Drilling and Design Considerations for Methane Drainage

Mongolia Coal Mine Methane Project Development Workshop
Ulaanbaatar Hotel
Ulaanbaatar, Mongolia

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## Presentation Outline

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REI DRILLING, INC.

- Operate 8 long hole directional drills and 2 core drills on a contract basis across North America
- Became affiliated with Valley Longwall International in 2008
- Jointly operate >25 long hole drills worldwide on a contract basis
- Turnkey package of directional drilling units for sale and training for coal mining
- Methane drainage consulting and directional drilling training
- Design and implement methane recovery and sale projects
- Managed and participated in numerous international directional drilling projects
- Expanded uses for directional drilling, e.g. exploration and dewatering
- >25 years experience
Coal is the most abundant fossil fuel. IEO predicts continued reliance and consumption of coal increasing by 50% by 2030.

Mining technology continues to evolve resulting in more rapid excavation and production techniques.

We continue to mine deeper, gassier and more challenging coal reserves. This has resulted in a need to improve methane drainage techniques.

Use of surface drilled methane drainage wells has been affected due to surface ownership, approvals, topography, culture, lack of equipment, etc.

Many coal reserves develop multiple coal seams and require flexible methane drainage approach.

Gas collection systems typically use steel pipeline and demonstrate significant erosion of gas quality from wellhead to surface.

There is a recognized need to mitigate methane emissions and demonstrate environmental awareness.

The international CMM industry shows tremendous growth and spread of upstream and downstream technologies.
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
OPTIMIZE VENTILATION AND METHANE DRAINAGE
Geologic and Reservoir Characteristics

- Gas content of the coal seam and shale is commonly determined through the “direct method.”
- Core or cuttings are placed in canisters.
- Simulate reservoir conditions.
- Monitor gas production from core/cuttings.
Geologic and Reservoir Characteristics

- Matrix permeability is the characteristic that affects the ability of gas (water) to flow through a material.

- Gas flow is also affected by cleat (face and butt) presence, spacing, and jointing.
Borehole Planning and Design

Reduction in Residual Gas Content as a Function of Drainage Time and Spacing of Cross-Panel Boreholes

Reduction in Residual Gas Content (%)

Months

300 ft Spacing
150 ft Spacing
100 ft Spacing
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
- Ability to steer borehole to stay in-seam or hit specific 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
Long Hole Directional Drills
VLD Series 1000 Track Mounted Directional Drill System

- Roof Stinger
- Rotation Unit
- DGS Uphole Unit
- Front Chuck
- Feed Frame
- Track System
- Stab Jack
VLD SERIES 1000 MODULAR DIRECTIONAL DRILL RIG

Modular system follows the same design principles as the track mounted system but is broken down into three main components - power pack, feed frame, and operator’s console - to be used in areas where access is difficult, or there is limited access from the surface.

Feed Frame
Power Pack
Operator’s Console
Water Power

![Graph showing GPM for CDP 70 and CDP 100]

- CDP 70: 60 GPM
- CDP 100: 120 GPM

![Images of hydraulic equipment]
Down Hole Motors

Torque

- 278/56
- 312/78
**Directional Drilling Technology**

- REI uses down hole motor directional drilling technology to accurately steer long holes in coal seams. A down hole motor, operating on the Moyno pump principle, converts hydraulic (water) energy to mechanical torque (bit) without rotation of the drill rods.
- Drillers control direction by orienting a bent housing behind the bit through rotation of the rods. The axial force exerted by the drill on the rods is distributed to the bit by the bent housing according to its orientation.
Drill Bits

- Polycrystalline Diamond Cutter (PDC)
- Impregnated Diamond
Borehole Surveying Instruments

- Real Time Surveying – DMM MECCA Instrument
Directional Drilling Technology

- Drillers maintain boreholes in-seam by monitoring down hole motor pressure, axial thrust, cuttings, and survey information.
- Using this system, drillers can develop tangential boreholes (side-tracks) to help maintain the borehole in-seam, correct trajectory, or develop multiple boreholes from one main branch.
NORTH AMERICAN RECORD

- October 6, 2006
- 1623 meters
Drilling Configuration

Grout (Cement)

