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Simulation and Analysis of Fire Sprinkler Systems Using EPANET for Enhanced Hydraulic Performance

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Abstract: *EPANET is a simulation software program developed by the United States Environmental Protection Agency (EPA) used to model water distribution systems. It is used by engineers and hydraulics specialists to design and analysis networks of pipes, tanks, pumps, valves and other components of water distribution systems. EPANET can simulate the distribution of water flow and pressures in each network component.*
The program performs a detailed hydraulic analysis, calculating water flows, pressures and storage levels in the network, and can simulate the dynamic behaviour of the network over time, allowing users to see how conditions vary based on changes in water demand or other factors.

Keywords: *EPANET, hydraulics, water flow, water distribution*

1. Introduction

Conventional strategies for analysis of looped water distribution systems accept that accessible nodal streams are equal to the nodal requests and get available pressure heads at distinctive hubs. Available pressure heads less than the minimum required heads at one or a few hubs appear as network's failure to supply the craved requests. Beneath such pressure deficient conditions, the amount of water can supply at diverse hubs is requires in arrange to estimate short-fall in supply.
Such an analysis has been used in different networks issues like multi objective network design [1], calibration [2] and reliability based on design [3-7].
In this paper, we want to improve the hydraulic efficiency of a sprinkler system to achieve the maximum efficiency and required flow at the farthest sprinkler head and obtain an isometric diagram that facilitates the understanding and design of such a system.
The computer simulation is carried out using the EPANET program, which helps us to carry out detailed hydraulic analysis, calculate water flows, pressures and storage levels in the network.

2. Choice of input data for the EPANET software

The equivalence coefficient ("emitter coefficient") is a parameter in EPANET that can be assigned to a connection point (node or hole). The special device called a sprinkler cannot be recognized by the program, so it is equated with a simple hole through which water flows and which is characterized by the equivalence coefficient, just as the nominal value K characterizes the sprinkler head.
To determine the equivalence coefficient, an elementary network consisting of a tank, a connecting pipe and a node is created. The linear hydraulic pressure losses through the pipeline are completely reduced by assigning a very small length (1 m), a very large diameter (10000 mm) and a low roughness value (0.000001). The reservoir was also assigned an estimated value of 10 mH2O.
These steps are entered in the software according to Fig. 1.

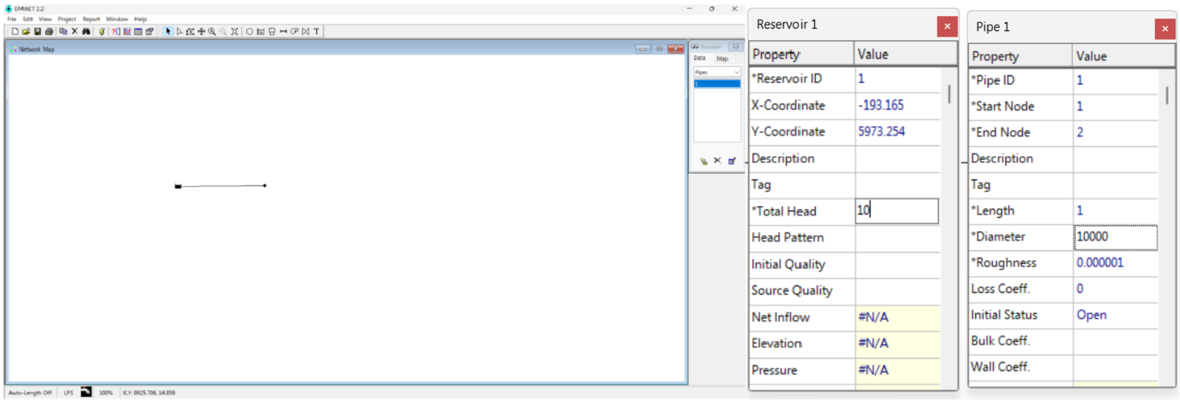

Fig. 1. Assigning properties for the elementary lattice

The equivalent coefficient is determined by tests and is correctly chosen when, after running the test, the node flow is equal to the water flow discharged through the hole of the last sprinkler head: qis= 1.91 l/s.

After the tests, the value of 0.605 was obtained for the equivalent coefficient (Fig. 2).

