Report on the second UNECE/GMI workshop on "Best Practice Guidance for Effective Methane Drainage and Use in Coal Mines"

Karaganda, Kazakhstan, 4 October 2016

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Introduction

In order to contribute to improving mine safety practices and mitigating methane emission worldwide, the organizations that supported the workshop in Karaganda, Kazakhstan (UNECE and Global Methane Initiative – GMI) developed a publication "Best Practices Guidance on Effective Methane Drainage and Use in Coal Mines". The publication covers the benefits, objectives and principles of coal mine methane drainage and utilization in order to reduce fatalities and injuries of mine workers, protect mine property, reduce greenhouse gas emissions and efficiently utilize valuable environment-friendly energy resources.

One of the key principles of developing the best practice guidance is securing exposure to a wide professional audience around coal fields in different parts of the world that may adopt some of described best practices and techniques as a part of their regular coal mining activities. At the same time, since the best practice guidance is an "active" document being updated on regular basis, these professionals also may contribute with relevant comments and cases from actual practice. Thus, the best practices guidance is being disseminated to a targeted audience over regional workshops close to the main coal mining regions with historical experience in problems and accidents related to methane gas release into longwall and goaf areas of coal mines.

The main purpose of the workshop in Karaganda (Kazakhstan) was to attract attention and discuss the most critical problems faces by deep mines operated in Karaganda coal basin and present potential solutions based on best international CMM practice in these regards.

1. Background

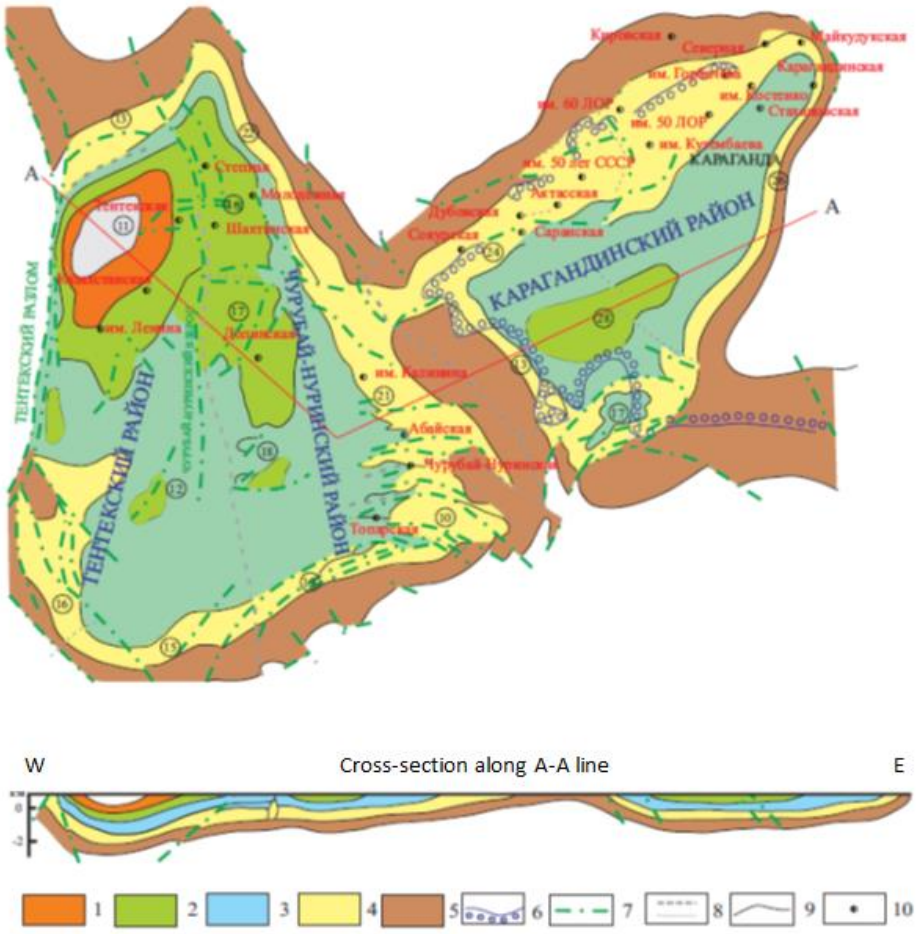
Coal mining is one of the key industries of Kazakhstan economy. Kazakhstan is considered in the first ten leaders by the volume of coal reserves after China, USA, Russia, Australia, India, South Africa and Ukraine.

All deep coal mines in the country are located in Karaganda coal basin and owned by Coal Division of ArcelorMittal Temirtau JSC (hereafter 'AMT'). The company currently operates 8

underground mines in the Karaganda Oblast (region) of the Republic of Kazakhstan. The mines produce around 11.5 million tons of metallurgical & steam coal per annum.

The coal mines in Karaganda basin are extremely gassy with in-situ methane contents ranging from 8.5 up to 28 m3/ton and higher. The methane is currently extracted from the mines for safety reasons by means of ventilation, pre-drainage and post-drainage methods (with application of the majority of the available up-to-date techniques). Current overall methane emission at the mines reaches up to 350 mln.m3/a.

