

Research on Definition and Risk Assessment of Near Miss Events in Coal Mine

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Abstract—At present, extraordinarily serious casualties in coal mine is often pay more attention, however, a large number of minor accidents, especially these events caused no casualties or economic loss is not seriously enough attention. Which lead to neglect or even let near miss and the presence of attempted events. In this study, the near miss of mines was definite, and its difference and relationship with hazards and risks was analyzed. Drawing on traditional LEC risk assessment methods, relative risk assessment model of near miss was constructed by using f risk index, practice has proved that the classification results are basically the same with the traditional LEC risk assessment methods, and it can reflect the risk characteristics of near miss events from the many perspectives. Which has great practical significance in eliminating all kinds of production safety hazards in coal mine, preventing the occurrence of major accidents in practical work.

Keywords- near miss; hazard; risk assessment; f index; coal mine

I. INTRODUCTION

The safety issues of coal mine production in China has drawn attention from all walks of life for a long time. In recent years, the government and coal companies have done a lot of work in the prevention and treatment of mine casualties, production safety accidents and fatalities of coal mine declined overall. But extraordinarily serious casualties in coal mine is often pay more attention, however, a large number of minor accidents, especially these events caused no casualties or economic loss is not seriously enough attention. Which lead to neglect or even let near miss and the presence of attempted events. Measures that should be taken did not to take, or taken measures were not sufficient to eliminate the risk, which make the dangerous situation be in a continuous state situation, and many accidents that should be avoided did not be avoided. If monitoring and diagnostics for the risk factors can be previously strengthen, warning message is issued before the sign of an accident but not yet formed the accident, corresponding measures was immediately taken to eliminate the risk, then it will play a proactive effect.

The aim of his study was to analysis and define the near miss, then the near miss of coal mine (especially near miss caused by human factors) were graded taking an improved LEC risk assessment method, In order to explore

measures to prevent accidents, and to avoid the occurrence of major coal mine accidents in the maximum.

II. DEFINITION OF NEAR MISS EVENTS

A. The understanding of concept for near miss

In 1930s, Heinrich pointed out the ratio of serious injury, minor injury and non-injury accident was 1:29:300 by statistics a large number of accident. Bode also found that the ratio of serious injury, minor injury, property damage and no loss and injury accident was 1:10:30:600 in the survey. Relative to the accident that has a very serious consequences, the impact of a large number of incidents was quite limited, even the event did not cause more injury or property damage. Within a certain period of time or a certain range, with diminishing the severity of the consequences, the number of accident is increasing, it showed a pyramid-type distribution. Near miss is the accident which did not cause a lot of damage or loss at the bottom of the pyramid.

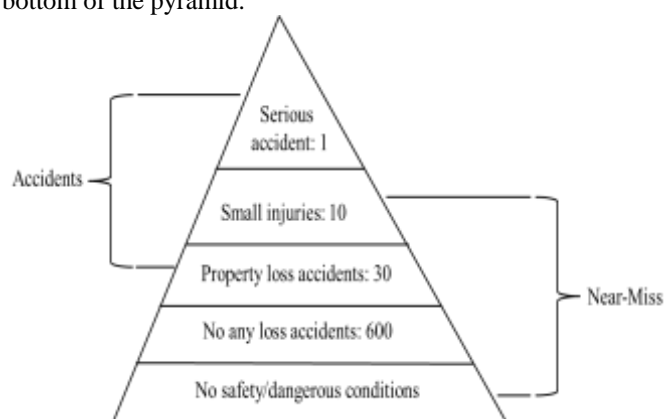


Figure 1. Security pyramid model

Early the definition of near miss tends to accident theory, it was called the near miss accident. But the accident has a loss, near miss is little incident with no loss or a slight loss. Therefore, the near miss incident is more scientific over the near miss accident^[1].

