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Risk Management and Control Model of Dangerous Chemicals in Chemical Enterprises in the Context of Big Data

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In order to contain the safety accidents caused by the leakage of dangerous chemicals, chemical enterprises need to use big data to reasonably control the risk of dangerous chemicals. Based on the analysis of related concepts of big data technology and risk management and control, this paper uses AHP and k-means clustering method to construct a risk management and control model of dangerous chemicals in chemical enterprises in the context of big data. Through the consistency check of the judgment matrix A and CR and the weight of all levels of variables, it is found that there are four levels of risk management and control of dangerous chemicals in chemical enterprises, namely targeted safety management, daily safety management, emergency safety management and safety planning management. Each of the four levels contains multiple risk mitigation measures and preventive measures, which can provide reference for the management and control of dangerous chemicals in chemical enterprises.

1. Introduction

1.1 Literature review

In recent years, China's chemical industry has developed rapidly (Tang et al., 2018; Jiang, 2018; Wang, 2018). The industry scale is expanding continuously and the number of chemical enterprises has continued to grow. As one of the country's basic industries, there is an inseparable relationship between the chemical industry and the national economy. The chemical industry is also closely related to the development of industry and agriculture in China and has penetrated into various fields of life (Zeng, 2014). In this context, the scale of production of dangerous chemicals in chemical enterprises has been further expanded, which poses higher requirements for their storage and transportation. On August 12, 2015, a major fire explosion accident occurred in the dangerous goods warehouse in Tianjin Port of Tianjin Binhai New Area, causing RMB6.866 billion direct economic loss. 165 people were killed in the accident and nearly 800 were hospitalized.

This accident triggered a strong reaction from all sectors of society (Wang, 2017). How to ensure the safe production, usage, transportation and storage of dangerous chemicals in the chemical industry has become an imperative issue at this stage. As one of the emerging products of information technology, big data has already been applied in many industries and fields. In terms of safety management and control, data analysis can be conducted on massive accidents through big data technology and comparative analysis of multiple safety parameters in the production process can be conducted to determine whether the object is in safe status (Huang, 2017). With the in-depth study of big data technology, the law of accidents can be found to facilitate the formulation of prevention program, reducing the occurrence of safety accidents from the source. Based on this, big data analysis is the development trend in the field of safety management and control (Sun et al., 2016).

1.2 Research purposes

In the process of development, chemical enterprises often involve the transport and storage of large quantities of dangerous chemicals. Especially in recent years, in order to effectively integrate resources, improve corporate efficiency and facilitate the unified supervision of relevant government departments, chemical enterprises have gradually gathered to form chemical parks. However, the development of risk management and controls far lags behind the industry development, resulting in greater security risks (Gao et al., 2018). In

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the event of an accident, if it cannot be handled promptly, it may lead to a chain reaction and cause even more accidents. In recent years, the chemical safety accidents in our country have occurred frequently, which has brought heavy costs to the society and enterprises (Huang, 2014).
At this stage, the application of big data technology in the research on risk management and control of chemical enterprises is still in its infancy. According to the industrial characteristics of the chemical industry, the risk management and control model for dangerous chemicals in chemical enterprises is of great significance for the safe production and operation of chemical enterprises. Based on this situation, this paper analyzes and studies the application of big data technology in the risk management and control of dangerous chemicals in chemical enterprises with a view to providing suggestions for reference for the risk management and control in the chemical industry.

2. Related concept of big data technology and risk management and control

The so-called big data technology refers to a computer technology that can quickly obtain valuable information from massive data (Reddy et al., 2017; Wang and Zhao, 2016). It is characterized by large volumes of data, fast speed, multiple data types and huge potential value, as is shown in Table 1. According to its data processing characteristics, big data technology mainly includes big data acquisition technology, big data preprocessing technology, big data presentation technology, big data analysis technology, big data computing technology, big data storage and management model. The big data acquisition technology and big data preprocessing technology refer to the acquisition of data and the control of data quality, eliminating useless data.
Big data analysis technology refers to mining clues and revealing the law of development of things through technology such as data mining and pattern recognition. The big data presentation technology refers to the intuitive presentation of analysis results to users, enabling users to have a deeper understanding of the analysis results. The big data presentation technology includes spatial flow, historical flow presentation technology and visual analysis technology. The big data storage and management technology is the key to fast data retrieval, including distributed databases and file systems, big data index and query technology (Zhu and Wang, 2017).

