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Analysis of Fire Safety System for Storage Enterprises of Dangerous Chemicals

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Abstract

In recent years, fire and explosion accidents of warehouses caused by dangerous chemicals frequently occur, such as "4 • 22" Jingjiang storage house explosion accident, and Tianjin port "8 • 12" fire explosion accident. Therefore, a mature and perfect fire risk assessment method should be established to further improve fire safety and eliminate fire safety risks. To evaluate the fire safety of dangerous chemical warehouse, identification of hazard source, fire and explosion model, analytic hierarchy process, and safety evaluation score over an interval have been applied in this paper. Combining with the actual situation of a dangerous chemical warehouse enterprise, fire safety situation of dangerous chemical warehouse is assessed, and a series of targeted measures are put forward. This paper provides a scientific basis for the fire risk assessment of dangerous chemical warehouse, and ensure to establish a perfect safety inspection system, and can manage fire safety effectively.

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Keywords: warehouse, dangerous chemicals, fire, explosion, fire risk assessment

Nomenclature

W_f	total mass of fuel in the steam cloud (kg)
W_{TNT}	weight of TNT equivalent of vapor cloud (kg)
Q_f	the heat of combustion of steam (J/kg)
Q_{TNT}	the explosion heat of TNT, 4.52MJ/kg
R	the distance from explosion spot (m)
m_{TNT}	the TNT equivalent weight (kgTNT)
E	explosive energy (kJ)
Q_{TNT}'	the explosive equivalent energy of TNT, 4686KJ/kg
R_0	the distance between the explosion position and the center of the explosion during testing explosion (m)
m_{TNT0}	the weight of TNT at the time of testing explosion (kgTNT)
Δp	explosion overpressure during actual explosion (kPa)
$\triangle p_0$	the explosion overpressure at the location of explosion during a test
$ri(i=1,2,3)$	the explosion damage radius
C.I	consistency index
λ_{max}	maximum eigenvalue
R.I	mean random consistency index
C.R	consistency ratio
W(Ai)	total weight of the first level of the criterion layer
W(Bi)	total weight of the second level of the criterion layer

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W(Ci)	the weight coefficients of the scheme layer
Ai (i=1 to 3)	the first layer of criterion layer
Bi (i=1 to 6)	the second layer of criterion layer
Ci (i=1 to 14)	the solution layer
Vs	the score of system safety evaluation
P_{EI}	the score of evaluation index EI
W_{EI}	the total weight of evaluation index EI
Greek symbols	
α	vapor cloud equivalent coefficient, 0.04
β	dimensionless similarity ratio of actual explosion to experimental explosion

1. Dangerous chemicals warehouse industry

1.1. Main features of dangerous chemical warehouses

With the development of industry, the number of warehouse places is increasing rapidly, and it brings a series of fire hazards. The existence of some hidden trouble is not static, but in continual changing processes, which also puts forward higher requirements for fire supervision, inspection and management[1-4]. Warehouses and yards in storage enterprises are the places where materials are concentrated. Any fire, no matter what the cause is, are results of the burning of a large number of flammable and combustible materials. Therefore, to prevent fire, it is necessary to effectively control flammable and combustible materials. And in order to do so, we must understand and study the burning and exploding properties of these materials. Safety measures should also be adopted to ensure the safety in the storage of dangerous chemicals and materials.

1.2. Risks of dangerous chemical warehouses

1.2.1. Geographical environment is complex, accidental effects are serious

At the same time, warehousing enterprises, adjacent to the risks of many sources, need high and difficult dealing processes. Once toxic, hazardous chemicals are released, leakage and proliferation will endanger the safety of personnel in the whole area. The smoke gas toxicity produced by combustion is big. When anti-explosion resistance ability of a building is poor, it is also prone to collapse. The storage structures of hazardous chemicals storage enterprises[5-6] are complex, and such companies can be divided into four main functional regions. As is shown in Figure 1. Zone I includes inspection bridge, heavy box area, packing area. Zone II includes comprehensive office building, dangerous chemicals warehouse. Zone III is used as the storage area, transfer depot, dangerous goods warehouse and empty container area. Zone IV, used as office buildings, is piled up with a large number of tank and ordinary containers in the yard.

