Design of standard security measures database for various types of maintenance operations

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Abstract. With the continuous deepening of smart grid construction, more and more smart substations are being used in actual projects. Compared with traditional substations, smart substations have realized digitalization of information, communication network, and standardization of sharing. However, the secondary circuit of intelligent substation has high integration and no obvious electrical isolation point, so the traditional safety measures are no longer suitable for the actual situation of intelligent substation. Therefore, based on the analysis of typical equipment security measures, this article designs a set of general rules for automatic generation of security measures according to the relevant specifications of security measures of intelligent substations. Through the modeling of different maintenance tasks, the characteristics of the safety measures applied to the intelligent substation equipment are analyzed, and the designed safety measures are classified according to the equipment type and operation mode to establish a safety measures database; finally, according to the established database Develop an automated ticket generation plan.

Keywords. Intelligent substation; maintenance measure; safety measures rules; database

1. Introduction

In the traditional substations, tripping, starting failure and other open circuits are connected with hard pressure plates. As long as the maintenance personnel follow the principle of "obvious electrical breaking point" during the maintenance of the equipment, the hard pressure plate can be pulled back to ensure that the equipment exit will not malfunction [1]. The secondary equipment in the intelligent substation uses the method of program construction to build the secondary circuit and hard pressure plate of the traditional substation into "virtual circuit" and "soft pressure plate". While improving the integration, it also results in no obvious electrical disconnection point in the secondary circuit. If the safety measures of traditional substations are followed during the secondary maintenance of smart substations, it is easy to cause equipment relay protection to malfunction or incorrectly operate, leading to more serious power grid failures.

In actual work, the secondary maintenance personnel of the intelligent substation need to manually compile the security measures through the operating conditions such as on-site operation and equipment operation. This results in the actual effect of the operation inspection operation only relying on the technical level and work experience of the maintenance personnel and the effect of equipment maintenance cannot be effectively guaranteed [2]. In order to solve the above problems, the literature [3, 4] proposed an automatic generation technology of smart substation based on expert system. It constructed the matching database by analyzing the SCD file, and then completed the matching with the secondary information through the expert system. Although the above literature proposed a method...
for automatically generating safety measures ticket, it did not classify the security measures rule, which resulted in a slow calculation of security measures ticket and a long matching time.

Based on the analysis of various types of typical equipment security measures, this paper designs general rules applicable to the automatic generation of security measures for smart substations. Then classify the security measures according to the equipment type and operation mode to establish a security measures database. Finally, an automatic generating scheme based on the established database is proposed. Provide protection for the maintenance work of smart substations and improve the stability and reliability of power grid operations.

2. Establish a standard security measures database for various types of maintenance operations

In traditional substations, there are hard pressure plates in the open circuit such as tripping and starting failure. The safety measures of the secondary circuit have always followed the concept of "obvious electrical breakpoints" [5]. During the maintenance process, the maintenance personnel stepped down these pressure plates. This will ensure that the equipment will not be mistakenly exported. However, the secondary circuit of a smart substation is very different from traditional substations, and its secondary circuits are highly integrated. Compared with the conventional substation relay protection, the intelligent substation relay protection realizes that the AC sampling circuit is replaced with optical fiber, and the traditional DC secondary circuit is replaced with GOOSE digital information flow. Therefore, it is difficult to complete the maintenance and repair tasks of intelligent substations using the traditional measures of substations. For a typical secondary circuit of a smart substation, the structure includes a merging unit responsible for data acquisition, a relay protection device responsible for determining the protection action, and an intelligent terminal responsible for the control of circuit breakers and disconnectors.

In intelligent substations, typical intervals include lines, transformers, busbars and so on [6-7]. Typical secondary safety measures can be divided into the following 6 categories: 1) put in overhaul of the pressure plate; 2) exit the soft plate of the relay protection device function; 3) exit the GOOSE receive / send soft plate; 4) exit the SV receive soft plate; 5) exit Intelligent terminal jump and close the exit hard pressure plate; 6) Unplug the communication fiber between the devices, including SV fiber, GOOSE fiber. According to the above isolation measures, making reasonable safety measures rules is the basis of completing the safety measures library. Through the analysis of a large number of typical equipment safety measures, combined with the relevant specifications of substation safety measures, the overall rules of automatic generation of safety measures are designed. Through the modeling of various maintenance tasks under different voltage levels, different wiring modes and different interval types, the characteristics of the maintenance safety measures rules currently applied to intelligent substation equipment are analyzed, and the rules are classified according to the applied equipment types and operation modes, and the safety measures rules database is established accordingly. The safety measures rule database is used to describe the general model of various maintenance safety measures under various types of intervals. For example, for 220kV line intervals, the connection between typical protection configuration and network is shown in Figure 1.
The types of maintenance and safety measures operation tasks contained in it can be roughly enumerated as follows:

1) In case of power failure of primary equipment, check the protection and maintenance of 220kV line.

