THE SUCCESSFUL RECOVERY OF THE DOTIKI MINE AFTER A MAJOR MINE FIRE

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ABSTRACT

Any uncontrolled fire can be a hazard. But a fire in a coal mine is especially hazardous. There is practically an unlimited amount of fuel. There is plenty of oxygen because coal mines use large fans to carry fresh air through the mine openings to the areas where the miners work. And those same openings can carry the deadly fumes and smoke from the fire to the areas where the miners work and block their safe escape.

When a fire on a diesel-powered supply tractor occurred at the Dotiki Mine in Kentucky, miners were in jeopardy. The tractor was located in a major intersection at the time of the fire, which quickly spread to the surrounding coal pillars. Seventy miners were working in the mine at the time and they all evacuated safely. Fire fighting efforts began immediately. Direct attack of the fire with fire extinguishers, water and foam was unsuccessful. The fire was spreading and, due to the threat to fire fighter safety, all of the firefighters were evacuated from the mine. It was decided to try to bring the fire under control by cutting off the oxygen to the fire. The mine was very large with a four surface openings. If all of the mine fans were turned off and all of the openings to the surface were sealed off, the fire would burn for a very long time, possibly even a year, before all of the oxygen that was in the mine was consumed. This would have been followed by an extensive recovery after breaching the seals. In a cooperative effort between the company, State of Kentucky Department of Mines and Minerals (KDMM), and Mine Safety and Health Administration (MSHA), a plan was developed to install remote seals from the surface at strategic locations. The remote seals in conjunction with existing ventilation controls provided a means for confining inert gas injection in the fire area. By inerting the fire area, the fire was controlled to allow installation of permanent explosion-resistant seals. The success of the operation is credited to the implementation of newly developed seal technology and the cooperative efforts of all parties involved in fighting the fire. Proper planning and execution of the plan

were key components to resuming production in only 26 days after the fire started and resulted in miners being able to return to work in record time.

INTRODUCTION

Alliance Resource Partners, L.P.'s wholly owned subsidiary, Webster County Coal Company, Dotiki Mine employed 380 miners and used six continuous miner units to produce approximately 4,500 tonnes (5 million short tons) of coal annually. The Dotiki IV shaft was the current main portal. The mine was located near Nebo, Kentucky. The mine has three airshafts and one dual compartment slope (belt conveyor/track) that penetrated the Kentucky 9 coal seam. The coal seam averages about 1.5 meters (5 feet) in thickness and is 180 meters (600 feet) deep. Two exhausting fans and one blowing fan ventilate the mine. Approximately 13,600 cubic meters (0.48 million cubic feet) of methane was liberated in a 24-hour period.

There are six mechanized mining units (MMU) with two continuous-mining machines on each MMU, operating two production shifts per day five days per week. Coal was transported from the miner units to the surface by a conveyor belt system. Diesel-powered equipment was the primary mode of transportation for men and supplies. The average production was approximately 22,000 tonnes (25,000 short tons) per day.

DIRECT FIRE FIGHTING OPERATIONS

On February 11, 2004, at 4:30 am, a fire was reported on a diesel-powered supply tractor in a major intersection approximately 800 meters from the bottom of the Dotiki IV intake and return shaft. The fire quickly spread to the surrounding coal pillars. In about an hour, the seventy miners who were underground when the fire started were safely evacuated except those necessary to fight the fire.

Local management and corporate personnel were notified and began arriving at the mine. The local offices of the KDMM and MSHA were also notified. Personnel from each of the agencies immediately responded to the mine to provide assistance. A command center was quickly established in the mine's engineering office.

Personnel on site at the fire attempted to extinguish the fire directly with rock dust, portable fire extinguishers, and water. As additional personnel arrived to help fight the fire, foam generating machines were put into use. Dotiki officials estimated that 2 kiloliters (500 gallons) of water and 10 liters (2.5 gallons) of foam were being used every minute. Firefighters wearing self-contained breathing apparatus approached the original fire area using foam generators and fire hoses. Changes were made to the ventilation system by making openings in stoppings to redirect the air in order to reduce the amount of smoke in the intake entries. Firefighters were able to reach the diesel tractor that had been the starting point of the fire, but the surrounding coal, timbers, cribs and a diesel scoop left in the area were now the primary fuel sources.

