

The Architecture Design of Detection and Calibration System for High-voltage Electrical Equipment

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Abstract. With the construction of Material Quality Inspection Center of Shandong electric power company, Electric Power Research Institute takes on more jobs on quality analysis and laboratory calibration for high-voltage electrical equipment, and informationization construction becomes urgent. In the paper we design a consolidated system, which implements the electronic management and online automation process for material sampling, test apparatus detection and field test. In the three jobs we use QR code scanning, online Word editing and electronic signature. These techniques simplify the complex process of warehouse management and testing report transferring, and largely reduce the manual procedure. The construction of the standardized detection information platform realizes the integrated management of high-voltage electrical equipment from their networking, running to periodic detection. According to system operation evaluation, the speed of transferring report is doubled, and querying data is also easier and faster.

1. Introduction

As the increasing improvement on “intensified management of three components and integrated systems of five processes” of state grid [1], Electric Power Research Institute takes on the job of material sampling [2], test apparatus detecting [3] and field test [4]. These detection and calibration work provides protection for the secure and stable operation of electrical equipment from the aspects of equipment entrance, the source of testing data and equipment operating process.

At present, material sampling, test apparatus detecting and field test remain in the manual stage and paper archive level, which cannot satisfy the demands of field production. First, receiving and distribution of equipment rely on manual records. The attributes such as factory number, model and manufacturer need hand-copying. Most equipment is inspected once a year. Since there is no database, the information is registered more than once and workload increases. Second, the experimental data in testing report are from the table or card in handwriting. The error and uncertainty rate are computed and input into computer manually, which is un-efficient and error-prone. Moreover, an instrument corresponds to a testing report. For different instruments, their testing items are diverse. We need to add or delete relative testing table manually, which is heavy and complicated. Last, along with the development of state evaluation and production management system, it is necessary to manage all the

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testing instruments from a high level. In the case, the computing error and error variation can be queried any time and state evaluation also can be more efficient.

Based on the above background, the construction of information platform is more important [5]. For material sampling and test apparatus detecting, their complicated process and manual work is simplified. For testing people, their testing reliability and accuracy are maintained. For condition-based maintenance of whole province, the platform can make sure the accuracy of state evaluation.

2. System framework

Detection and calibration system of high-voltage electrical equipment include material sampling, test apparatus detecting and field test. Material sampling is to carry on the quality detection for access network equipment through various experimental items, and give a test report. Test apparatus detecting is to check the high-voltage test instruments such as direct-current high voltage generator, voltage divider, DC resistance tester from power supply companies and power generation enterprises. Field test is to help district power distribution companies identify the possible causes of device defect or failure and give the further suggestions through field testing of technical personnel from electric power research institute. In the section we give the concrete flowchart of the three parts.

2.1. Material sampling

The module consists of six parts and its flowchart is shown in figure 1. The first is entering the handover form. The second is choosing the testing report, testing item and generate the final report. The third is generating the weekly report, monthly report and yearly report. The fourth is supporting the searching and counting function. The fifth is the circulation of testing report. The sixth is scanning and uploading the paper records.

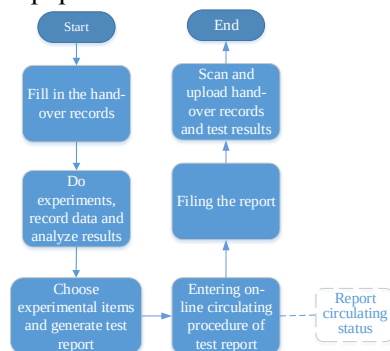


Figure 1. The flowchart of material sampling

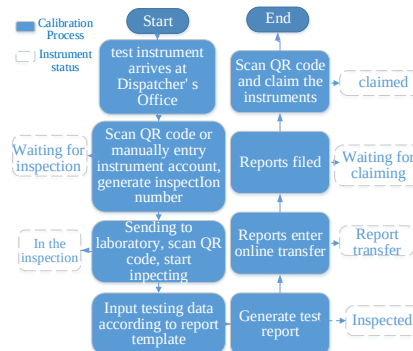


Figure 2. The flowchart of test apparatus detecting

1. Handover form include the attributes such as sample number, sample name, sample type, sample unit, client affiliation, handover time, testing type, notes. Sample name, sample type, sample unit, client affiliation and testing type are chosen from several options.

2. The template of testing report is loaded in advance. We integrate 11 kinds of templates, include dry type transformer, oil-immersed transformer, electric cable, pole-mounted circuit breaker, composite insulator, high-tension switch board, ring main unit, porcelain insulator, etc. The concrete testing report is generated dynamically according to the selected testing items [6]. If a testing report chooses three testing items, the report will show the tables of the three testing items. In addition, the testing instruments and detection criterion are brought into the report automatically. The table of contents is generated automatically, as well.

