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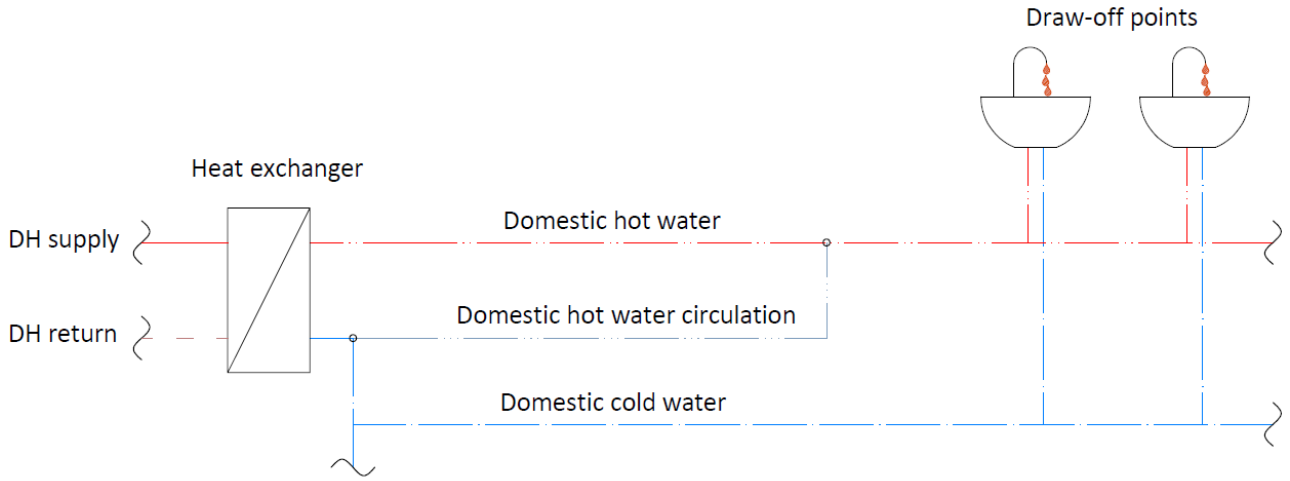

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by

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1. Foreword

This DCE Technical Report aims to present measured data from three domestic water systems in two Danish office and educational buildings: CREATE, Rendsburggade 14, 9000 Aalborg and TMV23, Thomas Manns Vej 23, 9220 Aalborg Ø. Before use, the measurement equipment is calibrated in the Laboratory for Indoor Environmental and Energy Engineering at Aalborg University. The data set can be found in [1].

This technical report and data set are supplementary material for the journal paper “High frequency flow and temperature measurements of domestic water in two office and education buildings”.

In the master thesis [2], the measurement equipment, calibration, and results are more detailed described.

NB By using the data set in published work, the authors should cite the paper “High frequency flow and temperature measurements of domestic water in two office and education buildings”.

2. Abstract

Measurement data of domestic water in non-residential buildings is sparse. More data is needed to describe the non-residential buildings' domestic hot water (DHW) demand and to be able to design more efficient DHW systems. This DCE Technical Report aims to present and describe the data set: "Data set - Domestic water at CREATE and TMV23". This data set contains measurement data from two office and educational buildings in Aalborg, Denmark. The measurements in the building CREATE are conducted from October 2018 to January 2019 and in the building TMV23 from April 2021 to May 2021. The data set consists of water flow rates and temperatures for the domestic cold water, domestic hot water, district heating for DHW production, and DHW circulation circuit.

3. Three domestic water systems

The data set consists of measured data from three domestic water systems in the two buildings in two different periods:

- CREATE, one system, measurement period from 19-10-2018 to 03-01-2019.
- TMV23, two systems, measurement period from 12-04-2021 to 24-05-2021.

Both buildings are academic buildings with staff and students using the draw-off points. Domestic hot water (DHW) is produced instantaneously with a heat exchanger (HEX) utilizing district heating (DH).

