Effects of Drilling Small Diameter Exhaust Shafts in a Gassy Longwall Operation

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ABSTRACT

As the title indicates, this paper deals with the ventilation of a gassy longwall mine through the use of small diameter exhaust shafts. Extensive background information is provided to show the evolution of the mine's ventilation system to correspond with changes in longwall mining techniques, particularly increases in face width. A description of the blind drilled shaft techniques, which proved to be the most economical ventilation choice for US Steel No. 50 Mine, is also included.

KEYWORDS

Longwall, Bleeder, Ventilation, Gob, Methane, Drilled, Shaft, Centrifugal, and Fan.

INTRODUCTION

US Steel No. 50 Mine, located near Pineville, WV operates longwall (LW) faces in the Pocahontas #3 seam. Seam heights range from 1.1 to 1.5 m (42 to 60 in). Since the beginning of longwall operations, more than 90 panels have been extracted. These have been mined using a plow rather than a shearer. US Steel No. 50 Mine has the only plow operating in North America.

The combination of low LW face height (typically the plow does not cut any rock for additional height), size of the equipment on the face, face width, productivity rates, and the methane liberation characteristics make effective longwall ventilation very challenging. Total methane liberation from the mine is up to 570,000 cu m (20,000,000 cu ft) per day.

Traditionally all of the LW face air was circulated through the gob and a series of Bleeder Evaluation Points (BEP's) in route to a low pressure axivane type mine fan. As the size of the mine, the amount of overburden, and thickness of overlying coal seams increased, the gob characteristics began to change. The biggest change was increased amounts of methane both during and after mining. As a result, the amount of air required to ventilate the gob increased significantly. It became challanging to provide sufficient intake to adequately ventilate the LW face and the growing gob areas.

Large diameter conventionally sunk shafts and additional mine fans are both costly and require long lead periods to install. A different approach had to be taken. The first approach was an insitu methane drainage program for the longwall. Horizontal holes were drilled into the longwall block and infused with water to displace the methane. The water infusion helped to reduce dust during mining but actually trapped the methane in place. The horizontal drilling technique has been refined to reduce face liberation. The next step was to drill a 100 mm (4in) diameter vertical borehole (VBH) into the gob in order to naturally vent gob methane to atmosphere. Vacuum blowers were then installed on the VBH's to increase the efficiency of each hole. Improvements in the level of sophistication in both drilling and blower control technology increased to the point that large gob areas could be effectively ventilated by the combination of a low pressure fan and a group of 355 mm (14 in) VBH's which were powered by methane driven engines utilizing radio telemetry to monitor performance and well output. This system worked well but proved itself to be very expensive to maintain.

As the size of the gob increased, the VBH size, blower horsepower, and the number of boreholes drilled also increased in order to maintain methane at safe levels underground. We were forced to operate up to 35 blowers at any given point in time. The mechanical liabilities, drilling costs, and the labor required to maintain the VBH network became greater than what US Steel Mining Co. was willing to accept as a way of doing business in the increasingly competitive global metallurgical coal marketplace.

Thus, we determined that in order to operate safely, to ventilate gob areas properly, and to remain an economically viable business we would develop a more efficient method of ventilation.

PRESENT VENTILATION SYSTEM

As the LW face width and production rates increased it became imperative that the methane be drained prior to mining to reduce the volume of air required to dilute face liberation. Degas drilling is now done by a combination of horizontal holes drilled underground and articulated boreholes from the surface into the coal seam in advance of mining. These same holes are then used for water infusion to help control dust underground. The articulated holes can also be used as a VBH to drain excess gob methane. Methane is conveyed outside via pipeline and boreholes. All methane produced as a result of premining degasification is sold comercially. Methane that mixes with air and is carried outside through the mine fans can not be utilized at this time.

