Target Drilling's long boreholes maximize longwall dimensions

G.M. DuBois & S.J. Kravits
Target Drilling Inc.

J.M. Reilly
Pennsylvania Services Corporation

T.P. Mucha
Thomas P. Mucho & Associates, Inc.

ABSTRACT: To address increasing ventilation and methane emission issues underground horizontal long boreholes (longholes) are utilized in the mine plan at a large Pittsburgh coal bed longwall mine. Considerations in designing the placement of long boreholes included existing mine ventilation design, reserve recovery, ventilation limitations of three entry development, belt air direction, federal ventilation criteria, longwall panel dimensions, and estimated methane liberations.

Evolution to the current in-mine longhole drilling pattern, shielding gate road development is reviewed. Utilizing this technology has allowed the mine operator to successfully and profitably mine the largest longwall panels (416 acres) in the Pittsburgh Coal Seam, extending both length and width of the panels.

Target Drilling Inc. employed their directional drilling technology and an experienced staff, to successfully drill all longholes utilizing two drills simultaneously. Target has directionally drilled one hundred sixteen in-mine longholes greater than 1,219 m (4,000'), in the Pittsburgh coal seam primarily shielding gate road development.

1 INTRODUCTION

Many US Longwall mines are located in relatively gassy coal beds. Mine planning has aimed to increase the percentage of longwall coal produced versus continuous miner development coal tons. This need was evident and was a result of the coal industry's need to stay competitive in a world energy market. At longwall mines, these economic forces have fueled the continuing expansion of longwall panel dimensions, improvements in reliability of longwall equipment. These actions have increased productivity and provided lower costs to the consumer. As we review the past 15 years of increasing longwall panel dimensions and productivity, it became apparent, that ventilation alone may not be sufficient to dilute the ever increasing volumes of methane that are liberated into the mine's ventilation system without adversely impacting advancement rates of continuous miner development and longwall sections. Due to higher and higher longwall productivity and advancement rates, coal operators continued to expand panel length and width to maintain a balance between section development rates and longwall retreat.

The coal industry's goal to maximize the ratio of longwall coal to more expensive continuous miner coal, thereby lowering overall production costs has been very instrumental in the continued expansion of longwall panel size. It is this expansion of longwall panel size that has driven the mine engineer to incorporate the use of longhole technology into the design of mine layouts and mine ventilation systems. Compliance with Federal Ventilation Regulations is mandatory. Ventilation design always incorporates a safety factor in its design, and all available options and technology needs considered. This paper discusses how the use of underground horizontal directional drilled longholes were effectively utilized to increase longwall panel dimensions, reduce longwall move frequency, enhance safety of the employees and the operation, reduce citations and increase the profitability of a Southwestern Pennsylvania underground longwall mine.

2 HISTORY OF LONGWALL PANEL DIMENSIONS

During the early 1990's typical dimensions of longwall panels at this mine were 2,438 m x 229 m (8,000' x 750'). This area encompassed 558,302
square meters (147 acres) with a Maximum Ventilating Perimeter (MVP) of the longwall panel = 5,105 m
(2,438 m + 2,438 m + 229 m). As global energy supplies continued to influence the downward trend of coal prices, coal operators looked to offset the downward price spiral with improvements in productivity. The obvious choices were to increase longwall panel size, and at the same time increase the ratio of longwall coal to continuous miner coal, thus lowering production costs. By the mid to late 1990's longwall panel dimensions had increased to 3,810 m x 283 m (12,500' x 930') with a MVP = 7,903 m (25,930'), encompassing 1,078,230 square meters (269 acres). Longwall panel dimensions in a new reserve at the mine were projected to be 4,419 m x 382 m (14,500' x 1250') and a MVP = 9,219 m (30,250') encompassing 1,688,058 square meters (416 acres). Comparing panel size of the early 1990's to the projected panels in the new reserve MVP's and acreage are projected to increase 81% and 183% respectfully. Monitoring of methane levels and air flow quantities indicated there was a direct one to one correlation between MVP and methane liberated into the section's ventilation system. This indicated the requirement for additional section ventilation capacity. It was apparent that completion of longwall panel development would be significantly hampered by an inadequately designed ventilation system, especially since section advancement is always critical at a longwall mine. Computer ventilation modeling of the 3 entry gate road development sections indicated that those current systems would probably not be capable of delivering sufficient quantities of air to adequately ventilate the development section without significantly affecting the section advancement rates. With the projected increasing MVP's new concepts were evaluated. Mine Wide Atmospheric Monitoring Systems and Underground Horizontal Directional Longhole Drilling were two potentials to supplement the ventilation system.

