

2014

# BioTechnology

*An Indian Journal*

FULL PAPER

BTAIJ, 10(22), 2014 [13655-13660]

## Research on the methods of the reliability test of electrical automation control equipment based on its developing status in China

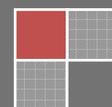
Yuhong Li<sup>1</sup>, Gang Li<sup>2</sup><sup>1</sup>Academic Administration, Luohe Medical College, LuoHe, 462002, (CHINA)<sup>2</sup>School of Computer Science and Information Engineering, Anyang Institute of Technology, Anyang, 455000, (CHINA)

### ABSTRACT

The modern electrical control equipment has been rapidly developing, showing tendency into the direction of modular, intelligent and systematic. Electric automation equipment has been comprehensively applied into various industrial fields, and the reliability of electrical automatic control equipment has gradually become the focus of attention, leading to the great efforts on testing the reliability. China also has made detailed specifications for the electrical automation control equipment to provide more comprehensive evaluation content for its production process. Starting from the current situation of the development of the electrical automation control equipment, this paper analyzes the research significance and the research direction and elaborates the factors that may have adverse effects on the reliability. Then the current common reliability testing methods are expatiated, and three testing methods are put forward and comprehensively analyzed to verify whether they can test the hidden danger and stability of electrical automation control equipment. Finally, the paper make an in-depth study of the measures to improve the reliability test to better eliminate the hidden danger and it is hoped that the research of this paper can provide a better theoretical basis and support for the engineering and technical personnel in the later process of practical application. And these testing methods are also being constantly analyzed and improved to promote the overall development of Chinese electrical automation control equipment.

### KEYWORDS

Electric automation; Control equipment; Reliability test; Production process.



## INTRODUCTION

The reliability of electrical automation equipment is the basis of the operation of the entire system, thus ensuring the reliability of the equipment is of extraordinary significance. In other words, the reliability testing methods greatly influence the quality of the equipment and the cost level of repairing products<sup>[1]</sup>. To ensure the reliability of electrical automation control equipment, can effectively improve the competitiveness of products in the market, especially in the current competitive market environment where the customers demands higher for the quality. Besides, it can reduce safety accidents in production process, and increase the cycle of safety operation. Generally speaking, factors affecting the reliability of the equipment addition to the design parameters of the equipment itself include air pressure, humidity, temperature and other natural environment influences. Therefore while in designing the electronic automatic control equipment, it should prevent the phenomena that the parameters being beyond the normal range caused by the environmental factors, leading the device structure out of control<sup>[2]</sup>. This paper, in addition to expounding the present status of the reliability test and its methods, makes an overall analysis of the reliability test, and puts forward some guarantee measures and methods with discussion about them.

### BRIEF INTRODUCTION OF RELIABILITY TEST

#### Definition

The basic definition of reliability test is the ability to complete the prescribed function in the prescribed conditions and time. The prescribed conditions mainly include voltage, using method and maintenance method, load, temperature and humidity, vibration, shock, magnetic field etc.; The prescribed time refers to the life cycle of the products (such as life 5-year life of mobile phone); the prescribed function mainly refers to the various technical performances in the product technical standards. Reliability test of the device started in the 50's of last century, mainly used in the weapons and equipment, aerospace equipment, missile systems, and other aspects of military electronic equipment. It is until the last century 60's that the reliability test is gradually used in civilian equipment, and its main role is to improve the reliability of products, ensure the quality and safety of the product, enhance the brand image and product competitiveness. From the 80's of last century, reliability test of the equipment has developed into the mature phase and come into a higher and wider level.

China started the research on reliability of electrical automation control equipment from 70's of last century, and established network for exchanging related information and issued *The Expected Reliability of Electronic Equipment Handbook* and other related documents to provide references for the reliability study<sup>[4]</sup>. The necessities of the reliability test are as follows:

- (1) Test whether the control equipment design is reasonable, and has hidden dangers;
- (2) Test whether it has ban parts;
- (3) Test whether it will produce variation;
- (4) Test the integrity of the control equipment;
- (5) Test the overall quality level of the control equipment;
- (6) Test whether there is adverse technology and processing equipment.

