Physikalisch-Technische Bundesanstalt
Braunschweig and Berlin
National Metrology Institute

Consumption characteristics in Europe – derivation of representative test profiles - requirements for test rigs

MetroWaMet

Metrology for real-world domestic water metering

Daniel Schumann, 1.45

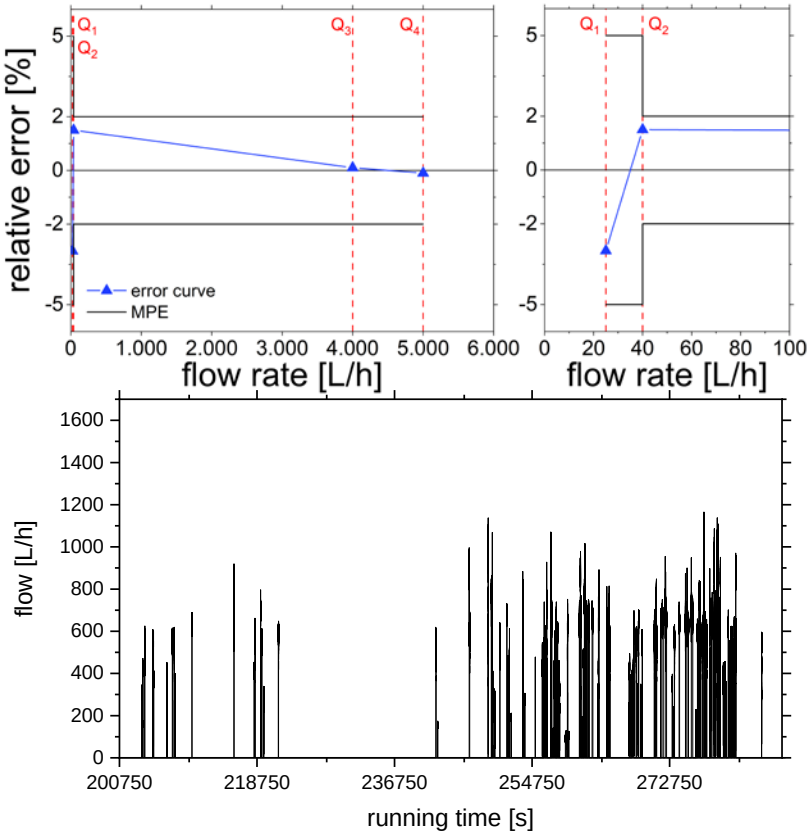
Introduction

- Reliable and resource-efficient supply of clean potable water is essential for a high quality of life
- Water supply to households, billing of water consumption and manufacturing of domestic water meters represent a 100 billion € business *(1)*
- Prescribed current test regimes for domestic water meters state to be run at well-defined constant and reproducible flow rates *(2,3)*
- BUT: Strong deviation of actual water consumption

Introduction

Example: Q_3: 4 m³/h R160

- Q_1: minimum flowrate
  $Q_1 = \frac{Q_3}{R} = 25\ L/h$
- Q2: transitional flow rate
  $Q_2 = 1{,}6 \cdot Q_1 = 40\ L/h$
- Q3: permanent flow rate
  $Q_3 = 4000\ L/h$
- Q4: overload flow rate
  $Q_4 = 1{,}25 \cdot Q_3 = 5000\ L/h$