On the basis of previous academic studies, the concept of near miss was clearly defined in this study. The near miss of coal mine referred to small events that has a

characteristic symptom of accidents, but did not produce losses and injuries or only a slight loss and damage due to lack of conditions. If the conditions changed, there will still be the possibility resulting in an accident

B. The difference and relationship between Near-Miss, hazard and risk

Hazards and accidents have in common, they are likely to cause the accident, but they are not equivalent concepts. Tian Shuicheng^[2] raised the view of three types hazards in 2001. The first type hazard was energy carriers or energy source; the second type hazard was the fault substance, physical environmental factors and individual human behavior mistakes; the third type hazard was organizational factors that are not consistent with the safety, including not safe behavior and mistakes, etc. And identification and control for the third type hazard were studied, which further deepen the understanding of hazards. Hazard reflected the objectivity of danger, some of the first type hazard must exist due to the need to produce. But the accidents did not necessarily exist.

Near miss is the accident between the cause of the accident and injury events, and it did not develop into injury events. But no matter it is an accident or near miss, it has an objective existence of hazardous substances or energy carriers (hazard belongs to the first category), which is a prerequisite for occurrence of near miss or accident. And there exists the second type hazard, such as people, objects and environments, it may lead to the release of hazardous substances or energy, this is the direct cause of near miss or the incident. The third type hazards or management deficiencies and organizational failures of potential hazards can be seen as an indirect cause of near miss or the accidents. The relationships between near miss and hazard and risk are shown in Figure 2.

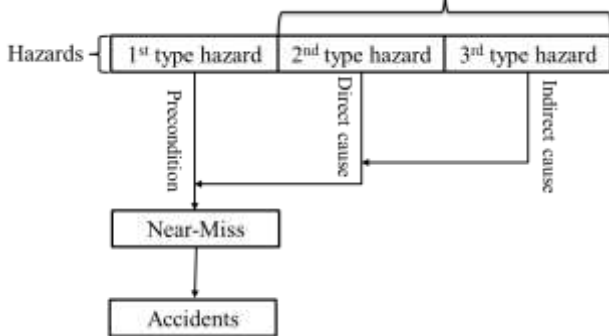


Figure 2. The relationship between near-miss, hazard and risk

III. RISK ASSESSMENT OF NEAR-MISS

In 2010, Shi Xiaohong divided attempted events into three categories based on the main cause of the event: attempted events caused by unsafe behavior, such as misuse or violation of rules; attempted event caused by unsafe condition, such as corrosion and aging; and attempted event caused by insecurity environmental and management deficiencies. According to the risk degree and consequences of attempted events, it can be divided into two levels: general attempted events and larger attempted events. General attempted event is an event that could lead to an accident of the enterprise; larger attempted event is

an event whose potential consequences is likely to result in group stage accident^[3].

In 2003, Phimister^[4,5] attempted to divided attempted events into seven categories: people's unsafe behavior; unsafe condition of matter; gradually serious tiny events; causing harm events in the future (did not happen now); resulting in property damage incidents; impact protection barrier events; potentially damage the environment events. In 2002, Ritwlk^[6] proposed a risk-based management approach based on attempted event, the method will attempt to divide attempted events into unsafe state of matter and people's unsafe behavior.

Although the above methods can be used to qualitatively classify near miss events, but this method is difficult to achieve accurate qualitative classification during the actual operation, it is not conducive to management of near miss events and the prevention of accidents. Based on LEC evaluation method, combined with the actual situation of coal enterprises, the risk of near miss was assessed by using five areas indicators related to the risk rate index of the system. These five indicators are: the possibility of near miss events leading to an accident, L; the frequent of personnel exposure to hazardous environments, E; the monitor extent of the event, M; the learn value of events, S; probable consequences of an accident once occurred, C. According to the characteristics of the five risk indicators, combined with LEC risk assessment, each risk indicator will be divided into seven levels for statistical analysis, specific criteria for the classification was shown in Table 1.