In order to evaluate the safety of the miners fighting the fire, air quality readings were taken downwind of the fire in the exhaust of the nearby Dotiki IV fan. Handheld gas detectors were first used to evaluate the gases traveling from the fire in the return aircourse. These detectors monitored Methane (CH_4), Carbon Monoxide (CO) and Oxygen (O_2). At 1:18 pm, MSHA personnel arrived with electro-chemical and infrared gas detection instruments and began continuous monitoring the Dotiki IV fan exhaust for CH_4, O_2, CO, and Carbon Dioxide (CO_2).

Smoke and high temperatures hampered direct fire fighting efforts. The gas readings at the Dotiki IV Fan exhaust continued to rise and by 4:30 pm, had registered as high as 2% CH_4 and 2000 ppm CO. Since the CH_4 and CO were climbing and the fire had not been brought under control, instructions came from the command center for fire fighting crews to evacuate the mine.

MINE SEALING

During the initial hours of firefighting, KDMM, MSHA, and company officials decided that preparations should be made to seal the mine if the fire could not be controlled. Both underground sealing and surface sealing were considered. The mine had been developed over 16 km (10 miles) from the slope to the farthest working section. Sealing underground could not be readily accomplished near the fire area. The best location to seal off the active portion of the mine was between Dotiki III and Dotiki IV shafts in the life of mine (LOM) entries. If the mine was sealed at the surface, the mine’s atmosphere would inert very slowly which would extend the recovery process. Alternate plans were developed, which included drilling into the mine and injecting water or inert gasses to extinguish the fire.

After the direct fire fighting efforts were abandoned, seal locations had to be determined. The decision was made by the command center to seal Dotiki IV intake and return shaft on the surface and underground at a point between the Dotiki III and Dotiki IV portals in the LOM entries. The underground personnel were given the general location of the seals they were to build, but also the latitude to select the best location for the seals based on underground conditions. The selected location was confirmed by the command center at 11:39 pm. The 16 seals were constructed by 3:33 am on February 12, day 2. Figure 1 shows the Dotiki Mine complex with the slope, shafts, sections, fire area, and the location of the LOM seals used to isolate the active area of the mine.

