Possibility of assessment of changeability of performance for selected electric apparatus and equipment by monitoring of the ambient pollution level

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Abstract: In the paper possibility of both destructive and positive effect of polluted environment on electrical parameters for selected apparatus and equipment under operation are presented and discussed. A simple monitoring system based on selected sensors available on the market as gaseous as well as of dust is recommended. The monitoring sensor system presented that is predicted to be assembled basing on the available as gas as well as dust sensors is recommended for control and diagnosis of operation reliability among others for both suspension and stand-off insulators of overhead electric power stations (MV and HV) located at area of particularly high environmental hazard. Appropriate conclusions and practical recommendations are formulated.

Key-Words: pollution, monitoring, performance parameter changeability, electric equipment, insulator, overhead electric power stations

1 Introduction
Monitoring of an ambient pollution is at present general requirement both with point of view of the adverse effect on the human health and life as well as of the harmful effect on, amount others, electric apparatus and equipment operated in overhead power stations. The goal of a control of the ambient air is:

• monitoring of indicator factors that determine an existing pollution density of air with respect to permissible level according to applied law [1,2],
• registration of present meteorological conditions to predict their variation within required, defined time,
• determination of reason – effect relationships taking into account location of the pollution sources, their intensity, direction of dust inflow related to both meteorological and topographical conditions etc.,
• assessment of the threat for human health and life as well as estimation of the unacceptable degradation of any electrical apparatus and equipment performance under their operation. Undertaking, as a result proper steps to keep the operation safety on require safe level.

Usually, the polluted environment exhibits negative influence on operation reliability of majority of the electric equipment [3]. However, for some specified cases it can, on the contrary, improve even the performance as it is indicated and explained in [4]. Therefore, independently on the environmental affect it is needed to know the correlation function between the ambient conditions and variation of electrical properties of the equipment and/or apparatus being exploited. It can be obtained only on the basis of experimental results under real conditions of operation. Thus, an appropriate measuring sensor system is needed to be developed for carrying out the investigations to find right correlation between variation of selected electrical properties and the environmental pollution level with dust and/or gaseous substances.

In the paper the selected cases of both negative and positive effect of the polluted environment on the electric equipment are presented and discussed. A simple monitoring sensor system for an assessment of the reliability of the insulators operated in overhead power substations of a middle and high voltage has been proposed. The appropriate conclusions and recommendations for use in practice are formulated as a result.

2 Examples of influence of the polluted environment on performance of selected electric equipment
Operation reliability of any electrical equipment is strongly related to air pollution level what is
particularly visible in the overhead electrical power stations or/and in hazardous industrial environment like: in mines, chemical, metallurgical and food-processing plants. It must be noted that independently on deterioration of the electrical parameters a safety of service due to corrosion of metallic housing is also reduced. Particularly sensitive for the environment interaction are any electrical contacts both splices as well as connectors. The contact resistance value under operation usually increases what is related to significant increase of the power loss within the contact area associated with the respective rise of temperature. As a result the contact can be lost what increases a fire or/and explosion hazard particularly in methane surroundings. Electronic devices and systems are also sensitive to the environmental conditions. For example in PLC or in any electronic convertor the cooling deterioration (e.g. due to corrosion of the thyristor footing – see Fig.1) can result in out of control of the thyristor ignition angle and injection as a meter of fact of an undesirable level of high harmonics (both voltage and current). It leads to significant decrease of the energy quality level.

However, it is worth to underline that for particular cases the polluted environment does not only deteriorate but even improves the equipment performance. It applies to newly developed composite material on base of copper and molybdenum (Cu-Mo) used in sliding contacts DC of the copper mine transportation [4]. Under heavy polluted ambient particularly with sulfur and rock-salt compounds the contamination films growing on a surface of the laminar Cu-Mo composition are characterized by a weak adhesion force. Therefore, under sliding motion they are easily removed resulting in so called “self-cleaning” effects. As a result a friction force value decreases significantly (at least by about 3-times) without evident deterioration of the contact electrical conductivity. With compare to the graphite based compositions the wear is considerably reduced what can be seen from Fig.2. If about the insulators they are selected properly depending on the pollution level (pollution zones [1]).

