Development of common technical requirements for monitoring and diagnostic systems to improve availability of substations

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Availability improvement is one of the top-priority targets when constructing and reconstructing substations. Automated systems of monitoring and diagnostics (ASMD) for high voltage substation equipment (HVE) develop rapidly both in Russia and all over the world. However, the generated standard technical base that regulates ASMD engineering and application does not cover all the HVE types. In 2008, the Federal Grid Company of the Unified Energy Systems introduced a company standard. It organized requirements used as a basis to implement ASMD for one type of equipment only – that is a supply transformer. And still, due to intensive development and implementation of a great number of ASMD lately all over the world, generation of standard technical references becomes one of the ASMD development major issues.

In 2014, the authors performed a work aimed at organization and compilation of scattered technical requirements for ASMD of various HVE types; those are supply transformers, high voltage circuit breakers, measuring transformers, gas-insulated switch gear, voltage suppressors, cable boxes, GIL.

ASMD is functionally considered as an information and measurement system. It performs functions of logical processing and presented results of direct measurement or calculation of diagnostic parameters that characterize signs of ageing, generation and development of defects of the monitored equipment.

Construction principals for ASMD in HVE are suggested. Their consideration will allow organizing a system of diagnostic monitoring taking into account state-of-the-art development of devices and analytical base including information technologies. The principals address organizational (support of integration of monitoring and diagnostics system into the system of information exchange of power object), technical (application of optimum quantity of sensors and other elements of monitoring and diagnostics system that provide solutions for set goals), and technological issues (number of levels in ASMD design is to be determined by number of management levels of the object). It is shown that in Russia it is possible to introduce three, four or five level ASMD. At any number of levels, the lower level is technological and the upper one is analytical.

An approach to evaluate economic performance of ASMD application for the reviewed HVE types and substation in general is developed. The payback time of ASMD was estimated depending on its relative cost expressed in percent of the substation equipment cost. In order to improve economic efficiency, it is suggested to optimize list of ASMD diagnostic

parameters based on the analysis of accidents statistics of a specific equipment type in each case and to identify the most common defects.
The authors defined general technical requirements both for ASMD instrumentation for each HVE type and each diagnostic parameter and for organizational and technological support of ASMD as a unified system. The requirements consider the current level of ASMD analytical procurement as well as experience and possibility for permanent monitoring of diagnostic parameters. The methods and conditions of elements assembling of ASMD measuring systems are listed.
Requirements for mathematical support are presented along with requirements for ASMD types of procurement. The mathematical support of VHE ASMD presumes a set of mathematical methods, models and algorithms used to evaluate technical condition and diagnostics of the equipment. There are three determined mathematical methods for these purposes. They are different in compilation: probabilistic, deterministic and statistical. It is observed that the next level of mathematical models development is a hybrid neuro fuzzy expert system. At that, evaluation of residual HVE potential should be one of the ASMD functions. Requirements for residual potential evaluation are developed; forecast algorithm for residual potential is presented. Forecast process is based on the defect development model built for example on the analysis results of types, consequences and failure criticality (FVECA), analysis of cause-and-effect tree for defect development, evaluation of failure risk.
Therefore, results of the presented work should be reviewed as a step towards generation of standard technical base of HVE ASMD and substation in general. It would implement state-of-the-art approach to online monitoring of equipment technical condition that allows improving significantly availability and control of substations.