This test summary, downloaded from the BESA website, indicates that the HIU listed below has been tested against the criteria of the BESA HIU Test Regime.

BESA BUILDING ENGINEERING SERVICES ASSOCIATION

Model: Greenstar HIU KE

Serial Number: 5570-273-000010-773560062

Year of manufacture: 2021

Test carried out by S.Broxham Enertek Int On: 12/15/21 Reference: E4616

NOTE: The VWART accuracy is in the range +/-2°C	HIGH TEMP VWART °C	LOW TEMP VWART °C
DHW	22	20
Keep-warm	38	40
Space heating	45	36
Overall with keep warm	32	32

Pressure test		
No HIU damage	Pass	Pass

Dynamic DHW operation	2a	
DHW not exceed 65°C	Pass	Pass

Low flow test at BESA flow rate of 0.02l/s	3a	3b
DHW not exceed 65°C	Pass	Pass
DHW temperature at set point +/- 3°C	n/a	n/a

Low flow test at manufacturer declared flow rate	3c	3d
Declared minimum flow rate (l/sec)	0.03	0.03
Not exceed 65°C	Yes	n/a
DHW temperature at set point +/- 3°C	Yes	n/a

Keep-warm test	4a	4b
Standby heat consumption - average (Watts)	49	57
Standby electricity consumption - average (Watts)	2.41	2.32
Total HIU heat loss (DH + electrical input) (Watts)		
Standby flow rate (the average flow rate) (l/hr)	3.96	6.0

DHW Response time test	5a	5b
DHW response time (Seconds)	13	13
Peak electrical heat during test (Watts)		
Output		
DHW temperature not exceed 65°C for more than 10 secs	Pass	Pass
DHW reaches 45°C with 15 secs	Pass	Pass

Scaling risk assessment as defined in 2.26	If any of the factors below occur then the risk of scaling of the DHW PHE in hard water areas increases		
HIU has a TMV or TRV on the DHW	No		
Test	2a	3a	3c
t32 above 60°C for more than 5 secs	Yes	No	No
t12 exceeds 55°C at any point of the test	No	No	No
Test	4a		4b
t12 exceeds 50°C at any time	No		No

Photo of HIU being tested with the cover off.

Photo of HIU being tested with the cover on.

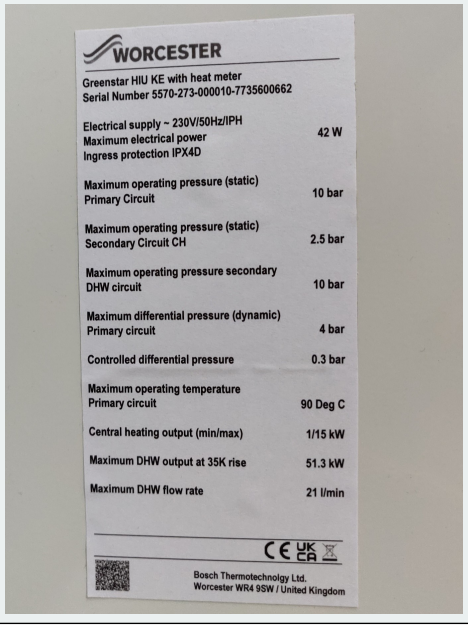

Photo of Manufacturers label and serial number.

COMPONENT DATA AND DOCUMENTATION

Component and Part No.	Manufacturer and Type	Documents submitted
Space Heating Heat Exchanger 8718665592	SWEP, Copper brazed	Yes
Domestic Hot Water Heat Exchanger 8718692051	SWEP, Copper brazed	Yes
Controller (Optional external control) 8737705195	External programmer (230V), Bosch sense 2 controller	Yes
Control Valve 8718692126	ESBE Actuator	Yes
Space Heating filter	No strainer required on SH	Yes
Controller for Domestic Hot Water	Braga, control board	Yes
Control Valve and Actuator for DHW 8718692126	ESBE Actuator	Yes
Temperature Sensors 8718651671	Exa-thermametrics	Yes
Domestic Hot Water Isolating Valve 8718694519	Altecnic	Yes
Primary Side Strainer 8718692897	Italfim SPA	Yes
Drain Valves 8718693210	Orkli	Yes
Vent Valves 8718694129	Novasfer	Yes
Circulation Pump set with AAV & PRV 8718692400	Grundfos	Yes
Heat Meter 8718692457	Sontex 749 Mbus Heat Meter	Yes
Domestic Hot Water Flow Sensor 8717002132	Serdar	Yes
Pipes 8718692125	Bosch, Stainless steel	Yes
Connections 8718693734	Altecnic	Yes
Joints 8718693734	Altecnic	Yes
Gaskets 8716107438	Altecnic	Yes
Expansion Vessel 8718699932	Zilmet	Yes
Insulation 8718692250	Synprodo	Yes
Pressure sensors 8718645792	Wika pressure gauge	Yes
'O' Ring 8716107438	Altecnic	Yes
		Yes
		Yes
		Yes
		Yes

