



Focusing on the patterns and characteristics of extraordinarily severe gas explosion accidents in Chinese coal mines



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ABSTRACT

Extraordinarily severe gas explosion accidents (ESGEAs) (thirty fatalities or more in one accident) have a high occurrence frequency in Chinese coal mines. There are 126 ESGEAs that occurred in China from 1950 to 2015, and they were investigated through statistical methods in this study to review the overall circumstances and to provide quantitative information on ESGEAs. Statistical characteristics about accident-related factors, such as gas accumulation, ignition sources, operating locations, accident time, coal mine regions and coal mine ownership, were assessed in this paper. The statistical analysis shows that disorganized ventilation fan management was the most frequent cause of gas accumulation in ESGEAs, while illegal blasting was the most prominent cause of the ignition source in ESGEAs. Furthermore, ESGEAs were found to occur frequently in certain provinces (e.g., Shanxi, Henan and Heilongjiang) and during November and December of the year. Moreover, most accidents and the largest death tolls generally occur in state-owned coal mines. Based on the results of statistical studies, some countermeasures were proposed in this study.

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1. Introduction

During the past 15 years, the Chinese government and State Administration of Work Safety (SAWS) has enhanced safety supervision and investment for coal mines, which has greatly improved the safety in the coal mine industry. In 2001, the State Administration of Coal Mine Safety (SACMS) reported that there were 5670 deaths and a death rate per million tons (DRPMT) of 5.07. This fell to 588 deaths and a DRPMT of 0.159 in 2015 (Fig. 1) (Chen et al., 2012; SACMS, 2017). Although the deaths and DRPMT have steadily decreased, ESGEAs still occur. Recent examples include the following: at 11:33 am on 31 October 2016, an ESGEA occurred in the Jinshanggou coal mine, Yongchuan district, Chongqing City, which killed 33 miners, and at 11:30 am on 3 December 2016, an ESGEA occurred in the Baoma mining company, Chifeng city, Inner Mongolia, which killed 32 miners (SACMS, 2017). By comparison, no ESGEAs occurred in coal mines in America and Australia from 2001 to 2015, though there were some gas explosions in the USA

(Sago 2006 and Upper Big Branch 2010) (Gao et al., 2016; Wu et al., 2011).

In the past 15 years, a number of significant preventive measures have been introduced by the Chinese government and SACMS in order to reduce gas explosion accidents, which include the following:

- Enhancement of coal mine safety legislation;
- Establishment of an independent coal mine safety supervision system;
- Implementation of 200 gas control demonstration mine projects;
- Investment in new equipment and technology for gas removal and gas monitoring; and
- Promotion of a new mine safety refuge system with “six subsystems”: monitoring and control system, staff location system, rescue water supply system, self-help system of pressure ventilation, communication system, and emergency rescue system.

The combined efforts of the Chinese government, SACMS and coal mine companies through the implementation of safe management and technological equipment to prevent gas explosions have resulted in great progress and development from 2001 to 2015. Despite these efforts, 926 fatal gas explosion accidents (killing three people or more in one accident) occurred and 8833 people died

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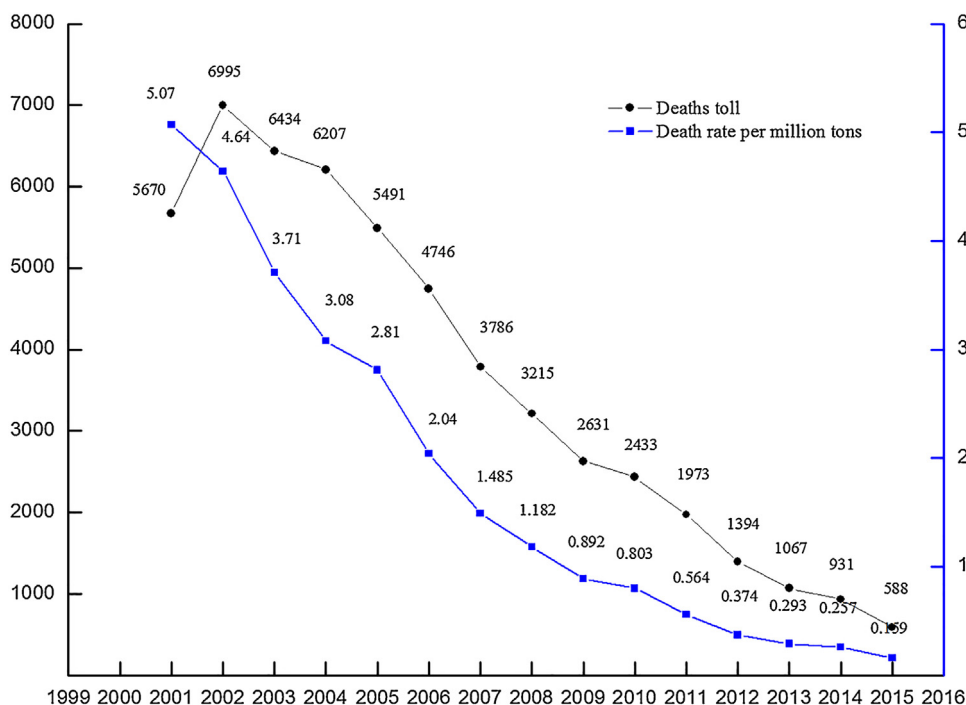