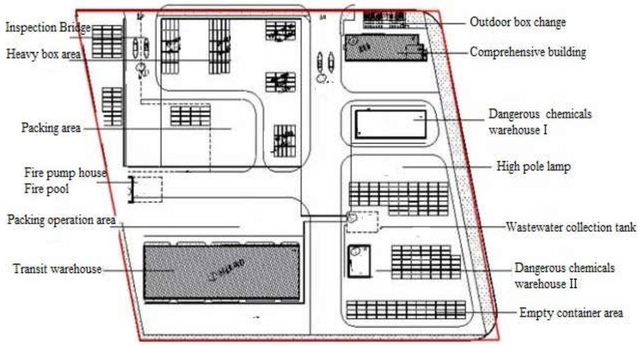

Fig.1 Structural site area of hazardous chemicals warehouse enterprise

1.2.2 Dangerous chemicals are various, and the risk of disaster is great

All kinds of organic and inorganic dangerous chemicals explode violently after burning, and flammable liquid can produce flowing fire. Flowing fire spreads rapidly and threatens the surrounding areas of a warehouse. For example, a large amount of hazardous chemicals in a warehouse enterprise, which are stored in a mixture[7-9], may interact with each other at any time and occur a series of chain reactions. Especially for a large number of dangerous chemicals storing in container, once in case of spontaneous combustion or exposure to an open flame, when encountering impact or friction, contacting with water or acid, will break down to release heat and ignite the surrounding materials under high temperature and will produce toxic gases, such as hydrogen cyanide, which may cause all kinds of potential dangers.

1.2.3 Disaster is complex and changeable, and the disposal process is difficult

A large number of chemical explosions in dangerous chemicals warehouse, may produce a lot of smoke, gas, sewage, drainage and flowing fire, and cause many explosions, leading to complex and changeable disaster situation, and dangerous chemicals are of various types and in large quantities. Many kinds of flammable and explosive dangerous goods scattered on the spot, as well as many uncertain risk factors, smoke and toxic substances, etc., will threaten personnels on the scene and pose great challenges to fire fighting and rescue work. And the pollutants of explosion will reach surrounding areas with water and air, resulting in secondary disasters, causing environmental pollution.

2. Fire safety analysis based on fire and explosion model of dangerous chemicals

2.1. Basic properties of common dangerous chemicals

In case of spontaneous combustion or combustion of the substances in dangerous chemical warehouse, the pressure will rise and will cause the container to explode; if package fails, fire will spread to surrounding combustible materials. Once different types of chemicals contact with each other, it may appear oxidation reactions, neutralization reactions, replacement reactions, etc. And some dangerous products tend to combust spontaneously, causing severe combustion and explosions [10-12] in the event of impact or friction. These chemicals of major risk include the following categories:

(1) Oxidizer: Nitrates, such oxidizers contain high valence N^{5+}, making electrons N^{3+} (NO), such as potassium nitrate, sodium nitrate, lithium nitrate, etc..

(2) Chlorine containing oxacid and its salts: the molecules of this kind of oxidant contain high valence chlorine (Cl^{+}, Cl^{3+}, Cl^{5+}, Cl^{7+}) are easy to obtain electron and turn into low valence chloride ($C1^{0+}$, Cl^{-}), such as perchloric acid, potassium chlorate, low calcium chlorate, etc..

2.2. Calculation of shock wave overpressure

Most fire and explosions will cause pressure vessels to explode due to overpressure by mixed gases. The TNT equivalent method applies to strong vapor cloud explosion. The following is a case in point of potassium nitrate which produces large explosion energy, oxidation, and severe destruction in fires and explosions [13-15]. TNT equivalent method is used to calculate the mixing gas after explosion, and then the vapor cloud explosion shock wave overpressure is formed.

