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Ways to improve operational reliability of water supply and wastewater disposal systems in buildings

Ensuring operational reliability of engineering systems of buildings, regardless of their functionality, is one of the most important problems of the state, regions, municipalities and specialized business. At the same time, operational reliability is not only a technical and technological category, but also an economic and social one, because the increase in the terms of safe and reliable operation, reduction of repair costs are equivalent to the effects that can be obtained only from the construction of new buildings. This implies the need for a targeted study of the operational reliability of engineering systems by solving a number of applied problems.
The global picture of drinking water losses and environmental pollution from wastewater is very sad. The figures are measured in billions of cubic meters per year. In Russia, with its difficult climate, and where a significant part of the engineering infrastructure of buildings is worn out, and new buildings are often delivered with corresponding deficiencies, this problem is particularly acute. Despite numerous discussions of theoretical provisions, analysis and systematization of experimental data in available publications, these issues remain on the periphery of scientific interests of specialists, and the indicators of operational reliability have not been fully investigated. In this article the key aspects and modern solutions of the way of formation and increase of operational reliability of water supply and drainage systems (hereinafter referred to as WSS) of buildings are considered. The authors analyzed the normative and technical regulation of these issues, the existing methods of determining reliability and ways to improve it, the prospects and projected effects of new technologies on this path, the challenges and opportunities of transition to predictive maintenance.
Keywords: *operational reliability of engineering systems, system failure, system accidents, sensors, predictive maintenance, system maintenance, system management*

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INTRODUCTION

Reliability of centralized WSS systems is one of the key requirements for modern buildings of any functional purpose. This applies to both cities and any settlements. The tasks in the sphere of water supply at the state level are reliable provision of consumers with quality drinking water, measures to reduce uncontrolled emergency wear and tear of water supply networks, leading to significant losses. And among the tasks in the field of wastewater disposal it is necessary to note the focus on reducing uncontrolled emergency wear of wastewater disposal networks, leading to the ingress of untreated wastewater into the terrain and water bodies[1]. Internal WSS systems in comparison with other systems are the most expensive to create and maintain and at the same time very vulnerable, but they largely determine the functional suitability, sanitary and epidemiological condition and comfort of buildings in which we live, study, work. Ensuring their stable and uninterrupted operation is the task of management organizations, city and district resource supplying organizations, operation services. To ensure their functions, water supply systems should be characterized by the necessary strength, durability, safety. All these properties determine the reliability of the systems.

[1] Strategy for the development of the construction industry and housing and communal services of the Russian Federation for the period up to 2030 with a forecast up to 2035.

NEGATIVE TRENDS

As of today, there is a high level of existing accumulated wear and tear of fixed assets and network facilities in urban and municipal WSS systems both in Russia and worldwide. There is a significant increase in the number of serious accidents, while minor accidents and leaks are not counted at all. This leads to large volumes of drinking water losses, which determines significant economic, social infrastructure risks, and not less loss of polluted water, which determines a number of environmental and engineering risks. Not to be overlooked is the risk of scouring of subgrade soils, overwatering of structures, and damage to finish coatings, which are always a concomitant result of severe or long-term leaks. Although the number of major accidents in the WSS system has been decreasing in recent years, their absolute value is still very high. For water supply it is more than 28.5 thousand, and for wastewater disposal more than 5 thousand accidents per year[2]. The overall wear and tear of engineering networks is steadily increasing. More than 80% of pipelines in Russia have 50 to 80 % wear and tear due to corrosion, mechanical damage and natural aging, degradation under the influence of soil, temperature differences and hydrostroke and require replacement.

Among the main environmental problems resulting from leaks in the sewage system are the probability of contamination of drinking water,

[2] Unified Interdepartmental Information and Statistical System (EMISS). URL: http://www.fedstat.ru/indicator/34186

discharge of chemicals, reagents and medical products into the system[3]. Even hidden sewer leaks inside buildings lead to bacterial contamination and development of black mold, threatening the health of residents. The role of negative design factors in the formation of unhappy statistics is great. Errors in determining the schemes, diameters, slopes, parameters of precipitation of engineering systems and buildings during design are becoming a frequent phenomenon. Errors in installation, replacement of materials or equipment with analogs, selection of applied laying technology are no less frequent.

