Practise and Technology for Effective Methane Drainage and Utilization

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Pre-Drainage of Deep Coal Seams

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Erwin Kunz
DMT GmbH & Co. KG
Germany
DMT GmbH & Co. KG

- independent technology services in consulting & engineering, testing & certification, measuring, research & development
- fields of activity: mining technology, coke making technology, exploration & geosurvey, infrastructure & civil engineering, building safety, mechanical engineering & plant construction
- annual turnover: 95 mio. € (2008)
- 540 employees
- 16 government approved expert bodies for safety
- 3 accredited testing laboratories
- 75 accredited experts
  (e.g. underground gas emissions, ventilation, gas outbursts, monitoring systems)
- since 2008 member of TÜV Nord group
- subsidiaries: UK (IMC GCL), Russia (IMC Montan), India (IMC SRG), Canada (AGL)
References

- cooperation with German hard coal industry for more than 100 years
- consulting & engineering service related to gas emission control and gas outburst prevention in Europe, CIS, Asia-Pacific and America
- extensive consultancy, engineering and exploration services for 100+ CBM, CMM, VAM and AMM recovery & utilization projects in Europe, CIS, Asia-Pacific, America and Africa
- significant role in building up Germanys AMM and CMM industry with > 220 MW_{el}
Overview on “Gas”

**Exploration**
Gas content, strata sequence, coal characteristic

- Gas emission forecast
- Assessment of gas release

**Gas emissions low**
Gas emissions controllable by ventilation

- Ventilation layout
- Bleeder systems
- Effective dilution

**Gas emissions high**
Gas drainage required

- Roof/ floor boreholes
- Surface boreholes
- Drainage roadways
- Drainage of sealed off areas

**Gas outburst risk existent**

- Pre-drainage
- Surface to seam
- In-seam

**No gas outburst risk**

- Identification of hazard
- Gas outburst prevention
- Control of residual risk

**Gas flow and methane concentration**

**Gas utilization**
Overview on “Gas”

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Pre-drainage
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Drainage of sealed off areas

Drainage roadways
Surface boreholes

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No gas outburst risk

Identification of hazard
Gas outburst prevention
Control of residual risk

Mine Safety first!

Gas flow and methane concentration
Gas utilization
Gas emission control

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Gas emission forecast
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Gas emission low
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Gas emission high
- Gas drainage required
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    - Surface boreholes
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    - Drainage of sealed off areas
  - In-seam
    - Surface to seam
    - Drainage of sealed off areas

Assessment of gas outburst risk
- Gas outburst risk existent
- No gas outburst risk
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Gas flow and methane concentration
- Gas utilization
German experience

- depth up to 1500 m, permeability usually < $10^{-3}$ mD
- underground in-seam drilling, surface drilling (tested during 1990ties)
- wide range of drainage efficiency in different seams
- reduction of gas content up to 70 % at 6 - 12 month pre-drainage
Pre-drainage
Reduction of gas content - 12 month
Pre-drainage
Reduction of gas content

Reduction of gas content

Gas content [m³/t]

Borehole length [m]

790 m

Coal face

Gate road

Pre-drainage borehole

Borehole for gas content test

Pre-drainage borehole
Pre-drainage
Volume flow

CH$_4$ volume flow [m$^3$/d]

Date

D = 50mm
L = 150,0m

$\dot{V} = 6.2e + 131e^{-0.0086t}$

$R^2 = 0.75$

150 m$^3$/d ~ 0.1 m$^3$/min
Pre-drainage
Influence of water

![Graph showing CH4 volume flow vs time]

- CH4 Volume flow [m³/d]
- Time [d]

www.dmt.de
Pre-drainage
Without pressure relief

Drainage efficiency [%]

Time [d]

Residual gas content [m³/t]

\[ a = 142.45 \times (e^{-0.0291t} - 1)/(-0.0291 \times 21590) \]
Pre-drainage
With pressure relief

\[ a = 211.93 \cdot (e^{-0.0084t} - 1) \cdot 100/(-0.0084 \cdot 28930) \]
- gas content 15 m³/t
- low permeability of coal
- seam thickness < 1 m
- coal production 2100 t/d
- maximum CH₄ concentration 1.3 %
- gas emission coal face max. 11.3 m³/min – limit !
- gas emission gob max. 55 m³/min, 33 m³/min drainable
no success by increasing gob drainage efficiency and ventilation air flow only

ventilation air flow of coal face limited by cross section

pre-drainage 1\textsuperscript{st} option

10 \% reduction of gas content results in +230 t/d
Strategy gas emission control

- Gas source?
- Possible options (low effort, best result):
  - Increasing ventilation air flow?
  - Effective dilution of gas?
  - Adjusting operation of shearer/plough?
  - Improving gob drainage efficiency?
  - Pre-drainage?
- Access to the coal & available pre-drainage time?

