White Paper

Dynamic Pressure Control Enhances Water System Operation

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Overview

Supervisory Control And Data Acquisition (SCADA) solutions provides a basis for a more reliable and efficient operation of water systems while also providing significant financial benefits. Both of these are important for utility management, by providing a means for increased productivity, helping to reduce the number of failure events, and by minimizing the loss of potable water.

In many of the urban centers in the world water scarcity prevails. At present the demand for water exceeds the supply mainly during the peak hours of the day, the daily capacity including the storage volumes, and in cases of dry periods throughout the year. Many of the cities suffer from high levels of Unaccounted-For Water (UFW), as a result of physical and administrative losses. The high levels of UFW is one of the main causes for the inappropriate management of the water system, leading to water scarcity and financial problems which prevent the needed liquidity and capital generation to enable the utilities to tackle and solve problems. In many cases the piping network is old and worn as the financial means to replace large sections of the network are unavailable due to the requirement for a large budget.

There are a number of instruments that the utility can use in order to deal with problems. Few are within its direct responsibility while others are located at the user's premises to enhance the conservation of water. This reduces the short term financial means at the disposal of the utility. The other tools are the direct responsibility of the Utility as they are available technological instruments to manage the whole network from a control center. They also reduce water leaks and it's scope by Dynamic Pressure Regulation, between the urban zones, daily hours, and the off peak weekend flows. In dryer areas where massive irrigation is needed the city parks are also major water wasting sites.

This article/paper describes the options and main functions of two important measures: 1) the SCADA central control technology, 2) the integration of Zonal Pressure Control methods, within its functions. Both have proved to be major instruments in dealing with network management as well as its function to maintain a reliable water supply, while minimizing water and financial losses.

Benefits achieved with SCADA Solutions

In SCADA systems the use of RTUs and wireless communication perform the monitoring and control functions as specifically required for each (field) site. Obviously, every function performed at a remote sites must be linked to a specifically defined operating or cost benefit.. Utilities may achieve reductions in their electric power bill, minimize failures, and be more effective in their handling of critical events. This is in addition to the operating benefits, modernization, and convenience in the work environment for maintenance teams.

SCADA systems help to achieve optimal water distribution by adding new features to the system, such as: level and flow monitoring, pump operation sequencing, electric energy consumption monitoring, historical scenario analysis (audit trail), and Dynamic Pressure Control (DPC). Sensors for flow monitoring are usually installed next to valves where they collect flow information. In turn, this is communicated to a SCADA control center via the RTUs. Using this data, the RTUs may maintain stable pressure, help optimize the flow rate, as well:

- optimize pressure level as needed thereby minimizing leaks through hundreds or thousands of non-identified (difficult to repair) pipe breaks and smaller holes
- reduce misuse or excessive use of water due to high pressure provided to the domestic and commercial consumers as well as industrial users, parks, and gardens
- record flow and pressure data in each section for analysis of operational optimization and planning

Pressure Control along Pipelines

Careful pressure and transient analyses are needed to understand the potential magnitude of this problem and, if necessary, to determine how the pressure should be adequately controlled. There are numerous solutions, available equipment, and operational alternatives for mechanical engineers to consider when developing their pressure and transient control strategies. This paper refers to the phenomena of excessive pressure which is a common problem occurring in water pipelines that leads to increased leakages and system failures.

Figure 1 illustrates a typical pressure situation along pipelines in urban areas as displayed on the SCADA control center screen. The system operation ensures minimum required pressure during the maximum flows normal con-

ditions, specific conditions, and fire extinguishing demands.
In this operating mode, whenever the flow is lower than the estimated maximum due to low demand, there is excessive pressure along the pipe. This causes an increased number of leaks and losses, unnecessary water consumption, and on occasion, it might cause new pipe-breaks.

