Metrology for Real-World
Domestic Water Metering

The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

17IND13 Metrowamet
Metrology for real-world domestic water metering

Recommendations for the acquisition of consumption profiles of potable water in households including guidelines for the selection of equipment, time scales and sampling rates

EMPIR Grant Agreement: **17IND13 Metrowamet**
Deliverable reference: **D1**
Lead Partner: **FORCE**
Due date of the deliverable: **January 2021**
Actual Submission Date: **February 2021**

Contents

1 Scope

The aim of this document is to give recommendations on how to acquire consumption profiles in households to obtain insights into flow rates domestic water meters encounter and whose total volumes the meters are expected to reliably capture.

2 Measurement Equipment

These recommendations are based on the measurements carried out in the EMPIR project 17IND13. To obtain recommendations on how to positively select locations to carry out the measurements for the profiles please refer to the site identification scheme developed in this project (appendix 1).

2.1 Accuracy

The recommended accuracy for the flowmeter used to acquire data for consumption profiles (master meter) should be at least ten times greater than the domestic water meters. It is recommended that the accuracy of the meter is 0.2 % or better.

2.2 Range (flow)

It is recommended that the maximum flow range of the master meter match the domestic meters in the area being tested. A dynamic range of the master meter of at least 20:1 is suggested.

2.3 Resolution

To obtain the required data regarding quick time events it is recommended that the resolution of the master meter is equal to 0.01 L/pulse or higher.

2.4 Temperature

A meter with maximum admissible temperature of 50 ^{o}C is recommended.

2.5 Pressure

A meter with maximum admissible pressure of 16 bar or better is recommended. Furthermore, it is recommended to use a flowmeter with the smallest possible pressure drop, as this could affect the overall hydraulic system. The maximum pressure drop over the master meter should not be more than the one of the water meter installed.

2.6 Flow disturbances

It is recommended to use a flow meter that is insensitive to hydraulic disturbances and to effects caused by variations in water quality such as solid particles, water conductivity etc.

2.7 Power supply

Battery-powered flow meters are to be preferred in order to access places where external power supplies are not available. Alternatively, a mechanical flow meter with a battery driven data acquisition system can be used.

3 Logging equipment

It is recommended to use an automated data acquisition system that is battery powered, and with enough battery power to last the full duration of the logging, to ensure that the measurements are securely logged.

3.1 Security

It is recommended that the logging equipment is secured from tampering, and from environmental damage from heat, humidity, flooding etc.

3.2 Memory

Ensuring that the data acquisition system has enough memory to record data for the full time of the duration of the recordings is recommended.

3.3 Communication

If transmission of acquired data using wireless communications of choice, it is important that all acquired data are transmitted and not only the summery of the daily consumption. It is also important that all acquired data if fitted with a timestamp.

4 Logging specifications

4.1 Rate

At least 1 Hz sampling rate is recommended to ensure that the full dynamics in the flow rates are obtained.

4.2 Duration

Optimally the recordings should be carried out over a full year to ensure that seasonal variations are included. Realizing that this is not feasible often, a minimum duration of four weeks is recommended to obtain a statistically significant consumption profile that reflects events, including their duration and amplitude.

The following meta-data is the recommended minimum to assist the data acquisition:

- Number of residents with division into adults and children.
- Country and city
- Type of dwelling (house or flat including number of utilization units)
- Type of water feed (direct or tank)
- Installation site of water meter (inside or outside of property)
- Type of water meter installed
- Base area
- Number of different types of sanitary installations (shower, bathtub, (kitchen) sink, dish washer, washing machine, pool, garden hose, toilet, urinal etc)
- Line pressure

4.3 Site identification

For a method to identify sites for carrying out a consumption survey please refer to appendix 1: Site Identification Scheme.

4.4 Risk mitigation

The following factors are important to assess before carrying out the data recordings:

- Water supply quality
  Sites with high amounts of air or particles in the water supply should be evaluated and if possible avoided
- Occupancy
  It is important to ensure that the housing(s) at the measurement site(s) are occupied and usage is estimated to be of a normal character, especially for shorter acquisition schemes.
- Validation of equipment
  The flow meter and other measurement equipment should be calibrated and validated before and after they have been recording at test sites.
- Security

  The meter should be secured to against access from unauthorised personnel

Appendix 1: Site Identification Scheme

1 Meter specification

The site identification scheme [SIS] is developed as a tool to determine areas for data collection. The data collection will be performed by a reference meter to determine the consumptions profiles at the selected households. The data collection should only be carried out in areas which use water meters approved according to MID 2014/32/EU. It is recommended that the minimum duration of data collection is one normal week (for further explanation relating to the duration of data collection see section "Data amount").

1.1 Master meter

An important part of the data collection is the reference meter used for data acquisition, which should be state of the art system, to ensure the most precise measurements possible. The chosen master meter should preferably be installed downstream of the approved water meter to prevent ingress of particles during installation. It is important that the installation of the master meter is carried out in to ensure the local laws are respected relating to sanitary conditions (see "Legal requirements" for more information).

