

Management and Control of Aircraft Maintenance Error Based on the Coordination of the Human-machine-environment System

WANG Xiao-hong¹, WANG Duan-min²

¹ Shaanxi Polytechnic Institute, Xianyang 712000, P. R. China;

² College of Management and Safety Engineering, Air Force Engineering University, Xi'an 710051, P. R. China

Abstract: All of the forming of aircraft maintenance error is not because of human error, but the results of the interaction of multiple factors. So the new concept of the aircraft maintenance error is advanced in this paper in order to change the traditional conceptions of people. In the view of the human-machine-environment system, causes of the aircraft maintenance error have been analyzed in depth. And the error mode which is the most lively and prominent is laid special stress in analyzing. In the end the, methods and measures of preventing various modes of the aircraft maintenance error are given in the view of the human-machine-environment system.

Key words: aircraft; maintenance; errors

1 Introduction

It can be read of such statements in papers related to human factors: because about 80% of aviation accident causes are human factors, the education and training of human are the most important. Such expounding is correct outwardly, but contradiction is appeared in deep thinking. The causes of the aircraft maintenance error is the incompatibility of the human-machine-environment system. Of course, people can say the first of all, the appearing of maintenance error means something wrong with human being. And the maintenance error can't be appeared without the error of humans. But it can be stated like this way: The maintenance error can't be appeared in causes the mechanical preventing measures of maintenance errors are extremely excellent. So it can be only said that the cause of the Aircraft maintenance error is a variety of

factors. The correct statement of the aviation accident causes is that about 80% of aviation accidents are related to human factors, so it is important to study the causes of human factors in the view of the human-machine-environment system.

Firstly, men don't make mistakes on purpose. No normal maintenance workers make mistakes on purpose. This simple truth is the starting point and premise of all the abroad human factor theories. On the guiding of this understanding, advanced airline companies and aircraft maintenance companies abroad get the rational knowledge of error after the error from widespread and profound investigation of error. Truly accomplish "acquiring knowledge from errors" and "taking preventive measures".

Internal, emphasis placing on the personality subjective activity enjoyed currency over a long period of time during of insufficient understanding of large-scale socialized production and complexity of modern

aircraft maintenance system. Emphasis is placed on the personality responsibility in accident investigation and the maintenance worker is placed in potential consciousness on the position making mistake intentionally. In dealing with the aircraft maintenance errors, undue stress is lying on the effects of punitive measures measure and lay their hope in punishing one or two persons severely to achieve the goal of “punish one to warn a hundred” and whole safety. The systematic causes of errors are concealed doing like this. Because greater attention of the maintenance worker is paid to their work, the level of safety is improved in a short time. But over a long period of time, the repetition occurring of accident and errors can't be avoided. On the other hand, in the investigation of errors, maintenance workers were prejudiced by first impressions in the defendant's seat. In conducting accident affairs, the guiding ideology of “sacrifice one person to awake the popular” and overcorrecting are bound to causing the effect that the maintenance worker be afraid to undertake maintenance work. And the maintenance workers see performing their duty in a perfunctory manner as principles for survival. Fundamentally this way of doing things harmed the self-confidence, sense of responsibility and the confidence to organization of maintenance workers and were contrary to the principle that the man is the foundation. In order to truly put reducing the maintenance errors into effect, correct understanding must be given to the personality responsibility and the effects to the maintenance worker of institution environment. Clearing up what has been confounded and set things right from the source, and regressed to the paths of science and reason.

Secondly punishments are not necessary measures of reducing and eliminating the maintenance errors.

