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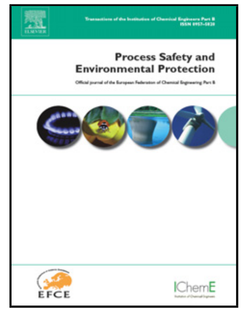
Reference:
Zhang Jinjia, Xu Kaili, Reniers Genserik, You Greg.- Statistical analysis the characteristics of extraordinarily severe coal mine accidents (ESCMAs) in China from 1950 to 2018
Process safety and environmental protection / Institution of Chemical Engineers [London] - ISSN 0957-5820 - 133(2020), p. 332-340
Full text (Publisher's DOI): https://doi.org/10.1016/J.PSEP.2019.10.014
To cite this reference: https://hdl.handle.net/10067/1656950151162165141

Journal Pre-proof



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PII: S0957-5820(19)30832-8

DOI: https://doi.org/10.1016/j.psep.2019.10.014

Reference: PSEP 1950

To appear in: *Process Safety and Environmental Protection*

Received Date: 5 May 2019

Revised Date: 29 August 2019

Accepted Date: 9 October 2019

Please cite this article as: Zhang J, Xu K, Reniers G, You G, Statistical analysis the characteristics of extraordinarily severe coal mine accidents (ESCMAs) in China from 1950 to 2018, *Process Safety and Environmental Protection* (2019), doi: https://doi.org/10.1016/j.psep.2019.10.014

Statistical analysis the characteristics of extraordinarily severe coal mine accidents (ESCMAs) in China from 1950 to 2018

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ABSTRACT

Extraordinarily severe coal mine accidents (ESCMAs) are characteristized by thirty fatalities or more in one accident. In this paper, such ESCMAs are analyzed using 188 cases which occurred in Chinese underground coal mines. The analysis shows that the number of ESCMAs and the death toll have decreased steadily over time. Gas explosions, mine water inrushes, coal dust explosions, and fire, coal and gas outbursts are the six major types of ESCMAs. Among the causes of ESCMAs, inadequate implementation of safety measures, deliberate violations and electromechanical equipment faults are the three top causes of ESCMAs, accounting for 27.13%, 21.81%, and 15.96% of incidences, respectively. Meanwhile, ESCMAs frequently occur in the heading face, especially gas explosions, mine water inrushes and coal and gas outbursts. Furthermore, ESCMAs reoccur often in certain provinces, such as Shanxi, Henan and Heilongjiang, and mostly during November and December in each year. The results of statistical studies have presented useful information for the prevention of ESCMAs in order to reduce the probability of such disastrous accidents.

Key words: Underground coal mine; Extraordinarily severe coal mine accidents; Accident statistics; Accident characteristics

1. Introduction

The mining industry has always been considered as an inherently high-risk profession worldwide (Patterson and Shappell, 2010; Liu, 2019). In China, with the increasing mining depths of underground coal mines, the geological conditions have become more complicated. According to previous publications, 188 ESCMAs occurred between 1950 and 2018, causing 11,526 deaths (SACMS, 2018; SAWS, 2005; SAWS, 2007; Wang and Li, 2002; Zhang et al., 2018; Zhang et al., 2019). Moreover, the case of more than 100 fatalities in one ESCMA occurred 25 times, causing in total 3,952 deaths (Table 1). From this data, it is clear that the control or elimination of ESCMAs is vital for reducing the death toll and improving coal production in Chinese underground coal mines.

To date, some scholars have conducted valuable work in general coal mine accidents (Amyotte, 2006; Beamish and Crosdale, 1998; Chen et al., 2012; Cliff, 2015; Patterson and Shappell, 2010; Lenné et al., 2012; Sun et al., 2016; Wang et al., 2014; Xu and Xu, 2018; Yin et al., 2014; Zhai et al., 2016; Zheng et al., 2009), but a focus on the characteristics of ESCMAs is very rare. In addition, engineering technology approaches themselves cannot address safety issues alone without considering safety management. Statistical analysis on accident cases is the basic prerequisite to implement hazard identification and safety management. ESCMAs occur frequently in Chinese underground coal mines and have similar accident causes, but we still have not learned from the experiences of past accidents. Our purpose is to analyze the regulations and characteristics of ESCMAs by reviewing 188 cases based on a statistical method, on illustrating what lessons should be learned from past accidents and what topics should be paid more attention to in future coal production. The aim is to prevent the occurrence of ESCMAs and improve the safety situation of the Chinese coal mining industry.

2. Structure of ESCMA types

According to the Chinese Coal Mine Accidents Report (2006-2014), the major accident categories in Chinese coal mines include gas explosions, coal and gas outbursts, roof falls, flooding, fire and haulage (SACMS, 2018). The obvious question is which accident categories are most likely to occur in ESCMAs. This question, although obvious, is still unanswered. In an attempt to answer this question, we have collected 188 cases of ESCMAs (see Appendix A) in Chinese underground coal mines from 1950 to 2018 and made a further analysis about the accident causes, as shown in Figs. 1 (a) and (b) (SACMS, 2018; SAWS, 2005; SAWS, 2007; Wang and Li, 2002).

It is shown in Figs. 1 (a) and (b) that gas explosion accidents, mine water inrush accidents, coal dust explosion accidents, fire accidents and coal and gas outburst accidents, were the six major categories of ESCMAs in Chinese underground coal mines. Among them, gas explosion accidents are the most common and dangerous because they have the highest percentage of ESCMAs and death toll, at 68% and 66% respectively. It is noteworthy to mention that gas explosions and coal dust explosions lead to more deaths than any other type of accident. The destructive modes of gas explosion and coal dust explosion, such as overpressure waves, thermal radiation and poisonous gas, prevent miners from escaping quickly. Hence, the prevention of gas explosions and coal dust explosions should focus on early warnings and monitoring. In addition, coal and gas outbursts and mine fires, easily caused by disasters such as gas explosions and coal dust explosions, may lead to more fatalities.

