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DWESD
6, C70–C77, 2013

Interactive
Comment

Interactive comment on "Effects of network pressure on water meter under-registration: an experimental analysis" *by* C. M. Fontanazza et al.

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Responses to the Referee 2

The authors are grateful to the Referee 2 for the detailed comments and useful recommendations. Generally the Authors have accepted Referee's comments changing the manuscript accordingly. Detailed responses to the Referee have been reported in the following paragraph.

First, the authors thank the Referee for the compliment and the kind words.

The authors are aware that several models have been developed for determining network components' optimal replacement time by means of a performance assessment of the network coupled with a technico-economical analysis of the costs to repair or

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replace the damaged parts of the system (Kanakoudis and Tolikas, 2001; Kanakoudis and Tolikas, 2004) or by means of a decision-support system (Makropoulos and Butler, 2005, among others). The methods used for identifying an adequate replacement frequency of water meters and determining the most suitable meter type are based on lab tests of used meters, field measurements of real consumption patterns, or the use of company billing data systems (Arregui et al., 2003; Arregui et al., 2011). A solution is generally obtained by minimising a function representing the average annual costs of the meter, which includes the cost of the equipment, its installation and the unaccounted-for water. Early meter replacement will result in a higher average cost due to the initial fixed costs. However, if a meter is replaced too late, a significant loss of revenue caused by metering errors will also increase the average cost. As a consequence of the multiple factors related to meter performance that affect apparent losses, the authors proposed a composite indicator in a previous study (Fontanazza et al., 2012). This indicator allows the performance of a meter to be analysed during its operating life and suggests a reliable replacement strategy aimed at the reduction of apparent losses caused by meter under-registration.

Kanakoudis, V. and Tolikas, D., 2001. The role of leaks and breaks in water networks – Technical and economical solutions. Journal of Water Supply: Research and Technology - Aqua, 50(5), 301-311. Kanakoudis, V. and Tolikas, D., 2004. Assessing the Performance Level of a water system, Water, Air & Soil Pollution, 4-5, 307-318. Makropoulos, C.K. and Butler, D., 2005. A neurofuzzy spatial decision support system for pipe replacement prioritisation. Urban Water Journal, 2(3), 141-150. Arregui, F., Cabrera, E.Jr., Cobacho R. and Palau V., 2003. Management strategies for optimum meter selection and replacement. Water Science and Technology: Water Supply, 3(1–2), 143–152. Arregui, F. J., Cobacho, R., Cabrera, E. Jr. and Espert V., 2011. Graphical Method to Calculate the Optimum Replacement Period for Water Meters. Journal of Water Resources Planning and Management, 137(1), doi:10.1061/(ASCE)WR.1943-5452.0000100. Fontanazza, C.M., Freni, G., La Loggia, G., Notaro, V. and Puleo V., 2012. A composite indicator for water meter replacement in an urban distribution net-

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work. Urban Water Journal, 9(6), 419-428.

Formal statistical tests have been added to the analysis as suggested by the Referee. The linear dependency of the average starting flow on pressure is checked for by means of t test, the results of that is showed in Table 3. Finally the assumptions of normality, homoscedasticity and linearity are tested by analysing the standardized residuals (Figures 9 and 10). The 143 water meters tested are worn-out devices replaced with new instruments in 2006 by the local Palermo water utility. They were not drawn from a more numerous sample but were the only available to test.

The three consumption profiles are used to make preliminary remarks, not general but to be generalized. The authors only measured the low flow rate parts of each error curve so they do not provide any measured error values at high flow rates. However, the authors do not believe that the errors at high flow rates, that are usually positive, are negligible. In this study, they paid attention to low and very low flow rates only. The aim of this paper is to deeply analyse what happed when flow rates passing through the meter is lower than the starting flow. Meter under-registration is greater when the demand is characterized by a high per cent consumption at low flow rates and this phenomenon occurs when a private tank is interposed between the meter and the end user.