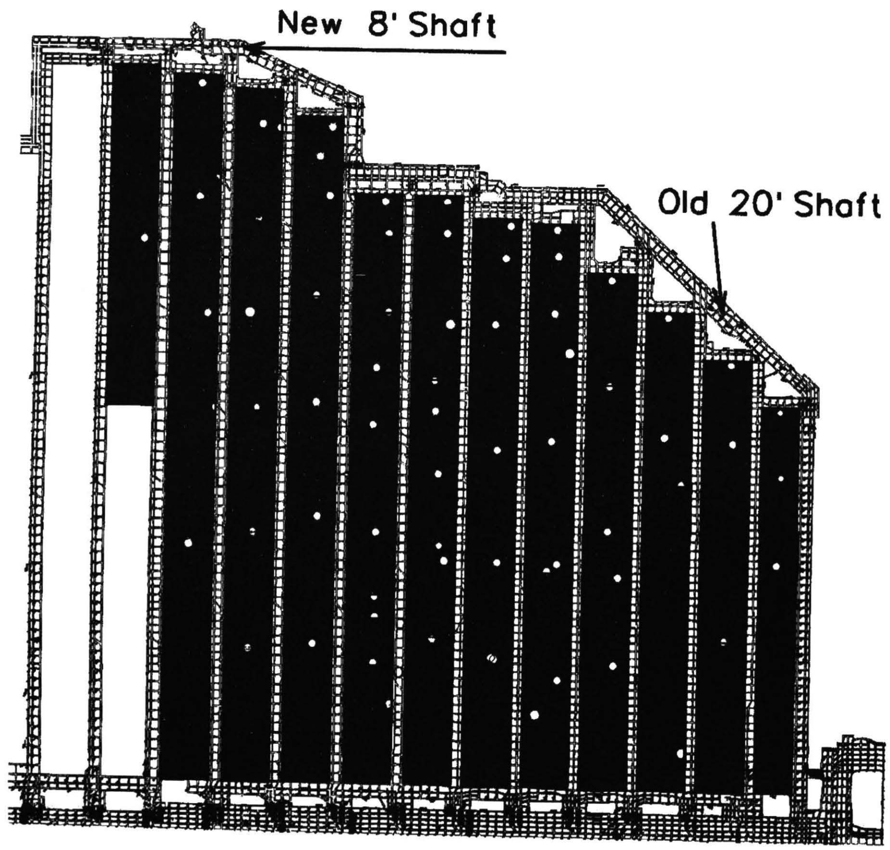


Figure 1. Typical Mine Map.

The airflow characteristics of our mine are such that a limited amount of air will flow through the gob with a moderate amount of pressure drop, but this process alone is not sufficient to ventilate an active face. Therefore, we developed a system that utilizes multiple fans to ventilate the LW face. This system allows us to exert sufficient pressure across the gob in the active mining areas to maintain the methane concentration at safe levels without depending on an elaborate system of boreholes and blowers. It also affords us the opportunity to move large quantities of face air in different directions to optimize face ventilation, gob pressures, and mine operating costs. Our present ventilation system is designed to deliver 8500 cu m/sec. (300,000 cfm) intake to each operating longwall.

To design a ventilation system that would be safer and more economical, we began by simulating various combinations of shaft sizes and fan operating pressures. We factored in the time that the shaft would be utilized and the electric power required to meet our projected ventilation requirements. We determined that an 2.4 m (8 ft) diameter hydrostatic steel lined shaft with a high pressure, high volume centrifugal fan located near the active LW panel is the most economical choice. The reduced cost of a smaller diameter blind drilled shaft more than offset the higher operating costs over the projected life of the shaft. We selected a Robinson 2.6 m (103 in) DWDI centrifugal fan with an identical backup fan on site.

