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RANKING OF MAJOR HAZARDS SUITABLE FOR THE GOVERNMENT SUPERVISION

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ABSTRACT

Based on the basic theory of risk, we add the sensitivity factor in the process of design the risk classification model of the major hazard sources, and establish the quantitative classification model and the qualitative classification three-dimensional model of the major hazard source. According to the risk status of the major hazard sources in the production site, the system of risk evaluation index is determined from the three dimensions of probability, severity and sensitivity. (AHP) was used to calculate the weights of each index, and established the mathematical model of risk classification of major hazard sources in production sites. Besides, there are more than 30 enterprises in Taiwan that were selected for empirical research. The empirical research shows that the risk classification model of the major hazard source which is established in this paper has good practicability and convenience. It is suitable for the government safety supervision department to carry out the hierarchical supervision work, and can systematically and conveniently realize the government's scientific safety supervision and the effective safety management of the enterprise.

KEYWORDS

Production site, Major hazard, Sensitivity, Risk classification

INTRODUCTION

With the development of social economy, China has paid more and more attention to safety production, and the rate of each dangerous industry accident has been decreasing year by year. The situation of national safety production is stable and showing a better trend. This shows that China's safety work has made great progress, but the number of casualties is still much higher than the developed countries. As the focal point of safety production and emergency management work, China's security work of major dangerous sources still have many problems, for example inherently safe technology is not in place, security education is not in place, security management is not in place and so on. In recent years, many major accidents occurred, due to the management major dangerous source is not very well. Among them, the major hazard of production is an important part of the work of major hazard management, and we can also ignore the danger result from it and its supervision work [1]. Risk assessment is the most basal work of Security management work in major hazard sources, and it is also the key link of accident prevention [2]. Therefore, to strengthen the risk management of major hazard sources, through risk identification and assessment and clear safety supervision purposes, in order to improve the level of safety management of major dangerous sources [3].

Although there are many major hazard classification methods at home and abroad, the author found through reading a lot of literature that the existing classification methods still have the following problems:

(1) Single grading index and lack of integrity. Many of the existing classification methods at present only considered dangerous chemicals critical mass, to critical mass classification standard for single, often ignored the environment of dangerous chemical storage conditions, for enterprise's management level and other important factors, they did not consider other necessary conditions for the existence of hidden dangers, not overall and systematic consideration of major hazard installation.

(2) The multi-dimensional risk factors were not taken into account and the system was not considered. Most of the existing major hazard classification methods in China only consider the severity of major hazard accident, take single consequence factors such as the number of deaths as the index of classification, and do not consider the possibility of major hazard accident and the time and space sensitivity of the accident. The multi-dimensional risk factors were not taken into account and the system was not considered.

(3) Evaluation procedures are numerous and complicated, and they are not suitable for government supervision. The existing classification and evaluation methods of hazardous chemicals have complex evaluation process, numerous steps, difficult calculation, high professional level required, and are applicable to professional safety evaluation, not applicable to government graded safety supervision.

By selecting risk evaluation indexes in three-dimensions, this paper evaluates the risk level of various major hazard sources, classifies major hazard sources and applies them to government supervision, making it more scientific and convenient for the government to manage major hazard sources, so as to formulate more effective safety measures and effectively reduce the accident rate.

THREE-DIMENSIONAL HIERARCHICAL MODEL OF MAJOR HAZARD RISK

The bring up of question

Major hazards are divided into two parts, there are the major hazard source in production site and the major hazard source in storage area [4]. Major hazard source in production site is the facilities or places where the number of production or use of civil explosives, Pyrotechnic compound, fireworks and firecrackers, flammable liquids, combustible gases, toxic substances etc., can reach or exceed the critical number. Safety [5] management of major hazards in production site is an important content in safety production, it has important significance to improve the level and effect of safety production management. Our government and relevant departments have always pay attention to the risk classification of major hazards [6], the existing classification methods of major hazards include: "death radii-method", "flammable, explosive, toxic and significant risk source evaluation" ext. [7]. Through the existing evaluation and grading methods of major hazards, we can see that the classification of major hazards has been mature. However, these evaluation indicators are too single. Most only consider the serious of the major hazard accident consequences, use death tolls and other single consequences factors as the grading indicators, not taking into account the possibility of major hazards and the sensitivity of time and space of accident [8]. The classification method of major hazard installations in metal and nonmetal underground mines and tailings dam, drafted by China Academy of Safety Science and Technology, is comprehensive and detailed, suitable for safety evaluation, but it is not suitable for government regulation. Therefore, combined with the needs of government safety supervision, to study the model and method of major hazards in production site, classify major hazard sources, for government regulation, make the government more scientific and more convenient to manage major hazards, so as to develop more effective safety measures to reduce the accident rate.