3 REVIEW OF PANEL SIZE, METHANE LIBERATIONS AND CONCENTRATIONS

In the early 1990's when the typical longwall panel was 229 m (750') wide and 2,438 m (8,000') long typical volumes at this mine's section regulators were set at 2,831 cubic meters per minute, (cmm) (100,000 cfm) and methane levels were just below the legal limits of 1.0%. The total methane being liberated from a single three entry development section was approximately 25.5 cmm (900 cfm) of methane when panel development was near completion.

By the mid 1990's typical longwall panel's MVP had increased to 7,903 m (25,930'). To meet the requirements of the federal and state regulations this operator began utilizing Atmosphere Monitor Systems (AMS) which permitted methane levels to increase by 50%, to 1.50% in section return entries. As longwall development section's MVP increased the quantity of methane liberated by a three entry system also increased. When reviewing the percent rise in methane generated by a 3 entry development sections compared to the percent rise in MVP, both entities were increasing at similar rates (see Tables 1 and 2).

After evaluating Tables 1 and 2 it is apparent the mine's ventilation system in a very long three entry development section will marginally meet the requirements of the federal ventilation criteria. What options are available to the mine engineer? This paper discusses utilization of an aggressive underground degasification program and how it resolved numerous regulatory and operational issues.

4 IN-MINE LONGHOLE DEGASIFICATION

In the mid 1990's the coal operator began to utilize longhole drilling technology to shield longwall development sections from the impacts of methane delays.
at the mining face. The initial drilling pattern involved a single horizontal longhole being drilled parallel to the return entry of the active section.

This initial drilling pattern provided some relief of methane accumulations at the mining face. However, because the underground drilling site is developed by section advancement the horizontal longhole had minimal time producing “free gas” that is trapped in the coal cleats. Within a few months section development advances passed the end of the horizontal longhole and the developing section was back to the same problems associated with methane accumulations at the face. It was obvious that more time was needed to allow the horizontal longhole to degasify the coal seam.

Drilling patterns evolved to maximize degasification time and drain the “free gas” trapped in the coal cleats by utilizing cross panel boreholes, this allowed up to 18 months degasification time prior to the continuous miner advancement.

It also became apparent the entire development section had to be shielded with horizontal longholes to effectively degas the entire mining area; therefore branches were drilled from the main longhole to obtain continuous coverage along both the return and belt entries.

5 MINE PLAN DESIGN – TIMING AND RESOURCE UTILIZATION

Planning for the new reserve, given the goals of increasing the mine’s viability, proved to be a departure from the past. There are many considerations and issues that must be evaluated and properly engineered when developing and designing a mine layout for an existing mine. For a longwall mine to be a viable entity the first overriding goal that must always be reconciled is that section development must always stay ahead of longwall retreat. This ensures maximizing the longwall productivity without major interruptions caused by section development not being completed in a timely manner. A second criterion for mine layout is to maximize the available coal reserves. Other design criteria include minimizing the impact from roof control and ventilation issues.

Utilizing Surv Cadd Software, numerous mine plan timing models and configurations were evaluated and it became apparent that the remaining coal reserve would not be split into two equal east and west halves off the mains section development. To meet the timing model projections, longwall panel length had to be reduced in the short term to ensure section development would be completed on the west side of the mains. This accomplished the first goal of the mine engineer: moving the longwall equipment from one recovery to the next set-up without a delay. Because the mine plan timing issues divided the coal reserve in unequal halves, the projected longwall panel’s MVP exceeded any previous developed panel’s MVP by 17%. However the proposed mine plan layout, maximized recovery of the coal reserve.

