

# Study on Effective Radius of Gas in Stress-released Coal Seams by Surface Borehole

ZHANG Shuchuan

*School of Energy Resources and Safety  
Anhui University of Science and Technology  
Anhui Huainan China*

*The Key Laboratory being built by Anhui Province and Ministry of Education for Coal Mine Safety and efficient exploitation  
Anhui Huainan China*

**Abstract:** In order to accurately see about effective radius of surface drillings draining pressure relief gas of coal seam, gain reasonable parameters of the layout of ground drillings, guide scientifically and effectively gas prevention work of mining coal, this paper first of all discusses the principle of surface drillings draining pressure relief gas of coal seam. This paper basing on the theory of gas storage and flow in coal seam, the theory of exploitation of protecting coal seam, using industrial-type test and two-tracer technique, in-depth study effective radius of surface drillings draining pressure relief gas of coal seam along the orientation and the direction. The results showed that: effective radius of ground drillings draining pressure relief gas along the orientation not less than 160m and not less than 240m along the direction.

**Keywords:** Surface drilling; relief gas; effective radius

## 1. Introduction

With the expansion of coal mining and the increase of mining depth, the safety production problems of coal mine become the dominant factors of restricting the production of high yield and high efficiency of coal mine. Coal and gas outburst is one of the main harm of coal mine safety production. Coal seam number 13 of Xinji diggings belongs to high gas coal seam, its working-face not only has the big gas flow-volume but also has the dangerous of outburst, its coal quality is soft, the original permeability is low, and taking out gas in advance is very difficult. To resolve the problem of gas overrun only relying on the ventilation is impossible and adopting local measures of preventing outstanding cannot guarantee safety production of mine and restrict the rate of excavating coal and digging coal. But coal seam number 11 below coal seam number 13 that has an average offset 70m distance from it is stable and its existing mining level does not have outburst danger. Item no.45 in the prescript of the preventing coal and gas outburst is "Regional and protective measures including mining coal gas pump to coal and gas outburst coal mine safety accidents, to prevent coal and gas outburst and promote efficiency and high production of coal mine. Coal seam number 11 was firstly exploited as protecting coal seam in the north central area of xinji no.1 coal mine, coal layer number 13 is its protected coal seam. In the same time earth drillings drawled out pressure relief gas of coal seam number 13. And the key technologies of earth drilling taking out pressure relief gas of coal seam

is to accurately research the effective radius of surface drillings.

## 2. General situation of experimental area

131105 fully-mechanized working-face is in 3 mining area of level 1, the eastern boundary of the working-face is protecting coal pillar of - 450m belt level crosscut, the western boundary is the cut-hole of the design, the southern boundary is the wind lane of the design, the western boundary is the machine lane of the design. The diphead of coal seam number 13 and 11, -450m is near the eastern of the working-face. Number 10 exploration is near the western of the working-face. There are two un-exploited working-face near the western and the northern. Actual mining 131103 working-face is near the southern of it. Mining feet of 131103 working-face is 790.55m by the end of 2006. The elevation working-face is about -497m~-594m, the length of the wind lane of the design is average approximately 1280m for long, the length of machine lane of the design is average about 1235m for long, working-face of the design for long is average 1257.5 m, the length of the trend is average 150m. Coal seam in general is anticline. The axis of the anticline is between 8-9 line and 9 line. Another F10 fault associating anticline structure thrills through the western of the working-face. The obliquity of coal seam is 18 ° to 30 °, average is 22 °.

## 3. The mechanism of the ground drilling taking out pressure relief of coal seam preventing coal and gas outburst [1]

The mine of the protective coal seam forms goaf in the earth-layers. The terrane and coal seam of the surrounding space will move and have a distortion towards the forming goaf. The stress of the stratum will be distributed, the arch of the caving will be formed above the goaf, and the pressure will be transmitted to the terrane outside the goaf, namely, the protective coal seam can have an effect on mining. Because of mining effect, the terrane and coal seam local uninstall pressure that comes into being expansion. The original natural cracks and macropore open, and a new crack is formed, thus increasing the permeability of coal and rock, and improving the intensity of the gas emissions and the desorption ability. The principles of the exploitation of protective coal seam being combined with gas extraction preventing coal and gas outburst is shown in figure 1.