Causes of ESCMAs

According to the 188 case reports of ESCMAs, Table 2 summarizes the information and frequency of direct causes of different types of accidents. As shown in Table 2, disorganized ventilation fan management and illegal blasting are the most common causes in gas explosions, causing 45 and 45 out of 128 gas explosion accidents, respectively. A mining waterproof coal pillar is the most common cause of mine water inrushes, resulting in 8 out of 21 mine water inrush accidents. Coal dust becoming too thick without being swept in a timely manner and illegal blasting are the most common causes of coal dust explosions, leading to 13 and 7 out of 13 coal dust explosion accidents, respectively. Electromechanical equipment with short circuits is the most common cause of fires, triggering 8 out of 13 fire accidents. Not implementing preventive measures for outbursts and blasting are the most common causes of coal and gas outbursts, causing 6 out of 10 coal and gas outburst accidents. In addition, illegal blasting and electromechanical equipment faults are the two major ignition sources, leading to 52 and 44 out of 188 ESCMAs, respectively. In the event of coal dust explosions, it is worth noting that coal dust was involved in 42 explosions (gas and coal dust, as well as coal dust) and had volatile ratios between 27% and 56%.

For a further analysis of the direct causes of ESCMAs, we divided the ESCMAs into six main types, as shown in Table 3: deliberate violations, skill-based errors, defective designs, change of geological conditions, electromechanical equipment faults and inadequate implementation of safety measures (Chen et al., 2012; Lenné et al., 2012; Patterson and Shappell, 2010; Xu et al., 2019). The results of the analysis of the 188 cases of ESCMAs showed that inadequate implementation of safety measures has the highest percentage, at 27.13%, followed by deliberate violations at 21.81% and equipment faults at 15.96%. It was noteworthy that human-related accident causes, such as deliberate violations, skill-based errors, defective designs and inadequate implementation of safety measures, accounted for 76.07% in total. In other words, more than 76.07% of ESCMAs resulted from weak safety awareness, poor occupational skills and ineffective safety management. Thus, most ESCMAs could not be regarded as "inevitable". Coal enterprises should therefore obviously strengthen safety training and safety management in order to enhance miners' safety awareness, occupational skills and strictly implement all safety measures.

3. Locations of ESCMAs

In theory, ESCMAs could occur at any location in an underground coal mine. However, statistical analysis shows that ESCMAs frequently occur at certain locations. As shown in Table 4, there are 26 types of accident locations in underground coal mines. ESCMAs are most likely to occur in the heading face, which result in 65 accidents and account for 34.57% of all accidents, followed by the coal face and the return airway. The primary cause is that the heading face and the coal face account for a large number of miners and equipment involved in various crafts because these locations are the major production areas in underground coal mines. Inevitably, violations, equipment faults and inadequate implementation of safety measures occur with a higher probability in these locations. Illegal blasting, local fans with recirculating air, not implementing the regulations of exploring water or prevention measures of outburst are just some examples. It was noted that gas explosions, mine water inrushes and coal and gas outbursts frequently occur in the heading face. Safety managers should strictly supervise the work of miners and inspect the equipment and implementation performance of safety regulations and safety measures.

4. Time of ESCMAs

As shown in the analysis of numbers of accidents per year in Fig. 2, the occurrence frequency of ESCMAs indicate a downward trend from 2006 to 2018 after an upward movement between 1990 and 2005. Indeed, the occurrence frequency of ESCMAs demonstrates fluctuation, and can be roughly divided into three stages: a stable stage with a slight fluctuation from 1950 to 1989; an increasing stage from 1990 to 2005; and a declining stage from 2006 to 2018. These phenomena may be related to economic activities, legislation and safety technology. From 1950-1989, coal consumption was low because China's economy still rooted in agriculture. After 1990, industrialization with a high consumption of coal in the economy rapidly rose year after year. Meanwhile, safety related legislation and safety technology lagged far behind the actual development of the mining industry. Especially during 2000-2005, the number of ESCMAs and death toll reached a peak of 49 accidents causing 2999 deaths. Faced with the severe situation of safety in production, the Chinese government and SACMS improved the laws, regulations, safety technology and equipment for the prevention of coal mine accidents. Although the number of ESCMAs have decreased since 2006, ESCMAs still have not been thoroughly eliminated in Chinese coal mines.

As shown in Fig. 3, the months of May, November and December are in the top three with respect to the number of ESCMAs, while January has the least number of accidents. This phenomenon may be linked with the seasonality of coal output and energy structure. Coal is the dominant energy source in China, accounting for more than 70% of energy consumption. However, more than 60% of coal output is employed to generate power and supply heating (Zheng et al., 2009). Generally, in November, December and January, coal demand rapidly increases because of the onset of winter, and waterpower decreases sharply in China as power generation and heating demand reaches a peak in Northern China. Then, most coal enterprises usually pay more attention to increasing output and neglect safety issues in order to maximize profits. In addition, the results in month of May may result from the fact that sensible heat in the working place shows a tendency of steer increase from spring to summer in China. Some phenomenon a related to the body and mind may be related to this rise of temperature, such as exhaustion, dysphoria and inattention, and may increase the occurrence possibility of ESCMAs (Zhang et al., 2006). It is interesting to note, however, that January has the least number of ESCMAs. Possibly, the reason for this is that the Spring Festival usually occurs in January, and then coal enterprises take long holidays.

