Research on Development and Design of Maintenance Control System Based on Five -Prevention

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Abstract. During the operation of the substation, the operation and maintenance personnel in the station need to perform electrical switching operations. In the event of accident, it will often result in personal injury or death, equipment damage or power outages, and even major accidents such as grid collapse, directly affecting the company's social image and economic benefits. The generation and development of the microcomputer "five-prevention" system is to reduce the probability of accidents caused by misoperations, and even to avoid misoperation. It has three main advantages, including a high degree of intelligence, complete functions, and simple operation. Its operation steps have very strict requirements, due to the natural environment, human error, the failure of the anti- misoperations device itself, the "five-prevention" system to go empty, and other factors, causing the five-prevention system to malfunction. In view of the above problems, this program studies the problem of overhaul prevention in this mode, and provides targeted solutions to improve the locking and control functions of substation maintenance operations, increase the safety control of the operating electrical secondary equipment, the safety control of the isolation equipment, the safety control of the maintenance equipment, and the equipment status information comparison, etc. In combination with the business process and system application of the maintenance work, the original anti-misoperation safety control system will become a standardized, informational, Platform-based maintenance control system throughout the whole process of the maintenance work.

Keywords: Five-prevention system; Maintenance operation control; Microcomputer "five-prevention" system; Reliability analysis; Evaluation parameters

1. Introduction

In accordance with the requirements of the “three sets of five” of the State Grid for “major overhaul”, with the promotion of “professional maintenance” and “operation and maintenance integration”, the work organization model of substation, the operation of substation equipment and the work of substation maintenance, a two-way fusion will take place. At present, there is a lack of technical means for compulsory management and control of substation maintenance operations, such as: manager the operation authority of the same equipment by different personnel; different maintenance work teams control the same isolation surface equipment; technical guarantee measures for switching operation,
safety measures arrangement and maintenance operations are not perfect, there are many hidden dangers; in the above various situations, there are problems such as entering into charged interval, incorrect power transmission, and wrong electric drive. Therefore, it is imperative to explore scientific maintenance anti-misoperation mode, reduce accident, and ensure the safety and stability of power grid operation. According to the requirements of the five defense rules, the substation has also launched a variety of anti-accident operating systems. There are mainly mechanical lockout, electromagnetic lockout, program lockout, electrical lockout system, and microcomputer "five-prevention" locking system. At present, the most mature is the microcomputer "five-prevention" locking system. The application of this system can greatly reduce the electrical accident of the staff, effectively reduce the accident rate, and improve the safe operation of the power grid. At present, China's "Electricity Safety Work Regulations" also stipulates: "In order to prevent misoperation, high-voltage electrical equipment is equipped with a locking device that prevents accident." The microcomputer "five-prevention" locking system has become an effective means to prevent personnel from misoperation, to ensure the safe operation of the substation and to ensure electrical equipment and personal safety [1-2].

2. There are problems with the current five-prevention maintenance system

2.1. Maintenance ticket issue
In the integrated mode of full remote control and transportation maintenance, the equipment is remotely executed from the running to cold standby at the dispatching end, and the cold standby equipment is maintained at the station end by the computer key unlocking operation. Because the maintenance ticket needs to be opened under the condition that the equipment meets the maintenance conditions (that is, there is reliable grounding on both sides of the maintenance equipment), the maintenance ticket can only be sent to the site by the maintenance personnel. After the equipment is turned into the maintenance state, it is opened at the station [3].

2.2. The operation authority manager problem of the maintenance isolation surface equipment
During the maintence, the operation right of the electrical equipment for the maintenance isolation surface is still in the hands of the operating personnel. If the maintenance work is not completed, or the maintenance personnel have not left the site, or the operation personnel mishandled, there will be the risk of the maintenance equipment being charged, resulting in damage to the maintenance equipment or maintenance personnel. In condition of multi-team, multi-access cross-operation, the risk is more difficult to control.

2.3. Maintenance equipment drive
During the equipment maintenance, the maintenance equipment needs to be driven. At this time, the locks on the maintenance equipment are unlocked by the following two methods: after the equipment is manually set by the anti-misoperation system, the simulation generates the operation sequence and transmits the computer key operation; Use the master key to unlock. In the manual setting or unlocking operation, there are accidents such as accidentally entering other charging intervals, causing malicious accident, causing personal injury and death, affecting the safety of the equipment and the power grid operation [4].

2.4. Blocking control of secondary equipment

2.4.1. Air switch blocking isolation. During the maintenance operation, the secondary equipment is usually listed for operation. For example, after some air switch exits, the operator hangs a warning sign of “no closing, some people working” to prevent someone from mistakenly opening. However, the listing is easy to fall off and lost, and there is a risk of closing the air switch, which leads to a vicious accident.
2.4.2. Strap blocking isolation. The hard strap isolation blocking adopts the indirect blocking mode. Because the state acquisition (strap collecting device) is realized, the sound and light alarms and the state recovery are reminded when the state is illegally changed. Since the soft strap is not physically visible, and the soft strap state cannot be collected on the anti-accident control system, the state monitoring and blocking of the soft strap needs to be realized by communicating with the monitoring system.

2.5. Equipment status check problem after maintenance
During the maintenance operation, the maintenance equipment may be subjected to the pull-in test. If the equipment is not repaired (tested) and returned to the previous position, the equipment status may be inconsistent with the work permit status, resulting in an accident [5].

