

Fourth International Flyash Symposium
March 24-26, 1976: St. Louis, Missouri

REFUSE PILE FIRE ABATEMENT USING
FLYASH INJECTION

Christopher R. Ryan¹

ABSTRACT

At many locations in the Pennsylvania - West Virginia coal regions, spontaneous combustion has resulted in fires smoldering in coal refuse piles. The burning piles emit noxious gases and smoke; in advanced stages, the burning can cause large voids and slope failures. The solution discussed is to:

- drive pipes into and through the affected zones.
- measure the underground temperatures using a geothermal probe in the pipes to delineate the extent of underground burning.
- inject a flyash/water slurry down through pipes driven into the burning zone to extinguish the fire and to cool the hot material.
- control the injection process and assure completion by a continuing program of temperature measurements.

This process has been applied on about ten refuse embankments. Quantities of flyash used have generally varied from 1000-3000 tons.

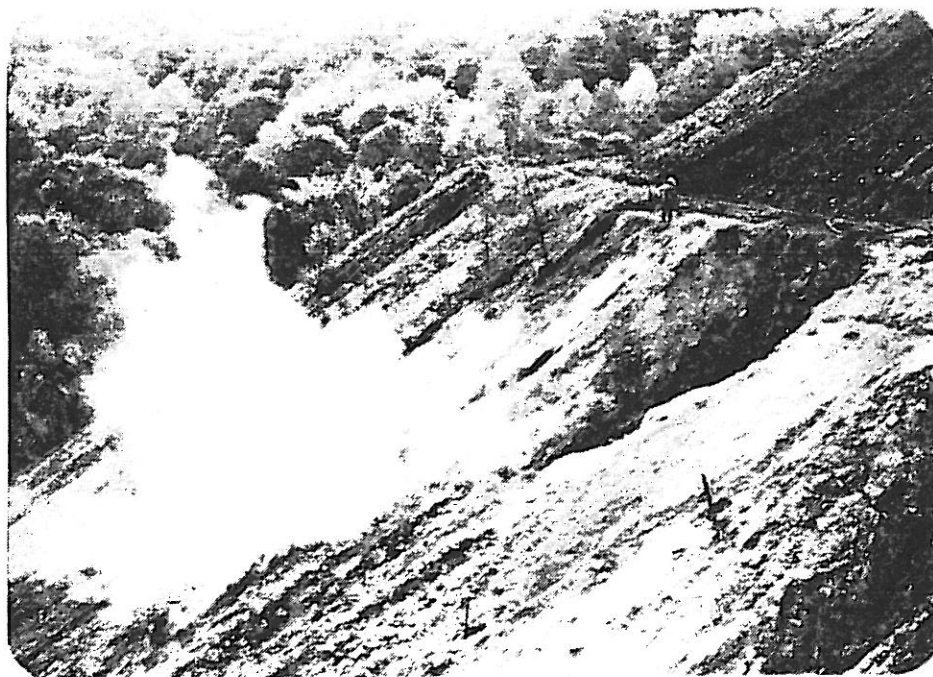
INTRODUCTION

Burning spoil piles are a common problem in coal mining regions. In a survey taken in 1964, almost five hundred such fires were listed in an area covering fifteen states². The piles are the waste product of deep coal mining operations; coal is separated from rock fragments

¹ President, Geo-Con, Inc.
Pittsburgh, PA

² Stahl, R. W., "Survey of Burning Coal Mine Refuse Banks,"
Bureau of Mines Information Circular 8209, 1964.

and the rock is stockpiled in large "slate piles" or "culm banks". Since the separation process is not completely efficient, significant quantities of combustible material are included in the spoil. The average percentage of coal may be as high as 30 to 60 percent. The method of dumping frequently causes segregation and pockets of material within the pile with even higher percentages of coal. These pockets can ignite through spontaneous combustion and smolder for years, progressing through the piles at a very slow pace. Fig 1 shows a typical fire burning in a coal refuse pile.



1. Typical Coal Refuse Fire

The burning piles are a problem from two standpoints: pollution and safety. The noxious smell of hydrogen sulfide gas and the foggy smoke emanating from these fires are familiar to most residents of the coal regions. As to safety, the primary problem occurs in cases where subsequent operations entail cutting into the piles with earth-moving equipment. Not only are the gases dangerous to workers, but coal dust in the air may ignite as hot spots are exposed. A recent incident killed two men and blackened a valley near Logan, West Virginia. The fires also produce dangerous carbon-monoxide gas. Out of concern for safety, some workers refuse to work in areas where fires are being uncovered.

