Directional Drilling for Gob Gas Drainage at the Belozerskaya Mine

Practices and Technologies: Coal Mine Methane Recovery and Utilization In Ukraine

Victoria Hotel
Donetsk, Ukraine

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Methane Drainage Considerations

- **Source of gas emissions**
  - Adjacent gas bearing strata, geologic features or working seam

- **Geologic characterization**
  - Coal thickness, rank, stress, friability, other mechanical properties

- **Reservoir characterization**
  - Gas content, permeability, porosity, reservoir pressure, and desorption time constant

- **Mining technique and schedule**
  - Gate road development, start of LW, available drainage times, multiple seams

- **Drainage approach**
  - Source, feature, or shield focused

- **Logistics**
  - Surface and underground access

- **Gas Utilization**
  - Alternatives, gas quality
  - Market
Methane Drainage Techniques

- Pre-Mining
- Gob Degasification
Drainage Considerations in Ukraine

- Many coal reserves develop multiple coal seams and require flexible methane drainage approach.
- Working seam is very low permeability and little success has occurred with in-seam gas drainage techniques.
- Overlying and underlying strata typically contains numerous other coal seams, sandstone and shale measures that release gas following undermining.
- Typically, cross-measure borehole drainage techniques are used to drain gas after strata has been relaxed as a result of mining.
- Use of surface drilled methane drainage wells has been affected due to multiple seam mining, expense, depth, surface ownership, approvals, topography, culture, lack of equipment, etc.
- Gas collection systems typically use steel pipeline and demonstrate significant erosion of gas quality from wellhead to surface.
Gob Gas Drainage Techniques

- Vertical Gob Wells
- In-Mine Horizontal Gob Boreholes
- Cross-Measure Boreholes
- Longwall Panel
Why Consider Long Hole Directional Drilling?

• Allows longer length and more accurate placement of boreholes for improved methane drainage efficiency and longer drainage times
• Allows implementation of innovative gob gas drainage techniques to develop boreholes remotely and away from working face.
• Ability to steer borehole to stay in-seam or hit specific gas bearing targets
• Promotes a more focused, simplified gas collection system
• Less labor intensive
• Provides additional geologic information (such as coal thickness, faults, and other anomalies, etc. prior to mining
PEER Project Objectives

• Primarily funded by US Department of Labor. This project initiated in 2005.
• Demonstrate the application of long hole directional drilling technology
• Evaluate the application of long in-mine horizontal gob boreholes
• Demonstrate a cost effective gob degasification alternative
• Provide training and improve mine safety
Ukraine Directional Drilling
Program Overview

- **Project Management**
  - PEER

- **Project Design and Training**
  - REI

- **Objective**
  - Design, implement, and evaluation of the use of long, directionally drilled boreholes in a coal mine in the Donbass region.

- **Approach**
  - REI provided equipment design, selection, and procurement. Project provides training of directional drilling techniques to Ukrainian counterparts and implementation at a local Mine.

- **Candidate Mines**
  - Initially Krasnolimanskaya, demonstrated at Belozyorskaya Mine. Current discussions with other Ukraine mine operators.
Long Hole Drill (LHD)
Design Considerations

• Compact, skid mounted, high thrust LHD equipped with hydraulic controls typically used in directional drilling.

• Will be constructed in components. Each piece will be taken down shaft and assembled underground.