PVC or Steel Casing

Roof

Reinforced Hose to Pipeline or Diffusion Line

Provisions for Gas Measurements

Blow Out Preventer

Stuffing Box

Valve

Drill Rod

Drill Rig

As Necessary

Overflow

Cuttings / Drilling Water
Valve and Blow Out Control
Gas Handling and Collection

Drilling and Post Drilling

- Both ends of Dilution Zone are lined with Canvas or Cement Block.
- Dilution Zone is Rock Dusted and kept free of Ignition Sources.
- Gas Flow Measurement Provisions are provided.
- Canvas Door is used at both ends.
- Return Air is directed towards the examination point.
- Dilution Zone is marked with Caution Signs and Fencing.
- Permissible Drill Rig Line Canvas with Posts (as necessary).
Gas Collection

Well head design:

- 4 inch Casing
- 4 inch Ball Valve
- 4 inch Spring Return Pneumatic Full Port Ball Valve
- 4 inch Check Valve
- 4 inch Flex Suction / Discharge Tube
- 4 inch Gauge
- 90 Deg Elbow
- P Gauge
- Veribar
- 4 inch Flex Suction / Discharge Tube
- 36 inches Schedule 40 (X3)
- 4 inch Tee
- King Nipple
- 1/2 inch Pipeline Integrity Line
- 1/2 inch Pipeline Integrity Line
- Sample Port
- 1/4 inch 1/4 inch 8 inch Blind Flange Clean Out
- Gas / Water Separator Tank
- 3/16 inch Gage Steel
- 14 inches X 36 inches
- 1 inch
- 4 inch
- 1 inch Y Strainer
- 5/8 inch X 3 1/4 inch Bolts / Nuts
- King Nipple
- 1 inch Hose (X3)
- Pneumatic Valve, Spring Open
- Pneumatic Valve, Spring Closed
- 2 inch
- 1 inch
- 1 inch
- 1/2 inch Float Valve with Sending Unit
- Gas Collection Tank
- 3/16 inch Gage Steel
- 14 inches X 30 inches
- 1/4 inch
Gas Collection
Methane Drainage Techniques

- Pre-Mining
- Gob Degasification
Ultra Long Boreholes

To Drain Gas Significantly in Advance of Mining:

- Borehole No. 5
- TD = 5040 ft

![Graph showing cumulative recovery and borehole lengths.]

- Cumulative Recovery (MMCF)
- Borehole Length (ft)
Methane Drainage

- Warrior Basin - Alabama
Methane Drainage

- Mexico – Case Study
- Pre-Mining - Long, In-Seam Directionally Drilled Boreholes:
Effect on Gate Road Development
MIMOSA #1 Mine

Methane Emissions, Airflow Requirements, and Advance Rate
Before and After Degasification for 2 West Developments, Mine I

- Advance Rate (10's of Meters Per Month)
- Methane Emissions (1000's of Cubic Meters Per Day)
- Airflow Rate (Cubic Meters Per Second)

500 m Borehole on Production

Months in 1994

October
November
December
January
February
March
April
May
June

Advance Rate
Methane Emissions
Airflow Rate

80
80
85

45
45
45
45
55
70

10
20
30
40
Gob Gas Drainage Techniques

- Vertical Gob Wells
- In-Mine Horizontal Gob Boreholes
- Cross-Measure Boreholes
- Longwall Panel
Design of Vertical CBM and CMM Wells

- Pumping Unit
- 13-3/8" Casing
- Blower
- 13-3/8" Casing
- 12-1/4' Open Hole

- No. 4 Coal Seam
- 5-1/2" Production Casing with Formation Packer Shoe
- No. 3 Coal Seam
- Rathole
- Longwall Mining Equipment
Methane Drainage

Gob Gas – Vertical Gob Wells

TO GOB WELLHEAD

10 5/8” BOREHOLE

7” OD. 6” CASING

FLOW WITHIN CASING

SLOTTED CASING (USED SOMETIMES)

5 5/8” OPEN HOLE

Mined SEAM
High Capacity Horizontal Gob Boreholes

Low Pressure Zone Created By In-Mine Horizontal GOB Boreholes

Gob Gas Flow (MCFD)