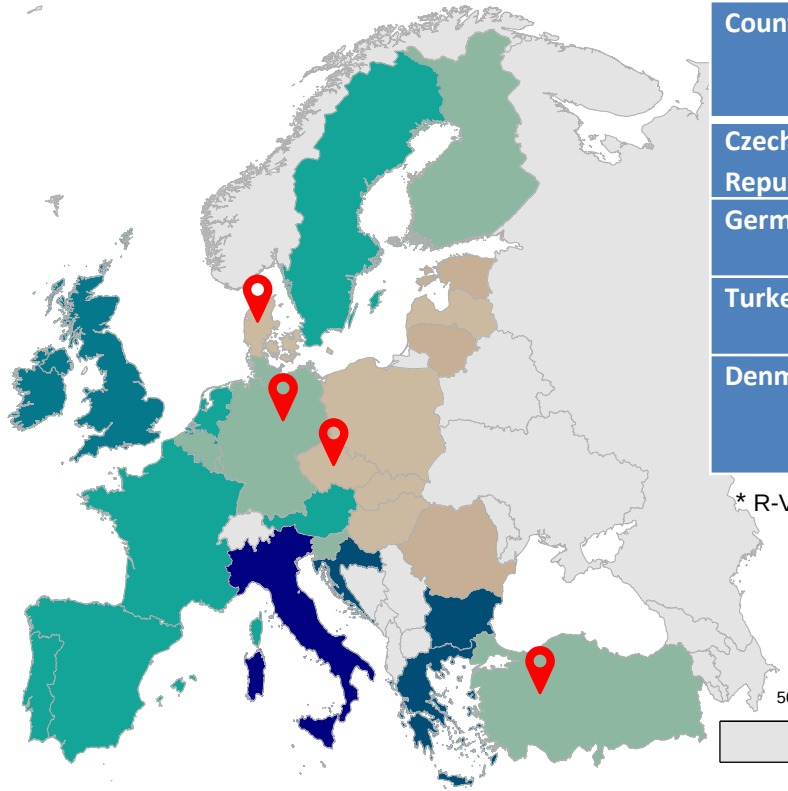


Requirements

1. Current water consumption measurements
   - Representative
     → **Presentation** Johan Bunde Kondrup, FORCE
   - Comparable

2. Representative test profiles for test rigs
   - Derivation of test profiles from real-world data
   - Flow standards for calibration under dynamic conditions
     → **Presentation** Florestan Ogheard, CETIAT

Consumption Characteristics Europe



Country	Water meter for data acquisition	Measurement resolution [L/pulse]	Duration [days]	Objects [#]
Czech Republic	Q_3: 1.6 m³/h R 250 ultrasonic water meter	0.02	15	2
Germany	Q_3: 4 m³/h R160 ultrasonic water meter	0.1	24 – 75	59
Turkey	Q_3: 2.5 m³/h R160 Piston type water meter	0.0167	1 – 23	32
Denmark*	Q_3: 2.5 m³/h ultrasonic water meter	Current flow L/h with 2 Hz resolution	2 – 26	24