The technical requirements for the master meter are the following:

- This document will not recommend certain technologies for the master meter. Such recommendations will be made at the end of the MetroWaMet project. (Recommendations)
- The resolution of the master meter shall be good enough, that it records all changes in flow.
- The head loss of the master meter should be as low as possible, to ensure that the head loss from the master meter has no effect on the system. In case of high head loss, the master meter added to the system, the amplitudes of pressure oscillations will be limited, and therefore not equivalent to the results of normal consumption.
- The master meter should start detecting flow that corresponds to the unit at the household's cut-off to ensure small leaks will be detected. This is should be implemented without increasing the precision of the master meter significantly.

1.2 Technical specification for households

Technical specifications for the approved water meters should at least, fulfil the following demands according to flowrates. I should be decided to choose households where the meter size, represent the majority of the area's meters.

Q_3 = 1.6 m^3/h, R250
Q_3 = 2.5 m^3/h, R400
Q_3 = 4 m^3/h, R400

If the water meters in the selected areas fulfil the demands for flowrates listed above, the flowrate can be determined (in accordance to the legal rules) from 6.25 l/h to 5000 l/h. As mentioned in the above section "Master meter", it is known that the over longer periods the flowrate at certain occasions will be below 6.25 l/h, which also might be detected by the approved water meter depending on low flow cut-off (for ultrasonic water meters) and starting flowrate (for mechanical water meters).

1.3 Installation parameters

It is important to register the installation of the approved water meters, to determine a possible correlation between deviating results and types of installation is caused by the installation parameters. The following points are expected to have an influence of the results:

- The water feed to the dwelling. If a dwelling is using a tank as buffer, the water meter should be placed downstream for the tank. If the water meter is located upstream for the tank, the flowrate will be relatively constant, and therefore will not show the correct dynamic in the flowrate. In this case is should be determined by the data collecting entity if households with tanks give the required measurement data.
- It is expected that the different types of tapping points and the number of each type will have an influence on the flow profiles (this will be compared to the number of inhabitants). A high number of taping points and inhabitants will cause a more alternating dynamic load profile.

2 Data

To create models and statistics which describe the real-world domestic water metering, it is important to ensure the collected data are correlated. The data collection can be split in to two parts. One which determine which data is needed from the master meter and one part which describe the areas/utilization which has been used for testing. The following section describes which information is relevant to record according to the areas for testing.

2.1 Dwelling information

For this project the water meters are limited to Q_3 = 1.6, 2.5 and 4 m^3/h. Therefore, the investigated types of dwellings are single-family houses (up to 3 utilization units). One utilization unit equals roughly 2.5 residents.

The following information about each utilization should be recorded to determine correlation between the results and facilities, and which type of water usage results in deviating results. The number of the following:

- Number of residents
- Country and city
- Type of dwelling (house or flat including number of utilization units)
- Type of water feed (direct or tank)
- Location of water meter (inside or outside of property)
- Base area
- Number of different types of sanitary installations (shower, bathtub, (kitchen) sink, dish washer, washing machine, pool, garden hose, toilet, urinal etc).

2.2 Data amount

The duration of measurements is up to the entity who carries out the measurement. The goal of the measurements is to derive a statistical load profile, that reflects events, duration and amplitude. Four weeks, where the housing unit is occupied, is recommended as a minimum.

2.3 Statistically supported selection

To ensure independence when choosing a measurement object, it is necessary to fall back on proven statistical methods. In the following section a probabilistic approach is described to foster an unbiased choice of objects.

At first, the relative distribution of house types (categories as stated in section 2.1 in this annex) for the supply area must be obtained. This information is available from federal or regional statistical offices. An example is given in Table 1.

Table 1: Selecting targeted house sizes

	Single-family house (SFH)	Multi-family dwelling (MFH)	Housing complexes (HC)	SUM
Distribution within supply area	40 %	40 %	20 %	100 %
Given an amount of 50 planned measurements	20 objects	20 objects	10 objects	50 objects

Zip codes divide the measurement area (most likely the supply area of the water utility). For each zip code area and the whole supply area, the following parameters should be derived from federal or regional statistical offices:

- number of inhabitants
- average residential rent and/or residential rent distribution
- average household size and/or household size distribution.

A set of representative zip code areas is derived from the average values of the parameters of the whole supply area. Therefor the zip code areas that lie within the inter quantile range (values between the 25 and 75 quantile) of the distribution of parameters of the supply area are selected. The selected zip code areas will be scaled according to their size in terms of number of inhabitants in relation to the supply area (in percentage). Under the assumption of a uniform distribution, the objects to measure are drawn from this pool. An example is given in Tables 2 - 6.

