MODERN TECHNOLOGICAL SOLUTIONS IN ELECTRICITY SUPPLY

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Abstract: *This paper examines the impact of electrotechnical installations on the environment, in particular the influence of an electromagnetic field, a source of which in the residential buildings are the transformer substations, the distribution boxes for power supply, as well as the conductors from the supply network. Attention is paid to thermal imaging as a modern technological solution that can be successfully applied to the diagnosis of building energy systems.*

Keywords: *thermo-vision research, transformer, electromagnetic field, electric smog.*

Introduction

The problem of the interaction of energy objects and the environment in the modern stage of the development of mankind is gaining new dimensions, influencing both the vast territories of the planet and the atmosphere and the hydrosphere.

More significant volumes of energy consumption in the foreseeable future predetermine the further expansion of the area of impact on all environmental components on a global scale.

The environmental problem - in particular, the impact of the electrical facilities of the environment is one of the most important issues in the energy sector.

Any electrical equipment, to some extent, has a negative impact on the environment, including living beings, from insects to humans.

The damaging influence of various electrical objects involves air, water and soil pollution with TPP and NPP waste, releasing unused energy into the environment in the form of heat; influence of the electromagnetic field on living organisms, increase of the noise level, etc.

Over the past decade, with advances in technology and medicine, there is increasing evidence that low-frequency electromagnetic fields, noise, vibrations and emissions from harmful gases are adversely affecting human health.

For these reasons, the European Commission Directorate for Research is increasingly funding studies related to the determination of the potential human health effects of long - term exposure to low frequency electromagnetic fields, noise, vibrations and carcinogen emissions from electrical installations, installations and appliances.

I. INFLUENCE OF ELECTRICAL EQUIPMENT ON THE ENVIRONMENT

In the last third of the 20 th century the intensive use of electrical energy in the modern information society has led to the emergence and formation of a new significant environmental pollution factor – electromagnetism.

The reason for defining such a factor is the intensive development of information and energy technologies, remote control and monitoring, some modes of transport, and the development of a number of technological processes.

It is now clear that the electromagnetic field of artificial origin is an important ecological factor of high biological activity and is becoming more and more scalable with electromagnetic pollution of the urban environment.

The growth in electricity consumption and the development of electricity grids united in a single energy system have led to a significant increase in the number of people exposed to electromagnetic fields from high-voltage power lines.

Electromagnetic radiation, like radiation, has neither taste nor smell, but one encounters it every day.

The more comfortable life becomes, the more the assortment of the available electric appliances increases.

Human life is submerged in electromagnetic fields – 98% of the population uses household electrical appliances and the remaining 2% of the population is surrounded by electromagnetic fields created by each conductor running alternating current, including the wires of the power grid.

If the possibility of damage to tissues and cells associated with exposure to X-rays is beyond doubt, the effects of electromagnetic radiation on living organisms whose sources are power lines, cell phones, electrical appliances, and transformer posts have only recently begun to attract attention as a potential threat to the health of humans.

Among the sources of electromagnetic field in residential buildings, the transformer substations, the distribution boxes for power supply, as well as the wires from the power supply network are particularly important.

The safest distance from a person to them can be defined only by using special devices.

The typical safe distance is 1.5 ÷ 5.0 meters.

The electrical effect of the buildings, namely the cable lines, the distributors and the transformers, has the greatest influence on the electromagnetic environment in the living rooms in the industrial frequency range of 50 Hz.

In the rooms where these sources are located, the magnitude of the field is usually increased and the field strength is usually not high and does not exceed the allowable levels of 500 V/m.

Power transmission lines create electromagnetic field, which is distributed among tens of meters.

The load on these lines changes over time and through different seasons of the year, resulting in a change in the field intensity level.

From an environmental point of view, the fields are too dangerous, because these lines as well as the transformer substations are located directly in cities, including in residential buildings.

Electromagnetic fields from these facilities bring an important, and often a determining, part of the overall electromagnetic environment in cities.

Electromagnetic emissions of technogenic origin are a major source of physical environmental pollution. Recently there has been talk of electromagnetic smog (by analogy with the chemical).

