

## **Modeling the behaviour of flow regulating devices in water distribution systems using constrained non-linear programming**

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Currently the modeling of check valves and flow control valves in water distribution systems is based on heuristics intermixed with solving the set of non-linear equations governing flow in the network. At the beginning of a simulation, the operating status of these valves is not known and must be assumed. The system is then solved. The status of the check valves and flow control valves are then changed to try to determine their correct operating status, at times leading to incorrect solutions even for simple systems. This paper proposes an entirely different approach. Content and Co-Content theory is used to define conditions that lead to the guarantee of the existence and uniqueness of the solution. The work here focuses solely on flow control devices with a defined head discharge versus head loss relationship. A new modeling approach for water distribution systems based on subdifferential analysis that deals with the non-differentiable flow versus head relationships is proposed in this paper. The water distribution equations are solved as a constrained non-linear programming problem based on the Content model where the Lagrangian multipliers have important physical meanings. This new method gives correct solutions by dealing appropriately with inequality and equality constraints imposed by the presence of the flow regulating devices (check valves, flow control valves and temporarily closed isolating valves). Two example networks are used to illustrate the concepts.

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