Since the 21<sup>st</sup> century, electric automation control equipment has been completely fused with the development of science and technology, showing the tendency of modular, intelligent, systematic development. It also makes higher demand to the electric automation control equipment reliability tests, mainly in the aspects of more demanding environment, longer time period, more complex electronic products system, stricter equipment structure, and higher customer requirements in testing the prescribed functions of the equipment. Only better implement its prescribed function can more reliable electrical automation control equipment be obtained. And in the actual production environment there are many external factors influencing the equipment control and maintenance, and these fault factors are extremely random, which can be described generally only through the probability. Taking a full range of reliability test for the device can timely discover the hidden danger and the unstable factors, which can take timely remedy, to improve the overall operation quality of the equipment<sup>[3]</sup>. Figure 1 shows the classification of common reliability tests:

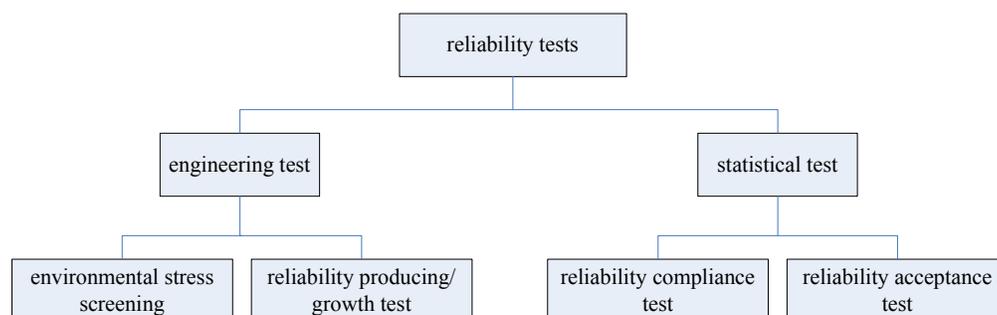


Figure 1 : The classification of common reliability tests

Overall speaking, focuses of the purposes of taking reliability tests are different according to the stages of the products namely: the research and development stage, the pilot run stage, and production stage. The purpose at the research and development stage is to confirm whether the raw material, structure, process and environmental adaptability can meet the requirements, so as to make overall improvement. And obtain the best product reliability through repeated tests; At pilot run stage, test the products according to the technical conditions and test the reliability of products from a comprehensive evaluation rules; at production stage, the purpose is mainly to monitor the stability of product quality. Take a series of tests to verify the possible failure mode, failure mechanism of the product, so that the design scheme and production process can be changed timely.

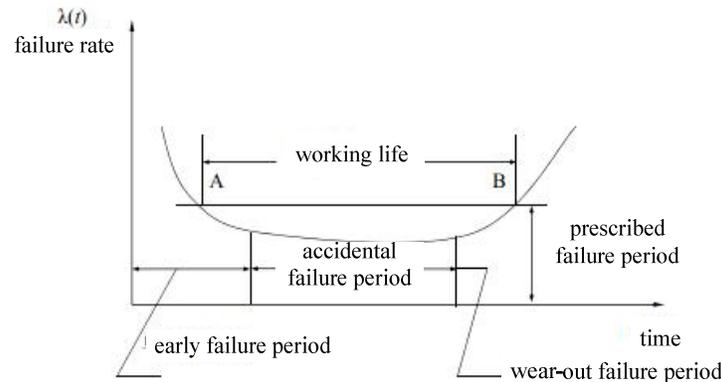
**Analysis of the status of the reliability test**

The reliability of electrical automation control equipment is confined to various complicated working environment and many external influencing factors, so the current reliability test still have many shortcomings. Reliability is one of the most important standards to measure the quality of equipment, and the higher reliability of products can greatly reduce the probability of product failures, and improve the competitiveness of the equipment in the market. The function of the reliability of electrical automation control equipment mainly manifests in following several aspects<sup>[5]</sup>:

(1) An effective guarantee of increasing the market share. The current status of the economic development does not only focus on product performance, but pays more attention to the reliability of the product. Survey data shows that continually developing new products and improving the reliability of the product are the basis of surviving in the competitive market environment.

(2) Effectively improve the overall quality level of the products. The product value is achieved through the quality of the product. And the reliability occupies a lot in the quality of the product. Higher reliability means the lower rate of fault which will greatly reduce the repairing costs and improve the safety performance of the product.

Different industries have completely different production working environments, so that the electrical automation control equipment is always in a variety of working environments, even many of which are extremely harsh environments. And the harsh environments will make great loss of electronic automatic control equipment, as well as cause various unpredictable equipment failures<sup>[6]</sup>. The reliability test can well find the existence of possible failure mode of products. Figure 2 and TABLE 1 are respectively the description of the common failure curve and its analysis.



**Figure 2 : Typical failure curve (bathtub curve)**

**TABLE 1 : Analysis of the failure curve**

Curve segment	Failure period	Failure characteristic	Failure type
The first segment	Early failure	Failure rate decreases with time	Decrescendo
The second segment	Accidental failure	Failure rate is low and stable	Constant type
The third segment	Wear-out failure	Failure rate increases with time	Crescendo

**METHODS AND MEASUREMENTS OF RELIABILITY TEST**

**Common testing methods**

Ensuring testing method: commonly known as the "running the equipment"<sup>[7]</sup>, its main working content is to take a series of fault testing of equipment before they leave the factory, so as to ensure the normal operation of the equipment after entering the market. But the disadvantage is that the testing time and costs are rather huge, so in order to reduce this defect, the sampling method is commonly used (TABLE 2 is a common sampling standard). In addition to reducing the time and cost, sampling method also can increase the testing contents and testing accuracy greatly. This method is generally used in reliability test of small scale products.