Schematic geological map and cross-section along the main part of Karaganda coal basin (by V.N. Bekman)



1 – 5 - Tentekskaya, Dolinskaya, Nadkaragandinskaya, Karagandinskaya and Ashlyarikskaya suites accordingly; 6 – contour of Jurassic sediments; 7 – faults; 8 – boundaries (a - coal bearing areas; b - sites); 9 – coal seams; 10 – mines (including abandoned); figures in circles – coal bearing sites (11 – Tentekskiy, 12 – Karagachskiy, 13 – Manzhinskiy, 14 – Sasykolskiy, 15 – Taszaimskiy, 16 – Karajaro-Shakhanskiy, 17 – Dolinskiy; 18 – Kolpakskiy, 19 – Kichkinekolskiy, 20 – Southern, 21 – Central, 22 – Northern, 23 – Alabasskiy, 24 – Saranskiy, 25 – Industrial, 26 – Maikudukskiy, 27 – Taldykudukskiy, 28 – Dubovskiy)

Courtesy of Coal Division of AMT

AMT provided historical information on the volumes of gas released along with some projections for Deep Gassy Coal Mines of Karaganda Coal Basin study prepared for the U.S. EPA Coalbed Methane Outreach Program by the Methane Center, Kazakhstan, through an Interagency Agreement with Pacific Northwest National Laboratory in 2011 and a pre-feasibility study sponsored by the USEPA and GMI and conducted in 2012 by Eastern Research Group, Inc. (Massachusetts, US), with support from HEL-East Limited (UK) and Ruby Canyon Engineering (Colorado, US), to enable better understanding of the potential for CMM drainage and utilization across six of the most gassy coal mines in the area. The pre-feasibility study revealed there is vented CMM distributed across these mines with the equivalent electrical generation capacity of over 40MWe.

Table 1. Key CMM/VAM details of AMT mines (Karaganda coal basin)

Item	Value	Meas. unit
Number of active mines	8	pcs
Methane drainage units: Mobile drainage stations Stationary drainage stations	 29 13	 pcs pcs
Coal production by AMT mines	11.4	mln.t/a
Drainage system produced CH4 with concentration >30%	57-148	mln.m3/a
Drainage system produced CH4 with concentration from 20% to 30%	35-80	mln.m3/a
Ventilation system produced CH4 with concentration 0.2-0.73	260	mln.m3/a
Gas temperature at the outlet of the drainage system	about + 30	Degree C, depending on ambient temperature
Gas pressure at the outlet of gas drainage system	100 to 150	mbar
Moisture content of methane-air mixture	about 70	%
Power consumption of AMT mines	461	mln.kW/a

ArcelorMittal recognizes that its core business activities in the Karaganda region are steel production and coal mining, and that for this project to be successful the company needs an experienced long term strategic partner to work with in order to maximize this investment opportunity. Thus, AMT is looking for partners with proven expertise in CMM capture and Power & Heat Generation.

2. Survey

The survey arranged through a questionnaire, distributed over CMM related specialists at the all active underground mines of Karaganda region, was called to help the workshop team to arrange the event in a way to address the coalmine gas management issues relevant to the local mining conditions in the most appropriate manner (*example of a filled-in questionnaire is attached in the Annex 1 to the report*).

To be more focused the survey contained the following sections:

- General Questions
- Gas Drainage and Ventilation
- Methane Utilization

The sections covered 12 question with mining conditions, application of different methane drainage techniques, gas use and critical problems to be discussed. As a result all the respondents selected at least half of the issues listed below and up to 90% selected all of the following:

- Pre-drainage efficiency in conditions of low permeability
- Prevention and control of coal and gas outbursts and existing best practice
- Stability of subsurface pre-drainage boreholes
- Utilization of mine gas from drainage system
- Utilization of ventilation methane
- Effective practice of incentives for mine gas utilization.

The invited international experts were informed accordingly so that they arrange their presentations to meet expectations of the local audience and prepare to further discussions.

3. Opening remarks

Dr. Gazaliyev, Rector of Karaganda State Technical University (KSTU), as the host party of the workshop, gave an introductory speech, introduced all the participants and encouraged local colleagues to use this unique opportunity of first-hand discussions between the participated international CMM experts (members of the UNECE Group of Expert on Coalmine Methane) and local coalmining specialists.

Mr. Branko Milicevic, the Secretary of the Group of Experts on CMM, Sustainable Energy Division of UNECE, introduced the purpose of the workshop and gave a general overview of the Group of Experts and the Best Practices along with the Chairman of the Group of Experts.

As local experts, Evgeniy Alexeyev, UNECE Consultant, and Dr. Sergazy Baimukhametov, Advisor to the Coal Division of AMT gave an overview on current status of CMM sector in Kazakhstan and results of the survey above.

Courtesy of "KAZPRAVDA"

4. Presentations of international and local experts

First part of the program formal presentations on the "Best practice guidance…" and analysis of the workshop survey results mentioned above as well as overview of GMI, its achievements and activities in Kazakhstan, provided by Volha Rochanka of PNNL (USA).

