Research on Safety Evaluation of Aviation Material Warehouse based on AHP

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Abstract. Aviation material warehouse is the base for storage and supply of aviation materials and is an important part of military aviation equipment support system. The special social attributes and technical characteristics of aviation materials put forward higher safety requirements for aviation materials warehouse. Aviation materials warehouse is of great significance to ensure the status of aircraft flight safety. Therefore, improving the safety management level of aviation materials warehouse is an urgent task. According to the characteristics of many safety factors of aviation material warehouse and the uncertainty among the factors, a safety evaluation method based on Analytic Hierarchy Process (AHP) is proposed. Finally, combined with the actual situation of the air material warehouse, the countermeasures for risk control are formulated, and a safety management model based on the "new barrel theory" is constructed, which provides a reference for the prevention of safety accidents in the air material warehouse.

Keywords: aviation material warehouse; AHP; safety evaluation; index weight; countermeasures

1 Introduction

Since the 21st century, the navy has accelerated the pace of reform and established many practical development goals. In the special period of naval transformation, there are many internal and external factors that affect the safety of aviation material warehouse. Aviation material safety is very important for the development of naval aviation force. Although departments at all levels and leaders pay enough attention to safety management and invest a lot in hardware construction, the investment in safety education is relatively limited. The investigation found that the safety incidents of aviation material warehouse are usually caused by many factors, including equipment and facilities, environmental factors, personnel factors and so on. At present, most aviation material warehouses only pay attention to the business process and the cultivation of personnel's business ability, but the lack of safety education, the cultivation of confidentiality awareness, and the strength of personnel control make the guarantee quality unable to meet the needs of safety management. Only by effectively solving the factors endangering the safety of the aviation material warehouse, can the stability and harmony of the aviation material warehouse be maintained, which is conducive to the smooth progress of the aviation material support work.

Safety evaluation usually adopts qualitative, quantitative or a combination of qualitative and quantitative methods to evaluate the factors affecting the safety system, and reduce the

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influencing factors to the allowable range. The reliability of the quantitative evaluation method of warehouse safety is not high in China. Most research results have large deviations from the actual situation in the process of theoretical application due to the single evaluation method. For the management research of warehouse safety, at present, most of them stay on the basis of qualitative analysis, because the judgment of qualitative analysis is mainly based on human influence, and the final judgment will be distorted due to human factors, so the formulation of hazard control measures is not targeted, and does not really achieve the intrinsic safety of the warehouse. Based on the above problems, using the Analytic Hierarchy Process can effectively solve the subjective uncertainty and ambiguity of the evaluation personnel, carry out a reasonable and objective evaluation of the warehouse safety performance, and better balance the interference of human factors. On the premise of establishing multi-level evaluation indicators, corresponding preventive measures can be taken against the influencing factors to achieve the purpose of evaluating the warehouse safety performance [1-2].

2 Basic Principles of Safety Evaluation Index System Design

The final result of the safety assessment is to ensure that the safety management of the aviation material warehouse is standardized. Through the implementation of such work, the aviation material warehouse can fully recognize the shortcomings of its own unit in the management of safety, improve its own unit's safety management level, and realize the safety of the warehouse. The implementation of safety assessment will also enable relevant departments to have a deeper understanding of the safety situation of grass-roots units, so that the management of grass-roots units is more targeted.

2.1 Principle of Comprehensiveness

It is required to ensure that the scope of safety is fully covered without omission, so as to play a guiding role in the safety management of aviation material warehouse.

2.2 Principle of Operability

The evaluation index should be operable, and the evaluation can fall on specific people and objects, and the participants can clearly understand its meaning and give effective suggestions.

2.3 Principle of Full Participation

This work requires the joint participation of all personnel in the aviation materials warehouse, and the grass-roots staff have a more comprehensive understanding of the working environment, transportation of aviation materials, safety protection, etc. Therefore, the design of indexes should follow the principle of full participation.

3 Establish the Safety Evaluation Index System of Aviation Material Warehouse

3.1 Determining Indexes

For the comprehensiveness, reliability and accuracy of warehouse safety evaluation results, if the number of evaluation indexes selected is too small or too many, the evaluation results will be affected. Therefore, a comprehensive analysis and scientific selection of evaluation indexes at all levels are the premise and basis for establishing a good model.

Based on theoretical analysis and on-site investigation, combined with the aviation material support situation and the historical experience of aviation material warehouse management, four first-class indexes and 14 second-class indexes are established to form the aviation material warehouse safety evaluation index system, as shown in Table 1.