The new mine plan layout proposed longwall panels 4,419 m (14,500’) long x 382 m (1250’) wide, mining 416 acres per panel, with a MVP = 9,220 m (30,250’). Again it was assessed that these larger panels would create a situation where the presently
The main emphasis of the in-mine degasification strategy was focused on capturing the "free gas" trapped in the fractures or cleats of the coal and directing it into an underground gas pipeline gathering system and ultimately to the surface (through vertical boreholes), rather than releasing the gas into the mine's ventilation system during mining. This would be accomplished utilizing safety measures approved by the governmental agencies in a safe and responsible manner. Because the main line development split the coal reserve into unequal parts, special emphasis for degasification was put into the larger portion of the coal reserve where the longwall panels were 4,419 m (14,500') long, 382 m (1,250') wide with Maximum Ventilating Perimeter (MVP) of 9,220 m (30,250'). The degasification plan focused on those issues that would most effectively impact the reduction of methane in the coal reserve. They were:

- Drill longholes as soon as possible to maximize degasification time.
- Plan drilling far enough in advance to insure continuous coverage along both the belt and return entries in all three entry longwall development sections.

The strategies to minimize these two ventilation risks associated with the mine layout utilizing very large panels were:

1. Increase mine ventilation capacity by increasing fan horse power 33%.
2. Reduce section return methane concentrations below 1% thus eliminating the required AMS system. This goal would allow a 50% margin of safety in the ventilation requirements (1.0% to 1.5%) to meet the federal ventilation standards.
3. Develop an aggressive underground degasification strategy to capture and safely transport the "free gas" to the surface before mining activities released the "free gas" into the Mine's Underground Ventilation System.

6 DEVELOPMENT OF IN-MINE DEGASIFICATION PLAN

The main emphasis of the in-mine degasification strategy was focused on capturing the "free gas" trapped in the fractures or cleats of the coal and directing it into an underground gas pipeline gathering system and ultimately to the surface (through vertical boreholes), rather than releasing the gas into the mine's ventilation system during mining. This would be accomplished utilizing safety measures approved by the governmental agencies in a safe and responsible manner. Because the main line development split the coal reserve into unequal parts, special emphasis for degasification was put into the larger portion of the coal reserve where the longwall panels were 4,419 m (14,500') long, 382 m (1,250') wide with Maximum Ventilating Perimeter (MVP) of 9,220 m (30,250'). The degasification plan focused on those issues that would most effectively impact the reduction of methane in the coal reserve. They were:

- Drill longholes as soon as possible to maximize degasification time.
- Plan drilling far enough in advance to insure continuous coverage along both the belt and return entries in all three entry longwall development sections.
- Utilize surface to in mine vertical boreholes to maximize gas flow and vent gas to atmosphere or capture for sale.

7 MAXIMIZE DEGASIFICATION TIME

Longwall panels were projected to be developed from both sides of the mains. The smaller western panels were to be mined first while the larger eastern panels were not scheduled to be mined for 2.5 years. This allowed a unique opportunity to drill longholes into the eastern reserve as the main's development advanced north, maximizing degasification time for this portion of the reserve. Drilling sites favorable to longhole orientation were developed to maximize longhole shielding along both the belt and return entries. Sumps were cut in the mine floor to allow separation of drilling fines and water. Longholes drilled from the mains section would effectively shield the first 25% of the gate road development and were completed prior to the longwall section "neck in" being developed. The longholes were planned, oriented, and drilled through the longwall recovery entries in such a way that the "neck in" of the development section would not intersect the longholes, again maximizing the effective time the longholes were producing methane. This drilling strategy permitted longholes to be active for 6–24 months prior to any mining development near the longholes. Prior to the continuous miner section intersecting the longholes, the longholes were water infused, mined through, and reactivated utilizing a mechanical flow through packer on each side of the section where the longhole was intersected.

Additional challenges presented themselves when the first longwall panels in the eastern side of main's development were started. The orientation of the belt entries in the tailgate and headgate sections created a situation where a degasification longhole could not follow the typical plan of drilling with the wellhead in the return entry. This would have left 75% of the section without sufficient number of shielding longholes. If degasification longholes were to be drilled to shield the belt entries of either the headgate or tailgate sections, it would require the wellheads would have to be located in an active belt entry. Working with federal and state agencies, local mine management and representatives of the UMWA local, a plan was developed and approved to permit drilling from the intake entry, with wellheads in an active belt entry of an active development section.

The approved plan included the following guide lines:

- Methane monitor sensors were positioned in the belt entry. These sensors were continuously monitored on the surface, and included audible and visual alarms at the section tailpiece.
Figure 3. Longholes drilled from mains sections.