Schematic diagram and drawing showing the structure and arrangement of the HIU with dimensions and weight	Included within the HIU installation manual	Yes
Technical specification for electronic components including version of software	Software version: NF51.05 Power 230v/ 50Hz	Yes
Installation guide	Included within the installation manual	Yes
Commissioning guide	Included within the appliance literature pack	Yes
Operation guide with a function description/ description of operations and care instructions as suited to the intended user category	Included within the HIU user guide	Yes
Declaration of Conformity for CE-marked HIUs	Seperate certificates	Yes
Full parameter list for electronically controlled HIUs	Included with the installation manual	Yes

HIU Marking	Comment	Info present
Model name and type no.	Worcester Greenstar HIU KE with heat meter	Yes
Serial no.	5570-273-000010-7735600662	Yes

HIU MANUFACTURERS' DECLARED INFORMATION (TO BE COMPLETED BY THE MANUFACTURER)

HIU Model	Worcester Greenstar HIU KE with heat meter
Part No.	7735 600 662
Software version	NF 51.05
Test Date:	
Test No.	

DIMENSIONAL INFORMATION	
Dimensions with casing (HxDxW) (mm)	700 x 270 x 440
Primary connections top/bottom	top and bottom
Secondary HTG connections top/bottom	top and bottom
Secondary BCW/DHW connections top/bottom	top and bottom
Connection sizes Prim/Sec DHW/Sec HTG (mm)	22mm
Empty weight kg** (Kg)	34
Operating weight kg** (Kg)	36

ELECTRICAL INFORMATION	
Power supply (230V 1 phase)	**230V 1~**
Maximum power (Watts)	41.3
Standby power demand (Watts)	3.1

HYDRAULIC INFORMATION	
Maximum primary pressure (Bar g)	10
Maximum primary temperature (°C)	80
Primary water volume (l)	0.8
Maximum secondary DHW pressure (Bar g)	10
Maximum secondary DHW temperature (°C)	60
Secondary DHW water volume (l)	1.98
Maximum secondary HTG pressure (Bar g)	3
Maximum secondary HTG temperature (°C)	70
Primary operating DP range min/max (kPa)	400

DECLARED MAXIMUM PERFORMANCE LT TEST CONDITIONS	
DHW	
Maximum DHW production at 70°C (kW)	51.3
Primary flow temperature (°C)	**70**
Primary return temperature (°C)	20.8
Primary flow (m3/h)	0.9
Primary △P* (kPa)	45.1
Secondary in/out temperature (°C)	**10/55**
Secondary △P (bar)	
HTG	
Maximum HTG production (kW)	
Primary flow temprature (°C)	**70**
Primary return temperature (°C)	
Primary △P* (bar)	
Secondary in/out temperature (°C)	**40/60**
Secondary available DP at the output of HIU	

DECLARED MAXIMUM PERFORMANCE LT TEST CONDITIONS	
DHW	
Maximum DHW production at 60ºC (kW)	
Primary flow temperature (ºC)	**60**
Primary return temperature (ºC)	
Primary flow (m^3/h)	
Primary △P* (kPa)	
Secondary in/out temprature (ºC)	**10/50**
Secondary △P (bar)	
HTG	
Maximum HTG production (kW)	
Primary flow temprature (ºC)	**60**
Primary return temperature (ºC)	
Primary △P* (bar)	
Secondary in/out temperature (ºC)	**35/45**
Secondary avialable DP at the output of the HIU (kPa)	
HIU P&ID supplied by manufacturer with a legend for the components	

*DP pressure not to include HM. Designers must add HM pressure drop.
** Including HIU, casing and wall hung bracket

The information included in this page is for the specific model of HIU detailed in this test report. It is additional information voluntarily provided by the manufacturer who is solely accountable for the details sumbmitted.

MANUFACTURERS' DECLARATION

This is to confirm that the information supplied by relates to the specific HIU tested and is an accurate representation of the product listed on the BESA HIU Register.

Signed  Position Technical operations manager Company Bosch Thermotechnology

COMMENTS/HISTORY

Enertek International

International Consultants in Product
Research, Design, Development
& Certification

BESA HIU TEST REPORT

BOSCH Greenstar HIU KE

Client: BOSCH

Project Number: E4616 Report Issue: 2

24 January 2022

Prepared By:

Simon Broxham - Project Engineer

Approved By:

Josh Welburn – Project Engineering Manager

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BESA SUMMARY SHEET

This test summary, downloaded from the BESA website, indicates that the HIU listed below has been tested against the criteria of the BESA HIU Test Regime.