* R-Value unknown

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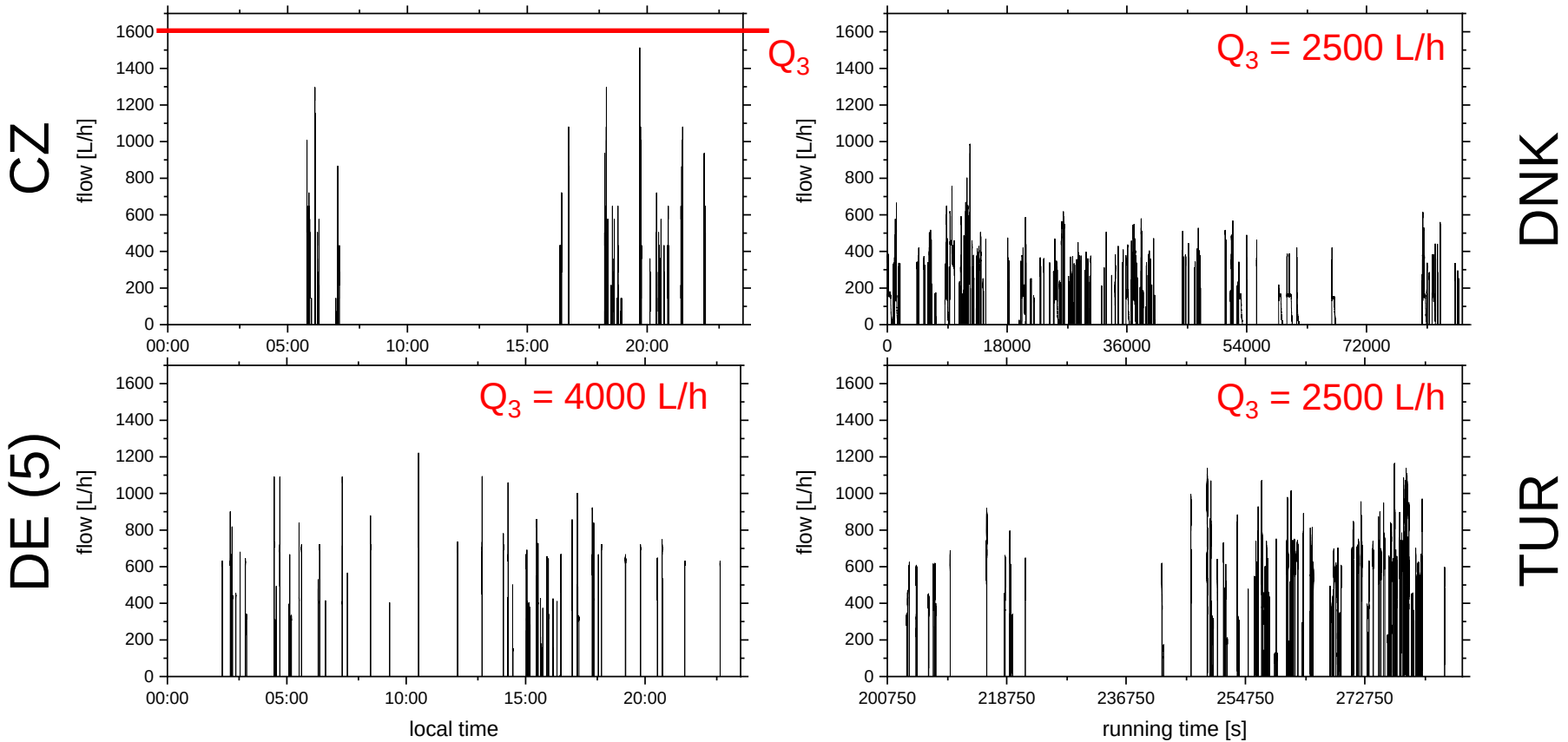
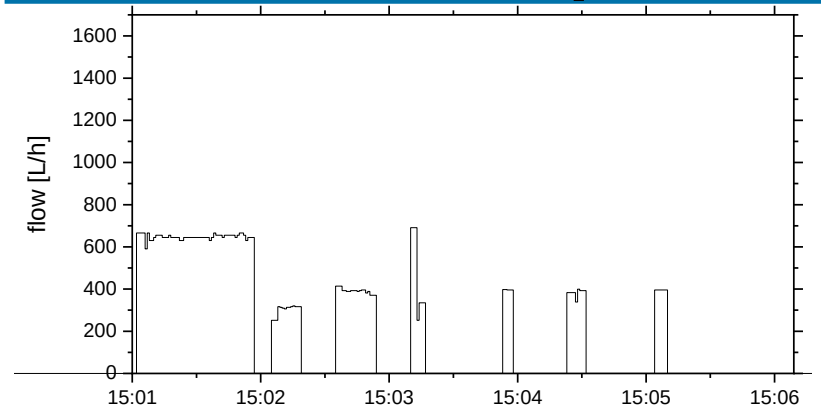
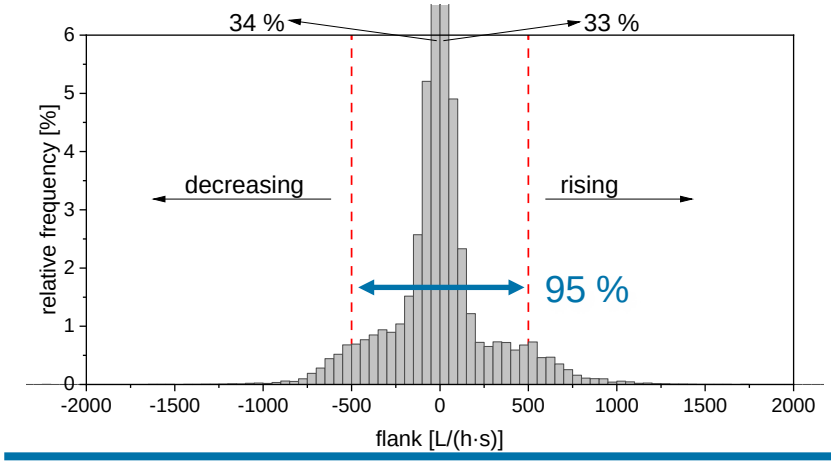
Consumption measurements



