

# Use of Pressure Reducing Valve for Preventing Pipeline Rupture: A Case Study

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## Abstract

In the present work, hydraulic modelling is designed so as to prevent the damage or leakage of water distribution networks due to water hammer pressure by maintaining adequate pressure. In water supply systems, water is transported from one unit to another by means of pumping or by gravity or by combined pumping-gravity methods. For this purpose, various components like junctions, pipes, joints, pumps, valves, fittings and other appurtenances are used. To provide proper design discharge along with sufficient quantity, adequate pressures are maintained by designing effective hydraulic modelling. In order to prevent damage, rupture or bursting of pipelines due to water hammer pressure, pressure reducing valves (PRV) are considered. The sudden or gradual, opening or closure of valves are decided by considering the pressure that is to be maintained so as to allow the proper flow at outlet or consumer end. In the present case study for Akot, an attempt has been made on hydraulic modelling of water distribution networks. Designing and analysis are done by placing the pressure relief valves at different locations and flow are adjusted by pressure settings using trial and error methods.

## Keywords

Distribution Network, Flow, Pressure Reducing Valves, Water Hammer

## Introduction

Water and wastewater discharges from different industries and from the surrounding cities or towns causes contamination of the receiving natural water bodies and thus causes water pollution in the environment [1]. This same sources are most of the times used for drinking. So it is necessary to treat this water [2]. As these water is supplied through water distribution networks for drinking purpose and end use purpose by the city or town.

The water supply scheme has a key component i.e pipeline network, a key component with a complex structure involving huge investment, its stability and reliability is the important factor. Maintaining public health is the main moto. In the pipeline network, when water flow from upstream side to downstream side with a larger head and greater velocity, bursting or rupture of pipes take place. If the velocity of flow is suddenly diminished, the pressure generated by the water will try to compress the water by stretching the pipe walls and frictional resistance to wave propagation. As the demand for water increases and at the same time the longer time for water transportation will be required. This leads to the elongation of the pipe with a huge elevation difference from the upstream side to the downstream side.

As the Government of India has taken initiative in developing the rural area [3] some schemes related to water supply are launched like the Swajal Scheme for the steady supply of clean drinking water in a rural area, National Rural Drinking water Programme, Mukhya Mantri Rural Drinking Water Programme. For the urban area Smart City Mission (SCM), Atal Mission for Rejuvenation and Urban Transformation (AMRUT) and many more. All these missions play a key role in development. There are many drawbacks of water supply schemes [4] with the long-distance supply of water through pipes and with higher elevation like hammering, bursting, leakages, pressure maintenance and many more. In the present case study, Akot water supply scheme along with surrounding associated villages are considered. A small part is taken into consideration, where, pressure in the pipe crosses the permissible limit due to higher head loss. To prevent damage to a network of water distribution pipelines, pressure reducing valves are used. In hydraulic modelling, analysis is done using Water GEMS software to substantiate its suitability to prevent damage in the water circulation network [5].

## Methodology

The present study incorporates data collection and consumer survey, a study of the water distribution system, upstream and downstream elevation, generation of the hydraulic model in Water GEMS, residual head, pressure measurement at various locations of study area, analysis of the calibrated model for residual pressure under gravity main.

## General Topography and Climate

Akot and its surrounding villages are located in the Akola district of Maharashtra state (India). These villages are well connected by road to taluka place Akot and Telhara. The nearest railway station is Akot. The main occupation

is agriculture, horticulture and small scale horticulture activities. The source of the crude water is Wan dam. The coordinates of the project area are topmost left corner situated at latitude 21°10'39.4"N and longitude 76° 07' 02" E and bottom-most right corner situated at latitude 19° 15' 84" N and longitude 76°27' 14" E The general slope of project area is from North to South. The highest R.L is 413 M and the lowest R.L is 250 M., The necessary salient features of the case study along with details of pipes diameters, material and lengths of rising main used in the present study are shown in Table 1 and Table 2. In general, Akot and its surrounding villages are characterized by warm and hot weather. Summers are very hot and last from March to the middle of June. Winter is between October and February. Monsoon is from June to October. The average annual rainfall in the region is 773 mm.

Area of Supply Zone	Malthana, Akot
MBR Capacity	215 KL
Number of ESR served	12 nos
Rate of Water Supply For villages For Periurban villages	40 lpcd 70 lpcd
Population Served (at present)	16873

**Table 1: Salient Features of Case Study**

Component	Diameter (mm)		Material	Length(m)
Pure Water Gravity Main	110	98.6	HDPE 6 kg/cm <sup>2</sup>	2597
	140	125.4		219
	160	143.4		5461
	180	161.4		294
	200	179.4		3614
	225	201.8		2842
	250	224.4		5091
	280	251.0		639
	315	282.0		810
Total Length			21567	

**Table 2: Details of Pipes Diameters, Material and Lengths.**

The area considered for case study is Malthana zone of Akot having master balance reservoir of 215 KL capacity. Through this 12 elevated service reservoirs are filled. Other details are given in Table 1. The details of pure water gravity main pipe network are as shown in Table 2.