Model: Greenstar HIU KE

Serial Number: 5570-273-000010-773560062

Year of manufacture: 2021

Test carried out by S.Broxham Enertek Int On: 12/15/21 Reference: E4616

NOTE: The VWART accuracy is in the range +/-2°C	HIGH TEMP VWART °C	LOW TEMP VWART °C
DHW	22	20
Keep-warm	38	40
Space heating	45	36
Overall with keep warm	32	32

Pressure test		
No HIU damage	Pass	Pass

Dynamic DHW operation	2a	
DHW not exceed 65°C	Pass	Pass

Low flow test at BESA flow rate of 0.02l/s	3a	3b
DHW not exceed 65°C	Pass	Pass
DHW temperature at set point +/- 3°C	n/a	n/a

Low flow test at manufacturer declared flow rate	3c	3d
Declared minimum flow rate (l/sec)	0.03	0.03
Not exceed 65°C	Yes	n/a
DHW temperature at set point +/- 3°C	Yes	n/a

Keep-warm test	4a	4b
Standby heat consumption - average (Watts)	49	57
Standby electricity consumption - average (Watts)	2.41	2.32
Total HIU heat loss (DH + electrical input) (Watts)		
Standby flow rate (the average flow rate) (l/hr)	3.96	6.0

DHW Response time test	5a	5b
DHW response time (Seconds)	13	15
Peak electrical heat during test (Watts)		
Output		
DHW temperature not exceed 65°C for more than 10 secs	Pass	Pass
DHW reaches 45°C with 15 secs	Pass	Pass

Scaling risk assessment as defined in 2.26	If any of the factors below occur then the risk of scaling of the DHW PHE in hard water areas increases		
HIU has a TMV or TRV on the DHW	No		
Test	2a	3a	3c
t32 above 60°C for more than 5 secs	Yes	No	No
t12 exceeds 55°C at any point of the test	No	No	No
Test	4a		4b
t12 exceeds 50°C at any time	No		No

CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 BRIEF

1.1.1 Enertek international Limited (EIL), were contracted to receive, install, and commission a production sample of the Greenstar HIU KE with Heat Meter.

1.1.2 To carry out the work involved to evaluate the performance of Domestic Hot Water (DHW) and Space Heating (SH) in accordance with the BESA UK HIU Test regime Technical Specification, Rev-009 October 2018, a publicly available online Test Regime. This is here-on referred to as the Test Regime throughout this document.

1.1.3 To provide a report detailing the tests carried out and generated results in accordance with the Test Regime criteria, including calculations for Volume Weighted Average Return Temperatures (VWART).

2 DEFINITIONS

2.1.1 The following definitions and abbreviations which have been used within this report can be found in table 2.1 below.

Table 2.1 – Definitions and Abbreviations

Symbol	Description	Unit
P_1	Power, Primary Side	kW
P_2	Power, Space Heating Side	kW
P_3	Power, Domestic Hot Water	kW
t_{11}	Temperature, Primary Side Supply Connection	°C
t_{12}	Temperature, Primary Side Return Connection	°C
t_{21}	Temperature, Space Heating Side Return Connection	°C
t_{22}	Temperature, Space Heating System Supply Connection	°C
t_{31}	Temperature, Cold Water Supply	°C
t_{32}	Temperature, Domestic Hot Water Output from HIU	°C
q_1	Volume Flow, Primary Side	L/s
q_2	Volume Flow, Space Heating Side	L/s
q_3	Volume flow, Domestic Hot Water	L/s
Δp_1	Primary Pressure drop across entire HIU Unit	kPa
Δp_2	Pressure Drop, Space Heating System across HIU	kPa
Δp_3	Pressure Drop, Domestic Hot Water across HIU	kPa
$VWART_{DHW}$	DHW Volume Weighted Return Temperature	°C
$VWART_{SH}$	Space Heating Volume Weighted Return Temperature	°C
$VWART_{KWH}$	Keep Warm Volume Weighted Return Temperature	°C
$VWART_{HEAT}$	Annual Volume Weighted Return Temperature for Heating Period	°C
$VWART_{NONHEAT}$	Annual Volume Weighed Return Temperature for Non-Heating	°C
$VWART_{HIU}$	Total Annual Volume Weighted Return Temperature	°C
DHW	Domestic Hot Water	–
HIU	Heat Interface Unit	–
SH	Space Heating	–
TMV	Thermostatic Mixing Valve	–
EIL	Enertek International Limited	–

3 TEST OBJECT

3.1 Appliance Details

3.1.1 Details of the Greenstar HIU KE appliance are given in Table 3.1. Photograph of the installed appliance is given in Figure 8.2.

Table 3.1 – Appliance Details

Item	Description
Manufacturer	BOSCH Worcester
Model	Greenstar HIU KE
Serial Number	5570-273-000010-7735600662
Year of Manufacture	2021
DHW Priority	Yes

3.2 Appliance Design Maximum Pressures

3.2.1 The maximum design pressures of the Greenstar HIU KE appliance for the primary side and the secondary side for both Space Heating and DHW are given in Table 3.2.