Quantitative classification model of major risk sources

In the area of security, risk generally refers to the combination of the likelihood of a particular hazard event and its consequences [9]. A large number of accident investigation studies have shown that the severity of accidents at different times or locations is different, that is, time and space have a sensitive effect on the accident [10]. Therefore, based on the risk function, taking into account the sensitivity of the accident, adding the sensitivity factor, and add the three influencing factors influencing the major hazard source to the mathematical model, according to factor index and score of Possibility influencing factors of risk source, the score of sensitivity influencing factors index and the weight of each index, establish the quantitative grading model of major risk source, as shown below.

$$R = P \times L \times S = \sum_{i=1}^{n} d_i \omega_i \bullet \sum_{j=1}^{m} d_j \omega_j \bullet \sum_{k=1}^{l} d_k \omega_k \qquad (1)$$

In the formula: R is the risk value of the major hazard; P, L, S, respectively represent the possibility, severity, sensitivity.

Possibility P represents the possibility influencing factors, that is, select the risk factors that affect the likelihood of occurrence of major hazard sources, to reflect the different possibilities of the accident, such as the storage of dangerous chemicals.

Severity L represents the consequences of the consequences of the consequences, that is, select the risk factors that affect the consequences of major hazards, to reflect the severity of the loss after the accident, such as population density.

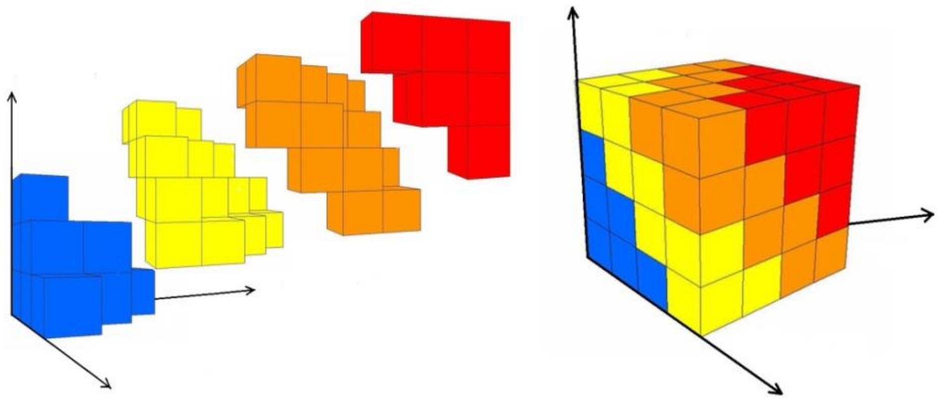
Sensitivity S represents the sensitivity of factors, that is, special time or special location, the consequences of the accident occurred in different degrees, this time and place is divided into sensitive factors such as the equipment in which the environmental function area.

Di, dj, dk are the actual scores of the i, j, k indicators, respectively; ωi, ωj, and ωk are the weights of the i, j and k indices relative to the primary index respectively; n, m, l represent respectively, Severity, sensitivity evaluation index number;

According to the above quantitative grading model, a single index according to the degree of danger is divided into four grades, respectively, assigned 1,2,3,4 points, as shown in Table 1. According to the actual situation, select the actual risk level of each index, the index risk value and the index weight multiplied to calculate the final risk value of the risk source. According to the overall risk level of local risk sources, according to the principle of ALARP to extract the corresponding proportion of major hazard sources, risk classification. For example, a major hazard risk value in the top 20% in a city is divided into level one major hazard source .The risk value in the middle 20-50% is divided into level two major hazard sources. The risk value in the back 50% - 80 % is divided into level three major hazard sources; the risk value in the last 20% is divided into level four major hazard sources, represent the risk is acceptable. And finally according to the classification standards, the development of appropriate risk improvement measures to take different levels, different strength of the safety supervision measures [11].