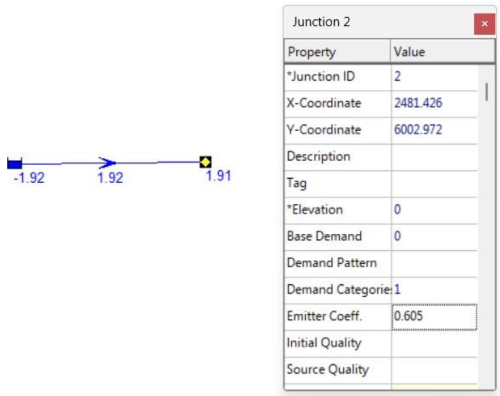

Fig. 2. Equivalent coefficient

3. Drafting of the isometric scheme of the simultaneous triggering area

The isometric diagram of the simultaneous release area is created in the AutoCAD program and uses simple lines whose intersection is read by the EPANET program as a node point. Basically, the sprinklers are marked by discontinuity points that are not visible in the AutoCAD program. The diagram in Fig. 3 shows the isometric diagram of the simultaneous release area, which is saved using a file with the extension "dxf".

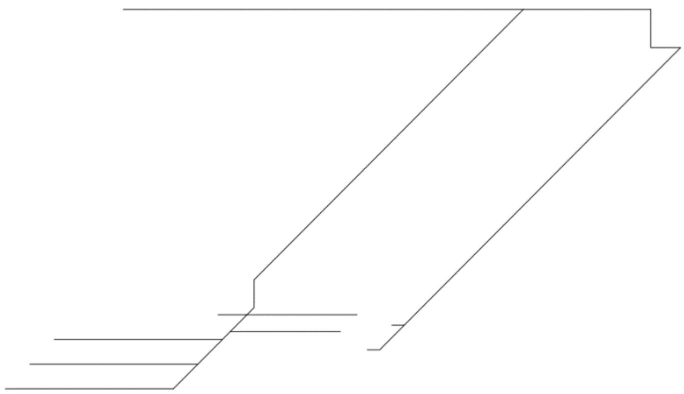

Fig. 3. Isometric diagram

The file with the extension "dxf" is imported into another program called EPACAD, which uses the extension "inp" to import the isometric scheme into the EPANET program, as can be seen in Fig. 4.

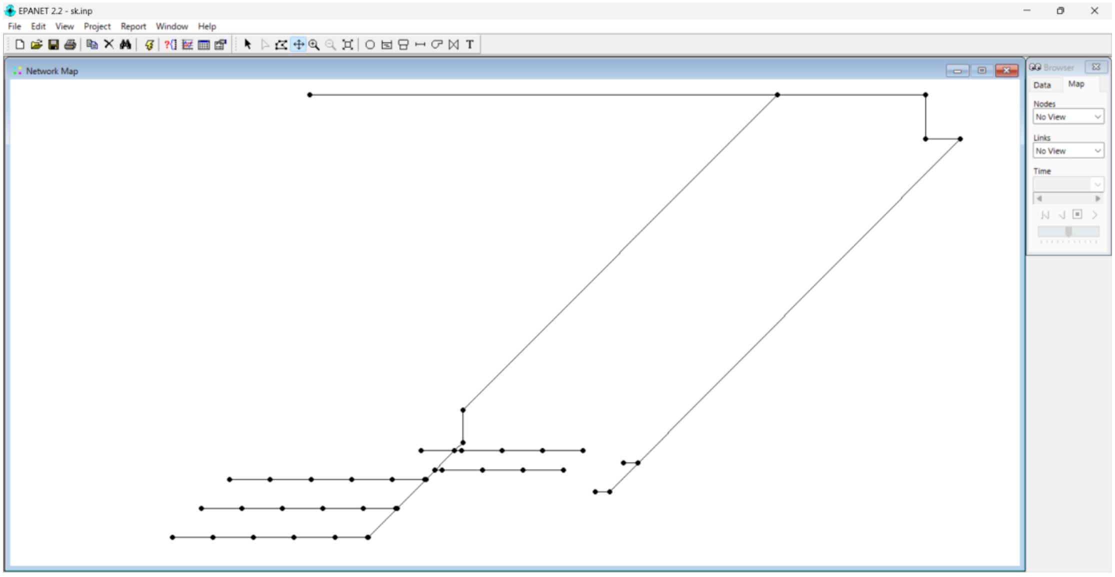

Fig. 4. Isometric diagram in the EPANET program

4. Assigning properties in the EPANET program

First, the water tank and the connecting pipe to the network of nodes are placed. The program automatically adopts the length units used in the AutoCAD program. All pipes are also assigned a roughness value of 0.01 (Fig. 5).

