# Energy inspection of the boiler room

To establish **the efficiency of energy use** in the boiler house, **an energy audit** is conducted, which involves the following works: collection of source statistical information; visual inspection of equipment; instrumental examination with the help of portable devices; processing and analysis of the obtained data (statistical and experimental); assessment of **fuel and energy efficiency**; development of proposals for **energy saving measures**; registration of survey results.

During the collection of initial information the questionnaires of unlimited forms are used, which include: technical characteristics of the main and auxiliary equipment of **the boiler room**; monthly financial expenses for **fuel** and **electricity**; cost data and tariffs for **energy produced**; monthly quantitative and qualitative characteristics of the main and reserve **fuel**; monthly output, **energy supply** and **energy consumption** for own needs; monthly **energy losses** in **thermal and electrical networks**; specific **fuel consumption** rates for produced and released **energy**, for own needs and losses in networks.

The source information should include simplified schemes of **energy sources**, **energy supply** schemes and **energy metering schemes**, technical reports on performance of regime-adjustment tests and regime maps of **boilers** developed on their basis, data on **energy costs** obtained at the enterprise with the help of standard stationary devices.

The following are subject to visual inspection: technological equipment of the **boiler room** (**boilers**, **heat exchangers**, deaerators, pumps, etc.); **boiler house** fuel economy; technological pipelines and fittings; b**oiler** heating and ventilation system, thermal curtains; enclosing constructions of **boiler rooms** and auxiliary buildings; **heat**, **fuel**, **electricity** and water metering system.

When inspecting the **boilers** you should pay attention to the condition of the masonry (physical condition, surface temperature); thermal insulation of flues; stability (absence of large pulsations of rarefaction on a gas path and brightness of a torch in a fire chamber) of a mode of burning at constant thermal loadings; on the availability of automation and regulation; on staffing in accordance with the project, or control and measuring devices, and their serviceability, on the presence of steam leaks and **fuel** leaks (near the burners); leaks of blast air from distribution boxes; for the presence of a regime card on each boiler, with the date of its approval and compliance of the physical modes of operation of the boilers with its requirements.

When inspecting the fuel economy of the **boiler house**, attention should be paid to the state of external thermal insulation of **fuel** tanks, **heat exchangers**, **fuel**, steam and condensate pipelines, especially laid between the **boiler room** and the **fuel** storage, the state of acceptance, accounting, **fuel** storage conditions.

When inspecting process pipelines, flange connections and fittings, it is necessary to pay attention to the condition of thermal insulation and the presence of leaks of steam, water or **fuel**.

During the inspection of heating and ventilation systems, attention is paid to the presence of condensate drains (when working on steam), control systems, the state of thermal insulation of pipelines and fittings, the presence of steam and water leaks.

Instrumental survey is used in the absence of information necessary to assess the efficiency of energy use, and which can not be obtained from documents or raises doubts about the reliability.

Stationary or specialized portable devices should be used for instrumental examination. During the measurements it is necessary to make maximum use of existing **energy** metering units, both commercial and technical. During the instrumental survey, the institution is divided into systems or objects that are a subject to a comprehensive research.

Measurements during the instrumental examination are divided into the following types.

Single measurements - the simplest type of measurement, which examines the **energy efficiency** of an individual object when working in a certain mode. An example is the measurement of **boiler efficiency**, inspection of pumps, fans, compressors, etc. For single measurements, a minimum set of measuring devices is sufficient, which are optionally equipped with recording devices.

Balance measurements are used when drawing up the balance of distribution of any **energy** resource by separate consumers, divisions or objects. Before carrying out balance measurements it is necessary to have the exact scheme of distribution of **energy** carriers on which the plan of measurements necessary for consolidation of balance should be made. To perform balance measurements, it is desirable to have several measuring instruments for simultaneous measurements at different points.

Parameter registration - determining the dependence of any parameter in time. An example of such measurements is the removal of the daily load schedule, determining the temperature dependence of heat consumption, etc. For this type of measurement it is necessary to use devices with internal or external devices for recording and storing data and the ability to transfer them to a computer. In some cases, the use of stationary meters without recording devices is allowed, provided that their readings are taken at regular intervals.

In the process of **energy audit**, the actual values of the main parameters (**heat** and mains water consumption, temperature and pressure) are determined using measuring instruments, comparing them with the calculated values, and then the reasons for the discrepancy between the calculated and actual values.

Determination of the composition of **boiler** combustion products, flue gas temperature and **fuel** combustion **efficiency** is performed using gas analyzers. The obtained data can be used to calculate the **efficiency of boilers**, adjustment of **boilers** and for environmental analysis of the composition of combustion products.

The efficiency of the boiler unit characterizes the degree of perfection of the process of converting the chemical **energy of fuel** into thermal **energy of steam** or hot water.

**Gross efficiency** takes into account the use of thermal **energy of fuel** in the **boiler** and is the ratio of **heat** produced to spent:

$$\eta_{\text{ка}}^{\text{бр}} = \frac{Q_{\text{пол}}}{Q_{\text{затр}}} \cdot 100\% = 100\ \% - \Sigma q,$$

where *Σq* is the sum of specific (per unit mass or volume of **fuel**) **heat losses** with exhaust gases, as a result of chemical and mechanical incomplete combustion of **fuel** and **losses** to the environment,%.