Three-dimensional model of qualitative classification of major hazard sources

The risk factor of the major hazard sources is based on the two-dimensional elements of the risk function - the likelihood of the occurrence of the accident and the seriousness of the consequences. Adding the sensitivity factor, from the serious consequences of the accident (in order of ABCD to indicate the severity), the possibility A、b、c、d in turn express the possibility of size) and sensitivity (1234 in order to indicate the degree of sensitivity) three dimensions to consider the relative dynamic risk of various types of risk, comprehensive consideration of personnel, equipment, environment, management and other factors and the relationship between time and space. Establish a qualitative three-dimensional model of hazard risk assessment, as shown in Figure 1. According to the ALARP principle, the unacceptable range of risk is expressed in red. The ALARP area is divided into orange and yellow. The acceptable Range of risk is indicated by blue, see Table 1.



（a） （b）

Fig. 1 - Three dimensional model of qualitative classification for risk assessment of major hazard sources as a whole (a) and grading (b)

Tab. 1 - Risk combination table of three-dimensional model elements for risk assessment of major risk sources

Risk level	Factor risk combination
Level IV risk	Aa1, Aa2, Aa3, Ab1, Ab2, Ab3, Ba1, Ba2, Bb1, Bb2, Ca1
Level Ⅲ risk	Aa4, Ab3, Ab4, Ac2, Ac3, Ad1, Ad2, Ba3, Ba4, Bb3, Bc1, Bc2, Bd1, Ca2, Ca3, Cb1, Cb2, Cc1, Da1, Da2, Db1
Level Ⅱ risk	Ac3, Ad3, Ad4, Bb4, Bc3, Bc4, Bd2, Bd3, Ca4, Cb3, Cb4, Cc2, Cd1, Cd2,Da3, Da4, Db2, Db3, Dc1, Dc2, Dd1
Level Ⅰ risk	Bd4, Cc3, Cc4, Cd3, Cd4, Cb4, Cc3, Dc4, Dd2, Dd3, Dd4

METHOD OF RISK CLASSIFICATION FOR MAJOR HAZARD SOURCES IN PRODUCTION SITES

Selection of risk assessment index for major hazard sources in production sites

Through the combing of major safety accidents in production sites in recent years and the investigation of accidents in production sites, it is found that the main types of safety accidents in the production sites are the ones to focus on. Therefore, the author from the three aspects of the possibility of occurrence, severity and sensitivity to consider the design of risk-based, for the needs of government safety supervision of the production site of the major risk of risk assessment index system. Including a total of eight factors affecting the occurrence of accidents in production sites, four severity influencing factors and two sensitivity influencing factors. And take the questionnaire survey method, the index is preferred. A total of 35 risk assessment indexes for major hazard areas were collected, 10 of which were filled out by government safety supervisors, 15 were filled by technical staff and 10 were filled by researchers. After three rounds of Delphi method and expert meeting method, part of the repeated and non-critical indicators, through the index screening, and ultimately determine the production site risk assessment index system and a single index grading standards as shown in Table 2 below.