Electromagnetic smog represents pollution of the man-made environment with non-ionizing emissions from devices using, transmitting and generating electromagnetic energy arising due to imperfections in technology and/or irrational use.

The reason for the internal smog in the premises is the parasitic overlaps of the sine wave of the industrial frequency current.

Both types of pollution, electromagnetic and chemical, have common features and can adversely affect humans, animals and plants.

A characteristic feature of electromagnetic pollution of cities is its multifrequency and multifactoriness when multiple radiation sources of different frequencies, intensity and location are available in a certain area of the site.

The lack of a correct assessment of electromagnetic fields as an environmental pollutant leads to a deterioration of the ecological situation.

Supply lines and high voltage devices are the most powerful sources of electromagnetic radiation.

Research into the impact of radiation on human health begins with the construction of the first such facilities when there is an inexplicable worsening of the health of workers and residents around them.

Nowadays, in the context of the continuous growth of energy consumption, there is an open question about the power supply of residential buildings, businesses and offices. Greater power is needed for urban substations under tight construction.

This issue is solved with the use of transformer equipment up to 35 kV up to the user (home, block, enterprise).

More consumers can get electricity at the expense of increasing power consumption, which reduces electricity transmission losses.

However, the increased power of the transformers leads to an increase in the substation size and to the permissible noise levels during the day and at night.

Therefore, environmental solutions to reduce the noise of the transformers, the main sources of which are magnet ducts, cooling systems, windings, metal structure, resonance fluctuations from the overlapping of sound frequencies.

There are many methods to reduce the noise level of the transformers - constructive, technological. It is also possible to use vibration suppressors.

One of the cardinal methods is the use of screens in the form of wall-type constructions built on sites when installing transformers.

But all of these measures are costly, as substantial inputs of additional materials are needed, the construction of large-scale enclosures.

There are many methods to evaluate the technical condition of transformers.

Diagnostic methods are best suited for the application of which no voltage drop is required.

The most widely used are the following methods: thermal imaging, vibration diagnostics and oil analysis.

II. THERMOVIZIONAL DIAGNOSIS OF POWER TRANSFORMERS

Thermal imaging studies make it possible to diagnose the following defects in the transformer installations:

- short circuits in the windings;
- faults in the contact system for voltage regulation;
- the appearance of scattered magnetic fields in case of isolation of individual components of the magneto conductor;
- defects in the transformer cooling system oil pumps, filters, fans);
- variation of the internal oil circulation in the transformer (formation of stagnation zones), displacement of the insulation of the windings;
- heating in the contacts of the windings with the transformer terminals;
- earthing bus interruption, etc.

Together with the diagnostics of the oil, the thermal imaging study of the transformer structures and assemblies is related to the group of basic methods of investigation of its technical state.

This study is performed in load mode of the transformer.

Thermal imaging and photographic capturing and assessment of the thermal state and efficiency of the studied elements are made.

Thermal imaging diagnostic of power transformers is a rather complicated procedure because local defects in them can „dampen" heat flows from the magnet and windings. In addition, the cooling equalizes the temperature distribution in the defective areas.

In thermovision is estimated thermal condition of electrical and current conductors depending on operating conditions and type of construction.

The elevated temperature sections are compared to the Transformer Technical Documentation, which provides information on the design of the windings, oil circulation zones, the magnet and its elements.

This monitors the operation of the cooling system, evaluates the oil circulation area.

This control makes it possible to detect anomalous heat zones on the surface of the transformer tank due to displacement of the oil flows.

The experience of conducting such a study under different climatic conditions indicates that a number of requirements are required to diagnose defects.

The reason is the low heat dissipation in isolated structures and the low temperature contrast, which is significantly affected by the optical properties of the surfaces and the environment.

In order to diagnose with a thermal imaging camera, a number of requirements must be met:

- the camera should be oriented towards the surface under investigation at a certain angle, depending on whether it is metal (0 ÷ 40°) or dielectric (0 ÷ 60°);
- measurements taken at temperatures of 20 ÷ 25°C and wind speeds of not more than 2 m/s;
- the capture of the transformer takes place no less than 3 hours after sunset; day-to-day measurements are allowed in the presence of heavy clouds;
- the current load on the previous measurement has a value close to the nominal value, etc.