In the past, attempts have been made to extinguish these fires by essentially two methods. The first method smothers the fire by covering the surface over the fire with compacted clay or flyash. Experience has shown that this can be a temporary solution, especially where steep slopes are burning; eventually, air may find new channels to the

fire, and the heat and smoke will crack the surfacing. The second method involves excavating into the hot zone and dowsing the excavated material with water at high pressure. This method, besides being expensive, has several technical defects. Exposing the hot material is dangerous because of the dust created even when quenched with water; all the pollutants which had been slowly working their way out of the ground are freed into the atmosphere in a short period of time, thereby increasing concentrations.

The solution discussed herein solves all the technical problems at an economical price. Hot zones are defined by observation, infrared photography and direct measurements of underground temperatures. Grout is injected down pipes driven into the spoil pile; the grout quenches and smothers the fire. Voids are filled, preventing entry of air and also trapping pollutants in the ground.



2. Akron Project -- Slope Failure
Caused by Burning

This technique has been in use since before 1960 and first used on a large scale in the fall of 1969, by the Pennsylvania Department of Mines and Minerals. The project was located near Houston, in Washington County, Pennsylvania. Since then, about ten projects using the same basic technique have been completed by the crews of Engineered Construction International, Inc.

In the following sections, the method of fire abatement is described and a summary of results on a number of recent projects is provided. A more detailed presentation of data is provided for one recent project for Ohio Edison in Akron, Ohio. In this case, the refuse was composed of incompletely burned coal slag which was used as fill behind the plant. A fire ignited and smoldered for several decades. Attempts to excavate the hot material caused the fire to extend deeper into the fill. Recently the fire began progressing more rapidly, causing the failure of a slope immediately behind the plant (Fig 2) and heating the conduit carrying power from the plant to dangerous levels.

