Water losses in internal water supply services of residential buildings

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Abstract. Internal water supply is intended to provide a consumer with potable quality water for various needs. Leakages appearing in the course of internal water supply operation have a negative effect on the operation of a whole system. All mains reasons of water losses in internal water supply services have been studied. It was found that losses can be caused by a human factor and caused by technical errors in a system, for example, network faults. Based on the study of scientific works on water losses of internal water supply systems, as well as on analysis of various water loss options there is a new well grounded method presented aimed to achieve sustainable water saving directly in a building in the process of water consumptions. There were conclusions drawn saying that: design of an internal water supply system of a residential building should follow the scheme of reducing water consumption on the lower floors of buildings by zoning the entire system; it is advisable to use a system with water tanks; to achieve indirect saving of electric energy, it is necessary to use pumping units with an adjustable drive.

1 Introduction

Internal cold water supply is intended to provide a consumer with water not higher than 30°C degrees. Internal hot water supply provides consumers with water of 50-75°C degrees. Water is supplied directly to a building and is used for various needs that are utility and drinking, fire fighting, industrial and watering needs.

Nominally all residential buildings in the Russian Federation are supplied with potable quality water that complies with SanPiN 2.1.4.1074-01 «Drinking water. Hygienic requirements for water quality of centralized drinking water supply systems. Quality control. Hygienic requirements for provision of safety of hot water supply systems».

A noteworthy detail is that water losses of internal cold and hot water supply services have significantly risen lately. This happens mainly due to the heavy wear of facilities as well as irrational water consumption.

It was previously believed that in order to save potable water and reduce water losses of cold water supply it was reasonable to use impotable water for certain needs, for example for clothes washing and WC bowl washdown. To implement this idea it was suggested to design an internal cold water supply system of non-drinking quality water which led to erection of an extra water supply system. This solution has not become popular due to the fact that capital expenses for maintenance of two water systems wouldn't have paid off.

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Besides, water losses matters are not being addressed at all while designing and constructing. This is because cost of water recourses is quite low presently and that leaves no option to proclaim water a vital and valuable resource since it is widely available and affordable.

Internal cold water supply is being designed routinely and in many cases there are no attempts suggested to reduce water losses neither from a design team nor a developer/owner. Eventually an operating organization or a consumer – an inhabitant of a block of flats – faces this problem.

However, a coordinated decision and creation of a long-term strategy for water saving and water losses reduction of internal water supply systems has potential to solve the problem of rational water consumption not only for a certain building but also for micro districts as well as for a whole city, if desired.

Issues regarding water losses of internal water supply in residential buildings were addressed by Russian and Soviet scientists, among them V.N. Isaev, E.N. Lovcov, V.S. Kedrov, A.A. Otstavnov, E.M. Galperin [1-2]. These issues have also been addressed in the works of foreign researchers and scientists: Kopeček P., Barnett F.A., Gray S.T., Tootle G.A. and others [3-5].

The works of A.A. Otstavnov present various options for reducing water losses through the use of new pipelines made of polymeric materials. In addition, the author offers various water saving solutions [6-7].

The articles of V.N. Isaev present options of using pressure regulators to reduce unproductive pressure right before water fittings. The author also suggests using various types of modern water fittings, which are initially designed to allow a reduced flow rate. That, when performing sanitary procedures, can significantly reduce water losses in the systems of internal cold water supply [8-9].

In the present work it is suggested to develop a well grounded method of reducing water losses in the systems of internal cold water supply in order to achieve sustainable water saving in new designed residential buildings because these issues are addressed so little nowadays. Besides, the main attention is suggested to pay not only to the basic approaches of designing but also to maintenance of systems which will allow significant saving of this valuable resource – clean potable water.

2 Methods

It is suggested to study and analyze the main reasons of water losses in internal water supply services of a residential building and then to present a new well grounded method in order to achieve sustainable water saving directly in a building.

Water losses happen due to the following reasons. The first is that losses are caused by a human factor. The second is that losses are caused by technical errors regarding choices of internal cold water supply systems, equipment, etc. Also technical errors include losses related to equipment wear and its breakdowns due to network faults [10-12].

Water losses are also directly affected by reliability of equipment and internal water supply networks themselves. Reliability of cold water supply consists of several components which are listed below.

Faultless performance of a system is a parameter that characterizes the ability of a system to come to such a point when it is fully capable of performing its function, i.e. to supply water of a given quality for a certain period of time.

Durability is a property of a system to work for a long time until reaching a limit state where a limit state is understood as a state when supply of a given flow rate or water of the appropriate quality becomes impossible.