From above point of view, theories of human factors abroad think universal that punishments are not necessary measures of reducing and eliminating the maintenance errors, and may be have nothing to do with the solving the problem. To prevent the duplicated occurring of the maintenance errors, the best way is to find the focus of the problem. And therefore they do not proposal to punish the maintenance workers. To say comparatively, we pay attention focus to the person who must be punished after the errors and accidents and ignored the true causes of the errors and accidents. In practice, the aids of finding the true cause of the error provide the basis of punishments. Theories and practices of human factors abroad see the true causes and the actual correcting measures of the error as the end of error investigation. But we always see punishment as the end of error investigation. Because too much effort is involved in the distinction of responsibility and weighing various gain and loss, the searching for the true cause of the error is ignored. That is to say, theories and practices of human factors abroad lay stress on drawing inferences about other cases from one instance and clarify matters and get to the bottom of things, but what we do now is confusing cause and effect, and climbing trees to look for fish.

2 The definition of aircraft maintenance error

There are many definitions of aircraft maintenance error, the mostly cited definition is: “the aircraft maintenance error is the deviation between the maintenance operation and the planed destination caused by violating the maintenance object objective requirement of the maintenance workers in their maintenance work, which casing the effects of abnormal of order and condition or the injuries and

deaths of person as well as the damage of equipments”^[2].

This definition of aircraft maintenance error is correct completely, but in tone, man is easily to think that the maintenance error is the man's error, and the man must assume full responsibility. And violating to the maintenance object objective requirement is even more easily to be regarded violating regulations intentionally. Therefore, the measures of management and control of maintenance errors are always concentrated on how to strengthen the education and training of the maintenance workers, and ignored the improvement of preventing design of machinery to maintenance errors, the maintenance environments and the specification of working procedure.

For the above-mentioned reasons, we must first begin with the renewal of sense. It is beneficial to renewing of man's traditional sense to define the maintenance errors correctly. The aircraft maintenance error is “the deviation between the maintenance operation and the planned destination caused by the inharmonious factors of man-machine-environment system in which the activity of maintenance is conducting, which causing the effects of abnormal of order and condition or the injuries and deaths of person as well as the damage of equipments”.

Aircraft maintenance error can never be caused by one single factor but the synthetic interaction of a variety of factors. This conception is just embodied by the concept of inharmonious factors of the human-machine-environment system.

On the other hand, in the area of international civil aviation, the idea of designing fit to humanity is embodied in the airworthiness standards. And the idea is embodied in the above aircraft maintenance error definition: the designer of aircraft is not just designing

a set of aircraft, but a human-machine-environment system. Because the aircraft which the designer designed must be used and maintained, so the man's behavior and the condition of the using and maintaining environments must be taken into account, therefore, the aircraft designer is essentially design a man-machine-environment system, so the error-preventing design must be taken into account. Of course, the error-preventing design has its limit. Every error can't be eliminated by the error-preventing design. The difficulty of realization, reliability and cost must be taken into account synthetically in the weighing of error-preventing design, control of environment condition, improvements of working procedure and the education and training of the persons etc.

3 The management and control of aircraft maintenance errors

3.1 The machinery error-preventing design

Many causes of aircraft maintenance errors can be found in an insufficient design of a system. Follows are the six design principles for the system maintenance^[3].

- 1) Be easy to get to the parts.
- 2) Parts related in function should be divided into one group.
- 3) Parts tag must be clear and distinct, and should provide enough information.
- 4) The special-purpose tool must be used as few as possible.
- 5) Precision adjustments must be avoid out-field.
- 6) The design of equipments must be convenient for failure segregation.

3.2 The design preventing errors of software

The software here refers to the no-physical boundary of the man and the system, the software includes:

rules , regulations , programs , manuals , check sheets and symbols etc. The soft error refers to errors causing by the software problem. Therefore the software problem solved well can improve the working efficiency , ensuring the working quality and therefore reducing or eliminating the presenting of errors ^[4]. In the aircraft maintenance work , measures of preventing software errors are as follows: (1) Establish rational rules and regulations that are easy for the maintenance worker to execute; (2) The maintenance program are detailed in contents and are clear-cut in procedures that are easier for the maintenance worker to understand , remember and operate; (3) Maintenance checking items must be defined avoiding being left out by the maintenance worker; (4) The maintenance work must have strict links of planning , organization , enforcement and checking the maintenance worker's idea of maintaining as their pleases.

