

An Analysis of Water Pressure Affecting Metering Performance of Domestic Meters in Taipei

C.L.Huang

Associate Engineer
Water Supply Division, Taipei Water Department, 131 Chang Xing street., Taipei, Taiwan
(E-mail: *chille@twd.gov.tw*)

Abstract

By means of comparing historical meter readings with water pressure data, in a selected area, it revealed that when water network pressure rise by 0.5kg/cm^2 , the metering accuracy of domestic meters increase by 2.1% and along with household water consumption arise by 2.1%, the two rising components contribute 4.2% registered volumes of domestic meters. It is clear that metering performance grow due to pressure rising.

Within the two components, on the one hand, the reason resulting in the increase of “metering accuracy” term is because the rising pressure generates higher flowrate which makes meters working in a much accurate condition. On the other hand, the increase of “consumption” term is because the rising pressure increases faucet’s discharge which causes higher household consumption, in other words, wastes of water.

This research developed a practical method to identify the increase of “metering accuracy” and “consumption” components from meter reading data, although its values are very small and hard to extract. Using a technique of Master-Sub meter grouping data analysis, it is easy to estimate the two components varying with its water pressure.

Keywords

Domestic Water Meter; Water Pressure; Metering Accuracy; Water Consumption

EFFECTS OF INCREASING WATER PRESSURE

Raising pressure of pipeline network will increase overall revenue of water supplied and there are two components of increasing revenue:

Overall Revenue Increase $\left\{ \begin{array}{l} \text{Increase in metering accuracy} \\ \text{Increase in consumption} \end{array} \right.$

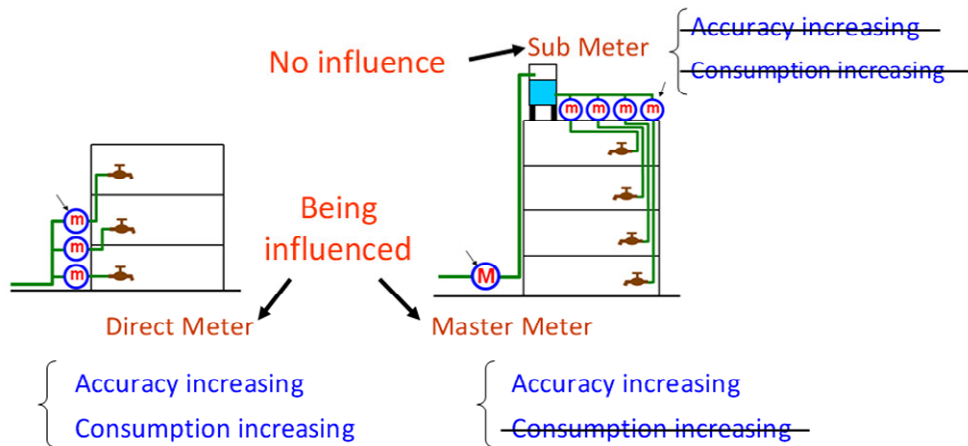
Increase in metering accuracy: Due to the physical behavior of water meter, it has poor accuracy while working at low flow and results in under registration; on the other hand, at the high flow side, water meter has better accuracy in metering. So, when water pressure is increased, the flowrate is increased as well and the accuracy is higher.

Increase of water consumption: When water pressure is raised, the discharge rate at faucet of customer will be increased in large scale, and when completing the same washing work, the water consumed is more, or it may termed as while the water consumption is increased, the extra discharged volume is nothing less than waste. However, utility company will have revenue increased.

Pressure effects on water meters located at different locations

In Taipei’s 1.6 million domestic water meters, more than 99.6% is of Multi-Jet type, but they are referred differently due to difference in installation location, such as Direct Meter, Master Meter and Sub Meter. Direct Meter refers to the situation that there is no water tank behind meter and the network water pressure directly supply water to faucet / tap. In case of Master Meter, the water flowing through it to fill the water tank behind the meter and it is then pumped up to roof tank at the top floor for supplying all Sub Meters by gravity.