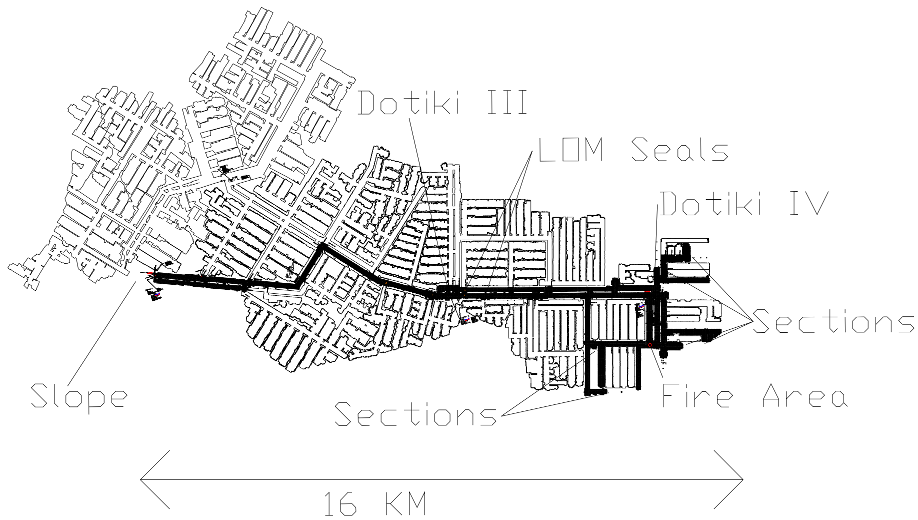

Figure 1. Dotiki Mine Complex

Within 30 minutes of the completion of the LOM seals between Dotiki III and Dotiki IV, all personnel were evacuated from the mine. After confirmation of the complete evacuation, the command center ordered the Dotiki IV fan to be de-energized. Samples lines were extended down both the intake and return side of the Dotiki IV shaft and plumbed back to a pumping station a safe distance from the shaft. The cage at Dotiki IV was positioned such that it could act as part of the seal. Steel plates and plywood were placed on the cage and the entire area was sprayed with expanding foam to form the seal on the intake side of the shaft. Anti-reverse doors inside the fan housing, the return side, were braced and foamed. The sealing of the Dotiki IV shaft was completed by 5:15 a.m. For 72 hours, only those persons necessary for sampling were allowed within 150 meters of the Dotiki IV shaft.

INERT INJECTION AND REMOTE SEALING

Fortunately, the surface area over the fire was a cultivated field that was readily accessible. A road was constructed and the first two boreholes were positioned and drilled near the original fire area. As the holes were being drilled, there was discussion in the command center as to how to utilize them upon completion. Water injection was considered, but ruled out since the topography of the mine would allow the water to run away from the fire area. Several inert gasses were considered, carbon dioxide, nitrogen, and argon. Carbon dioxide was used on a limited basis, but nitrogen was the main inert gas injected.

Remote seals are seals that effectively seal off a mine entry but are installed from the surface by pumping a concrete mixture into the mine entry from a borehole rather than have miners travel physically underground to construct a seal at that location. A remote sealing procedure was adopted and approved as the plan of attack to reduce the size of the sealed area. Arrangements were made with Halliburton Energy Services to install the remote seals. The remote seals were commonly referred to as Halliburton seals. The fire area was at an intersection of five sets of entries. Initial plans included five possible sets of remote seals to surround the fire area. However, through strategic planning of the seal locations and the use of existing ventilation controls the final seal plan required three sets of remote seals. On the east side of the fire area, using existing ventilation controls helped to reduce the number of remote seals to four. Nineteen remote seals were required to surround the fire area. All of the potential drill holes were named based on their location. For example SE27, was the 27^{th} seal in the "E" group of seals. Since there were four different proposed locations for the "E" group of seals that crossed 7 entries, there were 28 potential drill holes named in the "E" seals. As the boreholes were drilled and while the seals were being pumped, they were referred to by these names. After the remote seal installation, the seal groups were simply referred to as the North, West, and East seals.

The drilling and pumping of the remote seals took 8 days. In addition to drilling the holes that were to be used for remote seals, observation holes and monitoring holes were drilled. Cameras were dropped into the boreholes to evaluate the mine conditions for fire damage, evaluate the air flow patterns, determine if the remote seal holes were in the center of the entry, and to observe a remote seal installation. Three monitoring holes, MI 1, MI 2, and MI 3, were drilled on three sides of the fire area, but within the boundaries of the remote seals. Sampling lines were run from the three monitoring boreholes to MSHA's IR truck for continuous monitoring through the end of the recovery. After the permanent seals were built and the mine emergency personnel departed, these holes became sample points to evaluate the conditions within the sealed area.

While the remote seals were being installed, the command center personnel continued to evaluate and consider modifications to the approved plan. The company always had one person in the command center designed to handle the information flow. This person would communicate with all of the parties that were to report information to the command center. In order to keep everyone informed, dry erase boards were utilized to post the status of the drilling, remote seals pumped, loads of nitrogen and carbon dioxide injected, and what downhole camera videos were available. Having this information readily available at a glance allows the person in charge of communication from the command center to concentrate on his job. Computer network specialists also worked on connecting the command center operations to the MSHA gas analysis computers to more readily transfer information. Mine atmosphere samples were collected from the boreholes and analyzed by gas chromatography. MSHA then used the results of the gas analysis to determine fire gas trends. Mine ventilation simulations were produced to plan the best method to re-ventilate and re-enter the mine. Natural ventilation currents develop within the sealed area due to ventilating pressures developed by the heat of the fire. Inerts were still being injected into the mine since these currents continue to deliver oxygen to the fire area. Mine atmosphere sampling was done through boreholes on all sides of the fire area. Samples were collected for gas chromatograph analysis and instantaneous readings were taken using handheld gas detectors. Oxygen readings on the handheld gas detectors were indicators of the inerts flowing through the mine.