Table 1: The basic method of controlling risk

Basic method	Method	objective	implementation phase
Loss control	Setting up an emergency plan	Reduce the loss probability	Before, in, and after the accident
Risk avoidance	Give up potential income at the expense of	Avoid specific risks	Before the accident
Risk transfer	Transfer risks to others or enterprises through contracts and agreements	Reducing the degree of self risk	Risk occurrence
Risk reservation	When risk occurs, bear the consequences of loss of capital or property	Reducing post risk risk	Risk occurrence

The risk management and control means that the risk managers effectively reduce the incidence of various risk events through various methods or that reduce losses after the accident (Liu et al., 2017). There are four basic methods for controlling risks: loss control, risk avoidance, risk retention and risk transfer. Specifically, the loss control refers to the formulation of relevant emergency plans and measures to reduce losses. The specific implementation stage can be before, during and after the accident. The control before the accident can effectively reduce the probability of losses and the loss control during and after the incident can reduce losses (Xia et al., 2017). The risk avoidance refers to the fact that managers consciously give up risk-taking behavior to avoid specific risks.
In contrast, risk avoidance is a conservative method, often at the expense of abandoning potential benefits. The risk transfer refers to the behavior of transferring risks to other people or enterprises through contracts or agreements. The risk transfer can greatly reduce the risk degree of itself. Except for contracts and agreements, the most commonly used method of risk transfer is insurance transfer. The risk retention refers to taking the consequences of fund losses or property losses in the event of risk events (Cheng, 2016).
In view of the analysis of the causes of chemical accidents, accidents often cannot be separated from four types of factors, namely human factors, physical factors, environmental factors and management factors. The

human factor is that the behavior of operators can often affect the safety of the environment (Wang et al., 2017). The physical factor refers to the insecure state of the equipment in the production operation, such as failure or failure of protective measures. The environmental factor mainly refer to the abnormal situation in the environment. The management factor refer to potential flaws in the management process.

3. Construction of the risk management and control model of dangerous chemicals in chemical enterprises

3.1 Establishment of the index system and judgment matrix

Table 2: Index system for the risk management and control of dangerous chemicals in chemical enterprises

Target layer	Criterion layer	Index layer
Risk control measures of dangerous chemicals	Mitigation measures (M)	Equipped with special extinguishers, reserving special firefighting resources (M1)
		Formulating special fire emergency plans (M2)
		Setting fire barriers, including barriers and fire dikes (M3)
		(Mn)
	Preventive measures (N)	Stored in strict accordance with regulations and standards (N1)
		Limited filling in strict accordance with the proportion of the tank volume filling (N2)
		Strengthening the safety operation training and safety supervision of employees (N3)
		(Nn)

In order to effectively control the leakage of dangerous chemicals in China, reduce the incidence of safety accidents and improve the management efficiency and safety of chemical enterprises, this paper builds the risk management and control model of dangerous chemicals in chemical enterprises in the context of big data in the principles of comprehensiveness, scientificity, relevance and stratification (Sun et al., 2016). The target layer is divided into preventive measures and mitigation measures. The index system is established, as is shown in Table 2.

For the pairwise comparison of factors, a_{ij} is used to represent the ratio of the impact of factors x_i and x_j on Z, and then the pairwise comparison matrix $\mathrm{A} = [a_{ij}]$ can be established. The 1-9 scale method is used and the reciprocal $a_{ij} = \frac{1}{a_{ij}}$ of each factor ratio is obtained through expert interviews and group decision. The judgment matrix of the criterion layer can be further obtained:

$$\begin{bmatrix} & M & N \\ M & 1 & 1/3 \\ N & 3 & 1 \end{bmatrix} \tag{1}$$

3.2 Consistency check

In order to check the consistency of the weight of each variable, it is necessary to determine the weight of the judgment matrix of variables in the criterion layer and index layer (Li et al.,2016).

The normalization is conducted on a_{ij}, obtaining $\overline{a_{ij}} = a_{ij} / \sum_{k-1}^{n} a_{kj}\ (i,j = 1,2,3 \ldots)$. The results of the normalization processing of all variables are then added together for the overall normalization process, obtaining $W_i = \overline{W}_i / \sum_{i=1}^{n} \overline{W}_j\ (i = 1,2,3 \ldots)$. Among them, the $W_i = [W_1, W_2, .., W_n]^T$ represents the required feature vector, namely the weight coefficient of each factor.

Then, calculate the maximum eigenvalue λ_{max} of the judgment matrix, the consistency index *CI* and the random consistency ratio *CR*, which are $\lambda_{max} = \sum_{i=1}^{n} \frac{(AW)_i}{nW_i}$, $CI = \frac{\lambda_{max}-n}{n-1}$ and $CR = \frac{CI}{RI}$ respectively.

Eventually, the risk management and control measure W={W_1,W_2}=(0.25,0.75) is taken. The *CR* is less than the threshold 0.1, indicating good reliability. The *CR* of W_1 and W_1 is 0.0388 and 0.0967 respectively, which is also less than 0.1, indicating that good reliability of the criterion layer. Then, the weight of each variable can be obtained, as is shown in Table 3.