TABLE 2 : Sampling standard

Lot size	Optimum number of the prototypes	Maximum number of prototype
1-3	total number	total number
4-16	3	9
17-52	5	15
53-96	8	19
96-200	13	21
more than 200	20	22

Mechanical strength test: continuously change static dynamic load conditions, so as to test the structural strength and reliability of the equipment. It can also verify whether the shell, internal and external architecture of the equipment has good resistance of anti-external forces.

The laboratory test<sup>[8]</sup>: usually simulate the realistic running environment in the laboratory to test the electrical automation control equipment. The important significance of laboratory test is as follows: (1) effectively evaluate the overall quality of the product; (2) provide reasonable reference for later testing. The advantage of laboratory testing method is that the test results are reasonable and persuasive, and the disadvantage is that it needs to simulate real life environment, costing too much but often still existing certain differences.

Field test: it has many different points with the above two testing methods. It tests the electrical automation control equipment in the field, and has the following three kinds of specific operation methods: offline testing method, machine-stopping testing method and online testing method. Offline testing method completes the whole reliability test of the equipment through the special testing device; machine-stopping testing method is to complete the test when the device stops; online testing method takes real-time monitoring of the equipment operation, and makes the analysis after obtaining the most accurate testing data. Overall, the former two methods are relatively easy to operate, while the third one is more suitable for large-scale complex systems.

The life accelerating test: set a certain testing environment, and accelerate the working life of the equipment, so as to judge whether it meets the requirements of equipment reliability. Its significance is to greatly saving experimental reagent, and provides full experimental information. The experiment of acceleration testing is shown in Figure 3:

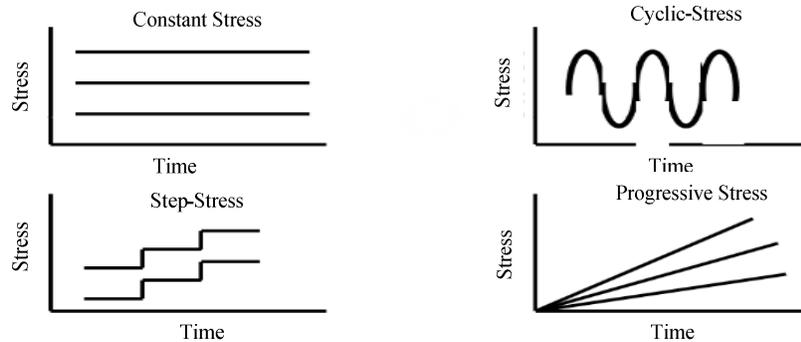


Figure 3 : Types of the life accelerating testing

**Determination of the conditions and analysis of vertical steering of the reliability test**

Taking reliability test needs to determine the following aspects: environment, places, products, operating procedures, etc<sup>[9]</sup> as shown in Figure 4:

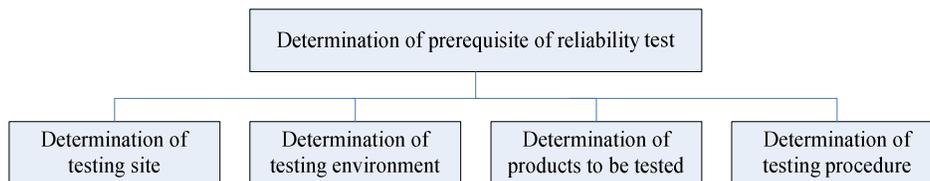


Figure 4 : Determination of the conditions of the reliability test

(1) Determination of the testing site. The site should enables the reliability test of electric automation control equipment being carried out under normal condition; it should also be able to enable the test in the relatively harsh

environment, which can better test the reliability of the equipment. When the testing site is closer or similar to the real use environment, the obtained experimental data will be more accurate and reliable.

(2) Determination of the testing environment: Because different equipments need different testing environments, harsh testing environment will be more helpful in getting more objective and overall data in terms of testing the reliability of the equipment.

(3) Determination of testing products: The scope of application of electric automation control equipment is very broad, so it can be generally divided into large equipment and small equipment, also can be divided into intermittent operation equipment and continuous operation equipment.