Dr. David Creedy (UK) presented Best practice gas control and explosion prevention including a practical risk assessment tool that is recommended to use in these regards.

Ray Pilcher, President of Raven Ridge Resources (USA), gave a practical presentation on application of Advanced drilling technology and well designs in overpressured formations.

Clark Talkington of Addvanced Resources International (USA) presented Best practices in CMM utilization for Achieving Near-Zero Methane Emissions from Coal Mine Mining.

Courtesy of "KAZAKHSTAN KARAGANDY"

Evgeniy Romanov of UMG/DTEK (Ukraine), provider a brief on current CMM status in Ukraine and UMG strategy on utilization of wastes from coalmining and power station operations, including CMM as one of the key targets.

Prof. Drizhd of KSTU (Kazakhstan) made presentation on pilot CBM extraction activities in Karaganda coal basin covering main relevant statistical data and technical challenges faced while preliminary drainage of coal seams from the surface.

5. Open discussion

Branko Milicevic articulated that the main goal of activities of the Group of Experts is to contribute to mine safety and mitigation of climate change due to methane emission to the atmosphere. The presented "Guidelines…" provides base principles for governmental agencies,

managers and politicians. It was explained to the audience that international experts cam to Karaganda not to teach local miners to do their work but to discuss actual problems with regards to local mining activities in light of the best proved international practice. The meeting would not help to resolve global problems but to discuss relevant possible approaches and to learn for each other. A similar workshop was held in China and other ones are planned for Ukraine and India.

Further open discussion was actively supported by financial and technical experts representing coal mines of AMT and other local stakeholders.

Thus the issues of financial compensation and relevant incentives for CMM utilization involved financial management of AMT, representatives of GMI and UNDP. Financial Director of AMT expressed the company interest in use of the drained methane but also explained the economic obstacles restraining from further investment into CMM projects. The discussion was supported by Yerbol Suleimenov of UNDP, Astana. He noted that his group is currently involved in development of a so called "Green funding center" that supposed to provide an alternative instrument for such environment-oriented projects in different areas that may also include CMM.

Another topic of the discussion was related to specifics of local geological conditions, drilling practice of AMD drainage teams and possible testing/adapting of advanced methods of drilling related to controlled directional drilling to target specific zones of gassy and outburst dangerous coal seams in order to prevent gas and coal outbursts, improve safety and performance of mining activities.

Thus this part of the open discussion was focused on the following specific problems of methane drainage and safety operations in Karaganda basin: The Coal Division of AMT has a special sub-divisione responsible for these issues that draines up to 150 mln.m3 of methane per year from the company mines. At certain mining sites gas emission reaches up to 150- 200 m3 per minute and the existing drainage system, at these conditions, captures up to 80 % of the gas. The Coal Division designed a complex program on increase of methane capture from the coal mines and seams and involves leading international service companies to elaborate a proper solution. However, the problem of spontaneous outbursts of coal and gas is still there as well as the issues of prediction of dangerous zones, mitigation of gas content of the coal seams at the depth over 500 meters due to their very low permeability. The lack of geological surveying (exploration wells were placed 250 – 500 meters apart), zoning of gas content of the coal seams, complicates

prediction of the volumes of gas release at the working areas. For instance, at Saranskaya mine the overall gas release at the working area fluctuates in a range of 4 times (from 50m3 up to 503 per minute) at the same rate of coal production.

Regulatory documents on prevention of spontaneous outbursts of coal and gas while building headways were designed on the level of understanding of geomechanical processes of the 1960–s and do not consider achievements of modern computing technologies.

Provision of pre-drainage in conditions of their low permeability remains being the most critical issues. All the drainage measures currently undertaken at the coal mines of Karaganda area do not allow decreasing gas content of the seams for more than 15-20%. A special problem in this light is mitigation of gas content of the lower part of seam D6 that is considered highly dangerous in terms of outbursts. Thus, having extensive experience in drainage of mine gas AMT mines still have critical issues to work on and are keen to involvement of international experts to generate relevant solution in these regards. This year the company was faced a problem of gas-dynamic occurrence in longwall that did not happen earlier in the history of coal mining in Karaganda.

With regards to the issues above, AMT involved DMT (Germany) that currently analyses the collected data in order to elaborate relevant recommendations.

Another issue the specialists of AMT were interested to discuss is application of directional drilling rig VL1000 for drilling of long drainage boreholes. Unfortunately, the company was unable to master drilling boreholes in coal with this rig and invited "REI drilling" to assist in resolving the issue. AMT also welcomes any other possible cooperation with international expert that lead up to generation of a practical solution.