Direct Meter and Master Meter connect directly to pipeline network and is affected directly by the water pressure of pipeline network. When the water pressure is increased, the metering accuracy and consumption of Direct Meter will be increased. Since there is not faucet behind Master Meter, therefore no increase in consumption after raising water pressure, but only the metering accuracy will be increased. Sub Meter is not connected with pipeline network, pressure of pipeline network has no effect on Sub Meter, and neither the metering accuracy nor the consumption is increased with rising pressure. [See Fig. 1]



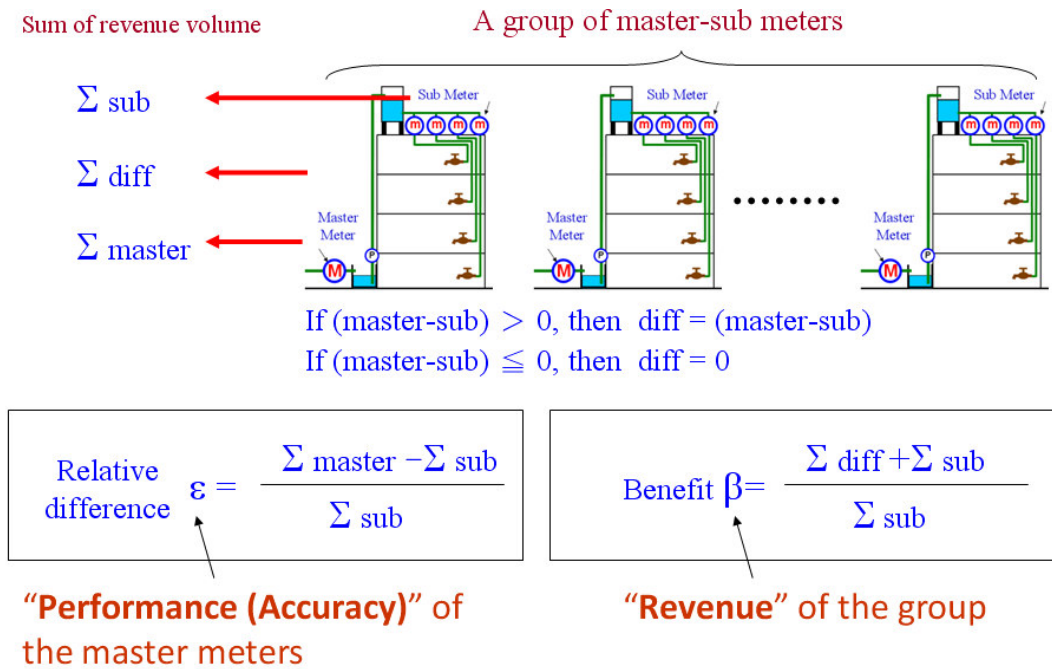
[Fig. 1] Effect of Water Pressure on Meters of Different Installation Location

CALCULATION OF COMPONENT OF METERING ACCURACY INCREASE

In Fig. 1, the right side is the standard meter location of apartment house in Taipei and it is called “Master-Sub Meter Set” . Increase in water pressure will only increase the component of metering accuracy and is therefore less complication and easier in calculation of quantitative way. We will introduce here firstly with Macro Performance Indices for calculation.

Macro Performance Indices

The Macro Indices referred here is the indices that can analyze massive water meter’s total performance, without considering behavior of individual meter. In this Study, we use 2 indices, namely “Relative Difference ε ” and “Revenue β ”. Definitions and calculation manner are shown in Fig. 2. “ ε ” is the difference rate of water volume of a bunch of Master Meter with Sub Meters. The higher “ ε ” is, the registration volume of Mater Meter is more than sum of Sub Meters. “ β ” is the revenue rate under the unique billing mechanism of Taipei and the higher “ β ” is the better the revenue of the specific Master-Sub meter set. Taipei Billing System: When the registration volume of Master Meter is larger that the sum of all related Sub Meters, this apartment house will be charged for water tariff by the water volume of Master Meter; on the other hand, when the volume of Master Meter is smaller than the sum of the Sub Meter, it will be charged by the volume of Sub meters.