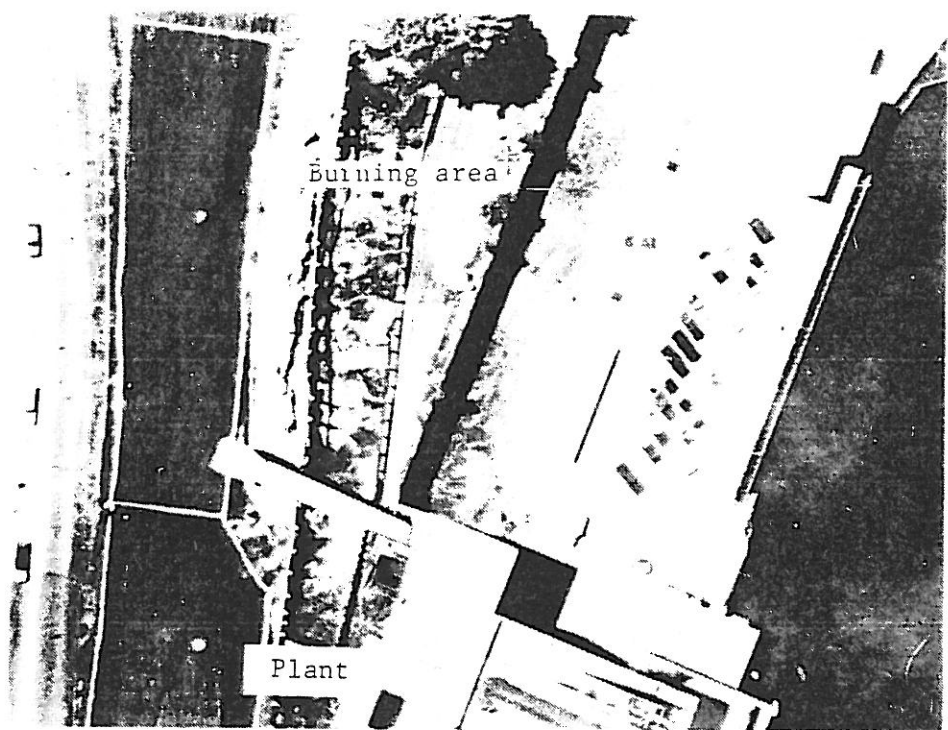
LOCATING THE BURNING ZONE

The first step towards extinguishing underground burning is to accurately locate the extent of burning. Surface indications such as cracks emitting smoke, sulphurous deposits, and open flames are not good indicators of the location of burning. For example, signs of burning will frequently be found on a line at the top edge of steep slopes. Air enters at a point lower on the face and moves in an arc upwards. Once combustion begins, the heat generated causes a "chimney" effect, increasing the flow of air and the burning. In advanced stages, actual voids and large cracks will form; the bank may begin to slide on the slip surface thus created. The burning zone may lay as much as fifty feet down-slope and as little as ten feet below the surface. Thus, treating the area of the surface indications will do little good and in fact may not even be necessary.

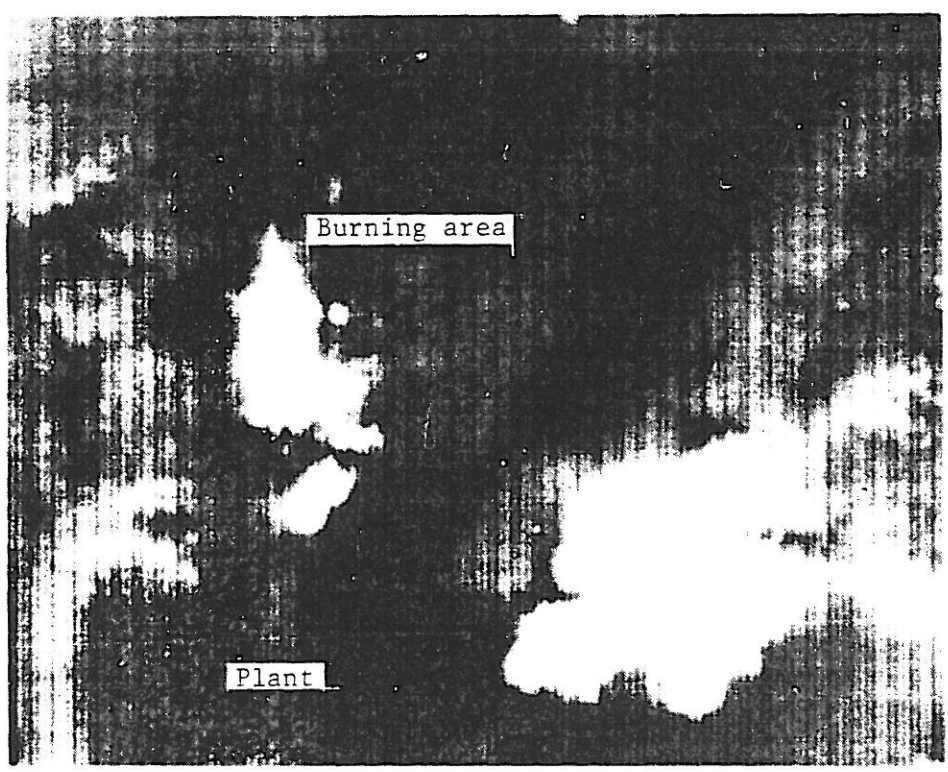
The program used involves interpreting surface indications to determine probable burning areas and then following up with in situ temperature measurements. Pipes are driven into and through suspect areas. A thermal probe is lowered into the pipes and sufficient measurements are taken to determine the extent and depth of burning areas. Combustion temperatures are typically in the range of 600-900°F and may go as high as 2000°F.

On projects where further accuracy is required or where a thermal survey is desired before mobilizing construction equipment, aerial thermal imagery may be used to locate burning areas^{1/}. A special

^{1/} Stingelin, R. W., W. M. Knuth, E. C. Stamm, "An Airborne Infrared and Ground Control Analysis of Ten Selected Coal Refuse Banks in the Pennsylvania Anthracite Region," HRB-Singer Report No. 4480-F, October 1971.



3. Akron Project -- Aerial Photo



4. Akron Project -- Thermal Image

technique produces an image of infrared emissions which can be referenced to a standard aerial photo to determine the extent of burning. This technique has been shown to be best applied when used in conjunction with a few temperature probe measurements taken for reference purpose. Figs 3 and 4 show an aerial photograph and a thermal image of a burning refuse pile. The light areas in the thermal image correspond to areas of high heat.