By words of Dr. Sergazy Baimukhametov, Advisor to the management of AMT Coal Division, local mines really require some relevant assistance from outside. That should include not only advisory on mine gas management practice, but also possible financial solutions to make integrated CMM projects economical. Coal enterprises of Karaganda region emit to the atmosphere about 350 million cubic meters of methane per annum, including 70 million m3 of

gas of conditioned concentration. This gas may be used as an alternative energy resource but so far the manes have knowledge and capabilities to use a minor part for heating of mine facilities and pilot power generation with a CHP unit at one of the mines.
AMT had some attempts to attract investors to use CMM resources more efficiently and reduce emission but did not succeed so far. The company hopes the situation will change soon and these efforts will get support at the governmental level. The new management of the Coal Division of AMT is actively involved in work on these issues looking for a contractor(s) that would take care of utilization of CMM generated by mines of the company.

By top managers of the Coal Division the company pays significant attention to the issues of safe gas drainage. Thus, for instance, degasification teams drain up to 150 mln.m3 of methane from coal seams, when, while operation of some mine sites, up to 150-200 m3 of pure methane is released into the longwall areas. Such a situation happens at Saranskaya mine. In order to deal with this problem and reduce risk of release of large volumes of gas into mining areas the company had to involve foreign specialists. However, the problem is not solved completely yet. In particular, with regards to spontaneous coal and gas outbursts and relevant prediction of dangerous zones.

Unfortunately, by gas drainage specialists working in Karaganda coal basin, preliminary drainage of coal seams currently provides rather small gas output with regards to overall gas drainage at the mines mainly due to low permeability. AMT involved German experts in these regards that helped to improve methane drainage at Kazakhstanskaya mine and reach 60 percent of drainage efficiency. At the same time, as noted above, the company acquired a directional drilling rig to pre-drain gas prior to development and mining operations but local specialists are still unable to operate it due to softness of coal of the most gassy seams that has a certain impact on safety and production performance.

Besides, there are some institutional problems. Even the mines use modern machinery and technologies regulatory documents governing mining activities in the country are dated back to

the 1960-s.

As noted by Ray Pilcher, Chairman of the Group of Experts on Coalmine Methane of UNECE, it is indeed the main goal of this professional meeting to provide a first-hand opportunity to discuss the issues above and to build a bridge for further consideration of possible relevant solutions. Mr. Pilcher stated the task is to try to make methane drainage a profitable activity but at the same time environmental friendly so that it would be beneficial from safety and ecological prospective as well as to bring some economical dividends. In order to reach that stage it is necessary to analyze all relevant methods and techniques of coal gas extraction applied around the world. That is a huge job. Thus UNECE and GMI initiated collection of best practice applied in different countries to help mining and gas drainage professionals to learn from each other.

By Volha Rochanka, representative of PNNL/GMI they have been cooperation with Kazakhstan for several years and already have some results of relevant studies. GMI maintains partnership with 43 countries around the world. Kazakhstan is represented by the Department of Coal Industry Development of the Ministry of Energy and national gas operator KazTransGas. The mission of the Initiative is to help to reduce methane emissions, overcome information and technical barriers by using practical experience of other countries. There are some relevant project opportunities, including sale of coal methane as a natural fuel. Implementation depends on geological specifics and mining conditions, incentives from the government. In case of Kazakhstan it may be more economically viable to use drainage methane for energy purposes due to its high concentration. It should be discussed further on in more details with relevant specialists. It is necessary to consider many project elements and anticipate risks.

6. Outcomes and concluding comments

Based on the fact that all the presentations were well received and followed up with active discussion it is possible to say that even having reached high proficiently in implementation of different drainage techniques CMM specialists of AMT still express great interest in cooperation

with international experts and are faced critical problems due to specifics of local conditions. Thus, the workshop provided a platform for the initial discussion.

CMM utilization in Kazakhstan is still a subject to project economics due to the absence of any stimulation mechanisms after completion of the Kyoto term in 2012 and thus, relevant alternatives have to be discussed to reset the process. In this light assistance of international experts in elaborating of efficient governmental policy on CMM would be greatly appreciated by the coal mining industry.

To sum up the meeting discussion Ray Pilcher, Chairman of the UNECE Group of Expert on Coalmine Methane, commented that mine methane is a complex problem with many elements and aspects. It deals with issues of safety and the environment and at the same time provides viable opportunities to apply waste utilization technologies, exploiting on alternative energy resources. With regards to Karaganda coal basin the issue of mine safety has certainly to be given the first priority. However, at the same time mining activities cause significant contribution to greenhouse effect due to large volumes of methane being vented to the atmosphere.

By Dr. Pilcher the results with regards to management of coalmine methane may be reached while combining of the three main pillar of CMM project development – social, environmental and economical. A certain governmental stimulation policy is required to gain success in these regards.

How to benefit from using the dangerous energy resource is a clear but complex question. Coal companies all over the world are focused on coal production as their core business. They traditionally consider CMM as a waste resource that costs nothing. At the same time this gas actually has a certain value. The international experts noted this situation as a mental issue. There is a widespread understanding that mine gas utilization technologies are very expensive and are not economical to apply without certain incentives. Thus, one of the solutions is so-called “green-oriented” funds that provide financing for implementation of such projects on favorable terms.

