Regulo - Practical Water Pressure Management

With the passage of time, distribution systems become old and corroded, concentrations of population build up in large suburban areas and away from rural areas, and usage of water multiplies, contributing to the need to replace, rehabilitate and sometimes redesign the old network.

Mains replacement is an expensive process which leads to significant highway disruptions, and is usually considered as a last resort. Wherever possible, water companies have sought to maintain their networks at an acceptable efficiency and performance level to defer replacement.

They often face the following sources of problems:

(i) High leakage levels and burst frequency.

(ii) Loss of pressure in old mains.

(iii) Undersized networks for current demand.

Controlling Leakage

From as early as the mid 1970's, the water industry started to develop methods for active leak localisation such as step-testing. During the 1980's many water companies opted for full scale implementation of permanent monitoring of night flows in network zones or District Metered Areas (DMA's), to identify which parts of the network exhibit the worst leakage and to systematically pick-up new bursts. This technique became known as "district metering".

One significant aspect of district metering is that zones are isolated by closing valves thereby creating boundaries, and that each zone is then supplied by very few supply points (often only one), all of which are metered.

Low Pressure Problems

Whether gravity fed or pumped, a mains network can only deliver sufficient pressure to its extremities given there is enough pressure at the supply point(s) and sufficiently low resistance to flow. The following effects can all contribute to worsening low pressure problems:

- As the mains age, their internal surfaces become increasingly roughened by corrosion build-ups, which increases frictional losses.

- Without any intervention, the leakage in a network naturally rises with time, which introduces additional flow within the network and corresponding head loss.

- Domestic demand for water has risen substantially. In addition, recent historic droughts have taken demand to record levels. Networks designed some 30 or 40 years ago may well be inadequately sized for today's demand.

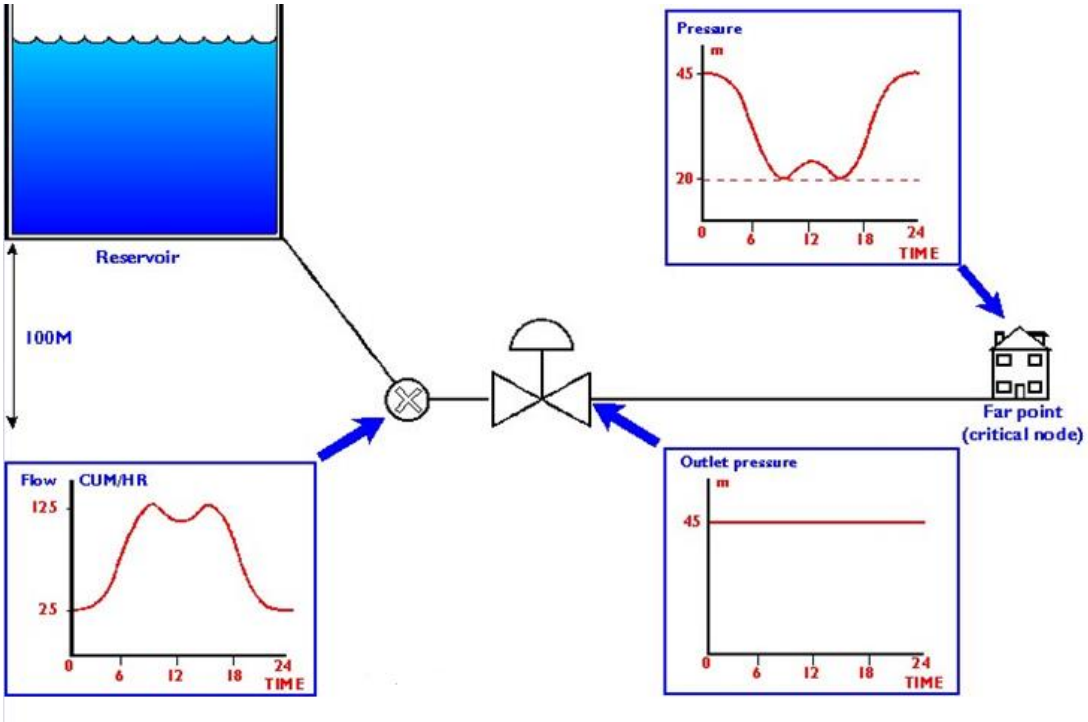
Pressure Management

It is generally acknowledged that reducing pressure in the mains reduces leakage rates and frequency of bursts. Although research work is still proceeding to quantify the effects of pressure reduction, its effectiveness is no longer in doubt.