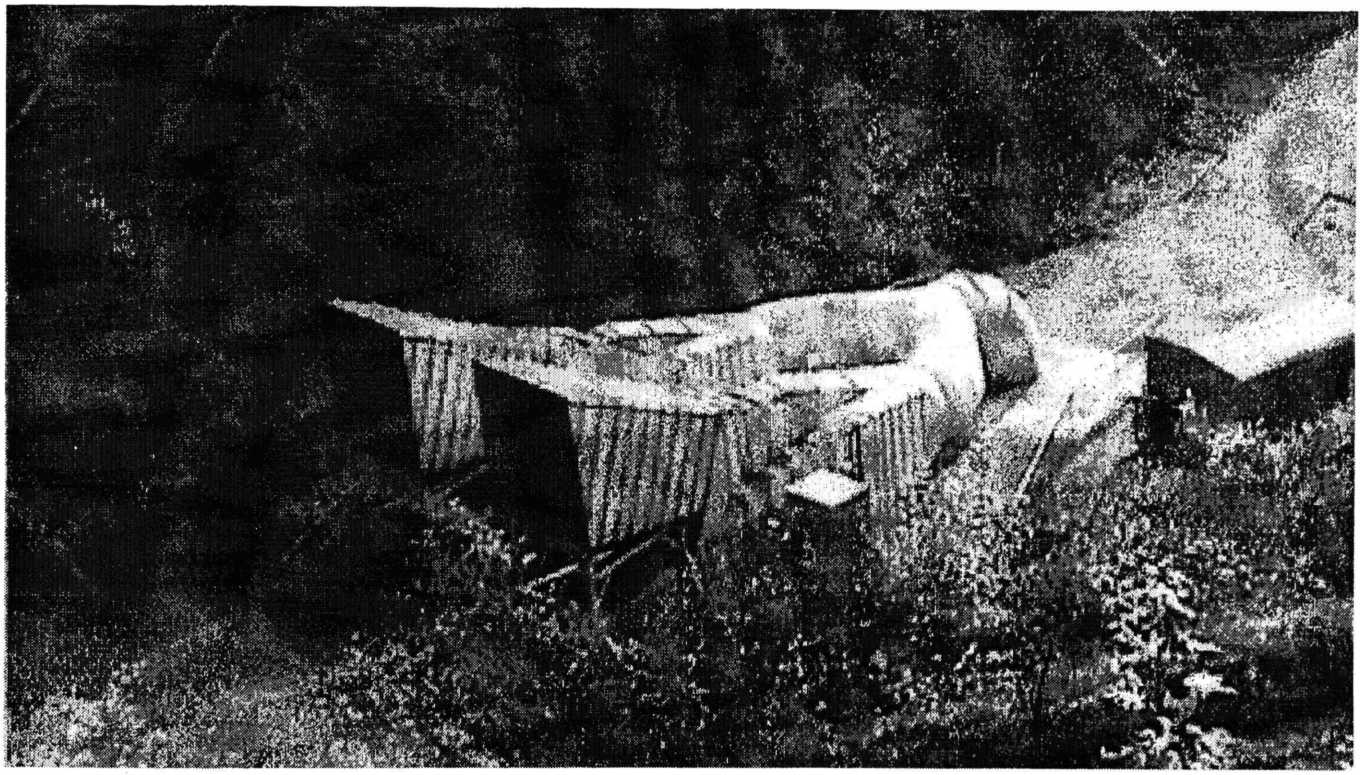


Figure 2. Centrifugal fan setup.

