Guidance Notes on Apparent Losses and Other Non-Revenue Consumption

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The IWA Water Loss Specialist Group (WLSG) has been promoting an Apparent Loss (AL) Initiative to work on the reduction of four main AL components: meter under-registration, illegal consumption, meter reading errors and water accounting errors. The strategies developed are aimed at implementing the most cost effective programmes to reduce apparent losses to an economically, environmentally and socially acceptable level. Another objective is to fill the existing gap between real losses and apparent losses in terms of knowledge and management. This paper introduces some pertinent aspects of the draft Apparent Loss Guidance Notes.

The intent of the AL Guidance Notes is to provide an introduction to Non-revenue Water (NRW) practitioners of the processes required to identify and reduce apparent losses. There are economic, social and environmental benefits of minimising apparent water losses.

Apparent Loss Cross and indicators

The standard IWA (WLSG) Water Balance approach remains the basis for calculating the level of apparent and real losses; however, suggestions are provided to improve confidence in the management of apparent losses.

Apparent losses can result from metering errors, data errors, estimating errors and unauthorised consumption (e.g. illegal) as illustrated by the Apparent Loss 4 Pillars Diagram in Figure 1, the form of which is similar to the well-known Real Loss 4 Pillars Diagram

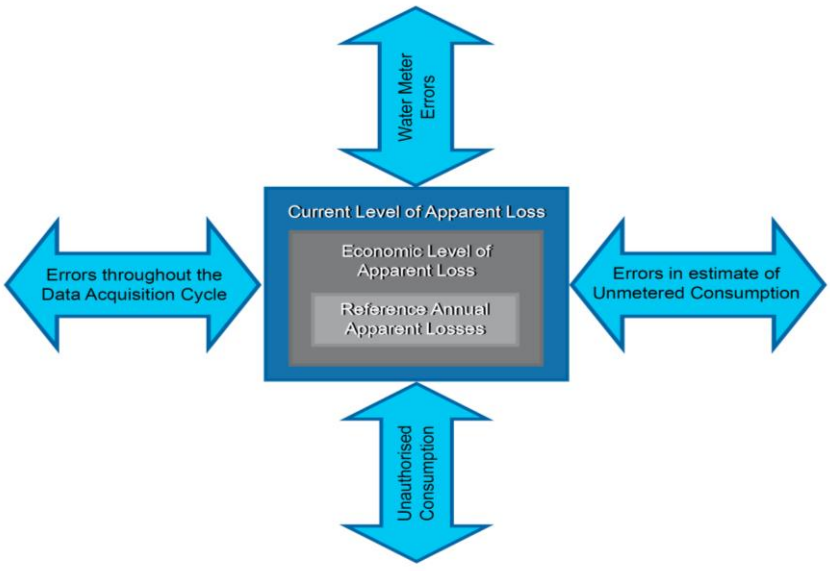

Figure 1 Apparent 4 Pillars Diagram

Apparent Loss Indicators have been defined and these are the Current Annual Apparent Losses (CAAL), Reference Annual Apparent Losses (RAAL) and Economic Level of Apparent Losses (ELAL).

The defining of an international reference to evaluate the level of apparent losses is based on the following two concepts:

- The Apparent Loss Index (ALI) that could be compared to the Infrastructure Leakage Index (ILI) that is applicable for referencing real losses.
- The Reference Annual Apparent Loss Level (RAAL).

ALI = CAAL / RAAL .....**(i)**

Where RAAL = 5% x Authorised (metered or estimated) Consumption (expressed in volume)

A 5% value is taken as a default value unless historic records can demonstrate otherwise.

Guidance is provided on the calculation and reduction of apparent losses. A key requirement is that there is more accurate measurement of input water volume when preparing a water balance.

For each category of apparent loss – metering errors, unauthorised consumption, data acquisition errors, errors on consumption estimate - the objective of the measures proposed is to facilitate the assessment of losses, to reduce these losses and to maintain the losses within an acceptable benchmark.