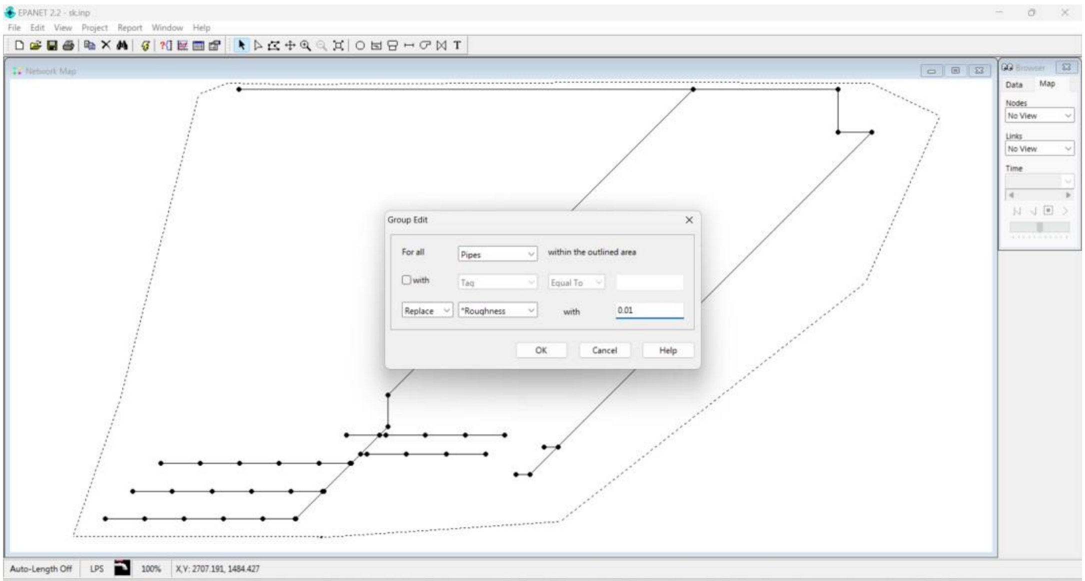

Fig. 5. Roughness assignment

The next step is to assign diameters to the pipes in the network. They will be assigned initial values, which will be returned to later in order to achieve the appropriate dimensioning. Branches containing sprinklers will be assigned DN50 diameter, secondary pipes DN80 and main pipes DN100. This is done by selecting the region on which the changes are made and assigning the desired value. In Fig. 6 shows the assignment of the diameters for the branches, and in Fig. 7 shows the same action for the secondary and main pipes.