5. Regions in which ESCMAs occur

In China, 23 major produce coal provinces have suffered from ESCMAs. The number of ESCMAs and the death toll for every province are shown in Fig. 4. Shanxi, Henan and Heilongjiang are the top three provinces in the number of ESCMAs and death toll. This distribution may be related to the coal resources, reserve conditions and the number of coal mines. For instance, Shanxi's coal resources account for approximately 25% of the national total (SXBCI, 2017). Though coal resources are very rich in Shanxi, there are major coal-bearing rocks of Lime-Permian and lithologies including sandstone, mudstone and limestone, which have the characteristics of high gas contents and high aquosity. With the increasing depths of coal mines, the geological characteristics have become more complicated, and there has been a higher frequency of gas explosions and mine water inrushes. In addition, small coal mines with poor production conditions and outdated equipment account for approximately 70% of Shanxi's coal mines (SXBCI, 2017). The owners of small coal mines are reluctant to increase safety investments for safety equipment and facilities in order to maximize the enterprises' profits. In addition, approximately 80% of miners come from rural regions with education lower than junior middle school (including junior middle school), and they have difficulties understanding the importance of safety precautions and the serious consequences of ESCMAs (Chen et al., 2013).

7. Discussion

The major types of accident have different ESCMAs and common accidents (less three fatalities in one accident) in Chinese underground coal mines. Gas explosions, mine water inrush and coal dust explosions are the major types of ESCMAs. Some literature indeed indicates that gas explosions, roof falls and mine water inrush are the top three types of common accidents in Chinese underground coal mines (Deng et al., 2014; Wang et al., 2015; Chen et al., 2012). Thus, gas explosions and mine water inrush need to be emphasized on prevention for ESCMAs and common accidents in Chinese underground coal mines.

In addition, mismanagement is an indirect but important cause of ESCMAs. Among the direct causes of ESCMAs, deliberate violations, skill-based errors and inadequate implementation of safety measures accounted for 63.3% of the total, and showing that the control of mismanagement is vital for preventing ESCMAs. The primary cause of this phenomenon is due to the low professionalism of miners that consist mainly of rural and immigrant workers. If coal enterprises could enhance effective safety management and safety training, unsafe behaviors may be greatly avioded, and the occurrence probability of ESCMAs reduced.

Further, complex geological conditions may indirectly have an influence on the occurrence of ESCMAs. For example, China's State Administration of Coal Mine Safety classified the nation's coal mines with respect to gas mines and hydrological mines in 2012, and revealed that there were the 1191 coal and gas outburst mines, 2093 high gas mines and 905 hydrogeological complexity mines (Sun, 2014; Sun et al., 2016). Meanwhile, a large number of coal mines have characteristics of coal dust explosion. These complicated geological conditions are the basic cause of ESCMAs. Therefore, coal enterprises should increase safety investments for safety technology and equipment (e.g., gas monitoring and controlling system, drill rigs, safety protection facilities), and strictly implement the safety measures (e.g., gas pre-extraction measure, outburst prevention measures, dewartering measures, sweeping coal dust measures).

Though the Chinese government and coal enterprises have made great progress in preventing ESCMAs in recent years, two ESCMAs still occurred in 2016. However, the two ESCMAs in

2016 still reappered in the past accidents causation. It is crucial to learn from the experiences of past accidents for peventing ESCMAs. Based on this, Chinese university should focus on the accident causation, risk assessment model and simulation system of ESCMAs, and explore new clean energy sources, such as biomass (Ge et al., 2019; Yan and Xu, 2019;). Besides, the Chinese government and coal enterprises also should realize that the work of the preventing ESCMAs is a long-term systematic engineering that ivolve in the perfecting legislation, improving the system of safety supervision, innovating safety technology and equipment, and enhancing miners' professional rate.

8. Conclusions

There is rarely a focus on the regulations and characteristics of ESCMAs in Chinese underground coal mines. Through the analysis of 188 ESCMAs, some useful conclusions can be drawn:

(1) Gas explosions, mine water inrushes, coal dust explosions, and fire, coal and gas outbursts were the six major categories of ESCMAs in Chinese underground coal mines. Gas explosions and mine water inrushes are the primary types of ESCMAs.

(2) Disorganized ventilation fan management, illegal blasting, electromechanical equipment faults, mining waterproof coal pillars, coal dust accumulation without timely sweeping, not implementing measures of outburst prevention and blasting are the six major causes of ESCMAs.

(3) Inadequate implementation of safety measures, deliberate violations, and electromechanical equipment faults are the three top causes of ESCMAs that accounted for 27.13%, 21.81%, 15.96% of incidents, respectively.

(4) The occurrence frequency of ESCMAs shows a decreasing downward trend since 2006. ESCMAs most frequently occur in May, November and December.

(5) The Shanxi, Henan and Heilongjiang provinces have the highest number of ESCMAs and the highest death tolls.

Acknowledgments

Jinjia Zhang greatly acknowledges the assistance and guidance of Professor Genserik Reniers at the Universiteit Antwerpen.

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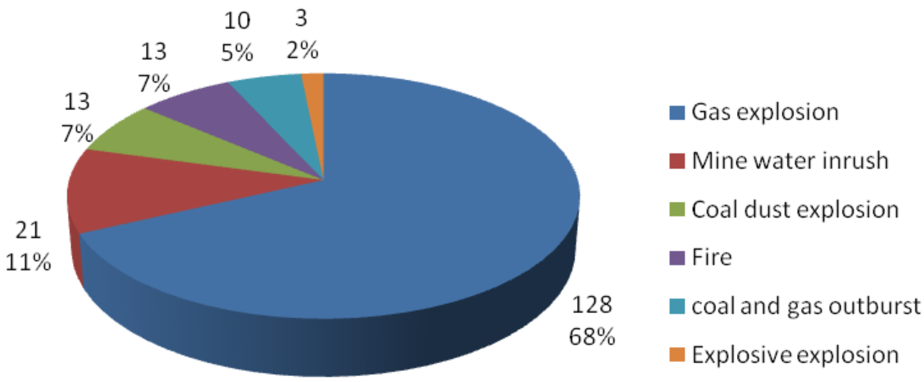
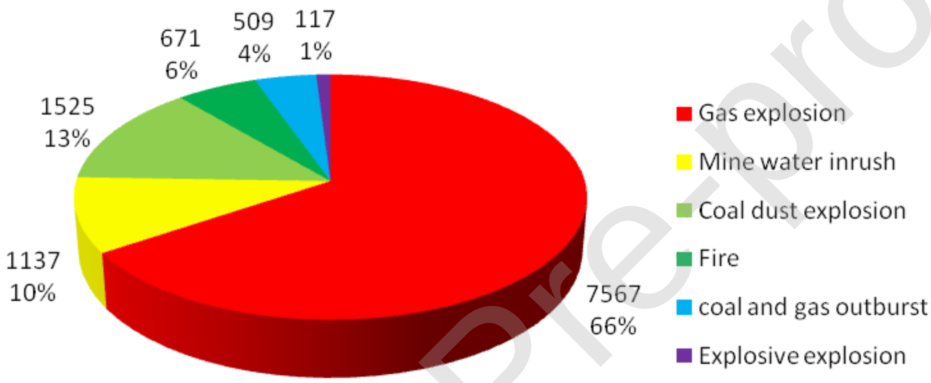


