Drink. Water Eng. Sci. Discuss., 6, C43–C46, 2013
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Interactive comment on "Effects of network pressure on water meter under-registration: an experimental analysis" *by* C. M. Fontanazza et al.

Anonymous Referee #2

Received and published: 24 July 2013

General comments The article highlights some interesting phenomena regarding the relation between distribution pressure, meter age and measurement bias of water meters, with special attention for situations where consumers use buffer tanks. I would like to compliment the authors for the clearness of their text and for their enthusiasm that shines through. I am aware that it is much easier to comment an article, than to set up a study and write an article. I hope that my comments are useful for the authors and can help them in doing some revisions.

In the closing sentence of the abstract the authors state: "The presented results are useful for understanding the effects of operating conditions on water meter under-registration, which can aid water managers in implementing effective replacement campaigns." But to my opinion the conclusions of this study are soft. Furthermore they will

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only apply to a very limited range of conditions. And in addition, I do not support the idea that replacement campaigns should be based upon cost-effectiveness for the water supply company. That is a one-sided approach. The criteria for water meter replacement should take into account the interests of both the water supply company and the consumers. The risks for both parties involved should be balanced. In the following I will elaborate on these points.

Specific comments Even though many data are gathered for this study, only descriptive statistical methods are used. The article lacks formal statistical testing, which makes the conclusions soft. At some points the term 'significant' is used, but no mention is made of any formal statistical test to underpin the use of that term. It is better not to use the term 'significant' if that is not supported by the results of a statistical test. It is unclear how the sample of 143 water meters were drawn and how the stratification by age class was taken into account. If the samples were not drawn at random (after stratification), it will be hard to draw general conclusions. Therefore, please explain how the samples were drawn (using the theory and terminology of statistical sampling). At least a formal statistical test should be used to test the hypothesis of a relation between pressure, age and starting flow, because that hypothesis is central to the discussion. However, in doing so take into account the non-normality and heteroscedasticity of the results (these phenomena can be seen in figure 6).

The results of this study will mostly apply only to the following combination of factors: 1) multi-jet velocity meters, with Q3 of 1.5 m3· h-1, 2) three very specific consumption profiles (of which two with a buffer tank) and 3) error curves that cause under-registration. About point 2), the three selected conumption profiles At page 127, line 14 the authors state that the three consumption profiles are not presented as typical of users in Palermo, because of the small number of monitored users (15). Of course, this makes it even harder to draw any general conclusions from this study. Especially consumption profile C (no tank) will be just one of many possible profiles, because depending on the kind and severity of in-house leakages (such as leakage caused by

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a a disfunctioning valve of the toilet), there can be relevant differences in the percentage of water volume that is consumed at low flow rates. About point 3) error curves that cause under-registration In the article the amount of under-registration ('apparent losses') is estimated as the percentage of the consumption profile below the starting point. However, for each combination of water meter and consumption profile the amount of under- or over-registration should be estimated as the sumproduct of error curve and consumption profile. In other words, the whole range of possible flow rates should be used for that estimate and not just the range below the starting flow. The reason for this is that positive errors can occur at higher flow rates, that cancel out the negative errors below the starting flow, especially for older water meters. In the Netherlands there are many examples of this. In particular somewhat older multi-jet velocity meters can suffer from this, sometimes leading to severe over-registration. The most probable cause is biofilm formation in the water meter. Can the authors please provide measured data to underpin their very important assumption that the errors at flow rates above the starting point are irrelevant for the total mis-registration? It will be especially interesting to see if there are any differences regarding this phenomenom between the age classes of the water meters. If I understand correctly, the authors only measured the low flow rate parts of each error curve (see page 126, line 12), so there might be a problem here.

It seems reasonable to assume that the consumption profiles will change somewhat with pressure, because pressure will affect the flow rates. So, we may assume that the horizontal axis of the consumption profile will shift when the pressure changes. However, nowhere do the authors account for that. They should at least discuss this point and try to justify why the effect is neglected. In my opinion, this phenomenon might affect the conclusions, especially for consumption pattern C (no tank).

At various points the article advises to treat water meter replacement as an optimization problem, aimed at maximizing the revenues of the water supply company. However, that is a very one-sided approach, as if the only risk involved is that of the water sup-

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ply company. A balanced approach should consider the risks of both the water supply company and the consumers. Situations with over-registration should be just as undesirable as situations with under-registration. A way to achieve this is for example regular sampling inspection, where a decision to replace the population of water meters of a certain age is based upon the quality of a random sample of water meters of that age. The quality of each individual water meter of the sample should be determined with a test bench, where positive and negative registration errors are given the same weight.

Some minor points systemic error -> systematic error

The following text from page 126, line 3 is not clear: “The error curve of the 143 water meters for low flow rates were defined for four different pressure values, representing the network pressure measured upstream of the instruments: 0.5, 1.0, 1.5 and 2.0 bar. For each test pressure, the meters were tested at four different experimentally determined flow rates: the first being the highest flow rate at which the meter sensor remains at rest, with the other three at increasing intervals of one litre per hour (i.e. the second flow rate is one litre per hour greater than the first, and so on).” However, how does this reconcile with the shown example of an error curve (figure 5), containing 25 data points, while from this text I understand that only 4 data points were obtained? Or does figure 5 contain a mix of measured and modeled points? If so, that would be misleading.

Interactive comment on Drink. Water Eng. Sci. Discuss., 6, 119, 2013.