The Comprehensive Management System of High Voltage Electrical Test Apparatus

Ma Yan¹, Zou Lida²*, Yu Naihai¹, Qi Dali¹ and Chen Yufeng¹

¹ State Grid Shandong Electric Power Research Institute, Jinan 250002, China
² Shandong University of Finance and Economics, Jinan 250014, China
³ Shandong Electric Power Industrial Boiler Pressure Vessel Inspection Center, Jinan 250002, China

*Corresponding author e-mail: yanpony@126.com

Abstract. High-voltage test is critical to electrical equipments, and test apparatus used in high-voltage test and their test items are various and complex. In the paper we focus on the standardized management of test apparatus. Adapting to information-data-intelligent tendency, we construct a comprehensive management system for high-voltage electrical test apparatus to improve test accuracy and efficiency. We use two-dimensional bar code to build transceiver system. Through simple scanning, the instruments could easily change their status and location, and we can also get all its data stored in the database. The online report generation are achieved as well based embedded template, bookmark and electronic signature. The trial operation shows that our detection processing time reduces more than 33 percents, which increases detection accuracy and reliability.

1. Introduction
State Grid Shandong Electric Power Research Institute is a large experimental research institution of State Grid Shandong Electric Power Company, which is technical supervision, technical service and technical information centers. Our high voltage metering laboratory is approved by the national conformity assessment committee and undertakes many verification items of high-voltage test apparatus.

All the high-voltage test apparatus in Shandong power grid need to be verified by high voltage metering laboratory and we manage all the related information of these test apparatus. We also provide examining information of subordinate units for provincial branches each month or year. The data statistics and analysis are necessary [1]. Therefore, constructing a comprehensive management system of test apparatus has visible benefits, such as easy to evaluate instrument, reducing manual cost and improving testing accuracy [2].

Our comprehensive management system of electrical test apparatus aims to build intelligent transceiver system, build apparatus information database and achieve intelligent management of apparatus verification.

2. Module design
Our comprehensive management system mainly has four functions. First, the intelligent transceiver system achieves rapid typing and delivering based on two-dimensional bar code [3][4]. Second, the apparatus information database manages all the account of test apparatus, records and give early
warning of detection period for each type of equipment, which could maintain the reliability of experimental data. Third, intelligent process control system achieves the precise positioning and recording of all the test apparatus. It also can dynamically trace and manage whole detection progress. In the process, the test data are directly entered into the system and the detection reports are automatically generated. Fourth, data statistics module analyzes the number of detected equipment, acceptable rate of test apparatus and personal workload etc.

Figure 1 shows the whole flow of instrument detection from entering the lab to leaving the lab. The test instrument has seven statuses, which is waiting for detection, in the detection, detected, report transfer, waiting for claiming and claimed. The status is changed when scanning two-dimensional bar code [5]. The report transfer flow is separate with the detection flow, which could realize the online signature of different levels.

Next we introduce the concrete design of each module in comprehensive system. (1) Account management. The equipment from all the enterprises or institutions are uniformly managed through system account. The attributes include instrument large category, instrument type, standard instrument, instrument name, instrument format, production factory, production number, production date, accuracy level, instrument status, storage location, last detection date, detection period, attachment, etc. The instrument statuses include normal, scrapped, sealed, detected and maintained. Detection periods of test apparatus are normally 12 months or 24 months. The maintenance of detection period is managed separately according to instrument type. Instrument large category, instrument type, standard instrument, production factory and instrument format are uniformly managed. If there is any new production factory or new instrument format, the lab faculty build and check it before entering into standard database. These attributes are selected by users in the system's interface.

(2) Test apparatus reception. According to the different filling contents of acceptance form, test instruments fall into the following categories: high-voltage metering, electrical measurement, gas relay and safety apparatus. After test instruments are received by dispatchers, an acceptance form for once detection of an institution is generated according to different categories. Next the instruments waiting for detection are added into the acceptance form and each instrument has a detection number. If the instrument is already in the database, its account is pulled. If not, the institution of the instrument could type the information in advance or add the information on the spot.

(3) Two-dimensional bar code scanning. When an instrument is first sent for detection, a two-dimensional bar code is generated and attached to it. Our bar scanner is wirelessly connected in convenience. The bar code follows uniform coding standard [6]. After scanning the instrument, its account information is obtained, its detection number is generated and the detection status changes to waiting for detection.
(4) Detection report generation. The report templates for different types of test apparatus are imported into database and the bookmarks for some attributes in the report are created. Different detection items are done in different sites. Each detection site has an intranet computer. After high-voltage metering equipment are sent to detection and the bar code is scanned, data entering interface is pulled, the detection status is changed to in detection and the storage location is changed as well. After the testing data is entered, the corresponding detection results are computed automatically. Before the final confirmation, the testing data can be modified. After all the testing items are finished, the detection report is produced and the detection status is detected.

