Development and improvement of methods of diagnostics of heating systems in modern conditions

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Abstract. The article is devoted to the matter of the achievement of the best result and cutting of costs during the diagnostics and repair of the heating systems. The subject is very urgent, as the performance of the heating systems in Russia is quite poor. The authors revealed the causes of the need for diagnostics of the performance of the heating systems and analyzed the existing methods of technical diagnostics, summarizing their advantages and disadvantages. The ways of the development and improvement of the diagnostics of the heating systems, both new and under maintenance, were offers in the article.

1. Introduction

The need for diagnostics of the performance of the heating systems in Russia is caused by the following factors:

• low-quality norms of the heating systems design and maintenance;
• low-quality construction.

The reasons of the high damageability, according to the analysis, completed for the 20-year period of maintenance, include:

• the existing regulatory base of the design and construction does not correspond to the modern operating conditions of the underground heating systems;
• the low protective properties of traditional isolation materials aggravated with poor quality of design and construction;
• inefficiency of the existing drainage systems;
• errors of designers and insufficient (for the networks of such quality) amount of works on maintenance of reliability of networks [1, 2].

The fact that the pacing corrosion factors on the level of decrease proves that the poor quality of isolation materials is caused by flooding with by ground waters, the thaw or leakages on the heating system, the silted channel. The annual analysis of damageability of the heating systems, performed by Joint Stock Company Mosenergo proved that the service life of the pipelines in the corrosion-dangerous conditions depends only on the pipe wall thickness. The insufficiently worked design led to the fact that more than a half of damages from outside corrosion falls on cameras in which absence of cooling leads to 100% of humidity and abundant drop-out of condensate for isolation constructions inappropriate to these conditions [3].
Thus, the need of research and practical work in the field of the increase in efficiency of diagnostics of the performance of heating systems and cutting down of cost for their diagnostics and repair is obvious. The majority of research on the matter has the general character. The most interesting works (from the scientific and practical point of view) were presented by L.D. Gitelman, B.E. Ratnikov, M.V. Merkulov, V.A. Kosyanov, I.F. Livchak, Yu.Ya. Kuvshinov, B.M. Khrustalyov, Yu.Ya. Kuvshinov, V.M. Kopko, V.I. Sharapov, P.V. Rotov, M.E. Orlov, B.Ya. Yakovlev, M.V. Smirnov.

2. Method
The authors studied and generalized the existing methods of technical diagnostics of heating systems, including their analyses from the point of view of the volume of necessary financial expenses [4-5].

1. Method of acoustic emission. The method is checked in the world practice. It allows to define precisely the location of defects of the steel pipeline, which is under changeable pressure, but under the terms of application of the heating systems under maintenance it has the limited field of use.

2. Method of magnetic memory of metal. The method is good for the detection of sections with the increased metal tension in case of direct contact with the pipeline of the heating systems. It is used for the sections, where it is possible to roll the carriage on bare metal of a pipe. That also caused the limitation of its application.

3. Method of terrestrial thermos-vision surveying by the means of a thermal imager. In case of the available surface of the route, it is desirable with the uniform covering, existence of exact executive documentation, using the special software, the method can demonstrate the performance of the inspected section very well. In the aforesaid conditions the application of the method is possible only for 10% of old spacers. In certain cases the method is effective for the search of leaks.

4. Thermal aerial photograph in the Infrared range. The method is very effective for the planning of repairs and detection of sections with the raised heat losses. It is necessary to carry out the shooting in the spring (March-April) and in the autumn (October-November) when the heating system works, but there is no snow on the earth. The survey and obtaining results on all territory of Moscow takes only three weeks. But during three years the flights are hindered by the Federal Security Service, as the permissions on any flights are given out with such a red tape that they fall on the period of the year, when shooting does not make any sense.

5. Method of acoustic diagnostics. Within this method the correlators of advanced construction are used. The method is new and trial applications for networks of the Russian Joint Stock Company MTK have not yield single-digit results yet. But the method has its perspective, as the information component in the complex of methods of condition monitoring of the heating systems maintenance, it is well inscribed in the process of maintenance and design features of spacers of the heating systems (Figure 1). [6]

6. Pressure testing on durability by the means of elevated pressure. For the first time it has been applied in 1976 in the JSC Mosenergo. Justification of the method and strength calculations were carried out in the USSR in 1975. Since then it is carried out annually with minor change of size of pressure and time of its endurance separately on the giving and return pipe. The method was developed and applied for the purpose of the identification of the weakened places of the pipeline during the repair period and exceptions of emergence of damages during the heating period. It had the long period of development and introduction, but now on average steadily proves the efficiency of 93-94%. That is 94% of damages come to light during the repair period and only 6% leave for heating. With the use of complex operational system of collecting and analysis of the heating systems performance, pressure testing has become possible to consider as a method of diagnostics and planning of repairs, turns of the heating systems.
7. Method of magnetic tomography of metal of the heating system from the ground. The method has not enough statistics but authors consider that it is very perspective in the conditions of the large city.

### 3 Results

According to the authors' opinion, for achievement of the best result and cutting of costs for diagnostics and repair of the heating systems the list of works is to include some items (Table 1).

The experience of planning of repairs, the analysis of the performance of the heating systems under maintenance and the experience of application of various methods of diagnostics allow to make the following offers for the heating systems.

1. Technical diagnostics at the heat-supplying enterprises needs to be introduced systemically along with the change of system of planning and carrying out repair work and individually depending on features of the concrete enterprise.

2. Standards of operation need to be developed separately for each heat-supplying organization on the basis of the translation of all data in an electronic look and the subsequent analysis.