This article assumes that the mass of potassium nitrate is 1046 tons, assuming that the explosion would completely change into steam. At the same time, assuming that the volume of the explosion source at the time of explosion is negligible and that the energy is released instantaneously when the explosion occurs. TNT equivalent calculation can be seen in Equation (1).:

$$\mathrm{W}_{TNT} = \alpha \cdot W_f \cdot Q_f / Q_{TNT} \tag{1}$$

where W_{TNT} is the TNT equivalent of vapor cloud, kg. W_f is the total mass of fuel in the steam cloud, kg. α is the vapor cloud equivalent coefficient, 0.04. Q_f is the heat of combustion of steam, J/kg. Q_{TNT} is the explosion heat of TNT, 4.52MJ/kg.

The molecular weight of potassium nitrate is 101, the amount of potassium nitrate material is 990mol/kg. The burning heat of potassium nitrate is 28732.77kJ/kg. The total mass of potassium nitrate in the steam cloud is 265968.83kg.

When explosion occurs on the ground, the total energy will be 1.8 times because of reflection, so the mass of potassium nitrate on the ground is converted into 478743.89kg.

2.3. Range of shock wave damage

Shock wave overpressure can cause damage to surrounding personnel and buildings in varying degrees. When 1000kg TNT explodes in the air, the shock wave overpressure and grades of danger are classified as is shown in Table 1 and Table 2.

Table 1 Shock wave overpressure of 1000 kg TNT during explosion in the air

R_0 (m)	△p (MPa)	R0 (m)	△p (MPa)
14	0.330	55	0.020 5
16	0.235	60	0.018 0
18	0.170	65	0.016 0
20	0.126	70	0.014 3
25	0.079	75	0.013 0
30	0.057	90	0.010 0
35	0.043	109	0.007 5
40	0.033 0	144	0.005 0
45	0.027 0	166	0.004 0
50	0.023 5	201	0.003 0

Table 2. Classification of grades of danger

Severity of danger	Degree of injury to humans	Overpressure △p (MPa)
Ⅰ Fatal	Cause (most) people to deaths	>0.10
Ⅱ Severe	Damage people's internal organs seriously	0.05-0.10
Ⅲ Dangerous	Injure people's hearing organ or result in a fracture	0.03-0.05
Ⅳ Negligible	Body is slightly damaged or harmless	<0.03

The overpressure of shock wave can be obtained, using Equation (2) and Equation (3) :

$$z_e = \frac{R}{m_{TNT}^{1/3}} \tag{2}$$

$$m_{TNT} = \frac{E}{Q_{TNT}^{'}} \tag{3}$$

where m_{TNT} is TNT equivalent weight on the ground, kgTNT; R is the distance from explosion spot, m; E is the explosive energy, KJ; $Q_{TNT}^{'}$ is the explosive equivalent energy of TNT, 4686KJ/kg.

According to the cube root scaling laws and Baker's distance criterion of TNT equivalent ratio, which can be seen in Equation (4) :

$$\frac{R}{R_0} = \sqrt[3]{\frac{m_{TNT}}{m_{TNT_0}}} = \beta \Leftrightarrow \Delta p = \Delta p_0 \tag{4}$$

where R_0 is the distance between the explosion spot and the center of explosion in experimental explosion, m; m_{TNT_0} is the weight of TNT in experimental explosion, kgTNT; Δp is explosion overpressure during actual explosion, kPa; Δp_0 is the explosion overpressure at the location of explosion during a test. β is the dimensionless similarity ratio of actual explosion to experimental explosion.