### Results and Discussions

Bentley Water GEMS V8i version was used for the generation of the Hydraulic model design and analysis with and without pressure reducing valves (PRVs). The flow diagram of case study area is shown in Figure 1. The details of various input parameters required for different components of the network like pipes, nodes, tanks, pumps, and reservoirs were collected from field surveys and by Google Earth software. After the generation of the model, using pressure gauge, field measurements for residual pressure were taken. The model was calibrated [6] for residual pressure and adjusted values of the roughness coefficient for different pipe material were determined.

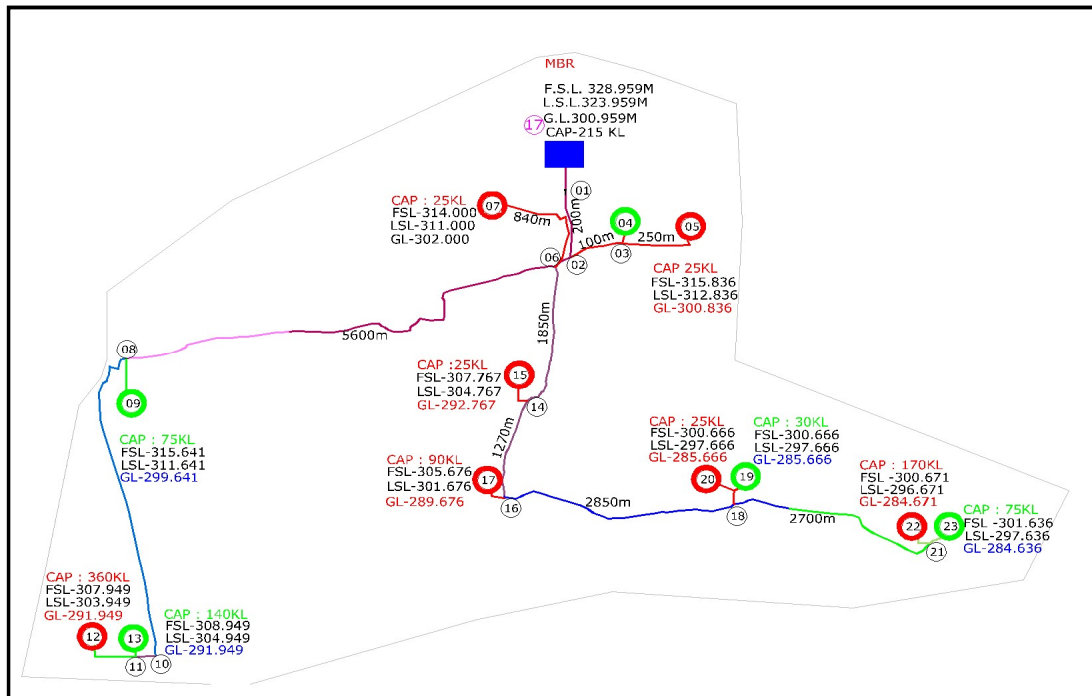


Figure 1: Flow Diagram of Case Study Area

The model was run for steady-state analysis [7] initially without PRVs. Through the Malthana MBR the distribution is done to 12 different locations. The flow, velocity, pressure are analyzed the solution obtained is observed. It was found that the pressure obtained was too high as PRVs were not considered. Therefore so as to maintain the pressure, PRVs are introduced at the starting point between the two junctions from the direction of the flow of water (as shown in Figure 2). Both Pressure readings are shown in Table 3 and Table 4. Water GEMS hydraulic model's part with pressure reduce valve and its property table are shown in Figure 3.

Junctions	Pressure (m H <sub>2</sub> O)	Junctions	Pressure (m H <sub>2</sub> O)
J-1	4.21	J-6	<b>18.56</b>
J-2	<b>25.6</b>	J-7	4.68
J-3	<b>24.85</b>	J-8	<b>21.56</b>
J-4	4.89	J-9	<b>20.57</b>
J-5	<b>28.2</b>	J-10	<b>18.42</b>
J-6	<b>22.3</b>	J-11	<b>16.52</b>

Table 3: Pressure at Junction Point without Pressure Reducing Valve

Junctions	Pressure (m H <sub>2</sub> O)	Junctions	Pressure (m H <sub>2</sub> O)
J-1	4.21	J-6	4.93
J-2	4.59	J-7	4.68
J-3	4.81	J-8	4.59
J-4	4.89	J-9	4.53
J-5	4.58	J-10	4.81
J-6	4.16	J-11	4.81