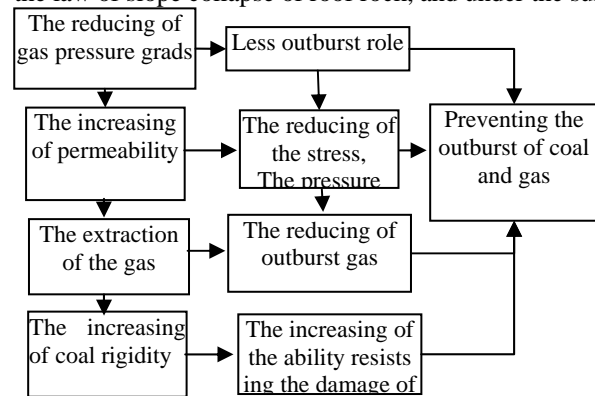
With the working-face footage of protective coal seam, caving zone and fractured zone are formed in the terrane above it. That is the cause of the pressure relief gas of adjacent coal seam the flow of pressure relief gas. A plenty of pressure relief gas from adjacent coal seam and the terrane flocked to the working-face through the cranny of the layers. During the course of the exploitation of the working-face, surface drills in the main taking out the gas of the high concentration of pressure relief coal seam of fractured zone prevents it from the inburst of the working-face. In the meantime the pressure relief gas of the caving zone and the lower protected coal seam swarm into the gob of the working-face. The height and the range of the caving zone of the working-face gob are gradually increased, and negative pressure of the ventilation is gradually lower. The gas of the goaf will be continuous drawn out by surface drillings when the negative pressure of the surface drillings extraction is bigger than negative pressure of mine ventilation. After the exploitation of the working-face, the gas of the upper and lower protected coal seam will continue to swarm into the goaf and the ground drilling will take out the gas of the old mined-out area for long. The above analysis show that the ground drillings can draw out the gas of the protected coal seam and the gob during the course of the exploitation and the finish of the working-face long time reducing the danger of coal and gas outburst of the protected coal seam, the quantity of gas into mining tunnel, gas concentration in the wind, and the burden of ventilation, ensuring safe production efficiency.

## 4. The experiment of the surface drillings taking out the gas

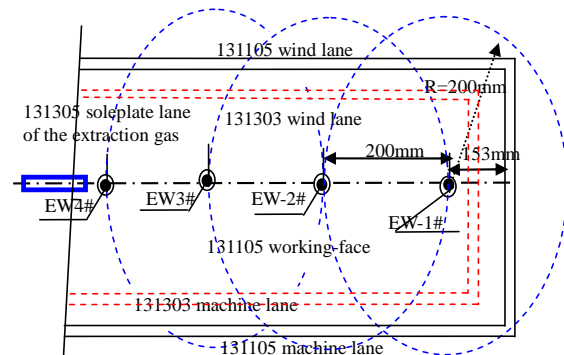
### 4.1. Layout parameters of the surface drillings

There are 4 surface drillings laid out in the 131105 working-face of the north central area of Xinji no.1 coal mine. 131105-1# Well lie in the western 153m of the open-off cut of the 131105 working-face, 131105-2#,3# and 4# Wells are respectively laid out in the eastern of the

cut-hole and the interval of them is 200m. According to the law of slope collapse of roof rock, and under the suff-



**Figure 1. The prevention mechanism for gas and coal outburst by mining protective coal bed and taking out gas**  
-icient condition of coal mining, the subsidence of working-face central surface is the largest, the active time is 2 month or 3 month, and roof is gradually becoming compaction, but it has not be returned to the original. Earth wells laid out the middle of the working-face is the best scope of the flowing of pressure relief gas of coal seam within of the best time because the expansion and the permeability of the terrane and coal seam overlying are the largest. Therefore all the surface drillings locate in the middle of level bulbiferous of 131105 working-face in the trend direction, have a distance 70m with the wind lane along the tendency, namely the position is the design midline of the soleplate lane of 131305 working-face. Specific layout diagram is shown in figure 2.