Whilst pressure reduction is beneficial, high pressure may need to be fed into districts to counteract the increasing 'head loss' due to ageing pipes, naturally rising leakage and growth in demand. The challenge in pressure management is to address these two conflicting requirements by applying the optimum pressure within the network at all times.

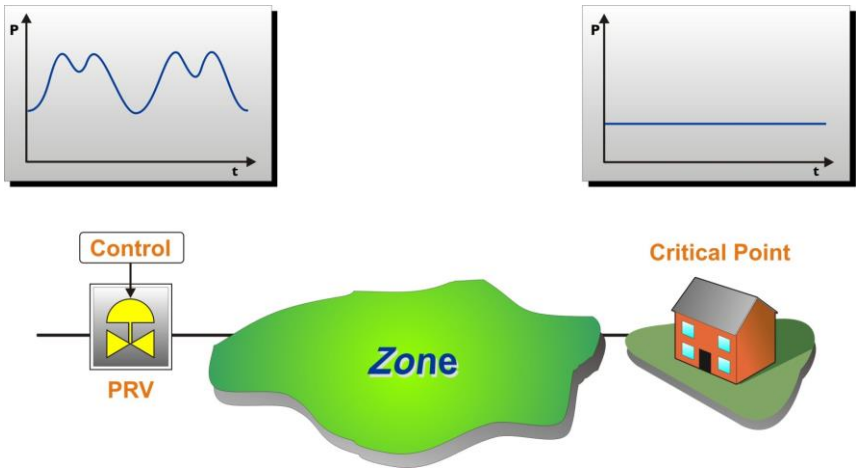
Basic Pressure Control

Conventionally, excess pressure at the supply point to a district is removed by a service reservoir or water tower, or less expensively by a hydraulic regulator device known in the water industry as a Pressure Reducing Valve (PRV). The PRV is normally set to deliver a constant pressure to the district such that there is sufficient head at all times at the point(s) within the district that experience the lowest pressures (critical node). However, this means that only static excess pressure is removed, and that the district network may remain over-pressurised most of the time except during peak demand (see Figure below)



Advanced Pressure Control

In an ideal distribution system, the regulator device supplying the district should supply only sufficient pressure to maintain the necessary minimum pressure at the critical node. The Technolog Regulo PRV Controller can accurately achieve this by monitoring network parameters, and control the PRV accordingly, as shown below:



The Regulo PRV Controller

The Regulo is a battery powered PRV controller featuring an electronic pressure modulation device and multi-channel GSM data logger.

The Regulo controller records flow, Inlet pressure and samples PRV outlet pressure at 1 second intervals for the duration of each logging period. At the end of each logging period, the PRV controller stores the maximum, minimum and mean pressure for the logging period. This helps to identify pressure transients and PRV stability. All recording channels are sent to a desktop computer / server at regular intervals over the GSM network.

The Regulo controller incorporates a display to indicate the inlet and outlet pressures, flow and target control pressure.

