was made available to screen the raw coal. This proved more than ample. A slurry of minus ¼-in. material would then be pumped into the cleaning plant. An adjunct of this improvement is that, with wet screening being more efficient than dry, the chance of fine coal entering the cleaning circuit was materially decreased.

It was recommended that the classifier unit be removed from the circuit. This would not only eliminate dust around the unit itself, but also the necessity of taking air used in the classifier to the plenum chamber ahead of the fluid bed dryer. Calculations had shown that from 8 to 10 lb per minute of very fine dust particles entered the dryer circuit from this source. Since, in all probability, these particles were much finer than the fines collected during the heat drying, this would effect a reduction of particulates in the dryer stack. The dry, dusty, minus 48-mesh fine coal separated in the classifier would be cleaned by froth flotation and loaded wet, thus reducing further dusting.

As a result of the recommendations, all of the coal would be wet screened and cleaned by a wet process. As a further measure, it was recommended that the metallurgical filter cake be placed on the railroad car loading belt beyond the feed point of the heat-dried coal. Also, a mixing screw conveyor was installed to blend the primary cyclone dust collector material with the coarse fraction of coal discharged from the dryer, which has a slightly higher moisture content. By mixing the two products, some of the coarse coal moisture is transferred to the fine coal and dusting is reduced.

Clean coal now fuels dryer

With the elimination of the fluid bed dryer classifier, a change was made so that the primary dry cyclone separator product is now used as dryer fuel feed. Since this material is clean coal, as compared to the raw coal previously used, a reduction in the amount of coal necessary to effect the same combustion release was accomplished. This reduced fly ash particulates in the dryer exhaust.

All of the recommendations made by Robinson & Robinson were effected by the end of the Miners' Holiday in 1965, and an inspection in August showed material improvements in the overall dust emission situation. Dust had been practically eliminated at the dryer stack. A request was made to the Pennsylvania Air Pollution Commission for another survey of plant dust producing points but their schedule did not permit this. A visual observation of the plant, while admittedly not accurate, indicated a reduction of about 50 percent in total dust emission from levels existing prior to the changes that were made. Nevertheless, people in the surrounding area were still not satisfied, even after a large expenditure of time, effort and money, and litigation was initiated.

Dust from dryer stack considered excessive

In connection with the litigation, services of the U.S. Public Health Service were requested by the court. Its representative stated that, in his estimation, changes made prior to August 1965 had reduced dust emission at the Bird plant. However, it was felt that the dryer discharge stack contained too much dust for its location, even though the dust collecting equipment installed was operating properly and doing a very good job. It was felt that a discharge emission in the range of 0.05 grains per cubic foot would produce essentially a clean appearing stack. The stack need not necessarily appear completely clean at all times since combustion efficiency does vary, especially during start-up and shutdown. To obtain such dust collector performance would mean a material reduction in the emission from the dryer. This would be performance far and beyond any existing thermal coal dryer operation and also beyond the ability of any scrubbers presently in operation on thermal coal dryers.

It was pointed out to the court that (after extensive investigation by Robinson & Robinson of existing heat dryer stacks, their scrubbers, and the relatively small amount of test data available from different companies) that this figure of 0.05 was not being attained at any installation in the United States operating under comparable conditions. Therefore, the court directed Robinson & Robinson to make a survey of equipment manufacturers to determine their response to the problem confronting Bird. Under these instructions, a letter was sent to 14 of the major dust collection equipment manufacturers in the United States. Specifications submitted were as follows:

Capacity @ 175°	125,000 cfm (normal) 135,000 cfm (maximum)
Dust loading in exhaust gases	1.5 to 3 grains/cu ft
Size consist of dust in exhaust gases	0 to 2 microns – 40% 2 to 5 microns – 40% 5 to 10 microns – 10% +10 microns – 10%
Composition of dust in exhaust gases	coal dust and fly ash

The letter requested type of equipment and operating costs of a scrubber that could provide an exit dust concentration under these conditions of not more than 0.05 grains per cubic foot of standard gas.

Bag type collector ruled out

Only four replies indicated a full appreciation of the problem and the type of equipment that might have to be employed. It was obvious that a bag-type collector was not applicable because of the inherent danger of live sparks entering the collector and the possibility of excessive temperatures. The use of electrostatic equipment was not considered. The only type of equipment left to consider was the wet type of scrubber employing higher pressure drops than those currently available and of a different design and figuration. The general type of scrubbers, even with units in series, would not do the job because of the vast improvement that had to be obtained in overall performance. The normal pressure drop of scrubbers in the industry is somewhere between three and seven in. w.g. One company in the dust control field felt that on this problem a pressure drop of approximately 18 to 22 in. w.g. would be required on a venturi-type scrubber.