Courtesy of "KAZAKHSTAN KARAGANDY"

Dr. Nikolai Drizhd, Professor of KSTU, noted the following relevant legislation steps undertaken in Kazakhstan:

- On April 28, 2016 the President signed the Law "On transfer of RK to a "green economy".

- Some amendments on coal methane and obligatory degasification of coal fields were included in the Code "On subsoil and subsoil use".

- The government released a decree on negotiation of contracts on subsoil use for exploration and production of coal methane.

Dr. Drizhd added that at the same time in order to provide sufficient basis for the new industrial fuel and energy segment of coal methane it is necessary to move further with legal issues. It is necessary to legalize the status of coal methane and elaborate a special relevant state program. The program, besides others, may cover such provisions as concessional taxation and investment preferences.

International experts thanked the host party of the event and all the local participants for their contribution to the discussion and confirmed commitment of the Group of Experts on Coal Mine Methane to maintain dialog with local professional community and to keep the Best Practice

Guidance… active to reflect advances in CMM drainage and use as a virtual facility providing exchange of relevant practical experience in different conditions.

7. Publications on the workshop in local media:

The workshop was followed up with the following relevant articles in local press and electronic media:

- "Industrial Karaganda" (newspaper) - http://inkaraganda.kz/articles/142611
- "Association of Mining and Metallurgical Enterprises of Kazakhstan" - http://inkaraganda.kz/articles/142611
- "KazInform" (information agency) - http://www.inform.kz/kz/paradoksy-shahtnogo-metana-ot-istochnika-tragediy-do-nesmetnyh-bogatstv_a2962004
- META.KZ - http://www.meta.kz/497116-nevidimyy-shahtnyy-ubiyca.html
- "KazPravda" (newspaper) - http://www.kazpravda.kz/articles/view/metanu-trebuetsya-investor1/
- "24 KHABAR" (national TV-channel) - https://www.youtube.com/watch?v=qdUEtCxSNck
- MetalMiningInfo (industry information portal) - http://metalmininginfo.kz/archives/4334
- "KAZAKHSTAN KARAGANDY" (regional TV-channel) - http://kartv.kz/ru/news/society/gaz-metan-nuzhno-ispolzovat-na-100-schitayut-mezhdunarodnye-specialisty

ANNEX 1

Example of filled-in survey questionnaire

Шахтинская

ОПРОСНИК

Круглый стол по передовой практике по эффективному извлечению метана и его использованию на угольных шахтах

Караганда, Казахстан, 2016 г.

Уважаемые господа,

Просим вас ответить на несколько вопросов, приведенных ниже. Данный опрос имеет целью помочь нам организовать круглый стол 4 октября 2016 г. таким образом, чтобы более подробно рассмотреть вопросы управления шахтным газом, имеющие отношение непосредственно к вашим условиям горных работ.

Общие вопросы:

1. Область вашей спеуиализации на шахте:
   - Дегазация Да
   - Безопасность Да
   - Использование газа Да
   - Прочее (пожалуйста, уточните) проветривание
2. Применяются системы сплошной отработки лавами, камерно-столбовые, или и те и другие? длинными столбами по простиранию
3. Шахта использует прямоточную или возвратноточную систему вентиляции в лавах? возвратнототочную
4. Шахта разрабатывается многоуровневым методом, т.е., сверху вниз (от самого неглубоко залегающего пласта к самому глубокому, или наборот)? сверху вниз (от самого неглубокого залегающего пл. к самому глуб.)
5. Имели ли место на шахте аварии, связанные с метаном (пожары или взрывы) в последние три года? Если да, то, пожалуйста, опишите их. нет
6. Имеется ли на шахте статистика по газовым выбросам? Да
7. Имеет ли добываемый уголь склонность к самовозгоранию? Да

Дегазация и вентиляция:

8. Какие технологии дегазации применяются на вашей шахте:
   - Скважины с поверхности в выработанное пространство Да

Example of filled-in survey questionnaire (2)

- Предварительная дегазация с поверхности нет
- Подземная предварительная дегазация да горизонтальны скважины по пласту да дренажные выработки да
- Скважины в купола обрушения нет
- Прочее (пожалуйста, уточните) в верхний куток лавы

9. Какова основная проблема шахты к отношении эффективности ее систем управления метаном? сроки дегазации.

Использование шахтного газа:

10. Имеется на вашей шахте какая-либо практика утилизации газа:
    - Использование метана дегазации да
    - Использование вентиляционного метана нет
11. В случае утилизации, газ используется в целях:
    - Отопления да
    - Генерации электроэнергии нет
    - Прочее (пожалуйста, уточните) нет

Круглый стол:

12. Какие дискуссии вам бы хотелось рассмотреть во время дискуссий круглого стола:
    - Эффективность предварительной дегазации в условиях низкой проницаемости да
    - Предотвращение и контроль угольных и газовых выбросов, имеющийся передовой опыт да
    - Стабильность скважин подземной предварительной дегазации да
    - Использование шахтного газа системы дегазац да
    - Использование вентиляционного метана да
    - Эффективная практика поощрения использования шехтного газа да

CASE STUDY 1: Gas drainage gallery (subsurface pre-drainage)