Table 3.2 – Appliance Design Maximum Pressures

Item	Value	Unit
Primary Side	10	Bar
Secondary Side Space Heating	2.5	Bar
Secondary Side DHW	10	Bar

3.3 Appliance Design Maximum Temperatures

3.3.1 The maximum design temperatures of the Greenstar HIU KE appliance for the primary side and the secondary side for both Space Heating and DHW are given in Table 3.3.

Table 3.3 – Appliance Design Maximum Temperatures

Item	Value	Unit
Primary Side	90	°C
Secondary Side Space Heating	70	°C
Secondary Side DHW	60	°C

4 TEST METHOD

4.1 Installation of Appliance

4.1.1 The appliance was installed and commissioned (as received) and as defined in the product literature provided. Testing was carried out without further adjustment other than disabling the internal space heating pump and adjusting the setting of the SH and DHW set points through the user interface on the HIU controller to suit the conditions of the HIU test rig. The HIU rig schematic is given in Figure 4.1.

4.2 Test Regime

4.2.1 The testing described in this report was carried out in accordance with the BESA Test Regime. The Test Regime outlines a series of static and dynamic tests to determine the performance of a HIU's DHW and SH functions. The Regime outlines the test method including the reporting of the results, the performance requirements and the VWART calculations.

4.2.2 The setup of the BESA tests is reproduced in Table 4.1. The basis of reporting the performance of the HIU from the BESA Test Regime is reproduced in Table 4.2.

4.2.3 The Test Regime specifies the testing of two different test temperature packages. The first is the high temperature package, with a district primary supply of 70 °C and the second is the 'low temperature' package, with a district primary supply temperature of 60 °C.

4.2.4 As the Greenstar HIU KE is suitable for both high and low temperature operation, both test packages were carried out and results recorded within this report.

4.3 Measurement & Uncertainties

4.3.1 All measurements and uncertainties adhere to the requirements stipulated in the BESA Test Regime. All measurements were sampled at a rate of 1 Hz for all tests.

4.3.2 The BESA uncertainties of measurement requirements are as follows: Differential Pressure, ± 1 kPa; Temperature, ± 0.1 °C; Volume Flow, ± 1.5 %. Note: the time constant for the temperature sensors is less than 1.5 s.

4.3.3 EIL's reported uncertainty is based on a standard uncertainty by a coverage factor K=2, providing a level of confidence of approximately 95%. The uncertainty evaluation has been carried out in accordance with UKAS requirements. The EIL equipment list and uncertainties are given in Table 8.2, Appendix B.