3. The weekly report, monthly report and yearly report can be generated and exported periodically. They include the attributes such as sample name, sample type, sample length (number), testing item, qualified or not, unqualified items, completion time, testing people. The above attributes are acquired from testing report or handover form.

4. The searching and counting function is also supported. Queries based on client affiliation, start date, end date and testing result are realized and Querying results can be exported in form of EXCEL.

5. The testing report needs three signatures: writer, reviewer and approver. Previously the signature is done offline [7]. Now we develop the system to circulate the report electronically. The flow is divided into five steps: generation, writing, reviewing, approval, filing. Different persons are granted different permissions. The person could see all the reports and only edit the granted reports. The rollback operation is supported. After the previous step is finished, a sending button triggers the next status of the report.

6. All the paper records need uploading and storing into database. We provide the uploading and downloading functions.

2.2. Test apparatus detecting

The flowchart of test apparatus detecting is shown in figure 2. First, after test apparatus is sent to dispatcher's office, acceptance forms are generated according to the types of equipment and each acceptance form is attached by several apparatuses. Each test apparatus has an inspection number.

Here we note that test apparatus is divided into four kinds: high-voltage metering type, electrical testing type, gas relay and safety equipment. High-voltage metering type has account management. Its attributes include product type, standard product name, product name, product factory, product model, product number, manufacturing date, product status, test date last time, test period. If the test apparatus is already in the database, the data is directly extracted. If it is not in the database, its account is added.

Also, each apparatus has a QR code [8], which is associated with base information of apparatus. When the apparatus is tested next time, we can just scan its QR code to get the record in database. If the apparatus is sent to test for the first time, we automatically generate a QR code, print the QR code and stick it on the surface. After the inspection number is given, the status of the apparatus is waiting for inspection.

Second, after finishing the inspection, each apparatus corresponds to a test report. The report is an instance of report template for this kind of apparatus. We input all kinds of report templates in advance. The report instance is generated according to its account and apparatus type. The report is modified online and all the computation is integrated with equation. After the report is saved, the apparatus is changed to the inspected status.

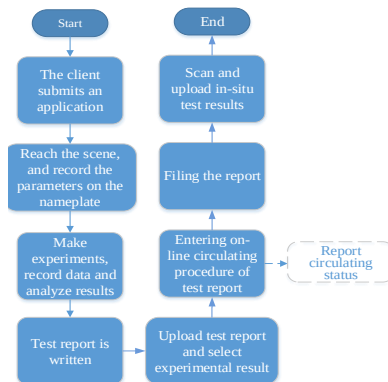
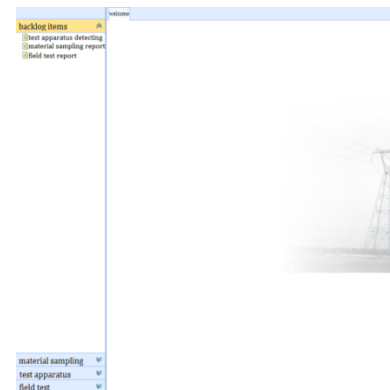
Third, another highlight of our system is to realize the electric signature and online transfer of the report. The nodes of a whole report include generating, writing, reviewing, approving, filing. Each identity has its own username and password of logging in the system. Each identity also has its own password of electric signature, which could maintain the safety of system. We also build a function of backlog items, which could remind them of the reports to be treated.

Last, after the report finishes transferring and is filed. The status of the apparatus is waiting for claiming. When the clients come to get their apparatus back, we scan the QR code and the apparatus is claimed.

The module also supports to query workloads of different persons, besides the general query and statistical computation, such as testing rate, qualification rate, the apparatus of exceeding the testing period, the apparatus close to testing period. The status of tested apparatus can also be queried by clients.

2.3. Field test

Figure 3 shows the flowchart of field test. It mainly includes three functions. The first is inputting the client's application form. The second is uploading the testing report, filed test record, and realizing the electronic signature. The third is querying and counting functions.

**Figure 3.** The flowchart of field test**Figure 4.** The login page**Figure 5.** The first page

1. The client's application form include testing date, equipment type, testing item, client affiliation, substation, applicant and applicant phone. Testing date, equipment type, testing item and client affiliation are chosen from fixed items.

2. The testing report has various formats, which support uploading WORD form. After uploading is complete, electronic signature follows. Our electronic signature procedure needs to record the name of operator, status of testing report. It supports the rollback function. After the review and approval, the report is generated. It could connect the printer and directly print paper report. It also could upload the scanned report. When filing the report, the conclusion of the report is extracted as an attribute.