Fig. 1 (a) The number of ESCMAs



(b) Deaths toll

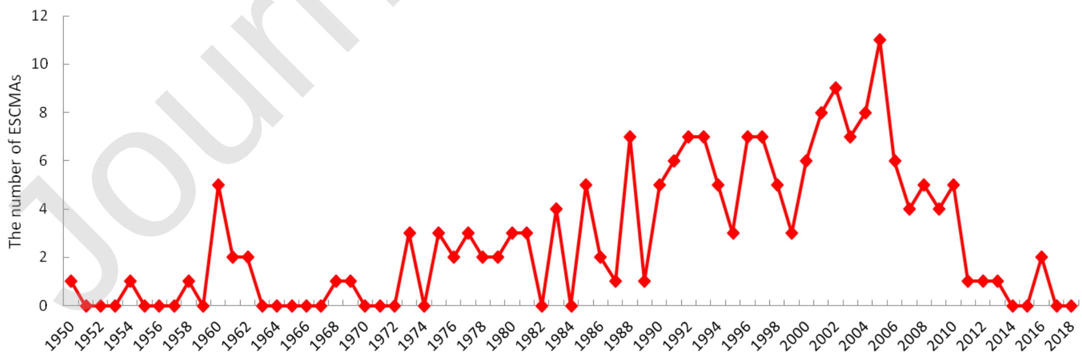


Fig. 2 Frequency distribution of ESCMAs at a yearly level

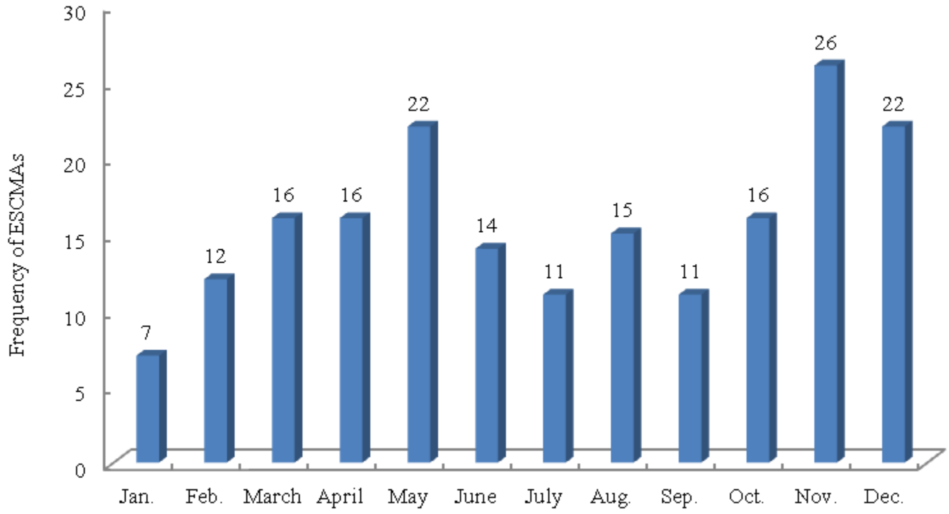


Fig. 3. Frequency distribution of ESCMAs at a monthly level

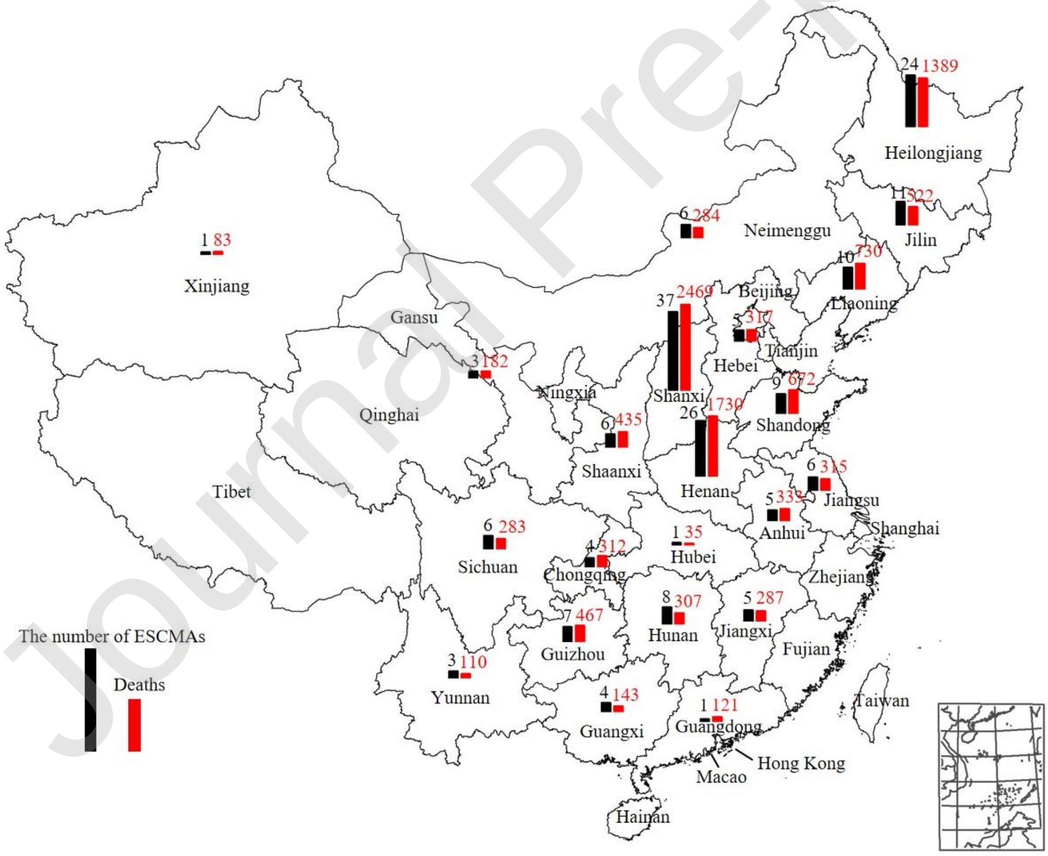


Fig. 4 The number of ESCMAs and deaths toll in different provinces

Table 1 ESCMAs with more than 100 deaths in Chinese underground coal mines from 1950 to 2018

Date	**Province**	**Mine Name**	**Accident Type**	**Deaths**
27/02/1950	Henan	Yiluo mine	Gas explosion	187
06/12/1954	Neimenggu	Dafa mine	Gas and coal dust explosion	104
09/05/1960	Shanxi	Laobaidong mine	Coal dust explosion	684
14/05/1960	Chongqing	Songzao mine	Coal and gas outburst	125
28/11/1960	Henan	Longshanmiao mine	Gas explosion	187
15/12/1960	Chongqing	Zhongliangshan mine	Gas and coal dust explosion	124
16/03/1961	Liaoning	Shengli mine	Fire	110
24/10/1968	Shandong	Huafeng mine	Coal dust explosion	108
04/04/1969	Shandong	Panxi mine	Coal dust explosion	115
11/05/1975	Shaanxi	Jiaoping mine	Gas and coal dust explosion	101
24/02/1977	Jiangxi	Pinghu Mine	Gas explosion	114
24/12/1981	Henan	Pingdingshan fifth mine	Gas and coal dust explosion	133
21/04/1991	Shanxi	Sanjiaohe mine	Gas and coal dust explosion	147
27/11/1996	Shanxi	Dongcun mine	Gas and coal dust explosion	114
27/09/2000	Guizhou	Muchonggou mine	Gas and coal dust explosion	162
20/06/2002	Heilongjiang	Chengzihe mine	Gas explosion	124
20/10/2004	Henan	Daping mine	Gas explosion	148
28/11/2004	Shaanxi	Chenjiashan mine	Gas explosion	166
14/02/2005	Liaoning	Sunjiawan mine	Gas explosion	214
07/08/2005	Guangdong	Daxing mine	Mine water inrush	121
07/11/2005	Heilongjiang	Dongfeng mine	Coal dust explosion	171
07/12/2005	Hebei	Liuguantun mine	Gas and coal dust explosion	108
17/08/2007	Shandong	Huayuan mine	Mine water inrush	172
05/12/2007	Shanxi	Ruizhiyuan mine	Gas explosion	105

21/11/2009	Heilongjiang	Xinxing mine	Gas explosion	108

Note: Data are from the China's Coal Mine Accidents and Comments of Safety Specialists, Extraordinary Severe Accidents with Collection Cases and Online Accident Inquiry System of SACMS

Table 2 Direct causes of ESCMAs from 1950 to 2018

Accident categories	**Direct cause**		**Frequency**