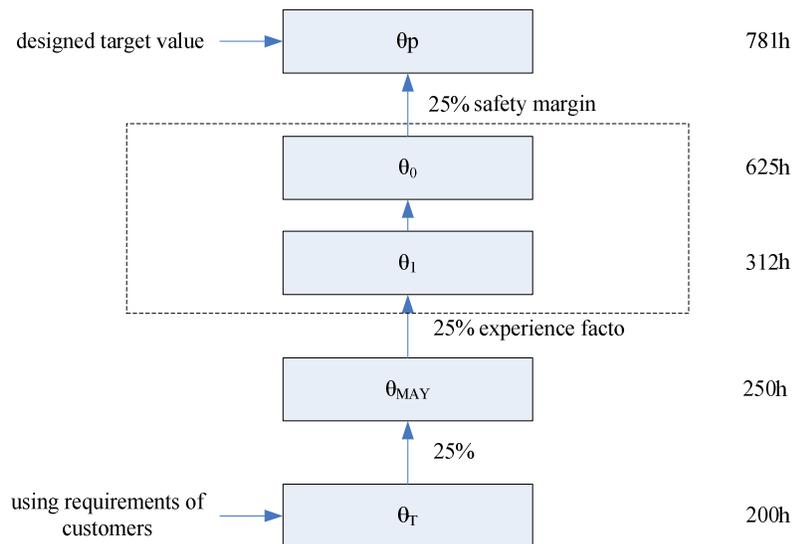
(4) Testing steps: The start and end time of the test, data that need to be collected, reasonable assurance abnormal event handling method and other specification needs to be clarified. Only with scientific and efficient arrangements and plan can response to the problems in each link of the test. At the same time, omissions or leakage test will not happen, guaranteeing the steady running of the test.

Through the analysis, it can be seen that the quality of the components used in electric automation control equipment is the key factor that influencing the reliability of the equipment. Using poor-quality components will directly lead to the shortening of the working life of the equipment; Improper operation, vibration of equipment, centrifugal acceleration will also reduce or even fail the quality of the components; in addition, ambient pressure, temperature and humidity, pollution and other environmental factors can also greatly reduce the equipment performance, and damage structural until the equipment loses its function. Especially, in China which covers broad areas from south to north, from the arctic to tropical, from the plateau to the plain, equipments will suffer the damage brought from sand and dust, and high and low temperature and altitude; electromagnetic radiation produced by the equipment when it is running will also affect the precision control instrument of the equipment<sup>[10]</sup>.

Therefore, to improve the reliability of the equipment needs to fully consider the characteristics of their equipment, and a scientific and reasonable testing scheme is needed to ensure that the data is valid. Generally the testing scheme has the following several aspects:

(1) Use the components with unified specifications as far as possible in designing and production, and the chosen equipment suppliers are required to provide high quality materials. In addition, in the design how to simplify the assembly should be fully considered to reduce installation risk because the high precision. And the designers should be very familiar with the technical standards of the possibly used components so as to be able to calculate the reliability of the product.

(2) In addition to meeting the requirements of basic equipment operation, the quality of the components must leave much room to resist the influences of other external factors. Compare the variety, type, manufacturer when choosing and buying components. Figure 5 is the reference of the basic requirements of customer on MTBF:



**Figure 5 : The requirements of the design of reliability growth**

(3) Take a full consideration of the cooling equipment and protection work in harsh climate. Prevent the damage, brought by temperature and humidity, and polluted gas, on the components from the source. Prescribe the content and period of maintenance to ensure the equipment being in normal operation condition.

Through the above analysis, it can be seen that in testing the reliability of the electrical automation control equipment, a comprehensive analysis of each step is needed and the whole process is an extremely rigorous pilot project. The test requires the whole staff to cooperate with highly uniform behavior and consciousness. Only in this way, can the final test results meet the actual needs.

## CONCLUSIONS

The electrical automation control equipment has been deeply integrated into industrial field and people's daily life, so more attention should be paid to the research on the reliability test. But blindly test should not appear, and scientific testing method is needed. The test should be carried out according to the designed requirements of the product and the actual conditions of the using environment, and then according to the experiments, find the feasible measures to improve the reliability and stability of electronic control automatic control equipment. However, it should not to blindly insist on the best stability, and the applicability of the product should be paid attention to from the customer's point of view. Through the comprehensive analysis and discussion of current developing situation of electrical automation control equipment in China, formulate a reasonable practical and effective testing method. The reliability test of the equipment can fully draw lessons from the national standard and industry standard. What's more, conducting market research aiming for the needs of different customers is the best test.

## ACKNOWLEDGEMENT

(1) Funded by the Natural Science Foundation Research Project of The Science and Technology Department of Henan Province (No. 142300410286) Research on Intelligent Management System of Coal Mine Blasting Equipment Depot.

(2) Health and Family planning Committee of Henan Province, The reform and research project of the medical teaching and education of Henan Province (No. WJLX2014081)

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