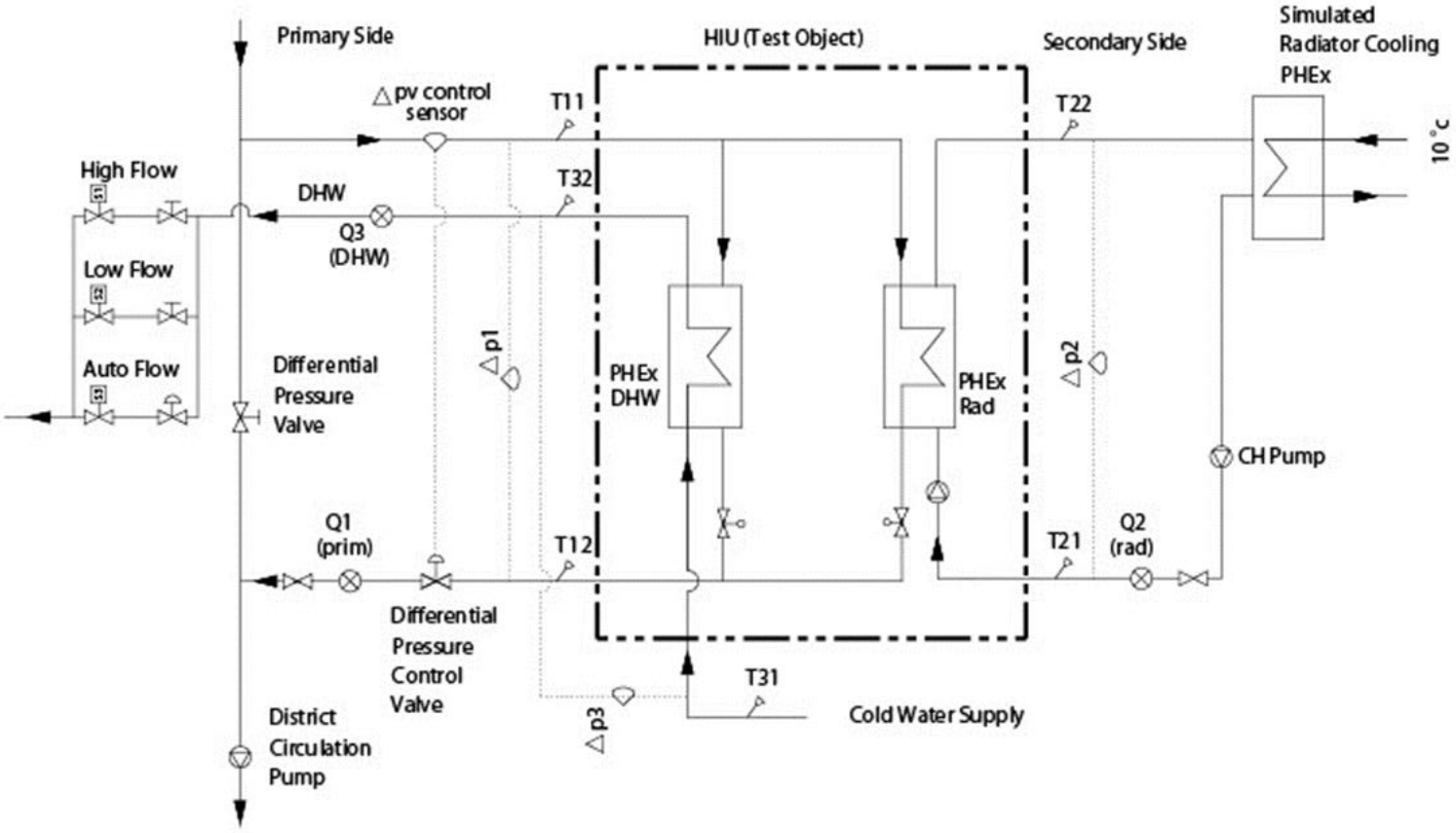

Figure 4.1 – EIL's HIU Test Rig Schematic

Table 4.1 – Setup of Tests (Based on BESA Test Regime, Table 1: Test Schedule)

		District Circuit			*Domestic Hot Water*			*Space Heating*		
		Static Pressure	Differential Pressure	Flow Temperature	Temperature Set Point	Flow Rate	Heat Load	Flow Temperature	Return Temperature	Heat Load
Symbol		*[p_1]*	*[Δp_1]*	*[t_{11}]*	*[t_{32}]*	*[q_3]*	*[P_3]*	*[t_{22}]*	*[t_{21}]*	*[P_2]*
Units		*[kPa]*	*[kPa]*	*[°C]*	*[°C]*	*[Ls^{-1}]*	*[kW]*	*[°C]*	*[°C]*	*[kW]*
Static Tests										
0a	District Pressure Test	1.43 X Claimed Value	-	-	-	-	-	-	-	-
1a	1kW Space Heating	3.0	0.5	70	-	-	-	60	40	1
1b	2kW Space Heating	3.0	0.5	70	-	-	-	60	40	2
1c	4kW Space Heating	3.0	0.5	70	-	-	-	60	40	4
1d	1kW Space Heating	3.0	0.5	60	-	-	-	45	35	1
1e	2kW Space Heating	3.0	0.5	60	-	-	-	45	35	2
1f	4kW Space Heating	3.0	0.5	60	-	-	-	45	35	4
Dynamic Tests										
2a	Dynamic Tapping	3.0	0.5	70	55	See Test Profile	See Test Profile	-	-	-
2b	Dynamic Tapping	3.0	0.5	60	50			-	-	-
3a	Low Flow	3.0	0.5	70	55	0.02	Record Value.	-	-	-
3b	Low Flow	3.0	0.5	60	50	0.02	Record Value.	-	-	-
4a	Keep-Warm	3.0	0.5	70	55	0.00	0	-	-	-
4b	Keep-Warm	3.0	0.5	60	50	0.00	0	-	-	-
5a	DHW Response	3.0	0.5	70	55	0.13	Record Value.	-	-	-
5b	DHW Response	3.0	0.5	60	50	0.13	Record Value.	-	-	-

Table 4.2 – Test Reporting, (Adapted from BESA Test Regime, Table 5)