3. Design of new heating systems has to be carried out with the forecast of reliability and provide the built-in system of diagnostics with the description of technology of her carrying out and calculation of necessary financial and labor expenses.

4. For development of the normative documents regulating operation of the heating systems that is necessary to carry out previously rather deep analysis of relevant passport data of laying of network, conditions of their operation and data of monitoring of a state for a row of years. According to authors, any enterprise of heat supply in Russia does not possess the full list of similar data of the required standard. The matter arises: what is the basis for the normative documents, which are being developed? In old norms on the basis of which were under construction the heating systems there were discrepancies, for example standard service life of underground laying is accepted 25 years, and the most applied integumentary layer of thermal insulation of 8-10 years.

5. The development strategy of the heating systems has to be aimed at planned replacement of networks and outdated designs by new more reliable, with the guaranteed service life and the built-in automatic system of identification of places of violation of service conditions. Repair has to be only scheduled preventive.
Table 1. List of works during diagnostics and repair of the heating systems

| Stages | Works |
|--------|-------|
| **Stage 1**<br>Operation of the heating system is not required | 1. Carrying out the analysis of structure of the heat-supplying equipment, measurements of devices of heating.  
2. Scheduling of the arrangement of the existing heating devices, ventilating systems and devices of consumption of hot water supply.  
3. Drawing up the full register of the heat-accepting equipment.  
4. Obtaining objective data on the volume of consumption of heat, drawing up and analysis of power balance. Carrying out calculations of optimum heat loading of the facility and analysis of sufficiency/redundancy of the current quantity and capacities of the heating equipment.  
5. Analysis of contracts of heat supply.  
6. Drawing up the technical report with results of assessment of settlement potential of energy saving. |
| **Stage 2**<br>Work of heating systems and weather conditions for thermos-vision shooting are demanded | 1. Inspection of thermal point:  
- Examination of thermal point, measurements and analysis of operating modes;  
- Check of level of automation and existence of metering stations of heat;  
- Analysis of the temperature schedule of heat supply;  
- Check and development of recommendations about adjustment of work of internal contours of heating.  
2. Inspection of the ventilation system:  
- Check of level of automation and existence of systems of recovery;  
- Measurements and analysis of an operating mode of the ventilation system;  
- Inspection of characteristics/condition of the equipment  
3. Inspection of heating system:  
- Inspection of types/characteristics of radiators of heating;  
- Measurements and the analysis of an operating mode and the temperature schedule in the system of heating;  
- Development of recommendations about adjustment of an operating mode of system of heating  
4. Inspection of hot water supply:  
- Analysis and development of recommendations about optimization of expenses of hot water.  
5. Thermovision inspection of the protecting structures of buildings and constructions with development of the technical report of current state and issue of recommendations about elimination of places of leakages of heat.  
6. Drawing up report of comprehensive examination and development of the program of actions for optimization of expenses on heat supply. |

4. Discussion
Some researchers also discuss the role of investments in the course of diagnostics and repair of heating systems.

We will review the situation caused by the specifics of the Russian practice of investment in the heat-supplying organizations. According to various estimates losses from unproductively spent thermal energy are characteristic also of all chain of heat supply and make: by production – up to 22%, when transporting thermal energy – up to 25%, at the consumer - up to 30% of total amount. Investment into the capital repairs of worn-out thermal networks which give some effect was and remains the "standard" solution of management of overwhelming number of the domestic heat-supplying organizations in these
conditions. There is the most indicative example of JSC "Mytishchi heating system" on the comprehensive program of modernization of system of heat supply of the city until 2020. As the result of realization of investments many indicators have been improved: consumption of thermal energy is reduced by 23.4% and achievement of the minimum level of losses of heat to 5-7%, the decrease in payment by consumers for consumption of thermal energy in the amount of 10 to 40%, reduction of costs of transfer of heating energy in relation to 2010 from 136.2 thousand Gcal to 105.0 thousand Gcal.

However according to authors, "standard" approach to investment in the domestic heat-supplying organizations in the detailed analysis is not represented "creative". Option of "creative" investment which will allow to gain effect of other quality and for much bigger term is investments into the automated information systems of a condition of thermal networks on the basis of which data it is possible to predict indicators of operation and at the expense of it to invest means in capital repairs much more precisely. Calculations made by authors have proved the unique character of the considered investments – owing to the high cost of an information system (70 million rubles) that is difficult to master them even the large heating systems organization, however the initiative investor (the heating system organization or consulting structure with attraction of loan financing) can gain considerable effect at sales in the territory of the Russian Federation. In the Russian Federation there are 330 cities with the population more than 50 thousand people, heat supply is centralized. Investments into any information system which structure and volume of functionality determine estimated cost of 500 thousand rubles are necessary for them. At the organization of effective sales all market size which is 165 million rubles can be mastered. Owing to universality of approach of operation of all linearly extended objects used for transportation of any carrier as perspective it is necessary to recognize as well the market of the enterprises operating gaz- and oil pipelines. The aforesaid cost estimates are in the course of crisis response solutions which formation and implementation corresponds to the current state policy of the Russian Federation.

5. Conclusions
The authors suppose that the research of Development and improvement of methods of diagnostics of heating systems within the concept of the sustainable and balanced development is sufficiently reasonable approach to the analysis of instruments of management of the organizations and allows to pass in the analysis of resources from one sphere of his management – financial to another - production within which resources (first of all due to updating of such fixed assets as heating systems), expenses for which are essential, have investment character, in comparison with the costs of traditionally used resources within the current activity. At the same time the phenomenon of the heat-supplying organizations transformations, arising in strategic prospect, is in the course of classical ideas of balance of development, however defines absolutely other quantitative values of parameters which are defined by specifics of functioning of this subject of the energy industry of the Russian Federation.

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