Assessing real water losses: a practical approach

Water Loss

IWA TASK FORCE

● In this sixth article in a special series for *Water21* by the IWA Water Loss Task Force, PAUL FANNER highlights practical developments over the last decade in managing water losses in public water supply systems.

The scope of this series of articles 'A practical approach to water loss reduction' was outlined in *Water21* in June 2003 by Ken Brothers, chair of the Water Losses Task Force. This latest article outlines three methods of assessing real (physical) losses, including component analysis and economic considerations.

Assessing real losses

The IWA recommended definition of real losses is 'the annual volumes lost from transmission and distribution systems through all types of leaks, bursts and overflows on mains, service reservoirs and service connections, up to the point of customer metering'. Real losses can be assessed by any one of three different methods: 'top-down' annual water balance; 'bottom-up' analysis of night flows; component analysis; or a combination of two or all of these methods. Each of these methods is outlined in the following sections.

Top-down annual water balance

Real losses can be assessed through the IWA best practice 'top-down' annual water balance (Figure 1) as the volume remaining after volumes of authorised consumption and apparent losses have been deducted from the system input volume.

Because all metered or assessed input data to the water balance are subject to errors and uncertainty, to a greater or lesser extent, these errors accumulate in the calculated volumes of real losses, resulting in uncertainty in the calculated value of real losses. A practical approach to dealing with the uncertainty is the calculation of 95% confidence limits using customized software (Lambert, 2002). This approach to dealing with uncertainty is applicable to each of the methods of evaluating real losses.

The total volume of real losses is determined by the top-down annual water balance. However, this analysis does not provide any information on the components of this total volume, e.g. detectable bursts (that can potentially be managed through speed and quality of repairs, and active leakage control), or real losses due to background losses (that can only be reduced by pressure management or infra-structure renewal). This analysis also provides no information on losses from the various elements of infrastructure, required to develop appropriate loss management strategies. For these reasons, it is recommended that, if possible, the top-down annual water balance is undertaken in conjunction with the other two assessment methods.

Bottom-up real loss assessment

The real losses volume obtained from the top-down water balance can be independently checked by 'bottom-up' calculations based on analysis of night flows into small sectors or zones of the distribution system (Ofwat, 2001). These small sectors or zones of the distribution system may either already be established in the distribution system or may be temporarily zoned to undertake this analysis. The minimum night flow (MNF) in urban situations normally occurs during the early morning period, usually between around 02:00 and 04:00 hours, although the exact timing will vary from zone to zone. During the MNF period,

Figure 1 The IWA 'best practice' standard water balance

System Input Volume (corrected for known errors)	Authorised consumption	Billed Authorised Consumption	Billed Metered Consumption (including water exported)	Revenue Water
			Billed Unmetered Consumption	
		Unbilled Authorised Consumption	Unbilled Metered Consumption	Non-Revenue Water (NRW)
			Unbilled Unmetered Consumption	
	Water losses	Apparent Losses	Unauthorised Consumption	
			Customer Metering Inaccuracies	
		Real Losses	Leakage on Transmission and/or Distribution Mains	
			Leakage and Overflows at Utility's Storage Tanks	
			Leakage on Service Connections up to point of Customer metering	

real losses are at their maximum percentage of the total flow.

The estimation of the real loss component at minimum night flow is carried out by subtracting legitimate night consumption (assessed and measured) for the customers connected to the mains in the zone being studied. The result obtained from subtracting the legitimate night consumption from the minimum night flow provides an estimation of the volume of real losses during the MNF period. In order to convert this estimate into a daily volume of real losses, it is necessary to take account of diurnal variations in system pressure (hour/day factor, normally less than 24, but depends on the degree of pressure management). Because the legitimate night consumption is estimated, and in reality varies from night to night, this calculation also has errors and uncertainties.

The benefits of the bottom-up real loss assessment are that it provides an independent determination of the volume of real losses and, if this analysis is undertaken across the whole distribution system, areas of high real losses can be prioritised for active leakage control work. It also provides a cross-check on the water balance calculation - the two volumes should balance (but often don't because of the cumulative errors in each method's calculation). The field work for the bottom-up assessment also facilitates collecting the field data required for determining the pressure/leakage relationship (N1) and the infrastructure condition factor (ICF).