Test Designation		Reporting
0	District Pressure Test	Pass/Fail as to whether HIU manages pressure test without leaks or damage.
1a	Space Heating 1 kW, 60/40 °C secondary.	t_{11} – Primary flow temperature. t_{12} – Primary return temperature. Plot of key metrics over duration of test. **Note**: Outputs used as input data to 'High Temperature' Space Heating Volume Weighted Average Return Temperature calculation.
1b	Space Heating 2 kW, 60/40 °C Secondary.	
1c	Space Heating 4 kW, 60/40 °C Secondary.	
1d	Space Heating 1 kW, 45/35 °C Secondary.	t_{11} – Primary flow temperature. t_{12} – Primary return temperature. Plot of key metrics over duration of test. **Note**: Outputs used as input data to 'Low Temperature' Space Heating Volume Weighted Average Return Temperature calculation.
1e	Space Heating 2 kW, 45/35 °C Secondary.	
1f	Space Heating 4 kW, 45/35 °C Secondary.	
2a	DHW Only, DH 70 °C Flow, 55 °C DHW.	Pass/Fail on DHW (at t_{32}) exceeding 65.0 °C (to 1 decimal point) for more than 10 consecutive seconds. State the maximum and minimum DHW temperatures over the period of the test when there is a DHW flow. Assessment of scaling risk as per the criteria detailed in 2.26. **Note:** Outputs used as input data to 'High Temperature' Space Heating Volume Weighted Average Return Temperature calculation. Plot t_{32}, t_{31}, q_3, t_{12}, q_1
2b	DHW Only, DH 60 °C Flow, 50 °C DHW.	State the maximum and minimum DHW temperatures over the period of the test when there is a DHW flow. **Note:** Outputs used as input data to 'Low Temperature' Domestic Hot Water Volume Weighted Average Return Temperature calculation. Plot q_1, q_3, dp_1, dp_3
3a	Low Flow DHW, DH 70 °C Flow, 55 °C DHW.	Pass/Fail on DHW (at t_{32}) exceeding 65.0 °C (1 decimal place) for more than 10 consecutive seconds. Comment on ability to deliver DHW at low flow based on DHW temperature reaching at least 45.0 °C (1 decimal place) at the end of the 180 second period of low flow DHW. Comment on the ability to deliver stable DHW flow temperature (at t_{32}), defined as ability to maintain 55.0 +/- 3.0 °C (1 decimal place) during the last 60 seconds of the test. Maximum temperature achieved and +/-°C variance around 55.0 °C (1 decimal place) to be stated. Plot of key metrics for 60 seconds of 0.13 l/s flow and the subsequent 180 seconds of 0.02 l/s DHW flow. Assessment of scaling risk as per criteria detailed in 2.26.
3b	Low Flow DHW, DH 60 °C Flow, 50 °C DHW.	Comment on the ability to deliver DHW at low flow rate based on DHW temperature reaching at least 45 °C (1 decimal place) at the end of the 180 second period of low flow DHW. Comment on the ability to deliver stable DHW flow temperature (at t_{32}), defined as ability to maintain 50.0 +/-3°C (1 decimal place) to be stated. Maximum temperature achieved and +/-°C variance around 50.0°C (1 decimal place) to be stated. Plot of key metrics for 60 seconds of 0.13 l/s flow and the subsequent 180 seconds of 0.02 l/s DHW flow.

Test Designation		Reporting
4a	Keep-Warm, DH 70 °C Flow, 55 °C DHW.	Assessment of whether valid keep-warm operation, based on 5a response time criteria: Pass/Fail. Comment on HIU keep-warm controls options. Assessment of scaling risk based on duration of temperatures in excess of 55.0 °C (1 decimal place). State average heat load for the duration of the test. State the average primary flow rate for the duration of the test. Note: Outputs used as input data to 'High Temperature' Keep-warm Volume Weighted Average Return Temperature calculation. Plot of key metrics over duration of test.
4b	Keep-Warm, DH 60 °C Flow, 50 °C DHW.	Assessment of whether valid keep-warm operation, based on 5b response time criteria: Pass/Fail. Observation on the operation of the HIU during keep-warm. Comment on HIU keep-warm controls options. Assessment of scaling risk based on extent and duration of temperatures in excess of 55.0 °C (1 decimal place). State average heat load for the duration of the test. State the average primary flowrate for the duration of the test. **Note:** Outputs used as input data to 'Low Temperature' Keep-warm Volume Weighted Average Return Temperature calculation. Plot of key metrics over duration of test.
5a	DHW Response Time, DH 70 °C Flow, 55 °C DHW.	Pass/Fail on DHW (at t_{32}) exceeding 65.0 °C (1 decimal place) for more than 10 consecutive seconds. State time to achieve 45.0 °C (1 decimal place) and not subsequently drop below 42.0 °C (1 decimal place). Plot t_{32}, t_{31}, t_{12}, q_1 over duration of test.
5b	DHW Response Time, DH 60 °C Flow, 50 °C DHW.	State time to achieve a DHW temperature 45.0 °C (1 decimal place) and not subsequently drop below 42.0 °C (1 decimal place). Comment on stability of DHW temperature. Plot t_{32}, t_{31}, t_{12}, q_1 over duration of test.

5 TEST RESULTS

5.1 Test 0 – Pressure Test

5.1.1 The appliance has passed the requirements of the static pressure test, Test 0 of the BESA Test Regime as:

5.1.2 There was No damage observed during the static pressure test, with the primary flow pressurised to 14.3 bar (1.43 times the rated value), and

5.1.3 There were No leaks observed during the static pressure test, with the primary flow pressurised to 14.3 bar (1.43 times the rated value).

