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Study on Influencing Factors and Countermeasures of Mine Gas Grade Identification

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Abstract: This paper analyzes the significance of mine gas grade identification, that is, dividing the mine into different gas grades, selecting different grades of explosion-proof equipment, selecting different technical protective equipment and implementing different ventilation gas management systems according to the air volume required for different supply of mine gas grades, and implementing graded management, which is economical, reasonable, safe and reliable to ensure mine safety production. According to the commonly used gas grade identification methods, the factors affecting the identification results are analyzed. Through the comparison of a large number of identification data, the analysis and research shows that the identification time, mine output and calculation method are the three main factors affecting the identification results. The problems easily occurred in the appraisal process are analyzed, mainly including the layout of appraisal measuring points, the analysis of mine gas source is not specific, the test of mine air volume data is not accurate, the calculation results of mine gas appraisal are wrong, and the influence of mining geological factors on gas emission is not considered. According to the influencing factors, this paper puts forward three corresponding countermeasures to improve understanding, strengthen organization and leadership and improve training quality, which has certain guiding significance to improve the accuracy of appraisal results.

Keywords: Gas Grade, Identification Time, Mine Output, Countermeasure Research

1. Introduction

In order to facilitate mine gas management, the mine is divided into different gas grades according to the size and hazard degree of gas emission. According to the air volume required for different supply of mine gas grades, different levels of explosion-proof equipment are selected, different technical protective equipment are selected, different ventilation gas management systems are implemented, and hierarchical management is implemented to ensure mine safety production, It is economical, reasonable, safe and reliable [1, 2].

Through the appraisal of mine gas grade, we can clarify the size of mine gas emission, clarify the source of mine gas, and divide different mine gas grades. The appraisal process is also a comprehensive inspection of mine ventilation, gas, ventilation equipment, ventilation facilities and air volume allocation, from which we can find problems and weak links. Whether the appraisal of mine gas grade can reflect the real situation of mine gas emission directly affects mine ventilation and gas management. The correct appraisal results and appraisal data reflecting the real situation of the mine can reflect the harm degree of mine gas, and play a guiding role in improving the ventilation and gas management of the mine and ensuring the safe production of the mine. Mine grade appraisal is a normal and important daily technical management work that must be carried out every yea [3, 4].

The result of gas grade identification is very important for the targeted measures to be taken in the mine, which affects the safety investment and safety management of the mine. Therefore, it is necessary to sort out and summarize the problems existing in the identification process, so as to take targeted countermeasures in the identification process and avoid the distortion of the identification result. The research on the influencing factors of the identification result is of certain significance.

Relevant scholars at home and abroad have conducted relevant research on the influencing factors of gas grade identification, but they all focus on the impact of human factors, and there are few studies on the impact of

identification time, production factors and calculation methods on gas emission. Therefore, it is necessary to study the factors affecting the identification results and formulate corresponding countermeasures to minimize the error.

2. Identification Method and Standard of Mine Gas Grade

Provisions of *Coal mine safety regulations,* According to the relative gas emission, absolute gas emission and gas emission form of the mine, the gas grade of the mine is divided:

1) Low gas mine: The relative gas emission of the mine is less than or equal to 10m^3/t, and the absolute gas emission of the mine is less than or equal to 40m^3/min.
2) High gas mine: The relative gas emission of the mine is greater than 10m^3/t or the absolute gas emission of the mine is greater than 40m^3/min.
3) Coal and gas outburst mine: Coal and gas outburst occurred once or coal mine with outburst coal seam identified.

The appraisal time is generally selected in the month with the largest gas emission in the mine. One day is taken in the first, middle and last ten days of the appraisal month (with an interval of 10 days) and divided into three shifts (or four shifts). According to each natural mine, coal seam, first wing, level and mining area, measure and calculate the monthly average gas emission of 1t coal per day, that is, the relative gas emission (m^3/t), and take the maximum value to determine the mine gas grade [5-7].