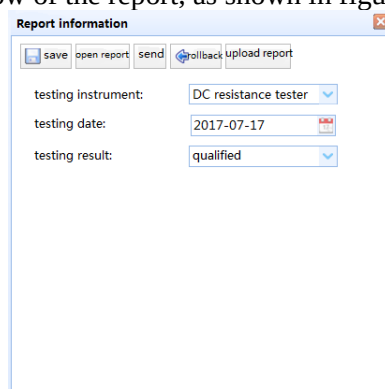
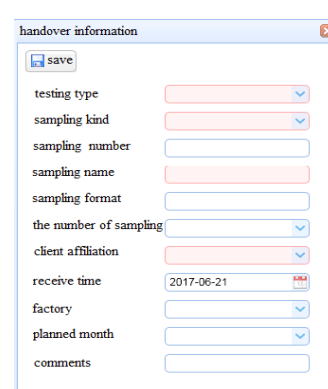
3. The model support querying and counting functions. The querying attributes include client affiliation, experimental date, testing conclusion. Querying results can be exported in EXCEL format.

3. System Implementation

In the section, we give some system screenshots to further introduce our system.

The login page is shown as figure 4. The system consists of four modules: backlog items, material sampling, test apparatus detecting and field test. After logging into system, it is like figure 5.

First we see the backlog items, which are divided into three parts: material sampling, test apparatus detecting and field test. Each part has its own backlogs. On the page, it shows the base information of reports to be treated by the login user. When the user clicks the report, it can directly go into the processing flow of the report, as shown in figure 6.

**Figure 6.** The backlog items**Figure 7.** The handover record

Second we introduce the material sampling. Figure 7 shows how to record the handover information, including testing type, sampling kind, sampling number, sampling name, client affiliation, factory, etc. Figure 8 gives how to opening a report, how to sign a name and how to send a report to the next person. In the module the comprehensive query page is also designed, which could query the handover and report information according to different attributes.

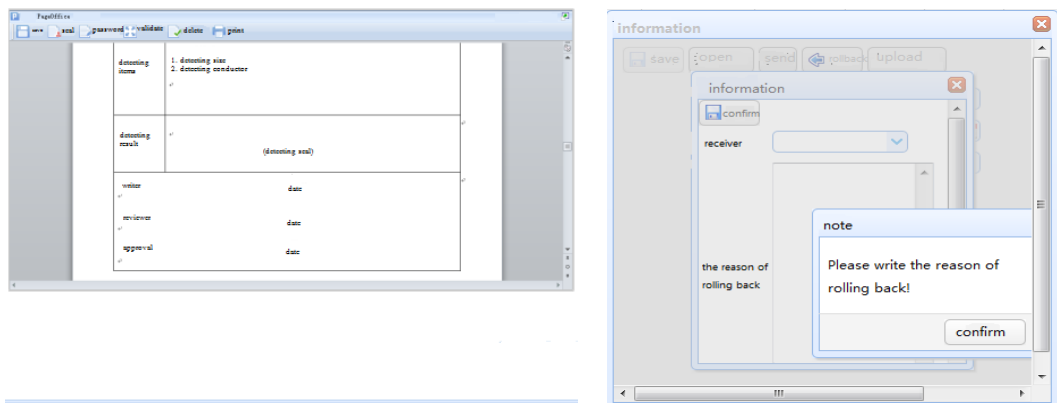


Figure 8. The report instance and report transferring

Third we next introduce the module of test apparatus detecting. Figure 9 gives the account management. We standardize all the factory name, apparatus type, apparatus model, and get them into database. Figure 10 shows how to build an acceptance form, which consists of four steps. First a new form is built, second the client affiliation is chosen, third the apparatus is added and last select the detecting time. For the testing report management function, we add the reminding button. When there is a red button before the report, the report processing deadline is close. Our testing faculty should accelerate work schedule. Figure 11 shows the workload statistics. It includes the times of acceptance, testing, writing, reviewing, approval, filing, claiming for each person. Figure 12 gives the apparatus claiming page. We just scan the QR code of the apparatus, and it is change to the claimed status.