5.2 Test 1a to 1f – Space Heating 1-4 kW at 70 and 60°C

5.2.1 The plot of the key metrics of Tests 1a-1f for the space heating 1 - 4 kW at both 70 and 60 °C are displayed in Figure 7.1 to Figure 7.6 respectively. See Table 5.1 for summarised test results including the average primary return temperature, t_{12}

Table 5.1 - Test Results for Space Heating Tests 1a to 1f

Test No & Description	Primary					Secondary				
	Flow Temperature $[t_{11}]$ *[°C]*	*Return Temperature* $[t_{12}]$ *[°C]*	*Flow Rate* $[q_1]$ $[Ls^{-1}]$	*Differential Pressure* $[\Delta p_1]$ *[kPa]*	*Heat Load* $[P_1]$ *[W]*	*Return Temperature* $[t_{21}]$ *[°C]*	*Flow Temperature* $[t_{22}]$ *[°C]*	*Flow Rate* $[q_2]$ $[Ls^{-}]$	*Differential Pressure* $[\Delta p_2]$ *[kPa]*	*Heat Load* $[P_2]$ *[W]*
1a - 1 kW Space Heating (DH 70 °C flow)	69.5	42.2	0.012	51.7	1290	39.7	60.4	0.012	2.4	1039
1b - 2 kW Space Heating (DH 70 °C flow)	69.5	43.9	0.023	49.2	2277	40.0	59.9	0.024	1.9	1963
1c - 4 kW Space Heating (DH 70 °C flow)	69.7	45.7	0.048	50.9	4604	39.8	60.3	0.048	0.2	4117
1d - Space Heating 1 kW (DH 60 °C flow)	59.8	34.7	0.012	46.4	1224	34.6	45.1	0.023	2.0	1012
1e - Space Heating 2 kW (DH 60 °C flow)	59.6	35.4	0.024	54.9	2411	34.6	45.2	0.047	0.5	2095
1f - Space Heating 4 kW (DH 60 °C flow)	59.8	35.9	0.045	53.2	4483	34.6	45.4	0.094	4.9	4341

5.3 Test 2a – DHW Dynamic Tapping at 70 °C

5.3.1 The appliance has passed the requirements of the DHW only at 70 °C, Test 2a of the BESA Test Regime as:

5.3.2 The domestic hot water output temperature, t_{32} did not exceed 65 °C for more than 10 seconds.

5.3.3 The maximum and minimum temperatures of t_{32} were 60.8 °C and 38.0 °C respectively.

5.3.4 The plot of the key metrics of the duration of Test 2a is displayed in Figure 7.7, Appendix A.

5.4 Test 2b – DHW Dynamic Tapping at 60 °C

5.4.1 The maximum and minimum temperatures of t_{32} were 52.7 °C and 36.0 °C respectively.

5.4.2 The plot of the key metrics of the duration of Test 2b is displayed in Figure 7.8, Appendix A.

5.5 Test 3a & 3c – Low Flow DHW at 70 °C

5.5.1 The appliance has passed the requirements of the Low Flow at 70 °C, Test 3a of the BESA Test Regime as:

5.5.2 The domestic hot water output temperature, t_{32} did not exceed 65 °C for more than 10 seconds, and,

5.5.3 The appliance did not maintain the DHW output temperature, t_{32} at 55 ± 3 °C during the last 60 seconds of the test.

5.5.4 The maximum and minimum temperatures of t_{32} were 59.9 °C and 14.5 °C respectively.

5.5.5 As the appliance did not maintain a stable flow temperature at 1.2 l/min, the appliance was retested as test 3c at the manufacturers declared low flow rate which was 1.8 l/min.

5.5.6 At the manufacturers low flow rate of 1.8 l/min the appliance did maintain the DHW output temperature t_{32} at 55±3 °C during the last 60 seconds of the test.

5.5.7 The plot of the key metrics of the duration of Test 3a is displayed in Figure 7.9, Appendix A.

5.5.8 The plot of the key metrics of the duration of Test 3c is displayed in Figure 7.11, Appendix A.

5.6 Test 3b & 3d – Low Flow DHW at 60 °C

5.6.1 The appliance did not maintain stable flow temperatures during Low Flow at 60 °C, Test 3b of the BESA Test Regime.

5.6.2 The appliance was retested as test 3d at the manufacturers declared low flow rate which was 1.8 l/min, the appliance was then seen to maintain DHW output temperature t_{32} at 50 °C during the last 60 seconds of the test.

5.6.3 The plot of the key metrics of the duration of Test 3b is displayed in Figure 7.10, Appendix A. Test 3d is displayed in Figure 7.12, Appendix A.

5.7 Test 4a – Keep-Warm at 70 °C

5.7.1 The appliance has passed the requirements of the Keep-Warm at 70 °C, Test 4a of the BESA Test Regime as:

5.7.2 This is a valid keep warm operation based on 5a response time criteria, see 5.9.3.

5.7.3 The appliance is performing keep-warm cycling as the primary flow temperature, t_{11} varies by more than ± 3 °C during the final 3 hours of the test. Please see BESA HIU Standard technical note TN-018 Version 1 for a more detailed definition of cyclical data.

