

# Research on Maintenance and Management Optimization of Electromechanical Facilities in Highway Tunnel

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**Abstract:** The implementation of maintenance and management of electromechanical facilities can ensure the operation quality of equipment, prolong the service life of equipment, and meanwhile effectively reduce the probability of accidents and risk loss. The targeted optimization methods are formulated to make the maintenance and management of electromechanical facilities of highway tunnel develop in a systematic, scientific and refined direction.

**Keywords:** Highway, Electromechanical Facilities, Maintenance and Management Optimization.

## 1. The Importance of Maintenance and Management Optimization

A lot of accidents happened in highway tunnels are caused by problems of electromechanical facilities, such as system function missing of ventilation facilities, environmental detection equipment, fire control and rescue facilities, or deficiency of illuminance in tunnel. Even the leakage of electricity of electric accessory can cause a severe accident. Considering the professionalism and subjectivity of the detection technology in maintenance company, such problems are hard to be figured out immediately. And these problems can be solved out by the maintenance and management optimization combined with specific maintenance plan of each tunnel, after which the electromechanical facilities in highway tunnel keep healthy and the loss of casualties and properties can be reduced.

## 2. Deficiency of Maintenance Work in Highway Tunnel

After checking the reason of accidents in highway tunnel, we investigate the systematic problems of 5 main aspects of electromechanical facilities in highway tunnel, such as environmental detection equipment, illuminance equipment and fire control facilities.

### 1) Environmental detection equipment

The ordinary problems of environmental detection equipment can be summarized as aging and efficacy loss of communication module and components. Besides, most of the environmental detection equipment have an accuracy deviation problem, which is as common as other ones mentioned above. And the chief causes are unreliable PE lines, dirt, unpunctual standardization, etc.

### 2) Low-voltage distribution facilities

Low-voltage distribution facilities are formed by several low-voltage switches and auxiliary components, such as measuring, controlling, protecting and signaling. The common problems of low-voltage distribution facilities are unable to close and trip fault of circuit breaker, abnormal changes of the value of capacitor, abnormal sound of

contactor, wrong action of air switches in fan soft starter and so on.

### 3) Fire control and rescue facilities

The main facilities of fire control and rescue are fire controllers, fire detectors, manual fire alarm buttons, etc. And the major faults are made of manual alarm buttons hitch, communication hitch, abnormal alarming and short circuit of wires.

### 4) Illuminance facilities

Circuit fault and the deficiency of illuminance are the major problems of illuminance facilities. Besides, short circuit, broken circuit and leakage of electricity are the troubles for the illuminating circuit.

### 5) Other potential risks

Other kinds of potential risks in tunnel are included as listed below:

1. Distribution box not plugging, breakdown of outside the distribution box, ponding and dirt of inside the distribution box lead to the short circuit, broken circuit and breakdown of facilities. Rustiness and damage of outside the box, which dissatisfy protection standards can have a great effect on the whole electromechanical system.

2. Rusted connection piece and fastening piece in jet fans, severe vibration of fans, overtop temperature ascending, too big of the current, insufficient of wind pressure, high possibility of fans dropping, unable to discharge harmful gases are the main risks of jet fans.

3. The grounding resistance—from the joint grounding of tunnel and substation to the grounding of facilities outside the tunnel, which exists in all scenarios of electromechanical facilities in highway tunnels, is one of the most important part of electromechanical system in highway tunnel. Excessive resistance value of some grounding resistances, which is found in daily maintenance work, is very likely to cause the potential safety hazard. And it leads to incapable of protecting the facilities.

Since we have not found any significant safety accident in highway tunnel in China, we can get the analysis and conclusion that the maintenance work needs to be strengthened of the existed troubles in environmental detection facilities, low-voltage distribution facilities, fire control and rescue facilities, illuminance facilities, etc. And

the optimization of management pattern and elimination of faults and problems are the important prerequisite to make sure that the facilities run healthy.

### 3. Optimization Methods

After analyzing and summarizing, the electromechanical facilities in highway tunnel have 5 main characteristics:

1) Since the facilities cover a relatively broad, the variety of electromechanical facilities in highway tunnels makes the management and maintenance work of facilities difficult if we need to keep the electromechanical facilities run safely.

2) The cost of equipment running is really high, which leads to a large number of human and financial resources of daily management and maintenance work of electromechanical facilities in highway tunnel.

3) It takes enormous requirements on the installation and operation of equipment.