However, a preventive maintenance (surface cleaning) is being performed periodically often independently on verified deterioration of the electrical parameters. Each such action requires the de-energizing of selected portion of the power station. To avoid the useless stoppage of energy supply an employment of a specially developed sensor system (for on-line monitoring density as well as type of dust being deposited on the insulators surface) is needed. However, it makes sense only if correlation between level of pollution and electric strength is known. As a results it allows for elongation of the insulator operation in time without the servicing as well as for avoiding of the
overhead power station failure in a case of sudden decrease of the electrical parameters of the insulators applied [7].

3 Suggested measuring sensor system

Due to variety of the industrial pollutions the proper sensor selection is not trivial. As far as chemisensors of gases (e.g. sulphur oxide) are available, the choice of the dust detecting element determines the technical problem. Analysis of gaseous compositions in air consist in (to/put in simply) “burning” of collected small gaseous quantity under specified conditions and next by measurement of the resistance of a circuit sensitive for the products of the burning process. Therefore these sensors are service free, multiple use, durable and automatically operated elements. On the contrary a control of physical parameters of air is much more easy. On the market there are available numerous full digital sensors of temperature, humidity and pressure as well. Only challenge is control of the dust particles suspended in air (PM) [5,6]. The most of the dust sensors however, are characterized by crucial defect due to principle of operation. Since they need hand operation therefore, they are not suitable for use in any automatic system. Luckily, a few of them meet requirements if about as applicability as well as a way of integration (API available, controller technical aid of producer or distributer). For consideration two sensors were selected:

• sensor of family Dust Trak II, TSI Incorporated, USA [8],
• isotopic sensor Vereva F-701-20, Durag Group AG, Germany [9].

The Dust Track sensor however, uses traditional measuring method but is equipped with automatic system for control of an absolute weight of the dust sample collected from air. The more it is able to collect simultaneously two samples of the dust with possibility of a size segregation (PM10, PM5, etc.). The metering pomp is precisely controlled by a microcomputer therefore, the sensor can continuously operate automatically for many weeks. (It is worth to note that the collected samples are available and can be subjected to a chemical test). The selected Dust Track II 8535 sensor together with battery and modem for wireless transmission located inside a protective housing is presented in Fig.3.

Totally different principle of the dust measurement is employed in Verewa F-701-20 sensoring system. Testing here is fully automatic using C-14 isotope to control the air sample weight flowing through a measuring chamber. The front view of such the measuring station is presented in Fig.4, while its structure – in Fig.5 respectively.

This isotopic sensor system is characterized by higher measuring accuracy and of course by much higher price as well. However, integration possibility with the automatic system are similar for both considered measuring sensoring stations but the Dust Trak requires periodical exchange of the chamber for samples. The Verewa system operates automatically but application of a few of such sets (for monitoring a considerable area) can be a financial problem.

Fig.3 View of the Dust Trak II 8535 measuring station [8]

Fig.4 Front view of the Verewa F-701-20 measuring station to control the dust particles suspended in air [9]
Fig. 5 Structure and principle of operation of the Verewa F-701-20 measuring station [9]

4 Conclusion
- Monitoring of an ambient pollution level is at present a general requirement due to necessity of determination of its adverse effect on both human health and life as well as on performance degradation of electrical equipment and apparatus.
- The correlation between the state of degraded environment and variation of electrical parameters for various equipment (for reliability analysis purpose) can only be based on measuring data recorded by the appropriate sensoring system applied.
- The monitoring sensor system presented that is predicted to be assembled basing on the available as gas as well as dust sensors is recommended for control and diagnosis of operation reliability among others for both suspension and stand-off insulators of overhead electric power stations (MV and HV) located at area of particularly high environmental hazard.

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