3.3 The preventing measures in environments

The environment here refers mainly to the environments of illumination , noise , vibration and temperature etc. The influence of the environment to individuality can be listed approximately in three aspects: health , work quality and the comfortableness of working. Therefore , good working environments can make people working in pleasant , helping the people to improve their working quality and prevent the huge lost caused by the environment error. One effective way of preventing environment errors of aircraft maintenance worker is providing with relatively good working environments , the other is adopting a correct recognition of social environment and improving their adaptation to the social environment.

3.4 The control of tasks

3.4.1 Fatigue

Fatigue can increase the probability of errors to the extent as alcohol. No units embolden a drunken

maintenance worker to bear liability , but many units permit the maintenance worker in fatigue to bear liability , also their dangers are equal. The fatigue management is the most important problem facing every units when the maintenance work outside outlast the schedule time. Rational planing the maintenance work is an effective method to reduce the fatigue danger.

3.4.2 Tasks frequency

Engineers used to describe the fault frequency of equipment in its whole life cycle as "bathtub curve". According to this model , faults may occur in a relatively high frequency at their earlier running-in time , and once their earlier problems have been solved , it will enter upon the period of high reliability. Then , as the end of the equipment's design life-span comes , their fault frequency will increase. The reliability of maintenance is independent to the period of equipment's life-span but is related to the working experience of the maintenance workers. The maintenance error frequency will increase when the maintenance worker are carrying out tasks that are not be carried out frequently , the major reason of which is that the maintenance workers lacking of experience are easily carrying out their tasks under the basic knowledge of wrong tendencies. Therefore , once they get the working experience , the frequencies of maintenance error caused by the wrong basic knowledge will decrease , but the frequencies of maintenance error caused by neglecting will increase. The problem of absence of mind of the experts is more difficult to overcome than the new hand.

When allotting tasks to maintenance workers , where the continuous working experience be persisted in is necessary to be considered in order that the maintenance workers accomplish their tasks.

Both no-routine and routine tasks have their errors, but suitable allot of tasks helps to reduce their error emergence rate. Also they have rarely control rights.

3.5 The education and training of persons

Although it is the systematic reasons causing the maintenance accidents, the maintenance workers them self are the last line of defense. Most of the maintenance workers have rarely control rights of the problems such as working time, equipment, paces of work in the system, but they can reduce the probability of accidents in other aspects. The most important point is that we can change all of our skill, habit, conviction and knowledge. And with the help of these changes, we can improve our effectiveness and reliability.

3.5.1 The comprehensive factors causing errors

The first step that maintenance workers must to do is to master the basic knowledge of human effectiveness. They must realize the limits of the men's short memory, the influence of fatigue to their performance, and other large amounts of the strong and weak points of the human beings. Following are the main factors causing the errors in the maintenance activities.

1) Depend too much on their memories. Man's memories are not as reliable as what they think, especially when they are tired. Blank of memory is the most common error of the maintenance work. A task that is started can't be accomplished if the workers are not reminded of the stage schedule and other measures are not taken. Every time you try hard to store the key work schedule up in your heart, in order that you can work without reminding in the future, you are taking the risks of memory blanking. It is much better to take preventive measures in advance being afraid of forgetting than believe that one remember it.

2) Disturbance. The maintenance activity is always disturbed frequently. Every disturbance, no matter what properties it has, can aggravate your extent of nervousness, and increase the appearing probability of your memory blank. Omission is the most possibly occurred errors. To be aware of what are the risks and take preventive measures in advance is the most important means of avoiding errors. An obvious countermeasure is to think over the problems in advance, which will encounter when we go on with some tasks next time. "where did we do last time?" and afterwards left clearly marks of where the work was stopped last time.