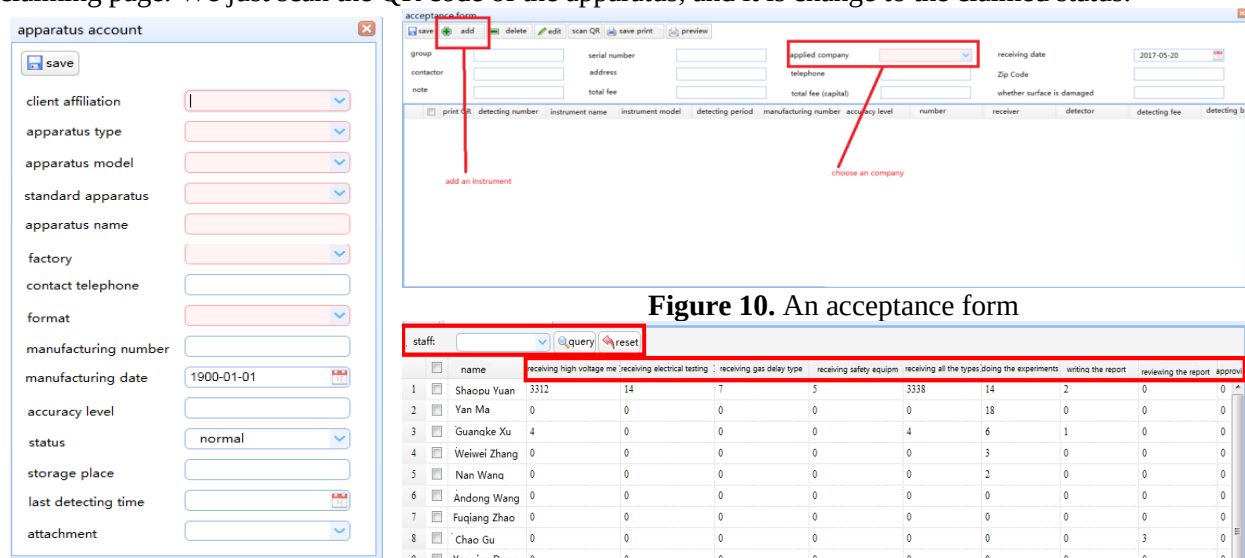


Figure 9. Test apparatus account

Figure 11. The workload statistics

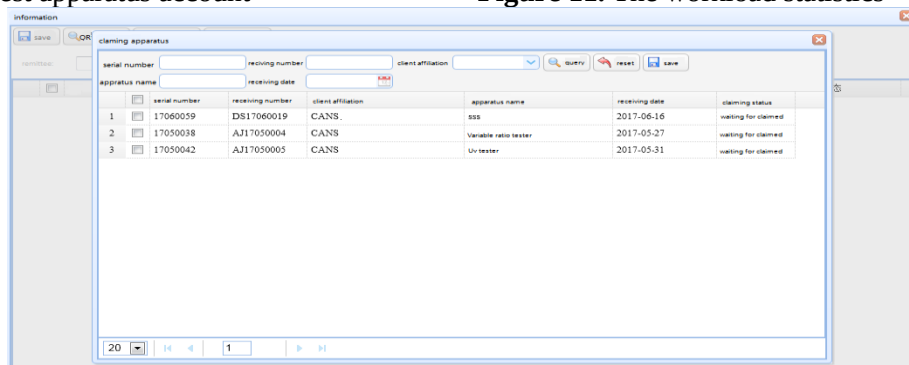


Figure 12. The apparatus claiming

Figure 13. The client application form

Figure 14. The online transferring of report

Last we introduce the field test module. Figure 13 shows how to generate the client application form, which is similar to that of material sampling. Figure 14 gives how to transfer the field testing report online. Since the report has no fixed template, we do not integrate report template into system. We instead directly upload the report, but the transferring of the report supports online format. All the signatures are signed electrically. Figure 15 shows the workload statistics function, which is similar to test apparatus detecting.

staff		name	receiving	experimenting	writing	reviewing	approval	filling
1	☐	Wei xu	0	1	0	0	0	0
2	☐	Jian Zhang	0	1	0	0	0	0
3	☐	Fuchun Sun	0	0	0	0	0	0
4	☐	Chunlu Wang	0	0	0	0	0	0
5	☐	Qin Zhang	0	0	0	0	0	0
6	☐	Hui Wang	0	0	0	0	0	0
7	☐	Jinxia Yao	0	0	0	0	0	0
8	☐	Chao Gu	0	0	0	0	0	0

Figure 15. The workload statistics of field test

4. Conclusions

In the paper we design and implement a detection and calibration system for high-voltage electrical equipment. Through system operation lasting close to two years, the test quality and job efficiency are improved largely, where report transferring is reduced from 3 days to 1.5 days. Our system not only guarantee the accuracy and reliability of the test data, also introduce bar code, electric signature, automatic report generation to perfect the information level of instrument detection. In the future, we will further add the input module of real-time testing data to record the whole testing process.

Acknowledgments

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