TABLE I. GRADING STANDARD OF RISK INDICATORS

Risk indicators	Grading standard (score)						
	1	2	3	4	5	6	7
L.	Completely possible (10)	Quite possible (6)	Possible, but not often (3)	Small possible, unexpected (1)	Impossible (0.5)	Highly impossible (0.2)	Actually impossible (0.1)
E.	Continued exposure (10)	Working time exposure (6)	Exposure once a week (3)	Exposure once a month (1)	Exposure several times a year (0.5)	rare exposure (0.2)	No exposure (0.1)
M.	completely monitor (10)	Most monitor (6)	Occasionally monitor (3)	not easy to monitor (3)	Impossible monitor (0.5)	Highly impossible monitor (0.2)	Actually impossible monitor (0.1)
S.	great learn value (10)	Large learn value (6)	Certain learn value (3)	Less learn value (3)	Small learn value (0.5)	No learn value (0.2)	Actually no learn value (0.1)
C.	10 people dead (10)	3-9 people dead (6)	1-2 people dead (3)	Serious (3)	Significant disability (0.5)	Attractive (0.2)	no consequent (0.1)

In order to better reflect that the risk of near miss incidents is relative, this study f index was used to represent the relative risk of near miss incidents, namely:

$$f_i = \sum_{j=1}^7 \left(\left| 100 \times \frac{h_{ij} - q_{ij}}{q_{ij}} \right| - \frac{1}{n} \sum_{i=1}^n \left| 100 \times \frac{h_{ij} - q_{ij}}{q_{ij}} \right| \right)$$

Where, f was the dimensionless; h_{ij} was the overall score of j -th indicator for the i -th near miss event; q_{ij} was the lowest value of the j -th indicators in the i -th near miss event; n is the number of near miss incidents, herein, $n=30$. F values were shown in Table 2.

TABLE II. THE F VALUE

No.	Near-Miss	L	E	M	S	C	<i>f_i</i>
1	Replace cutter tooth of roller when the coal stoker was stopped and locked.	28952	39472	83103	41676	330734	-14.60
2	Charged maintenance, relocation equipment	59075	199235	81439	42815	107978	18.44
3	Staff taking a rest on the arm when shearer shutdown, or sleep leaning on the arm	42687	114169	83222	37942	279478	-4.63
4	Stoker Walking, dragging and hanging cables	59427	199235	75969	27044	52472	8.89
5	No stop and latch bolt machine, person drill pipe or duct between the two treatment arms	55903	169633	83220	43150	81236	11.27
6	Do not close the air door, while open two doors, causing short circuit of Merry	56608	13701	8414	43083	68427	5.79
7	Free to get rid of power lockout of gas and wind power lockout device	26916	23720	19548	6139	48697	-27.25
8	Monitoring equipment failure for a long time without treatment and reporting	8247	17524	7760	7198	86000	1.40
9	Maintenance of mining face not cut the power and locked	52467	10419	6911	5966	80562	-4.51
10	Riding running belt	55903	18708	7457	2610	90000	11.39
11	Not rinse coal	6	21	7	0	24	-

1	bunker clear to overhaul into the bunker	493	715	8240	0764	26.48	
12	Start belt falsely; not alarm to start belt	54423	143562	71855	37091	34899	-0.15
13	Personnel across while belt and crusher are operating	50053	74248	5479	32849	29371	-12.73
14	After coal excavation is completed, the driver observed tunneling under the empty top	40520	3166	000	7044	30270	-30.26
15	Imperfect equipment management, such as not timely maintenance or replacement	55463	18708	8474	3658	34090	6.55
16	Using unsafe equipment, such as non-explosion-proof electrical equipment	58018	19058	7874	32061	113596	16.01
17	Command workers to take risks, such as stopping the wind not to withdrawal of workers underground	59427	19058	8474	39068	135843	20.75
18	Unreasonable work assignment, coordinating work not in place	000	000	4818	2473	57011	-27.28
19	Cross-border mining	51339	148470	79179	4609	67079	5.67
20	No construction program, disorderly exploitation	56784	14810	78964	3464	47303	3.25
21	No clear punishment rules about the safety	4393	18997	7810	3500	0000	-20.85