Background information:

The coal seams mined by AMT mines are considered to be highly gassy with inherent methane contents of 8.5 – 27 m3/ton. Thus the mines have been active implementing advanced methane drainage techniques in order to improve and sustain drainage capture efficiency and mine safety. One of the most dangerous coal seams developed by Karaganda coal mines is D6. The seam is a thick high quality coking coal, with a very distinct shear zone (0.2-1.2 m) in the bottom section. The D6 seam has been found to be extremely outburst prone, particularly in the lower bank. The permeability of the seam is extremely low and wet drilling through the bottom section zone has to date been found to be most challenging, most probably because of the soft coal within the shear zone and swelling clays within the seam itself. The diffusion coefficient of the bottom section has also been found to be several orders of magnitude greater than the top section of the seam.

D6 is being developed by Lenina and Kazakhstanskaya mines known for series of accidents with fatalities caused by gas outbursts and explosions. After the accidents mining activities there became more careful and initially the roadways on coal advanced no more than 50 meters a month. That negatively affected operation efficiency of the available heavy-duty equipment and overall economics of the mine activities.

Solution:

There was a decision made to implement a new drainage method: another roadway was built under the gassy seam and boreholes drilled from there towards D6 with a purpose to drain gas downwards from the coal face just before the front abutment, where the strata becomes de-stressed. Thus a certain efficiency of pre-drainage was reached. A headway (gallery, width of 5,7m) driven in the floor rocks 10 meters below the mined coal seam along the future longwall gate. The gallery is set up only for drilling of the fans of five up-holes (see the Figure 1 below). After the passage of the longwall face the roof is deformed, the support is left in place, the access is prohibited.

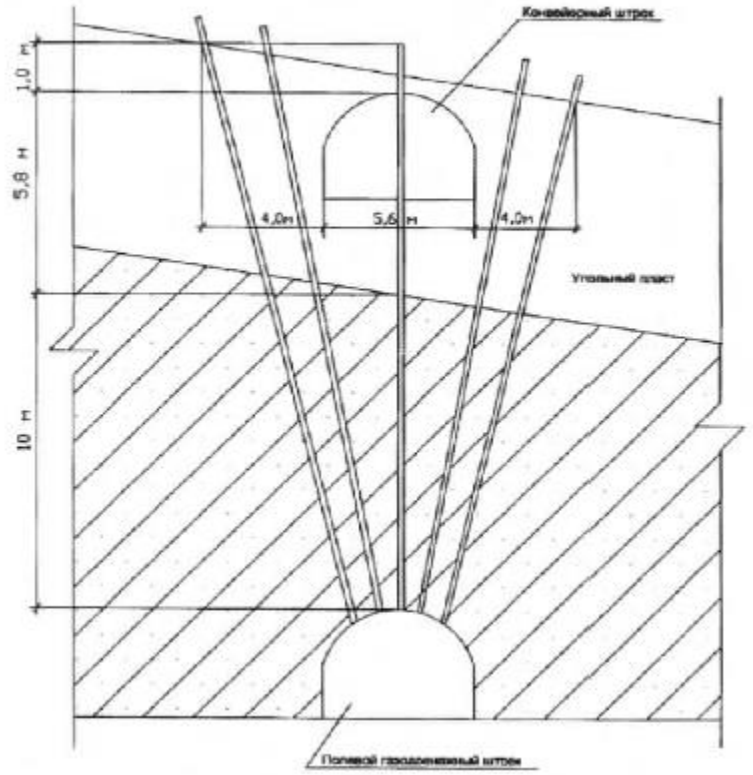


Figure 1. Drainage gallery (pre-drainage) - *Courtesy of Coal Division of AMT*

Borehole length is 17 – 19m, borehole diameter 93mm, standpipe diameter 80mm, standpipe length 12m. Standpipe is said to be sealed by synthetic resin. The final section of the borehole is cased with perforated pipe (dia. 80mm). The span of borehole fan is 4m. The boreholes are connected via 2“ rubber hose to pipe manifold that is linked with a rubber hose to the reticulation system. There is no regulation valve at the borehole valve, at some boreholes simple „valve“ is stabbed in the hose for gas sampling. Flow rate is measured in the orifice meter installed in the pipeline for the whole gallery. Methane concentration is less than 20%. Boreholes must be ready for gas drainage more than 3 months before the start of the longwall face. The boreholes are disconnected just after the passage of the longwall face. The gallery is supported with steel arches and steel bolts.

Results of implementation:

As a result the company did not come up to any serious outbursts over the last five years. The applied technique above made it possible to drain enough gas to provide opportunity to mine this coal seam. Application of this technique allowed increased development rates in seams to be implemented from 25-40m per month to 120-150m in the outburst prone areas. The solution is not cheap for the mine operator. However, the extra costs were paid back since it increased the speed of drifting over the working seam up to five times.