Table 3: Weight distribution of risk management and control of dangerous chemicals in chemical enterprises

Target layer	Criterion layer	weight	Index layer	weight
Risk management and control of dangerous chemicals W	Mitigation measures W1	0.25	Equipped with special extinguishers, reserving special firefighting resources (M1)	0.098
			Formulating special emergency plans including fire, explosion and intoxication (M2)	0.092
			Setting fire barriers, including barriers and fire dikes (M3)	0.135
			Purchase of safety tank equipment (M4)	0.087
			Setting approachable safe distance of dangerous chemicals with big data technology (M5)	0.095
			Equipped with fire detectors, leak detectors and other monitoring equipment (M6)	0.131
			Setting up ventilation and constant temperature equipment (M7)	0.143
			Positioning and routing of transfer with big data technology (M8)	0.117
			Transferring and filling of dangerous chemicals wearing antistatic clothing (M9)	0.102
	Preventive measures W2	0.75	Stored in strict accordance with regulations and standards (N1)	0.231
			Limited filling in strict accordance with the proportion of the tank volume filling (N2)	0.245
			Strengthening the safety operation training and safety supervision of employees (N3)	0.098
			Strengthening staff's daily operation specification and process (N4)	0.093
			Establishing emergency plans for natural disasters and security accidents (N5)	0.107
			Regular equipment testing and potential risks identification with big data technology (N6)	0.226

3.3 Model construction

The data is imported into SPSS22.0 software and the k-means clustering method is used for the analysis and grouping of the data. The W_1 and W_2 are taken as variable parameters and the category and stratification of new variables are reclassified, then obtaining the risk management control model of dangerous chemicals (see Figure 1). The "..." in the figure indicates the unlisted control measures and the new measures used in the practical work used for the continuous optimization and improvement of the model.

From the summary analysis of the above-mentioned model elements at each layer, it can be found that the risk management and control of dangerous chemicals in chemical enterprises can be considered from four aspects.

Firstly, targeted safety management, such as limited storage in strict accordance with the standard and limited filling in strict accordance with the proportion of the tank volume. This focus of the control direction in this aspect is the control of the storage location of dangerous chemicals.

Secondly, daily safety management, such as regular equipment testing and potential risks identification with big data technology and equipped with monitoring equipment such as fire detectors and leakage monitors, preventing the occurrence of safety accidents of dangerous chemicals.

Thirdly, emergency safety management, such as formulating special emergency plans including fire, explosion and intoxication and establishing emergency plans for natural disasters and security accidents. By the continuous improvement of the emergency management system of chemical enterprises, the major safety accidents and domino accidents can be prevented.

Fourthly, safety planning management, such as setting fire barriers, including barriers and fire dikes and purchase of safe tank equipment. The safety risk of dangerous chemicals in chemical enterprises is controlled from the source and the loss after the occurrence of risks is minimized.

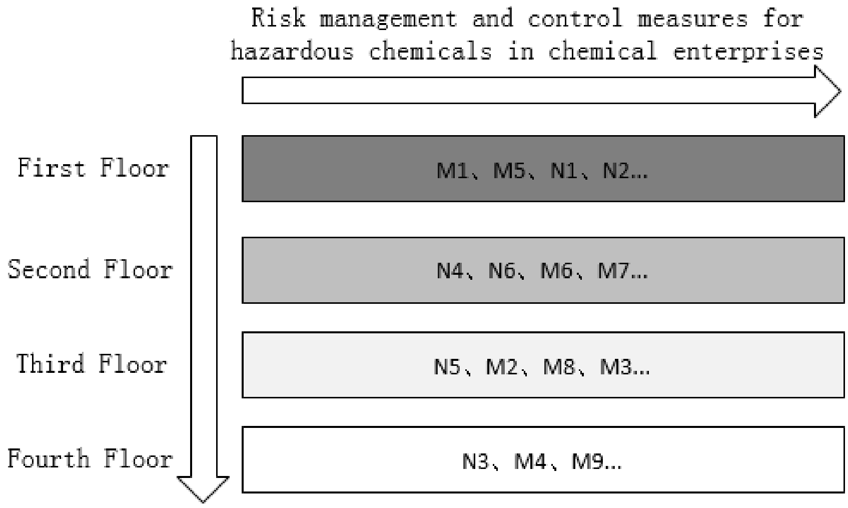

Figure 1: Risk management and control model of dangerous chemicals

4. Conclusion

In summary, the application of big data technology in the risk management and control of dangerous chemicals in chemical enterprises can effectively reduce the incidence of risk accidents and improve the safety of chemical enterprises. The risk management and control model of dangerous chemicals constructed under big data background provides four management and control directions for chemical enterprises to prevent the risk of dangerous chemicals, namely targeted safety management, daily safety management, emergency safety management and safety planning management.

Therefore, Chinese chemical enterprises should carry out the risk management and control of dangerous chemicals according to this and constantly improve and supplement relevant control measures to effectively protect the safety of the enterprise development. The risk management and control model proposed in this study supplements the literature on dangerous chemicals management and control and can provide reference and basis for the risk management and control of the processing, storage and transportation of dangerous chemicals in chemical enterprises in the context of big data.

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