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Human Factors in Civil Aviation Maintenance

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***Abstract*:** In civil aviation maintenance in my country, a series of problems caused by human factors are becoming more and more serious, which poses a serious threat to the development of civil aviation in my country. For this reason, this article introduces the theory of human factors, statistics the causes of civil aviation maintenance human factors errors in the past ten years, proposes countermeasures to prevent aviation maintenance human factors errors, and strives to reduce the occurrence of aviation maintenance human factors errors.

1. Introduction

In recent years, with the innovation of civil aviation safety management concept, the improvement of laws and regulations, the improvement of team quality, and the promotion and application of new navigation technology, the foundation of China's aviation safety has been continuously consolidated, and aviation safety has maintained a stable and good development trend. However, with the rapid development of China's civil aviation industry, the expanding fleet size and the increasing workload of maintenance personnel, the safety risks brought by human errors in aviation maintenance to the civil aviation industry are becoming increasingly obvious.

Paying attention to the influence of human factors on aviation safety and studying human errors in aviation maintenance will become an important way to further reduce the occurrence rate of flight accidents, and improve the level of flight safety. Scholars have conducted research on the influencing factors of human error. For example, Zhao Tao[1] and others have used Murphy's law to summarize the law of human error. Cao Yange[2] introduced the SHEL model and Reason through the system and analyzed the necessity of human factors in combination with cases; Chen Lijia[3] gave a detailed introduction to the Reason model and summarized the types of human errors. Che Changchang[4] and others used Bayesian qualitative analysis to analyze the importance of human errors and put forward relevant countermeasures. W. C[5] studied the types of errors made by aircraft pilots. Matthew Merzbacher[6] operates in the error control system data mining technology is used to improve the system's ability to control errors, and this result is applied to an aviation explosives detection system, which reduces the false alarms of the aviation explosives detection system.

For these purpose, based on the theoretical analysis of human factors, this paper provides statistics on the human errors that have occurred in Chinese civil aviation maintenance in the past decade, analyzes the main factors that affect the errors of aviation maintenance personnel, and proposes feasible countermeasures to reduce the occurrence of aviation maintenance personnel.

2. Human factors theory

Human Factors originated in the United States and is also known as "Human Factors Engineering" and "Ergonomics" in Europe. In our count, the National Bureau of Standards has named this subject "Human Ergonomics" since 1980. It is a subject based on psychology, physiology, anatomy, anthropometry, etc., to study how to make humans one machine one environment The design of the system conforms to the human body structure and physiological and psychological characteristics to achieve the best match between human, machine and environment, so that people under different conditions can effectively, safely, healthily and comfortably carry out work and life. science. The International Civil Aviation Organization (ICAO), the Federal Aviation Administration (FAA), Boeing and Airbus have been conducting research in this area for many years and have achieved relatively mature research results. Among them, there are the following 6 kinds of theories that are widely used.

2.1 Survey of Aircraft Wreckag Murphy's Law [7]

n -fold Bernoulli test derivation.

The probability of event A happening exactly k errors is

$$P_k(n,p) = C_n^k p^k q^{n-k} (k = 0,1,\ldots,n)$$

(q is the probability that an error must occur, $q = 1 - p$)

The probability that an error will not occur is $P_0(n,p) = q^n$

due to $0 < q < 1$,so

$$\lim_{n\to\infty} P_0(n,p) = \lim_{n\to\infty} q^n = 0$$

the probability of at least one error is

$$\sum_{k=1}^{n} P_k(n,p) = 1 - P_0(n,p) = 1 - q^n$$

When

$n \to \infty$,

$$\lim_{n\to\infty} \sum_{k=1}^{n} P_k(n,p) = \lim_{n\to\infty} (1 - q^n) = 1$$

Its mathematical interpretation is that it is impossible for an event to occur without an error, and there must be an event with at least one error. Murphy's Law is an important experience that has been summed up by the western aviation community for a long time. It shows that wherever there is a possibility of error, there will be someone making a mistake, and it happens in the worst way and at the most unfavourable time.