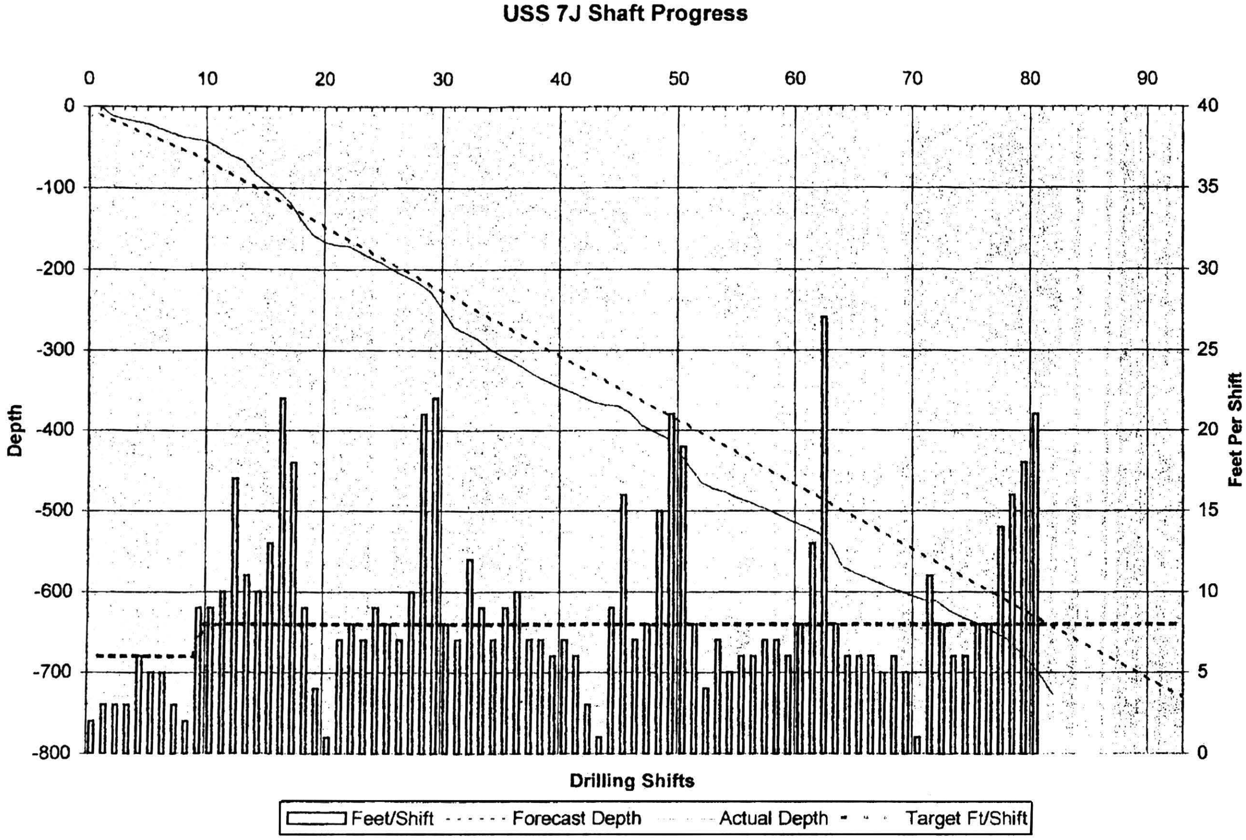
Difficult drilling conditions due to the massive crystalline sandstone formations that sometimes exceed 345 Mpa (50,000 psi) compressive strength made a tradtitional vendor contract impractical. At this point US Steel Mining Company LLC (USM) entered into a partnering agreement with North American Drillers (NAD).