• Dimensions – L x W x H less than 3.8 x 1.3 x 1.3 meters

• Weight – less than 6.8 tonnes
Long Hole Drill (LHD) Design Considerations

- Electrical System – 660 volts, 50 Hz
- Permissibility – will meet US Mine Safety and Health Administration permissibility standards.
- Thrust – 40,000 lbs.
- Orientation – Boom capable of $\pm 15$ degrees
- Water pump, wire line hoist, methane detection.
- Training, spare parts
Ukraine Long Hole Drill
Design of Drilling Room

Drill Rig Site

Upper Coal Seam

Drill Rig Axis

Ventilation Stopping

Ventilation Stopping

Drill Rig

Drill Rig Site - Plan View

Drill Rod Axis

Ventilation Stopping

Drill Rig

Haulage Way Axis

Southern Slope Axis

REI DRILLING
DIRECTIONAL UNDERGROUND
Design of Drilling Room
Horizontal Gob Borehole Design Considerations

- Place boreholes near edges of the longwall panel where strata will be in tension
- Place boreholes along ventilation return (tailgate)
- Place boreholes along high elevation side of the gob
- Place above rubble zone (> 5 times mining height) to remain intact during undermining
- Typical placement 20 to 30 m above top of coal
Belozyorskaya – Design and Approach

- Three boreholes were drilled along the up-dip side of the panel near the tailgate entry.
- Borehole 1 was drilled approximately 20 m from the tailgate entry.
- Boreholes 2 and 3 were maintained generally 40 m and 60 m from the tailgate entry, respectively.
- Boreholes 2 and 3 were connected to the same collar.
- A fault limited the lengths of the boreholes.
- Boreholes maintained 14 to 16 m above the top of the coal.
- Boreholes could not be drilled in higher elevation formation due to borehole stability problems.
Belozyorskaya Mine – Plan View
Long Hole Directional Drilling
Belozyorskaya Mine - Ukraine
Belozyorskaya Mine  
Gob Borehole Performance

- Following undermining the boreholes produced significant volumes of gob gas
- Placement of the first half of Boreholes 2 and 3 was apparently too low above the top of the coal and produced mostly ventilation air.
- The outby half of boreholes 2 and 3 was higher above the top the coal and resulted in the production of higher quality gob gas.
- Borehole 1 produced higher quantity and quality gob gas than Boreholes 2 and 3 combined.
- The gas flow rates for Boreholes 2 and 3 combined should have been higher than that of the Borehole 1. This may have resulted from:
  1) Borehole collapse when undermined (drawing in ventilation air from the longwall face and not the gob gas reservoir).
  2) One or both of the boreholes may have collapsed after drilling or blocked by cuttings.
Belozyorskaya Mine
Gob Borehole Performance

- Borehole 1 produced between 3,500 and 4,500 m³/day of methane on a consistent basis

- The horizontal gob boreholes produced 800,000 m³ of methane

- The performance of the horizontal gob boreholes at Belozyorskaya compare with the performance of horizontal gob boreholes applied at other underground mines
  - Gob gas flow rates and methane concentration ranges compare with applications operating at similar vacuum pressures
  - Similar performing projects compared horizontal gob boreholes with cross-measure boreholes. These projects demonstrated that:
    - horizontal gob boreholes are 1.5 to 2 times more efficient than a system of cross-measure boreholes
    - horizontal gob boreholes are cost effective compared to cross-measure boreholes
# Gob Borehole Performance at other Projects