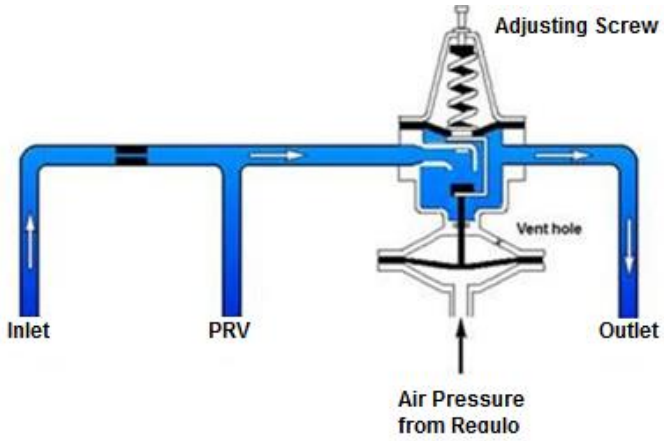
The Regulo controller is protected / sealed to IP68 with the capability of long term submergence in 1m depth of water.

The Regulo PRV controller features an integral GSM antenna as standard and the facility to automatically switch to an external antenna when used in poor coverage areas.

The PRV controller may be either powered externally or by a site replaceable external battery pack.

Regulo Key Functionality

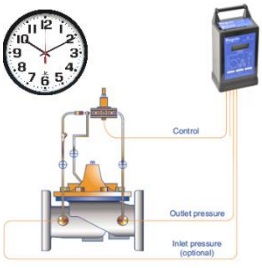
The Regulo performs the functions of a data logger for monitoring of inlet, outlet pressure of the PRV and the flow into the district. Independently of its logging function, the Regulo can act on the original pilot of a pressure reducing valve (PRV), as shown below.



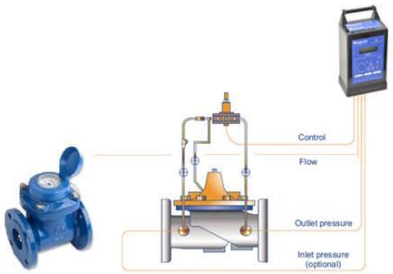
The Regulo is capable of modulating the outlet pressure automatically according to either the time of day, the flow rate from a nearby flow meter or with direct feedback from one or more Cello GSM data loggers installed at critical points:

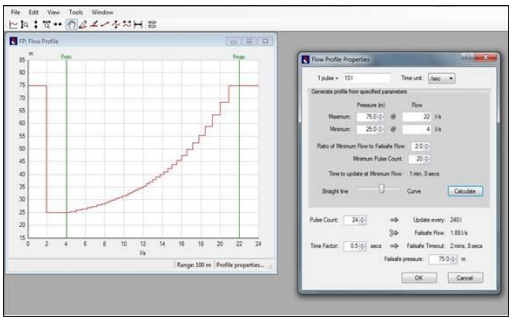
(a) **Time-based profile modulation:** The Regulo monitors the PRV outlet pressure at 1 second intervals and adjusts the PRV outlet pressure with respect to the time of day.

The Regulo stores two time profiles. Each time profile resolves to 6 minute intervals. The time vs pressure profiles are user configurable as daily or weekly (i.e. a separate profile for each day of the week).



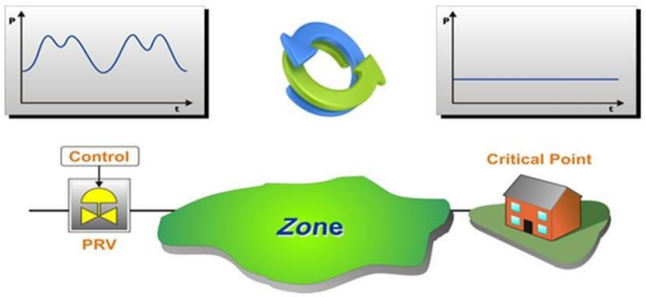
(b) **Flow based modulation:** The Regulo is capable of constantly monitoring the flow rate and adjusting the PRV outlet pressure with respect to flow rate according to a 'flow rate vs pressure' profile entered by users. In Flow Modulation, the Regulo controller can help compensate for frictional losses in the distribution network to ensure most of the available inlet pressure is supplied to the district when needed (i.e. during peak demand) whilst keeping low pressure in the distribution system during periods of low flow, thereby reducing leakage and burst frequency.