Table 1. Safety evaluation index of aviation material warehouse

Target layer	Criterion layer	Measure layer
Research on safety assessment of aviation material warehouse	System	Rules and regulations
		Operating procedures
		Safety inspection
	Environment	Natural environment
		Social environment
		Warehouse layout
	Equipment and facilities	Fireproof
		Explosion-proof
		Lightning protection
		Damage prevention
		Temperature and humidity control
	Personnel	Leadership literacy
		Professional quality of professionals
		Safety education for all personnel

When considering system factors, the weight of rules and regulations, operating procedures, safety inspection and other indexes is mainly determined according to the implementation of various laws and regulations, procedures issued by the army and the system of managers.

When considering environmental factors, the natural environment is evaluated by comprehensively considering the terrain around the warehouse and the advantages and disadvantages of the environment. The social environment index is determined by the social complexity around the warehouse. The warehouse layout index is determined by the capacity of aviation materials in stock and the rationality of stacking.

When considering the indexes of equipment and facilities, there are many indexes that can be set up for warehouse safety protection. However, due to the different impact of the indexes, only five indexes with prominent characteristics are selected, including explosion-proof, fire prevention, damage prevention, lightning protection and other indexes.

When establishing the evaluation index, considering the personnel factor, the weight of the indexes such as leadership literacy, professional literacy, and safety education of all personnel is mainly established according to the safety education of the unit to the personnel, the frequency of business learning, and the reasonable deployment of the plan by the manager, so it is considered to be included in the index system [3-4].

3.2 Calculating Weighs

Using AHP method to construct analysis hierarchy process model, the process is shown in Fig. 1.

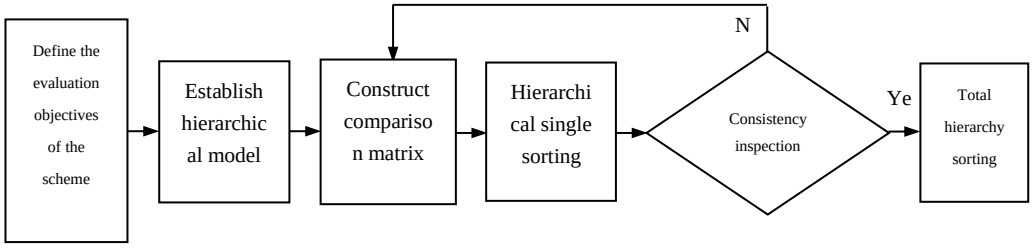

Fig.1. The basic process of AHP

3.2.1 Establish judgment matrix

AHP method is used to build the Analytic Hierarchy Process (AHP) model [5-8]. The "1-9 standard method" is used to evaluate the two matrices. First, element i is set, and then element j is set. Through comparison, the weight values of i and j are analyzed and confirmed. The scale interpretation is shown in Table 2.

The judgment matrix has the following characteristics:

$A_{ij}>0$; $A_{ij}=1/A_{ij}$ ($i\neq j$); $A_{ij}=1$ (i, j=1,2, …n)

3.2.2 Calculate index weight

(1) Calculate the score of each line element of the judgment matrix M_i

(2) Caculate M_i 的 n-th root $\overline{W_i}$

$$\overline{W_i} = \sqrt[n]{M_i} \quad (1)$$

Table 2. Scale interpretation

importance scale	meaning
1	indicates that the two elements are of equal importance
3	indicates that the former is slightly more important than the latter
5	indicates that the former is significantly more important than the latter
7	indicates that the former is more important than the latter
9	indicates that the former is more important than the latter
2,4,6,8	represents the intermediate value of the above judgment

(3) Nornalized vector $\overline{W}$

$$\overline{W}=[\overline{W_1},\ \overline{W_2},\ \ ...\overline{W_n}]^T \tag{2}$$

$$\overline{W}=\left[\overline{W_1},\ \overline{W_2},\ \ ...\overline{W_n}\right]^T \tag{3}$$

$$W_i = {\overline{W_i}}/{0\sum_{j=1}^{n}\overline{W_j}} \tag{4}$$

Then the eigenvector is

$$\overline{W}=[\overline{W_1},\ \overline{W_2},\ \ ...\overline{W_n}]^T \tag{5}$$

(4) Calculate the maximum eigenvalue of the judgment matrix λ max

According to the judgment matrix, the maximum eigenvalue of the judgment matrix based on the judgment matrix is solved λ max, we have the eigenvector.