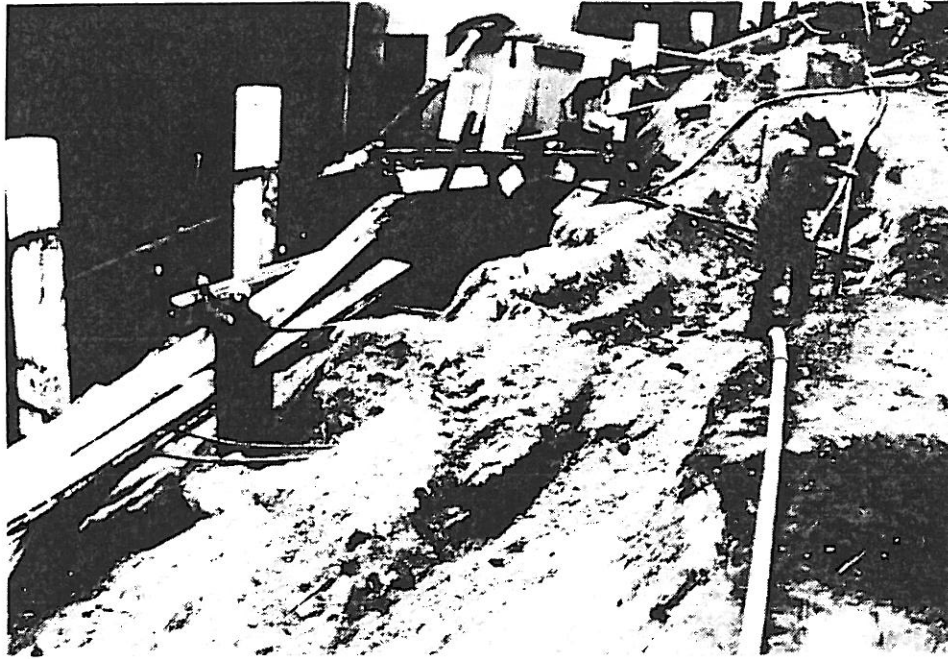
FLYASH SLURRY INJECTION

Once the hot zones have been defined, a flyash slurry is pumped into the voids and crevices to extinguish the fire. Flyash is dumped into high volume mixers with about 100-200 gallons of water per ton of ash. The resultant slurry is pumped from the batch plant, through a high pressure hose (Figs 5 and 6) and down the grout pipes driven into the ground.



5. Akron Project - Batch Plant

The grout pipes are equipped with a disposable point and can be driven as much as forty feet into a pile with a large hand-operated jackhammer. The pattern of grout pipes is important since it is essential not to force hot gasses back into the pile. When the burning area is on a relatively flat area of the pile, the fire should be encircled with a ring of pipes which are grouted to form a "curtain".