1000-cfm test unit installed in plant

Robinson & Robinson decided to work with American Air Filter Co. on the problem because of the company's extensive experience in connection with thermal coal dryers, its awareness of the problem at hand, and its ability to supply a complete line of wet scrubbers, including the venturi type. Arrangements were made to have a 1000-cfm Kinpactor test unit shipped to the Riverside preparation plant. This test unit was identical in design features to full size production models. It would be used to determine the pressure drop required to obtain a stack discharge of 0.05 grains per cubic foot of standard gas, since there was no known information on the particle size distribution of the dust leaving the dry cyclone collectors, especially that less than two microns in size, or any information on dust sizing leaving the discharge from the existing Rotoclones.

The test unit was installed in December 1965. Tests were run and completed and data forwarded to the interested parties in approximately two weeks. All sampling was done isokinetically, using specially designed equipment. The temperature of the air sampled was recorded and pressure drop across the calibrated orifice measured to determine the air flow during the testing period. A filter pad of extremely high efficiency, followed by a back-up pad, was used to prevent escape of any particulate matter in the air that was sampled. Both inlet and outlet tests were conducted simultaneously to ensure the utmost accuracy.

The basic principle of operation of the Kinpactor (figure 2) or venturi collector is to make a dust particle

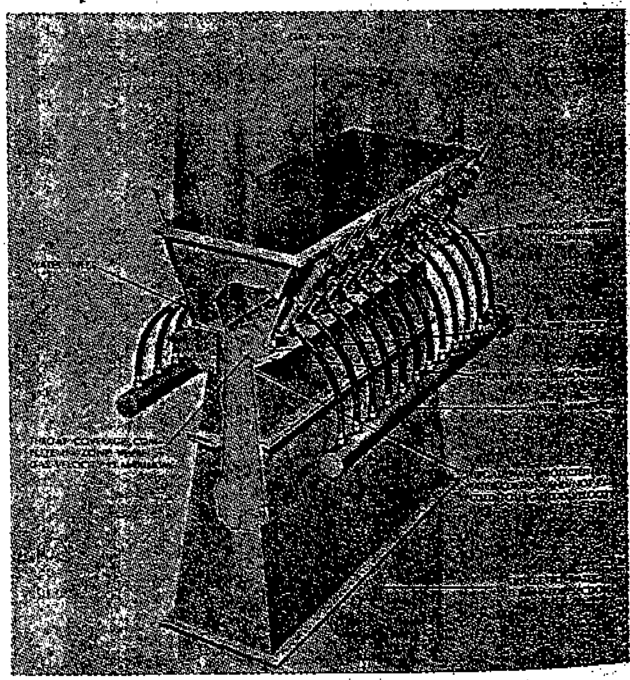


Fig. 2. Function of the gas scrubber tested is to bring dust particles in the gas stream into contact with water particles in the throat of the collector. Increasing pressure drop through unit reduces size of water particles, and the combination of higher dust particle velocity and more and smaller water particles results in increased collection efficiency

which enters at a high velocity impact into an area saturated with fine water particles. The dust particle cannot pass through this area without being contacted by a water particle. Increasing the pressure drop reduces the size of the water particles generated and the combination of higher dust particle velocity and greater number of smaller water particles results in increased collection efficiency.

Tests indicated pressure drop required

A series of 10 efficiency tests were performed at pressure drops of 15, 20 and 26 in. across the throat. Exhaust loadings ranged from .0273 to .0680 grains per standard cubic foot (SCF) depending upon the pressure drop across the venturi (see figure 3). Grain loading of gases leaving the dry collectors (feed to the venturi) was three grains per SCF.

Basic engineering data desired was developed by these tests. It was obvious that a pressure drop across the venturi throat somewhere in the vicinity of 20 to 21 in. would be required to produce an exhaust grain loading of less than 0.05 grains per SCF. Also, water at approximately eight gpm per thousand cfm of gases would be required for operation of the venturi. This water is refuse thickener overflow. About 20 percent is recycled to the venturi.

At the same time that the foregoing tests were performed, samples were taken of the material entering the test unit for size analyses. This indicated an average particle size of approximately 4.5 microns. The particle sizing is somewhat smaller than some comparable installations which range up to almost 20 microns on average. During the final testing program of the commercial size unit, samples were again taken for size consist determination (figure 4). These are somewhat coarser in size, approximately 12 microns at the 50 percent mark.