It is impossible not to mention the lack of funding for programs and activities to modernize and repair systems. Most municipalities in our country are facing budget deficits, which makes it difficult to carry out repairs, replacements, and the introduction of new technologies. Attraction of private investments is complicated due to long payback periods of projects in this sector. And there are no incentives for insurance of this type of activity.

The most frequent culprits of any accidents in the systems are local management, resource supplying or maintenance organizations. The problem of low-quality maintenance services has been topical for years. Clogs, bursts, odors are on the lips of almost all residents of apartment buildings. In most cases, the population is unaware of the distribution of responsibility for the quality of drinking water between water utilities and management companies. And if the former ensure quality in external networks, the latter ensure quality in internal networks, and their poor condition also leads to the provision of poor-quality service[4].

OPERATIONAL RELIABILITY OF WSS SYSTEMS

In accordance with SP 517.1325800.2022[5], reliability of centralized systems and structures of WSS of buildings is defined as their property to preserve in time, within the established limits, the values of all parameters characterizing the ability to perform the required functions in the given modes and conditions of application, maintenance, storage and transportation of water. Reliability indicators are quantitative characteristics or parameters for each of the properties that make up the reliability of the system. For example, for a water supply system, the reliability indicator is the number of interruptions in water supply as a result of accidents, damages, violations. And for wastewater disposal system — specific number of accidents or blockages in terms of the length of the system[6].

At the same time, as for other building systems, the reliability of WSS is necessary during the operation period, which can be defined as a stage of life cycle, at which their operable state is realized, maintained and restored. It takes into account the work of specialists, equipment, technical systems to maintain, restore engineering systems, minimize damage from accidents. Against the background of failure statistics, their causes, scope, risks of recurrence come first. Therefore, the definition of operational reliability becomes more capacious and informative.

Some authors define reliability of WSS systems as the probability that the system fulfills its functions in accordance with given requirements during time *t*. And if the system should supply 100 % of water, then this ability should be evaluated, rather than calculating the possible water supply of the system at given reliability indicators of its elements [1]. Approximating this and a number of other definitions, we can conclude that the operational reliability of an engineering system can be defined as “the technical capability to use the system for its intended purpose at the right time and with the required efficiency”.

It follows from the obtained definition that along with strength and durability, the WSS systems should have in their maintenance manufacturability, maintainability and cost-effectiveness. It is these properties that make engineering systems more flexible and efficient, and thus reliable in operation. These properties make it possible to take into account collected and systematized data on all damages and accidents in the systems, to identify their causes, to plan changes in operational measures, to apply information technology and to carry out operational control more effectively. Fulfillment of all requirements imposed on the water supply system ensures normal level of operational reliability.

The level of operational reliability can be considered as a key indicator that determines the ability of a system to maintain its functional characteristics throughout its service life. Increasing the level of operational reliability reduces operating costs, reduces the risk of accidents and extends the lifetime of systems. Establishing, ensuring and assessing compliance of operational reliability levels is fully consistent with the current transition to the parametric method of standardization in construction, which is defined as a method of establishing regulatory requirements, in which the establishment of key requirements is applied only to the functional and (or) operational characteristics of the object of standardization, including in the form of requirements for quantitative parameters, regardless of its design and performance[7]. The normative also determines that the ways to achieve the key requirements are established with the possibility of using acceptable and (or) alternative solutions.

ASSESSMENT AND IMPROVEMENT OF OPERATIONAL RELIABILITY

WSS systems are multifunctional, as they provide not only supply or withdrawal of given amounts of water for consumers of different categories, but also the required water quality, pressure, and flow rate at the required points. As already mentioned, operational reliability can be achieved only within the framework of an integrated approach throughout the entire life cycle. Establishment of functional and operational characteristics in the design task, development of design solutions on their basis, selection of appropriate equipment, preparation and carrying out of installation and commissioning works, realization of effective operation and management. It is a set of measures for the operation of systems, provides water supply of the required quality, head and quantity, prevent losses in the system, eliminate the overgrowth of pipes and corrosion, possible freezing, to realize the current repair if necessary [2].