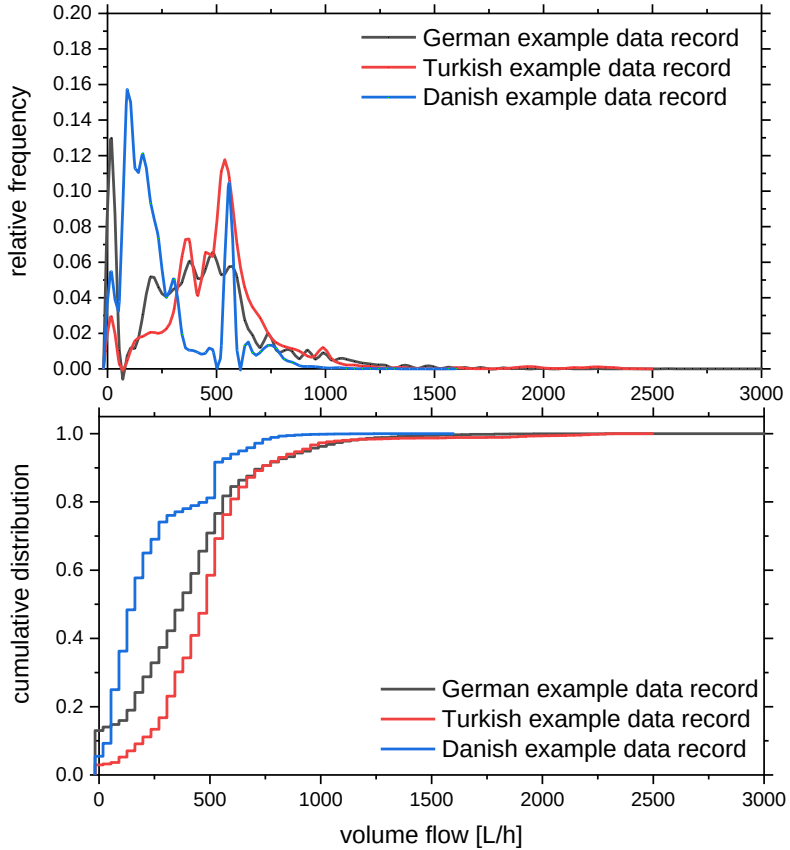
Consumption measurements





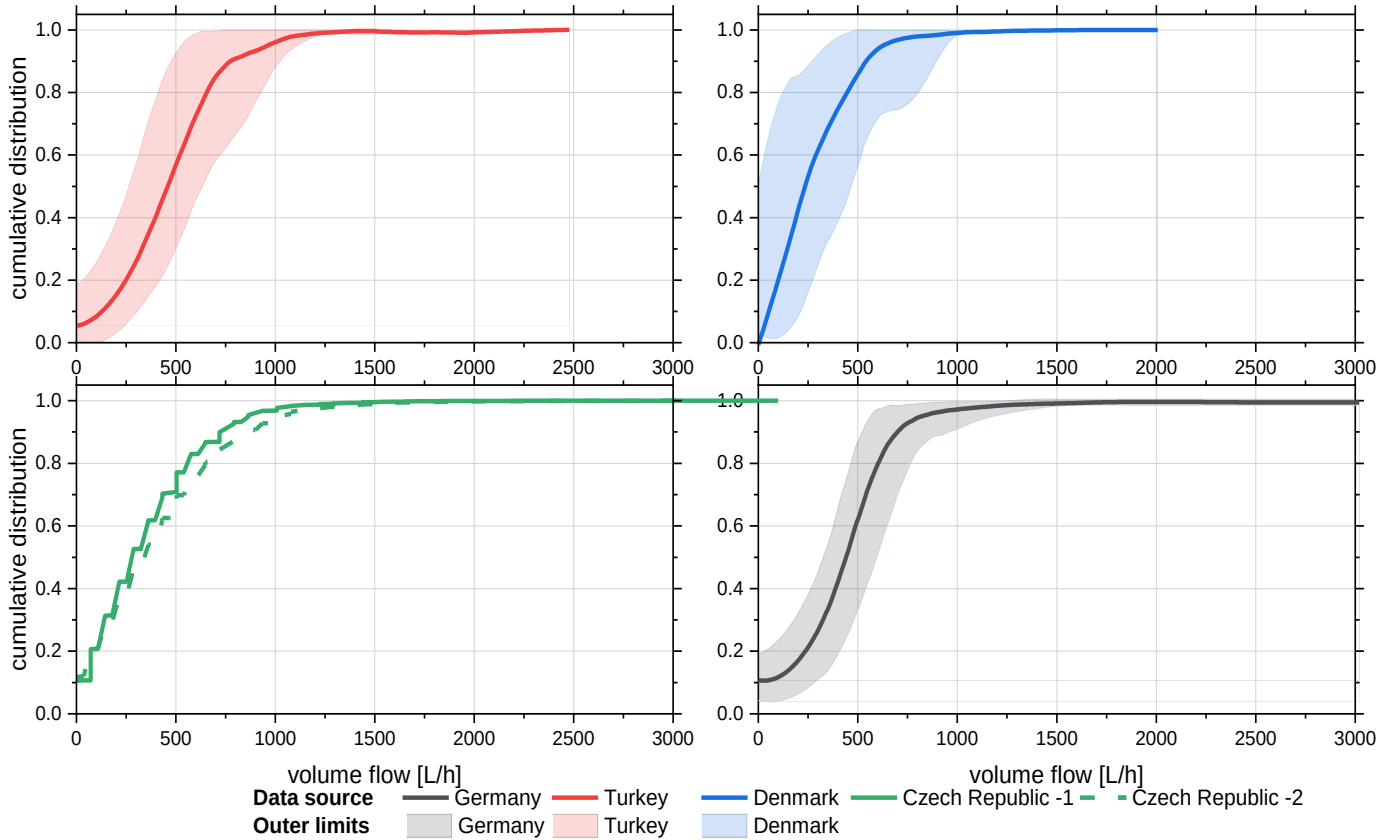
- Characterized by a multiple of single tappings
- Different quantity and duration
- Analysis of data:
  - Minimum, Maximum, Median → identifying outliers
  - Change in flow amplitudes
  - Duration of flow amplitudes
  - Probability of flow amplitudes

Consumption measurements



- Probability of flow amplitudes
  - Different courses and intensities
  - Partly identical local maxima
  - Sum function as central concept
  - Comparison of different probability densities possible
  - Cumulative distribution function of all objects
  - 95 % of all flows < 1200 l/h