Actions required to reduce apparent losses

In any water supply system there is a natural entropic tendency to disorder and misinformation: if nothing is done, there will be an accelerated propagation of leaks and occurrences of defective water meters as well as the accumulation of out-of-date information in the database. The migratory nature of errors associated with the establishment of a water balance are such that errors in the measurement of water volumes can be incorrectly interpreted as real losses at the initial planning stage of a project resulting in failure to achieve water saving targets once implemented.

Considering the variety of causes of apparent losses the guidance notes provide a wide range of solutions that address specific needs to select from. These measures range from the well known procedures to improve operation efficiency to the most recent techniques. Suggested actions required to reduce the level of apparent losses are summarised in Table1.

Table 1 List of Actions Required to Reduce Apparent Losses

Categories of AL	Subcategories of AL	Cases	Type of Actions
Errors through Data Acquisition Cycle	System Input and Water Supplied	Error in bulk metering	Establishment of calibration protocol Calibration procedures Accredited calibration quality system Large meter replacement
		Error in data capture and transmittance	Technical Audit Repair or replacement
	Errors in customer metering	Manual or semi manual Meter reading	Audit of the meter reading procedure Use of digital electronic devices
		Automatic meter reading	Technical audit Installation of an AMR system
	Data processing errors	Billing system errors	Billing system and procedures audit Improvement of existing billing systems Purchase of a new billing system

Categories of AL	Subcategories of AL	Cases	Type of Actions
		Errors in other data manipulation	Specific audits
Metering Errors	Meter errors (small consumers)	Aging (e.g. as a proxy variable for accumulated volume)	Definition of the aging/ usage curve Meter Replacement policy
		Inappropriate meter installation	Define standard procedures & drawings Training Replacement of non-standard installation
		Impact of customer's in-house installation	Carry out laboratory survey Correct selection and sizing of meters
	Meter errors (large meters)	Meter Aging (e.g. as a proxy variable for accumulated volume)	Definition of the aging/ usage curve Meter Replacement policy
		Meter Oversizing	Establish Customer's consumption patterns Sizing & selection guidelines Replace meters when oversized
		Inappropriate meter installation	Define standard procedures & drawings Training Replacement of non-standard installation
		Impact of customer's in-house installation (e.g. domestic tanks for instance)	Carry out laboratory survey Correct selection and sizing of meters
	Meter management	Meter out of operation	Define detection replacement procedure
Unauthorised consumption	Registered customers	Meter by-pass and other frauds	Customer database survey Targeted field survey
		Additional unregistered connections	Customer database survey Targeted field survey
		Disconnected customers illegally reconnected	Customer database survey Targeted field survey
		Non active customers illegally reconnected	Customer database survey Targeted field survey
	Unregistered customers	Unregistered (illegal) connection	GIS mapping approach Field survey
		Unregistered consumption in low income areas	Multi purpose approach including social and communication components
	Network equipment	Water theft on hydrants or other equipment	Install more secure equipment Develop security procedure Specific supply procedures
Estimation errors in unmetered consumption	Small consumers		Water meter installation budget & programme Sampling surveys for unmetered connections
	Large consumers		Water meter installation programme

Economic considerations for managing cohorts of meters

Application of economic and financial principles can facilitate the preparation of an apparent losses reduction programme as well as establish the economic and reference levels for apparent losses for a cohort of meters with similar installation dates and/or volumetric amounts registered. These include cost-benefit analysis, optimisation techniques and present value analysis. However, the weighted error of measurement of a meter must be established as part of this analysis and includes the following:

- water volumes measured by meters at various flow rates with reference to the meter's signature curve;
- the rate of decay in the meter's measurement error with cumulated use; and
- the sequencing of the meter replacements.

Accuracy of large input volumes

Large bulk water supply meters provide key volumetric data for the determination of water imbalances (e.g. losses). As these meters can also be used to measure water for custody transfer purposes their perceived and actual accuracy (or inaccuracy) can be a contentious issue. The volumetric amounts of water are derived from flow rates and hence are subject to potential processing errors.

As there is a requirement for the calibration of large meters on site there is a need for the development and implementation of an in situ calibration system. The in situ calibration system is defined by a Quality System, consisting of portable meters and qualified personnel, a Quality Manual, as well as purposely built chambers, pipe sections and access points.