Figure 1, shows a sketch of the measured draw-off points in the domestic water system in CREATE. At the highlighted six draw-off points, water temperature and flow rate are measured (four washbasins, one kitchen sink, and one service sink). The pale color draw-off points exist but are not measured. At the HEX for DHW production, the following are measured: DH flow rate, DH supply temperature, DH return temperature, DHW circulation flow rate, DHW circulation return temperature, DHW supply temperature, and domestic cold water (DCW) flow rate to the HEX.

Figure 2, shows the sketch for TMV23 with two DHW systems. The 2nd floor has six measured draw-off points (three washbasins, two kitchen sinks, and one service sink), and the 3rd floor has three draw-off points (three washbasins). Besides the measured quantities described for CREATE, the DCW temperature at the HEX is measured at TMV23. An overview of the measured quantities is shown in Table 1 in the following section.

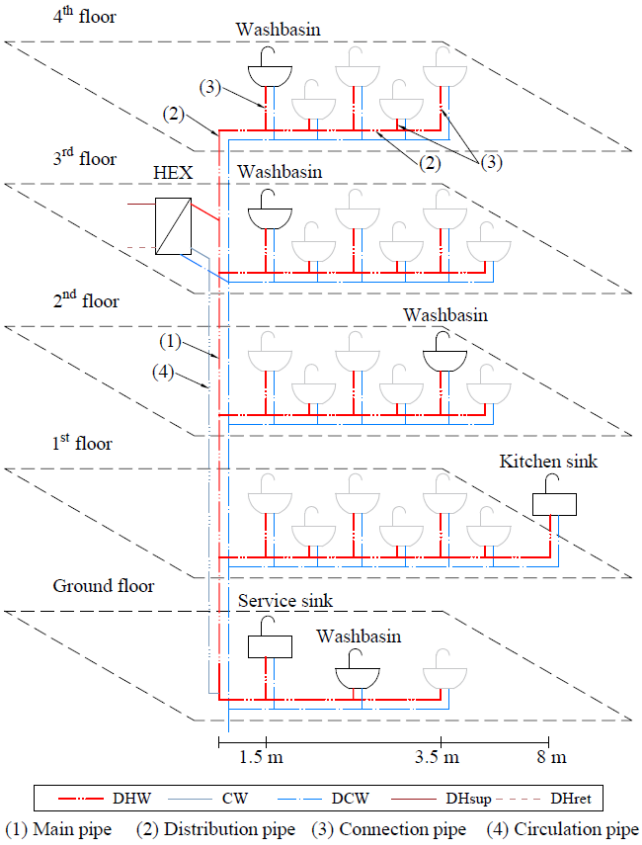

Figure 1: Sketch of the domestic water system in CREATE (not to be scaled). The measured draw-off points are highlighted. CW - circulation water.

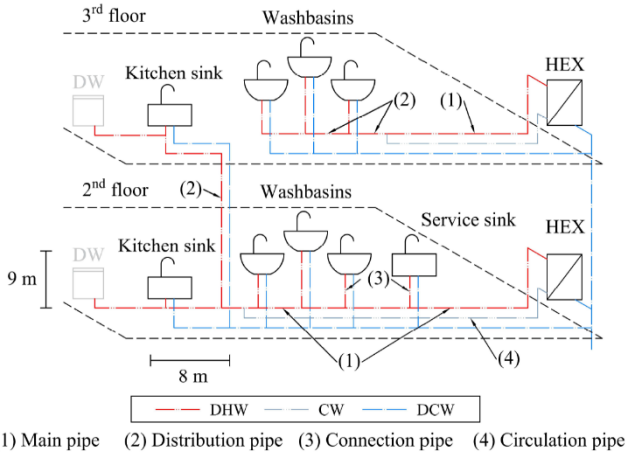

Figure 2: Sketch of the two domestic water systems in TMV23 (not to be scaled). The measured draw-off points are highlighted. CW - circulation water.

4. Measurement equipment

A small variety of measurement equipment has been used to measure the quantities in the domestic water systems. Table 1 lists the measured quantities, location, and equipment used. The measurement equipment and the location of use are described in the following.