- Planning of gas drainage scheme
Gas outburst prevention

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Roof/ floor boreholes
Surface boreholes
Drainage roadways

Pre-drainage
Surface to seam
In-seam

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Gas flow and methane concentration
Gas utilization

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Gas outburst prevention at RAG anthracite mine – cooperation for 30+ years

Basic conditions
- multiple seam mining, depth up to 1500 m
- seam thickness around 1 m
- gas contents up to >20 m³/t
- low permeability (~10⁻⁴ mD)
- gas outburst hazard present

Work performed
- development, planning & inspection of gas outburst prevention
- gas outburst risk assessment
- expert reports, cooperation & coordination with mining authorities
- inspection of gas & ventilation monitoring systems
- training of technical personnel
- research & development
Pre-drainage – 7 month

- Total gas content
  - Residual gas content
  - Desorbable gas content

- Borehole depth in meters

- Gas content at methane pressure 1 bar
  - 20.2 m³/t
  - 3.4 m³/t
  - 16.8 m³/t

- Gas content in methane pressure 1 bar
  - 19.0 m³/t
  - 3.4 m³/t
  - 15.6 m³/t
## Permeability

<table>
<thead>
<tr>
<th>Coal field</th>
<th>Permeability [mD]</th>
<th>Pre-drainage / CBM</th>
</tr>
</thead>
<tbody>
<tr>
<td>San Juan, USA</td>
<td>1.5 - 50</td>
<td>successful</td>
</tr>
<tr>
<td>Black Warrior, USA</td>
<td>0.5 – 25</td>
<td>successful</td>
</tr>
<tr>
<td>Karaganda, Kazakhstan</td>
<td>$10^{-4}$</td>
<td>difficult</td>
</tr>
<tr>
<td>Ibbenbüren, Germany</td>
<td>$7 \times 10^{-3} - 10^{-4}$</td>
<td>not successful</td>
</tr>
<tr>
<td>n°54 seam (virgin pressure)</td>
<td>$2.9 \times 10^{-4}$</td>
<td></td>
</tr>
<tr>
<td>n°54 seam (over mined at +22 m)</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>n°57 seam (virgin pressure)</td>
<td>$3 \times 10^{-3}$</td>
<td></td>
</tr>
<tr>
<td>n°57 seam (over mined at +26 m)</td>
<td>$1.6 \times 10^{-1}$</td>
<td></td>
</tr>
</tbody>
</table>
Hydro frac

source: Halliburton

<table>
<thead>
<tr>
<th>Fracture Curve</th>
<th>Half-length, ft</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>100</td>
</tr>
<tr>
<td>B</td>
<td>200</td>
</tr>
<tr>
<td>C</td>
<td>300</td>
</tr>
<tr>
<td>D</td>
<td>400</td>
</tr>
<tr>
<td>E</td>
<td>500</td>
</tr>
<tr>
<td>F</td>
<td>600</td>
</tr>
</tbody>
</table>

Cumulative Gas, MMscf

Permeability, md

source: Halliburton
Exploration and pressure relief drilling
Exploration and pressure relief drilling

not over mined

over mined
Exploration and pressure relief drilling

Diagram showing the drainage of deep coal seams with different angles and depths indicated.
De-stressing by drilling

Incline < 10°

5 m

heading

5 m

maximal length of development

10 m

borehole 1b
borehole 1 – indications
borehole 1f
borehole 2 – indications
borehole 2f
borehole 3
borehole 4
Strategy gas outburst prevention

- Origin of gas outburst?
- Coal properties (permeability, desorption characteristic)?
- Drillability of coal prone to gas outbursts?
- Can 100% safety be achieved by pre-drainage?

- Research & Development
- Experience, monitoring and ongoing data acquisition & analysis
- Effective flow and use of information
- Combination of different methods
Gas production & utilization

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**Gas flow and methane concentration**
**Gas utilization**
Gas qualities

- **VAM** (<1% CH₄)
- **CMM (~5-50% CH₄)**
- **CMM (~5-90% CH₄)**

Diagram showing intake air, return air, old workings, coal face, and development.
Underground CMM drainage & VAM

- Roof boreholes
- Drainage roadway
- Intake air
- Return air
- Pre-drainage
- Floor boreholes
- Coal face
- VAM
Strategy gas utilization

- Gas production only or pre-drainage & gas utilization?
- Reservoir properties (gas content, gas pressure, permeability, water, cleats ...)?
- Drillability of coal (seam thickness, tectonic, coal structure ...)?
- Time gap available for pre-drainage?
- Targets for mine safety / reduction target for gas content?
- Market (gas, power, heat, carbon credits)?

- Proper exploration
- In-depth feasibility assessment
- Combining mine planning and gas production planning in early stage
- Gas management
Thank you!

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