1. Introduction

Operational ability of infrastructure in cities and villages is today dependent from 100% on drinking water and energies supplies. Technical-operational problems appear even after a short term interruption of the supplies to media mentioned above. For example, a short term interruption of direct drinking water supplies to medical and accommodation services causes collapse in their working. Similar situation arises in the food processing plants and sanitary institutions of other infrastructure and in residential areas.

Should technical-operational facilities of water systems carry out their required function, they have to have sufficient hydraulic and operational preconditions. The input preconditions of hydraulic efficiency of water systems develop as soon as the waterworks are projected by the calculation or mathematical modelling of water mains and can be considered as sufficient. But real operational conditions change and in the terms of time get worse. The following article in its basic form implies under which conditions and in which situations this happens.

2. Operational and hydraulic preconditions for waterworks systems working

Water systems of crude and especially drinking water are significantly different compared to other types of technical infrastructure. They do not work only with media but with one of the most important kind of food, without which the human life, food processing and operating minimally all kinds of the city and village sanitary institutions are not possible.

2.1. Operational preconditions of waterworks systems function

Basic technical-operational and functional preconditions of waterworks systems of water mains for the public need in the Czech Republic must meet two preconditions given below, depending on the type of water used for production or subsequently treated drinking water in distribution plants.

Crude water meant for drinking water treatment

In EU drinking water can be made only from the water meeting conditions for the category of treatment A1, A2, A3 [1]. For the need of the technological facility of the water treatment plants the operator can set approximate treatment index \(I_u\) at selected indicators, when regarding higher quality unsteadiness of crude water during the year, it is not possible to fit the source clearly into one category [1]:

\[
I_u = I_{a1} + I_{a2} + I_{a3} + I_{a4} \quad (1)
\]
Stationary flow is a flow the quantity of which does not change with time but only with location. The equation is:

$$Q = v \cdot S = \text{const.} \quad \text{[m}^3 \cdot \text{s}^{-1}]$$

Nonstationary flow is a flow the quantity of which changes with the location and time.

- stationary flow of a liquid ($Q = \text{const}$)
- even $S_1, S_2 = \text{const.}$, $v_1 = v_2 = \text{const.}$
- uneven delayed $S_1 < S_3$, $v_1 > v_3$
- accelerated $S_3 > S_4$, $v_3 < v_4$

A scheme of even and uneven liquid flows in pipes [2] is given in Fig. 1.

Fig. 1 Scheme of the liquid flow in pipes (adjusted by 2)

a) section of even flow
b) section of uneven flow delayed
c) section of uneven flow accelerated

Drinking water

Drinking water distributed by the waterworks systems of the water mains for the public use has very strict criteria which have to be kept during the whole process from its processing to the supply for the final consumer. The basic preconditions of the quality of drinking water and the qualities connected with drinking water are:

- Sanitation of drinking water while observing microbiological and physical-chemical index of water quality [1].
- Water freshness in each profile of water distribution mains
- Certifications of all materials in contact with drinking water
- Permanent monitoring of the drinking water quality in characteristic points of the distribution system.

The operational preconditions of the waterworks systems given above can be carried out in real operation only in coaction with hydraulic parameters by accumulation of drinking waters and specification of suitable dimension of water distribution mains.

2.2. Hydraulic precondition of function of distribution mains of drinking water

To guarantee the optimal working functions of all types water mains it is necessary to take into consideration surrounding in the pipe systems.

From the whole range of the matters dealing with the hydraulic of drinking water pipes and its output effect on the parameters relating consequently to the amount and quality of water it is inevitable to take into consideration the following terms and definitions.

Water flow under the pressure

Resistance of the surrounding and the liquid is evident as:

- loss caused by friction $Z_t$
- loss by locality $Z_m$

Total loss $\sum Z = \sum Z_i + \sum Z_o$

According to the type of designed pipes $Q = v \cdot S = \text{const.}$, the rate should move within the following limits:

$$d = \sqrt{\frac{4Q}{\pi v}}$$

$$v = \sqrt{\frac{2gH_0}{1 + \frac{\lambda}{d}}}$$

$d$ - searched average [m].
$Q$ - flow rate [m$^3$/s].
$v$ - proposal speed of water in the pipeline [m/s].

$$H_0 = \frac{v_i^2}{2g} + \sum Z$$

According to the type of designed pipes, the rate should move within the following limits:
For the calculation of a looped system, which consists of $m$ sections and $n$ nodes, we shall get $s$ loops:

$$s = m - n + 1$$  \hspace{1cm} (11)

Source path condition: The loss in the source path equals to the difference between height levels, free discharges, etc. of end nodes of the source path. If the number of pressure-dependent nodes is $y$, the number of source paths is equal to $y-1$.

$$\sum_{i=1}^{y} (c_i h_i) = H^K_i - H^K_j$$  \hspace{1cm} (12)

$hi$ – head loss in section $i$ [mm],

$c_{iy}$ – orientation of sections of the source path,

$HyPK$ – level of pressure head at nodes at the beginning and at the end of the source path.

Detailed knowledge of operating and hydraulic parameters of the water supply system being dealt with substantially increases the efficiency of safety planning and improves preventive preparation for coping with potential extraordinary events.

### 3. Safety risks of the functional changes of waterworks systems

It is not possible to prevent the cases of emergency in the water-supply engineering. It is possible to prepare on their progress and negative impact in advance from operational-safety analysis. The changes in functioning of the waterworks facilities are always caused by two causes with different potential of negative impact on the supplies of drinking water to consumers.

#### 3.1. Natural influence

Natural influence is tightly connected with water ecosystems and also with the resources of surface and subterranean waters. Negative impact on the waterworks systems functioning can be caused by:

- the change of climatic conditions (long-term droughts, water temperature and floods),
- natural higher releasing of inorganic rocksubstances into water,
- earthquake and following breaks of the land relief including the disturbing of aquiferous levels,
- landslides disturbing linear constructions of the waterworks systems.

Natural operational-safety risks can be predicted by the means of risk analysis and reasonably the lowest negative impact can be prepared.
Discussion on this and other issues in the field of water management can considerably advance and make more effective not only the waterworks but, in the wider context, also water management especially in the conditions of the forthcoming changes in the mild climatic zone.

5. Conclusion

This article in its basic range shows the ways and means for increasing the reliability of drinking water deliveries for built-up areas of the cities and villages to which the discussion and attention are focused with the aim to increase efficiency of operational waterworks systems. Regarding the forthcoming minimally regional shortage of water the present change of the approach to the water management can be considered absolutely necessary.

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