The explosive energy is shown in Equation (5) :

$$E = m_{TNT} \cdot Q_{TNT} \tag{5}$$

where m_{TNT} is 478743.89kg, by substituting it into the formula, the explosive energy is 2.243×10^9 J.
Therefore, Equation (4) can be written in form of Equation (6):

$$\frac{R}{22.766}=\sqrt[3]{\frac{m_{TNT}}{1000}}=\beta \Leftrightarrow \Delta p=\Delta p_0 \tag{6}$$

(1) When the shock wave peak overpressure is Δp <0.03MPa, corresponding to R_0 >42.5m, then the human body will be slightly damaged. According to Equation (6), the explosion damage radius of potassium nitrate can be calculated, and the explosion damage radius is R >332.473m.
(2) When the shock wave peak overpressure is Δp =0.03—0.05MPa, corresponding to R_0 =32.5m—42.5m. At this time, the stuff is dangerous, and the explosion damage radius of potassium nitrate calculated is R =254.244m—332.473m.
(3) When the shock wave peak overpressure is Δp =0.05—0.10MPa , corresponding to R_0 =22.77m—32.5m. At this time, the stuff will be seriously injured, and the explosion damage radius of potassium nitrate calculated is R =178.127m—254.244m.
(4) When the shock wave peak overpressure is Δp >0.10MPa , corresponding to R_0 < 22.77m. At this time, the stuff are fatal, and the explosion damage radius of potassium nitrate calculated is R <178.127m.
The explosion damage radius is shown in Figure 2, where r_1 is 178.127m, r_2 is 254.244m, r_3 is 332.473m.

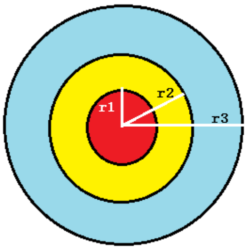

Fig. 2 Explosion damage radius of potassium nitrate

When exploding on the ground, the TNT equivalent of potassium nitrate is 478743.89 kg. The explosive energy is 243×10^9J. The minor damage radius is R >332.473m, the dangerous radius is R =254.244m—332.473m, and the serious injury radius is R =178.127m—254.244m, the lethal radius is R <178.127m.

Through the above calculation, the inflammable and explosive substances stored in the warehouse of dangerous chemicals[16-17] can be quantitatively analyzed and calculated. Energy of burning and explosion accidents can be calculated, the storage amount of material can be controlled, and the safety range of security can be restricted when fire and explosions occur.

3. Fire risk assessment of dangerous chemical warehouses

3.1. Establishment of the evaluation index system

Table 3 Fire risk assessment index system of dangerous chemical warehouses

The first level of criterion layer	The second level of criterion layer	The scheme layer
Inherent risk degree of hazard sources A1	Inherent risk of hazardous substances B1	Fire explosion hazard C1
		Toxicity degree C2
	Inherent risk of hazard source enterprises B2	Varieties of dangerous goods C3
		Quantity of dangerous goods C4
		Surrounding hazard sources C5

Risk offset ability of hazard source A2	Risk of management system on hazardous source B3	Perfection level of emergency plans C6
		Quality of full-time security personnel C7
		Safety management system C8
	Risk of management technology of hazardous sources B4	Safety science and technology investment C9
		Safety of processing route C10
Hazardous consequence degree of hazard source A3	Hazardous risk at the site of hazard source B5	Property quality at the site C11
		Number of on-site personnel C12
	Social harm and risk of hazard source B6	Number of people around C13
		Number of surrounding properties C14

The establishment of fire risk assessment index of dangerous chemical warehouses is mainly based on the two aspects of fire and can be considered as follows: First, according to the risk sources of fire and explosion, the layout of environment and the characteristics of the technological production process[18-19], related preventive measures can be carried out for the storage enterprises; Second, confirming the fire controlling measures be adopted after the fire and effective disposal of the disaster be carried out, ensuring the development of fire emergency rescue work and extinguishing the fire. Taking into account the properties and characteristics of the actual use of such sites [20-22], an evaluation index standard hierarchy and an evaluation system are established, as is shown in Table 3.

3.2. Index weight calculation

Yaahp V10.3 is used to evaluate the index of fire and explosion accidents, and the weight of each index is determined. To ensure the reliability and scientific nature of data sources, 10 experts were invited to evaluate conditions of the dangerous chemical warehouse, including 5 staffs from the local Fire Brigade, as well as 5 staffs from the Bureau of Safety production supervision and Administration of the local government.