[3] Environmental problems of wastewater disposal systems in the 21st century — News from TD Eurotrading LLC. URL: http://WWW.GIDROLICA.RU/NEWS/EKOLOGICHESKIE-PROBLEMY-SISTEM-VODOOTVEDENIYA-V-21-VEKE/?YSCLID=MCDQJJHMUN401858333

[4] The Russian Association of Water Supplyand Sanitation — RABBI about dilapidated pipes, tariffs, the consequences of the largest accidentin Volgograd and other problems of water utilitiesin an interview with the publishing house “NewIndustryMedia” for the Housing and Communal Services Administration project. URL: http://raww.ru/pressroom/association-news/2112-ravv-o-vetxix-trubax,-tarifax,-posledstviyax-krupnejshej-avarii-v-volgograde-i-drugix-problemax-vodokanalov-v-intervyu-izdatelskomu-domu-»novyie-otraslevyie-media»-dlya-proekta-upravdom-zhkx.html?ysclid=mcdqx0byih22870671

[5] SP 517.1325800.2022. Operation of centralized systems, water supply and sanitation facilities. Ministry of Construction of Russia

[6] On Approval of the List of indicators of reliability, Quality, and EnergyEfficiency of Centralized Hot Water Supply Facilities, procedures and Rules, and determination of planned values : Order of the Ministry of Construction of the Russian Federation dated April 4, 2014 No.162/pr. Ministry of Construction of Russia.

[7] SP 555.1325800.2025. The system of regulatory documents inconstruction. Basic provisions. Ministry of Construction of Russia.

Existing methods of reliability assessment contain theoretical or statistical methods of determining the distribution function of uptime, which determine the degree of probability of system operation without failures for a certain period of time. They are probabilistic in nature and are measured in fractions of a unit or percent. For example, reliability can be assessed by the ratio of the total duration of periods of decline in the quality of functioning to the total duration of operation. Or the degree of decline in certain indicators and the frequency of periods of deterioration in performance.

To calculate the reliability of WSS systems, it is necessary to obtain a large amount of data on their actual operation. Indicators are determined for individual sections of the operated systems as a result of long-term observation of their operation during operation, recording and processing statistical data on all damages and accidents. Very important is a continuous registration of accidents and damages [3].

When carrying out calculations, when only some important factors are taken into account or average values are used, inadmissible errors occur, which makes the forecast of accidents incorrect, and consequently incorrect maintenance plans, repair volumes, frequency of inspections, leads to increased costs for repair and maintenance works. In addition, the complexity of assessment and forecasting of water supply systems is that today there are no tools for their diagnosis for individual elements and equipment. Therefore, at present, it is considered optimal to assess with the collection of statistical data on the operation of the water supply system and their subsequent processing. At the same time, the service life of the water supply system is long enough and the results of statistics collection are presented for a very long period[8]. These conditions reduce the reliability of statistics in this issue.

Other researchers propose a different methodology for assessing the reliability of water supply systems based on the probability of accident occurrence based on Poisson's law. To estimate the probability of X accidents in a certain ($t + i$) year, it is necessary to use statistics for t years and determine the value of $lt + 1$. To do this, determine the value of the average acceleration b, and the change in the value l, which is the accumulated initial value. After that, the calculated values are compared with the existing physical values and changes with accident occurrence statistics [4]. This method is also not absolutely accurate, since almost no one maintains the history of accidents with their clear ranking.