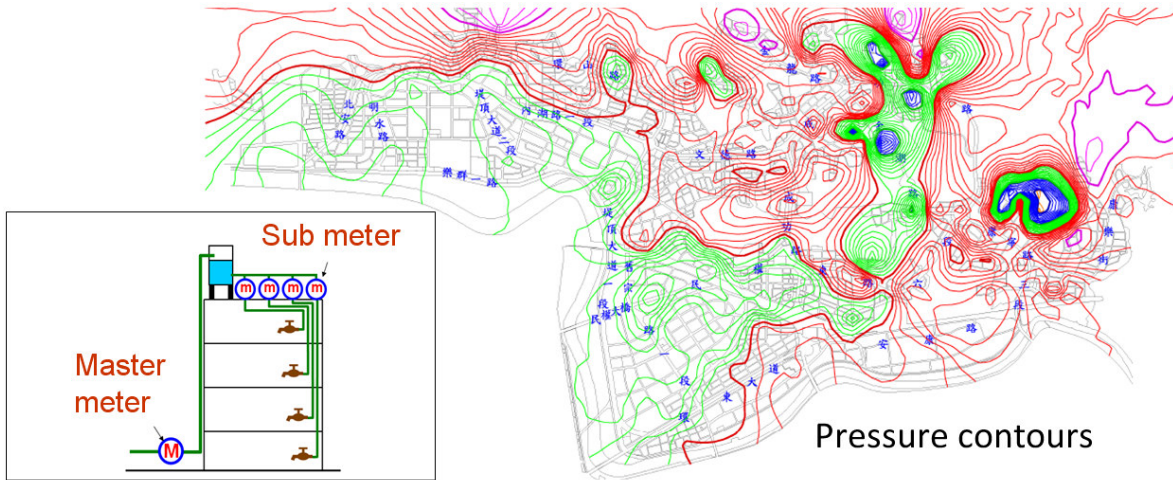
[Fig. 2] Calculation Manner of Water Meter Macro Performance Indices

Both ε and β are the performance of Master Meter using Sub Meter Volumes as reference. Since the performance of Sub Meter is not affected by network water pressure, it is a very good reference that enables us to find the metering performance change of Master Meter under different water pressure clearly.

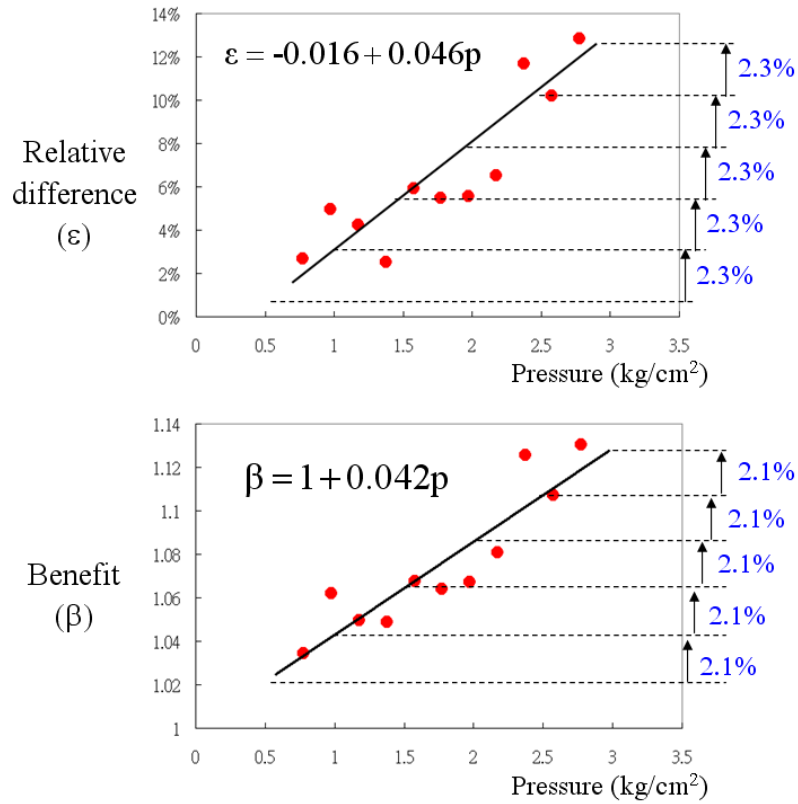
Results of Calculation of Metering Performance