Cognisance must be taken of the following when developing an in situ calibration system:

- A meter installed outside its pattern approval reference conditions cannot always be assumed to be operating within the limits of its error of measurement. These non-reference conditions would result in errors that cannot be established without in situ calibration. The error of measurement of meters operating under these non-reference conditions is unknown and an in situ method that establishes these errors and provides some indication of the 'accuracy' of the meter should be implemented; and
- The in situ calibration of large meters generally cannot be undertaken in a single operation for the full operating range of the meter. A revised process will therefore require establishing a history of flow rate comparisons that is inconsistent with current metrological requirements.

In some applications the results of an in situ calibration might not comply with the mandatory requirements for custody transfer purposes but would provide important data for the determination of the statistical uncertainty of a water balance. Imbalances associated with mass (or volume) balances into and out of a water system have an associated uncertainty for each of the constituent in and out-flows that require combining.

Unauthorised consumption

A variety of Apparent Losses are due to human behaviour and in some utilities the impact of unauthorised consumption is significant. It can be a challenge to distinguish between real losses and unauthorised consumption. The level of unauthorised consumption is not only the consequence of poverty, dishonesty or cultural aspectsissues: it also often results from the laxity of the Water Utility and its poor strategy in terms of social involvement and communication. Relevant solutions in terms of customer management, including revenue collection, are also outlined in the Guidance Notes.

Concluding comments

The migratory nature of errors associated with the establishment of a water balance are such that errors in the measurement of water volumes can be incorrectly interpreted as real losses at the initial planning stage

of a project resulting in failure to achieve water saving targets once implemented. The interaction of these errors within the water balance are due to the fact that the water balance is governed by the principle of conservation of mass, which is also defined by the equation of hydraulic continuity. The implication of this conservation principle is that flow volumes into and out of a system must be equal and overall equilibrium between the various components must be maintained. The units of the various components of a water balance therefore, must all be in the same volumetric units.

The management of the apparent loss component of Non-revenue Water must take into account the various types of measurement errors and their interactions in the determination of water imbalances. The reduction and control of NRW must also take note of the gradual change in the water balance as an action plan is implemented, and finally reaches a new equilibrium represented by a new targeted water balance. These last points are detailed further in the Apparent Loss Guidance Notes.

References (Useful examples referred to in the Guidance Notes)

Arregui, F., Cabrera, E., & Cobacho , R. (2006) Integrated Water Meter Management. IWA Publishing.

Arregui, F., Cobacho , R., Soriano J & Garcia-Serra J. (2010) Calculating the Optimal Level of Apparent Losses Due to Water Meter Inaccuracies. IWA Water Loss 2010. Sao Paulo, Brazil.

Carteado, F and Vermersch, M (2008) Dynamics of Water Losses, IWA Water Loss Conference, Cape Town 2009

Farley M, Trow S (2003) Losses in Water Distribution Networks, A Practitioner's Guide to Assessment, Monitoring and Control. IWA Publishing

Johnson, EH (2011).The 'Apparent' Real Losses of a Water Balance. IWA Efficient 2011 Conference. Specialist Conference on Efficient Use and Management of Water. 29 – 31 March. Jordan.

Johnson, EH (2009).Management of Non-revenue and Revenue Water Data. Engineers Media, Crows Nest NSW, Australia. ISBN 9780858258839 (2nd Edition)

Johnson, EH (2007).Estimating the Uncertainty of Flow Measurement for the In situ Calibration of Large Water Meters. Australian Journal of Water Resources Vol 11. No.1. Engineers Australia

Rizzo A (2006) - Apparent Water Loss Control: Theory and Application, ADKOM and IWA Skopje 2006

Rizzo A and Vermersch M (2007), Apparent Losses: the Way Forward, Water 21, August,2007

Vermersch M and Carteado F (2006) The " Water Loss Circle »: a global approach and an integrated method to reduce and control water losses in the water distribution systems, Ingeniería Sanitaria y Ambiental, AIDIS n°84, January - February 2006

Vermersch M and Rizzo A (2007), An Action Planning Model to Control For Non-Revenue Water, IWA – Bucharest 2007.

Vermersch M. and Rizzo A. (2008) Change Management as an Indispensable Component when Planning for NRW Control, IWA Cape Town 2009.