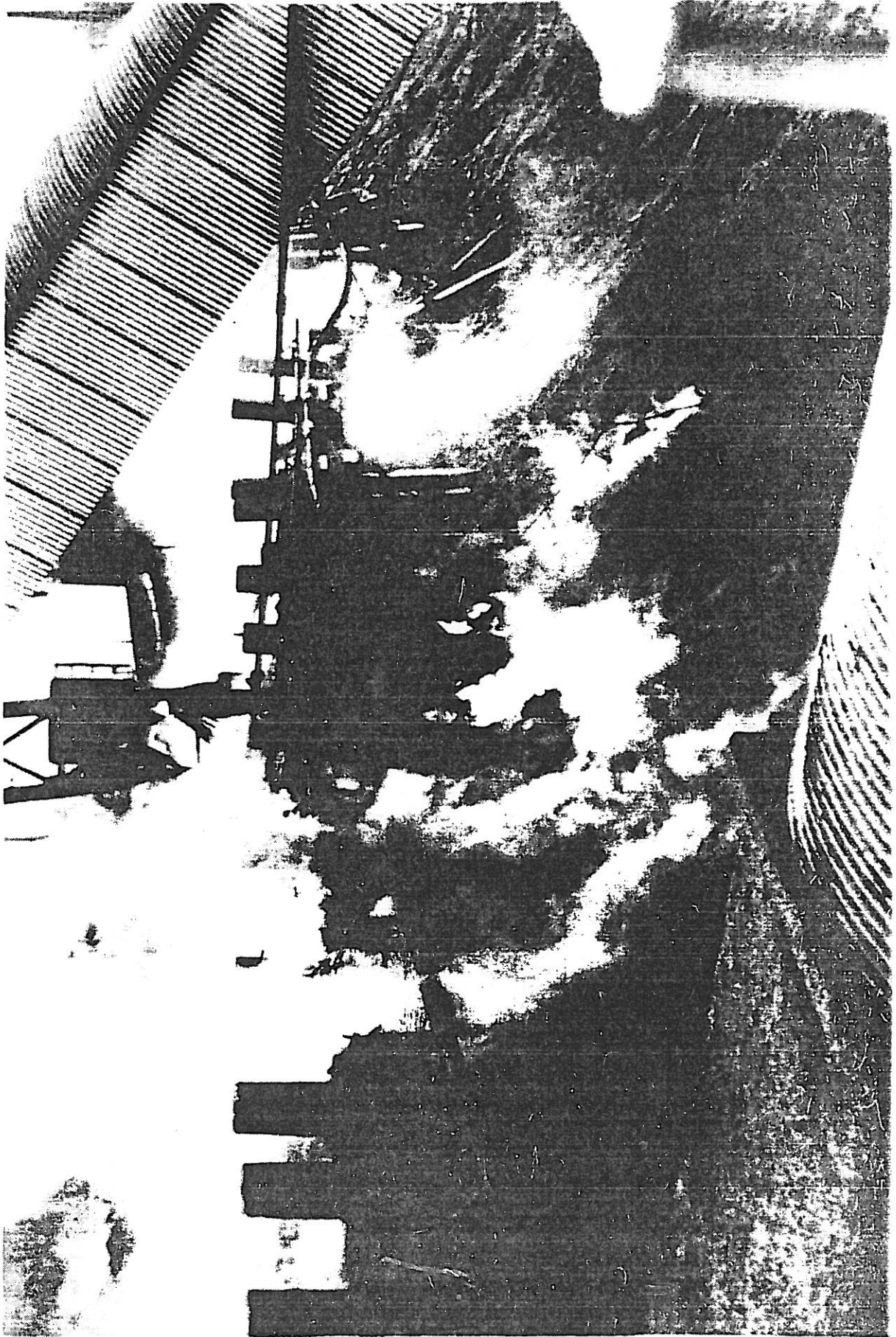


6. Akron Project - Injection Pipes

Then the central area is extinguished by driving additional pipes. On a slope, the pipes should be driven and slurry injection so as to force hot gases to the slope surface. Figure 7 shows the Akron project during grouting. Note the steam given off from the slurry and the gases forced from the ground igniting at the base of the wall.

The best flyash to use is that excavated from slurry ponds. The water content (20-50%) allows the ash to be transported by dump truck, stored in stockpiles, and handled with conventional earthmoving equipment with no dust problems. The ash should be fine grained, preferably at least 90% passing the 200 sieve, with no pieces of bottom ash, stone or organic matter.

The slurry serves two essential purposes: the fire is "snuffed" due to the blocking and filling of annular spaces and crevices with the flyash which remains in place after the water evaporates; and the burning zone is cooled due to the evaporation of water in the slurry and the heat capacity of the flyash itself. The failures of "covering" operations which are used for underground fire control are frequently caused because the burning zone is not cooled; as soon as oxygen finds new access, the burning resumes, even after a period of years. An ongoing



7. Akron Project - Slurry Injection in Progress

temperature measurement program helps to prevent this with the flyash slurry injection method. Completion is defined as bringing all hot zones to below 200°F. This criterion was selected after analysis of data in publications of the Bureau of Mines^{1-2/}. Experience has shown that, if hot spots are cooled to below 200°, they will continue to cool slowly to ambient temperatures. Fig 8 shows a summary of results of temperature surveys at the Akron project.

Finely ground lime has been used as a substitute for flyash on some projects^{3/}. When exposed to heat, the lime slurry gives off carbon dioxide which may aid in extinguishing the fire. However, physical smothering and cooling aspects are probably more important factors. To the best of the writer's knowledge, lime has only been used when, because of transport costs, the lime was a cheaper non-combustible additive than flyash.