Using the Pressure Contours of the Fire Hydrant Pressure Survey of Neihu-Dazhi Area of Taipei City in 2009-2010 (detailed in Fig. 3) and collecting the meter reading data in these two years

covered by the Pressure Contours in groups, we can calculate the ε and β under different water pressures, as shown in Fig. 4, it is clearly seen that the higher the water pressure is the macro performance indices are higher and the Metering Performance of Master Meters are better along with the increases of water pressure, i.e. the accuracy of water meter is better.



[Fig. 3] Pressure contours at Neihu-Dazhi Area



[Fig. 4] Macro Performance of Master Meters in Neihu-Dazhi Area increases along with the increase of water pressure.

When water pressure is increased with 0.5kg/cm^2 , the metering accuracy can increase 2.3%, if we look only at the performance of master meters “ ϵ ”, but when the billing mechanism of Taipei is taking into consideration, then benefit “ β ” increased with 2.1%.

CALCULATION OF COMPONENT OF WATER CONSUMPTION INCREASE

In last Chapter, we have calculated [Fig. 1] at the right, the increase of metering accuracy of Master Meters, and then we should continue the calculation of the left side of Figure 1, the increase of metering Accuracy and Consumption of Direct Meter. Following the discussion in the previous chapters, as the Master Meters has the Sub Meters, which is free of the effect of water pressure, as reference, it can be calculated by using macro indices, however, Direct Meter does not have such reference value, so we can not apply macro indices for calculation. So, in this study, we will employ reverse approach: calculate the overall revenue first then deduct the contribution of Master Meters to obtain the part of Direct Meters.

Increase of Overall Revenue

Taipei had been totally boosting water pressure up for two years in 2000 & 2001 and the water pressure was adjusted back due to increase in pipeline leakage. During the two years of pressure increase, the overall revenue grew. As shown in Fig. 5, comparing with the two years without pressure adjusting up of 1999 and 2002, it is calculated that when the water pressure is increased with 0.5kg/cm^2 the overall revenue increased 4.2%.

	1999 & 2002 without pressure increase	2000 & 2001 with pressure increase
Average water pressure kg/cm^2	1.58	1.90
Average revenue volume (million m^3)	563	578

[Fig. 5] Average Pressure & Revenue Volume with and without the Boost of Water Pressure

Percentage of Increase in Consumption of Direct Meters

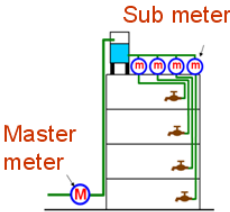
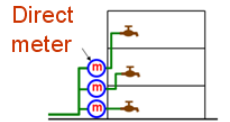
Like Master Meter, Direct Meter connects with water pipeline network and is subject to the effect of water pressure, so we can assume that when water pressure is increased with 0.5kg/cm^2 , the metering performance of Direct Meter increase is of the same, i.e. 2.1%. We recall the values that have been calculated before:

Increase in Consumption of Master Meter is “0”.

Metering Accuracy increase of Master Meter is 2.1% .