Consistency index CI expression:

$$CI = \frac{\lambda \max - n}{n-1} \tag{6}$$

Where the RI value of the order matrix is shown in Table 3.

Table 3. RI value of matrix of order

Order	1	2	3	4	5
RI	0	0	0.52	0.89	1.12
Order	6	7	8	9	10
RI	1.26	1.36	1.41	1.46	1.49

First, the consistency scale expression is listed:

$$CR = CI / RI \tag{7}$$

The matrix weight value obtained after the unified processing of eigenvectors:

$$CR = \sum a_j\, CI_j / \sum a_j\, RI_j \tag{8}$$

If CR<0.1, the decision matrix has consistency characteristics.

By inviting relevant business personnel and relevant industry experts from the aviation material warehouse, after discussion and table scoring, the relative scores of the main risks and subordinate indexes of system factors, environmental factors, personnel factors, equipment and facilities factors were determined respectively, and the weight of each index was obtained by using the cloud operator.

It can be seen from the table above that in the whole assessment process, the indexes that account for a large proportion of the safety factors affecting the aviation material warehouse are leadership literacy, rules and regulations, operating procedures and safety education for all personnel. The relatively small proportion of the impact is the social environment in environmental factors and the fire prevention in equipment and facilities [5-6].

4 Empirical Evaluation and Analysis

The comprehensive weight of each factor finally obtained by the Analytic Hierarchy Process is used to score the whole link. The safety situation of the aviation material warehouse is divided into five levels and the corresponding levels are carried out according to the percentage system. The relationship is as follows:

Grade A: 90 to 100 points; Grade B: 80 to 89 points; Grade C: 70 to 79 points; Grade D: 60 to 69 points; Grade E: less than 60 points.

The relevant business personnel and industry experts of the aviation material warehouse scored. After weighted comprehensive calculation, the weight of each index is shown in Table 4 and Table5.

Table 4. Score of each secondary evaluation index

Target layer	Criterion layer	Measure layer	Weight	Give a score	Weighted score
Research on safety assessment of aviation material warehouse	System	Rules and regulations	0.1897	97.3	18.4540
		Operating procedures	0.1044	94.8	9.8947
		Safety inspection	0.0572	92.5	5.2954
	Environment	Natural environment	0.0348	88.8	3.0863
		Social environment	0.0132	88.5	1.1697
		Warehouse layout	0.0607	85.5	5.1918
	Personnel	Leadership literacy	0.1896	92.4	17.5151
		Professional quality of professionals	0.0574	91.4	5.2471
		Safety education for all personnel	0.1043	92.6	9.6598
	Equipment facilities	Fireproof	0.0119	91.7	1.0913
		Explosion-proof	0.0263	93.7	2.4681
		Lightning protection	0.0645	96.1	6.2004
		Damage prevention	0.0146	95.7	1.3948
		Temperature and humidity control	0.0714	94.8	6.7690
		Total			93.4375

Table 5. Scores of evaluation indexes at all levels

Target layer	Criterion layer	Weight	Give a score	Weighted score
Aviation material warehouse Research on safety assessment	System	0.3513	94.8666667	33.32666
	Environment	0.1087	88.6	9.63082
	Personnel	0.1887	92.1333333	17.38556
	Equipment Facilities	0.3513	94.4	33.16272
	Total			93.50576

The calculation result is 93.5 points, the level is A, and the detection result is excellent. The aviation material warehouse should make certain changes in the warehouse layout of environmental factors in the later stage, and at the same time, further attention should be paid to the social environment.

5 Countermeasures

When establishing the research on the safety management countermeasures of air material warehouse, we should not only look for the influencing factors from the source, but also look for the causes, the whole process and the consequences of the accident, so as to reveal the multiple factors leading to the accident and their mutual relations and effects. Using the relevant knowledge of the "New Barrel Principle" can more comprehensively establish the management and control system and safety management countermeasures [9].

5.1 Connotation of "New Barrel Principle"

The Barrel Principle was proposed by Peter, an American management scientist. After a long period of development and evolution, it has evolved from the "Old Barrel Principle" to the "New Barrel Principle". The " New Barrel Principle" avoids the defect that "Old Barrel Principle" only considers short boards, and enriches its connotation. The "New Barrel Principle " not only takes into account the shortage of short boards, but also pays more attention to the gap and iron hoop between the floor and the board, and between the boards. The base plate is the foundation, which is the most basic. The gap of convergence is whether the coordination and cooperation are good and effective, which is more reflected in the cooperation between various departments. Iron hoop refers to the rules and regulations of a superior department, and attention should be paid to the strength of hooping (loose, "water" will leak; tight, "water" will have a rebellious mentality). Water is the management personnel and business personnel of each department in the station.