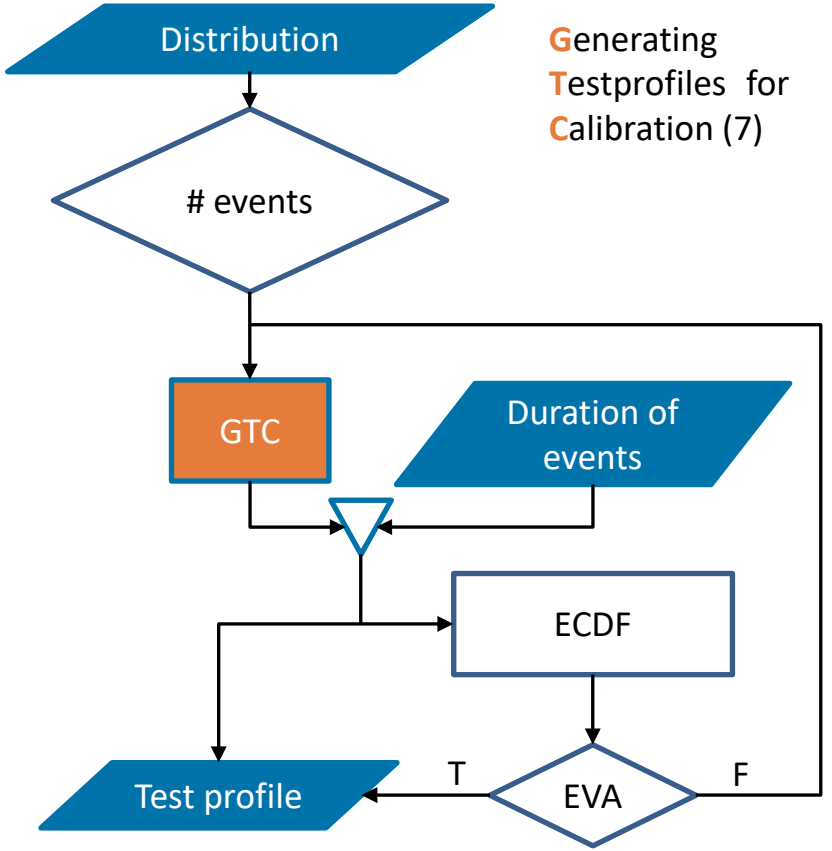
Consumption measurements



- Empirically determined band of flow rates incl. occurring probability
- Mean value curve as a statistically secured basis for model formation (6)

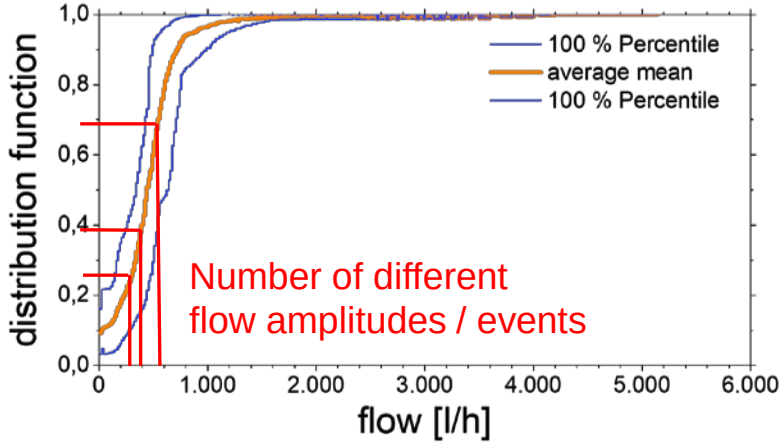
Derivation of test profiles

- Modeling
  - Generation of pseudo-random numbers (number of events) with weighted distribution based on a uniformly distributed [0,1] number sequence
  - Inversion method
    $F^{-1}(y) = \inf\{x : F(x) \geq y\}$