SAFETY CONSIDERATIONS

Slurry injection is probably the safest means of extinguishing underground fires in coal refuse banks. The material is treated in place, with minimum exposure to men and equipment. Since pipes are driven with air-powered hammers, it is not necessary for spark-producing equipment to be in the fire zone. The flyash in the slurry helps minimize the potential for steam explosions and pumping is not started until all personnel are cleared from the area. The stability of steep slopes is not threatened since the injection is localized and can be phased to allow sections of the slope previously grouted to "set up".

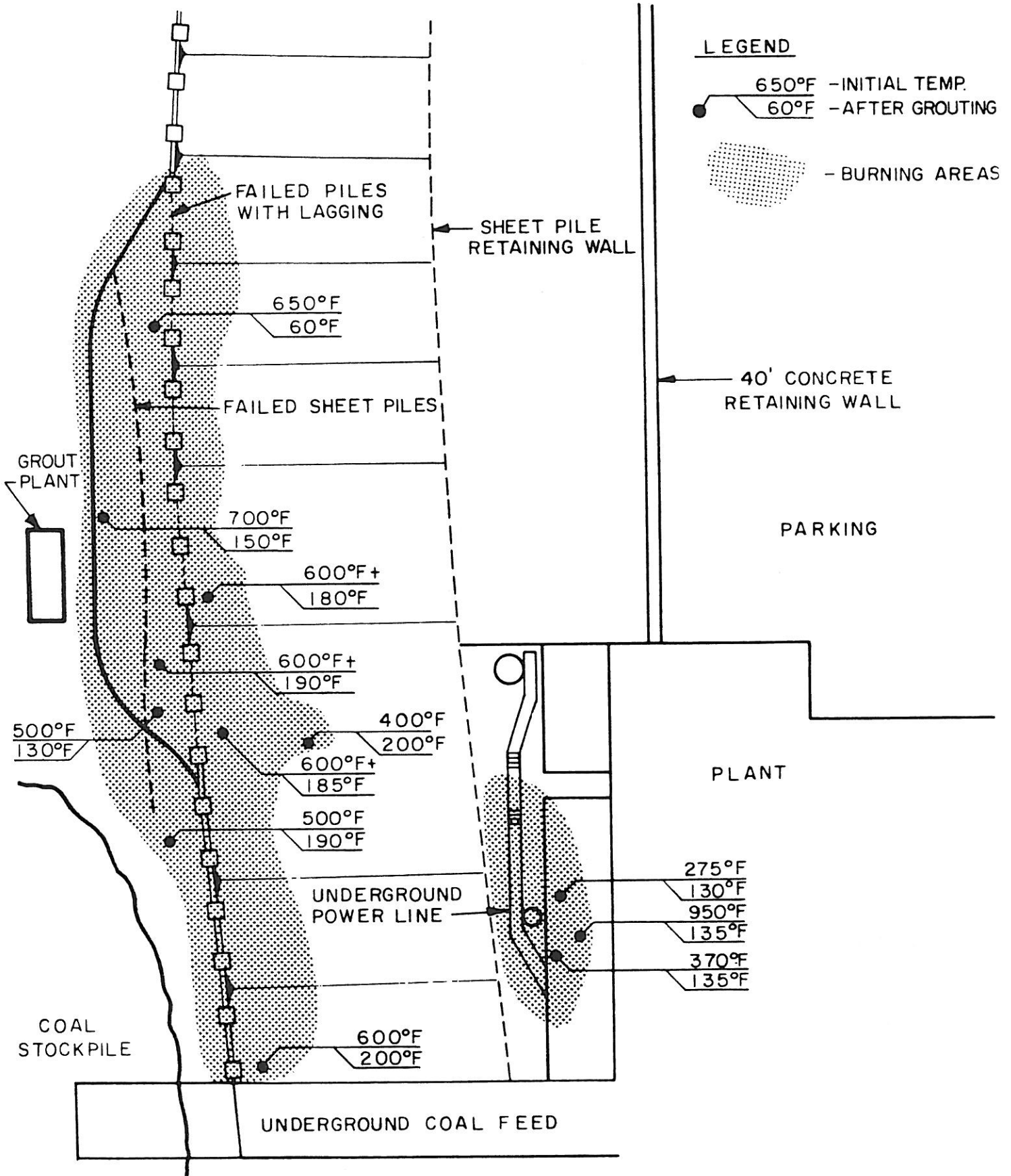
APPLICABILITY

Slurry injection has been found to be a most effective and economical solution to extinguishing burning coal refuse banks, particularly when burning is distributed over a number of isolated areas or when the areas present difficult access to equipment. Recent projects at coal mines have included an 800 ft high pile which abutted directly on a stream and property line, and a 1000 ft high pile which was burning in several areas.

