First International Symposium on Mine Safety Science and Engineering

**H₂S Management in 15# coal seam of Fenghuangshan Coal Mines**

Jin Shuqing\(^a\), Ding Yongming\(^b\), Yan Aihua\(^c\), Zhang Qin\(^d\), Li Qian\(^d\), Zhao Fei\(^d\)\(^a\)*

\(^a\)The mine ventilation area of the phoenix coal mine in Jincheng anthracite mining group, Shanxi, 048007, China
\(^b\)Xinjiang Plytechnical College, Wulumuqi, 830091, Xinjiang, China
\(^c\)Research Center of State Administration of Work Safety P.R.C, Beijing, 100713, China
\(^d\)Faculty of Resource and Safety Engineering, China University of Mining & Technology, Beijing, 100083, China

**Abstract**

Take the H₂S management in the 155301 working face of the phoenix coal mine as an example, through the use of strengthen ventilate, coal seam injection, strengthen the spray, individual protection and other methods, this paper solves the problem of production be limited by the high concentration of hydrogen sulfide, and it has guiding significance in the treatment work of hydrogen sulfide.

© 2011 Published by Elsevier Ltd. Open access under CC BY-NC-ND license. Selection and/or peer-review under responsibility of China Academy of Safety Science and Technology, China University of Mining and Technology (Beijing), McGill University and University of Wollongong.

Key words: Hydrogen sulfide; Ventilation; Water injection; Spray between hydraulic supports; individual protection

Recovering the 155301 working face of the phoenix coal mine was started in 2009, in the process of recovering, it was found that the hydrogen sulfide emission is bigger in working face, and have restricted mine production safety, therefore, it was needed to take a comprehensive treatment on hydrogen sulfide, and to ensure the health of the staff engaged in 15 # coal mining face to employees and the safety in mine production.

**1 A brief introduction of 155301 working face**

155301 face is the first fully mechanized working face of phoenix 15 # coal mine, tilt long 175.2 m, trend long 628 m and the average thickness of the coal seam is 2.3 m, average degree angle of inclination is 6°. The old roof and direct roof are all K2 limestone, direct bottom is shale. It takes use of the integrated mechanization method that mining overall height in one time. In extraction process, it was found that the concentration of H₂S on the leeward of the fuselage is bigger (maximum up to 200 ppm, specific such as table 1), cause the people near unit and in the ventilation roadway to appear the
symptoms such as eyes tears and the upper respiratory being stimulated and so on, which seriously restricted the mine production safety.

### Tab.1: The concentration of H₂S on 155301 working face

| The speed of coal cutting (m/min) | Fuselage place | The distance from former roller | The distance from backer roller | Ventilation roadway |
|----------------------------------|----------------|---------------------------------|---------------------------------|---------------------|
|                                  | 1m | 5m | 1m | 5m | 10m | 20m | 30m |
| 3                                | 30 | 55 | 68 | 62 | 80 | 100 | 106 | 30  |
| 4                                | 34 | 73 | 95 | 85 | 120| 140 | 153 | 42  |
| 5                                | 42 | 90 | 130| 99 | 155| 183 | 192 | 55  |

### 2 Abnormal reason of H₂S in the coal mine gas

Hydrogen sulfide (H₂S) is a kind of highly toxic combustible gas, colorless, with the smelly egg smell[1-4]. The chemical activity is extremely strong, can make the surface of silver, copper and other metals black. H₂S is easy to dissolve in the water and form hydro sulfuric acid, the H₂S in the water solubility is 2.7 times of CO₂’s, is as much as 93 times more than the CH₄ in the water. H₂S is heavier than the air (relatively density is 1.17). The lowest concentration of hydrogen sulfide can be smell by human body is (0.2-0.3)×10⁻⁶. The strong smells appears when the concentration of hydrogen sulfide is (20-30)×10⁻⁶, people’s sense of smell could be paralysis when the concentration of hydrogen sulfide is (100-150)×10⁻⁶, the person could be dead in a few seconds when the concentration of hydrogen sulfide is 1000×10⁻⁶.

The results of experiments of coal adsorbing CO₂, N₂ and CH₄ showed that the higher of the gas boiling point, the stronger of the adsorption ability of the adsorption material. The lowest boiling point for H₂S is -60.33°C, higher than CO₂, CH₄, N₂, and others gas, therefore, coal has a strong adsorption ability to absorb them. The H₂S gas formed by biodegradation and microbial sulfate reducing effect may exist only in the peat lignite phase, because of the moisture content of peat lignite phase is higher, and H₂S gas more soluble in water, general won't cause H₂S gas abnormal. But in individual dry areas, may appear H₂S gas abnormal when the moisture content of peat lignite phase is low. Secondary H₂S gas formed of microbial sulfate reducing effect may be exist in the peat coking coal stage, but the breeding of sulfate reducing bacteria relies on the surface water infiltration into coal seam, even if the H₂S gas had formed, also more soluble in water, and be take away by groundwater.