(5) Detection report transferring. After the report is created, its transfer supports electronic signature, digital seal and scanning copy uploading. The report statuses include waiting for auditing, waiting for approval, waiting for filing and archived. Each status corresponds to a process node. Each process node grants authorities to several persons. The authorized auditor or approver has a password. All the reports waiting to be signed would appear in to-do list of the person. The signed report can be printed or scanned. The printed report is archived in paper or electronic edition.

(6) Closed-loop receiving and distribution. After the report is archived, the instrument status is waiting for claimed and the storage location is dispatcher’s office. When the institution comes to claim the instrument, its two-dimensional bar code is scanned and the status is changed to be claimed. All the receiving, detection and distribution is a closed loop control process.

(7) Real-time query of instrument status. The institutions who send their instruments to detection have the user accounts of comprehensive system. They can submit the newly added factory, format and instrument, and then administrator is responsible for checking. They can also query the progress of detection and obtain the instrument status. Of course, each institution can only see their own instruments.

(8) Workload statistics. The workloads are recorded from instrument account entering, detection item, report editing, report distribution to instrument claim. In the module all the personal workloads and group performance can be analyzed. It is convenient to export workload form and the managers could control all the business flow precisely and roundly.

(9) Early warning of instruments due to expire. When an instrument is about to expire, we will set early warning to remind the institution of detection. In the order form, the institution could choose to get their detection report normally or in advance. The normal time is 20 workdays and the urgent time is 7 or 3 workdays.

(10) Summary statistics. The statistics includes querying detection rate, qualification rate, instruments exceeding detection period and instruments close to detection period, etc.

3. System implementation
Figure 2 shows the login interface of comprehensive system. We set six roles for our system, include administrator, detection institution, dispatcher, data editor, report reviewer and report approver. Detection institution can only see their own instruments. Different persons are authorized to different roles. Note that the user password management is separate with that of electric signature. The whole system have four functional classifications, which are fundamental information, standard test apparatus management, detection management and test apparatus management.

Fundamental information is used to maintain basic attributes such as detection foundation, instrument type, standard instrument, technical parameters, production factory, instrument format and detected institution. Figure 3 shows the attributes of detection foundation. Figure 4 gives the attributes of technical parameter.
Figure 2. Login Interface

Figure 3. Attribute setting of detection foundation

Figure 4. Attribute of standard instrument

Standard test apparatus management has three functions, which are standard test apparatus account, standard test apparatus detection records and standard test apparatus detection plan. Figure 5 shows a newly construction of a standard test apparatus. If the item of attachment is yes, we can add corresponding attachment for instrument. Figure 6 gives the adding attachment process for format. The new button is used to add a new attachment. We select one record and double click it, then the record can be modified. The detection records includes the attributes such as instrument type, name, factory, format, production number, production date, detection date and last detection date. Detection plan is to use remind the detection institution of expiration date, which can avoid the detection rush and shorten the average detection time as well. The detection plan supports uploading and downloading.
Detection management is used to generate and manage the test reports. It can also be responsible for claim instruments. Figure 7 describes the report generating page, which is for dc resistance tester. The system embedded the report template in advance. Figure 8 gives the final format of a report. When the detection institution gets the instruments back, we just need to scan two-dimensional bar code, which reduces the manual workload largely.

Test apparatus management includes four parts, which are account management, check-in and check-out management, maintenance management and detection plan. The account management of test apparatus is similar to that of standard test apparatus. The difference is they have different belonging institutions. Figure 9 shows the check-out page, which could choose check-out reason and operator. Figure 10 gives the instrument maintenance management. In the interface, system supports query, edit, delete and modification. Through check-in, check-out and maintenance management, all the instruments can be traced in the system, which fully realize the electronic management of test apparatus. After three-month running, the average processing time for an instrument reduces from 18 workdays to 12 workdays. Our members in the lab have much higher efficiency in managing and tracing test apparatus.
4. Conclusions

In the paper, a comprehensive management system of high-voltage electrical test apparatus for our lab are presented. In the past, all the check-in, check-out, detection and account of test instruments were managed in manually, which brings a lot of repeated work with the incoming. Data computation and analysis are simple and manual. It is hard to evaluate the instruments. Through operating the system, the complex process and massive workload of instrument warehouse management reduce largely. The intelligent data management also maintains the reliability and accuracy of detection results. Our trial running demonstrates that the average processing time from receiving the instrument to getting back the report shortens to 12 workdays from 18 workdays. In the future, we will introduce the Internet of Things technologies to automatically record the location and status of test apparatus.

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