Tab. 2 - Workplace major hazards risk assessment index system tables

Level 1 indicators	Level 2 indicators	Level 3 indicators	Index classification			
			Level 4	Level 3	Level 2	Level 1
Possibility Factors P	Technical factors P1	Storage material quality critical value P11	Amount of substance/ critical quantity ≤ 1	Amount of substance / critical quantity = (1,5]	Amount of substance / critical quantity = （5,10]	Amount of substance / critical quantity ＞10
		Production substance hazard P12	1.6 Insensitive substances and other substances	1.4 items, 1.5explosives, 2.2 gas, 4.3 solid meet one	1.2,1.3 explosives, 2.3 gas, 4.2 solid,5.2 substances, 9 categories of hazardous substances, to meet one	1.1 explosives, 2.1 gases, flammable liquids, 4.1 solids, 5.1substances, toxic, infectious, radioactive, and corrosive substances, to meet one
		Production technology Mechanization degree P13	Mechanization degree ≥95%	Mechanization degree [75%,95%)	Mechanization degree [50%,75%)	Mechanization degree ＜50%
		Safety alarm and control system P14	Have and can be used normally	have, some parts fail, does not affect the alarm	have, some parts fail, cannot alarm	no, or the overall failure, cannot alarm
	Management factors P2	Safety production standardization grade P21	Level 1	Level 2	Level 3	No review or grade.
	Use factor P3	Safety precautions of Production device P31	have security measures and personal protective equipment for workers	have security measures ,not have personal protective equipment for workers	Not have security measures ,have personal protective equipment for workers	Not have security measures and personal protective equipment for workers
		Years of use P32	＜5 years	[5,10） years	[10,1） years	≥15 years
		Total number of accidents in recent years P33	Nearly 10 years without casualties	no casualties in the past five years	no casualties in the past five years	no casualties in the past five years
Severity affecting factor L	Personnel influence L1	Population density L11	＜10 people	[30,50） people	[50,100） people	≥100people
	Property impact L2	Dangerous distance L21	≥500m	[100,500） m	[50,100） m	d＜50m
	Environmental impactL3	Without firewalls L31	yes	--	--	no
Sensitivity affecting factors S	Space factor S1	Environmental function area S11	industrial area	Agricultural area, business district	Residential area, administrative office area traffic hub area	Science and technology culture area ,and so on

Damage risk of major hazard sources in production sites

After determining the risk evaluation index of the production site, use the analytic hierarchy process to determine the index weight. Through the questionnaire, we can calculate the importance of each index as shown in Table 3 below:

Tab. 3 - Important degree of workplace major hazards risk assessment indicators

Level 3 indicators	Indicator importance RI
Storage material quality / critical value P11	9.60
Storage substance hazard P12	8.80
Production technology mechanization degree P13	7.21
Safety alarm and control system P14	9.03
Standardization of Safety Production Standard for Industrial Employees P21	8.4
Safety of production equipment P31	9.20
Number of years of production equipment P32	9.30
In recent years the number of accidents P33	8.40
Population density L11	8.66
Dangerous distance L21	8.29
Whether the firewall L31	8.15
The environmental function area S11	8.34

According to the importance of the above indicators and finally find the index comparison between the two scales, the contrast scale is entered into the AHP software, construct judgment matrix, probability influencing factor indicators need to construct the first level of the judgment matrix A1 and the second level of the judgment matrix (B1, B2). The severity influence factor index only needs to construct a judgment matrix A2.

Probability influencing factor index judgment matrix $A_1=\begin{bmatrix}1 & 2 & 3\\ 1/2 & 1 & 2\\ 1/3 & 1/2 & 1\end{bmatrix}$. Technical factor index judgment matrix $B_1=\begin{bmatrix}1 & 2 & 3 & 2\\ 1/2 & 1 & 2 & 1/2\\ 1/3 & 1/2 & 1 & 1/3\\ 1/2 & 2 & 3 & 1\end{bmatrix}$ .Use factor index judgment matrix $B_2=\begin{bmatrix}1 & 2 & 1/2\\ 1/2 & 1 & 1/2\\ 2 & 2 & 1\end{bmatrix}$ .Severity Factor Affect Judgment Matrix $A_2=\begin{bmatrix}1 & 2 & 2\\ 1/2 & 1 & 2\\ 1/2 & 1/2 & 1\end{bmatrix}$.