	aspects of the accident	0		9	1		
2 2	No specific regulations about safety rewards	3 3 6. 9 2	11 03 .9 6	7 1 2. 1 3	3 6 8. 1 0	14 0. 90	- 9.61
2 3	No regular safety education and training	5 7 7. 5 3	18 89 .4 5	7 9 8. 9 3	3 9 1. 3 5	75 2. 13	12.2 4
2 4	Inadequate hazard symbol set in workplace	5 5 0. 2 2	19 10 .5 5	8 2 6. 2 8	3 9 8. 7 3	40 8. 31	8.29
2 5	No lockout and lock the conveyor when Coal machine is repairing, and picks are replacing, no latch cradle within scope for the maintenance	5 3 2. 6 0	19 63 .3 2	8 1 0. 8 2	3 9 6. 7 8	64 8. 31	11.5 2
2 6	Secretly dumped scraper, loader lockout protection or shortened lockout protection distance	4 6 9. 1 6	10 67 .2 8	7 8 2. 2 8	4 1 2. 0 6	96 5. 17	3.32
2 7	Transmission power by lines the fault is not excluded	5 8 8. 1 1	19 58 .0 5	7 8 9. 5 4	4 2 8. 1 5	11 26 .9 7	18.2 5
2 8	When testing high-voltage cables, high voltage cables were not discharge	6 0 1. 3 2	19 63 .3 2	6 5 2. 7 8	3 2 7. 7 5	47 5. 28	7.37
2 9	When overhaul high-voltage electrical, not mount ground or cut power, just push out handcart	5 5 0. 2 2	18 08 .1 8	7 7 9. 9 0	4 1 5. 4 2	32 3. 37	5.58
3 0	While shuttle car and forklift car are walking, hands or arms of drivers exposed outside the cab	4 6 1. 2 3	18 55 .1 5	7 8 3. 0 0	3 3 4. 4 5	18 7. 64	2.39

Under the circumstances of considering positive and negative, f value was larger, which represents a higher relative risk of the near miss event, the more attention should be paid. For example the 18th events, where, employee assignments was unreasonable, and coordinating work was not in place, so the f value was -27.28, it was the relatively less risky events. After getting f values of 30 samples, a curve was drawn, and it was shown in Figure 3.

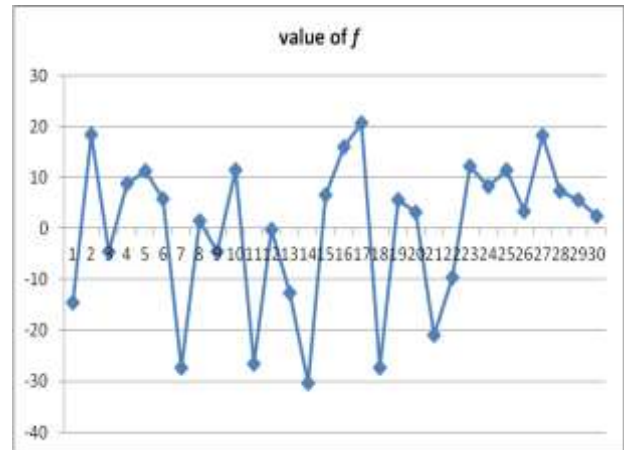


Figure 3. The f values of 30 near miss

Based on f index distribution in Figure 2.1, the relative risk degree of near miss can be divided into seven intervals: $f < -30$, $(-30, -20]$, $(-20, -10]$, $(-10, 0]$, $(0, 10]$, $(10, 20]$ and $f > 20$. Their corresponding risk levels are basic non-risk, small risk, less risk, general risk, relatively large risk, large risk and great risk.