4) The constitution of the electromechanical facilities system in highway tunnels is very complex.

5) The technical requirements of electromechanical facilities system in highway tunnels are really high comparing to that in ordinary tunnels.

Being direct against the problems and characteristics in the maintenance work in highway tunnels, we can improve the level of management and maintenance by optimizing the management and maintenance, changing the traditional methods, assembling excellent resources and implementing dynamic follow-up management. And we can deploy effective preventing methods by regular and high frequency of detection results of professional testing agency, combining with the principle of prevention first. Implementing the maintenance work of electromechanical facilities in highway tunnels can make sure that the operational quality of equipment is good and it can lengthen the life of the equipment. At the same time, the probability of safety accidents happening can be reduced effectively and the risk loss decreases. Therefore, we can optimize the management and maintenance and customize the maintenance project, which makes the management and maintenance work of electromechanical facilities in highway tunnels more intelligent, scientific and precise. The major methods include as listed below:

1) Follow the 3-detection rule

Firstly, 3-detection rule means there are three ways of detection: the self-detection, mutual detection and specialized detection. And these rules involve highway operation management units, detection units and maintenance units, which get in touch with each other by multi-media. Only in this way, the hitches and problems can be settled immediately. Then, these units report the rectification results in time to avoid severe accidents happening. It takes responsibility from staff to the leaders, which will optimize the maintenance work from the management system and organizational structure.

2) Strengthen the professionalism of maintenance team

Secondly, the maintenance team should strengthen the professionalism and follow the 3-detection rule. To achieve this goal, management is the first key point, which requires regularly file updating and internal standards of companies establishing. Meanwhile, the second key point is organization, which focus on the personnel selection. Staff who is in charge of management or technology requires both rich work experience and relative practicing qualification certificate. The third key point is technology, which means that we can learn from the excellent detection companies and keep in

touch with them. Besides, the implementation of the 3-detection rule can be strengthened.

3) Record the operating status of facilities and strengthen daily management

The work of recording the operating status of facilities can be done by the technology of information input of QR code. Specifically, the regular daily maintenance and examination work should combine with professional maintenance work. And we can customize the maintenance project through searching the usage record of equipment. As for the old, faulty or major facilities, we can increase the frequency of maintenance and examination. While the frequency of routing inspection of new and good running status facilities can be decreased appropriately. Last but not least, the human resources and material resources can be deployed, and that the problems will be solved quickly and efficiently by implementing differentiation management of maintenance inventory and developing maintenance work purposefully.

4) Fulfill the record of facilities running and push the policy of scientific maintenance

The policy and distribution of scientific maintenance can be driven through completing basic database adopted in daily maintenance work. Then, the construction of data analysis mechanism contributes to the operation and management. Next, the parameters such as life lengths, economic benefits, performance and safety can be estimated using mathematical modeling and statistics. And it takes two policies and three steps to achieve this goal.

Two policies: The first policy means facilities operating status can be analyzed through actual detecting data; second policy is to do quantitative analysis of entire operation condition by using data analysis with statistics and mathematical modeling. For example, if the facilities operating status will be indicated quantitatively, then,  $P$  is the value of assessment results, which stands for a better condition with a higher score of  $P$  value. Meanwhile,  $P$  value will be influenced by various factors like life length, cost, security and detection, which can be marked as  $a$ ,  $b$ ,  $c$  and  $d$ . Different factors have its own weight to the final score of  $P$  value, which can be coded as  $\alpha$ ,  $\beta$ ,  $\gamma$  and  $\delta$ . So, the mathematical model can be represented as:  $P = a \times \alpha + b \times \beta + c \times \gamma + d \times \delta$ , in which the values of weight are decided by highway operation companies. And the specialty of technical personnel in maintenance companies, quality of staff, infrastructure and the leadership of administrator will be the major factor to the weight.

Three steps: The first step is to rank the maintenance object according to importance of equipment operation, significance of economy and security; second step is to analyze and examine whether the existed control plan of equipment operation is scientific and reasonable; and the third step is to provide the optimal solution using the conclusion and results given in two policies.

### 4. Summary

The safety operation of highway tunnels is the most important insurance which protect the lives and properties of people. While it's a tough problem of predicting potential risks and completing maintenance management work for the companies, to whom it is also the social responsibility. To solve this problem, it needs companies to learn from each other and accumulate step by step. Only in this way, the optimal maintenance project can be carried out successfully.

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