At the draw-off points, Huba flow sensor type 236 [3], see Figure 3, is used to measure water flow rate and temperature. The Huba flow sensor is a vortex flow sensor that measures one flow rate and one temperature. Therefore, two sensors are necessary to measure a draw-off point with a hot and cold water supply. The sensors have been mounted below the sinks right before the faucet. To capture short and rapid changes in the flow rate and temperature without having a large data storage, a specially developed logging system with Porcupines by Seluxit [4], see Figure 4, is developed. The Porcupine only logs data (flow rate and temperature) if a flow is detected. When a flow occurs, the sampling rate of the Huba flow sensor is up to 8 Hz. In periods with no flow, the Porcupine logs data every five minutes to register temperature decay/rise in the stagnated water in the pipes. This logging solution catches the rapid flow rate changes and minimizes the need for data storage.

At the HEX for DHW production, see Figure 6, the buildings' Building Management System (BMS) measures the flow rate, supply temperature, and return temperature at the DH side of the HEX. On the DHW side of the HEX, the BMS measures the DCW flow rate, the DHW supply temperature, and the DHW circulation return temperature.

The DHW circulation flow rate and DCW temperature are measured by KATflow 100 [5], see Figure 5. The temperature is measured with a PT100 sensor and flow rate with ultrasonic clamp-on sensors. The KATflow 100 has a sample rate of 100 Hz and logs average values per second to a Raspberry Pi from where the data is accessible.

Before use, the Huba flow sensor and KATflow 100 are calibrated in the Laboratory for Indoor Environmental and Energy Engineering at Aalborg University. All equipment complies with the manufacturer's stated accuracy. Specification of the Huba flow sensor and KATflow can be seen in Table 2. The sensors types and specifications in the BMS system have not been available, therefore they are not listed in this report.

Figure 3: Huba flow sensor type 236.

Figure 4: Porcupine SLX by Seluxit.

Figure 5: KATflow 100.

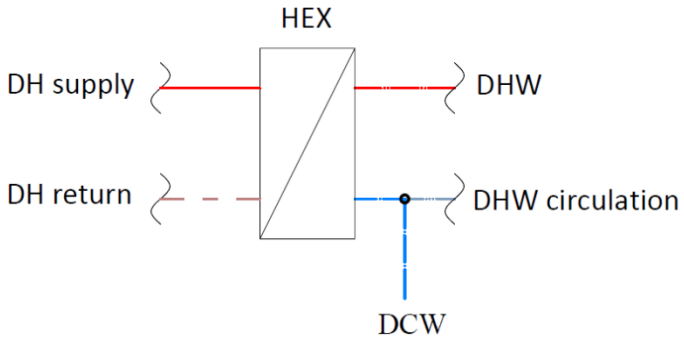

Figure 6: Sketch of heat exchanger (HEX) system. Left side is the DH side of the HEX. Right side is the DHW side of the HEX.

Location	Quantity	Equipment
Draw-off point	Cold water flow rate	Huba flow sensor + Porcupine
	Hot water flow rate	
	Cold water temperature	
	Hot water temperature	
Heat exchanger In technical room	DH flow rate	Building management system
	DH supply temperature	
	DH return temperature	
	DCW flow rate	
	DHW supply temperature	
	Circulation return temperature	
	Circulation flow rate	KATflow 100
	DCW temperature[1]	

Table 1: Overview of the measured quantities in CREATE and TMV23.

	Huba flow sensor 236		KATflow 100	
Specification	**Flow rate**	**Temperature**	**Flow rate**	**Temperature**
Sample rate	≤8 Hz	≤8 Hz	100 Hz	100 Hz
Measure method	Vortex	0 - 10 V	Ultrasonic	PT100
Measure range	1.8 to 32 l/min	-25 to 125 °C	0.01 to 25 m/s	-30 to 250 °C
Accuracy	<50 % fs: <1 % fs[2] >50 % fs: <2 % rd[3]	±1.25 °C	0.5 % rd	±(0.15 + 0.002·T) °C
Resolution	0.001 l/min	0.01 °C	0.25 mm/s	0.1 °C

Table 2: Specification of Huba flow sensor 236 and KATflow100. From manufacturers' data sheet.