2.2 Hain's law (error iceberg theory)

"Hain's Law" is a "mathematical model" for studying and analyzing human errors. It shows that there are 29 accidents in a major accident, and there are 300 accidents (serious errors) below it, and 1,000 unacceptable accidents. Security incident. Accidents are like the tip of an iceberg out of the water. There are many incidents below the water surface that have not yet developed into accidents. Below each incident there are many unsafe events that have not yet developed into accidents. This is vividly called the accident iceberg theory. Facts have shown that almost all investigations into the causes of major accidents have made a vivid interpretation of this rule.

2.3 The accident chain

The accident chain is a concept developed in the ICAO Accident Prevention Manual. Major accidents are rarely caused by a single cause, but by many factors, like chains, and accidents occur when all the links are joined together. Therefore, in order to prevent an accident, it is sufficient to cut a link in the chain.[8]

2.4 SHEL model

The SHEL model was first proposed by Professor Edwards in 1972 and modified by Professor Hawkins in 1975 (Figure 1). The model is composed of living bodies, hardware, software, and environment in the form of building blocks. The matching or mismatch between the building blocks (interface) is as important as the characteristics of the building blocks themselves, and the mismatch may become the source of human error. SHEL is not a word, but is composed of the initial letters of Software, Hardware, Environment, and Liveware. The basic idea is: "Errors are likely to occur at the connections between people-centered and hardware, software, environment, and others."

2.5 Reason model

In 1990, James Reason, a professor at the University of Manchester, proposed the Swiss Cheese Model based on the analysis and synthesis of previous models. Its conceptual model was proposed in Reason’s famous psychology monograph "Human Error". It is quickly and widely used in ergonomics, medicine, nuclear industry, aviation and other fields, and has become one of the theoretical models for aviation accident investigation and analysis through the recommendation of the International Civil Aviation Organization (ICAO).

The model points out that aviation production is an organized system of activities, and these organizational activities can be divided into different levels. From a system perspective, organizational activities at all levels are related to the eventual occurrence of the accident. There are loopholes at each level. Unsafe factors are like an uninterrupted light source. The accident happens when these loopholes are passed. Now, this is in line with the logic of the REASON model "light penetrating cheese". Its important value is that it reveals that the occurrence of accidents is not only related to the production activities directly related to the accident, but also related to other levels of activities and personnel far away from the accident. These other levels of defects and vulnerabilities are called potential failures. . Potential failures are mostly management decision failures, which have existed in the past and have been in a potential state. Current failure refers to errors and violations that have a direct negative impact, usually by production line workers.

2.6 MEDA model

MEDA (Maintenance Error Decision Aid) was first proposed by the merged Boeing company in 1995, and has now been adopted by more and more aircraft maintenance companies.

The goal of MEDA's help in investigating accidents is to not only identify existing error-causing factors but also prevent errors from recurring in the future. When an accident occurs, the operator generally follows the following steps (Figure 1).

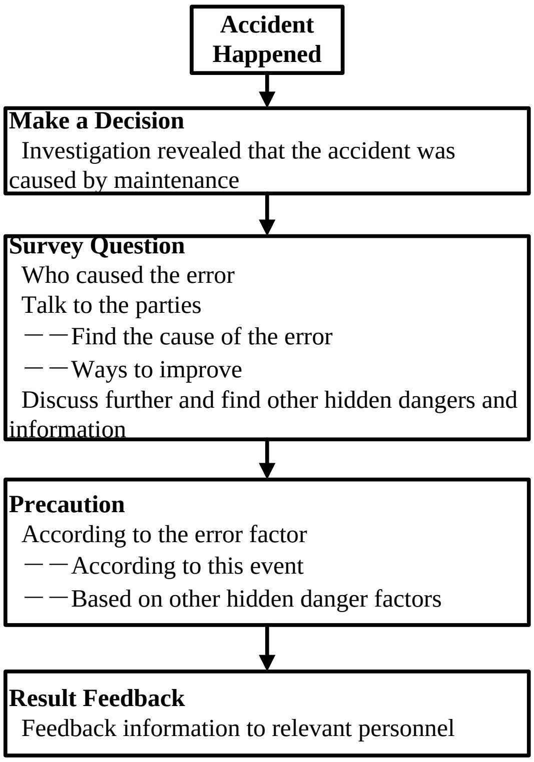

Figure 1: Flow chart of accident investigation

1) The accident occurs: When an accident occurs, the maintenance company has the responsibility to immediately eliminate the fault and make detailed records to lay a solid foundation for future investigations.