Gas explosion	Gas accumulation	Defective ventilation system design	26
		Chaotic ventilation duct management	21
		Disorganized ventilation fan management	45
		Chaotic ventilation facilities management	4
		Local Gas accumulation	15
		Roof fall caused by abnormal gas-effusion	7
		Coal and gas outburst	5
		Poor quality of roadway construction	5
	Ignition sources	Illegal blasting	45
		Fire without an extinguisher in fire area	2
		Smoking	4
		Illumination by open fire	3
		Dismantling cap lamp	7
		Cap-lamp without explosion resistance	4
		Strike spark	9
		Friction spark	4
		Spontaneous combustion	10
		Maintenance of electromechanical equipment with power	7
		Electromechanical equipment without explosion resistance	32
		Welding spark	1
Mine water inrush	Discovery of water inrush without taking measures		5
	Surface water intrusion		2
	Violating the regulation of exploring water first and then mining		3

	Mining waterproof coal pillar		8
	Blasting leading to water inrush of old mining area		3
Coal dust explosion	Coal dust accumulation	Coal dust accumulating too thick without sweeping timely	13
	Ignition sources	Illegal blasting	7
		Electromechanical equipment with short circuit	4
		Strike spark	1
		Welding fire	1
Fire	Electromechanical equipment with short circuit		8
	Spontaneous combustion of coal		3
	Spontaneous combustion of explosive		1
	Welding fire		1
Coal and gas outburst	Not implementing measures to prevent outburst and then blasting		6
	Coal cutter cutting coal		1
	Illegal drilling		1
	Illegal mining coal by pick		2
Explosive explosion	Poor ventilation resulting in spontaneous combustion of explosives		3

Table 3 Classified analysis of causes of ESCMAs in Chinese underground coal mines from 1950 to 2018

Causes of accidents	**Gas explosion**	**Mine water inrush**	**Coal dust explosion**	**Fire**	**Coal and gas outburst**	**Other**	**Sum**	
							Frequency	**Percentage (%)**
Deliberate violations	34	/	7	/	/	/	41	21.81
Skill-based errors	21	/	2	1	3	/	27	14.36
Defective design	16	8	/	/	/	/	24	12.77
Change of geological conditions	12	/	/	3	/	/	15	7.98
Electromechanical equipment fault	18	/	4	8	/	/	30	15.96
Inadequate implementation of safety measures	28	13	/	1	6	3	51	27.13