Table 2: Quantile values in a supply area (green: within inter quantile range, red: outside interquartile range)

Supply area					
Parameter	**Min**	**Q25**	**Q50**	**Q75**	**Max**
Residental rent in €/m²	5	9	14	18	25
Household size in person/household	1	2	3	4	5

Table 3: Checking which zip code areas lie within the interquartile ranges (green: values fit within interquartile range, red: values don't fit within interquartile range)

Zip code area		
ID	**Residental rent in €/m²**	**Household size in person/household**
A	7.5	6
B	12.4	2.3
C	12.4	3.4
D	13.8	2.7
E	5	1.2
F	16.7	1.8

From Table 3 it is seen that zip code areas A, E and F do not lie within the interquartile ranges regarding household sizes and residential rent.

Table 4: Scaling the selected zip code areas between 0 and 1

Overall inhabitants = 100 000						
ID	Inhabitants	Relative	Relative within group	Relative within group calculated	Scaled range from	Scaled range to
B	11 000	11 %	31 %	31 %	0	0.31
C	9 000	9 %	26 %	57 %	0.31	0.57
D	15 000	15 %	43 %	100 %	0.57	1

Table 5: Drawing randomized tickets for each object

Object number	Object type	Ticket	Zip code area
Object 1	SFH	0.20	B
Object 2	SFH	0.87	D
Object 3	SFH	0.45	C
Object 4	SFH	0.51	C
Object 5	SFH	0.48	C
Object 6	SFH	0.21	B
Object 7	SFH	0.85	D
Object 8	SFH	0.23	B
Object 9	SFH	0.99	D
Object 10	SFH	0.35	C
Object 11	SFH	0.47	C
Object 12	SFH	0.35	C
Object 13	SFH	0.91	D
Object 14	SFH	0.45	C
Object 15	SFH	0.72	D
Object 16	SFH	0.17	B
Object 17	SFH	0.80	D
Object 18	SFH	0.52	C
Object 19	SFH	0.98	D
Object 20	SFH	0.51	C
Object 21	MFH	0.56	C
Object 22	MFH	0.71	D
Object 23	MFH	0.71	D
Object 24	MFH	0.19	B
Object 25	MFH	0.08	B

Object 26	MFH	0,31	B
Object 27	MFH	0,13	B
Object 28	MFH	0.06	B
Object 29	MFH	0.83	D
Object 30	MFH	0.39	C
Object 31	MFH	0.81	D
Object 32	MFH	0.83	D
Object 33	MFH	0.13	B
Object 34	MFH	0.07	B
Object 35	MFH	0.64	D
Object 36	MFH	0.78	D
Object 37	MFH	0.45	C
Object 38	MFH	0.02	B
Object 39	MFH	0.23	B
Object 40	MFH	0.90	D
Object 41	HC	0.60	D
Object 42	HC	0.06	B
Object 43	HC	0.62	D
Object 44	HC	0.49	C
Object 45	HC	0.73	D
Object 46	HC	0.83	D
Object 47	HC	0.46	C
Object 48	HC	0.75	D
Object 49	HC	0.43	C
Object 50	HC	0.61	D

Table 6: Result of the statistical selection

Summary				
	Is SFH	Is MFH	Is HC	
In B	4	9	1	
In C	9	3	3	
In D	7	8	6	
				50

To summarize this example, the zip code areas B, C, D are within the inter quantile range and should therefore be chosen as representative (see Table 2 and

Table 3). This set of zip code areas is then scaled according to their relative share of the overall inhabitants within the supply area. A range between 0 and 1 is generated for the zip code area selection (see Table 4). Finally, the lottery takes place and for each object to be selected a ticket is drawn (see Table 5). The result of the statistical selection method determines how many measurements, of which house type (SFH/ MFH/ HC), are to be done in previously selected zip code areas (see

Table 6). Following the statistical selection, utility employees must find suitable properties in the zip code areas, e.g. four single-family houses, nine multi-family dwellings and one housing complex in zip code area B.

As this is an ideal solution we must take into account, that a ticket that has been drawn is not available in the chosen zip code area because

- the property owner denies the measurement
- no suitable objects in terms of size are available
- the meter cannot be installed for various reasons.

In this case, the draw must be repeated for the remaining objects or spread evenly over the other areas.

3 Legal requirements

Before the data collection can be started, it is important for each company/organization to ensure the collected data not interfere with the General Data Protection Regulation [GDPR]. The type of data that need to be collected in this project has been evaluated to determine if there are any issues regarding the GDPR. The data collected in this project has been evaluated in accordance to GDPR

- Type of households
- Household sizes
- Number of residents
- Geographical area
- District area (big city, town, country site etc.)
- Water usage for at least two years before test start up
- Number (and types) of dwelling points.

Those who oversee the data collection in the specific country, is obliged to ensure that the national regulations and laws do not interfere with the GDPR. In that case, it is the national laws that should be followed. All owners should agree in writing to the measurements and the associated recording of data. All data is to be anonymized.

For the use of master meter at households the national rules relating to sanitary conditions must at all time be respected to ensure not contamination of the water supply.