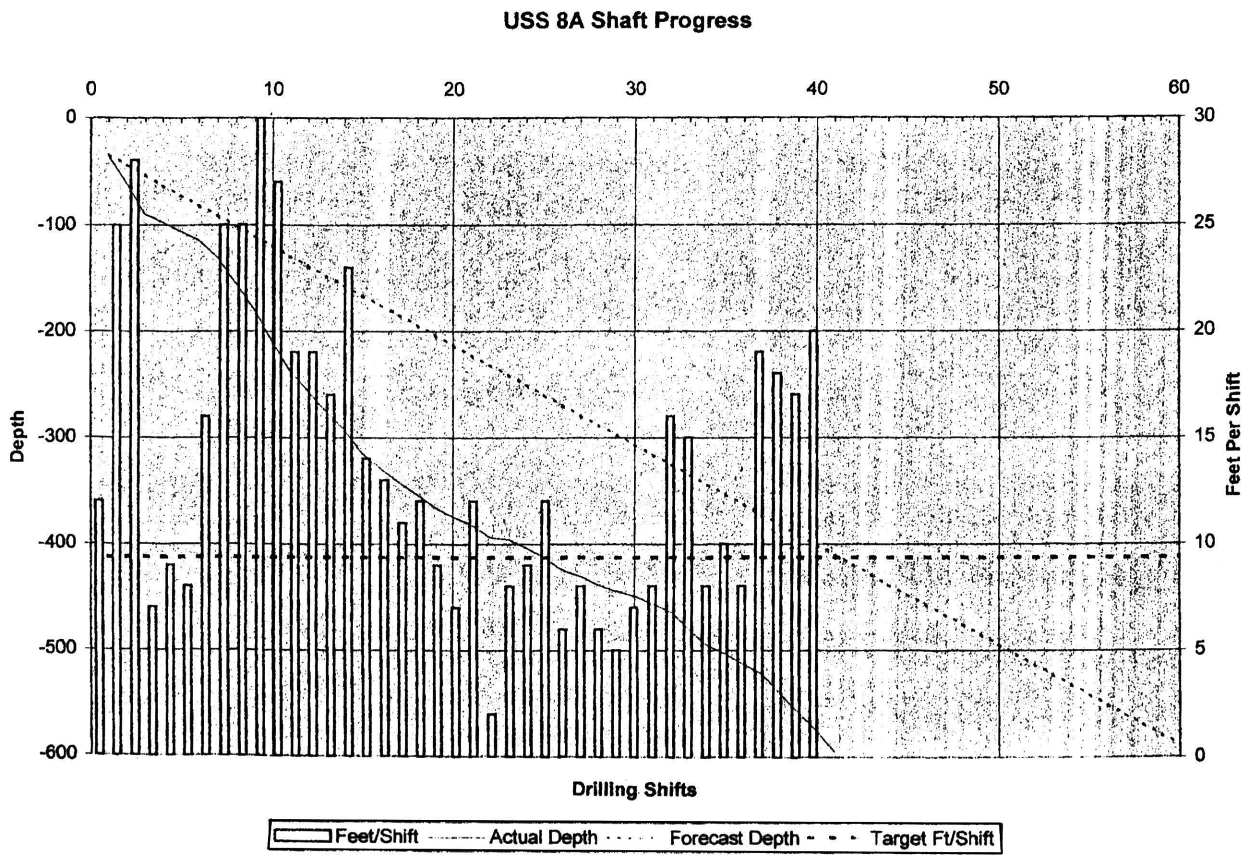
This partnering arrangement has been very successful to date. It has allowed USM to install shafts in a timely, cost effective manner by sharing the risks associated with drilling 345 Mpa (50,000 psi) rock. NAD has also benefited by being able to share the costs of some very expensive R&D which can benefit the entire industry in the future.

Thus far, two 2.6 m (8 ft) diameter bleeder shafts have been constructed for gob ventilation. Both shafts were completed ahead of mining, allowing the fan installation to be operational for the mine when it needed the air. The last shaft was 177 m (580 ft) deep and the fans were running within 2.5 months after shaft drilling began. The speed with which the shafts were installed allowed for maximum flexibility in mine development, planning and permitting.

CONCLUSIONS

The net result has been that by balancing gob pressures, draining face methane prior to mining, water infusion, and moving the source of pressure closer to the active LW panel we have developed an excellent system to safely ventilate longwall gob areas at a lower cost. We still drill a few VBH's but do not intend to use them unless conditions are encountered that exceed the capacities of our ventilation system. We have not had to use any VBH's and have not had any gob ventilation problems since switching to our present ventilation configuration.





Figures 3 & 4. Timelines of 7J vs. 8A shaft progress.