Just as can be seen in Figure 3, No. 2, 5, 10, 16, 23, 25 and 27 near miss falls within $(10, 20]$ interval, which indicated that seven near miss was worthy of attention, it belong to large risk and should be promptly stopped. Especially for No. 17 near miss, its f value is greater than 20, it belong to large risk event, and it should be strictly prohibited in the mine.

To further verify the accuracy of the results, this method was compared with the traditional LEC risk assessment methods, and the result was shown in Figure 4, we found that their result is basically the same, these objective data with describe of mine workers further proved the obtained experimental results.

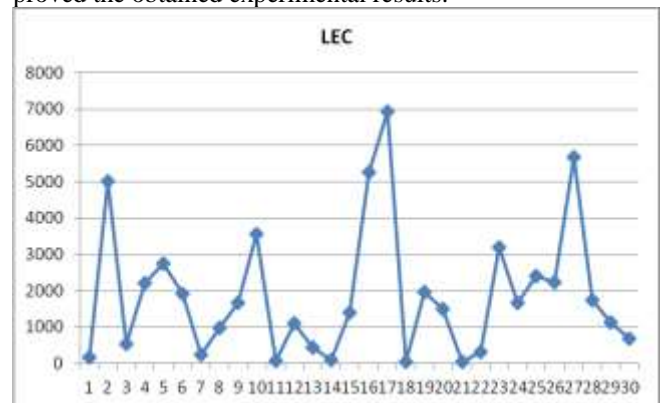


Figure 4. . LEC score of near miss

Such refined classification make employees have a more profound and accurate understanding on near miss events. By classification, the resources can be sufficiently and rationally utilized, simultaneously it can avoid waste, which is the effective pre-control method to avoid a major accident. In the coal industry, Wei Xiangrong raised that people's unsafe behavior is the biggest risk of accidents in 2011. Unexpected accidents often occurred on the basis of many times violations, the occurrence of an accident have repeatedly attempted events. The best way to prevent accidents is to eliminate the "three violations" and destroy "attempted." In 2007, He Peng proposed any a happened accident has signs to follow for the enterprise, it was the results of a variety of security risks and the risk factors during the producing process. How to detect the risk factors and take measures to eliminate the risk management is the top priority for coal enterprises, and this is the advantages of risk management theory. Therefore, the risk management ideas should be vigorously popularized in the coal enterprise, which help to discover risk factors and take measures in advance. In 2004, Su Liping proposed the cause of accident was people's unsafe behavior and unsafe condition of matter, and unsafe condition of matter was also caused by people's unsafe behavior in the final. Error caused by human was ubiquitous, but not every error caused by human induced failure of the system. Due to the time difference in which the system located, there are a considerable number of errors caused by human which only lead to attempted events or a potential failure, and it often failed to arouse people's full attention, but these potential failure phenomenon may induce potential problems for the safe production. Only by subdividing near miss events into different levels, different attention was pay to different levels, can we prevent possible trouble.

IV. CONCLUSION

(1) By defining concept of near miss, and analyzing its difference and relationship with hazards and risks, the near miss of coal mine referred to small events that has a characteristic symptom of accidents, but did not produce losses and injuries or only a slight loss and damage due to lack of conditions. If conditions change, there will still be the possibility resulting in an accident.

(2) Learn from LEC risk evaluation, the near miss risk was assessed by using five indicators associated with risk ratio. These five indicators are: the possibility of near miss leading to an accident occurring, L; frequent of personnel exposure to hazardous environments, E; the monitor extent

of the event, M; the learn value of events, S; the consequences of an accident occurring, C. The relative risk assessment model of near miss was constructed by using f risk index, practice has proved that the classification results are basically the same with the traditional LEC risk assessment methods, and it can reflect the risk characteristics of near miss events from the many perspectives.

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