An assessment of the state of the contact connections is made by comparing the temperatures of the same type of contacts in the same load and cooling conditions as well as by comparing the temperature of the contact connections of the current conductors.

A number of diagnostic requirements must be observed:

- when controlling contact chambers, the camera should be as close as possible to the measurement, and the measurement should not be in the rain;
- the wind speed must not exceed 4 m/s;
- the load must be close to the nominal.

As known, the state of the magnetic circuit of the transformer effectively can be assessed on the basis of chromatographic analysis of the composition of gases in the oil. In composition and saderzhanieto gas can judge the type of defect.

In case of damage to the magneto conductor as a result of overheating, the gases dissolved in the heating in the oil are ethylene (C_2H_5) or acetylene (C_2H_2).

Typical gases are hydrogen (H_2), methane (CH_4) and ethane (C_2H_6).

The formation of these gases may be caused by a failure of the insulation of the clamping studs, shock absorbers, local heating from magnetic fields, etc. Infrared Transformer Testing, as an auxiliary method of control in the presence of gas formation in the transformer, makes it possible to estimate the zone of defect formation in the magnet.

For more complete control and obtaining data on the nature of the defect development, it is advisable to perform a Infrared thermography (IRT) study of the transformer at a two- and three-degree load.

The resulting thermographic images can be used for building thermography information functions.

The temperature distribution on the surface of the transformer T (x, y) brings essential information about the presence of heat sources in its active part, the efficiency of the cooling system for the presence of local temperature anomalies caused by hidden thermal defects.

In the thermogram analysis, the properties of the radiating surface, the feature of the structure, and the presence of structural elements, partially shielding the object of control, are taken into account.

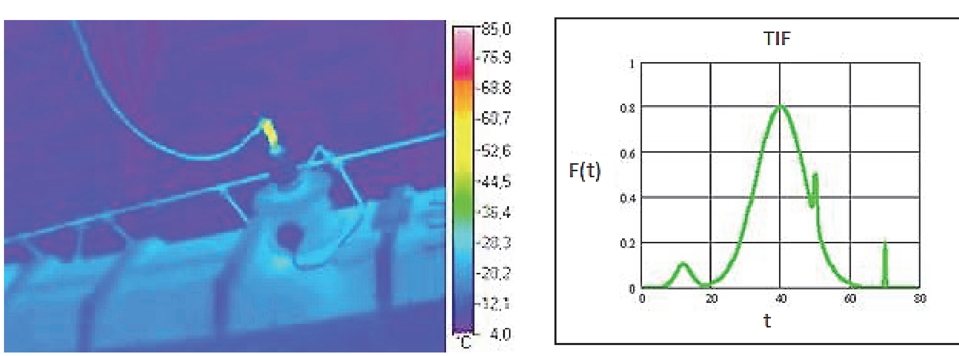
Thus, the function T(x, y) contains information about the above mentioned phenomena.

To obtain the thermographic information functions, the output function with a two-dimensional temperature distribution on the surface of the object T(x, y) is presented with a thermogram (Fig.1, A).

It integrates in the range [x1, x2] [y1, y2] to obtain the array F (t °) = ΣΣT (x, y, t °), tabulated data for the temperature (t) and the relative amount of surface this temperature (Fn).

Using the appropriate software, the table is converted into a thermographic information function (Figure 1, B).

The analysis is obtained by comparing a thermographic information function for a „reference“ transformer.



A. B.

Figure 1. A - Temperatures on the surface of the object;
B - thermographic information function

Conclusions

Thermal imaging diagnostics of energy equipment is a modern technological solution, which can be successfully applied in the diagnostics of building energy systems (for example – imbedded transformer in a building).

This research can be done in the form of periodic inspection of facilities, together with the methodology for conducting it.

This type of control can be combined with a modern system for monitoring the condition parameters of such a system that adversely affect the environment and the human body.

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