At present, the method of mine gas identification is to select the month with the largest gas emission according to the mining deployment of the mine and the law of local climate change, measure the return air volume and gas concentration in the return air flow in a certain area, level, coal seam and even the whole mine in three or four shifts a day, and then calculate the average absolute gas emission. The appraisal work is arranged to be completed in the first, middle and last ten days respectively, from which the maximum absolute gas emission is selected. According to this value, the absolute gas emission of the whole day is calculated as the sub item, and the average output of the appraisal month is taken as the parent item, which is the relative gas emission of 1t coal per day [8-10].

The basic data of methane and carbon dioxide shall be filled in according to the format of Table 1. The average gas emission of three shifts in the table (q) is calculated according to the following formula:

$$q = \frac{q_1 + q_2 + q_3}{3} = \frac{Q_1C_1 + Q_2C_2 + Q_3C_3}{3 \times 100} \tag{1}$$

Where: Q_1, Q_2, Q_3 — Air volume of the first, second and third shifts, m^3/min;

C_1, C_2, C_3—Gas concentration of air flow in the first, second and third shifts, %;

q_1, q_2, q_3—Gas emission of the first, second and third shifts, m^3/min.

Table 1. *Basic data of gas and carbon dioxide measurement.*

Gas name	Ten day farewell	Date	First, second and third shifts (Separate statistics)			Average discharge/ (m^3/min)	Gas drainage volume/ (m^3/min)	Total gas emission/ (m^3/min)	Monthly working days /d	monthly production/t	remarks
			Air volume/ (m^3/min)	concentration/ %	Emission/ (m^3/min)						
	Early ten days										
CH_4	Mid										
	Late										
	Early ten days										
CO_2	Mid										
	Late										

Table 2. *Report of mine gas grade identification and carbon dioxide measurement results.*

Gas name	place	Maximum gas emission/(m^3/min)			Actual working days/d	Daily coal production/t	Monthly average daily output/t·d^{-1}	Relative gas emission/ (m^3/t)	Mine gas grade	Gas grade of last year	Maximum relative gas emission of last year/ (m^3/t)	remarks
		Air exhaust	Pumping	total								
CH_4												
CO_2												

When measuring the gas drainage in the area, the q must be added with the amount of gas drainage, which is the total amount of gas emission in the area. According to the basic data in Table 1, select the total gas emission of the largest day in the first, middle and last ten days of the appraisal month as the basis for calculating the relative gas emission (gas emission with an average coal production of 1t), and then fill in the gas grade appraisal results of the mine or mining area according to the format in Table 2. The relative gas emission qt is calculated according to the following formula:

$$q_t = \frac{1440 \times q_{\max}}{T_P} \tag{2}$$

Where: $q_{\max}$ — Maximum gas emission in 30 days, $m^3/\min$;

T_P —Monthly average daily output, t/d

3. Study on Factors Affecting Mine Gas Grade Identification

3.1. Influence of Identification Time Factor

Two factors must be considered in the time selection of mine gas grade appraisal:

1) According to the local climate change law, the month with large temperature change should be selected;
2) According to the mining deployment of the mine, it should be carried out when the production is normal, that is, the output is equal to or close to the annual average daily output. The appraisal month can be determined artificially, but in the artificially determined appraisal month, whether the mine production is normal is not easy to control. In other words, it is impossible for the mining department to arrange evenly for gas identification. If the output in the appraisal month is significantly different from the normal output, the relative gas emission thus obtained will lose its objective authenticity and has no applicable value [11, 12].

Through statistical analysis, it is considered that the identification of mine gas grade should be carried out in advance from July every year, once in July and August respectively, and then the value with normal output and large relative gas emission should be selected as the standard for determining mine gas grade, which is more reasonable.