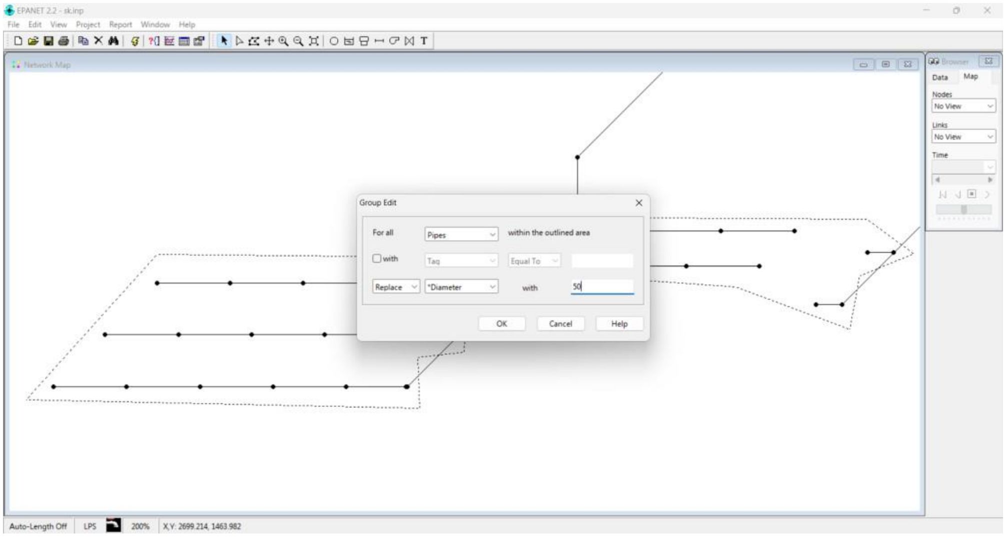

Fig. 6. Selecting the region containing the branches and assigning diameter values

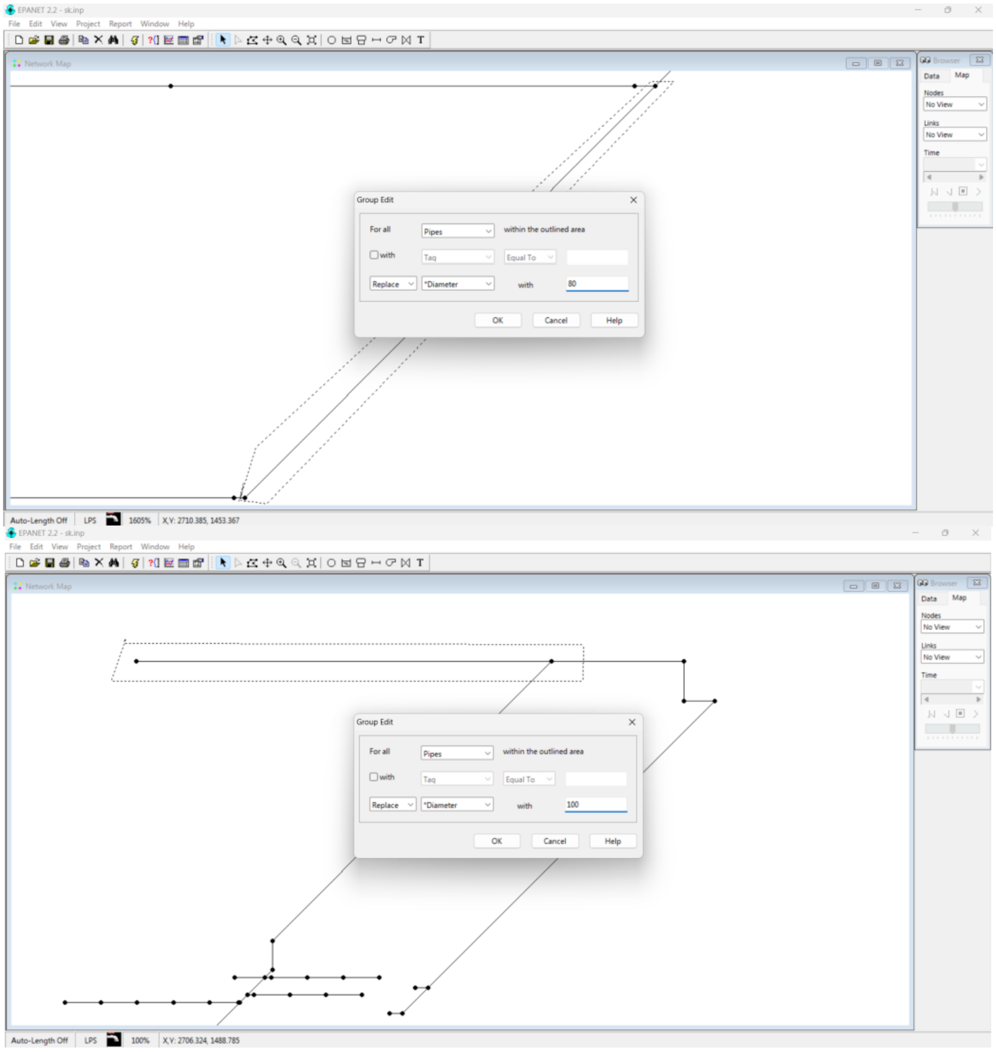

Fig. 7. Selection of the region containing the secondary and main pipes respectively and the diameter assignment

The next step is to assign values for the position height of the nodes (elevation) as shown in Fig. 8, taking into account the distance from the sprinkler head deflector to the elevation ±0.00 m: 6.55 m.