The H₂S gas formed by thermal and chemical decomposition in coal and surrounding rock and thermochemical reduction is not much, part of them soluble in water, partly is adsorbed by coal seam or using for filling the hole and crack existed in the coal. Generally, the H₂S gas won't cause abnormal if the CH₄, N₂ and CO₂ in the coal seam has been in a state of saturated; After the mine gas in coal seam diffused in the geologic uplifting process or under the action of groundwater, the new H₂S gas formed under the magmatic thermal action in the late was stored in coal seam, easy to cause the H₂S gas abnormal; If there are a lot of sulfate sock in the coal, it is often cause the H₂S gas abnormal under the action of thermochemistry.

If exist the magma activity accompany with inorganic genesis H₂S gas in the coal mine, it is also easy to cause H₂S gas which is in the mine gas abnormal.

To sum up, the main reason to cause H₂S gas which is in the mine gas abnormal is the storage condition of H₂S gas.

### 3 The treatment of H₂S gas on 155301 working face

According to the chemical properties of H₂S gas, decided take the way of combining the methods of strengthen ventilated, shallow hole water injection at working face, spray water by coal winning machine, set up water curtain in ventilation roadway and strengthen individual protective together to treat H₂S gas on 155301 working face.
3.1 strengthen ventilation

During coal production, the 155301 working face needs air volume for 600 m³/min, if you find the content of H₂S gas on 155301 working face is higher, first of all, optimized the ventilation system, increased the air volume at the mining face maximally on condition that the air speed in the 155301 face not overrun and the air needs in other places are ensured, make air volume up to 1400 m³/min, greatly diluted the concentration of H₂S gas by increasing the air volume.

3.2 shallow hole water injection measures

It is the fundamental measure to prevent and control the hydrogen sulfide gas that using shallow holes water injection in coal seam, early eliminating hydrogen sulfide gas stored in the body of coal. The basic principle is to drill holes and inject water in the coal seam where hydrogen sulfide gas gushed out abnormally before the recovery work, make use of the property that hydrogen sulfide gas is easy soluble in water, and dissolution absorbs hydrogen sulfide gas, so as to achieve the purpose of prevention and control hydrogen sulfide gas, ensure the operation safety.

(1) Construction method

The process of shallow holes water injection includes two main link that the construction of drilling hole used for injecting water and water injection. Using the pneumatic drill or electric coal drill with the drilling diameter for 42 mm, hit a drilling hole every 4 meters which is used for water injection and perpendicular to coal mining face wall, drilling hole deep 8 m; Drilling hole after, use the rapid closure for the holes sealing, using the water injection pump installed in the slot to inject water into drilling hole, as shown in figure 1. When finished water injection, if the condition of quantity of flow and pressure to allowed, can use a single or porous of water injection note way, terminate water injection when fringe of roof and coal seam or wall appears ooze water phenomenon.

Fig. 1 Arrangement of water injection drilling holes and installation connection type of equipment

Water injection system is composed of water injection pump, water tank, pressure gauge, control valves, high pressure pipe lines, hole packers and so on, arrangement of water injection drilling holes and installation connection type of equipment as shown in figure 1. According to experience, choose the water injection pump (WQB250/20) with pressure rated for 20 MPa and rated flow for 250 L/min's, with a water tank has a capacity of 2 m³. Demand water injection pump to install pressure gauge, water meter and pressure relief valve and other accessories, high pressure pipeline choose 2 inches high pressure hose.

(2) Technical requirements:
Drilling hole requirements: the drilling hole diameter for 50 mm, deep 8 meters, separation distance is 4 meters, apart from the roof 1.2 meters and sealing hole depth 1.5-2 meters.

Water injection requirements: the volume of injected water for 883-1324 L per hole, water injection pressure for 3 -8 MPa, injecting about 20-30 minutes (terminate water injection when fringe of roof and coal seam or wall appears ooze water phenomenon).

3.3 Water spray

Water spray is to inject the pressure water caused by rotate or impact effect through the nozzle, make the water flow atomized into drops of water scattered in the air. The effect of spray water managing hydrogen sulfide gas mainly reflects in the water spray range, spray mist can absorb and dissolve the hydrogen sulfide gas, and to reduce the concentration of hydrogen sulfide gas.

(1) Coal mining machine spray

Because of the fragmentation on coal cause by the coal mining machine roller cut in the process of cutting coal, lead the hydrogen sulfide gas gush out, although take the measure of shallow water injection hole, but the concentration of hydrogen sulfide gas in the area from coal mining machine windward side 10 m to leeward 30 m may still be overrun. Therefore, the coal mining machine wind side 10 m to leeward 30 m is hydrogen sulfide gas of the prevention and control of key areas. So it was the key area in management. Request the inside and outside water spray devices have to be opened when the coal mining machine cut coal, inner spraying pressure should not be less than 2 MPa, and outer spraying pressure should not less than 4 MPa, the spray devices should have good atomization effect, and take the fall coal spray and coal wall scour measures, to dissolve hydrogen sulfide gas as far as possible, and reduce the hydrogen sulfide gas gushed out.