2) Without power failure of primary equipment, check the protection and maintenance of 220kV line.

3) In case of power failure of primary equipment, 220kV line protection treatment defects (distinguish protection defects, merge unit defects, intelligent terminal defects).

4) Without power failure of primary equipment, 220kV line protection treatment defects (distinguish protection defects, merge unit defects, intelligent terminal defects).

5) Without power failure of primary equipment, general fault.

6) Stop and put Reclosing.

7) Setting value of primary equipment without power failure.

The safety measures ticket automatic generation system obtains the relevant information of the equipment by traversing the maintenance object, and automatically matches them in the safety measures rule database. Finally, the matching results are sorted according to priority to generate the security measures required by the operation and maintenance personnel ticket. The automatic generation flow chart of the secondary circuit trimming safety measure ticket of the intelligent substation is shown in Figure 2.

The steps of automatic generation of safety measures ticket are as follows:

1) Establish the correlation matrix of the electrical status of the secondary equipment of the intelligent substation. This matrix describes the correlation between the operation status of the maintenance target selected by the maintenance personnel and the normal operation status.

2) Extract maintenance related information. After the maintenance target is determined, the targets are arranged according to the protection device-merging unit-smart terminal, etc., and then the maintenance target is traversed in the system configuration database to search for related information, and the obtained results are stored.

3) Match the safety measures rules. Match the information obtained in step 2 in the safety measures rules database in order to get the safety measures rules. Each safety measures rule contains priority information. Arrange the obtained safety measures rules according to priority to get the required safety measures tickets.
Figure 2. The automatic generation flow chart of the secondary circuit trimming safety measure ticket of the intelligent substation.

The implementation steps of the internal maintenance safety measures of the line, transformer, bus and other bays are relatively fixed, so the safety measures steps in each maintenance safety measures task can be defined in the form of regular template. Operation objects of safety measures include operation of soft pressing plate, operation of maintenance of hard pressing plate, operation of intelligent terminal outlet hard pressing plate, and operation of optical fiber plugging. By defining the interval type code table, operation task code table, operation object code table, safety measure rule code table and equipment safety measure rule mapping table, the general safety measure rule library is constituted.

3. Implementation scheme of automatic generation of safety measure ticket based on standard safety measure library

Based on the coding of various intervals, operation tasks, operation objects and safety measures rules, the operation objects within a certain interval are instantiated. That is to identify the specific platen related to the safety measures operation task in this interval. Take the line interval as an example. The type of platens that need to be specified for such intervals include: various types of GOOSE outlet soft platens for line protection, reclosing soft platens, longitudinal differential protection soft platens, soft switch plates for switch failure, and maintenance of hard platens. And corresponding bus protection internal branch SV / GOOSE receiving soft pressure plate (or interval receiving soft pressure plate), start failure receiving soft pressure plate, isolation knife gate forcibly closing and closing soft pressure plate, corresponding to intelligent terminal maintenance of hard pressure plate and outlet hard pressure plate, combined unit maintenance Hard pressure plate and so on. Most of these types of platens can be automatically identified by the SCD library guide tool, and the unrecognized platens can be manually associated. For fiber insertion and removal operations, it is handled as a prompt item. After instantiating all types of pressure plates inside the interval, you can find the corresponding security measures coding table according to the equipment security measures mapping table and instantiate the security measures task steps.
The general principles of the automatic generation sequence of the security measures strategy are as follows: 1) Traverse all checked maintenance equipment, analyze the isolation point, and exit the SV receiving soft pressure plate of the maintenance equipment in the running equipment; 2) Traverse all checked maintenance equipment, analyze the isolation point, and exit the GOOSE receiving soft pressure plate of the maintenance equipment in the running equipment; 3) Traverse all checked maintenance equipment, analyze the isolation point, and exit the GOOSE sending soft pressure plate from the maintenance equipment to the running equipment; 4) Disconnect the maintenance if necessary Optical fiber circuit between the equipment and the operating equipment; 5) If the primary equipment does not lose power, exit the hard terminal at the interval intelligent terminal exit; 6) Put in the maintenance hard plate for maintenance equipment; 7) If the primary equipment fails, the current loop is disconnected.

4. Conclusion
In the intelligent substation, the data transmission channel uses optical fiber, and its secondary circuit is very different from the traditional substation. This article designs a new safety measure applicable to the intelligent substation. The new rules are classified according to the equipment type and operation mode to establish an intelligent substation security measures database. Finally, an automatic security measures generation plan is proposed. This technology reduces the manual coding workload of maintenance personnel, improves work efficiency, and reduces work errors caused by human factors. At the same time, it provides technical support for the safe operation and maintenance of intelligent substations, which greatly improves the safety and reliability of power system operation.

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