**Figure 2. Schematic layout of the ground drilling**

### 4.2. The test of the parameters of surface drillings drawing out gas

#### 1) The testing method of the parameters

Using orifice flow meter determines the quantity of gas drainage. Orifice flow meter is made of orifice plate having a central hole and pressure hole, etc. When the gas is passing through the orifice plate of the pipeline, the flow velocity will form the local contraction. Under the condition of constant pressure, velocity will be increased and static pressure will be reduced by contraction. Static

pressure difference will be produced in the front and rear of orifice plate. Under the same conditions of the gas pipeline section, if the flow is the greater the pressure difference is bigger also, thus measuring the pressure difference can determine the gas flow.

The formula of counting Mixed gas flow:

$$Q = 0.32K_0 b \Delta P^{1/2} \delta_T \delta_P$$

$K_0$ -- the coefficient of the orifice flowmeter,  
 $K_0=1.1879$  ;

$b$ —the correction coefficient of the gas concentration ;

$\Delta P$ —static pressure difference of the orifice plate, mmH<sub>2</sub>O ;

$C$ —gas concentration in the mixed gases of pipeline, % ;

$\delta T$ —the correction coefficient of the temperature ;

$\delta P$ —the correction coefficient of the pressure.

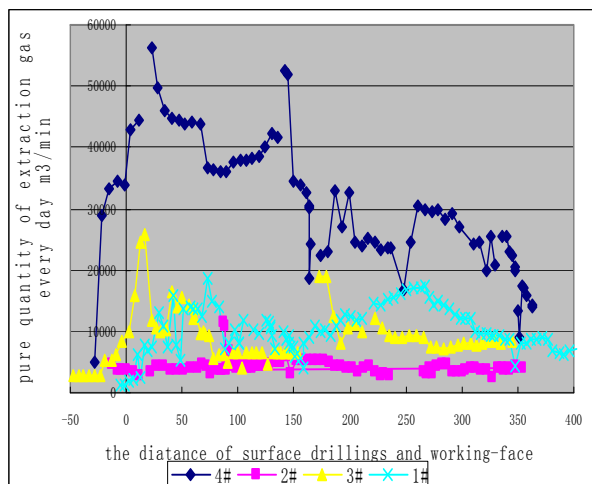
The formula of counting pure extraction gas flow:

$$Q_w = CQ$$

$C$ —actual gas concentration of the gas extraction pipeline, %.

2) Result analysis of determining parameters of extraction gas

According to the result of the determination of gas extraction parameter, we draw out four ground drillings taking out the quantity of pure gas every day and the distance of the working-face from the drillings, as shown in figure 3 below.



**Figure 3. The map of pure quantity of gas extraction and the distance of working-face away from the drilling**

Figure 3 shows that the quantity of pure extraction gas is larger every day and the effect of the extraction is the best when the distance of the working-face and the ground drillings is for 3m-100m range. When the distance of the working-face and the ground drillings is for 100m-300m range, the quantity of extraction gas is

increasing with the reducing of the distance. The quantities have no change in essence when the distance of the working-face and the ground drillings is outside 300m range.

## 5. Tracer technology determining the radius of the extraction [2-7]

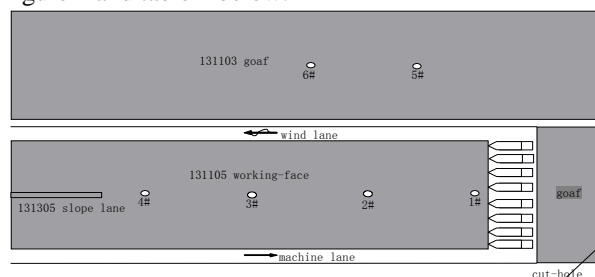
### 5.1. The characteristics of the tracer technology

Tracer technology is applied to research tracer and the law of the gas or liquid using tracer matter, especially researching the gas flow of the place that personnel can't reach has the unique superiority. Dual tracer technology is that two different kinds of tracer gas is released simultaneously or not simultaneously in two leakage of the same range, and the application of dual tracer technology can greatly reduce work of the sampling, shorten the sampling time, make full use of test equipment and facilities, improve work efficiency.

Tracer technology can be used for stable release and pulse quantitative release. Pulse quantitative release is that amount of tracer gas is released in the higher energy level and sampling work is finished in the lower energy level at intervals. Connectivity of the higher energy level and the lower energy level can be judged according to the result analysis of tracer gas.