3.2. Influence of Factors on Mine Output

The gas emission increases with the increase of coal production, but the growth of the two is not synchronous, but the growth multiple of gas emission is less than that of production, which is often doubled, and the gas emission only increases by tens of percent. There is a nonlinear relationship between the two, and its size is related to factors such as gas occurrence and mine geological conditions. Therefore, in the final calculation of gas grade, there will be low gas emission per ton of coal at high yield; The phenomenon of high gas emission per ton of coal at low production. In addition, the difference between the mine, coal seam or mining level, as well as the amount of gas emission and output composition in the initial and later stages, also reflects the difference in the amount of gas emission per ton of coal. Therefore, in the appraisal work, we should pay special attention to the influence of these factors, eliminate the false and retain the true, and objectively reflect the emission of mine gas. Otherwise, if the emission of gas per ton of coal is too small, the mining air distribution will be arranged accordingly, and the air volume will be insufficient and the gas will often exceed the limit; On the contrary, if it is too large, it seems to increase the safety factor in terms of safety, and even improve the mine gas level, which will cause corresponding waste to the allocation of mine electromechanical equipment and ventilation gas management [13, 14].

In the mine production, the output of one shift (8h) is regarded as the output of 1d. In the mine production of two shifts, the output of two shifts (16h) is regarded as the output of 1d, and 8h and 16h are regarded as the output of 1 / 3d and 2 / 3d to calculate the relative emission of gas. The calculation results are different. Its calculation method:

1) Calculation of one shift per day (8h)

$$Q_x = \frac{q_i \times 60 \times 8}{t} \tag{3}$$

Where: Q_x—Relative gas emission, m^3 / t ;

q_i —Absolute emission of gas produced by shift 1, m^3 /min;

t—Average daily output of appraisal month, t/d.

2) Calculation of two shifts per day (16h)

$$Q_x = \frac{q_i \times 60 \times 16}{t} \tag{4}$$

Where: q_i —Absolute emission of gas produced by shift 2, m^3 /min.

3) The output of one shift (8h) or two shifts (16h) is calculated as the output of one day (24h)

$$Q_x = \frac{q_i \times 60 \times 24}{t} \tag{5}$$

Where: q_i —According to the average absolute gas emission of 3 shifts, m^3 /min.

Taking the output of 16h as the output of 1d, the relative emission of gas sometimes increases by more than 40%, and the relative emission of CO2 increases by about 50%. For a mine produced by one shift, if the output of one shift (8h) is calculated as the output of one day (24h), it will increase by a larger proportion than the result obtained by the calculation method of only one shift, and may increase exponentially. In this way, some mines with small gas emission may be divided into high gas mines, The mines with low gas risk, small gas emission and low gas are divided into high gas mines, The classification of mines with high gas risk into low gas mines is a great loophole in mine ventilation and gas management and a major hidden danger of coal mine safety, which loses the significance of annual identification of mine gas grade [15].

The calculation method of formula (5) is to treat the mine produced by one shift or two shifts as a normal production mine of three shifts, that is, taking the average absolute gas emission of the production shift is larger than taking the average of three shifts or non production shifts, which reflects the actual situation of mine production and increases the safety factor of mine ventilation. Because the air is distributed according to the absolute gas emission of the production shift, The gas in the working face, working area and mine will not exceed the limit. The absolute gas emission and relative gas emission are selected according to the production shift. In fact, the output of one shift or two shifts is treated as 1 / 3 or 2 / 3 of the average daily output. If the mine resumes the normal production of three shifts, the relative gas emission of the mine is close to the calculation result, and the air supply

required by the mine will not increase. This reflects the real situation of gushing out during the coal production period of the mine. Considering this, the average daily ton of coal air distribution is not only safe and reliable, but also economical and reasonable.

3.3. Influence of Calculation Method Factors

According to the requirements of the current mine gas grade appraisal, whether the mine is produced in 24h or not, the calculation of the relative gas emission takes the 24h absolute gas emission as the sub item, which actually artificially increases the relative gas emission and even improves the gas grade. According to the usual calculation method, take the absolute gas emission of 24h as the sub item and the output of 18h as the parent item to obtain the relative gas emission. Obviously, the obtained relative gas emission is larger than the actual value. If the absolute gas emission of the production team is divided by the total output of the production team, the relative gas emission can objectively reflect the gas emission of the mine.