First of all, scoring indicators of the scheme level (Number 1 to Number 9) which corresponding to the second level of criterion layer in each group, related to the proportion of role[23-24]. In accordance with the significance degree, equally important, slightly important, more important, very important, we divide it into four grades, and construct pairwise comparison matrices. Then we can obtain consistency index and consistency ratio , referring to Equation (7) and (8) :

$$C.I = \frac{\lambda_{\max} - n}{n-1} \tag{7}$$

$$C.R = {C.I}/{R.I} \tag{8}$$

where $C.I$ is consistency index; $\lambda_{\max}$ is maximum eigenvalue; $R.I$ is mean random consistency index; $C.R$ is consistency ratio. Validation is done by consistency checking; on the contrary, it cannot pass the test. The weight coefficient of each weight index is obtained. At the same time, the total weight coefficient of each index to the total target is obtained. Taking dangerous chemicals warehouse in an industrial district as an example. Comparison matrix of the first level of criterion layer is shown in Table 4(a).

Table 4 (a) Comparison matrix of the first level of criterion layer by expert scoring

Fire risk	Consistency ratio of comparison matrix: 00909	Total target weight: 1.0000		
Fire risk	Inherent risk degree of hazard sources A1	Risk offset ability of hazard source A2	Hazardous consequence degree of hazard source A3	Wi
Inherent risk degree of hazard sources A1	1.0000	1.3723	1.9347	0.4219
Risk offset ability of hazard source A2	0.7287	1.0000	3.5338	0.4176
Hazardous consequence degree of hazard source A3	0.5169	0.2830	1.0000	0.1605

$\lambda_{max} = 3.094\ 6$, $C.I = 0.047\ 3$, $C.R = 0.0909 < 0.1$， it passed the consistency test.

Comparison matrix of the second level of criterion layer is shown in Table 4(b). We can also know target weight of A1, the first level of the criterion layer.

Table 4(b) Comparison matrix of the second level of criterion layer by expert scoring

Inherent risk degree of hazard sources A1	Consistency ratio of comparison matrix：0.0000；	Total target amount weight $W^{(1)}$：0.4219	
Inherent risk degree of hazard sources A1	Inherent risk of hazardous substances B1	Inherent risk of hazard source enterprises B2	Wi
Inherent risk of hazardous substances B1	1.0000	2.0000	0.6667
Inherent risk of hazard source enterprises B2	0.5000	1.0000	0.3333

$\lambda_{max} = 2.0000$, $C.I = 0.0000$, $C.R = 0.0000 < 0.1$， it passed the consistency test. Total weight of the first level of criterion layer $W^{(A1)}$ is 0.421 9. A2 and A3 follow the same procedure as A1, and $W^{(A2)}$ is 0.417 6， $W^{(A3)}$ is 0.160 5.

Comparison matrix of the scheme level by expert scoring is shown in Table 5. We can also know target weight of B1, the second level of the criterion layer.

Table 5 Comparison matrix of the scheme level by expert scoring

Inherent risk of hazardous substances B1	Consistency ratio of comparison matrix：0.0000；	Total target amount weight：0.2812	
Inherent risk of hazardous substances B1	Fire explosion hazard C1	Toxicity degree C2	Wi
Fire explosion hazard C1	1.0000	1.0000	0.5000
Toxicity degree C2	1.0000	1.0000	0.5000

$\lambda_{max} = 2.0000$, $C.I = 0.0000$, $C.R = 0.0000 < 0.1$， passed the consistency test. Total weight of the second level of criterion layer $W^{(B1)}$ is 0.281 2. B2 to B6 follow the same procedure as B1, and $W^{(B2)}$ is 0.140 6， $W^{(B3)}$ is 0.313 2, $W^{(B4)}$ is 0.104 4, $W^{(B5)}$ is 0.128 4, $W^{(B6)}$ is 0.032 1.

