ThermoSensor. Monitoring of the State of the Electrical Equipment Contact System in 0.4-20 kV Networks

Trends of modern power engineering are focused on digital network development. One of the tasks of PJSC "Rosseti" Concept of Networks Digitalization for 2018-2030 is the implementation of electrical network equipment capable to continuous condition monitoring and defects identification.

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ThermoSensor remote control system is designed for contact system of 6-10 kV Package Outdoor Switchgear (POS) cubicles, equipment of 6-20 kV Packaged Transformer Substations (PTS) and 0,4 kV switchgears. The system is fully compatible with PJSC "Rosseti" target technological model of digital network and provides with possibility to determine local emergency overheating of electrical equipment in continuous mode with subsequent automatic signal sending to the dispatcher console.

ThermoSensor system (Fig. 1) consists of gas-generating stickers, a gas sensor and checking and receiving device (CRD). Stickers are placed on the contact connections (CC). When heated, the stickers change the color and generate signal gas, which is captured by the sensor. The overheating signal is transmitted via CAN bus or Modbus RTU (RS485) to the CRD, then to the workstation (WKS), central control room (CCR), digital communication center (DCC) and fire alarm system. In addition, the sensor beeps. Also, automatic disconnection of protected object is possible.

ThermoSensor system provides fault-finding before an emergency shutdown and fire occur. Figure 2 shows CC heating chronology. Segment no. 1 on the life cycle line of electrical equipment demonstrates time period when CC emergency heating occurs (for example, as a result of short-circuit currents). On this segment, planned infrared control can detect CC heating only when flowing currents are close to the maximum. After some time, the defect grows. Line no. 2 shows stable CC heating, which is easily detected by thermal imagers or pyrometers regardless of the load. On this segment, significant degradation processes take place in CC (those processes characterize CC reliability). During any subsequent network disturbance, as well as long-term day-to-day operation, this CC can be damaged and go to the third phase (line no. 3 in Fig. 2). When emergency temperatures are reached, the CC is destroyed regardless of the load. When this happens emergency shutdown occurs and leads to fire in some cases.

ThermoSensor system automatically fixes single local CC overheating up to 80-120°C, and transmits a fault signal long before an emergency or fire occur.

ThermoSensor system advantages in comparison with classic

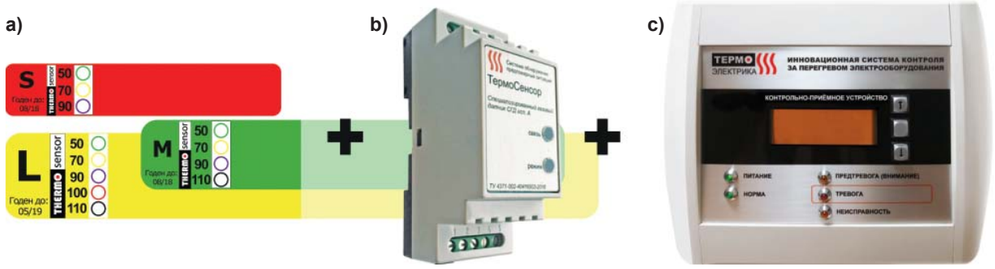

Figure 1. *ThermoSensor innovative system for monitoring of electrical equipment overheating: a) gas-generating stickers with heat-indicating scale; b) specialized gas sensor; c) checking and receiving device*