<table>
<thead>
<tr>
<th></th>
<th>MVP</th>
<th>Air quantity @ regulator (ccm)</th>
<th>Methane concentration</th>
<th>Total section, methane liberated (ccm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without De-gas (Est.)</td>
<td>9,220 m (act)</td>
<td>3,398 (est.)</td>
<td>1.36% (Cal)</td>
<td>46.2 (Est. No-degas)</td>
</tr>
<tr>
<td>With De-gas (Actual)</td>
<td>9,220 m (act)</td>
<td>3,822 (act)</td>
<td>0.80%</td>
<td>30.6 (Actual, With de-gas)</td>
</tr>
<tr>
<td>% Increase (Decrease)</td>
<td>Same</td>
<td>+12.5%</td>
<td>(41.2%)</td>
<td>(33.7%)</td>
</tr>
</tbody>
</table>

- Methane monitors were wired into the belt starter. This enabled the belt system to be de-energized when 1% methane was detected in the belt entry by the methane sensors.
- Gas transmissions lines that crossed intake entries from the belt entry to the return were encased in an additional steel or aluminum pipe for added protection.
- Wellheads were equipped with pneumatic shut off valves.
- Gas-water separator tank’s drain lines were coursed to the return airway to avoid methane being released into the belt entry in the event the water dump valves did not function properly.
- Belt air flow was directed out by at the wellheads and into the return entry before it passed over the belt drive or head roller. While methane drilling operations were being conducted in the belt entry, the belt air was never directed in by to the active working section.
- A pre-shift examination was conducted at the wellheads and the results recorded in the pre-shift examination book.

This approved plan was site specific, and was not replicated in other locations throughout the mine. With the ability to continuously monitor the methane levels on the belt entry and have this information connected to the section’s belt load center which was programmed to immediately de-energized the entire belt system when methane levels reached 1%, provided a level of confidence in the plan by mine management, employees and government regulatory agencies.

8 CONCLUSION

The use of longholes for degasification has been extremely successful; it has met the criterion for the project. These goals were:

1 Reduce production delays at the mining face on continuous miner sections. Delays associated with excessive methane at the mining faces has all but disappeared from the section foreman’s reports.
2 Reduce methane levels in section return below 1%; this eliminates the need for the Atmospheric Monitoring Systems (AMS). Methane levels in the section return have dropped to an average peak of 0.8%, primary due to the degasification program. Actual methane being liberated has dropped approximately 30%-35% (see Tables 3 and 4).
3 Most important, utilizing horizontal longholes drilled by Target Drilling Inc.’s experienced staff, has allowed the safe and timely development of the largest current longwall panels in the Pittsburgh coal seam. Development was successfully
Table 4. Comparison of % rise in MVP versus % rise in section methane liberated without/with degasification.

<table>
<thead>
<tr>
<th>MVP</th>
<th>Air quantity @ regulator (cmm)</th>
<th>Methane concentration</th>
<th>Total section, methane liberated (cmm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without De-gas (Act.)</td>
<td>5,105 m (act)</td>
<td>2,831</td>
<td>0.90%</td>
</tr>
<tr>
<td>With De-gas (Act)</td>
<td>9,220 m (act)</td>
<td>3,822</td>
<td>0.80%</td>
</tr>
<tr>
<td>% Increase/Decrease</td>
<td>+80.6%</td>
<td>+35%</td>
<td>(11.1%)</td>
</tr>
</tbody>
</table>

completed without delays associated with excessive methane at the mining faces or in the mine's ventilation system.

When analyzing the value of this project to the mine operation it is difficult to quantify, because of so many variables, but the following given.

Production delays for excessive methane associated with continuous miner development approach zero minutes compared to 4,000 minutes for previous sections without degasification.

1 Section advancement rates were not negatively impacted by methane delays.
2 Section methane delays were reduced 30% to 35%.
3 With the belt air direction reversed from intake to a neutral split, typical belt entry maintenance such as rock dusting were more easily managed.
4 Reversing the belt air direction eliminated significant amounts of methane reporting to the mining faces (14.2 cmm [500 cfm]). This methane reduction helped eliminate excessive methane delays.

In summary without an aggressive degasification strategy the methane delays would have severely impacted the development of the longwall development sections, and the mine plan's timing schedule would not have been met. As a result there would have been two choices, shorten the longwall panels and lose significant portions of the coal reserve or idle the longwall for numerous months and lose significant amounts of money. Either choice would have been unacceptable.