It should be remembered that low operational reliability of engineering systems and the building as a whole, leads to higher costs of current and capital repairs, as well as reconstruction. Reliable operation of engineering systems depends on factors that reduce reliability and those that increase it. Measures that increase reliability can be divided into two groups: increase of failure-free operation and increase of maintainability. Basically they go by using more reliable and durable pipes, valves, electric protection installations, providing redundancy of system elements, organization of effective operation and purposeful improvement of control systems of processes occurring in the system. More modern methods allow to predict the basic properties of reliability taking into account the variability of system characteristics during operation, heterogeneity of requirements of different equipment or elements. Here in a complex can be applied: optimization of functional schemes, unification of solutions, modern technologies of installation and repair works, more accurate accounting of negative factors, increasing maintainability, increasing the effectiveness of prevention.

[8] Bykov A.A., Bersugir M.A. *Methods of forecasting accidents in water supply systems*. URL: svs43343.pdf

A number of objective and not so objective factors, such as: lack of clear rules of operation, lack of qualified personnel, negligence in the work of employees of operation services, low quality of equipment and elements, lack of uniform terminology and formulations, lack of quantitative assessment of reliability of elements, haphazardness in the formation of information about repairs and maintenance, lack of continuous information about the state and wear of systems and their elements.

The development of modern technologies in the field of construction monitoring and engineering analysis makes it possible to significantly improve operational reliability, safety and efficiency of engineering systems. One of the directions on this path is the transition to predictive maintenance.

PREDICTIVE MAINTENANCE OF BUILDING ENGINEERING SYSTEMS

Predictive maintenance (hereinafter referred to as PdM) is a complex method of management of engineering networks and equipment, which includes collection of information on the state of equipment, its analysis and forecasting of failure dates of equipment of different levels for the purpose of timely preparation and implementation of measures to prevent failures in operation. In other words, it is a service when a "breakdown forecast" appears, without reference to normative-technical or design requirements. PdM has already been successfully implemented in the power industry, transportation, industry, oil and gas industry, and airlines. Monitoring and control systems detect any deviations in the operation of equipment and systems.

Sensors and sensors are the key elements of PdM. Based on the information from them, the status of system elements is constantly analyzed. The data is transmitted to the controllers of the monitoring system and, if the monitored parameters exceed the permissible values, the relevant equipment, elements, parts are included in the scope of the nearest scheduled maintenance. A forecast of the situation development is also made, and complexes of measures for replacement, repair or maintenance are developed. Thus, even the most complex engineering systems can function predictably and smoothly for a long period of time. The choice of sensors depends on the types of monitored equipment, elements, as well as the types of potential faults and the requirements of SCADA systems. They can be pressure, deformation, angle deviation, humidity and temperature, component wear, leakage sensors, remote visual inspection tools, acoustic, ultrasonic, infrared sensors.

The objectives of PdM include:

- engineering systems management;
- improvement of management processes;
- improving the operational reliability of systems;
- optimization of maintenance costs;
- reducing accident risks;
- planning of replacement and repair costs;
- increasing the functionality of systems;
- improvement of systems.

Implementation of PdM systems is most effective in the conditions of software and hardware complexes (hereinafter PAC), which provide real-time collection of information on the state of system elements, on processes in them, on deviations from the set parameters, on the need for maintenance, etc. PdM can be recommended when working with large engineering systems with equipment and elements with different characteristics, service life, modes of operation, maintenance and repair conditions. PdM can be rec-

Table 1. Comparison of service methods

Method	Advantages	Disadvantages
By resource	• ensuring standard service life of equipment and standard downtime; • reducing resource consumption; • reducing the number of failures	• mismatch of equipment resource utilization with actual operating conditions; • the need to invest in maintenance personnel and technology; • continuing probability of serious failures; • possible premature maintenance
By state	• reduction of resource consumption; • matching the service life of the equipment to the actual operating conditions; • reduced probability of serious failures	• the need to provide personnel for diagnosticians; • the need for diagnostic equipment; • the need for software; • unexpected occurrence of failures and accidents; • long downtime associated with repairs
PdM	• possibility to analyze data on the operation of equipment and elements in real time; • timely detection of faults and wear; • prediction of faults before failures occur[9]; • reduction of costs for serious and urgent repairs; • extension of service life of separate equipment and elements of engineering systems; • increased building safety; • increase of labor safety of the personnel; • the possibility of corrective maintenance; • planning of the most cost-effective volumes and terms of repairs and replacements; • reduction of the number and duration of downtime	• the need to implement SCADA systems and IoT platforms; • the need to implement statistical analysis tools, machine learning or neural networks; • necessity to verify sensors

ommended when working with large engineering systems that include equipment and elements with different characteristics, service life, operating modes, maintenance and repair conditions.