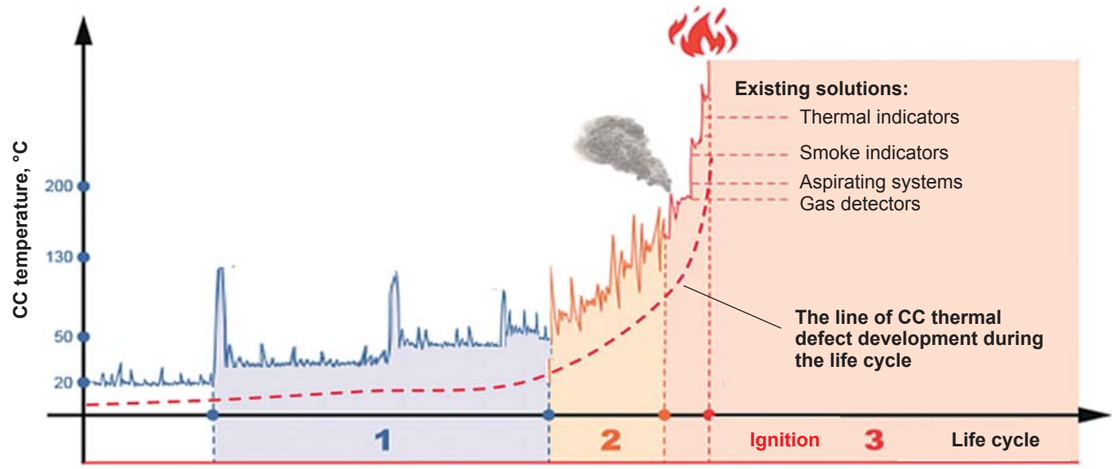

Figure 2. *Heating chronology of contact connection (CC)*

diagnostics of distribution network electrical equipment are:

- costs saving for expensive thermal imaging;
- inspection personnel drawdown;
- continuous electrical equipment monitoring without inspection interruptions (including monitoring during peak loads). It should be pointed that CC resistance measurement or CC heating control with pyrometers give a possibility to assess technical state at given time under given conditions. With that, firm prediction of obsolete electrical equipment reliability is a systemic scientific and technical problem;
- ability to control nodes which are not suitable for thermal imaging;
- absence of necessity to disconnect electrical equipment for inspection purposes. As a result, there is no need for additional switching and special modes in electrical network. It increases diagnosis accuracy and efficiency;
- efficiency upgrade and automatic transmission of data on detected defect to the customer or operational personnel and hence cutting time for remedial work organization;
- improvement of diagnosing efficiency for electrical equipment with excess operational lifetime and reducing operational costs for maintenance. The frequency of technical diagnostics approved by standards and technical documentation has to provide relative reliability of defects detection in electrical equipment within its rated lifetime. Defects in worn-out electrical equipment grow much faster in comparison with equipment working for rated lifetime. Due to this fact it can be necessary to shorten the time between scheduled diagnostics of obsolete electrical equipment, to reduce overhaul period and, as a result, to increase operating costs;
- ThermoSensor system provides observability of electrical network, and is a self-diagnosis system element for determination of contact system conditions. The development of data transfer system from ThermoSensor CRD to utility's network management system gives a possibility to provide intellectual adaptation of network operation modes depending on network technical conditions (as an example of such adaptation is interdiction to connect load to cubicles where emergency overheating is detected);
- integration of the ThermoSensor system in post-accident monitoring system (PAMS) improves accuracy of real technical condition index calculation. The improvement of the system for collecting and analyzing ThermoSensor operation results gives a chance to evaluate repair work efficiency. Among the estimated factors are materials and technologies used, the quality of repair crews operation, and distribution network elements deterioration.

Thus, the ThermoSensor system provides effective control of equipment reliability taking into account the revealed shortcomings of the classical diagnostic system. The technical result of the ThermoSensor system implementation is a reduction of emergencies in electrical networks and an increase of operation efficiency.

Experimental operation of the ThermoSensor system and its implementation as a pilot project are already conducted at a number of major Russian enterprises. ThermoSensor system efficiency was proved by full-scale tests carried out at the facilities of PJSC "MOESK", LLC "ABB" (tests in 6-25 kV switchgear cubicles) and JSC "UNECO" (tests in RM6 cubicles).

ThermoSensor system production is located in the Russian Federation. It is protected by patents and has the necessary certification, including certificate of FGBU VNIIPO of EMERCOM of Russia. The ThermoSensor system is the cheapest technology in the world, characterized by simple installation and maintenance.

THERMO sensor

ThermoSensor system is a Russian innovative solution for gas analytical control of CC heating of distribution network electrical equipment. The system has competitive advantages in comparison with technologies for CC overheating detection and has no analogues in the world.