The Design of Integrated Information System for High Voltage Metering Lab

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Abstract. With the development of smart grid, intelligent and informatization management of high-voltage metering lab become increasingly urgent. In the paper we design an integrated information system, which automates the whole transactions from accepting instruments, make experiments, generating report, report signature to instrument claims. Through creating database for all the calibrated instruments, using two-dimensional code, integrating report templates in advance, establishing bookmarks and online transmission of electronical signatures, our manual procedures reduce largely. These techniques simplify the complex process of account management and report transmission. After more than a year of operation, our work efficiency improves about forty percent averagely, and its accuracy rate and data reliability are much higher as well.

1. Introduction
With the perfection of “intensified management of three components and integrated systems of five processes” of State Grid [1], high voltage metering lab in Shandong electric power research institute undertakes responsibility for calibrating more than 30 kinds of high voltage test instruments from power generating company, power grid company and power equipment plant. Our annual calibration ability is up to several thousand instrument-times. With the development of smart grid [2], our work still stays on manual management and paper storage, which cannot satisfy the needs of field work.

First all the test instruments need our manual records and all the attributes such as production factory, production model, instrument type are input into paper table. Most instruments are calibrated once a year, and we have not formed a database. Each time we register again, which adds lots of workload.

Second, testing data are also recorded into handwriting table, and we manually compute uncertainty, which has a low efficiency. Third, the calibration tempo is purely managed by manual memory and experience. Last, condition assessment of power grid equipment needs our testing data. Now it is hard to query measurement error data and trace its variation for a certain instrument.

Combining work reality, it is essential to construct the integrated lab information system [3]. For high voltage metering lab, warehouse management of testing instruments is simplified and automated. All the account and testing data also realize the intelligent management, accurate storage and efficient assessment.
2. System Overall Design

Our high voltage metering lab is recognized by China National Accreditation Committee for Laboratory and National Committee for Conformity Assessment Laboratory, and now has a number of high voltage measurement test items. The information system aims to construct an intelligent transceiver system, the instrument database and automatic process control system.

![Flowchart of calibrating instruments](image)

Figure 1. The flowchart of calibrating instruments
Table 1. Different levels of system modules

| Level 1 module | Level 2 module | Level 3 module | Level 4 module |
|---------------|---------------|---------------|---------------|
| Query         | calibrating rate of process | calibrating number | maintaining record |
| Statistics    | calibrating rate | Qualified number, qualification rate | stock in and stock out record |
| Instrument account | Standard instruments (used to calibrate the other instruments) | Maintain account | Calibration plan |
|              | Calibrated instruments | Calibration records | stock maintenance record |
|              | instruments | stock calibration plan | Calibration plan |
|              | Commission | Quality and statistics | Verify account |
|              | Commission sheet | Calibration number (auto-generation) | Scan code or print code |
| Testing      | instruments | High-voltage metering type | Gas detection relay type |
|              | Testing data | Electrical measurement type | Safety appliance type |
| Report       | Testing report | Generating | Electronic signature |
|              | Online transmission | Printing | Review and approve, support rollback |
| Claim        | Claiming records | Scanning code | Registering |
| Public dictionary | Calibration specification | Instrument type | Instrument standard name |
|              | Instrument standard name | Technique parameters | Instrument state |
|              | Instrument affiliation | The maximum kind | Data verification |
|              | Instruments required to be calibrated | | |
| System configuration | Production factory | Maintain | Verify |
|              | Production model | Maintain | Verify |
|              | Testing items | Maintain | |
|              | Report template | Electrical measurement type | Six kinds |
|              |              | Safety appliance type | Two kinds |
|              |              | Gas detection relay type | Four kinds |
|              |              | Pressure relief valve type | Three kinds |
|              |              | Uploading pictures | |
|              |              | Generating directory | |
|              |              | Automatic typesetting | |

Fig. 1 gives the flowchart of our whole system, which describes the process of calibrating the instruments. First we select the instrument affiliation and instrument type. If it is high-voltage metering, gas detection relay or live detection equipment, we first find whether it has two-dimensional code [4] or account. If it has no account, we need to add it into database and print its two-dimensional code. If it is safety appliance or electric measurement equipment, we directly generate a commission sheet. A commission sheet can include many instruments. After receiving the instruments, they are sent to different labs. Then testers begin the calibrating items and all the original records are saved. Meanwhile, the data are input into our system, and the report is automatically generated [5]. Our system also support direct upload of WORD/PDF/EXCEL files. After that, reports go into online transmission. It is
sequentially sent from writer, reviewer to approver. All the persons can sign electronically [6]. Last the instruments go into the state of waiting for claimed. The instruments can be taken away through simple scanning.