**Heat losses** with exhaust gases, *q1* can be estimated by the formula:

$$q_1 = \frac{t_{\text{ух}} - t_{\text{в}}}{t_{max}} \cdot \left[c' + (h-1)nk\right](100 - q_3),$$

$$h = \frac{RO_2^{max}}{RO_2 + CO + CH_4},$$

where *q3* - **heat loss** from mechanical incomplete combustion of **fuel**,%; tyx, tв, tmax - respectively the temperature of the flue gases, the air supplied to the **boiler** unit, the maximum temperature of the flue gases, oC; c and k are correction factors that show the ratio of the average specific **heat** of dilute and undiluted flue gases in the temperature range from 0 to tyx to the average specific heat in the range from 0 to tmax; n is a coefficient showing the ratio of the average specific **heat** of air in the temperature range from 0 to tyx to the average specific **heat** of undiluted flue gases in the range from 0 to tmax; RO2 is the sum of triatomic gases (RO2max values for the main types of primary **energy** resources are given in the reference literature).

**Heat losses** from chemical incomplete combustion of **fuel** q2 can be estimated by a simplified formula:

$$q_2 = \frac{Q^{р}_{н.сг} h}{P} \cdot 100\% ,$$

where QPH.CГ - lower **heat** of combustion of 1 m3 of dry combustion products (calculated according to the analysis), kJ / m3; P is the lower heat of combustion of the working mass of **fuel**, attributed to the volume of dry combustion products, kJ / m3. Indicative values of P for the main types of primary **energy** resources are given in the reference literature.

$$Q^{р}_{н.сг} = [30{,}2CO + 25{,}8H_2 + 85{,}5CH_4] \cdot 4{,}19 .$$

Gross efficiency can be determined differently:

$$\eta^{бр}_{ка} = \frac{D \cdot (h_п - h_{пв}) + Q_{пр}}{BQ^р_н} \cdot 100\% ,$$

where D is the steam productivity of the boiler unit, kg / h; hп, hпв - enthalpy of steam, feed water, kJ / kg; Qрн - used thermal energy of purge water, kJ / h; B, Qрн - fuel consumption and calorific value, kg / h, kJ / kg.

Net efficiency takes into account the consumption of thermal energy for own needs.

$$\eta^{нт}_{ка} = \frac{(D - D_{сн})(h_п - h_{пв}) + Q_{пр}}{BQ^р_н} \cdot 100\%,$$

where Dсн - steam consumption for own needs, kg / h.

To determine the amount of **energy** that is useful in the utilization of **heat** of purge water, use the expression:

$$Q_{пр} = \varphi G_{пр}(h_{кв} - h_{пв}).$$

Coefficient of use of thermal energy of purge water:

The proportion of steam released in the separator:

$$\beta = \frac{h_{кв} - h_{св}}{h_{сп} - h_{св}},$$

where: hкв, hсв, hсп, hсв - enthalpy of **boiler**, source water, separated water and steam, kJ / kg.

Continuous or periodic purging in drum **boilers** is used to obtain a pair of specified parameters for the concentration of salts dissolved in the **boiler** water, while part of the **boiler** water is replaced by feed water.

Total **fuel losses** without the use of thermal energy of purge water:

$$\Delta B' = \frac{D\tau p_{п}(h_{кв} - h_{ив})}{Q_{н}^{р}\eta_{ка}^{бр}},$$

where τ is the number of operating hours of the **boiler house** per year; pп - the amount of purge as a percentage of steam productivity. The latter can be determined:

$$p_{п} = \frac{S_{х}П_{к}}{S_{кв} - S_{х}}100\%,$$

where: Sx - dry residue of chemically purified water, mg / kg; Пк - total l**osses** of steam and condensate in the shares of steam productivity of the **boiler room**; Sкв - estimated dry residue of **boiler** water, mg / kg.

Processing of the received statistical data and the analysis of the information are carried out by taking into account the results of inspection of the equipment of a **boiler room**, by studying thermal schemes, by checking the existence and serviceability of devices of thermal engineering control. The data are analyzed and clarified, the method of their determination, reliability is evaluated, violations of the requirements of normative and technical documentation are revealed when performing calculations of technical and economic indicators.

The dynamics of production and release of **thermal energy**, **fuel** consumption and **electricity** of the **boiler house** by years and months under consideration can be presented in the form of histograms.

During the development of the main directions and measures for **saving energy resources** and reducing the cost of their payment, the following procedure is recommended: to determine the technical nature of the proposed improvement and the principle of saving; calculate (estimate) potential annual **savings** in natural form and in cash; determine the list of equipment required for the implementation of the proposal, its approximate cost, taking into account delivery, installation and commissioning, as well as future operating costs; consider the possibility of reducing costs, for example, through the manufacture or installation of equipment on their own; identify possible side effects from the implementation of the measure that affect the real economic efficiency; assess the overall economic effect of the measure, taking into account all the above points.

To draw up a long-term implementation plan, all proposals should be classified into three categories: cost-effective and low-cost activities; medium-cost measures; multi-cost **energy saving projects and activities**.

Based on the results of the survey, a report is prepared, the approximate content of which includes a brief description of the equipment, assessment of the technical content, the state of accounting for **energy costs**, technical and economic performance of the equipment, conclusions and proposals.

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