(c) **Closed Loop:** Here the Regulo is permanently connected to the GSM network whilst still retaining a long battery life. The Regulo is capable of modulating the outlet pressure of a PRV by receiving alarm messages DIRECTLY from one or more Cello GSM data logger(s) located at one or more critical points within the network.

Unlike other systems, closed loop may be performed without the need of a foreign central server.



Control modes and stored profiles may be changed either locally and / or remotely over the GSM network via SMS or GPRS via our local proprietary software PMAC Plus or our web-based software, 'WaterCore'.

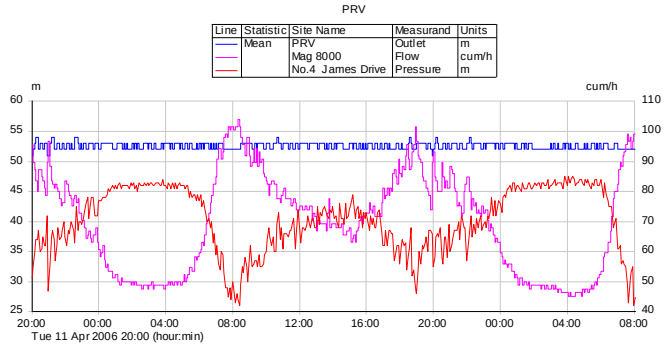
Typical Network Applications.

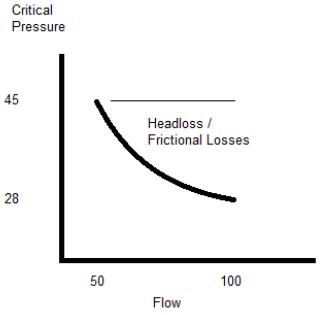
In single feed districts flow modulation or closed loop control is commonly used to help compensate for frictional losses in the network.

In the example below (fig 1), an initial survey of the district is carried out to identify the critical node and its relationship with demand. The recorded data illustrates an inverse relationship between the critical pressure and demand due to frictional losses in the distribution network.

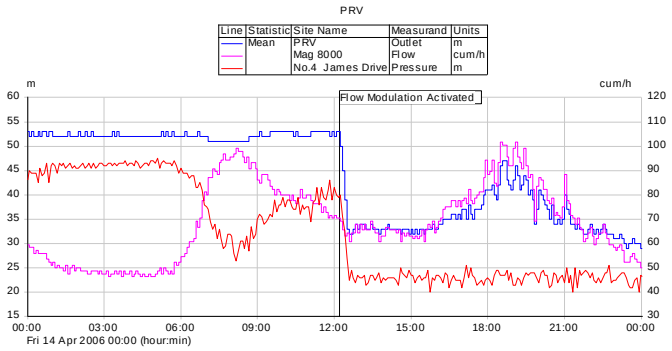
This cyclic excessive pressure leads to increased leakage / NRW, burst frequency and reduces the overall life expectancy of the distribution network

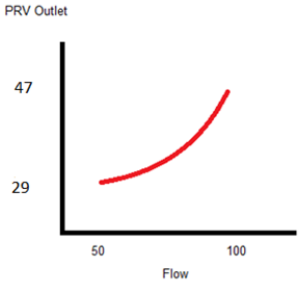
Fig 1





This information is programmed into the Regulo during commissioning and a corrected PRV Outlet pressure-flow relationship is calculated by the Regulo automatically. Alternatively this may also be manually entered as a tabular series of pressure flow values, hence non-linear and discontinuous relationships can be implemented. This compensating profile leads to a stable adequate critical pressure irrespective to changes in demand.





Additional measures that may be applied include:

- Maximum PRV outlet pressure is applied if a zero flow condition persists (which could mean the water meter connection to the Regulo is defective and, in the absence of flow information, the Regulo reverts to a safe pressure).

- Maximum PRV outlet pressure is applied if an abnormally large flow condition is reached, which could indicate fire flow.