Maintainability is a condition when a system performs its functions fully, provided that it is possible to bring lost values to the normal limit state.

Moreover, any theory of reliability includes parameters of mathematical statistics as well as the probability theory. Such parameters as the probability of system failure, the average resource of a system work until failure, the average number of failures measured in nominal units (hours, days, years, etc.) can be considered here.

Thus, it may be said that the study of water losses in internal water supply services of residential buildings is a rather complicated task consisting of various interrelated parameters which effect is not always predictable and requires long-term field studies and sample tests as well as real life inspections of constructed and operating facilities. The above can not always be objectively described in this article due to certain difficulties of conducting experiments.

3 Results

Water losses are leakages that can be caused directly by the inability to properly operate an internal cold water supply system and its equipment (water dispensing fixtures, etc.). For example, when using a system of internal cold water supply, occasional water discharge happens quite often. It is produced directly by inhabitants of a residential building. For instance, when using imperfect old-designed water dispensing fixtures (two-valve mixers), water is discharged when a consumer adjusts the necessary pressure [13-15].

High or low temperature of a heat carrier also leads to unnecessary water discharge. While a consumer adjusts the desired temperature water is pointlessly discharged to a residential sewage system of a residential building.

Users' failure to save water during sanitary procedures or, for example, washing dishes or washing is also worth mentioning. A lot of water is spent due to the lack of elementary understanding of the structure of integrated water saving.

Low quality of water dispensing fixtures and its poor leak-tightness leads to water leakage in the form of flowing through an equipment body (occurs mainly with brands of various unknown manufacturers). The same applies to the flush tanks of modern toilet bowls which often fail. For this reason more than 70 liters of clean potable water per day are lost because of just one defective flush tank.

Low level of operating personnel is also worth mentioning. They install water dispensing fixtures right before the start of operation by residents of blocks of flats [16-18]. According to statistics, there was poor leak-tightness registered in pipelines joints.

In systems with water-pressure tanks, which are installed in heated attics of residential buildings in order to stabilize the pressures and create an additional reserve source of water supply in buildings, where necessary, water losses are also quite often detected. This is due to the leakage of valves. In addition, in case of untimely repair after reached operational limit states, these tanks can leak. Considering their substantial volume, it is possible to talk about possible large losses of clean potable water directly for consumers of a residential building.

Additional and irrational water discharge in internal water supply systems may also occur due to possible deterioration of water quality in a system. For example, presence of rust in a system due to corrosion leads to the need to produce additional water discharge by residents of a residential building [19–20].

Nowadays an incorrect principle is used when designing internal water supply systems. It consists of supplying a sufficient amount of water to water dispensing fixtures which can be located in very unfavorable operating conditions. When constructing pressure distribution diagram it becomes clear that the fulfillment of the above requirements leads to a large overrun of water exactly on the lower floors of a residential building (fig. 1).

If there are leaks in a system, pressure in the system plays a big role. Figures 2 and 3 show graphs of water losses and leakage in internal water supply services of residential buildings. Figure 2 lets conclude that unproductive water waste (irrational water discharge, etc.) in a system decrease at night. Increased losses occur in the morning and in the evening.

Leakage increases in the hours of maximum pressure in the system. Leakage decreases in hours of maximum water consumption. Thus, Figures 2 and 3 are different from each other.

It can be said that leakages are a constant while unproductive water waste is a variable. Unproductive water waste depends on simultaneously opened water dispensing fixtures as well as on the number of consumers using water at a particular point in time.

It is also worth saying that monitoring of leakages and unproductive water waste must be made by specialists of maintenance organizations that have residential buildings as their assets.