Overall revenue increase is 4.2%.

Entering the above data into table in Fig. 6 and weighting by the ratio of revenue volume, the Direct Meter consumption increment can be calculated as 6.0%, and the average value of each component can be obtained.

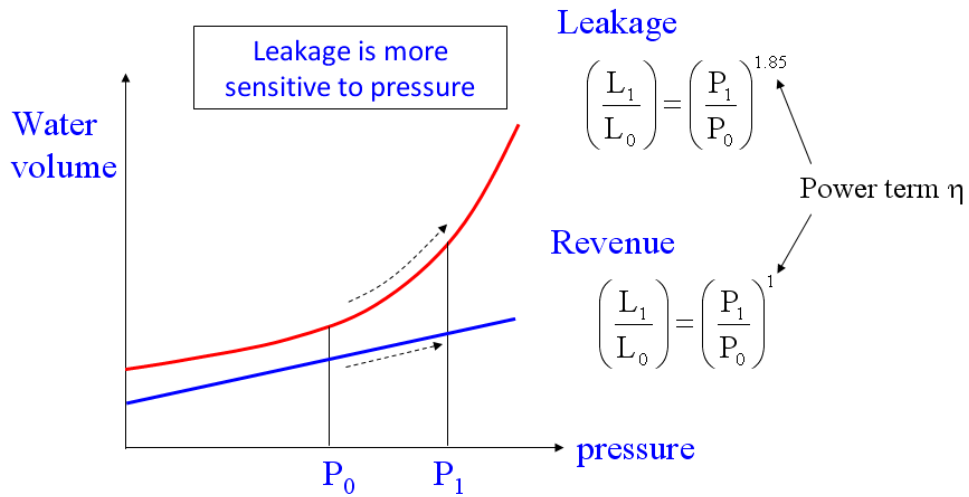
		Increasing 0.5kg/cm ² :		
Subjects	Ratio of Revenue	Increase of Accuracy	Increase of Consumption	Increase of Revenue
 <p>Sub meter</p> <p>Master meter</p>	65%	2.1%	0	4.2%
 <p>Direct meter</p>	35%	2.1%	6%	
Average		2.1%	2.1%	4.2%

[Fig. 6] Increment of each component when water pressure is increased with 0.5kg/cm²

CONCLUSION

- 1) As shown in the last line of table in Fig. 6, when water pressure is increase with 0.5kg/cm², both the Metering Accuracy and Consumption increased 2.1% in average and total revenue is increased with 4.2%
- 2) Within the water pressure range of Taipei (0.5-3.0 kg/cm²), increase of water pressure of pipeline network will indeed generate more revenue from domestic meters and is in linear relation between pressure and revenue, but when the water pressure is more than 3.0kg/cm², it is unable to predict whether the increment will maintain linear as we have not sufficient data to prove.
- 3) Due to the poor quality of Taipei Pipeline network and the leakage is rather high (19% leakage rate in 2013), when pressure is lift, the leakage increment from aged pipeline will be more than revenue from meter, as shown in Fig. 7. The power term η of Pressure-Leakage Relation is 1.85 and is higher than the η of Pressure-Revenue, and unless the pipeline network quality is

improved, it is unlikely to increase revenue or reduce NRW through increasing water pressure.



[Fig. 7] Pipeline network is more sensitive than meter and boosting pressure will generate more leaks.

BIBLIOGRAPHY

1. Francisco Arregui, Enrique Cabrera Jr. and Ricardo Cobacho, Integrated Water Meter Management. 2006. (IWA Publishing, Alliance House, 12 Caxton Street, London SW1H 0QS, UK)
2. Edgar H. Johnson, Management of Non-revenue and Revenue Water Data 2nd Edition. 2009 (EA Books, 2Ernest Place, Crows Nest, NSW 2065)
3. Taipei Water Department-Taipei Water Department Statistical Yearbook, 1999 – 2012.