3. System Module and Data Structure
We next introduce the concrete levels of different system modules, as shown in Table 1. We divide our system into concrete calibration and system configuration. Instrument calibration consists of eight parts including query, statistics, instrument account, commission, testing, report, claiming. It includes the whole process such as data input, data verification, data processing, data analysis, report generation, remote transmission. According to practical needs, the module can be connected with other management functions. We use two-dimensional code to identify each instrument, which is associated with all the information of the instrument. The data automated identification technique realizes the intelligent and paperless management.

We use Oracle11g as our database, and PowerDesigner is the designing tool. Table 2 gives the list of used tables. We design 26 tables and all the transactions in the lab are uniformly managed, including faculty, instruments, standard instruments and archive files.

Table 2. The listed tables in the system

| No. | Table name                                      | Code                        |
|-----|------------------------------------------------|-----------------------------|
| 1.  | Safety appliance main table                    | T_EPRI_SYYQ_AOQGQJ_MAIN     |
| 2.  | Instrument standard name                       | T_EPRI_SYYQ_BZTZ            |
| 3.  | Stock in and stock out table                   | T_EPRI_SYYQ_CRKGL_MAIN      |
| 4.  | Instrument department                          | T_EPRI_SYYQ_DEPARTMENT      |
| 5.  | Electrical measuring main table                | T_EPRI_SYYQ_DQCS_MAIN       |
| 6.  | Corresponding table of commission and specification | T_EPRI_SYYQ_DYGX           |
| 7.  | High-voltage metering main table               | T_EPRI_SYYQ_GYJM MAIN       |
| 8.  | Quota management                               | T_EPRI_SYYQ_INSTRUMENTMANGER|
| 9.  | Calibration specification                      | T_EPRI_SYYQ_JDYJ            |
| 10. | Corresponding table of specification and testing items | T_EPRI_SYYQ_JDYJ_DYGX |
| 11. | Technique parameter                            | T_EPRI_SYYQ_JSCS            |
| 12. | The maximum table                              | T_EPRI_SYYQ_PARNET_YQLX     |
| 13. | Gas detection relay main table                 | T_EPRI_SYYQ_QIJDOGQJ_MAIN   |
| 14. | Gas detection relay slave table                | T_EPRI_SYYQ_QIJDOGQJ_SUB    |
| 15. | Production factory                             | T_EPRI_SYYQ_SCCJ            |
| 16. | Calibration records                            | T_EPRI_SYYQ_SJI              |
| 17. | Testing report                                 | T_EPRI_SYYQ_SYBG             |
| 18. | Maintenance record                             | T_EPRI_SYYQ_WXJL            |
| 19. | Production model                               | T_EPRI_SYYQ_XH               |
| 20. | attachment                                     | T_EPRI_SYYQ_XHFGJLB         |
| 21. | Instrument claiming                            | T_EPRI_SYYQ_YQLQ            |
| 22. | Instrument second type                         | T_EPRI_SYYQ_YQLX            |
| 23. | account                                        | T_EPRI_SYYQ_YQTZ            |
| 24. | user                                           | T_EPRI_USER                 |

4. Performance Evaluation
In the paper, our software environment is JDK1.6, TomCat7.0 and Oracle11g. Two servers are deployed. One is for application server, the other is for database server. The operating system is Windows Server 2008. We develop both client and browser version. For users, the accessing PC should support IE8 or above version, and Microsoft Word is 2007 and above. Some plugins can be downloaded when you log into the system.
After we use the integrated information system, all the transactions in the lab are finished online. First our paper commission sheet can be directly printed online. Fig. 2 shows our entry of commission sheet. Second, all the instruments are added into database. We just need to scan its two-dimensional code, and all the information is abstracted. Fig. 3 shows the account attributes. Third, we input all the report templates in advance. After the testing data are entered, the testing report is automatically generated. The report format is shown as Fig. 4. Fourth, the report is sequentially signed electronically. We no longer need handwritten signature, and its system interface is like Fig. 5. Last, we also integrate many statistics and computation and can export them in EXCEL file.

Now the system has been running for over a year, and our work efficiency improves largely. Previously, finishing one report averagely needs 13 workdays and most time wastes on organizing data and take paper report to look for all the bosses to sign. Now, we just need 8 workdays to complete a report. Not only manual computation is avoided and time is saved, but also the error accuracy and uncertainty are more reliable and precise. In addition, the superior always asks for some periodic or occasional work sheet. Artificial statistic is tedious and time-consuming, and now it is finished just by several selections and one click. The time on statistics reduces from two days to several minutes.
5. Conclusion
In the paper, we develop an integrated information system for our high-voltage metering lab. It automates a series of calibrating procedure from receiving, testing, report, signing to claiming. It also realizes the intelligent management and automated control of our lab. During system development we use two-dimensional code, online editing of WORD, electronical signature technique, which help largely improve efficiency. After using the system, the calibration period reduces from 13 to 8 workdays and the statistics work just needs several minutes.

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