RE-ENTRY AND TEMPORARY SEALING

After the Halliburton seals were all in place and sampling points were established on both sides of the seal lines, the re-entry plan was approved and adopted. The seals in the LOM entries between Dotiki III and Dotiki IV were breached. At the same time, the intake side of Dotiki IV shaft was opened. Ventilation simulations confirmed that the mine could be adequately ventilated for recovery efforts, without use of the Dotiki IV mine fan. After the hoist cables were inspected and approved, rescue teams established a fresh air base at the bottom of Dotiki IV shaft. Rescue teams advanced along the mains to the North remote seals. The teams directed intake air with them to a point inby where the permanent seals were to be constructed. Between each remote seal and future permanent seal a substantial seal was constructed using posts, boards, and canvass secured to the roof, ribs and floor with nails from Hilti guns. These substantial seals were commonly referred to as Hilti seals.

It was suspected that the Halliburton seals would not completely fill the mine entry in all cases. The remote seals were considered as regulators designed to restrict air flow, and not as permanent seals. Their mission was to slow the exchange of inerted air around the fire area with oxygen rich air in a ventilated mine. The remote seal at location DF4 was suspected to be the least effective since it took more material than expected. Rescue teams estimated that it blocked about 75% of the entry. Figure 2 is a picture of one of the remote seals. The material from the remote seal slopes upward at about 30 degrees. The upper corners of the entry had been sealed off with expanding foam.

Figure 2. A Halliburton Seal After Being Foamed

After the completion of the north Hilti seals, the teams advanced to the west side of the fire area. The east seals were the last to be approached. While approaching the seals to the East of the fire area, the teams encountered water that had to be pumped in order to proceed. The water was pumped into a previously sealed area father to the east. The Hilti seals were completed on all three sides of the fire in less than two days.

PERMANENT SEALING

After the fire area had been surrounded by substantial seals, the flow of air through the area was greatly reduced. It was now time to build permanent, explosion-resistant seals outby the substantial seals. Water was flowing through the substantial seals from the fire area. It was discovered that some of the uncased boreholes were allowing water to pass into the mine. After casing the holes, the flow of water slowed and the seal areas were pumped dry. The explosion-resistant seals were completed on all three sides of the fire in less than four days. Figure 3 is a map of the area of the mine around the fire. The locations of the Halliburton, Hilti, and explosion-resistant seals are indicated on the map.