The consistency of the judgment matrix is obtained by calculating the influence factors CR=0.0089 < 0.10.Technical factors index judgment matrix consistency CR=0.0266 < 0.10； Judgment of matrix consistency using factor index CR=0.0517<0.10; Severity influencing factor index judgment matrix consistency CR=0.0517<0.10, Consistency is acceptable. Therefore, the calculation of the three indicators for the primary index weight: Possible Impact Factor Index Weight ωp =（0.2220,0.1009,0.0582,0.1579,0.2973,0.0511,0.0803,0.0324, Severity Impact Factor Index Weight ωl =（0.4934,0.3108,0.1958）,Sensitivity Impact Factor Index Weight ωs =（1）.

Production site risk classification model

Based on the above theoretical model and weight of risk assessment, the risk assessment model of production site can be obtained:

$$R = \sum_{i=1}^{n} d_i \omega_i \bullet \sum_{j=1}^{m} d_j \omega_j \bullet \sum_{k=1}^{l} d_k \omega_k = r_P \times r_L \times r_S$$

$$= \left[d_{p11}, d_{p12}, d_{p13}, d_{p14}, d_{p21}, d_{p31}, d_{p32}, d_{p33}\right] \begin{bmatrix} 0.0220 \\ 0.1009 \\ 0.0582 \\ 0.1579 \\ 0.2973 \\ 0.0511 \\ 0.0803 \\ 0.0324 \end{bmatrix} \bullet \left[d_{L11}, d_{L21}, d_{L31}\right] \begin{bmatrix} 0.4934 \\ 0.3108 \\ 0.1958 \end{bmatrix} \bullet \left[d_{s11}\right]\left[1\right] \tag{2}$$

According to the risk classification model, combined with the production site risk assessment indicators of the actual data information, calculate the production site risk value.

AN EMPIRICAL STUDY ON THE RISK OF PRODUCTION

Empirical analysis of production sites

In order to verify the scientific and validity of the above-mentioned risk classification model, we selected about 30 production facilities in Taiwan City, Shandong Province, Taiyuan Biotechnology Co., Ltd., Ningana County Hali Chemical Co., Ltd., Taiwan Sheng Chemical Co., Ltd. District for the empirical analysis of the object. Through the issuance of production site risk assessment empirical data questionnaire, the index system to collect the actual data of the indicators of information, the establishment of production sites risk assessment index database, Calculate the risk value of the production site (plant area). According to the production site risk assessment data, calculate the production site (installation area) risk value from small to large as shown in Table 4 below.

Tab. 4 - Workplace major hazards risk data tables

Serial number	Production site name	Risk value	Serial number	Production site name	Risk value
1	Acetylene gas workshop	1.68	16	Oxygen workshop	4.84
2	Acetaldehyde oxide production workshop	2.15	17	Acetaldehyde oxide production workshop	4.96
3	Synthesize a workshop	2.64	18	Pesticide six plants	5.14
4	Synthesis of two workshops	2.94	19	Pesticide three plants	5.25
5	Insoluble sulfur production workshop	2.96	20	Sulfur dioxide station	5.34
6	Air separation workshop	3.02	21	Cyclohexylamine plant area	5.37
7	106 workshop	3.03	22	waste acid enrichment device area	5.37
8	Nitric acid production plant area	3.11	23	Phosphorus dichloride production workshop	5.45
9	Propane storage filling device area	3.36	24	Argon workshop	5.49
10	Fine chemical plant	3.39	25	Nitrobenzene, aniline plant area	5.63
11	Dimethyl ether production plant area	3.44	26	Carbon dioxide production plant area	6.54
12	Sodium dichloroisocy anurate production of a workshop	3.84	27	Chloe-alkali plant	6.85
13	Barium chloride workshop	3.99	28	Optoelectronic plant	7.08
14	Phenolic resin production plant (place)	4.09	29	Synthesis of three workshops	9.64
15	Potassium nitrate production plant	4.20	30	Synthetic ammonia production area	9.76

According to the risk data table, the risk of production sites can be calculated as shown in Figure 2.