The application of controllers based on IoT and machine learning is promising; it allows collecting data from sensors and sensors, analyzing them in real time, providing the possibility of central monitoring, quickly responding to emerging problems[10].

In accordance with SP 255.1325800.2016[11] there are two main methods of maintenance:

- "by resource" or preventive maintenance, which implies scheduled maintenance with the planning of measures for the resource of engineering equipment and structural elements (e.g., standard service life by operating time, by the number of failures, etc.);
- "condition-based" or preventive maintenance, which implies scheduled maintenance with planning of measures based on the values of actual (current) parameters of the technical condition of engineering equipment elements of buildings.

PdM, compared to these methods, is able to provide cost savings by performing only those justified tasks and at a time when it is justified. Let us compare the advantages and disadvantages of these three methods (Table 1).

As can be seen from the comparison, PdM has significantly more advantages than the disadvantages or advantages of other methods. The main difference, however, can be seen as working with accurate information about the state of the system, based on actual data rather than average or expected values.

Nowadays, the development of customized models for PdM implementation is starting to gain popularity in the industry. They allow to incorporate a whole range of data and parameters from different sensors. Conduct operational adjustments under changing conditions of engineering tasks. And during operation, not only to monitor the exceeding of control values of parameters, but also to detect fluctuations in values, dynamics of deviations development, connection with changes in other parameters. In the field of operation of building WSS systems, such PACs can also be expected to have significant effects. For example, detection of dripping leaks in the joints of water pipes at the time of the lowest water consumption, i.e. at night and drying during the day. This cannot be detected by conventional floor sensors or daytime inspections, and the situation may indicate that a serious nighttime leak is approaching.

It is quite difficult to build your own PdM system for building engineering equipment. It is necessary to solve the problems of proper placement of sensors, organization of storing the necessary amount of incoming data, setting up the analytics and forecasting system, providing machine learning, and warning of failures. Several methods are most often used to analyze sensor data. From simpler statistical analysis, to complex neural networks. For maximum efficiency, sensors can be integrated with ERP (Enterprise Resource Planning) or CMMS (Computerized Maintenance Management System) systems. This integration allows for the creation of a unified information environment that always has up-to-date data and the ability to embed digital services. For example, assistance in the formation and maintenance of electronic passports, assistance in the maintenance of building information models.

We would especially like to note the possibility of integration with the information model of the capital construction object. After all, data from PdM systems can supplement the information model with models of behavior of engineering systems in real conditions of construction and operation. And this is already a serious step towards the application of digital twins, which are now defined in the professional environment as "information models of capital construction objects, further developed through the addition of models of processes related to the creation, operation and use of this object"[12]. Here we can even talk about mechanisms of integration

[9] On the development of predictive maintenance using the example of transformer diagnostics. Habr. URL: http:// habr.com/ru/companies/etmc_exponenta/articles/744174/

[10] Predictive maintenance of engineering systems using IoT. *TRIASK*. URL: http://triask.ru/prediktivnoe-obsluzhivanie-inzhenernyh-sistem-s-ispolzovaniem-iot/

[11] SP 255.1325800.2016. Buildings and structures. Operating rules. Basic provisions (Order of the Ministry of Construction of Russia dated August 24, 2016 No. 590/pr). Ministry of Construction of Russia.