4. Problems in Mine Gas Grade Identification

Through the sorting and analysis of a large number of data in the identification process and comparing the actual gas emission, the problems easy to occur in the identification process are sorted out as follows:

1) Arrangement of appraisal measuring points. If only one measuring point is arranged, it is impossible to analyze the source of mine gas; If only two measuring points of the whole mine and one wing of the mine are arranged, the gas emission of the mine cannot be closed and the underground air volume cannot be balanced.
2) The mine ventilation system diagram is inconsistent with the attached schematic diagram of the ventilation system, the facilities are incomplete, the air flow direction is not clearly marked, and it is inconsistent with the identification area. The same air volume label has several different data, such as the total inlet and exhaust air volume of the mine. The total exhaust air volume label of the mine is not the data during identification.
3) The analysis of mine gas source is not specific and accurate, and there is no data to explain the gas source.
4) The test data of mine air volume and gas are inaccurate. In some mines, the same data is obtained in the first, middle and last ten days of the appraisal month, and in the morning, middle and evening of each day.
5) The calculation results of gas identification in some mines are wrong.
6) The test data of some mines are incomplete. The appraisal month is not a whole month, and the interval between appraisal days is not 10 days. Most mines have not measured the meteorological parameters.
7) Gas emission is not only affected by climate change, but also by geological conditions, mining scale, mining sequence, mining method, mining technology, ventilation system and ventilation pressure. It is a relatively complex comprehensive parameter. There is a great difference between artificially specifying a month as the identification month and the actual maximum emission month. In the three days measured in the first, middle and last ten days of the appraisal month, the mine gas grade is determined by the relative emission calculated by the absolute emission of the maximum day. This method is very one-sided.
8) The current division of mine gas grade is based on the relative gas emission of the mine. The mine output affects the mine gas grade, and the change of gas emission is affected by many factors, such as coal gas content, pressure, coal seam exposed surface, mine ventilation mode, ventilation pressure, mining method, mining technology and geological conditions. Although the relative emission is directly proportional to the actual absolute gas emission of the mine to a certain extent, there will be great differences in terms of comparability alone. It is not comprehensive and objective to use the parameter of relative gas emission to reflect the harm degree of mine gas, and then carry out safety production management on this basis.

5. Problems and Countermeasures of Mine Gas Grade Identification

a) Improve the understanding of mine gas grade appraisal and pay more attention to the appraisal. Mine gas grade appraisal is an important basic work of safety technology for mine ventilation and gas management. The appraisal process is also a comprehensive inspection of mine ventilation, gas, ventilation equipment, ventilation facilities and air volume allocation, from which problems can be found and weak links can be found.
b) Relevant departments at all levels should strengthen the leadership of mine gas grade appraisal, do a good job in technical guidance, and carefully review the appraisal data. Whether the appraisal of mine gas grade can reflect the real situation of mine gas emission directly affects mine ventilation and gas management. The correct appraisal results and appraisal data reflecting the real situation of the mine can reflect the harm degree of mine gas, and play a guiding role in improving the ventilation and gas management of the mine and ensuring the safe production of the mine.
c) Strengthen the training of mine gas grade identification. A suitable period should be selected for the training. The best time should be arranged in May and June of each year to ensure the best appraisal time in July and August. At the same time, we should select appropriate training objects and strengthen the training of ventilation sections, team leaders or technicians in counties (districts) and key coal mines, so as to improve the technical level of the whole ventilation team.

6. Future Work Plan

1) The human factors affecting the appraisal results are systematically studied, mainly including the quality of employees, experience ability and instrument control ability, so as to minimize the human error in the appraisal process.
2) Comb and study the influencing factors of gas emission, find out the influence law of coal mining method and ventilation mode on gas emission, and correct the identification results under different identification conditions.

7. Conclusion

1) According to the commonly used gas grade identification methods, the factors affecting the identification results are analyzed. Through the comparison of a large number of identification data, the analysis and research shows that the identification time, mine output and calculation method are the three main factors affecting the identification results.
2) In view of the factors affecting the appraisal results of mine gas grade, eight problems in the appraisal process are put forward.
3) According to the easy problems, the improvement measures and suggestions are put forward, which is of certain significance to improve the accuracy of identification results.

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