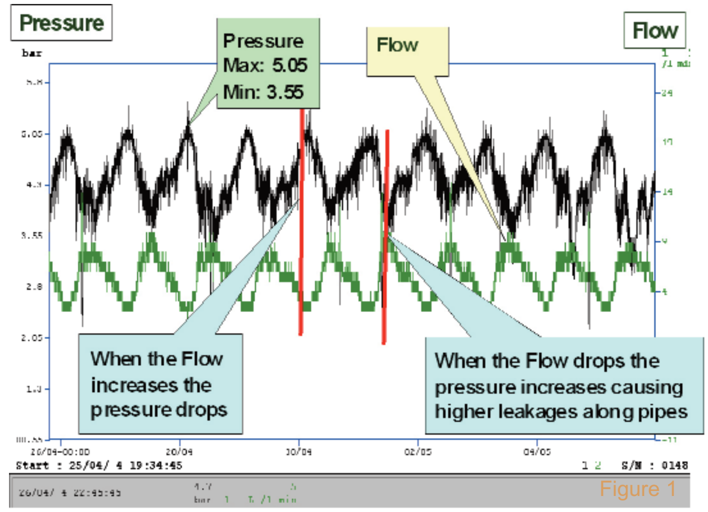

Figure 1

Figure 2 shows a simplified illustration of the flow and pressure, over time, described in Figure 1.
The conclusion obtained from analyzing Figures 1 and 2 leads to the potential implementation of an improved operating scheme for urban water systems. The design needs to ensure that during the time when the flow reaches its maximum level, there will be adequate pressure to serve all customers connected to the specific water pipeline.

The solution to this challenge is to reduce the pressure along the pipeline during the time when the flow drops due to reduced demand. Reducing the pressure along the pipe will help minimize water leakage through difficult-to-find holes while minimizing the probability of causing new breaks along the pipeline.

Note: *It is important to remember that in many countries fire trucks connect to the water pipe so the system must ensure minimum pressure for fire hose use.*

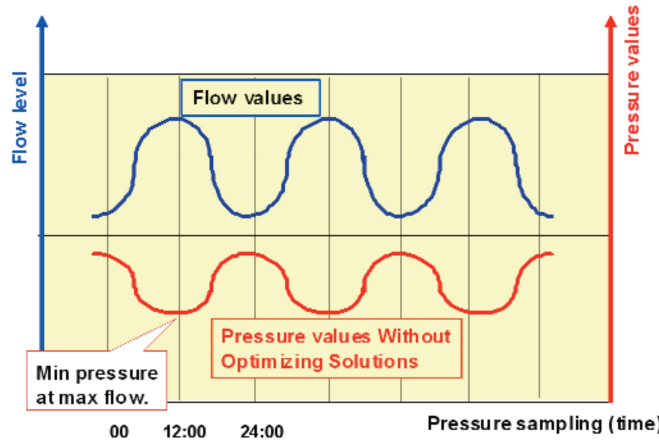

Figure 2

Implementing water pressure control using dynamically-controlled Pressure Reduction Valve (PRV) stations requires the installation of flow meters and pressure controlled valves along the pipeline, which are monitored by RTUs. Each meter records the flow into a “metered area” with a permanently defined zone. This can be done using a SCADA system with a relatively low investment. Adjusting the pressure according to the changing conditions throughout the day, as well as from season to season, is an efficient tool that contributes greatly to several aspects of the system's operation:

- makes efficient use of existing resources
- delays investments in renovations
- delays investments in development of new water sources and pumping stations
- results in reduced maintenance costs
- extends life span of the system

Figure 3 illustrates the challenge to provide adequate pressure to all customers connected to the pipeline while each building is at a different distance from the supply source. The reservoirs and the main valves can be located in hilled areas which affects the actual pressure at each point. An optimal solution requires segmenting the pipe into zones and adding multiple Pressure Regulated Valves (PRVs) tuned to optimal pressure output.

Figure 4 illustrates a system including a flow meter which monitors the actual demand. Based on that and inputs from the SCADA control center, its role is to determine the optimal setting for the output pressure from the PRV. The RTU output is fed to a solenoid via a special solu-

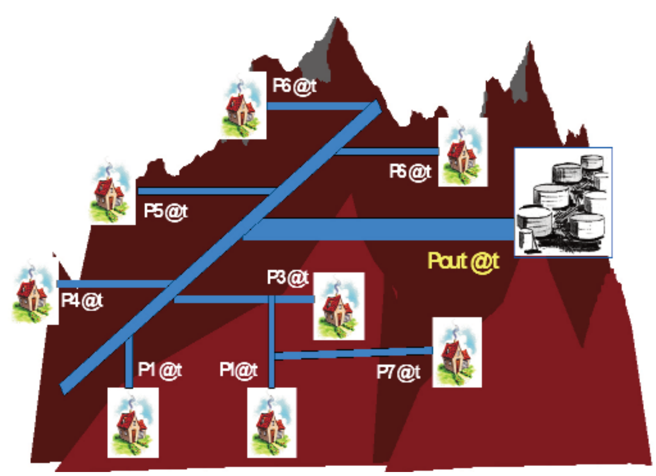

Figure 3

tion built into the hydraulic valve which controls the output pressure. The RTU may optionally receive its power from a solar panel and battery or from AC Power.