3) Pressures. Even the most careful maintenance worker may be omit some work procedures or looking a shortcut under pressures. So the pressures must be conscious and make sure that these pressures will not initiate adventures and behaviors seeking for convenient ways.

4) Fatigue. Fatigue can increase your errors, and it can especially increase the occurrence of memory blanking. Peoples are easy to be angry and more difficult to get along with when they are tired.

5) Lack of cooperation with the maintenance workers. Lack of cooperation is a most common case causing accidents.

6) Not familiar with the work. If what you are carrying out are not your routine duties, there are risks of making errors even though you have done the work in last few years.

7) Responsibilities are not clear. If you are not sure of the tasks progressing, it is a signal that you must stop and gather up the threads. This is very common in team coordination, because the decentralized responsibilities make the people suppose that others know the tasks progressing and taking the

responsibilities.

8) Highly routine programs. There exist risks of causing faulty errors in the working procedures that can be accomplished with the eye closed like opening and closing the entrance cove, checking the quantity of oil etc. Being much familiar with the tasks, our attentions may probably be diverted. And we are accomplishing our tasks subconsciously to a great extent. Also these cases can't be prevented, we can keep a clear head and discover those frequented errors.

3.5.2 To understand the reasons of rational programs' breaching

Breakings of rules are not the same as faults. Most of the breakings of rules are belong to intentional behaviors. For example some people decide to break the safety operating programs, operating regulations and approved standards etc. Because of this intentionality, breakings of rules assume large responsibilities of management problems of individual and teams. It is a very slow process for changing the deep attitude and sense, but can be accomplished yet. Three factors interrelated each other consists the intentions of the rules breakings:

- 1) The attitude of behavior (thinking that I can). This is the opinion of considering the effects of a rule breaking behavior. One knows that to do like is breakings of rules, but the good of doing like this is compensated for the probably risks and punishments.
- 2) The subjective standard (they don't want me do this work). All of these are the viewpoints about your behaviors holding by the reference groups (relatives, colleagues, friends etc.). Are they likely to agree? How much he hopes being appreciated and respected by his intimate persons.
- 3) The control force of perception to behavior (I can

not control myself). How much of one's perception of the control force to the rule breaking behavior? This factor is perhaps much more important to the fatalist especially in the judgments of the effects of breaking rules. Although the management tier claimed orally that the worker must obey the rules, but actually they did not take any actions against the behavior of breaking rules, especially when an urgent tasks can be finished in time by breaking rules. In case an individual finds the fact, one will percept that the factors of control force to behavior will be taking effects. If the tendency in the unit is never reward law-abiders nor punish rule breakers, the individual will feel that his control force to situations is very small. And the best way to harmonize with them is to do as the others do, you and I do so.

3.5.3 The methods of reducing the rule breakings

The most common method of reducing the rule breakings is aiming the first of above three factors—the attitude of behavior. Those plane playbills and videotapes spreading unsafe behavior bring about terrible consequences, and can be used to advise peoples to play the game.

These terroristic ways of propagating method have three functions. The first is to tell peoples the relation between the unsafe behavior and the safety. The second is the function of fright. The third is to point out the correct ways of doing things.

But the influence of these self-appeals is much limited. The main problem lies in those persons is most possibly to break rules—those young people—who have the immunity to these appeals because of unrealistic optimistic attitude.

The social controls have the second factor in mind: the subjective standards, the affective extent to individuals of the others' manifestation, including

agreeing or opposing with the rule breaking behavior.

So far, evidences indicate that social control is the most effective means of changing the individual behaviors. We are high-animals in the social needing the agreements, likeness and respects of the persons we are cared about. If we are sure that these important others will strongly oppose what we shall do, we will consider over and over before we act. This did not represent that we will not break rules for ever, but at least we have a breathing spell.

Many management methods of great influence that are easy for social control touched upon group discussion and group activities. Following is a method used by a Swedish company to improve its driver's behavior. This method has produced a marked effect.

