# SUBSTATIONS REFURBISHMENT AND THE INFORMATION MONITORING REQUIREMENTS AND SOLUTIONS

**VIZITEU IOAN, NEDELCU ION, VIZITEU MARIA-GEORGETA**

*S. C. TELETRANS S.A.–Bacau Agency, S. C. TELETRANS S.A.- Bucharest, Polytechnic University Bucharest*

**Abstract:** The use of information for condition monitoring of the substations refurbishment is a very important problem. The ensuring continuous supplies of electricity to customers require the improvement of the equipment operation reliability and safety as a continuous process. The constantly monitoring and the diagnose techniques can contribute, in an essential way, at an improvement of equipment reliability. We can identify in advance the deteriorating tendencies and if it is the case, respective elements can be isolated before reaching the state of total failure. The paper present the main requirements of the monitoring installations in the EHV and HV substations, different devices of monitoring primary equipments located in the substations and the Romanian solutions for power transformer and autotransformer monitoring and the web based acknowledge.

**Keywords:** substation refurbishment, information monitoring

## 1. WHAT WE WANT IN CASE OF MONITORING INSTALLATIONS IN SUBSTATIONS

Functional and performance specifications for the monitoring system should be maintained by the utility. Most likely, monitoring the functionality in substation where only the secondary equipment is retrofitted (primary equipment is not) is lower in substation where both primary and secondary equipment is retrofitted.

For the EHV substations the targets of the monitoring consist of:

- Identifying the equipment to be monitored (circuit breakers, disconnections, current transformers, voltage transformers, power transformers and auto-transformers, secondary equipment).
- Analysis of equipment in normal and faulty conditions (information for analysis, the correct operation of the secondary equipment, secondary system supervision, fault reports and analysis, and status reports of equipment).
- Maintenance assistance (relevant equipment parameter evaluation, adaptation of the maintenance methods to the
equipment real condition, and improvement of the maintenance procedures).

## 2. METHODS OF SUPERVISING OF DIFFERENT DEVICES

Parameter identification is critical to the design of a quality monitoring system. Assigning a value to each parameter is based on evaluating the correct and complete health of the equipment, and the cost to acquire and process the data measured for these parameters. The objective is to design a monitoring system that minimizes the cost/benefit ratio.

### 2.1. Monitoring circuit breakers

The content of adequate information offered could be contact-wear, which can be estimated by counting the number of circuit breaker operations and current disconnects. Shows an evaluation of the degree of wear using the on-line monitoring data for a type 10-110kV circuit breaker.
The reference curve shown in fig.0-1, is based on pair values (switch current and number of operations) guaranteed by the manufacturer. The switching capacity of a HV circuit breaker, defined in CEI publication 56, can also be evaluated through the number of operations and corresponding values of the short-circuit current guaranteed by the manufacturer
For a certain percentage-wear the operational duty slope of the breaker's switching sub-assembly remains identical with the standard duty slope. Based on [6], it is therefore possible to calculate the number of interruptions of the fault current for several percentages of wear; e.g., 50%, 25%, 10%. These curves are shown in fig.0-1

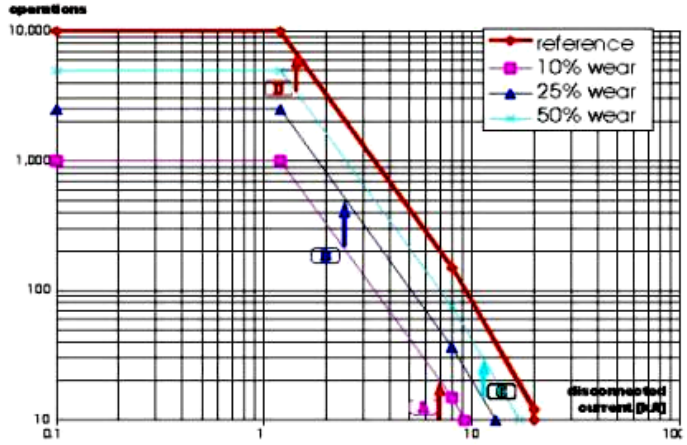


Fig. 1. Example of braker wear curves

*Example of switch acoustic impression:*
By acquiring and comparing the vibration "fingerprints" or signature with a reference, changes in the mechanical condition of the device can be determined from changes in the vibration patterns. Vibration patterns can be measured using accelerometers.

### 2.2. Monitoring disconnectors and earthing switches

The following parameters needed to monitor disconnectors and earthing switches are:

- Recording of motor current and voltage
- Storage of the records
- Comparison with a reference curve
- Calculation of the motor running time
- Monitoring of motor during the idle state.