The water consumption profiles were obtained from an experiment performed in 2008 when fifteen residential users in the Palermo distribution network were continuously monitored for approximately 2 months. During this period network pressure is recorded as well. Pressure ranges between 0 and about 3 bar. Pressure not much affects consumptions of profiles A and B. In profile A, the tank was empty when pressure becomes to increase and the flow rates depend on the float valve emitter coefficient and the valve effective discharge area above all. In profile B, the tank was always full and, once water flowed from the tank to the user, was rapidly replenished through a partially open float valve. The flow rates were in any case low, whatever pressure there was. The effect of the pressure on the consumption profile C has not been investigated

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because the measured values were within the pressure range taken into consideration.

Figure 5 has been corrected.

In the zip file, the Referee will find the new version of the manuscrit, the track change copy, figures and tables.

Please also note the supplement to this comment:
http://www.drink-water-eng-sci-discuss.net/6/C70/2013/dwesd-6-C70-2013-supplement.zip

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Table 3. Results of the *t* test.

Age class	t	α	$t_{\alpha/2}$
1	-23.453	0.01	5.597
2	-12.705		
3	-7.341		
4	-10.012		
5	-9.171		
6	-11.117		
7	-5.627		
8	-9.528		
9	-13.062		

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Fig. 1. Table 3. Results of the t test.

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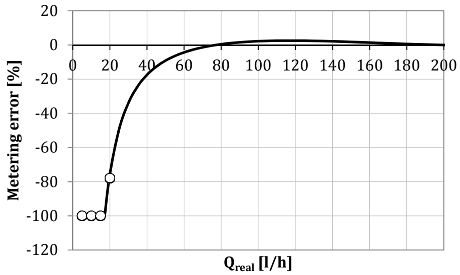

Figure 5. Example of an error curve for a sample water meter in age class 3 (test pressure p = 1.0 bar): $Q_{start} = 17.20\ l/h$, $k = 1.84$ and $Per = 38.22\ l/h$.

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Fig. 2. Figure 5. Example of an error curve for a sample water meter in age class 3 (test pressure p = 1.0 bar): Qstart = 17.20 l/h, k = 1.84 and Per = 38.22 l/h

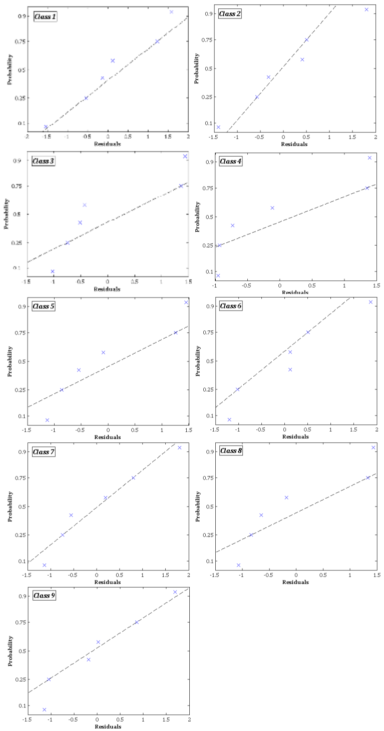

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Fig. 3. Figure 9. Normal probability plot of standardized residuals

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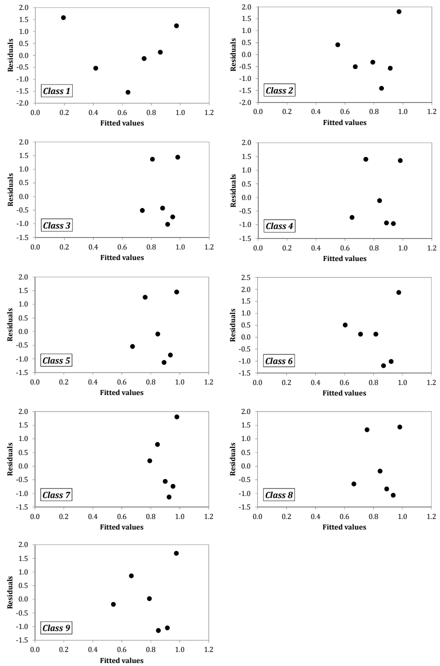

Figure 10. Residual plot for the mean starting flow data

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Fig. 4. Figure 10. Residual plot for the mean starting flow data

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