The discrepancy between the average particle size on

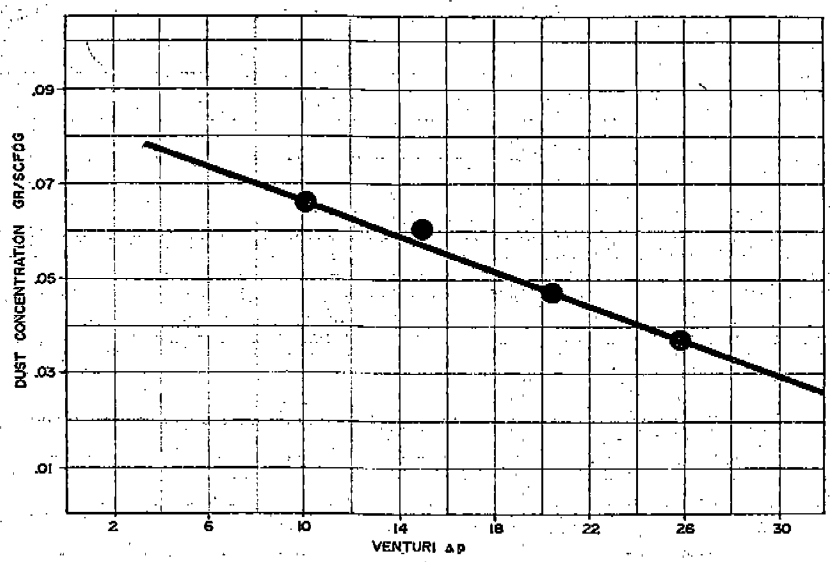


Fig. 3. Tests performed at pressure drops of 15, 20 and 26 in. across the throat of the scrubber gave exhaust loadings ranging from 0.0273 to 0.0680 grains per standard cubic foot of dry gas, depending upon the pressure drop

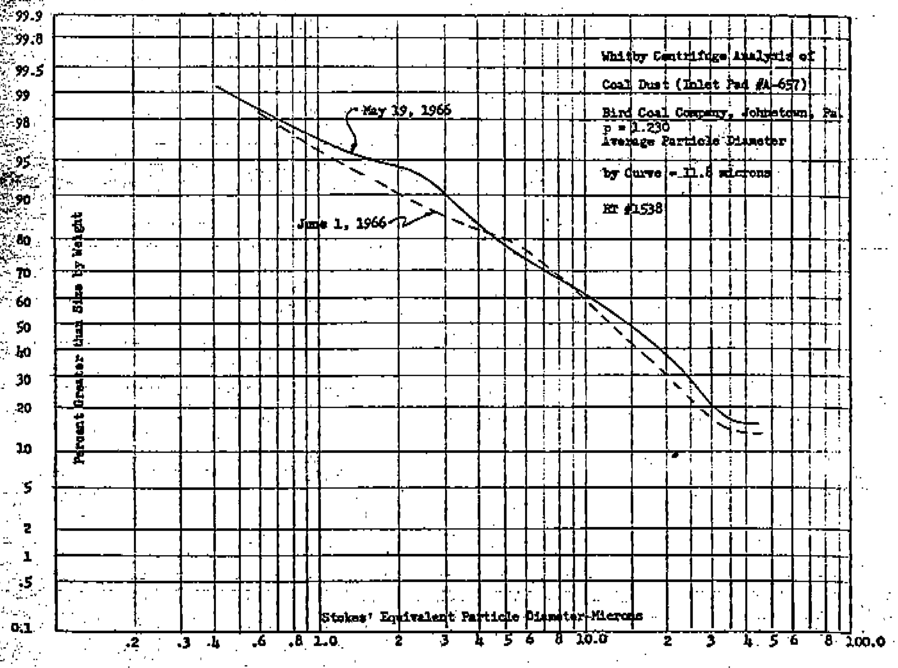


Fig. 4. Analysis of material entering the commercial scrubber indicated that average particle diameter was about 12 microns