5.2 Safety management measures of "New Barrel Principle"

5.2.1 Management measures for "water"

In the Barrel Principle, "water" refers to the management and business personnel of each department, who play a key role in an organization and are the soul of an air material warehouse.

The measures taken for them are as follows:

(1) Use reasonable time to conduct safety education for all personnel.

(2) Safety training can be carried out frequently for all personnel. After that, an examination is required to check the training effect.

(3) Regularly or irregularly carry out spot checks on safety factors to find out the responsible person of the area with problems.

(4) Regularly organize emergency drills, combine theory with practice, and summarize experience and deficiencies from the drills.

5.2.2 Management measures for "weak board"

The "weak link" in the Barrel Principle refers to the weak link or defective link in the previous safety assessment.

The following measures have been taken:

(1) Strengthen the importance of personnel on fire prevention and damage prevention, including not ignoring the impact of social environment because the warehouse location is remote.

(2) During the expansion or renovation of the air material warehouse, the layout of the warehouse shall be reasonably adjusted, or the layout of the two storey high building shall be changed, and the hidden dangers shall be checked in time to reduce losses and injuries.

5.2.3 Management measures taken for "base plate"

The "base plate" in the Barrel Principle refers to the equipment, facilities, social environment and natural environment of the air material warehouse. The measures taken for this include:

(1) For equipment and facilities that are prone to accidents, make good use of time for maintenance, maintenance and inspection, and record all conditions.

(2) Even if you have a good natural and social environment, you should also be more alert to the surrounding environment and not be taken lightly.

5.2.4 Management measures for "iron hoop"

The "iron hoop" in the Barrel Principle refers to the relevant systems and requirements formulated by the superior and the unit itself, and the measures taken for this are:

(1) We should strengthen the implementation of the systems received.

(2) On this basis, we should establish a warehouse safety management system that meets our own needs.

5.2.5 Management measures for "gaps"

The "gap" in the Barrel Principle refers to the coordination and cooperation ability between the command organs, grass-roots units and personnel. Measures taken for this include strengthening the communication between grass-roots units, command organs, officers and soldiers. More analysis, more understanding and more problem solving.

5.3 Establish safety management plan for air material warehouse

In order to achieve the goal of intrinsically safe air material warehouse, the warehouse shall formulate safety management plan, strengthen safety management and implement various safety measures.

5.3.1 Evaluate potential safety hazards

Risk analysis and evaluation shall be carried out for areas and places with potential safety hazards in the air material warehouse, and targeted and timely accident prevention and control measures shall be proposed.

5.3.2 Formulate effective measures

According to the characteristics of the air material warehouse, effective safety technical measures and organizational management measures are formulated. For each potential safety hazard, a set of targeted safety management system is formulated by category, and strict management control and spot check are carried out. The safety management measures

formulated shall include complete rules and regulations, correct maintenance system, safety inspection system and personnel safety training system.

5.3.3 Precautionary security warning

Formulate on-site emergency plan, carry out emergency education and drill for air material warehouse accidents, carry out professional training and education for accident prevention, and inspect and evaluate the effectiveness and perfection of the plan through standard formulation.

5.3.4 Carry out accident investigation

Announce the potential safety hazards of the warehouse on the bulletin board of the safety board of the air material warehouse and urge them at all times; Ensure that all warehouse management personnel are familiar with the escape measures in case of accidents; In case of any major warehouse accident, alarm and notify the relevant department at the first time [10].

6 Conclusions

Using AHP to establish warehouse evaluation method, combined with specific cases, taking the safety evaluation of aviation material warehouse as the standard, combined with the evaluation index to establish the model, build the evaluation matrix, determine the index weight, and sort the relative importance of the index. Finally, according to the evaluation results, the empirical analysis was carried out to find out the weak links and potential risk factors in the safety management of the air material warehouse. Using the relevant knowledge of the new barrel principle, according to the situation and characteristics of the air material warehouse, the safety management countermeasures were formulated to provide some theoretical guidance for the warehouse management to ensure the safety of the warehouse. Therefore, the evaluation of warehouse security performance will help the army to carry out more reasonable warehousing activities, find out warehouse security vulnerabilities, ensure warehouse security performance, and provide accurate scientific basis for improving material storage efficiency and preventing security accidents.

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