This information could be acquired only with future equipment.

### 2.3. Monitoring current and voltage transformers

Measurements made during maintenance could provide information about main isolation, partial discharges level, and Anti-Ferro-resonant circuit resistance.

**2.4. Monitoring power transformers and auto-transformers**

On large transformers there are multiple stages of cooling. When the transformer gets hot, there are pumps to circulate oil through the cooling loop. If the oil doesn't circulate the transformer will be damaged. Monitoring equipment must be designed to reliably detect faults in an incipient phase before the transformer or autotransformer is damaged.
There are several ways to detect a faulty oil pump. One approach is by logic: A command is sent to the oil pump to operate, but the temperature continues to increase. Another approach is to use a "sail" switch in the oil pump outlet to detect movement of the oil. Another approach is to measure the monitor the small pressure differential across the pump. Another is to monitor the running current of the pump motor.
Monitored data can be used to estimate the transformer age and remaining lifetime. These data are also used to determine when to inspect the insulating bushings.
Signalling (alarms) and disconnection functions can be monitored by a signalling relay measurement of oil limit temperature overrun with two thresholds: a signalling contact and a disconnecting contact. A signalling relay monitoring non-operation of the oil circulation pumps or cooling fans can correlate the x with the transformer's load. The signal is transmitted within 2 to 5 minutes. Disconnect within 5 minutes is required to prevent damage.

*1) Data collection:*

Data collected and reported by the monitoring system should include voltage from the primary side, primary line currents obtained from the current transformers, oil temperature from the transformer topside, ambient temperature, and network voltage frequency.

Monitored states should include:

- Gas Buchholtz relay position of 2 signals corresponding to the state of the signalling and release circuits
- Operational state of the protected equipment for the HV and/or LV insulating bushings capacitor type, 2 normally open contacts (signalling and release)
- Oil pumps state based on data obtained from the pump motors
- Cooling fan state based on data obtained from the fan motors
- State of MV and LV transformer switches
- Oil level from the conservatory
- Normally open contacts for the maximum level and minimum level
- The state of the relay that is part of the tap selector, which is normally an open contact.

*2) Software facilities:*

The software required for monitoring power transformers and autotransformers should include the following:

- Data displayed in tables and graphics form
- All monitored data displayed in the desired time interval
- Calculation of apparent powers for a phase and in a triphase system corresponding to the transformer load on the HV side
- Highlighting the overload periods
- Select the sizes presented simultaneously on the graphic
- Printing the desired data
- Monitored transformer marking, its power, its manufacturing series, the substation name, etc
- Protection functions doubling in case of damages or abnormal conditions
- Transformer age estimation from the themic point of view
- An over-control function of the monitoring system (e.g.; the hydrogen or partial discharges monitoring, etc.) or of tap selector connection.

*3) Online monitoring of moisture in the transformer oil:*

A capacity humidity sensor can be used to monitor the relative humidity in the transformer oil. These measurements and the oil temperature are then used to estimate the abnormal rate of paper degradation by detecting an increase in the overall moisture content.

*4) Intelligent transformer fault monitoring:*

A transformer incipient fault monitor can be used to measure the parts per million (ppm) composite value of gas generated by faults. This instrument should also detect and measure hydrogen and carbon monoxide gas in the oil, top oil temperature and load current. The monitoring device that receives this data could then evaluate the

status and capability limits of the transformer, and estimate the remaining life of its components. A device made in Romania able to resolve all this requirements is TRAFOMON [14], [15]

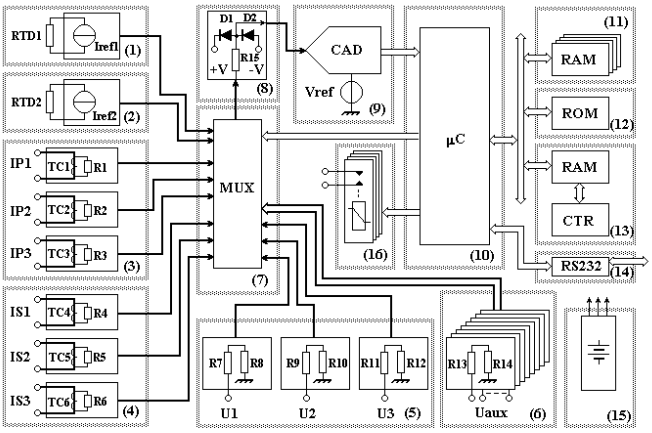


Fig. 2. The block diagram of the TRAFOMON equipment

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