[1] Unfortunately, there are no DCW temperature for CREATE. The temperature sensor has been placed too close to the HEX, and heat transmission in pipe material and water, has to high impact on the measured temperature.
[2] Percentage of full scale. For Huba flow sensor type 236 the full scale is 32 l/min.
[3] Reading scale - the measured value.

5. Data set structure

To understand the data in the data set, a structure and description of the files are presented and shortly elaborated in this chapter.

The data set structure is in two folder levels. Level 1 has a folder for CREATE and TMV23. Where level 2 consists of all the .mat-files. The .mat-files concerning the draw-off points consist of measured data from all draw-off points in the building. Each column in the draw-off point files is a draw-off point, and Table 3 shows this order and draw-off type. The order is the same for all draw-off point .mat-files for CREATE and TMV, but the order for the two buildings differs. The last column in Table 3 lists the draw-off types that should not be used because of unreliable data due to problems with measurement equipment.

Building	Washbasin	Kitchen sink	Service sink	Do not use
CREATE	4, 5, 6, 7	2	1	3
TMV	2, 6, 7, 8	5, 9	1	3, 4

Table 3: Order of columns in .mat-files for draw-off points in CREATE and TMV23. Concerning both flow rate and temperature .mat-files.

In Table 4 is seen an overview of the .mat-files for CREATE. There are nearly 11 weeks of draw-off point data, from 19-10-18 to 03-01-19. The measured data interval at the HEX that produces hot water is two weeks, from 18-12-18 to 03-01-19. Be aware that the files “Temp_DHW_Supply”, “Flow_Circulation”, Temp_Circulation_Return”, and “Flow_Hot_HEX” have an associated Timestamp file.

Table 5 shows the overview of .mat-files for TMV23. Here there are four weeks of draw-off point data, from 12-04-21 to 24-05-21. The measured data at the HEX is around nine weeks, with a slight variation in the measurement period start date and the measurement period end date.

CREATE

Description	Unit	Name .mat-file	Period start	Period end	Draw-off point	HEX
DHW flow rate	l/min	Flow_Hot_All	19-10-18 02:04:15	03-01-19 12:38:14	X	
DCW flow rate	l/min	Flow_Cold_All	19-10-18 02:04:15	03-01-19 12:38:14	X	
Mixed/tapped water flow rate	l/min	Flow_Mixed_All	19-10-18 02:04:15	03-01-19 12:38:14	X	
DHW temperature	°C	Temp_Hot_All	19-10-18 02:04:15	03-01-19 12:38:14	X	
DCW temperature	°C	Temp_Cold_All	19-10-18 02:04:15	03-01-19 12:38:14	X	
Mixed/tapped water temperature	°C	Temp_Mixed_All	19-10-18 02:04:15	03-01-19 12:38:14	X	
Duration of draw-off actions	s	Draw-off_Duration_All	19-10-18 02:04:15	03-01-19 12:38:14	X	
Duration of time between draw-off actions	s	Breaks_Duration_Draw-off_All	19-10-18 02:04:15	03-01-19 12:38:14	X	
Supply DHW temperature from HEX	°C	Temp_DHW_Supply	18-12-18 08:00:21	03-01-19 10:39:51		X
Circulation flow rate	l/s	Flow_Circulation	18-12-18 08:00:23	03-01-19 10:39:53		X
Return temperature circulation to HEX	°C	Temp_Circulation_Return	18-12-18 08:00:23	03-01-19 10:39:53		X
DHW flow rate measured at HEX	l/s	Flow_Hot_HEX	18-12-18 08:00:23	03-01-19 10:39:53		X
Timestamp DHW supply temperature	dd-mmm-yyyy tt-mm-ss	Temp_DHW_Supply_Time	18-12-18 08:00:21	03-01-19 10:39:51		X
Timestamp DHW flow rate	dd-mmm-yyyy tt-mm-ss	Flow_Hot_HEX_Time	18-12-18 08:00:23	03-01-19 10:39:53		X
Timestamp circulation flow rate and temperature	dd-mmm-yyyy tt-mm-ss	TempAndFlow_Circulation_Return_Time	18-12-18 08:00:23	03-01-19 10:39:53		X
DCW flow rate to HEX	l/s	Flow_DCW_HEX	18-12-18 07:00:21	04-01-19 13:31:21		X
DH flow rate	l/s	Flow_DH	18-12-18 07:00:21	04-01-19 13:31:21		X
DH supply temperature to HEX	°C	Temp_DH_Supply	18-12-18 07:00:21	04-01-19 13:31:21		X
DH return temperature from HEX	°C	Temp_DH_Return	18-12-18 07:00:21	04-01-19 13:31:21		X

Table 4: Overview of .mat-files in the CREATE folder.