^{1/} Magnuson, M. O., E. C. Baker, "State-of-the-Art in Extinguishing Refuse Pile Fires," Coal and Environment Conference, Louisville, Kentucky, October 1974.

^{2/} Myers, J. W., et. al., "Ignition and Control of Burning of Coal Mine Refuse" Bureau of Mines Report of Investigation 6758, 1966.

^{3/} Griffith, F. E., M. O. Magnuson, G. J. R. Toothman, "Control of Fires in Inactive Coal Formations in the United States," Bureau of Mines Bulletin No. 590, 1960.



8. Akron Project - Site Plan Temperature Survey Results

When burning is spread over isolated areas, grouting becomes economical because it is well suited to spot treatment. Covering or excavating localized hot zones can be more expensive because of the large areas or volumes required to be treated to extinguish relatively small burning zones.

A principal advantage of the slurry injection process is that access for heavy equipment to burning areas is not required. The only equipment located at the burning area is pipe and a hand operated jack hammer. In some cases, grout pipes have been installed on slopes steep enough to require life lines. The mixing plant and pumps can be located wherever convenient, as much as several hundred feet away. Covering steep slopes to extinguish burning is not practical because the covering material slides away. Excavating out pockets on steep piles may also be impractical because of the danger of earth slides and access problems.

EXPERIENCE SUMMARY

In the past year, the projects listed below have been completed using the flyash injection technique. The following table shows a summary of the projects including approximate flyash quantities used.

<u>Recent Projects</u>	<u>Location</u>	<u>No. of Areas</u>	<u>Approx. Burning Volume (Yards)</u>	<u>Flyash (Tons)</u>	<u>Effective Porosity %</u>
Wildwood Mine	Pittsburgh, PA	3	9,000	1,700	19
Guyan No. 5 Dump	Logan, W. VA	3	18,000	2,000	11
Robinette Dump	Robinette, W. VA	1	11,000	1,700	15
Guyan No. 4 Truck Dump	Lundale, W. VA		9,000	1,400	15
Guyan No. 4 Tram Dump	Lundale, W. VA	6	12,000	1,600	13
Ohio Edison	Akron, OH	2	8,000	1,500	19

Average effective porosity experienced: 15% (tons of ash/cu. yd. burning material).

The quantity of flyash used is the most important factor in determining the cost of a projected fire abatement program. Estimating quantities cannot be exact. A good approximation of the burning volume can be made by pacing-off affected areas to measure surface dimensions, reducing this area by a factor determined by observation to account for zones which are not burning, and multiplying the resultant area by an estimated thickness. The thickness of the burning zone will depend on the surrounding topography and the age of the fire. Typically it ranges between ten and thirty feet. The resultant volume is the amount

of burning material in cubic yards. Multiply this number by the effective porosity determined by experience to compute the projected tonnage of flyash required. (Tons of flyash as discussed herein are total weights and include moisture contents in the range of 30-50 percent).

The effective porosity selected depends primarily on the age of the refuse pile and the stage of advancement of the burning. The chart presented above shows a typical range of ten to twenty percent. Older piles tend to have larger lumps of material and a higher percentage of combustibles, due to less efficient separation processes than are used today. A pile which is in advanced stages of burning will develop open chimneys and large burned-out voids which will significantly affect the porosity experienced. The effective porosity selected for estimating purposes should reflect these factors.

SUMMARY

Refuse fire abatement using flyash injection has proven to be a safe and effective technique. Control of the process using temperature criteria has been shown to be reliable. On projects where steep slopes are burning or access to the burning area is difficult, flyash injection has been shown to be most economical and at times the only effective method of fire abatement. Using experience gained on past projects, the amount of ash required, and hence the cost, can be reasonably well estimated before beginning work.

ACKNOWLEDGEMENT

The writer expresses appreciation to Ohio Edison and GAI Consultants, Inc. for making available the data related to the Akron project. Other projects referred to were carried out for Island Creek Coal Co., Amherst Coal Co., Earth Resources Inc., and the Pennsylvania Department of Environmental Resources.