The weight coefficients of the scheme layer to the total target, $W^{(Ci)}$ $(i = 1,2\cdots,14)$ are shown in Table 6.

Table 6 The weight coefficients of each index of the scheme layer to the total target

Final result	
Alternative	Wi
Fire explosion hazard C1	0.1406
Toxicity degree C2	0.1406
Varieties of dangerous goods C3	0.0449
Quantity of dangerous goods C4	0.0785
Surrounding hazard sources C5	0.0172
Perfection level of emergency plans C6	0.1690
Quality of full-time security personnel C7	0.0930
Safety management system C8	0.0512
Safety science and technology investment C9	0.0348
Safety of processing route C10	0.0696
Property quality at the site C11	0.0428
Number of on-site personnel C12	0.0856
Number of people around C13	0.0214
Number of surrounding properties C14	0.0107

Ranking of the weight coefficients of each index of the scheme layer to the total target is as follows:

Perfection level of emergency plans > Fire explosion hazard= Toxicity degree > Quality of full-time security personnel > Number of on-site personnel > Quantity of dangerous goods > Safety of processing route > Safety management system >

Varieties of dangerous goods > Property quality at the site > Safety science and technology investment > Number of people around > Surrounding hazard sources > Number of surrounding properties, and the latter three items account for minor weight. Therefore, the main influencing factors of fire risk in dangerous chemical warehouse buildings are perfection level of emergency plans, fire explosion hazard, toxicity degree, quality of full-time security personnel, number of on-site personnel, quantity of dangerous goods, safety of processing route, etc.

3.3. Safety scoring table designation and evaluating grade division

3.3.1 Safety scoring table

Determine the total weight of factors in evaluation index, according to the fire safety management regulations in this site and fire hazard assessment standards. The evaluation index of the scheme layer is graded, and a safety scoring table is worked out, and the total weight of the index is multiplied by scoring value. In this paper, we take a dangerous chemicals warehouse as an example. Each score in the safety score sheet is marked by 10 fire experts from the fire brigade in the district of hazardous chemical warehouse, according to the importance of each aspect respectively. And then the average score is listed as security assessment mark, as is shown in Table 7. The final index score is also given in it.

In order to ensure the reliability and accuracy of each score, in this process, we invited 10 experts in the survey. The experts carried out investigation on the warehouse of dangerous chemicals respectively. And according to the opinions feedback from experts, the consistent items are given, and the score of each item is obtained. Finally, the average score of 10 marks is calculated for each item.

Table 7 Safety scoring table for assessment of hazardous chemical warehouses

Serial number	Evaluation index	Security assessment mark	Weight coefficiency index	Final index score
1	Fire explosion hazard C1	82	0.1406	11.5292
2	Toxicity degree C2	70	0.1406	9.842
3	Varieties of dangerous goods C3	78	0.0449	3.5022
4	Quantity of dangerous goods C4	80	0.0785	6.28
5	Surrounding hazard sources C5	72	0.0172	1.2384
6	Perfection level of emergency plans C6	40	0.1690	6.76
7	Quality of full-time security personnel C7	60	0.0930	5.58
8	Safety management system C8	10	0.0512	0.512
9	Safety science and technology investment C9	30	0.0348	1.044
10	Safety of processing route C10	45	0.0696	3.132
11	Property quality at the site C11	70	0.0428	2.996
12	Number of on-site personnel C12	60	0.0856	5.136
13	Number of people around C13	76	0.0214	1.6264
14	Number of surrounding properties C14	79	0.0107	0.8453
Total				60.0235

3.3.2 Evaluation grade division

The score of system safety evaluation can be expressed in Equation (9) :

$$V_S = \sum P_{EI} \cdot W_{EI} \tag{9}$$

where V_S is the score of system safety evaluation; P_{EI} is the score of evaluation index EI ; W_{EI} is the total weight of evaluation index EI . The evaluation indexes are divided into five grades in total. Fire hazard level, classification and illustration are shown in Table 8.