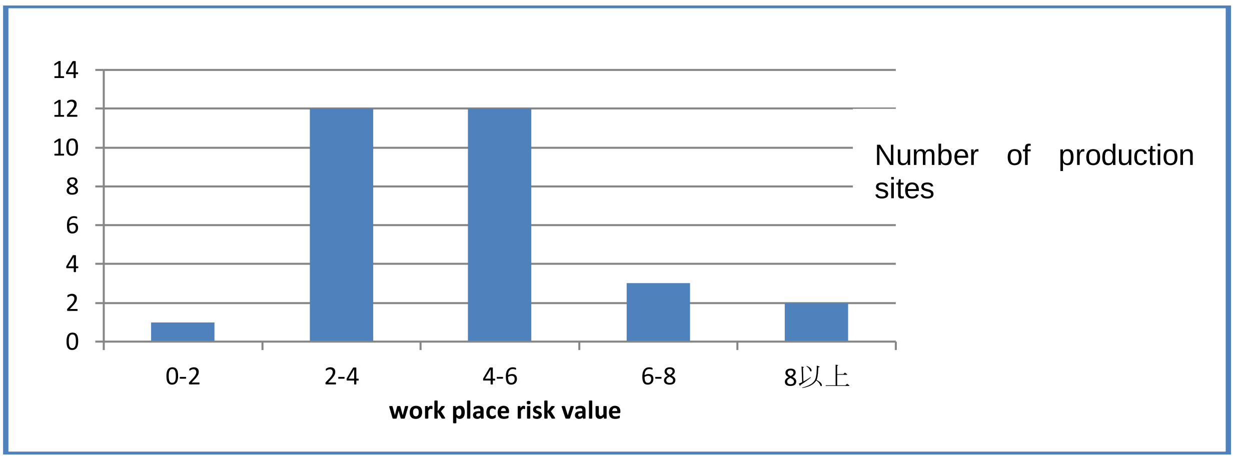


Fig. 2 - Workplace major hazard value distribution

From the figure of Figure 5-1, the risk value of the production site is also normal distribution. According to the risk index of the major hazard risk index developed earlier, the risk of production sites in the top 20% of the classified as a major hazard; the risk value in the middle 20-50%, divided into two major risk sources; risk value in the 50% -80%, divided into three major hazard;

The risk value is at the last 20%, divided into four major hazard sources, A source of danger that is acceptable. The specific grading standards are shown in Table 5 below.

Tab. 5: Workplace major hazards risk grade division standard

Risk level	IV (Acceptable risk)	Ⅲ	Ⅱ	I (Unacceptable risk)
Risk R	0~2	2~5	5~8	≥8
proportion	20%	30%	30%	20%

CONCLUSION AND PROSPECT

Based on the basic theory of risk, this paper adds the sensitivity influencing factors to the risk evaluation factors, constructs the classification model of the major hazard based on the risk three-dimensional model. This paper chooses the grading index of the risk assessment of the major hazard sources in the production sites, which is applicable to the government supervision, and establishes the three-dimensional model classification method for the risk of the major hazard sources in the production sites. And it carried out empirical research. The specific conclusions are as follows.

This paper takes two factors of risk: the probability of accident and the consequences of the accident, adding the sensitivity influence factor, considering the risk of the major hazard from three dimensions, and establishing the three - dimensional risk assessment model of the major hazard. And comprehensively and systematically evaluate the risk level of the major hazard sources from the three aspects of the influencing factors, the influencing factors and the influencing factors of the sensitivity.

In this paper, the production of major hazards as an example, the risk assessment index system of major hazard sources in production sites was established, and the risk evaluation index system of major hazard sources in production sites was constructed by Delphi method and questionnaire survey method. The model and grading method is a quick grading method for government regulation, it does not need complex data and calculation process, simple and practical, to meet the needs of government regulation.

In this paper, the author makes an empirical research on all kinds of major hazard data provided by Taiwan City. Collecting local actual data, statistical analysis, calculate the actual risk of various types of dangerous sources. According to the region's major risk of the overall risk level will be a major hazard into four levels, to achieve a major hazard classification, to verify the model's simplicity and practicality, and also more suitable for Taiwan City Safety Production Supervision and Administration of the city The scope of the production site of major hazard classification supervision work. However, due to limited data in Taiwan City, it is necessary to collect more representative data in more areas, so as to continuously improve the classification standards, and further ensure the classification method and model of practicality.

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