### 5.2. The release of tracer gas

Tracer gas of this experiment are SF<sub>6</sub> gas and 1211(two fluorine one chlorine one bromine methane), which are selected by the a great of research of laboratory experiments and local test, whose chemical and physical properties is stability, colorless, odorless and non-toxic and coal mines in the air, are electro negativity material, usable same detector of electronic capture (ECD), simple operation, high precision. This experiment using pulse release released five times tracer gas in all, including the former of 2 times using single tracer gas (SF<sub>6</sub>) examine the extraction radius of the ground drillings taking out pressure relief gas of coal seam along the tendency and the latter of 3 times using dual tracer gas SF<sub>6</sub> and 1211 examine the extraction radius of the ground drillings taking out pressure relief gas of coal seam along the direction. Specific parameters arrangements are shown in figure 4 and table 1 below.



**Figure 4. The map of test area investigating drainage radius of surface drilling**

### 5.3. The analysis of the results

The results of releasing Tracer gas is that the first test didn't detected tracer gas, and four tests of the latter detected tracer gas. The distance of release point and sampling level projection in the 2, 3, 4 and 5 experiment is about 160m, 125m, 170m, 240m. Second the tests of 2 times examine the extraction radius of ground drillings along the trend, and the tests of 3, 4 and 5 times

investigate the extraction radius of ground drillings along the direction.

The results showed that: effective radius of ground drillings draining pressure relief gas along the orientation not less than 160m and not less than 240m along the direction with the mining of the lower protective 131105 fully-mechanized working-face.

**Table 1. Parameter table of tracer gas release**

The sequence	Date	Tracer gas	The plate of the release	The plate of the sampling	Aspect
1	1-4	SF6	5# earth well	1#, 2# earth well、wind lane of 1105 working-face、high drainage roadway	The trend
2	2-28	SF6	6# earth well	3# earth well	The trend
3	4-28	SF6	10# drilling of soleplate lane	4# earth well	The direction
		1211	1# drilling of soleplate lane		
4	5-10	SF6	12# drilling of soleplate lane	4# earth well	The direction
		1211	1a# drilling of soleplate lane		
5	5-23	SF6	12a# drilling of soleplate lane	4# earth well	The trend
		1211	1b# drilling of soleplate lane		

### 6. Conclusions

The forepumping of pressure relief gas of coal seam using surface drillings can effective prevent coal and gas outburst. The effective radius of ground drillings draining pressure relief gas is not less than 300m along the direction through the determining of the extraction gas parameters. The experiment of tracer technology shows that: effective radius of ground drillings draining pressure relief gas along the orientation not less than 160m and not less than 240m along the direction To accurately see about effective radius of surface drillings draining pressure relief gas of coal seam will gain reasonable parameters of the layout of ground drillings and guide scientifically and effectively gas prevention work of mining coal.

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### References

- [1] Yu Bufan. The enchiridion of gas hazard prevention of coal mine [M].Beijing: the press of coal industry, 2000
- [2] Zhang Shuchuan, Qin Yongyang, Gao song,ect. Study on Air Leakage Law of Goaf in High Gassy Fully Mechanized Coal Mining Face with Y Type Ventilation [J].coal science and technology, 2009 (10).
- [3] Wang Baishun,Dai Guanglong, Shao Hui. Research into the Gob Air-leakage of Eryuanryihui Fully-mechanized Face and Distribution of the "Three-zones [J].The safety of coal mine, 2000 (12) .
- [4] Zhang Guoshu, Dai Guanglong. Theory of Coal spontaneous combustion and prevention practices [M]. Beijing: the press of coal industry, 2002
- [5] Qin Botao, Li Zenghua. Determination of air leakage by using SF6 in mine shaft [J].the coal of Hebei, 2002 (1)
- [6] Liu Yingzhong, Ma Zhongli. application of Tracer technology in mine leakage detection. The safety of coal mine, 2002 (4) .
- [7] Dai Guanglong , Shao Hui , Zhang Guoshu. Dual tracer technology application in mines [J]. The journals of Huainan mining college, 1997 (12)