CASE STUDY 2: CBM as a pre-drainage solution

Background information:

Coal methane reserves of Karaganda coal basin up to the depth of 1500 m comprise 490.47 billion m3 (KazTransGas JSC). High gas content of coal seams and coal-bearing strata cause significant problems for underground coalmining activities. At the same time methane content in the gas of Karaganda coal varies from 80 to 98% that makes it a viable potential alternative to natural gas.

Experience of CBM extraction in Karaganda basin for mine safety purpose traces back to 1960-ies. Specialists of "Karagandaugol" IE (main coal mining enterprise in the region for that time) jointly with scientists of Moscow Mining Institute (university) held scientific studies and pilot activities on steered hydraulic fracturing of coal seams at mines of Karaganda coal basin. The key purpose of these activities was reduction of natural (inherent) gas content and outburst probability of thick coal seams K12 and D6. Coal Division of Arcelor Mittal Temirtau maintain some of these activities until present time. The most significant input in elaboration and implementation of these studies was made by Professors N.A. Dizhd, S.K. Baimukhametov, N.H. Sharipov, Doctors I.A. Shvets, K.D. Li, F.A. Mullagaleyev and others.

Historically the pre-drainage activities were secured by drilling of vertical wells from the surface into virgin coal strata followed by hydraulic stimulation of the most outburst-dangerous seams to drain gas by formation pressure or with vacuum-pumping stations. Due to very low permeability of Karaganda coal seams application of this technology resulted in well yield of 0.2-0.7 m3/min at best. However, long-term draining through these wells over 5 to 7 years was able to provide reduction of inherent gas content of the coal for 6-9 m3 per ton of reserves or up to 25-35% at methane concentration in the drained gas reaching up to 85-95%. Since the subsurface gas drainage system of the coal mines is connected with vacuum-pumping stations as well leakages in the pipes reduce quality of the gas and complicate its utilization. Besides, coalmining operations go deeper these days that makes traditionally applied drainage techniques insufficient to secure safe working environment. However, application of expensive modern technologies to pre-drain gas from the surface may have negatively affect cost of the coal production.

Solution:

In light of the above, JSC "KazTransGas", the national operator in the field of gas and gas supply, pursuant to the President's instructions, starts in 2015 to conduct exploration CBM in the framework of a cooperation agreement with a subsoil user of JSC "National Company" Socio-Entrepreneurial Corporation "Sary-Arka" in the Karaganda coal basin. After carrying out exploration work results will be obtained about the prospects of gas-bearing Karaganda coal basin and made recommendations for future phased transition to the implementation of industrial mining operations. Stage of development of the project JSC "KazTransGas" for the extraction of coal-bed methane involves three stages. Industrial extraction of methane is planned in 2017.


Pilot CBM drilling at Sherubainurinskiy site - *Courtesy of KazTransGas JSC*

"KazTransGas conducts unique tests, which will allow the expansion of pilot projects run large state task - to get industrial gas", - a well-known in the industry expert, Professor of Karaganda State Technical University Nikolai Drizhd. - In the process of drilling obtained sufficiently high gas content of coal seams, which demonstrates once again the prospect of work done. This gas is essential for solving energy problems, not only of the Karaganda region, and Astana, and its production will have a fundamental impact on the further development of social and environmental concerns.

Further study of core will hold in the leading services in the field of international certified laboratories in the US, China and Poland. They already signed the relevant treaties. Completion of the 1st stage is planned in 2016, then the results will be elaborated into a feasibility study of the

prospects of development of this area of gas production and corresponding methane reserve calculations will be made.

Contribution to mine safety precautions and emission reduction:

The pilot CBM project is creating a precedent for economical drainage of gas from coal seams from the surface. In term of safety and improvement of operational practice in Karaganda coal mines AMT may potentially gain the following benefits from such practice:

- get gas removed in advance of mining and secure high-quality gas available for utilization;
- reduce inherent gas content prior to coal mining operations;
- opportunity to reduce emissions of methane to the atmosphere (reduction of GHG emission) from the mines, and potentially benefit form the National GHG emission trading system (potential opportunity to substitute coal and heavy oil in power and heat generation by the drained conditioned methane).

At the same time, there are still some economic and technical obstacles to overcome, such as absence of tax incentives (discussion of a “renewable” incentive is in progress), high design, implementation and operation cost of surface drainage program, very low permeability of most of the coal seams of Karaganda basin.

CASE STUDY 3: Mine gas utilization for heating purpose

Background information:

Karaganda coal basin is one of the gassiest in the world. Forecast resources of methane in the basin, by different experts, are estimated at the level from 850 billion m3 to 4 trillion m3. Due to high gas content of coal seams and coal-bearing strata of Karaganda coal basin coal mines have been employing gas drainage practices for over the last four decades to provide safety for underground mining operations. Thanks to application of different gas drainage techniques the mines have reached high level of gas extraction through the extensive CMM drainage system (over 70mln.m3 of conditioned gas in 2015).

At the same time Karaganda is located in the area of sharp continental climate where the ambient temperature usually reach over +30C^0 in summer time and gets down to -40C^0 in winter and the cold period of the year usually lasts for over 6 months.