[12] Digital twins of capital construction facilities. URL: http://niisf.org/biblio/glavnaya/tsifrovye-dvojniki-obektov-kapitalnogo-stroitelstva

Table 2. Projected effects as part of operational measures from the implementation of NeoDetect's smart system

Types of operational activities	Forme deffects
Maintenance	• reduction of the number of scheduled periodic inspections of routes, chambers, wells; • reduction of the number of inspections of the technical condition of system elements; • increasing the accuracy of inspections and checks; • localization of cleaning places
Analysis of network operation modes	• development of the hydraulic electronic model of the system; • refinement of pressure gauge survey; • clarification of water consumption values; • refinement of the results of the analysis of system operation modes; • tracking changes in the existing zoning structure; • identification of deviations from the operation modes
Overhaul	• possibility to take more accurate account of the results when planning capital repairs; • assessment of pipeline reliability indicators obtained on the basis of statistical processing and analysis of operational data; • analyzing the technical condition of pipeline sections based on the results of SCADA system data; • ranking of system elements according to the impact of negative factors and actual condition; • analysis of risks of material and environmental damage
Reconstruction	• justification of changes in initially established indicators of systems functioning; • restoration of the required functional characteristics
Provision of automated process control system (APCS)	• easy integration with automatic process control system at the local control level; • control of normal operating conditions of control and measuring devices; • control of automatic regulation and control systems serviceability; • simplification of connected equipment and applied data exchange standards; • increase of control accuracy due to the use of SCADA databases; • control of the efficiency of preventive maintenance, service and repair of systems
Searching for pipeline faults	• simplification of tracing of surveyed pipeline sections; • simplification of checking the serviceability of water fittings; • diagnostics of hard-to-reach areas; • alternative to correlation and acoustic leak detectors; • refinement of pipeline cleaning methods; • alternative to television diagnostics

of building doubles containing mainly geometry with doubles of engineering systems synthesized with PdM hardware and software. A digital twin of an engineering system may be a simpler and more accessible step than a building twin. Such a twin will be able to model the operational states, processes and life cycle of an asset and allows the generation of any amount of data that is difficult to obtain in reality[13].

In the future, we can assume the creation of digital doubles of equipment or systems by their manufacturer, providing them to designers so that they can put the necessary parameters into design solutions, and then to the operating organization as diagnostic systems. But predictive operation is our tomorrow. The nearest step in this direction is the development of the market of sensors and laying software supporting their operation. Let's consider what prospects have these PACs applied in WSS systems today.

HARDWARE AND SOFTWARE COMPLEXES IN BUILDING WSS SYSTEMS

Sensors, as a hardware part of PAC, are primary converters and elements of measuring, signaling, regulating or controlling element of the system. They convert the monitored quantity into a usable signal. The most popular applications in WSS systems are water leakage sensors and clog sensors. They play an important role in timely detection and prevention of leaks and clogs, which can lead to accidents and failures, flooding of premises, and property damage.

There are several basic types of sensors available and used today, each with its own advantages, disadvantages and applications. The most common, simple and inexpensive are point contact sensors. Linear cable sensors, are more complex devices, representing an entire contact cable that reacts to water at any point. These variants can be wired and wireless. More complex, expensive and rare are smart flow meters, acoustic and correlation systems. These are used predominantly on complex systems. In addition, pressure sensors are popular for signaling clogs, pump failures or overflow in the drainage part of the system.

The main disadvantages of most such sensors are: short time or lack of autonomous operation, lack of its own moisture protection, lack of notification by sound signal, small area of the sensing element, unreasonably high price [5].

Against this background, the implementation of modern sensors and PACs for leak and clog detection offers enormous benefits: the main ones are saving water and money, preventing damage from the devastating effects of floods and corrosion, improving system operational reliability, reducing response times to breakdowns, reducing the labor and cost of monitoring, maintenance and repair activities, preventing soil contamination, and reducing the risks of infections and allergies.