Table 8 Fire hazard level classification and illustration

Fire hazard level	Levels of system security classification	Fire hazard illustration
Better	[90,100]	Fire risk is relatively small
Good	[75,90]	Fire risk is relatively small
Medium	[60,75]	Fire risk is ordinary in general, as long as a certain link goes wrong, it can lead to a fire.
Bad	[45,60]	Fire risk is high, should take measures as soon as possible
Worse	[0,45]	Fire risk is great, fire safety management should be carried out at certain dangerous point, and business should be stopped for rectify if necessary

Taking the dangerous chemical warehouse in this article for an example, the final calculation of safety evaluation system score is 60.0235, compared with the control index. It is known that the fire safety level of this warehouse is bad, and fire safety measures should be taken as soon as possible, and unsafe factors[25-27] should be eliminated in time.

4. Conclusion

4. 1. Assessment results

From the above evaluation results of analytic hierarchy process, we can draw the following conclusions:

(1) This warehouse is a rather large and complicated place, and there are many fire hazards in the facilities and management. The fire safety situation is poor, and it is rated as a poor fire safety place, which is corresponded with actual situation. Thus, this fire safety evaluation method is feasible.

(2) In a given area, specific safety grade score over an interval can be set up to evaluate the local hazardous chemical warehouse. And on this basis, emphasized supervision is implemented. This evaluation method is of great practical significance.

4.2. Corrective actions and suggestions

According to the scoring results of analytic hierarchy process, the main influencing factors of fire risk of dangerous chemical warehouses are perfection level of emergency plans, fire explosion hazard, toxicity degree, quality of full-time security personnel, number of on-site personnel, quantity of dangerous chemicals, safety of processing route. Therefore, the following management of the dangerous chemical warehouse is put forward：

(1) In order to reduce fire risks, the following measures should be done:

①In order to reduce fire and explosion risk, warehouse location should be reasonable. Reasonable transportation routes for hazardous chemicals shall be established. As for large and medium-sized warehouses with large quantities of dangerous chemicals, they should be constructed independently in safety zones outside towns.

②Storage rooms of dangerous chemicals should be properly ventilated to avoid exposure and humidity. For example, thickening wall thickness. Air inlet holes should be arranged at the top and corner of the warehouse.

③Between warehouse storing all kinds of chemical dangerous goods and other buildings, as well as between walls of warehouses, it should use firewalls of fire-resistant limit. Adequate fire separation distance should be maintained. Any dangerous goods and cartons and other flammable substances should be cleared off within fire separation distance.

(2) In order to control the quantity of dangerous goods, we should put an end to improper storage or alteration of its functions. Illegal storage or mixed and high stacking of dangerous goods should be banned. Different types of dangerous goods shall not be mixed up. The distance between them shall be sufficient and ultra-high stacking violation phenomenon should be prohibited. Arbitrarily loading and unloading, dumping, moving locations of containers and storage should be stopped.

(3) In order to improve the quality of full-time security staff, it is necessary to strengthen the safety education of enterprise employees. And the technical level of production clerks, stevedores and transportation officers should meet the related requirements. Enterprises should strengthen fire safety inspections and the implementation of inspection censorship. Ensure that personnel are on the job and strengthen fire safety management, put inspection registration on records, and

find out and eliminate potential dangers in time. Special person should be assigned on the spot to supervise and guard against sudden dangerous situations, and avoid the deficiency and oversight of management. Dangerous chemical stacks and cargo should be managed consolidatedly. We should avoid barbarous stevedoring or dumping, leakage and other dangerous behaviors during packing and transporting. Hazardous chemicals should be removed in time and alter excessive storage of dangerous chemical goods.

(4) Formulate perfect emergency plans. Organize staff evacuation drills regularly, strengthen safety awareness, high attention should be paid to the maintenance and repairment of facilities and equipment, and the safety management personnel should take their responsibilities seriously.

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