<table>
<thead>
<tr>
<th>Project Location</th>
<th>Country</th>
<th>Diameter of Boreholes (mm)</th>
<th>Length of Boreholes (m)</th>
<th>Elevation above Seam (m)</th>
<th>Wellhead Vacuum (mm Hg)</th>
<th>Gob Gas Flow (m³/day)</th>
<th>Gas Quality (% CH₄)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taiheiyo Mine</td>
<td>Japan</td>
<td>125 - 75</td>
<td>700</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>methane drainage efficiency twice that of cross-measures system of gob degasification</td>
</tr>
<tr>
<td>Cambria 33 Mine</td>
<td>Pennsylvania, USA</td>
<td>88</td>
<td>400 - 700</td>
<td>20 - 30</td>
<td>150</td>
<td>10,000</td>
<td>40 - 90</td>
<td>5 times more effective than cross-measure holes applied to same panel</td>
</tr>
<tr>
<td>Daxing Mine</td>
<td>Tiefa Mining, China</td>
<td>90</td>
<td>150 - 300</td>
<td>35 - 45</td>
<td>100</td>
<td>8,300</td>
<td>35 - 90</td>
<td>Methane drainage efficiency 1.5 to 2 times relative to cross-measure system of gob degasification</td>
</tr>
<tr>
<td>Warndt/Luisenthal Mine</td>
<td>Germany</td>
<td>170</td>
<td>500</td>
<td>20 - 30</td>
<td>N/A</td>
<td>13,000</td>
<td>70 - 80</td>
<td>One horizontal gob borehole as effective as 30 cross-measure boreholes</td>
</tr>
<tr>
<td>Willow Creek Mine</td>
<td>Utah, USA</td>
<td>100</td>
<td>600 - 800</td>
<td>18 - 46</td>
<td>180</td>
<td>18,000</td>
<td>50 - 60</td>
<td>High CO₂ concentrations in gob gas, gas quality dependent on face activity</td>
</tr>
<tr>
<td>Belozyorskaya</td>
<td>Donetsk, Ukraine</td>
<td>96</td>
<td>700 - 800</td>
<td>14 - 16</td>
<td>100</td>
<td>5,000 - 6,000</td>
<td>30 - 75</td>
<td>Results comparable to other applications</td>
</tr>
</tbody>
</table>

![Gob Gas Flow Chart](chart.png)
Lessons Learned

Horizontal Gob Borehole Recommendations

• Optimize performance of long in-mine horizontal gob boreholes at another project site and demonstrate improvements.

• Drilling each horizontal gob borehole with its own dedicated collar/wellhead to enable individual borehole monitoring and vacuum control.

• Increasing the elevation above the top of the coal seam and drill each borehole at a different elevation to optimize vertical placement.

• Reducing borehole spacing and place all horizontal gob boreholes in the third part of the panel nearest the tailgate entry.

• Increasing wellhead vacuum and install provisions to control vacuum for each horizontal gob borehole and provide monitoring of flow and quality.

• Reaming the horizontal gob boreholes to a larger diameter as far as possible and installing perforated steel liner to ensure borehole stability irrespective of vertical placement.
Lessons Learned

Horizontal Gob Borehole Conclusions

• The Belozyorskaya Project Demonstrated:
  – Project results are favorable and results compare with similar projects
  – In-mine horizontal gob boreholes are an effective means of gob degasification
  – In-mine horizontal gob boreholes can be directionally drilled in Donetsk Basin mines
  – Directional drilling can be an effective methane drainage tool
  – Directional drilling can improve mine safety
  – Directional drilling technology can be applied by Ukrainian crews

• Another Project Site is Necessary to:
  – Train additional Ukrainian drilling crews to directionally drill
  – Further demonstrate the benefits of directional drilling to Donetsk mines
  – Expand the use of directional drilling in the Ukraine to increase mine safety
RELIEVES GAS PAINS ON CONTACT.

High methane emissions are enough to upset anyone’s stomach—as well as potentially proving disastrous for mining operations. That’s why so many mine operators call on REI for downhole directional drilling before mining operations advance. Because we are able to accurately steer and place boreholes in excess of 5,000 feet in length (depending on conditions), we can explore, discover and reduce the gas content of the mining or adjacent seams. Which creates greater productivity and safer mining conditions.

REI’s expertise and fleet of seven state-of-the-art directional drills allow us to accurately steer and place boreholes even through unpredictable coal seams. In many cases, the gas from these in-seam boreholes can be collected and sold in commercial markets. And that can prove significant given the rising value of and projected future demand for natural gas.

Put REI’s proven world-wide expertise to work for you today, and have peace of mind about your next mining plans. REI can also assist you with exploration for old workings, geologic exploration, and de-watering, from surface or underground.

So if the thought of high methane emissions give you a sick feeling, call REI today. After all, we’re the company that can relieve your gas pains on contact.

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Спасибо