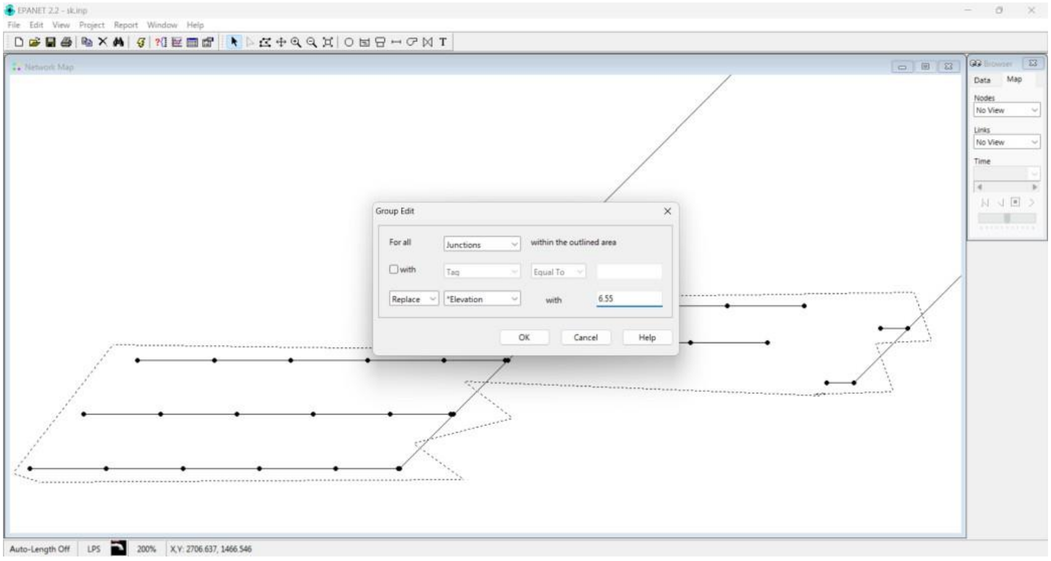

Fig. 8. Assigning values for node placement height

At the same time, for these nodes representing the sprinklers in the area of simultaneous release, the value of the equivalence coefficient determined in the initial design phase was assigned, as can be seen in Fig. 9. Later, we went back to the nodes representing directional changes and deleted this value, as they should not be read as holes by the program.