(2) Use water curtain in the roadway

In order to reduce the content of hydrogen sulfide gas in the return current, ensure the concentration of hydrogen sulfide gas not to exceed bid, two water curtain controlled automatically by light were installed in return air lane, it was realized that cover the whole section, make the hydrogen sulfide gas and water dissolve and mix fully, reduce the concentration of hydrogen sulfide gas in the return air lane further, and ensure the safety of staff in the return air lane.

(3) To realize the spray linkage between and the unit spray in working face

Ensure spray among the stents in the area from the coal mining machine’s upper hand side 10 m to leeward 30 m could spray automatically follow the coal mining machine in the process of cutting coal.

3.4 Control the speed of cutting coal

Through observation of H2S in all kinds of cutting speed of coal mining machine on the 155301 face, it was found that the faster of the cutting speed, the more of the emission of H2S, and the slower of the cutting speed, the smaller of the H2S emission, therefore, driver of coal winning machine equipped with a portable H2S detector, control and regulate the speed of cutting coal timely when the coal winning machine cut coal, to achieve the purpose of control hydrogen sulfide in the coal mining machine leeward.

3.5 Individual protection

It can effectively reduce the concentration of hydrogen sulfide gas in mining face through the above measures, but the concentration of hydrogen sulfide gas within the scope of mining machine leeward 30 meters still occasionally exceeds bid, so requires that all coal mining machine leeward staff must wear self-priming filter type gas mask (half a mask), protect the respiratory system, and wear chemical safety protective glasses, wear rubber gloves, to prevent hydrogen sulfide poisoning accidents.

3.6 Strengthen routine monitoring and worker training, prevent hydrogen sulfide exceeds bid

(1)To prevent hydrogen sulfide poisoning accidents, the 155301 face equipped with full-time inspectors could inspect the concentration randomly, every class check the gas concentration not less than 2 times, and randomized to tracking detection;
At the same time, provide the \( \text{H}_2\text{S} \) detection color comparison tube and portable hydrogen sulfide gas detection instrument for the full-time inspectors to detect the concentration of hydrogen sulfide gas, provides basis for adjusting management measures for hydrogen sulfide.

(2) Require the gas inspector make a key examination during the periodic press of mining face or when the coal winning machine cut coal, finds exceed bid, in time asks the driver to slow down the speed of cutting coal, reduces the gush of hydrogen sulfide gas.

(3) Through strengthen the train, make the broad worker making homework in 15 # coal master properties and harm, prevention and control principle, rescue common sense and the matters needing attention of hydrogen sulfide, prevent hydrogen sulfide poisoning accidents.

**4 Hydrogen sulfide treatment effect**

Through take the measures of improve working air, water injection with shallow holes, use the water curtain, increase individual protection, control the coal cutting speed of coal winning machine, daily monitoring and others on 155301 working face, make the concentration of unit leeward \( \text{H}_2\text{S} \) gas on 155301 working face reduced significantly, and concrete numerical value as shown in table 2.

| The speed of coal cutting (m/min) | Fuselage place | The distance from former roller (1m, 5m) | The distance from backer roller (1m, 5m, 10m, 20m, 30m) | Ventilation roadway |
|---------------------------------|----------------|---------------------------------|---------------------------------|------------------|
| 3                               | 4              | 10 (8)                         | 12 (7)                         | 7 7 7 3          |
| 4                               | 9              | 12 (9)                         | 13 (8)                         | 8 7 7 5          |
| 5                               | 13             | 15 (11)                        | 17 (9)                         | 8 8 6            |

**5 Conclusions**

After taken the integrated measures, the concentration of \( \text{H}_2\text{S} \) gas in 155301 working face has more dropped than before, reduced the damage of \( \text{H}_2\text{S} \) to personnel, and effective guaranteed the safety in production, provided a reference for the future hydrogen sulfide management in 15 # coal mining of phoenix coal mine and anthracite mining group.

**Acknowledgement**

This research is supported by National Natural Science Foundation of China (50874110). The authors would like to express their gratitude to these foundations.

**References**

[1] Wang Qiujian. Hydrogen sulfide protection training materials[M]. Beijing: China petrochemical press,2009. (in Chinese)

[2] Wang Junfeng. Measuring wind and dust in mine work[M].Beijing: Coal industry press, 2003. (in Chinese)

[3] Zhang Guangtai. H2S DePosition Mechanismand Management Research in Coal Mines[D].Taiyuan: Taiyuan University of Technology, 2007. (in Chinese)

[4] Fu Xuehai, Wang Wenfeng. Genesis analyses of H2S gas abnormality in gas of Bayi coal mine in Zaozhuang[J]. Journal of Coal Science and Engineering, 2006,31(2). (in Chinese)