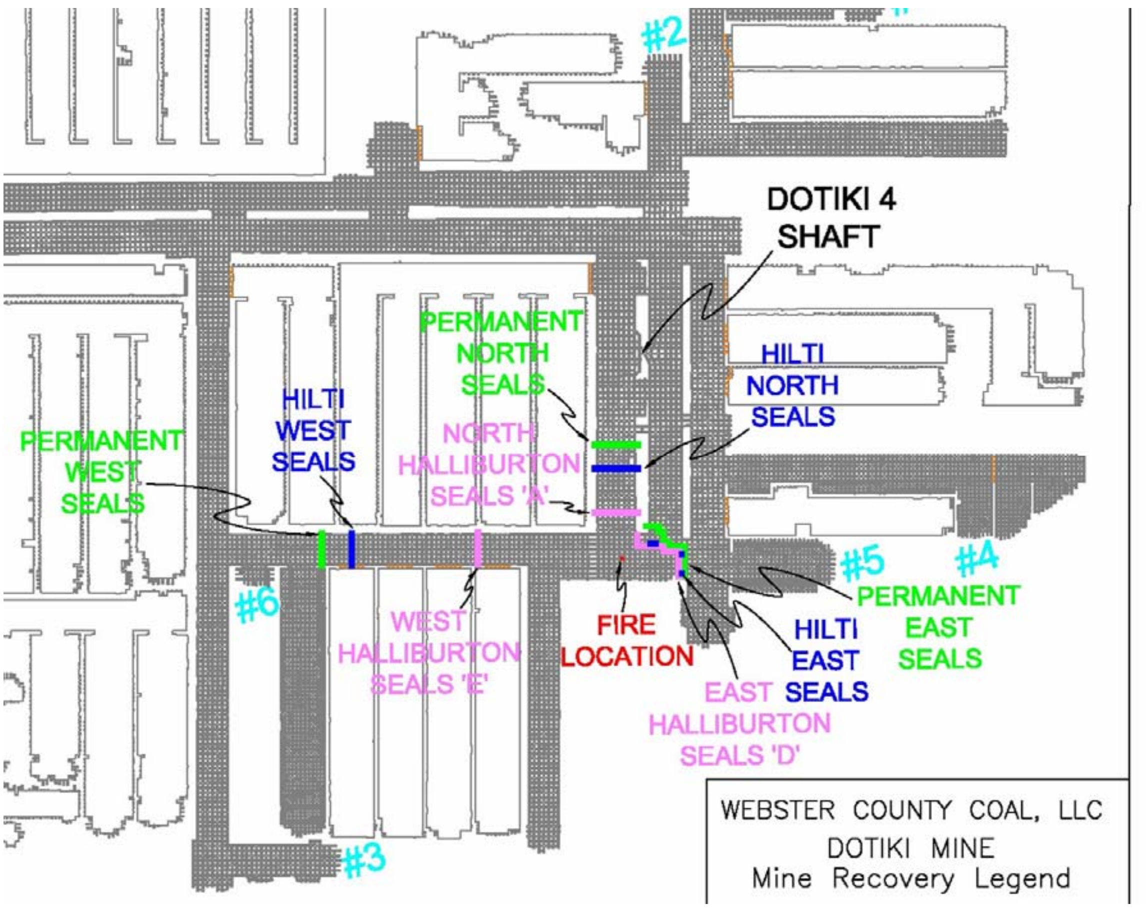

Figure 3. Map of Mine around fire area

REHABILITATION

An examination of the entire mine started on March 4 when teams composed if MSHA, State, and company employees explored the entire mine to evaluate air direction, quantity, and quality. Adjustments were made to the mine ventilation system as necessary. After the examination, miners worked to rehabilitate the entire mine. This included but was not limited to rock dusting all areas out by the permanent seals, belts, units, returns, and constructing more seals at the old No. 1 unit panels, adjusting regulators, and watering all haulage roads.

PRODUCTION RESUMES

On March 8, 2004, just 26 days after the fire was first discovered production resumed at the Dotiki IV Mine. Webster County Coal utilized all of their employees during this time either at the other company mines or helping with the recovery of the Dotiki IV Mine. No injuries occurred during the recovery period. A good working environment between the company, KDMM, and MSHA had been established and continued for ongoing monitoring of sealed fire area. During the entire time the company never lost sight of their goals to restore the mine to normal operations quickly and safely.

CONCLUSION

The co-operation and free exchange of ideas between the interested parties was one of the main factors that made for a successful operation. This created a positive atmosphere to formulate and execute the plan of attack. The ability to have ample supplies and a skilled workforce capable of installing the LOM seals in a short period of time was critical. This enabled the Dotiki IV fan to be de-energized and sealed to begin depleting the fire of oxygen. Having full access to the surface above the fire area allowed the placement of the remote seals in the best locations based only on underground factors. Keeping a continuous flow of inert gasses into the mine at the fire area kept the fire from getting further out of control or possibly setting off an explosion. The company’s decision to keep much of their workforce available to help with recovery efforts aided in sample collection, instantaneous gas readings, and delivery of supplies and information. The overall weather conditions were good.

The use of remote seals at the Dotiki mine provided a safe means to isolate dangerous areas and conditions from the rest of the mine. The effectiveness of the remote seals resulted in the successful recovery of the Dotiki mine following a major fire and demonstrated that these seals will have a future application in the mining industry.