In multi-feed systems, PRVs with a constant outlet pressure are usually set to maintain a good equilibrium between supply points. When modulating, care has to be exercised to maintain that equilibrium. Modulation can cause instability, leading to one PRV applying excessive pressure and the remaining PRVs shutting off. In this case, Technolog Regulo controllers can assist in the overall management and stability of the network. For example, a time profile could be programmed in all the Regulo's which simultaneously reduce pressure on all supply points by the same amount of modulation, maintaining equilibrium throughout the district.

Other applications of the Regulo in multi-feed networks may include cases of having three PRV's being modulated on a time basis and the forth on a flow modulation basis. A suitable time profile could be entered into the three time modulated PRV's which will under normal conditions supply and support the system. At extreme peak flows or unexpected high flows the flow modulated PRV could be set to open and supply extra water.

In critical applications, the addition of communication between the critical node and the Regulo (i.e. Closed Loop) can enable even greater control and performance.

Technolog have implemented pressure controllers in numerous multi-feed systems around the world, supported by either flow or closed loop control.

Network Safety

The Regulo incorporates many safety features; including whereby the PRV outlet pressure automatically reverts to a maximum "fixed" PRV outlet pressure, set by the pilot valve of the PRV, should either the PRV controller be disconnected or the main battery fails.

The Regulo PRV controller is immune to debris in the water supply and as such does not require any filters to be fitted in the control line between the bias chamber and PRV controller. No potentially dirty water enters the controller unit.

Alarms

In addition to monitoring and control, if any programmed alarm levels are breached (i.e. in the case of a burst), the Regulo may perform the following tasks:

- Send all historical data to the host server since the last data transmission time.

- Send an Alarm message to a host server which would then be forwarded to any number of mobile phones.

- Send live data to the host server for a programmable duration AFTER the alarm event.

All alarms are easily managed by the server. Alarms may be sent to any number of people according to a specific time or day of the week.

Web-Based Software

A web-based server software solution 'WaterCore' can be offered as a remotely hosted option to provide browser based monitoring and control.

WaterCore complements Technolog's cutting edge technology with a highly stable and configurable web based platform providing:

- Data analysis and configuration of sites.
- Site visibility
- Remote configuration and management of Technolog products

SCADA Integration

Regardless of software platform, Technolog can offer a number of methods for integrating recorded profile data into SCADA, including:

i) OPC –- HDA and AE

Both of our proprietary software packages PMAC Plus or WaterCore may be configured to use OPC AE (Alarm and Event) and OPC HDA (Historical Data) protocol components to facilitate transfer of recorded data / alarms to other client machines which also support OPC AE and HDA.

ii) Client socket comms integration which gives bi-directional integration with PMAC

Our proprietary software PMAC Plus may aggregate data from the Cello and Regulo and offer a TCP/IP sockets-based remote management facility. This method can be used by SCADA Engineers or third-party software integration companies to provide close integration between PMAC and a customer's own system. The client has freedom to bind, send/receive information and requests freely from PMAC. The protocol is being expanded to provide a full interface to PMAC allowing a remote application as much access to PMAC information as one of PMAC's own components. The protocol has been designed to be as simple as possible enabling fast and cheap application development.

iii) Standard .csv export

The Export Manager is a standard feature of PMAC and WaterCore. This can be used to automatically export data from selected sites into other systems. An export routine simply needs to be configured.

iv) .dat files

Technolog data loggers produce data files in a proprietary format known as .dat. Technolog can disclose the format of the .dat file in order for end-users to closer integrate the data from Technolog data loggers with existing systems.

v) API

A WaterCore API Web Service can be offered allowing remote access to data held within WaterCore, providing support for:

- Requesting the channel list.
- Obtaining channel details
- Access to data

Access control is handled via Digest Authentication. Libraries should be available for all modern programming languages to handle this type of authentication. The service communicates over the https protocol. All responses are returned in JavaScript Object Notation (JSON).

Alan Siddall