Table 4 Accident locations distribution of ESCMAs in Chinese underground coal mines from 1950 to 2018

Accident locations	**Gas explosion**	**Mine water inrush**	**Coal dust explosion**	**Fire**	**Coal and gas outburst**	**Explosive explosion**	**Sum**	
							Frequency	**Percentage (%)**
Heading face	44	10	3	2	6	/	66	35.11
Coal face	35	3	4	/	1	/	44	23.40
Return airway	8	/	/	/	/	/	8	4.26
Gob area	7	1	/	/	/	/	8	4.26
Blind roadway	5	/	/	/	/	/	5	2.66
Haulage roadway	4	/	/	2	/	/	6	3.19
Sublevel roadway	3	/	/	/	/	/	3	1.60
Excavation roadway	3	3	/	/	/	/	6	3.19
Cross-heading	3	/	/	1	/	/	4	2.13
Sealed area	2	/	/	/	/	/	2	1.06
Hoist control room	2	1	/	1	/	/	4	2.13
Rise	3	2	/	/	/	/	5	2.66
Cross-cut	2	/	/	/	/	/	2	1.06
Main haulage roadway	1	/	/	/	/	/	1	0.53
Drilling roadway	1	/	/	/	/	/	1	0.53
Unloading roadway	1	/	/	/	/	/	1	0.53
Dip	1	/	1	1	/	/	3	1.60
Shaft station	1	/	1	/	/	/	2	1.06

Coal bunker	/	/	1	/	/	/	1	0.53
Maintenance chamber	/	/	1	1	/	/	2	1.06
Substation	/	/	/	2	/	/	2	1.06
Hoist roadway	/	/	2	/	/	/	2	1.06
Pump station	/	/	/	1	/	/	1	0.53
Cross-hole	/	/	/	/	3	/	3	1.60
Blasting supply storage	/	/	/	1	/	3	4	2.13
Other	/	1	/	1	/	/	2	1.06

Appendix A

Statistical cases of 186 ESCMAs in Chinese underground coal mines from 1950 to 2015

Item	Date	Mine name	Region	Accident type	Deaths
1	27/02/1950	Yiluo mine	Henan	Gas explosion	187
2	06/12/1954	Dafa mine	Neimenggu	Gas and dust explosion	104
3	07/11/1958	Dahuangshan mine	Jiangsu	Gas explosion	48
4	09/05/1960	Laobaidong mine	Shanxi	Coal dust explosion	684
5	14/05/1960	Songzaoer mine	Chongqing	Coal and gas outburst	125
6	16/06/1960	Liangdu mine	Shanxi	Gas explosion	38
7	28/11/1960	Longshanmiao mine	Henan	Gas explosion	187
8	15/12/1960	Zhongliangshang mine	Chongqing	Gas and dust explosion	124
9	16/03/1961	Shengli mine	Liaoning	Fire	110
10	20/09/1961	Didao mine	Heilongjiang	Coal dust explosion	53
11	21/06/1962	Longfeng mine	Liaoning	Gas explosion	40
12	08/08/1962	Lingdong mine	Heilongjiang	Gas explosion	34
13	24/10/1968	Huafeng mine	Shandong	Coal dust explosion	108
14	04/04/1969	Panxi mine	Shandong	Coal dust explosion	115
15	04/03/1973	Jingyuan mine	Gansu	Gas explosion	47
16	19/03/1973	Taixin mine	Jilin	Gas and dust explosion	53
17	23/06/1973	Jiahe mine	Jiangsu	Coal dust explosion	50
18	27/04/1975	Maanshan mine	Hubei	Fire	35
19	04/08/1975	Yanmazhuang mine	Henan	Coal and gas outburst	43
20	11/05/1975	Jiaoping mine	Shaanxi	Gas and dust explosion	101
21	01/08/1976	Weitang mine	Jilin	Gas and dust explosion	50
22	13/08/1976	Wangzhuang mine	Henan	Fire	93
23	24/02/1977	Pinghu mine	Jiangxi	Gas explosion	114

24	14/04/1977	Laohutai mine	Liaoning	Gas explosion	83
25	19/12/1977	Meihe mine	Jilin	Mine water inrush	64
26	15/02/1978	Dongfu mine	Jilin	Fire	58
27	24/05/1978	Yaojie mine	Gansu	Coal and gas outburst	90
28	30/06/1979	Chaili mine	Shandong	Coal dust explosion	39
29	23/11/1979	Songshuzhen mine	Jilin	Gas explosion	52
30	08/06/1980	Sanjiaohe mine	Shanxi	Gas explosion	30
31	21/06/1980	Qinghemen mine	Liaoning	Gas explosion	34
32	08/12/1980	Hanqiao mine	Jiangsu	Coal dust explosion	55
33	08/02/1981	Suhetu mine	Neimenggu	Fire	35
34	19/03/1981	Wangzhuang mine	Hebei	Gas and dust explosion	46
35	24/12/1981	Pingshan fifth mine	Henan	Gas and dust explosion	133
36	06/03/1983	Xujiagou mine	Henan	Fire	47
37	20/03/1983	Muchonggu mine	Guizhou	Gas and dust explosion	84
38	05/08/1983	Majiazi mine	Liaoning	Gas explosion	34
39	21/11/1983	Shiliner mine	Henan	Gas explosion	45
40	10/02/1985	Duerping mine	Shanxi	Gas explosion	48
41	07/04/1985	Xingren mine	Shandong	Coal dust explosion	63
42	13/05/1985	Linsheng mine	Liaoning	Gas and dust explosion	36
43	20/09/1985	Lijiagou mine	Sichuan	Mine water inrush	61
44	06/10/1985	Chengzihe mine	Heilongjiang	Gas explosion	36
45	23/02/1986	Zhangwan mine	Henan	Gas explosion	32
46	30/06/1986	Gangtou mine	Hebei	Gas explosion	79
47	09/12/1987	Panyi mine	Anhui	Gas explosion	44
48	06/05/1988	Anlecui mine	Guizhou	Gas explosion	46
49	29/05/1988	Shengfu mine	Shanxi	Gas explosion	50
50	18/06/1988	Mogou mine	Shanxi	Gas explosion	40