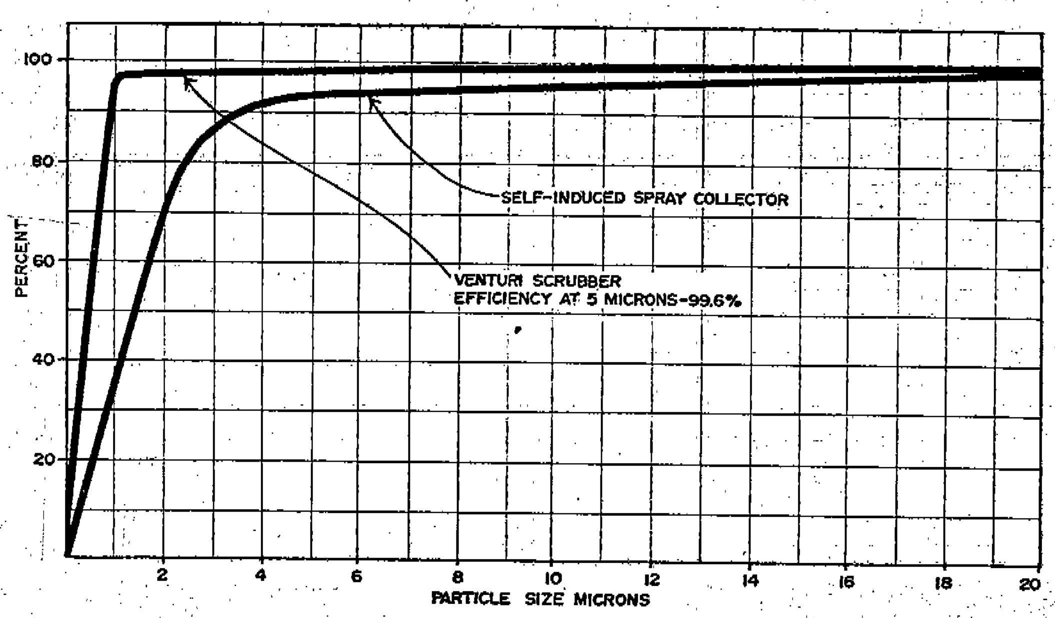


Fig. 5. Collection efficiency with a conventional wet type collector operating at two to seven in. of pressure drop on particles above five microns in diameter is good but falls rapidly on particles below this size. Much higher efficiencies are possible on the smaller size particles with a venturi type of scrubber

the test setup and on the full scale operation is due to stratification that probably occurred during the tests. Even though extreme care was given to the proper location in the sampling tube in the duct, it was impossible to approach ideal take-off conditions on the test setup. Sampling on the operating system is quite good, so results must be considered as correct.

Particle size influences equipment selection most

This single factor of particle size has probably the greatest influence on selection of equipment to reduce particulate emisison. As shown in figure 5, a conventional wet type collector of two to seven in. pressure drop has excellent efficiencies on particles above five microns in diameter, but efficiency falls parabolically quite rapidly on material below five microns. Correspondingly, as also shown in figure 5, the same type efficiency curve for a venturi scrubber shows much higher efficiencies at the less than five micron size range. Thus, the extreme fine nature of this material, plus its hydrophobic characteristics, indicate that a medium to high pressure drop wet scrubber is the only equipment currently available for meeting the evermore stringent requirements for air pollution control.

1200-hp needed for circuit

The tests indicated that approximately 1200 hp would be required to produce the necessary pressure drop across the circuit. This includes the venturi, the dryer itself, primary dust collectors, and water separator, and is approximately 40 to 41 in. water gauge.

Fortunately, there existed a 500-hp motor and ventilating fan used to handle gases from the dryer classifier, which had been removed from the circuit. With engineering assistance from Robinson Ventilating Co., a layout was made whereby this 500-hp fan was placed in series with the existing 700-hp fan on the fluid bed dryer.

Test work conducted during the pilot plant program indicated that an actual air flow of 95,500 cfm existed in the exhaust from the fluid bed dryer. By placing the two existing fans in series, their combined output exceeds this 95,500 cfm by some 5000 cfm with a combined pressure potential of 42 to 44 in.

Since a water separator is an essential portion of any venturi installation, and in effect constitutes almost 50 percent of the capital costs of such an installation, it was decided to utilize the existing Roto-clones for this service. The pressure drop through the Roto-clone is five to six in.