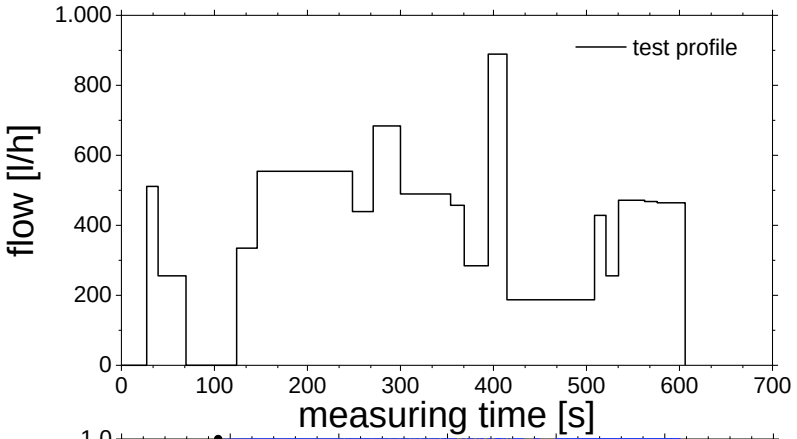


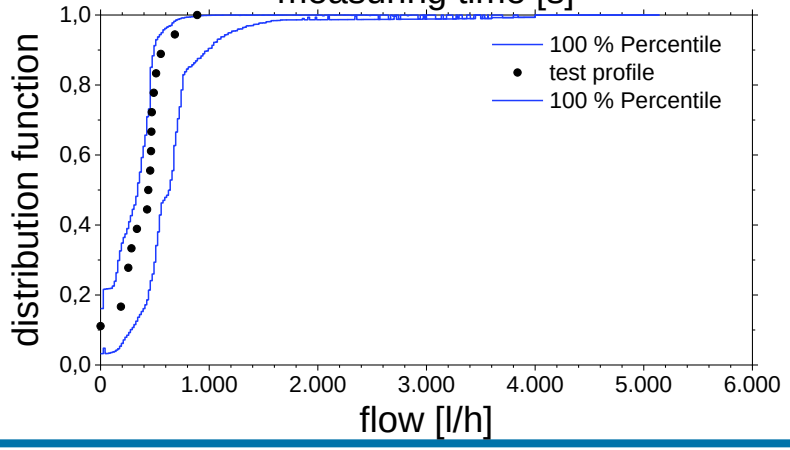
Generating Testprofiles for Calibration (7)

Derivation of test profiles



flow [l/h]	duration [s]	cum. duration [s]
511.2	27.174	27.174
255.6	12.262	39.436
0.0	30.000	69.436
334.8	54.432	123.868
554.4	22.103	145.971
...	...	...





Requirements for test rigs

- Mapping of generated test profiles
  - Suitable references
  - Determine accumulated volume and time synchronous flow rate
  - Time resolution < 1s
  - Repeatable and reproducible
  - Change of flow amplitudes within < 1s
  - Small deviation from the specified target flow rate
  - Stable Environmental and test rig conditions

Summary Pt. 1

- Occurring flow amplitudes are characterized by a multiple of single tappings
- Tappings are of different quantities and duration
- 95 % of rising and falling flanks of the flow rates are within ± 500 L/h
- Main class (67 %) of changing flow amplitudes are within ± 50 L/h
- Comparison of the recorded data via cumulative frequency possible
  - Creation of distribution ribbon for each country (except CZ)
  - Similarity in their course,
  - no seasonal effect

Summary Pt. 2

- …
  - Maximum recorded flow between 2500 L/h and 4000 L/h
  - 95 % of all flow amplitudes < 1500L/h
- Water consumption behavior within Europe is comparable
- Derivation of test profiles:
  - Based on the median cumulative distribution and the mean duration of flow amplitudes
  - Algorithm for the generation of stochastically secured and computer-aided test profiles
  - Validated, tested and applied

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State: 09/21

Literature

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