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<tr>
<th>Location</th>
<th>Flow (MCFD)</th>
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<tr>
<td>Cambria 33</td>
<td>450</td>
</tr>
<tr>
<td>Tiefa</td>
<td>350</td>
</tr>
<tr>
<td>Saarland</td>
<td>300</td>
</tr>
<tr>
<td>Willow Creek</td>
<td>400</td>
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Ukraine - Methane Drainage Approach

Degassing Boreholes Drilling Diagram

Drill Rig

9th South Panel

Conveyor Entry

Legend

Intake Air

Return Air

Ventilation Door

Crossing

Haulage Way

Water Sump

Southern Slope, 2nd Stage

Manway

Upper Coal Seam

Degassing Boreholes

9th South Longwall

Upper Coal Seam

Haulage Way

Manway

Southern Slope

2nd Stage
Horizontal Gob Borehole Design Considerations

- Near edges of the longwall panel where strata will be in tension.
- Parallel and along ventilation return (tailgate).
- On high elevation side of the gob.

- Above rubble zone (> 5 times mining height) to remain intact during undermining.
- Typical placement is 20 to 30 m above top of coal.

Krasnolimanskaya Mine
Liuzhuang is located in East China Coal Region. Faulting and fragile coals with low permeability makes in-seam drilling less effective.
Top: Retreat longwall mine employing 220-280 m x 1500-1700 meter panels

Currently, cross-panel in-seam boreholes are drilled from the tailgate 80-110 m long on 6-m spacing.

Boreholes probably stay in the lower half of the 4.5-m thick seam 13-1.

Bottom: Recommended changes to in-seam borehole drilling strategy

- Directional drilling equipment
- 19-m borehole spacing
- 225-m long in-seam boreholes should be feasible.
- Top and bottom of seam drained
- Similar residual gas content reduction with > CH₄ quantity/concentration
• **Top:** Cross-measure boreholes are drilled toward the retreating longwall face.

• Drill stations are spaced ~80 m along tailgate entry, ramped up 10 m into overlying strata.

• Boreholes up to 110 m long and 50-90 mm diameter are angled up 15-30° into the overlying rock strata.

• Stations are sealed and connected to vacuum.

• CMM is produced as panel is mined through and gob created. It later is isolated to limit ventilation air contamination.

• **Bottom:** Drilling gallery is developed in rock about 18-25 m above seam.

• Gallery is located along tailgate side of panel.

• Gallery is sealed to limit air influx.

• Gallery is connected to vacuum system.
Gob Drainage : RECOMMENDED

IN-MINE GOB BOREHOLES DRILLED FROM STATIONS ALONG THE TAILGATE ENTRY

- Current design could be replaced by long, 1000-m horizontal gob boreholes directionally drilled from the ends of the panel.
- Could accomplish similar results.

PLAN VIEW

CROSS SECTION VIEW
Benefits of Recommended Cross-Seam and Gob Borehole Improvements

- 75% fewer boreholes drilled (counting the tangential boreholes individually)
- 88% fewer drill setups, borehole collars, standpipes, and wellheads
- Same volume of methane recovered
- Fewer wellheads minimizes potential for air intrusion into gathering system, thus improving recovered gas quality
- Fewer boreholes reduces methane drainage costs
- Potential for reduction in drainage time by reducing borehole spacing
- Fewer boreholes provides for reduced time required for drilling
- Reduced residual gas contents improves mine safety
- Reduced residual gas contents enables increased coal production

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<tr>
<td>Current</td>
<td>5 -15</td>
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<tr>
<td>Recommended</td>
<td>40 - 70</td>
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Summary

• Acquisition of geologic and reservoir properties allows mine operator to optimize methane drainage technique rather than use “trial and error.”

• Evaluate alternatives from drill bit to burner tip (e.g. drainage techniques, equipment, well heads, pipeline, safety systems, surface facilities, and gas use options).

• Directional drilling will allow application of modern methane drainage techniques tailored to site specific conditions.

• Provides geologic information such as coal thickness/thinning, identification of faults, intrusions, other anomalies, old workings, etc., prior to mining.
REI Drilling
The source for your directional drilling needs
toll-free (877) 838-5614 www.reidrilling.com