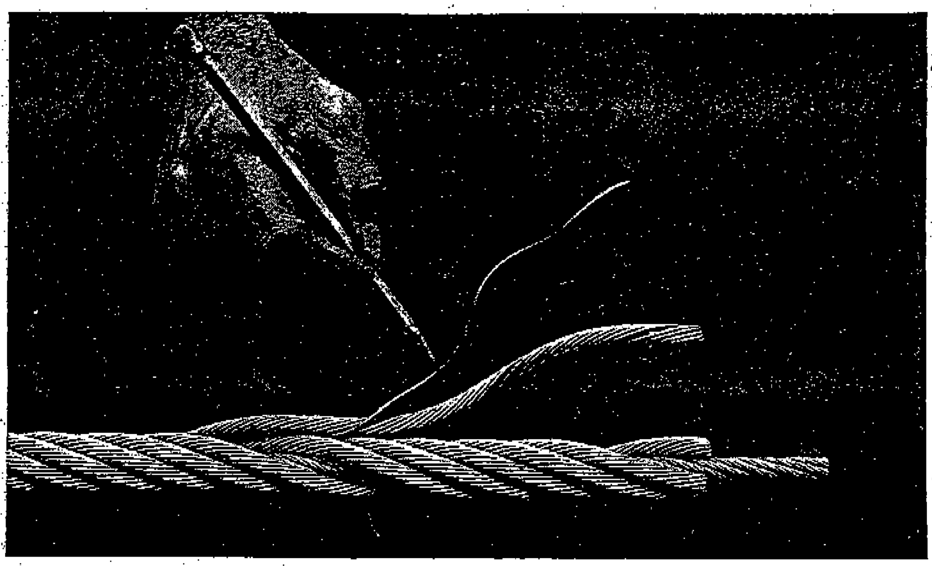
Gas flow split in two

It was decided to split the gas flow into two streams, with each to be handled by a Kinpactor unit of approximately 50,000 cfm capacity, since there were two Roto-clones.

Early in May 1966, the installation was completed and exhaust dust loading tests were made. All tests and analyses were performed by American Air Filter personnel according to the AAF testing methods and were observed by representatives of Robinson & Robinson and Bird Coal. The cleaning plant and dryer were operating under normal loading and operating conditions.

The Kinpactor unit was set up initially to operate at approximately 20 in. water gauge across the throat. One of the features of the installation at the Riverside plant is a damper which can be inserted into the throat up to 12 in. if required. This provides flexibility in that a higher pressure drop at slightly less air volume can be attained if it is ever required. Since the adjustment was available, the throat was adjusted so that a pressure drop of approximately 25 in. was obtained. This resulted in performance exceeding the initial design re-

wire rope facts FROM BETHLEHEM STEEL



Basic elements of wire rope

This is a piece of wire rope. Its component parts are wire, strand, and a core. Here's what these terms mean.

WIRE—Bethlehem wire ropes are made from cold-drawn, round, high-carbon steel wires. Two standard classifications or grades of wire are commonly used.

Extra-Improved Plow Steel Rope Wire—For applications where maximum strength and resistance to abrasion are among the primary requirements. Bethlehem ropes made from this type of wire are called PURPLE PLUS. They are manufactured with an independent wire rope core and are 15 per cent stronger than our PURPLE STRAND ropes.

Improved Plow Steel Rope Wire—For many years this was the top grade. And it's still the most popular, since it meets most service conditions. PURPLE STRAND is Bethlehem's name for ropes made from this wire.

Wire rope fabricated from these grades of wire must meet strength specifications and it must also be able to resist pressure, fatigue, abrasion, and impact. The wire must have a high degree of toughness. Close diameter tolerances, controlled tensile strength limits, and torsional values are carefully maintained during manufacture on Bethlehem's modern wire-drawing equipment. Samples from each coil of wire are tested and checked before the coil is accepted.

STRAND—A strand is a number of individual wires which are arranged helically about a central wire. A number of strands, usually six, are laid around a "core" to form wire rope. The number and arrangement of the wires in a strand, and the strands in the completed rope are governed by the application of the rope.

CORE—The core is the center of wire rope. It may be fiber, strand, or an independent wire rope (IWRC).

Engineering Service . . . Prompt Delivery—Our engineers are always available to assist you with special problems, or in selecting the proper type of rope for each application. Just get in touch with the Bethlehem sales office nearest you. Or write to us in Bethlehem, Pa.

There's a Bethlehem distributor near you, supplied by our nationwide network of wire rope mill depots.

