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APPENDIX II: DISCRETIZATION OF EQ 3

The time derivative in Eq 3 can be discretized using Euler's method,

$$\frac{dP_i}{dt} = a_i \frac{P_i^{j+1} - P_i^j}{\Delta t} \quad (16)$$

The future time step pressure P_i^{j+1} can then be calculated explicitly.

APPENDIX I: ELEMENT MODELS

Three element models used in this paper are described below. These models define how the flow through the element is related to the pressure difference across the element.

Pipe

$$\dot{V} = \dot{V}_{nom} \left(\frac{\Delta P}{\Delta P_{nom}} \right)^{1/x} \quad (8)$$

Two-way valve

$$\dot{V} = u C_{v,nom} \Delta P_x \quad (9)$$

where

$$C_{v,nom} = \frac{\dot{V}_{nom}}{\Delta P_{nom}^x} \quad (10)$$

Pump Controlled by VFD

$$\dot{V}_{om} = u \dot{V}_{n} \frac{-a_2 - \sqrt{a_2^2 - 4a_3(a_1 - \Delta P^*)}}{2a_3} \quad (11)$$

where

$$\Delta P^* = \frac{\Delta P}{\Delta P_{nom} u^2} \quad (12)$$

$$a_1 = 1.35348296 \quad (13)$$

$$a_2 = 0.0159317 \quad (14)$$

$$a_3 = -0.36941442 \quad (15)$$