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Water supply systems and their influence on increasing operational safety in industry☆

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Summary The reliability of the technical manufacturing base of each state depends on the supplies of energies and drinking water in standard as well as extraordinary conditions. An extraordinary event or crisis situation can be caused by natural influences and anthropogenic events. Whereas in standard conditions, the supply of energies follows from contractual relationships, in case of extraordinary event it follows from a real situation that has occurred in the concerned entity of technical infrastructure. A common condition of technical—operational safety and manufacturing activity of all entities in standard and extraordinary situations is the reliability and continuity of water supplies for technological and sanitary purposes.

This article presents what the threats and natural and anthropogenic conditions that can disrupt or completely exclude manufacturing processes are and how these threats can be effectively coped with in the real environment.

Introduction

Part of ensuring the operational safety and production reliability of each industrial entity is the supply of energies and water. If energy minerals (gas, coal, uranium and oil) have strictly defined functions in industrial entrepreneurial entities, then drinking water has a multipurpose role and has a variety of uses. It can be considered as primary precondition for activities of each industrial company, without exception. Without the supply of drinking water, any sanitary conveniences that must be part of manufacturing service buildings cannot be operated, meals to employees cannot be served and, in many cases, drinking water is used in technological manufacturing processes.

Inside water supply systems connected to public water supply systems act very often, especially in extensive industrial parks, as multipurpose sources of water for firefighting and are really a necessary precondition for ensuring the fire safety of the whole industrial park. From the above-mentioned facts it follows that water supply systems and industrial companies form one integral interconnected whole.

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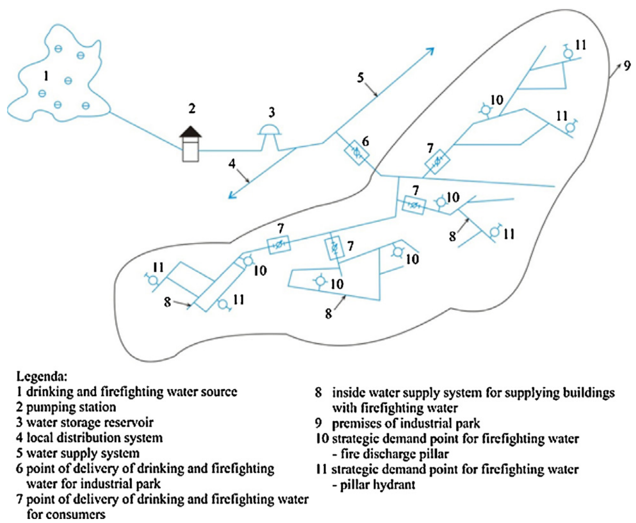

Figure 1 Diagram of connection of the industrial park to the water supply system of local water supply system.

Industry and its dependence on water supplies

Industrial companies and parks, see Fig. 1, are usually connected to local water supply systems of towns and municipalities or, in specific cases, to water supply systems of group and regional water supply systems.

A common feature of each connection of industrial consumers of drinking water is the construction of a water delivery point for an inside water supply system. In the case of industrial parks with more water consumers, it is absolutely standard that the industrial park has one central measurement of water demand and many measurements of water depending on the number of entrepreneurial entities.

From the technical operational point of view, the reliability of drinking and firefighting water supplies for the inside water supply system of industrial park, especially at maximal water demand, depends on the dimensions of water service pipe, correct type of measurement system at the delivery point and optimum dimensions of pipes of the inside water supply system.

To achieve a balance between water demand and water supply, it is suitable to use mathematical modelling for the design of facility construction. The mathematical modelling of a piping system can be suitably used also in water piping reconstruction. This will guarantee the operator of the inside water supply system a sufficient overview of, e.g. water flow rates in specific parts of piping, hydrodynamic pressure depending on water discharge and delay in water at minimum operating mode.

The stated measures have economic effects not only on the initial costs of piping construction but also, and above all, on the permanent operating costs of water quality maintenance and water disinfections for the whole process of supply to all consumers.

Mathematical modelling and its influence on operational reliability of water supply systems

The mathematical modelling of a water supply system is one of the most advanced methods for obtaining sufficient information about actual hydraulic parameters of the operating water supply system. So that the outputs of mathematical modelling may be realistic and exact, they have to be always calibrated before putting into operation, and for the use of the system, conditions have to be created.

Conditions of mathematical modelling of a water supply system

Each model requires input data on nodes, pipelines, storage reservoirs and other subjects of the system. It is not difficult for the operator to transfer most of this information to the creators of the mathematical model. In the case of older water supply systems with a higher degree of pipeline incrustation, one of important conditions of modelling is the knowledge of roughness of the pipe inner walls. On the accuracy of this information the output value of modelling depends as well.

Methods of water supply system calculation

For the successful mathematical modelling of local water supply systems of towns and municipalities and simultaneously also inside water supply systems of industrial parks, the following conditions must be fulfilled (Ingedult and Vyčítal, 1999; Odula, 2001):

(1) *Node condition*: The sum of inflows, outflows and quantities demanded at each node of the water supply system must be zero.

$$\sum_{i=1}^{m}(a_{ij}Q_i) + G_j = 0 \tag{1}$$

Q_i — rate of flow in section i ($m^3\,s^{-1}$), a_{ij} — expresses whether node j is the initial or final node of section i, G_j — quantity demanded from node j ($m^3\,s^{-1}$).

(2) *Loop condition*: In each loop of the water supply system, pressures will be equalized. If we give the sign, which is identical with that of the direction of flow at the same basic orientation of the positive flow in the loop, to the head losses in the section, the sum of the head losses in the loop will be zero.

$$\sum_{i=1}^{m}(b_{ik}h_i) = 0 \tag{2}$$

h_i — head loss in section i (m), b_{ik} — expresses whether the given section i is part of loop k.

(3) *Hydraulic condition*: It describes a relation between head loss and flow rate in the section.

$$h_i = k_i Q_i^2 \tag{3}$$

h_i — head loss in section i (m),

$$k_i = \frac{8}{g\pi^2}\lambda_i\frac{l_i}{d_i^5} \tag{4}$$