TMV23

Description	Unit	Name .mat-file	Period start	Period end	Draw-off point	HEX
DHW flow rate	l/min	Flow_Hot_All	12-04-21 00:00:00	24-05-21 23:59:59	X	
DCW flow rate	l/min	Flow_Cold_All	12-04-21 00:00:00	24-05-21 23:59:59	X	
Mixed/tapped water flow rate	l/min	Flow_Mixed_All	12-04-21 00:00:00	24-05-21 23:59:59	X	
DHW temperature	°C	Temp_Hot_All	12-04-21 00:00:00	24-05-21 23:59:59	X	
DCW temperature	°C	Temp_Cold_All	12-04-21 00:00:00	24-05-21 23:59:59	X	
Mixed/tapped water temperature	°C	Temp_Mixed_All	12-04-21 00:00:00	24-05-21 23:59:59	X	
Duration of draw-off actions	s	Draw-off_Duration_All	12-04-21 00:00:00	24-05-21 23:59:59	X	
Duration of time between draw-off actions	s	Breaks_Duration_Draw-off_All	12-04-21 00:00:00	24-05-21 23:59:59	X	
Supply DHW temperature from HEX 2nd floor	°C	Temp_DHW_Supply_2floor	29-03-21 02:56:03	28-05-21 07:35:48		X
Supply DHW temperature from HEX 3rd floor	°C	Temp_DHW_Supply_3floor	27-03-21 03:03:39	27-05-21 09:56:24		X
Circulation flow rate 2nd floor	l/min	Flow_Circulation_2floor	01-04-21 00:03:06	25-05-21 01:03:31		X
Circulation flow rate 3rd floor	l/min	Flow_Circulation_3floor	28-03-21 01:02:34	25-05-21 01:03:14		X
Return temperature circulation to HEX 2nd floor	°C	Temp_Circulation_Return_2floor	29-03-21 02:56:03	28-05-21 07:35:48		X
Return temperature circulation to HEX 3rd floor	°C	Temp_Circulation_Return_3floor	27-03-21 03:03:39	27-05-21 09:56:24		X
DCW flow rate to HEX 2nd floor	l/s	Flow_DCW_HEX_2floor	29-03-21 02:56:03	28-05-21 07:35:48		X
DCW flow rate to HEX 3rd floor	l/s	Flow_DCW_HEX_3floor	27-03-21 03:03:39	27-05-21 09:56:24		X
DCW temperature to HEX 2nd floor	°C	Temp_DCW_HEX_2floor	01-04-21 00:03:06	25-05-21 01:03:31		X
DCW temperature to HEX 3rd floor	°C	Temp_DCW_HEX_3floor	28-03-21 01:02:34	25-05-21 01:03:14		X
DH flow rate 2nd floor	l/s	Flow_DH_2floor	29-03-21 02:56:03	28-05-21 07:35:48		X
DH flow rate 3rd floor	l/s	Flow_DH_3floor	27-03-21 03:03:39	27-05-21 09:56:24		X
DH supply temperature to HEX 2nd floor	°C	Temp_DH_Supply_2floor	29-03-21 02:56:03	28-05-21 07:35:48		X
DH supply temperature to HEX 3rd floor	°C	Temp_DH_Supply_3floor	27-03-21 03:03:39	27-05-21 09:56:24		X
DH return temperature from HEX 2nd floor	°C	Temp_DH_Return_2floor	29-03-21 02:56:03	28-05-21 07:35:48		X
DH return temperature from HEX 3rd floor	°C	Temp_DH_Return_3floor	27-03-21 03:03:39	27-05-21 09:56:24		X

Table 5: Overview of .mat-files in the TMV23 folder.

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