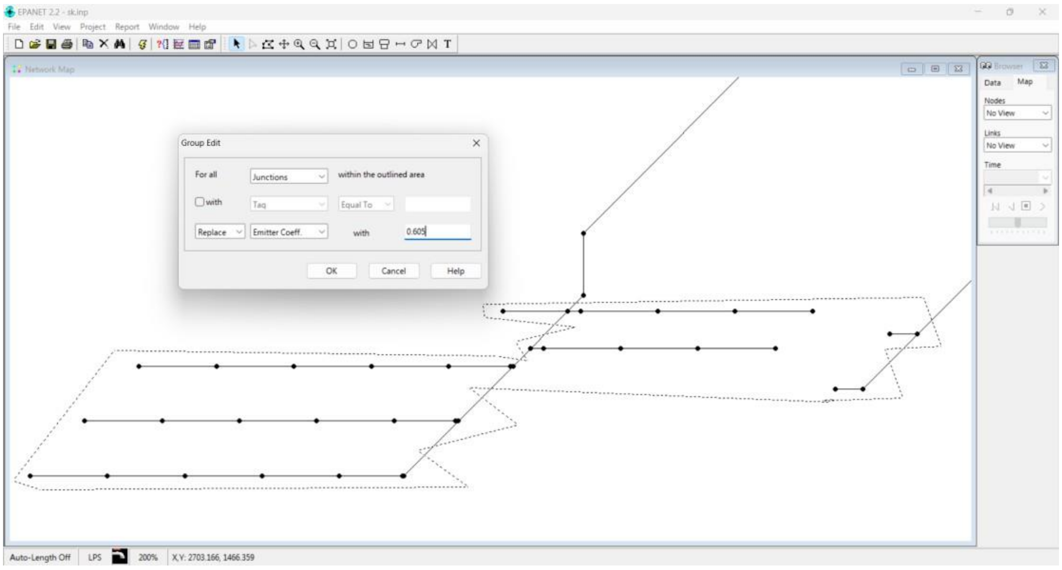

Fig. 9. Assigning the value of the equivalent coefficient

Finally, before performing the test, the water tank is assigned a value of 20 mH2O, which is estimated by summing the pressure of 1 bar determined for the last sprinkler head with a pressure loss of also 1 bar in the distribution network (Fig. 10).

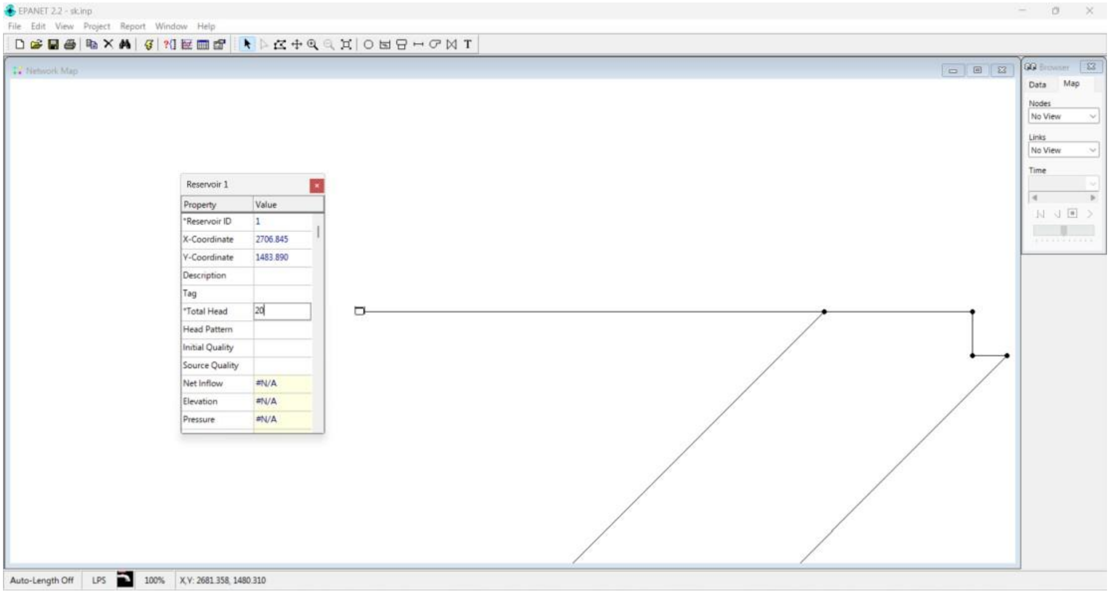

Fig. 10. Assigning the value of 20 mH2O for the water tank

5. Running the test to obtain the required flow at the farthest sprinkler head

Carry out the test and obtain the values shown in Fig. 11. To obtain the flow rate value of 1.91 l/s resulting from the calculation instead of 2.17 l/s displayed after the first run, the pipe diameters are reduced, as shown in Fig. 11 and Fig. 12.