51	17/07/1988	Banpo mine	Yunnan	Gas explosion	35
52	05/08/1988	Xipo mine	Gansu	Gas explosion	45
53	26/11/1988	Pinggang mine	Heilongjiang	Gas explosion	45
54	30/12/1988	Caozhuang mine	Shandong	Gas and dust explosion	33
55	20/10/1989	Mingshan mine	Jiangxi	Gas explosion	36
56	06/04/1990	Dongfeng mine	Sichuan	Mine water inrush	57
57	15/04/1990	Taoshan mine	Heilongjiang	Gas explosion	33
58	08/05/1990	Xiaohengshan mine	Heilongjiang	Fire	80
59	13/07/1990	Panxi mine	Shandong	Gas and dust explosion	48
60	07/08/1990	Dongyanshang mine	Hunan	Mine water inrush	57
61	02/01/1991	Baohe mine	Heilongjiang	Gas explosion	53
62	07/03/1991	Liejiaqiao mine	Hunan	Coal dust explosion	35
63	24/03/1991	Hongwei mine	Hunan	Coal and gas outburst	30
64	21/04/1991	Sanjiaohe mine	Shanxi	Gas and dust explosion	147
65	18/05/1991	Yaozitou mine	Shanxi	Gas explosion	42
66	09/08/1991	Zhongba mine	Sichuan	Mine water inrush	42
67	13/03/1992	Gangzicun mine	Jiangsu	Gas and dust explosion	30
68	24/04/1992	Yanpangou mine	Shanxi	Gas explosion	40
69	17/06/1992	Longpowan mine	Hunan	Gas and dust explosion	43
70	29/08/1992	Huagusahan mine	Jiangxi	Gas explosion	46
71	06/09/1992	Mengjiaowan mine	Hunan	Mine water inrush	33
72	05/11/1992	Shenyigou mine	Shanxi	Mine water inrush	51
73	07/12/1992	Qingciyao mine	Shanxi	Gas explosion	36
74	20/01/1993	Panyi mine	Anhui	Gas explosion	39
75	08/05/1993	Pingdingshan eleventh mine	Henan	Gas explosion	39
76	05/08/1993	Longshan mine	Shandong	Mine water inrush	59
77	11/10/1993	Baohe mine	Heilongjiang	Gas explosion	70

78	18/10/1993	Daliu mine	Jiangsu	Coal dust explosion	40
79	15/11/1993	Niangniangshan mine	Henan	Gas explosion	49
80	30/12/1993	Miaowan mine	Shanxi	Gas explosion	40
81	24/01/1994	Erdaohezi mine	Heilongjiang	Gas explosion	99
82	27/01/1994	Huaqiaolian mine	Hunan	Gas and dust explosion	36
83	21/05/1994	Mopancun mine	Sichuan	Gas explosion	36
84	17/09/1994	Nanshan mine	Heilongjiang	Gas explosion	56
85	13/11/1994	Taixin mine	Jilin	Coal dust explosion	79
86	06/05/1995	Gucheng mine	Shanxi	Gas explosion	35
87	23/06/1995	Xieyi mine	Anhui	Gas explosion	76
88	31/12/1995	Laowuji mine	Guizhou	Gas explosion	65
89	21/05/1996	Pingdingshan tenthi mine	Henan	Gas explosion	84
90	11/09/1996	Sixiang mine	Guangxi	Mine water inrush	41
91	19/10/1996	Cuijiagou mine	Shaanxi	Gas explosion	50
92	19/10/1996	Xingan mine	Heilongjiang	Gas explosion	34
93	17/11/1996	Jiaoyun mine	Heilongjiang	Gas explosion	30
94	27/11/1996	Dongcun mine	Shanxi	Gas and dust explosion	114
95	02/12/1996	Hejiashe mine	Shanxi	Gas and dust explosion	44
96	04/03/1997	Hongtupo mine	Henan	Gas and dust explosion	42
97	19/05/1997	Tongda mine	Neimenggu	Gas and dust explosion	30
98	28/05/1997	Longfeng mine	Liaoning	Gas explosion	69
99	12/07/1997	Qiaotouqiu mine	Jiangxi	Gas explosion	40
100	25/10/1997	Zhangzhuangcun mine	Henan	Gas explosion	32
101	13/11/1997	Pansan mine	Anhui	Gas explosion	88
102	10/12/1997	Dajing mine	Henan	Gas explosion	79
103	24/01/1998	Wangying	Liaoning	Gas explosion	78
104	15/10/1998	Dongxing mine	Heilongjiang	Gas explosion	46