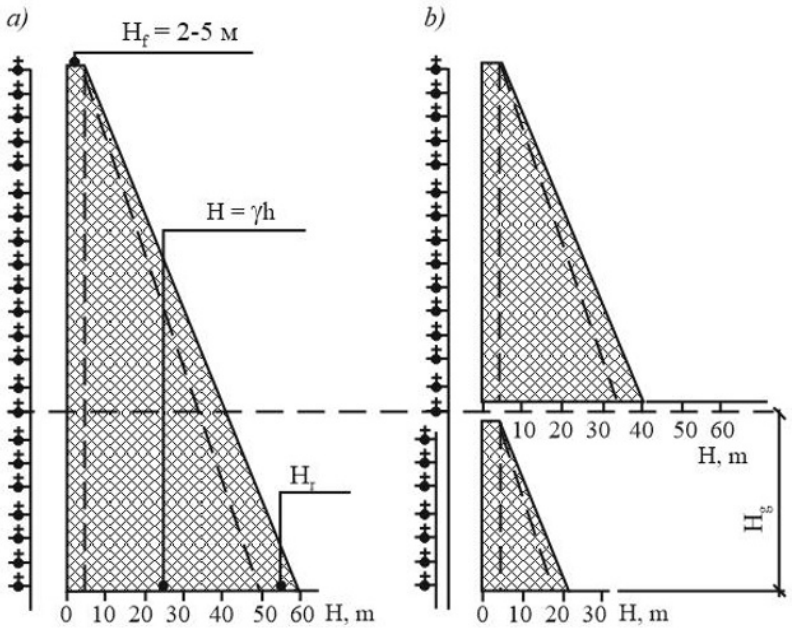

Fig. 1. Pressure distribution diagrams of water dispensing riser pipe for one-zone scheme (a) and when using pressure of an external water supply network (b):
H_f – standard hydraulic head of sanitary appliances; H_r – pressure loss; H – hydraulic head; H_g – minimal ensured pressure in an external water supply; h – height of a building.

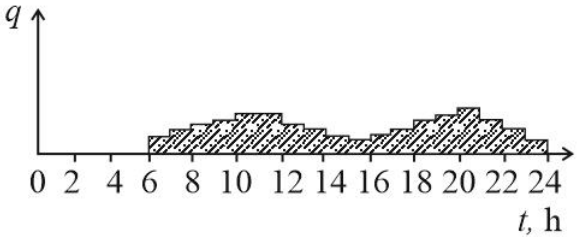

Fig. 2. Internal water supply unproductive water waste graph.

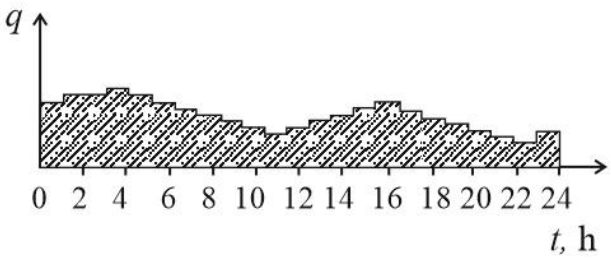

Fig. 3. Internal water supply leakages graph.

4 Discussion

Internal water supply should be designed with due regard to all reliability requirements for a pipeline and its elements (water dispensing fixtures, fittings, etc.)

Reducing water losses can be accomplished through the use of modern water dispensing fixtures (a single lever or a contactless mixer). In addition, it is necessary to give priority to models with a reduced seconds flow rate, which provides the required pressure in the system, but allows saving water significantly compared to imperfect water equipment.

Another solution for water loss reduction is the use of water-saving heads. They are special devices which are put on a spout of a water dispensing fixtures. The device can be turned on by pressing the special rod and can be turned off the same way. This principle of operation leads to water losses reduction in an internal water supply system of a residential building.

Using modern pipe fittings (pipelines made of polymeric materials) can significantly improve reliability of internal water supply networks. In addition, pipelines made of copper have become more preferable recently. They work well in harsh environments and have a significantly longer life cycle than steel.

It is suggested to make compilations of balance schemes of water consumption for each building viable and practical in future. Each building is a consumer of water resources. Compiling a balance of water consumption will allow distributing water more rationally

among consumers, pointing out ones that are more water-intensive and that consume the largest amount of potable water for various needs.

A promising direction is the installation of special facilities preventing leaks in each apartment, which, in the event of water, will be able to turn off water supply in an apartment. Thus, a possibility of water losses due to pipeline breakthroughs in case of a network failure or malfunctioning of water fittings is completely excluded. According to the operating experience, these devices have proven themselves well and they work without any failures when properly installed and aligned.

5 Conclusions

Based on the study of scientific works on water losses of internal water supply systems, as well as on analysis of various water loss options, the following conclusions can be drawn:

- designing of an internal water supply system of a residential building should follow the scheme of reducing water consumption on the lower floors of buildings by zoning the entire system;
- it is advisable to use a system with water tanks;
- to achieve indirect saving of electric energy, it is necessary to use pumping units with an adjustable drive;
- it is necessary to use water dispensing fixtures of a perfect design (mixers);
- it is necessary to improve quality of supplied water and pipelines of internal networks, which will allow to avoid unnecessary unproductive water waste in the form of excessive water discharge through the water fittings;
- creation of environmentally-oriented education and water use among inhabitants of residential buildings with compulsory education on the basic principles of water saving in the internal water supply system;
- to use automated machines for washing clothes and washing dishes (reducing water consumption by more than two times);
- performing systematic major repairs of entire water supply network within regulated periods.

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