***Note:** Operating the valve requires very little electric power.*

Figure 5 illustrates the implementation of pressure reduction and process control solutions using PRVs.
As seen on the chart, the point of maximum flow (time 12:00) is also the point of maximum pressure at the output of the PRV. This is the same value as shown in Figure 3 above. However, here when the flow drops during the night (24:00) due to low demand, the pressure is reduced to the minimum level needed to satisfy the "most distant" customer. This minimum value is much lower than the value seen in Figure 3.

Figure 6 illustrates the implementation of the two level pressure control schemes as shown in Figure 5. Similar to the single level solution, the actual setting of the pressure is performed by the RTU, which is controlled by the SCADA master control center. However, compared to the single level operation, this helps to more accurately optimize the pressure adjustment while lowering the leakage levels from the damaged pipes.

***Note:** Here the hydraulic valve has two solenoid controlled devices able to set dual pressure set-points.*

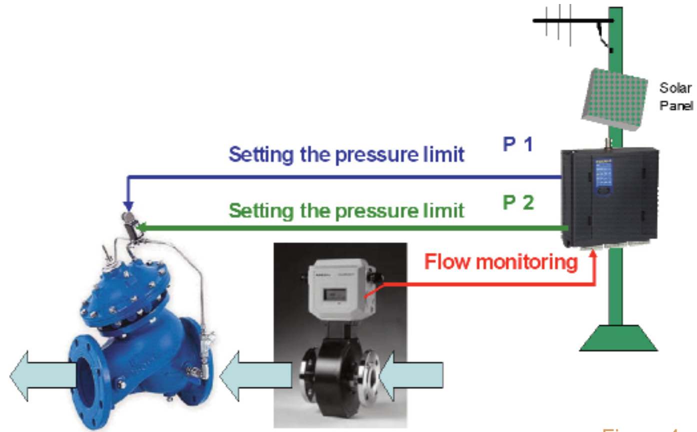

Figure 4

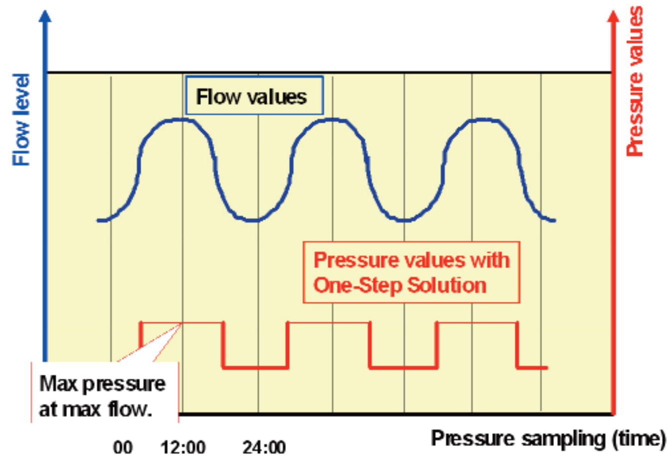

Figure 5

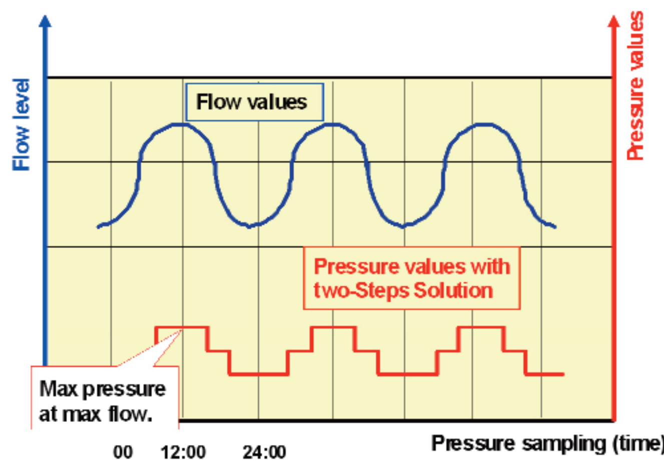

Figure 6

Summary and Conclusions

Management's decision to integrate and operate a SCADA system combined with Dynamic Pressure Control is aimed at improving the efficiency and effectiveness of the Utility operation. It involves the use of computer hardware, instrumentation and sensors, electric control panels, power monitoring devices, software programming, data communication, equipment, and system installation and commissioning. Appropriate selection of all SCADA related components may help achieve the system goals and expedite the Return On Investment (ROI). The use of SCADA for the management of water networks provides the means for a more effective operation of the water utility, financial savings, as well as other intangible benefits. This can be as important as the financial improvements. In addition to the tangible benefits, the use of the SCADA, as well as the DPC, will lead to improved operating procedures that contribute to the utility operations which are achieved with fewer interruptions of supplies, effective handling of the water infrastructure, more satisfied operators and maintenance staff, and enhanced customer satisfaction .

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