3. Based on the above problems, establish maintenance management and control system

3.1. System composition

3.2. System functions

3.2.1. Software Module Features. The safety control system integrated maintenance anti-misoperation software includes the isolation management module, the maintenance anti-misoperation module, the temporary locking management module of the equipment, and the maintenance equipment status comparison module. The modules have the following functions: First, the blocking management function is applicable to any device in the system. Secondly, it has the function of identifying the isolation status of electrical equipment, and forcibly controlling the isolation equipment. Thirdly, it has maintenance logic to judge whether the maintenance equipment meets the conditions of unlocking, and the maintenance logic is completely independent of switching operation logic [6]. Fourthly, it has the function of maintenance driving. During the maintenance, the maintenance equipment has multiple times and disorderly unlocking function. It can set the effective period of the maintenance key unlocking operation, automatically cancel the timeout, and the control right of the isolation surface equipment or maintenance equipment is always valid. Fifthly, it has the function of establishing the correspondence between the isolation locking device and the isolation lock. Sixthly, it has the automatic generation of the maintenance equipment status comparison table and the automatic comparison function of the maintenance equipment status. Seventhly, it has query statistics function, including query isolation management tasks, maintenance tasks, and isolation equipment locking tasks.
3.2.2. Maintenance keys. A computer key for receiving the control permission function of the maintenance ticket and the isolation surface equipment, and also has the function of receiving the anti-misoperation ticket and the smart lock ticket.

3.2.3. Isolation locks and accessories. The isolation lock is a special padlock that locks the temporary lock device in a fixed state, and the lock has built-in global unique ID identity information. According to the different locking devices, different portable locking accessories are used to complete the installation and locking. Bright color, with obvious warning effect, red, orange, yellow, green, optional; anti-electric shock design, lock body, lock hook engineering plastic, lock core pure copper, light weight (only 1/5 of the weight of metal locks) With a variety of accessories, it can be used for a variety of open locks. It is firm, beautiful, compact and flexible.

3.3. Maintenance process

| Switching operation | Arrangement of safety measures | Maintenance work |
|---------------------|-------------------------------|------------------|
| Generate a switching operation ticket (including secondary equipment blocking) | Information returned, switching operation done. | Issue ticket (Get the isolation surface) |
| Computer key to pick up the ticket to the on-site operation. | According to the work ticket. | Issue maintenance ticket |
| Maintenance key screamed the ticket. | Is the equipment unlocked? | Maintenance work |
| Withdrawal of the isolation surface. | In there any other maintenance tasks for the associated isolation surface? | Information returned maintenance work done |
| Secondary equipment blocking release. | The isolation surface continues to lock. | Maintenance work |

![Fig.2 Maintenance flow chart](image)

4. Five-prevention system Weibull statistical reliability test

In recent years, the Weibull distribution model has been widely used in the reliability analysis of equipment life, which is a mathematical model proposed by Professor Weibull. In order to describe the entire bathtub curve, you need to rely on the Weibull distribution, which is mainly used to process failure data. It is currently the most widely used model in the reliability field. The distribution function of the Weibull statistical three-parameter model is as follow [7].

\[
F_m(t, m, \eta, \gamma) = \begin{cases} 
1 - e^{-\left(\frac{t}{\eta}\right)^m} & t > \gamma \\
0 & t \leq \gamma 
\end{cases}
\]  

(1)

Where the \( m \) is a shape parameter, \( \eta \) is a scale parameter, and \( \gamma \) is a position parameter. It is often referred to as the typical Weibull three-parameter distribution model.
The reliability function is as follow.

\[
R(t) = 1 - F(t) = \exp \left[ -\left(\frac{t}{\eta}\right)^m \right]
\]  

The failure rate function is as follow.

\[
\lambda(t) = \frac{f(t)}{R(t)} = -\frac{mt^{-1-i}}{\eta^m}
\]

The Weibull distribution usually uses two parameters, one shape parameter and the other scale parameter, which makes it have many advantages that the exponential distribution does not have in the characterization process. The two parameters also make their parameters more complicated, and the new research direction is how to estimate the parameters. This chapter uses the least squares estimation method and the average rank method.

The estimation of unknown parameters in linear functions usually uses the least squares estimation method. Since the Weibull distribution is a nonlinear parameter, its parameters should be transformed into linear before being estimated. Therefore, by taking the logarithm of the reliability function \( R(t) \) twice, it is possible to replace the linear parameter with is called complex variable parameter, so that it can be estimated using the least squares method, and there is a formula.

\[
\ln \left[ -\ln R(t) \right] = mt \ln t - m \ln \eta
\]

After the device is put into used, the Weibull distribution reliability distribution map is obtained from the number of failures.

![Fig.3 Reliability function diagram](image-url)
The mechanical code lock starts from the start of operation. If there is no fault within two years, it means that the actual operation of the site is good. In this paper, the shape parameter B of Weibull is obtained by calculation, which is called consistent with the actual situation. If taking the micro-machine type to prevent the mechanical coding lock in the electrical accident system as an example, we can use the least square method and the average rank method are combined to obtain a very accurate Weibull parameter estimation value, which achieves the expected effect. The accuracy of the parameter estimation increases as the sample size increases. Therefore, in order to more accurately evaluate the reliability of the "five-prevention" system, it is necessary to collect a large amount of data [8].

5. Conclusion
In view of some problems existing in the actual operation, this paper determines the improvement of the lockout and control functions of the substation maintenance work from the actual project. It increases the safety control of the operating electrical secondary equipment, the safety control of the isolation equipment, the safety control of the maintenance equipment, the equipment status information comparison and other functions. In combination with the business process and system application of the maintenance work, the original anti-misoperation safety control system will become a standardized, informational, Platform-based maintenance control system throughout the whole process of the maintenance work. At the same time establish a mathematical model of reliability assessment to evaluate the reliability of the “five-prevention” system.

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