Fig. 1. Death toll and rate in Chinese coal mines from 2001 to 2015.

Table 1

The classification of coal mine accidents in China.

Accident grade	Ordinary	Major	Severe	Extraordinarily Severe
Deaths	<3	≥3, <10	≥10, <30	≥30
Serious injuries	<10	≥10, <50	≥50, <100	≥100
Property loss	<¥10 ⁷	≥¥10 ⁷ , <¥5 × 10 ⁷	≥¥5 × 10 ⁷ , <¥10 ⁸	≥¥10 ⁸

(SACMS, 2017). Among them, 42 accidents were ESGEAs with 2598 deaths, which accounted for 5% of the total fatal accidents and 29% of the death toll (SACMS, 2017). This highlights that the control or elimination of ESGEAs is crucial to significantly reduce the death toll in Chinese coal mines.

Currently, researchers have focused heavily on coal mine gas explosion accidents and have published numerous papers (Amyotte and Eckhoff, 2009; Chen et al., 2012, 2013a, 2013b; Gao et al., 2016; Lenné et al., 2012; Li et al., 2010, 2012; Oh et al., 2001; Patterson and Shappell, 2010; Wang et al., 2014; Xiao et al., 2010; Yin et al., 2013; Zheng et al., 2009), but there is a lack of study on ESGEAs. In fact, the ESGEAs that occurred most frequently in Chinese coal mines had similar characteristics and causes, which suggests that lessons can be learned from past ESGEAs. Hence, the purpose of this paper is to study the patterns and characteristics of ESGEAs in Chinese coal mines from the viewpoint of the gas accumulation, ignition sources, operating locations, accident time, coal mine regions and coal mine ownership. The results of this study are helpful for the prevention of ESGEAs and the improvement of safety in Chinese coal mines.

2. Background analysis

According to the “Coal Mine Production Safety Accidents Report and Investigation Handling Regulation” issued by the State Administration of Work Safety (SACMS, 2017), accidents are classified into four categories based on death, injury and property loss (Table 1): (1) Ordinary; (2) Major; (3) Severe; and (4) Extraordinarily Severe. This classification applies for gas explosion accidents, e.g., an acci-

Table 2

Frequency and deaths of major, severe, and extraordinarily severe gas explosion accidents in Chinese coal mines from 2001 to 2015.

Year	Accident Grade					
	Major		Severe		Extraordinarily Severe	
	Frequency	Deaths	Frequency	Deaths	Frequency	Deaths
2001	86	461	24	363	6	280
2002	112	454	24	396	6	318
2003	72	429	18	318	6	325
2004	103	398	15	242	6	453
2005	75	314	27	452	7	597
2006	75	445	12	212	4	143
2007	51	266	12	186	2	136
2008	36	190	4	84	/	/
2009	37	150	4	51	3	262
2010	25	136	6	82	/	/
2011	22	114	8	118	/	/
2012	9	52	3	46	1	48
2013	6	36	7	135	1	36
2014	2	9	3	47	/	/
2015	4	20	2	29	/	/
Total	715	3474	169	2761	42	2598

Note: Data are from the Online Accident Inquiry System of SACMS.

dent with 1–2 fatalities is an ordinary gas explosion accident, 3–9 fatalities is a major gas explosion accident, 10–29 fatalities is severe, and 30 or more fatalities is extraordinarily severe. According to this classification, Table 2 summarizes the frequency and deaths of major, severe and extraordinarily severe gas explosion accidents in Chinese coal mines from 2001 to 2015 (SACMS, 2017). This shows that ESGEAs have a much lower occurrence frequency and higher death rate compare to major and severe accidents. Moreover, ESGEAs have caused substantial losses to both the international image of China and coal enterprises, especially in miners’ lives and health. It is thus important that Chinese coal enterprises eliminate ESGEAs.

Table 3 shows the 184 cases of extraordinarily severe coal mine accidents (ESCMAs) in China from 1950 to 2015 (SAWS, 2005; SAWS, 2007; SACMS, 2017; Wang and Li, 2002). The ESCMA cat-

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