Component analysis of real losses

Annual real losses can also be assessed from first principles using Component Analysis. This approach uses numbers, average flow rates and average run-times of different types of leaks and bursts (background, reported and unreported) on different parts of the distribution infrastructure (mains, service reservoirs, and different sections of service connections). Other data required to undertake a full component analysis of real losses include basic infrastructure data (mains length, number of service connections, length of the privately owned service line from property boundary to meter); infrastructure condition factor (ICF) for background leakage; numbers of reported and unreported bursts, and their average run-times based on utility policies; average system pressure and pressure/leakage relationships (using appropriate N1 values).

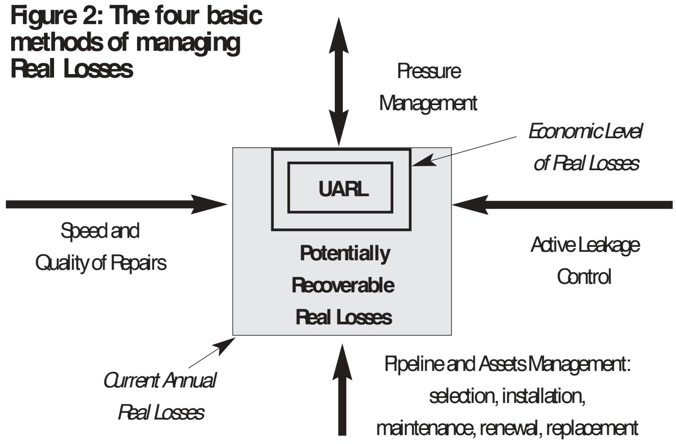
A component analysis model breaks down the overall volume of real losses into its constituent components for each element of the system infrastructure, based on their most influential parameters. A calibrated component analysis model is therefore very useful for evaluating alternative options for managing real losses.

Unavoidable annual real losses

Real losses cannot be eliminated totally. The lowest technically achievable annual volume of real losses for well-maintained and well-managed systems is known as unavoidable annual real losses (UARL). Figure 2 shows the relationship between current annual real losses (CARL) from an IWA water balance – represented by the large rectangle - and UARL (the small rectangle). Using the four methods of leakage management (the four arrows), real losses can be controlled, but (at the current operating pressure) cannot be reduced any further than the UARL. However, although the UARL represents the minimum level of real losses that could technically be reached, for most utilities it will not be economic to reduce real losses to this level. There will be some intermediate economic level of real losses which it is appropriate for a utility to achieve.

System-specific values of

Figure 2: The four basic methods of managing Real Losses



UARL can be assessed using a formula developed by the IWA Water Losses Task Force. (Lambert et al, 1999). Data required for this assessment are the number of service connections, the length of mains, the length of private pipes between the street/property boundary and customer meters, and the average operating pressure. UARL is used in the calculation of the infrastructure leakage index (ILI), which is the ratio of CARL to UARL. Performance indicators will be discussed in a later article in this series.

Economic level of real losses

The economic level of real losses (ELL) occurs when the sum of the value of water lost through real losses and the cost of activities undertaken to minimise real losses is at a minimum. Calculations of ELL can be extremely data intensive, but a practical approach to achieving ELL for any system can be explained using Figure 2. Every system experiences some number of new leaks and bursts each year, and economic management of the real losses volume arising from these events can be achieved. In the short term, this can be achieved by managing their average duration, through active leakage control (to locate unreported bursts), and speed and quality of repairs of all leaks and bursts however arising. In the medium to long-term, it is achieved by influencing the numbers of leaks and bursts which occur each year (through improved pressure management, and pipeline and assets management).

By ensuring that each of the four component methods of managing real losses in Figure 2 is individually economic, and implementing as priorities those aspects with highest benefit:cost ratio (or payback period), the economic level of leakage should eventually be achieved. Analytical approaches to economic active leakage control policies will be dealt with in a later article in this series.

In the next article in the series, Alex Rizzo, leader of the apparent losses team in the IWA Water Loss Task Force, will outline the practical approach to 'managing apparent losses'. ●

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