3.5.4 Psychological preview

Large amounts of evidence indicated that to prepare previously before a task is truly started can greatly improve the quality and reliability of man's effectiveness. This evidence comes from the nearly researches of psychology and behavior on Olympics sportsman and top surgery doctors. Both two researches indicated that it is much more helpful to their later behaviors to imagine in advance seriously accomplishing the task. This is called psychological preview by psychologist. The ability to obtain and practice this psychological skill is the difference between the outcomes and the ordinary.

In the following paragraphs, we will first describe the properties of this psychological previewing activity, and then interpret how it improves the attention degree of concentration.

1) To imagine actively. Master-hands will think the tasks before it is truly started, and imagine the process before the things truly happened. For example, surgery doctors will transform the two-

dimensional documentary photograph to the three-dimensional real image in their brain. They preview in heart each step of the program so that they can operate more easily. This imaging is regarded positive because it concentrates one's attention on imaging the ideal effect of each step.

2) Be prepared for facing difficulties. The other important function of the psychological preview is forecasting the problems arising and prepared effective countermeasures. Master-hands clear constantly the importance of one step ahead. The following paragraph is quoted from a top surgery doctor, his words tell the quintessence of doing like this.

I preview the programs of the surgical operation in my brain, and I practice it the next day. The process is very real, also going on step by step, seeing myself performing an operation, going on with various procedures, in which you must think over what problems you will meet, how to resolve them. It is impossible that you always think of all of the problems, but you must be prepared when the problems appears.

3) Be prepared in mind. You are required to be prepared in mind to do well. For example, surgery doctors will be helped with the assistant research equipments such as books and models. They will plan their procedures of the program on their own, and also will consult and hold group consultations with their colleagues.

4) Control to attention distracting. Disturbance and attention distracting are often met in the course of maintenance. Nearly psychology researches indicate that the best way of avoiding disturbance and attention distracting is predict the happening of disturbance and attention distracting and overcome them one by one.

5) Avoid the forgetting error of progress procedures.

In the maintenance work , especially in the work that needed to be operated in task's procedure order , it is possible to be confused or forgot which step we worked to , some important procedures may be forgot when the works are resumed after interrupting.

We are guided by three things: written program (work card and manuals) . The actual conditions faced the psychology mood of the following events. This psychology mood consists of the images about the tasks and our knowledge structure in our long memory. This psychology mood is needed although it is imperfect and inaccurate , because we cannot read the program while we are operating.

The benefit of the psychological preview mainly lies in the improvements of the psychology mood quality stimulating it to produce correct ways (working procedures) .

4 Conclusions

All of the aircraft maintenance error is not because of human error , but the incompatibility of the human-machine-environment system in which the activity of maintenance is conducting. In order to reduce the rate of aircraft maintenance error to the lowest limit , and prevent the occurrence of the aircraft maintenance error , and ensure the flying safety , we must analyze the reasons of error conscientiously and carefully in the view of the human-machine-environment system

and take directed measures.

References

- [1] Wang D M. Management and controlling of aircraft maintenance error [M]. Beijing: National Defense Industry Publishing House ,2013 (in Chinese)
- [2] Wang D M. Quality and safety management of aircraft maintenance [M]. Beijing: National Defense Industry Publishing House , 2008: 135-135 (in Chinese)
- [3] Reason J , Hobbs A. Managing maintenance error [M]. Xu J X , translate. Beijing: Chinese Aviation Publishing House ,2007 (in Chinese)
- [4] Wang H , He C Q. Essentials of USA promoting equipment information [J]. The Air Force Equipment , 2004 (11) : 42-43 (in Chinese)

Brief Biographies

WANG Xiao-hong is a master degree and a lecture in Shaanxi Polytechnic Institute. His research interests include equipment maintenance and fine mechanic. 735900481@qq.com

Wang Duan-min is now a Ph.D and a professor in the College of Management and Safety Engineering , Air Force Engineering University. His research interests include equipment management and Safety Engineering. kgwdm@126.com