Table 4: Pressure at Junction Point with Pressure Reducing Valve

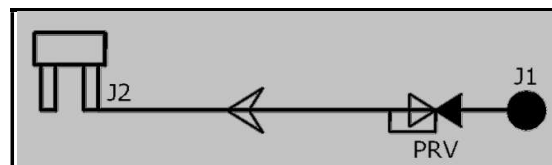


Figure 2: PRV's Location

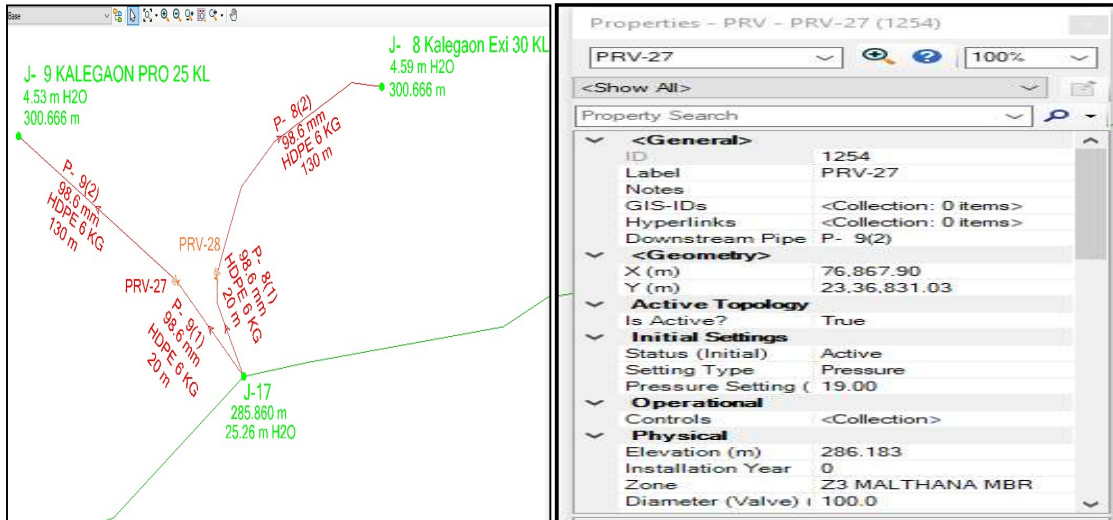


Figure 3: Water GEMS Hydraulic Model's Part with Pressure Reduce Valve and its Property Table.

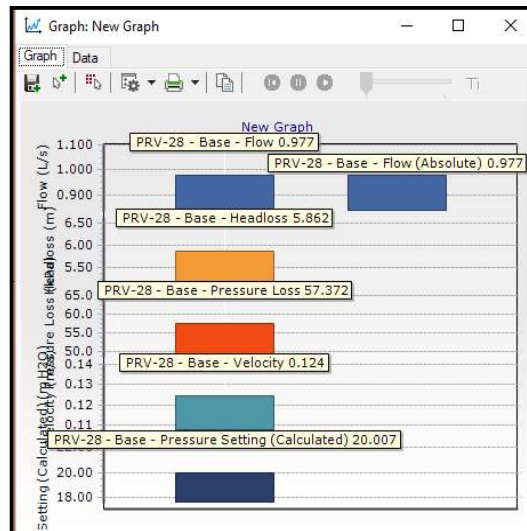


Figure 4: Sample Graph for PRV - 28

In the hydraulic model HDPE, 6 kg/cm<sup>2</sup> pipes are used of different diameters like 110 mm, 140 mm, 160 mm, 180 mm and many more. The results obtain without PRV's are shown in Table 3. The pressure obtain is high at some junction due to larger head [8]. The pressure and flow can be reduced by installing a larger diameter pipe which leads to an increase in the cost and the pressure is also not reduced satisfactorily [9]. The results obtain with PRV's are shown in Table 4. It indicates that the reduction in pressure is achieved by adjusting the initial settings keeping the status active and adjusting the pressure setting [10]. Figure 4 shows sample graph for PRV-28.

### Conclusions

The hydraulic model of the Malthana zone is generated and calibrated in Water GEMS software. It was assessed for its adequacy in term of pressure setting at different nodes with and without PRV's. Based on the analysis and while operating the network without PRVs, it is observed that the head from start to end is large, the pressure at some nodes is less than 20 m H<sub>2</sub>O. Secondly by replacing the smaller diameter pipes with larger diameter pipes, the results are not found to be satisfactory. In that condition water hammering and bursting of pipes can happen. While operating the network with PRVs, it is observed that instead of larger head from start to end, the pressure at nodes is controlled by pressure setting to maximum 5 m H<sub>2</sub>O. In that condition HDPE 6 kg/cm<sup>2</sup> pipes withstand the pressures and flow velocities. Like this way, rupturing and bursting of pipes due to water hammer pressures can be avoided.

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