2) Make a decision: After troubleshooting and the aircraft is put into use, the maintenance company should immediately make a decision to determine whether the accident is related to maintenance. If the answer is yes, then the responsible company should investigate.

3) Investigation question: Using MEDA's survey thinking, first affirm that the employee's intentions are good, and then have an open and open conversation with the employee who made the mistake, find out the factors that caused the error (except for some items that are extremely accidental and unmanageable), and discuss how to eliminate the factors that cause the error. And add it to the maintenance fault database.

4) Preventive measures: The investigators will find the items that can eliminate the error-causing factors and sort them according to the priority order of the possibility of occurrence, and turn the corresponding strategies into systems to prevent or reduce the recurrence of similar errors.

5) Results feedback: As a key step of MEDA, the investigator must feed back the results to all the maintenance personnel, so that everyone knows which conditions must be paid attention to in the future maintenance work, and the management personnel should ensure that the maintenance of each maintenance personnel Participating seriously and fulfilling the regulations is the key to avoiding mistakes in the future.

3. Statistics of human error in aviation maintenance of civil aviation in the past ten years

According to statistics, there were 481 incidents of human error in civil aviation maintenance in my country from 2006 to 2020[9], as shown in Table 1. Among them, maintenance errors are often not caused by a single cause, but are the result of the interaction and superposition of multiple factors. For statistical convenience, only one main reason is counted here.

Table 1: Statistics on the causes of man-made errors in civil aviation maintenance in my country from 2006 to 2020

reason	violation	personal reason	lack of knowledge and skills	information communication	improper writing of maintenance card and program	planning and monitoring	environment and facilities
quantity	271	138	27	18	12	12	3
percentage	56.34%	28.69%	5.61%	3.74%	2.49%	2.49%	0.62%

Among the causes of human errors in aviation maintenance from 2006 to 2020, violations accounted for nearly 56%, ranking first. According to the statistics of "Civil Aviation Human Factors Training Manual", among the causes of human error in aviation maintenance from 1990 to 2001, violations accounted for 45%, which was also the first. It can be seen that violations are still a chronic problem affecting aviation safety and one of the main causes of human errors in aviation maintenance.

From the perspective of aviation maintenance worldwide, violations are also relatively common. The survey data cited in the Australian Transportation Safety Agency's 2008 Aviation Research and Analysis Report shows that violations are not actually a specialty of China's aviation maintenance industry. The official report said that a survey of the daily work of European aircraft maintenance engineers showed that 34% of engineers admitted that their recent work was done in violation of formal procedures. An investigation of certified maintenance engineers in Australia found that violations or shortcuts accounted for the second place in the reported unsafe maintenance behaviors. More than 30% of them admitted that they had signed the relevant technical documents before the work was completed. Words, more than 90% of people reported that their work was done without suitable tools or equipment. It can be seen that violations of regulations worldwide are also widespread. [10]

4. Conclusion

Maintenance standard procedures are the code of conduct for maintenance work. Maintenance personnel must refer to maintenance manuals and follow work procedures to eliminate empiricism in the maintenance process. This is the most fundamental point in a scientific approach to preventing human error.

If you want to improve the safety of maintenance work, you need to strengthen the quality checks of maintenance work." The theory of the "accident chain" shows that an accident does not necessarily break out when unsafe factors are present, but only when they are present throughout all the links. Strict compliance with all links is the basic way to eliminate human error. The maintenance work should be strictly enforced with a system of re-inspection control such as "self-inspection, re-inspection and special inspection" to realise the "safety precautionary gate forward".

Safety is a science of failure research. We should understand the process, causes and lessons of every unsafe incident in civil aviation, and strive to promote the improvement of systems and measures, the improvement of training methods and the advancement of safety management from the source, so as to achieve the goal of improving safety and making our flights safer.

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