105	25/10/1998	Huangyiping mine	Guangxi	Mine water mine	36
106	21/11/1998	Xigou mine	Shanxi	Gas explosion	48
107	12/12/1998	Yi mine	Henan	Gas and dust explosion	66
108	14/02/1999	Xinjian mine	Heilongjiang	Gas explosion	48
109	02/04/1999	Hongtugou mine	Henan	Gas and dust explosion	30
110	24/08/1999	Hanzhuanger mine	Henan	Gas and dust explosion	55
111	15/04/2000	Yongle mine	Shanxi	Gas explosion	43
112	05/09/2000	Yongdingzhuang mine	Shanxi	Gas explosion	31
113	27/09/2000	Muchonggou mine	Guizhou	Gas and dust explosion	162
114	05/11/2000	Xi’an mine	Jilin	Gas explosion	31
115	25/11/2000	Dayantaer mine	Neimenggu	Gas explosion	51
116	03/12/2000	Tianlong mine	Shanxi	Gas explosion	48
117	05/02/2001	Pingan mine	Heilongjiang	Gas explosion	37
118	01/03/2001	Xinhuanongchang mine	Heilongjiang	Gas explosion	32
119	06/04/2001	Chenjiashan	Shaanxi	Gas explosion	38
120	21/04/2001	Xiayukou mine	Shaanxi	Gas and dust explosion	48
121	07/05/2001	Nanshan mine	Heilongjiang	Fire	54
122	18/05/2001	Qinglongzui mine	Sichuan	Mine water inrush	39
123	22/07/2001	Gangzicun mine	Jiangsu	Gas and dust explosion	92
124	15/11/2001	Podi mine	Shanxi	Gas explosion	33
125	20/06/2002	Chengzihe mine	Heilongjiang	Gas explosion	124
126	04/07/2002	Fuqiang	Jilin	Gas and dust explosion	39
127	08/07/2002	Dingsheng mine	Heilongjiang	Gas explosion	44
128	03/09/2002	Qiuhu mine	Hunan	Coal and gas outburst	39
129	23/10/2002	Zhujiadian mine	Shanxi	Gas explosion	44
130	29/10/2002	Ertang mine	Guangxi	Fire	30
131	10/11/2002	Taixi mine	Shanxi	Gas and dust explosion	37

132	02/12/2002	Yangquangou mine	Shanxi	Gas explosion	30
133	06/12/2002	Wanbao mine	Jilin	Fire	30
134	11/01/2003	Baoxing mine	Heilongjiang	Gas explosion	34
135	24/02/2003	Muchonggou mine	Guizhou	Gas explosion	39
136	22/03/2003	Mengnanzhuang mine	Shanxi	Gas and dust explosion	72
137	13/05/2003	Liling mine	Anhui	Gas explosion	86
138	26/07/2003	Mushi mine	Shandong	Mine water inrush	35
139	11/08/2003	Xingergou mine	Shanxi	Gas explosion	43
140	14/11/2003	Jianxin mine	Jiangxi	Gas explosion	51
141	23/02/2004	Baixing mine	Heilongjiang	Gas explosion	37
142	30/04/2004	Liangjiahe mine	Shanxi	Gas explosion	36
143	18/05/2004	Caijiagou mine	Shanxi	Coal dust explosion	33
144	20/10/2004	Daping mine	Henan	Gas explosion	148
145	11/11/2004	Xinsheng mine	Henan	Gas explosion	33
146	28/11/2004	Chenjiashan mine	Shaanxi	Gas explosion	166
147	09/12/2004	Daxian mine	Shanxi	Gas explosion	33
148	12/12/2004	Tianchi mine	Guizhou	Mine water inrush	36
149	14/02/2005	Sunjiawan mine	Liaoning	Gas explosion	214
150	19/03/2005	Xishui mine	Shanxi	Gas explosion	72
151	24/04/2005	Tengda mine	Jilin	Min water inrush	30
152	19/05/2005	Nuanerhe mine	Hebei	Gas explosion	50
153	02/07/2005	Jiajiabao mine	Shanxi	Gas explosion	36
154	11/07/2005	Shenlong mine	Xinjiang	Gas explosion	83
155	07/08/2005	Daxing mine	Guangzhou	Mine water inrush	121
156	03/10/2005	Hebier mine	Henan	Gas explosion	34
157	07/11/2005	Dongfeng mine	Heilongjiang	Coal dust explosion	171
158	02/12/2005	Sigou mine	Henan	Mine water inrush	42

159	07/12/2005	Liujiatun mine	Hebei	Gas and dust explosion	108
160	29/04/2006	Wayaobao mine	Shaanxi	Gas explosion	32
161	18/05/2006	Xinjing mine	Shanxi	Mine water inrush	56
162	28/06/2006	Wulong mine	Liaoning	Gas explosion	32
163	05/11/2006	Jiaojiazhai mine	Shanxi	Gas explosion	47
164	12/11/2006	Nanshan mine	Shanxi	Fire	34
165	25/11/2006	Changyuan mine	Yunnan	Gas explosion	32
166	16/04/2007	Wangzhuang mine	Henan	Gas explosion	31
167	17/08/2007	Huayuan mine	Shandong	Mine water inrush	172
168	08/11/2007	Qunli mine	Guizhou	Coal and gas outburst	35
169	05/12/2007	Ruizhiyuan mine	Shanxi	Gas explosion	105
170	13/06/2008	Anxin mine	Shanxi	Explosive explosion	34
171	14/07/2008	Lijiawa mine	Hebei	Explosive explosion	34
172	21/07/2008	Youjiang mine	Guangxi	Mine water inrush	36
173	20/09/2008	Fuhua mine	Heilongjiang	Fire	31
174	21/09/2008	Xinfenger mine	Henan	Coal and gas outburst	37
175	22/02/2009	Tunlan mine	Shanxi	Gas explosion	78
176	30/05/2009	Tonghua mine	Chongqing	Coal and gas outburst	30
177	08/09/2009	Xinhuasi mine	Henan	Gas explosion	76
178	21/11/2009	Xinxing mine	Heilongjiang	Gas explosion	108
179	05/01/2010	Lisheng mine	Hunan	Fire	34
180	01/03/2010	Luotuoshan mine	Neimenggu	Mine water inrush	32
181	28/03/2010	Wangjialing mine	Shanxi	Mine water inrush	37
182	21/06/2010	Donger mine	Henan	Explosive explosion	49
183	16/10/2010	Yusi mine	Henan	Coal and gas outburst	37
184	10/11/2011	Sizhuang mine	Yunnan	Coal and gas outburst	43
185	29/08/2012	Xiaojiawan mine	Sichuan	Gas explosion	48

186	29/03/2013	Babao mine	Jilin	Gas explosion	36
187	31/10/2016	Jinshan mine	Chongqing	Gas explosion	33
188	3/12/2016	Baoma mine	Neimenggu	Gas explosion	32