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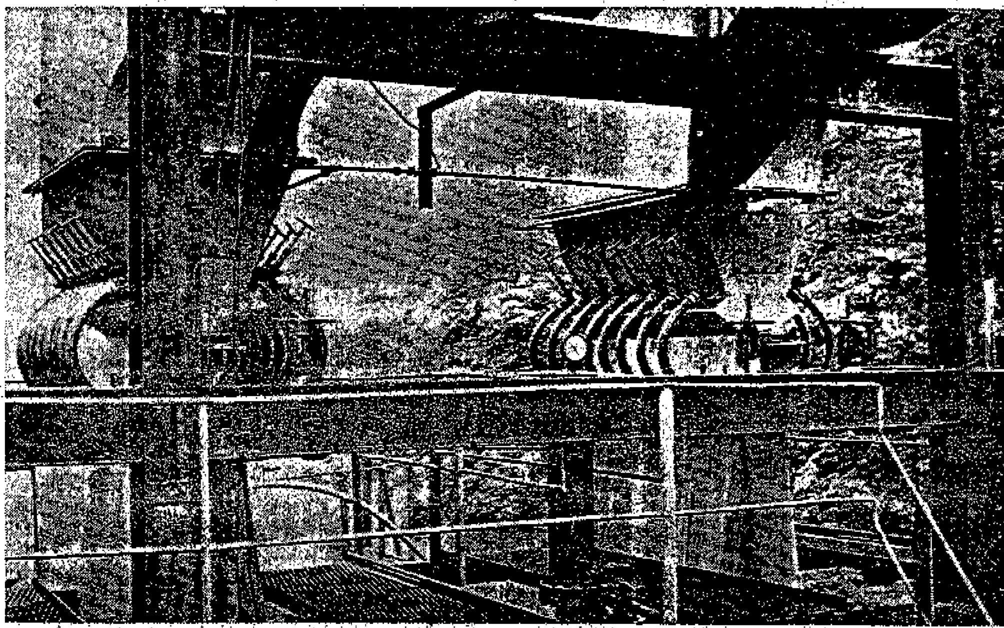

The separator installation was set up initially to operate at 20 in. water gauge across the throat, but this can be altered by means of a damper. A test at 25 in. of water gauge showed performance exceeding design requirements

quirements of 0.05 grains per standard cubic foot. Gas flow into the installation was again checked and found to be approximately 95,500 cfm. Temperatures of the gases entering the equipment were approximately 140° F.

Four tests on the water separator exhaust were conducted over several shifts' time. During each test, pressure drops were recorded by manometer, temperatures were recorded by thermocouple. The results of the tests showed 0.036 grains per SCF of dry gas at 70° F, or about 0.034 grains per cubic foot at stack conditions. A close check of the exit sample showed no dust particle larger than two microns. Subsequent to these findings, a test was performed by the Pennsylvania State Air Pollution Commission under the same conditions as outlined above. For this test, exhaust gases from the water separator averaged 0.023 grains per standard cubic foot at 70° F.

The dryer at Bird Coal is operating on an average of approximately 175 tph feed with size consist as given below:

	% Wt.	Cumulative % Wt.
+ 3/4	2.73	2.73
3/4 × 1/2	11.48	14.21
1/2 × 1/4	19.31	33.52
1/4 × 14 mesh	40.16	73.68
14 × 28 mesh	12.66	86.34
28 × 48 mesh	6.46	92.80
48 × 100 mesh	4.09	96.89
100 × 200 mesh	1.57	98.46
– 200 mesh	1.54	100.00
	100.00%	

As indicated previously, minus 48-mesh filter cake is not fed to the metallurgical dryer, but joins the dried product on the loading-out belt going to railroad car loading.

The actual grain loading checked during the commercial test of the material entering the Kinpactor again averaged three grains per standard cubic foot, which check quite closely with the results obtained from the smaller test unit.

Installation cost about $400,000

In the overall dust suppression program at Bird Coal, approximately $400,000 above the original plant cost has been expended. The Kinpactor installation (capital and labor) cost was about $1.00 per cfm of gases. In evaluating these costs, one should recall that it was possible to utilize much existing equipment. Starting from scratch, a similar arrangement would probably cost about $1.50 per cfm.

It is felt that the Riverside cleaning plant has the lowest dust emission of any cleaning plant in the United States. While it is granted that the unique location of this particular plant presented it with a relatively uncommon problem, the day is perhaps not too far off when every plant will be required to meet standards as stringent as those now attained at Bird.

Elliott Northcott joined Heyl & Patterson Inc. this spring as contracting engineer, coal and minerals processing. He was previously associated with the consulting engineering firm of Robinson & Robinson. Before that he was manager of coal preparation for Roberts & Schaefer Co. and earlier still was manager of applied research for International Minerals & Chemical Corp.