As an example, here is one of the variants of such sensors. This is an intelligent water detection system by NeoDetect. This system allows monitoring and timely preventing flooding of premises by shutting off the water supply. The linear sensor extends along

[13] On the development of predictive maintenance using the example of transformer diagnostics. Habr. URL: http://habr.com/ru/companies/etmc_exponenta/articles/744174/

the pipes, which allows you to detect a leak along the entire length of the pipeline, determine the exact location of the leak or clog, and prevent serious flooding. It is a system that can be used to monitor the drying process of water, see the temperature, and the exact location of the affected area [6].

The developers of this intelligent system predict that its development, improvement of its sensors and expansion of the range of software, creation of a common digital environment, will gradually lead to a number of tangible effects at the stage of operation of any buildings as part of the relevant operational measures (Table 2).

From the analysis of effects, it is obvious that the introduction of intelligent systems will not only help to improve the safety of building WSS systems, but will also make maintenance professions more "digital" and attractive to young people. The digital tools themselves, such as chatbots and applications, when implemented in a comprehensive manner, will simplify interaction between building owners or residents, operating or management companies, and resource supply organizations.

REQUIREMENTS TO HARDWARE AND SOFTWARE COMPLEXES IN BUILDING WSS SYSTEMS

The main task of PAC in building WSS systems, as part of the ACS, is to maintain the operable state of the control system in all modes and at all stages of its operation, as well as to organize its efficient use. Hence, the following requirements can be made to all developed complexes:

- support of remote and automated system control;
- maintainability and modularity of design;
- unified in terms of connected equipment and applied data exchange standards;
- protection against unauthorized access to the object control and SCADA databases;
- duplication of control communication for the most critical objects;
- connection of mobile users to SCADA servers of objects.

CONCLUSIONS

Improving the operational reliability of buildings' WSS systems requires a comprehensive approach: from replacing worn-out pipes to implementing intelligent systems and switching to PdM. Some Russian cities, such as Rossosh, have already started modernizing networks under concession agreements, investing hundreds of millions of rubles. However, success depends not only on technology, but also on legislative support, staff training and awareness of the importance of prevention by all participants in the process — from management companies to residents. The logical subsequent transition to PdM using IoT of all engineering systems of buildings, will become an accepted standard for the majority. And with the development of artificial intelligence technology, its success will increase many times over. This method of maintenance will require careful planning, proper selection of equipment and operating algorithms. There is already a strong need for the development of electronic components, PACs, regulatory and technical requirements, and training of maintenance personnel.

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Пути повышения эксплуатационной надежности систем водоснабжения и водоотведения зданий

Обеспечениеэксплуатационнойнадежностиинженерных систем зданий, независимо от их функционала, является одной из важнейших проблем государства, регионов, муниципалитетов и профильного бизнеса. Вместе с тем эксплуатационная надежность является не только технической и технологической категорией, но и экономической и социальной, ведь увеличение сроков безопасной и надежной эксплуатации, сокращение затрат на ремонты эквивалентны эффектам, которые могут быть получены только от строительства новых зданий. Это предполагает необходимость целенаправленного исследования эксплуатационной надежности инженерных систем посредством решения ряда прикладных задач.

Мировая картина потерь питьевой воды и загрязнения окружающей среды стоками весьма печальна. Цифры измеряются миллиардами кубов в год. В России с ее сложным климатом, где значительная часть инженерной инфраструктуры зданий изношена, а новые здания часто сдаются с соответствующими недоработками, эта проблема стоит особенно остро. Несмотря на многочисленные обсуждения теоретических положений, анализ и систематизацию экспериментальных данных в имеющихся публикациях, данные вопросы остаются на периферии научных интересов специалистов, и показатели эксплуатационной надежности полностью не исследованы. В данной статье рассмотрены ключевые аспекты и современные решения пути формирования и повышения эксплуатационной надежности систем водоснабжения и водоотведения (ВиВ) зданий. Авторы проанализировали нормативно-техническое регулирование этих вопросов, существующие методы определения надежности и пути ее повышения, перспективы и прогнозируемые эффекты от применения новых технологий на этом пути, задачи и возможности перехода на предиктивное обслуживание.

