Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 107 (2017) 314 – 320

Energy Procedia

3rd International Conference on Energy and Environment Research, ICEER 2016, 7-11 September 2016, Barcelona, Spain

Relationship Analysis of Causal Factors in Coal and Gas Outburst Accidents Based on the 24Model

Gui Fu, Jialin Cao*, Xiuming Wang

School of Resource and Safety Engineering, China University of Mining and Technology (Beijing), Beijing 100083, China

Abstract

In order to identify the causal factors of 88 coal and gas outburst accidents and their relationships, this paper proposed a cause classification framework based on the accident causation "2-4" model (24Model). The correlations between the high level and low level causes were analyzed by the Chi-square test for independence. Results showed that root causes, indirect causes and unsafe acts were prevalent in all cases. The main direct causes were violation operation and violation action; the main indirect causes were lack of safety knowledge and low safety awareness; the main radical cause was safety management procedures; the main root causes was safety depending on safety awareness. And there were ten groups of causes with significant correlation between the high level and low level causes. The work paths of different causes in coal and gas outburst accidents were identified by using the proposed cause classification framework.

Peer-review under responsibility of the scientific committee of the 3rd International Conference on Energy and Environment Research.

Keywords: Chi-square text for independence; classification; coal and gas outburst; relationship analysis; 24Model.

1. Introduction

Gas accident has always been one of the major disasters in coal mines worldwide, especially in China. In recent years, gas control efforts in coal mines in China have produced remarkable results. The frequency of coal and gas outburst accidents has been markedly reduced, but major coal and gas outburst accidents do still happen sometimes.

* Corresponding author. Tel.: +86 13466389692.
E-mail address: cjl608@163.com.

Peer-review under responsibility of the scientific committee of the 3rd International Conference on Energy and Environment Research.
doi:10.1016/j.egypro.2016.12.160

According to the data on the website of State Administration of Work Safety, there were five major coal and gas outburst accidents with a death toll of 58 since 2014. Therefore, it is important to analyze the reasons of coal and gas outburst accidents.

As a systematic attempt to describe the behaviors causing accidents, The accident causation "2-4" model (24Model) [1-5] has been proposed based on the accident causation chains of Heinrich [6], Bird [7], and Reason [8]. The 24Model has been applied extensively to analyze the causes of accidents in coal mine, chemical industry, fire and other areas. However, only few studies [9-12] have used the 24Model to analyze the causes of coal and gas outburst accidents. While most of the studies focused on studying unsafe acts, few studies focused on how the causes affected the high level and low level causes. Therefore, it is necessary to analyze all-level reasons of coal and gas outburst accidents and to establish correlations between high level and low level causes.

In this paper, a cause classification framework of coal and gas outburst accident is proposed based on the 24Model. The framework is used to statistically analyze all-level reasons and their influences on coal and gas outburst accidents, and to analyze the correlation between the high level and low level causes by Chi-square test for independence. This paper also discusses how the causes at each level are affected by the high level causes. The findings of this study are expected to provide a valuable reference for coal mine industry to control the main causal factors and to establish corresponding safety measures.

2. Methods

2.1. Accident cause classification framework

For a given organization, the 24Model [3-5] divides the causes of accidents into internal factors and external factors. The internal factors include four levels of factors as direct causes, indirect causes, radical causes and root causes. Direct causes refer to unsafe acts and unsafe conditions. Indirect causes refer to safety knowledge, safety awareness, safety habits, psychological status and physiological status. Radical causes refer to safety management system. Root causes refer to safety culture.

This paper mainly analyzed the organization internal factors of coal and gas outburst accidents using the 24Model. As shown in Fig. 1, the cause classification framework of coal and gas outburst accident based on 24Model was established by considering the actual situation of coal mine production and the accident investigation.

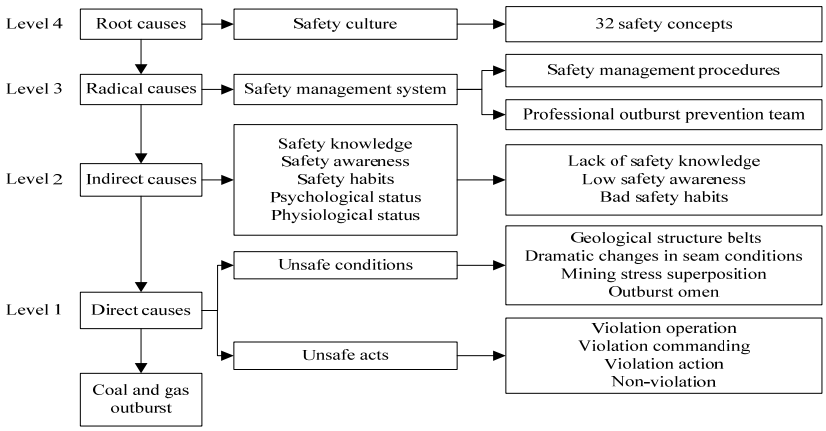

Fig. 1. The cause classification framework of coal and gas outburst accidents

- *Direct causes*: Unsafe acts represent the acts directly causing an accident or having important influence on the accident. According to whether the unsafe acts are against the national laws and regulations, they can be divided into violation acts and no-violation acts [12]. Further considering that the action objects are different, the violation acts could be divided into violation operation (in which objects are specific physical objects), violation