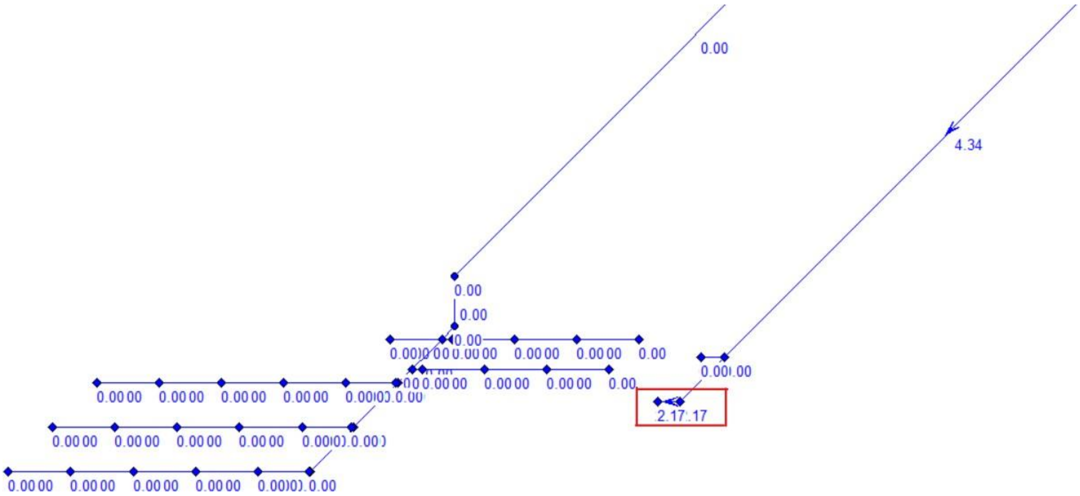

Fig. 11. Obtaining a flow rate of 2.17 l/s after the first test run

Following changes in the diameter of the secondary pipe from the value DN80 to the value DN50, a flow value for the farthest sprinkler of 1.95 l/s is obtained (Fig. 11), so that the diameter of the last branching portion from the DN50 value to the DN25 value (Fig. 12).

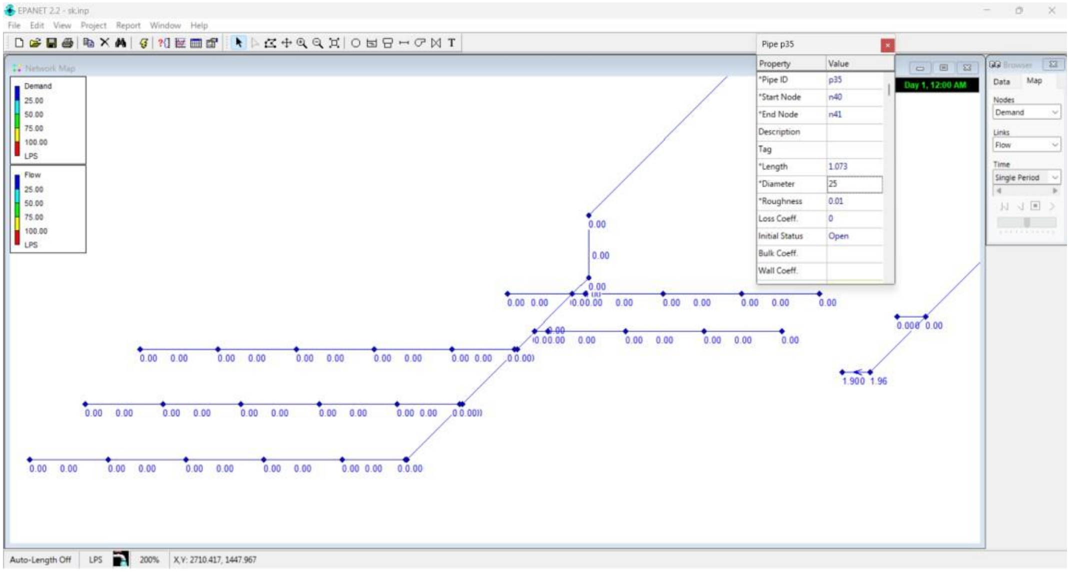

Fig. 12. Reducing the diameter of the last branch portion from DN50 to DN25

Thus, a value very close to the desired one of 1.90 l/s was obtained, being very close to the desired value of 1.91 l/s. In this way, the dimensioning of the supply network of the simultaneous triggering area was achieved by adapting the diameters in accordance with the STAS in force, so that the flow of water discharged through the office of the last sprinkler head corresponds to the calculated specific flow: qis = 1.91 l/s.

6. Conclusions

EPANET proves to be an effective tool for modeling and analyzing the hydraulic performance of sprinkler systems. Its ability to simulate complex pipe networks with different flow rates, pressures and pump dynamics enables accurate assessment of sprinkler system performance in different fire scenarios. Through hydraulic simulations, EPANET helps identify critical areas of pressure loss, inadequate water supply or inefficient systems, enabling engineers to optimize their fire protection designs.

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