Ключевые слова: *эксплуатационная надежность инженерных систем, отказ систем, аварии систем, датчики, предиктивное обслуживание, обслуживание систем, управление системами*

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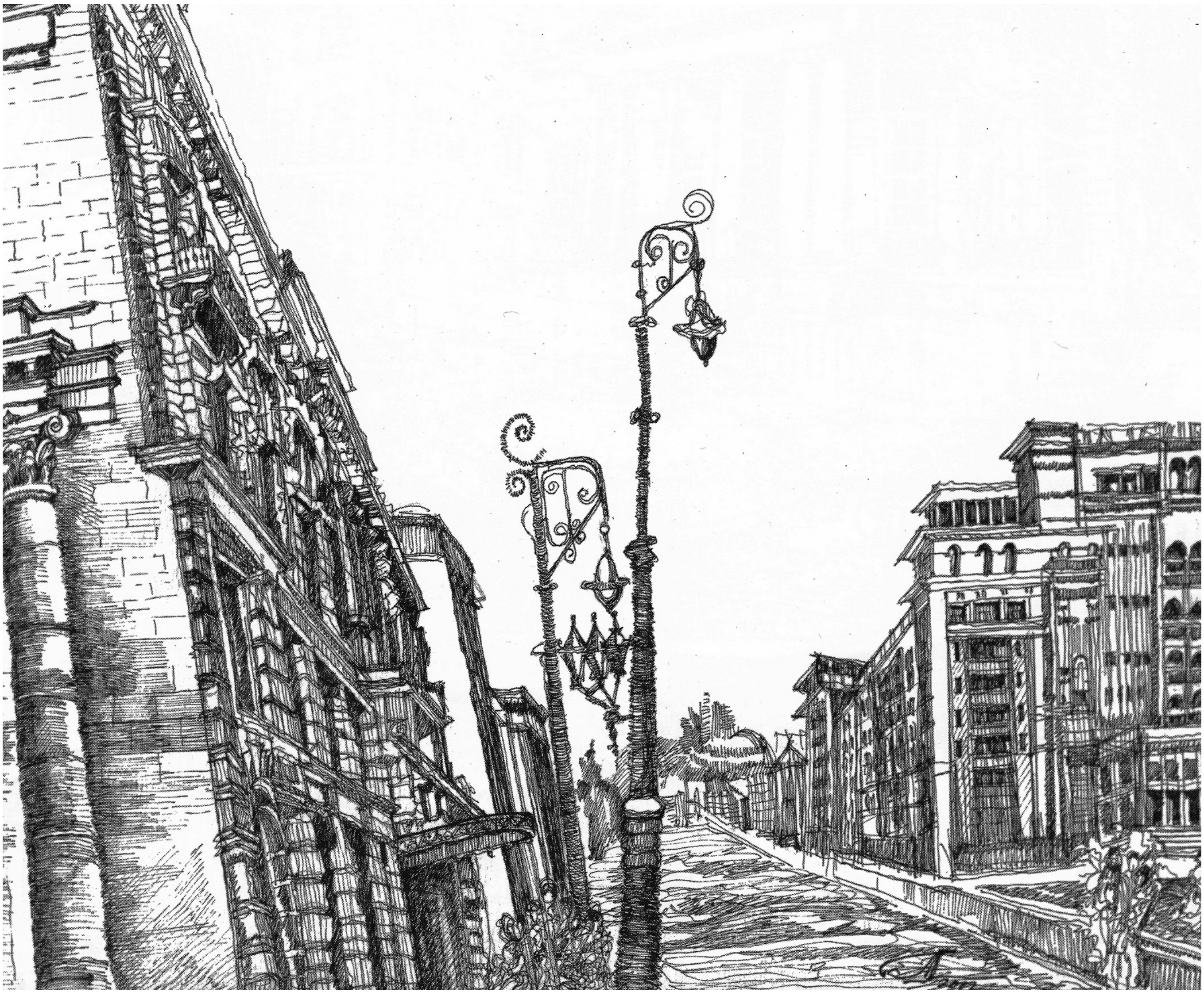

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