MEASUREMENT PROBLEMS WHEN INSPECTING
THE USE OF ENERGY BY ENTERPRISES

N. I. Khanov and L. S. Semenov

This article is devoted to one of the most important contemporary problems, namely the efficiency of utilizing energy resources in organizations and enterprises. An indication is given of the role of the Gosstandart Rossii metrological institutes, and particularly of the D.I. Mendeleev Institute of Metrology, in solving the problems of examining the use of energy by organizations and enterprises, of auditing the energy of commercial centers for making the payments due when transferring oil, oil products, and electrical and heat energy. The specific metrological features of the payment centers are described and problems which it will be necessary to solve are formulated.

In 1966 the Russian Federation approved an "energy saving law" which in particular made provision for adopting measures and carrying out work to economize the energy resources at all stages of their production, transportation, and consumption. In this connection special importance was attached to energy-saving State policies implemented using the principles of a combination of the interests of the suppliers and users in the efficient consumption of energy resources and a State review of their use in enterprises and organizations which was carried out in the form of energy inspections (energy audits). A considerable fraction of this work consists of instrumental monitoring, i.e., performing measurements.

Metrological problems of energy auditing are not new for the State Scientific Metrological Center of Gosstandart Rossii. They essentially repeat the problems which the institutes have successfully solved for many years when carrying out metrological certification of leading and basic organizations [1], namely an analysis of the status of measurements and metrological expertise in technical documentation and measurement techniques. The real picture concerning the efficiency of the consumption of energy resources in enterprises is revealed on the basis of the results obtained together with other data. A comprehensive analysis of the gathered information makes it possible to develop recommendations for solving problems in the energy-saving field and to introduce progressive measurement technology into enterprises [2].

A typical example of the successful implementation of such experience at present is work at the Mendeleev Institute of Metrology on monitoring the environment (ecological monitoring) which is being performed on the basis of the standard facilities located at the institute for the unit of the molar fraction of components in gas mixtures, the unit of refractive index using standard samples of gas mixtures and aqueous solutions created and certified at the institute.

An analysis of the status of measurements as applied to typical objects liable to energy auditing was made on the basis of the experience of the colleagues at the Mendeleev Institute. As a result, a determination was made of priority forms of measurement, the required measurement ranges and accuracies, the status of the normative base, a list of the required measuring instruments, and their metrological assurance. These are given in Table 1.

It can be seen from Table 1 that the energy inspections rely on data from measurements of various indicators which characterize the quality, consumption, and losses of the resources being consumed. When compiling the heat balance and determining the heat losses it is necessary to make reliable measurements of such quantities or parameters as the thermal conductivity, heat-transfer resistance, specific heat, thermal radiation coefficient, pressure, temperature, flow rates of cold and hot water and steam. When monitoring the quality of a fuel it is necessary to make measurements of its density, viscosity (for fuel oil), calorific value (heat of combustion), moisture content, to determine the component composition (for a gas), etc. The quality of combustion is determined on the basis of an analysis of the content of the exhaust gases CO, CO₂, O₂, SO₂, H₂S, NO, and NO₂.

When monitoring the cold water the content of compounds of Fe, Cu, dissolved O₂, the pH value, and the salt content are determined. The traceability and accuracy of these measurements is ensured by transferring the sizes of the units of the State standards of these quantities and parameters held at the Mendeleev Institute.

Understanding the importance and promise of the Mendeleev Institute participating in carrying out energy inspections, specialists of the institute formed an applied scientific field of study, the metrological assurance of energy-saving technology [3], based on scientific-research laboratories equipped with State standards and measuring devices of the highest accuracy to which were attached instruments for measuring the quantitative and qualitative indicators of energy resources for their extraction, production, reprocessing, transportation, storage, and use.

The principal aims of this scientific field are to provide the required accuracy, reliability, and traceability of measurements when accounting for released and consumed energy resources, improve existing methods and develop new methods for accounting for and monitoring energy resources, develop and introduce energy-efficient measuring and diagnostic technologies, structural and thermally insulating materials, and instruments to account for the quantity and quality of energy resources and to monitor their use.

While offering its energy inspection services, the Mendeleev Institute can perform its expertise at enterprises in documentation and instrumental calibrations of systems to account for and monitor the quality and quantity of different forms of energy and energy carriers entering the enterprises and being consumed and generated by them, of the technological equipment, and of the structures and thermal insulation materials used, with the appropriate suggestions and recommendations regarding the improvement of measurement technologies. The participation of our institute in the work of this field has been made possible by the polytechnic profile of scientific and applied research performed at the Mendeleev Institute and the presence of standards which reproduce and transfer the sizes of units of quantities for the majority of kinds and areas of measurements directly related to energy saving (State primary standards for the units of density, kinematic viscosity, pressure, temperature, air and water flow rates, combustion energies, electrical power, loss angle, working standards for liquid and air flow rates, etc.).

Of special importance is a particular but widespread energy inspection problem, namely performing an energy audit of commercial centers for the payment for natural energy resources [4]. It seems to us that with further development of the restructuring the monopolistic departments of the fuel-energy complex there will be a considerably increasing role played not only by commercial payment centers but also by the commercial accounting centers themselves as the objects of an energy audit, and consequently the requirements imposed on the quality of the measured results on the basis of which the payments are made will also increase.

Measurements at commercial accounting centers are complex indirect measurements, and their reliability is determined by the accuracy of the measuring instruments used, the rational planning of the measurements, and the quality of the technique for performing the measurements. The former is provided by the State standards in the various fields of measurement. The latter is based on the methods of planning measurements developed at the Mendeleev Institute. Thus, the quality of oil and oil products is assessed from the data of laboratory tests. If the quality of the oil supplied by one of the parties deteriorates, this party bears the financial responsibility, i.e., payment is made at a low rate for the entire period of the deterioration of the product. The indicators of the degree of the conformity of the results obtained under prescribed conditions serve as the assessment criteria. Under conditions when there is the necessary metrological assurance of the measuring instruments used to assess the quality of the oil or oil products, there is a reduced risk of a conflicting situation in a commodity exchange between the supplier and the user. However, in the absence of metrological assurance and norms the closeness of the tolerance of a deviation of the results from the normative value cannot be monitored.

During an energy audit at locations where the oil is extracted it is necessary to have automated instruments for measuring pressure, temperature, and flow rate, and continuous-flow densimeters and hygrometers making it possible to measure the water content in the oil products in the range from 0 to 100% when user payments are being made. The principal problems which must be solved as part of the scientific field of the metrological assurance of energy-saving technologies include the following:

- analyzing the system of legal relationships between producers, suppliers, and users for the purposes of combining their mutual interests and developing the requirements imposed on the metrological assurance of commercial centers (as regards the accuracy of the measuring instruments and of the measurement techniques used);
- analyzing the level of technical equipment and measurement technologies used when determining the quality of energy resources at the payment centers at the stages of their production, reprocessing, transportation, and use;