CMM fueled boiler house of AMT - *Courtesy of "Industrial Karaganda" and Methane Center PA*

Solution:

Specialists of AMT maintenance facilities elaborated special upgrade equipment to install at several mines of the group in order to utilize CMM with concentration exceeding 30% drained from coal seams and coal-bearing strata while mining operations for the purpose of heating ventilation air for the mines over cold seasons and, at a few mines, to generate heat and hot water for the mine facilities. By these means the company managed to replace earlier used coal with

coalmine gas that was traditionally considered as a waste resource at the mines and was mainly vented to the atmosphere uncontrollably.

CMM-fueled boilers are to the most extent conventional natural gas based industrial heating devices with some specific adjustments that allow controlling the combustion process based on conditions of the used air-gas mixture (chemical composition, concentration, moisture content, etc.). As a fact coal mine methane extracted from subsurface in Karaganda coal basin is represented by CH_4 up to 98%. That certainly simplifies the process of utilization and extends lifetime of the applied equipment.

Implementation results:

Over 17 mln.m3 of CMM were used in boiler of five AMT coal mines in 2015 to supply heat and hot water for mining facilities. Since cold season of 2016-2017 is going to be longer and colder (about 6 months) by weather forecasts the level of CMM consumption for heating purposes is expected to increase. The scaled relatively "low-cost" solution helps not only reduce emission, use an alternative environmental-friendly energy resource available at hand, but also create significant opportunities for the coalmining operator to safe on coal itself that would otherwise be used to cover the noted heating needs of the mines.

Although being a good tool for utilization of waste gas and mitigation of emissions methane-fueled boilers do not provide a stable solution for beneficial use of this resource. While this method represents the least cost option for CMM utilization, the lack of demand for heat during the summer months would mean a poor overall utilization rate. Thus, it makes more sense to consider it as one of the elements of CMM utilization program to support more efficient elements that may be potentially implemented into the mine infrastructure, such as, for instance, CMM-based power generation with waste heat recovery whenever required. Considering oxidation of vast VAM resources along with beneficial heat recovery would potentially add some value to the program as well, especially when emission reduction trading scheme will be officially enforced in the country.

CASE STUDY 4: Drained CMM to power

Background information:

As a part of long term sustainability and environment improvement program AMT committed to reducing the emission and release of greenhouse gases into the environment. As a heavy-duty industrial enterprise the company is a subject to inventory and penalties for extra emissions that may happen at different stages of the vertically integrated coal-and-metallurgical process. At the same time AMT mines emitted up to 400 mln.m3/a in terms of pure CH4 from the 8 mines of the Coal Division of AMT. Insignificant part of the drained gas has been used at the mined for heating purposed (12-17 mln.m3/a) for a long time but no any other scale options were tested until very recently.

At the same time coal mines of AMT group in Karaganda typically use between 5MW and 15MW of Power per mine. The electricity used by the mines is generated by both the local government heat-and-power company and by own power stations of AMT. Both sources are predominantly based on coal fired boilers and steam-electric power generators. The external regional high voltage grid is owned by the local government. AMT owns and operates an internal electric distribution system that serves mines as well as other facilities of the industrial group.

Solution:

Thus, being suffered from environmental issues with local authorities the company made a decision to test industrial option of emission mitigation and came up with a local mine methane power generation project that would provide direct mitigation of GHG emission and also may help to reduce load from the national electricity grid up to some extent.

In order to maximize the value of generated power and to minimize grid network connection cost, it was recommended that any power produced by such a project is supplied into the internal mine electrical system. In this case the value of power to the project does not seem to be the price of electricity sold but the cost of electricity supplied from the grid.

Since AMT has long term plans to continue coal production in the region, at least, to support the metallurgical activities of the group the CMM will be produced as a byproduct of mining activities and electricity will be required to power the coal mines as long as they are in operation.


The pilot CHP installation in Karaganda area - *Courtesy of Coal Division of AMT*

Implementation results:

Thus a 1.4 MW GE Jenbacher 420 series containerised CHP has been in operation (initially at Lenina mine) since late 2011 as a pilot project using gas between 25% and 50% CH4 from surface gob wells. The generated electricity is fed to the group substation of Lenina mine and covers up to 20% of its power load. The unit is operated in automatic mode.

Practical experience of the CHP operation revealed that at a certain point it is also possible to use most of the waste heat (from exhaust system, etc,) for the purpose of heating water for the mine needs even in summer period and thus to provide additional mitigation of emission and coal consumption by the boiler house of the mine.

As noted above over the pilot project phase the electric power generation by the CHP project with CMM is supplied to the internal grid of the mines. It is noted by the CMM experts that most likely during certain shutdowns/slowdowns or longwall shifts where production slows there will certainly still be a need to import power from the external grid. The frequency and value of these cases will be studied further on over the operational stage of the project but there is a strong expectation that the volume of this export would be minimal. At the same time as the CMM power generation would increase there is a likelihood of export of the poser to external consumers. Thus, as a part of commercial development phase the company plans corresponding discussions on establishment of a separate local CMM-based power generation/distribution company.