5.7.4 The average heat load on the primary side P_1 is 49 W.

5.7.5 The average electrical consumption was 2.41 W.

5.7.6 The average primary flow q_1 over the 8 hours test was 3.96 l/hr.

5.7.7 The keep-warm control was set to on.

5.7.8 The plot of the key metrics of the duration of Test 4a is displayed in Figure 7.13, Appendix A.

5.8 Test 4b – Keep-Warm at 60 °C

5.8.1 The appliance has passed the requirements of the Keep-Warm at 60 °C, Test 4b of the BESA Test Regime as:

5.8.2 This is a valid keep warm operation based on 5b response time criteria, see 5.10.1.

5.8.3 The appliance is performing keep-warm cycling as the primary flow temperature, t_{11} varies by more than ± 3 °C during the final 3 hours of the test. Please see BESA HIU Standard technical note TN-018 Version 1 for a more detailed definition of cyclical data.

5.8.4 The average heat load on the primary side P_1 is 57 W.

5.8.5 The average primary flow q_1 over the 8 hours test was 6.0 l/hr.

5.8.6 The average electrical consumption was 2.32 W.

5.8.7 The keep-warm control was set to on.

5.8.8 The plot of the key metrics of the duration of Test 4b is displayed in Figure 7.14, Appendix A.

5.9 Test 5a – DHW Response Time at 70 °C

5.9.1 The appliance has passed the requirements of DHW Response Time at 70 °C, Test 5a of the BESA Test Regime as:

5.9.2 The domestic hot water output temperature, t_{32} did not exceed 65 °C for more than 10 seconds.

5.9.3 The DHW response time for t_{32} to reach 45 °C (and not subsequently drop below 42 °C) was 13 seconds; therefore this is a valid keep warm.

5.9.4 The plot of the key metrics of the duration of Test 5a is displayed in Figure 7.15, Appendix A.

5.10 Test 5b – DHW Response Time at 60 °C

5.10.1 The DHW response time for t_{32} to reach 45 °C (and not subsequently drop below 42 °C) was 13 seconds; therefore this is a valid keep warm.

5.10.2 The plot of the key metrics of the duration of Test 5b is displayed in Figure 7.16, Appendix A.

5.11 Overall Scaling Risk Assessment

5.11.1 If any of the below factors occur, then the risk of scaling of the DHW plate in hard water areas increases.

Table 5.2 - Overall Scaling Risk Assessment

HIU has a TMV or TRV on the output of the DHW plate heat exchanger.	No	
Test Designation	**2a**	**3a**
t_{32} above 60°C for more than 5 seconds	Yes	No
t_{12} exceeds 55°C at any point of the test	No	No
Test Designation	**4a**	**4b**
t_{12} exceeds 50°C at any time	No	No

5.12 VWART Calculations

5.12.1 The Volume Weighted Average Return Temperatures (VWART) have been calculated as stipulated in the BESA UK HIU Test Regime document. The calculated VWART values for both the high temperature and low temperature tests described in this report are given below in Table 5.3 and Table 5.4 respectively.

Table 5.3 – High Temperature VWART Calculations

Description	Symbol	Value	Unit
Annual Heating Period Percentage	SH_{PROP}	7.1	%
Annual Non-Heating Period Percentage	NSH_{PROP}	92.9	%
Space Heating Volume Weighted Return Temperature	$VWART_{SH}$	45	°C
DHW Volume Weighted Return Temperature	$VWART_{DHW}$	22	°C
Keep Warm Volume Weighed Return Temperature	$VWART_{KWM}$	38	°C
Annual Volume Weighted Return Temperature for Heating Period	$VWART_{HEAT}$	44	°C
Annual Volume Weighted Return Temperature for Non-Heating	$VWART_{NONHEAT}$	31	°C
Total Annual Volume Weighted Return Temperature	$VWART_{OVERALL}$	32	°C

Table 5.4 – Low Temperature VWART Calculations

Description	Symbol	Value	Unit
Annual Heating Period Percentage	SH_{PROP}	6.9	%
Annual Non-Heating Period Percentage	NSH_{PROP}	93.1	%
Space Heating Volume Weighted Return Temperature	$VWART_{SH}$	36	°C
DHW Volume Weighted Return Temperature	$VWART_{DHW}$	20	°C
Keep Warm Volume Weighed Return Temperature	$VWART_{KWM}$	40	°C
Annual Volume Weighted Return Temperature for Heating Period	$VWART_{HEAT}$	35	°C
Annual Volume Weighted Return Temperature for Non-Heating	$VWART_{NONHEAT}$	32	°C
Total Annual Volume Weighted Return Temperature	$VWART_{OVERALL}$	32	°C

6 CONCLUSIONS

6.1.1 The appliance has passed the performance requirements of the BESA HIU Test Regime.

7 APPENDIX A

7.1 Key Metric Plots

7.1.1 The graphical plots of the key metrics of the tests described in this report are given in this section.

GRAPHICAL PLOTS START ON NEXT PAGE

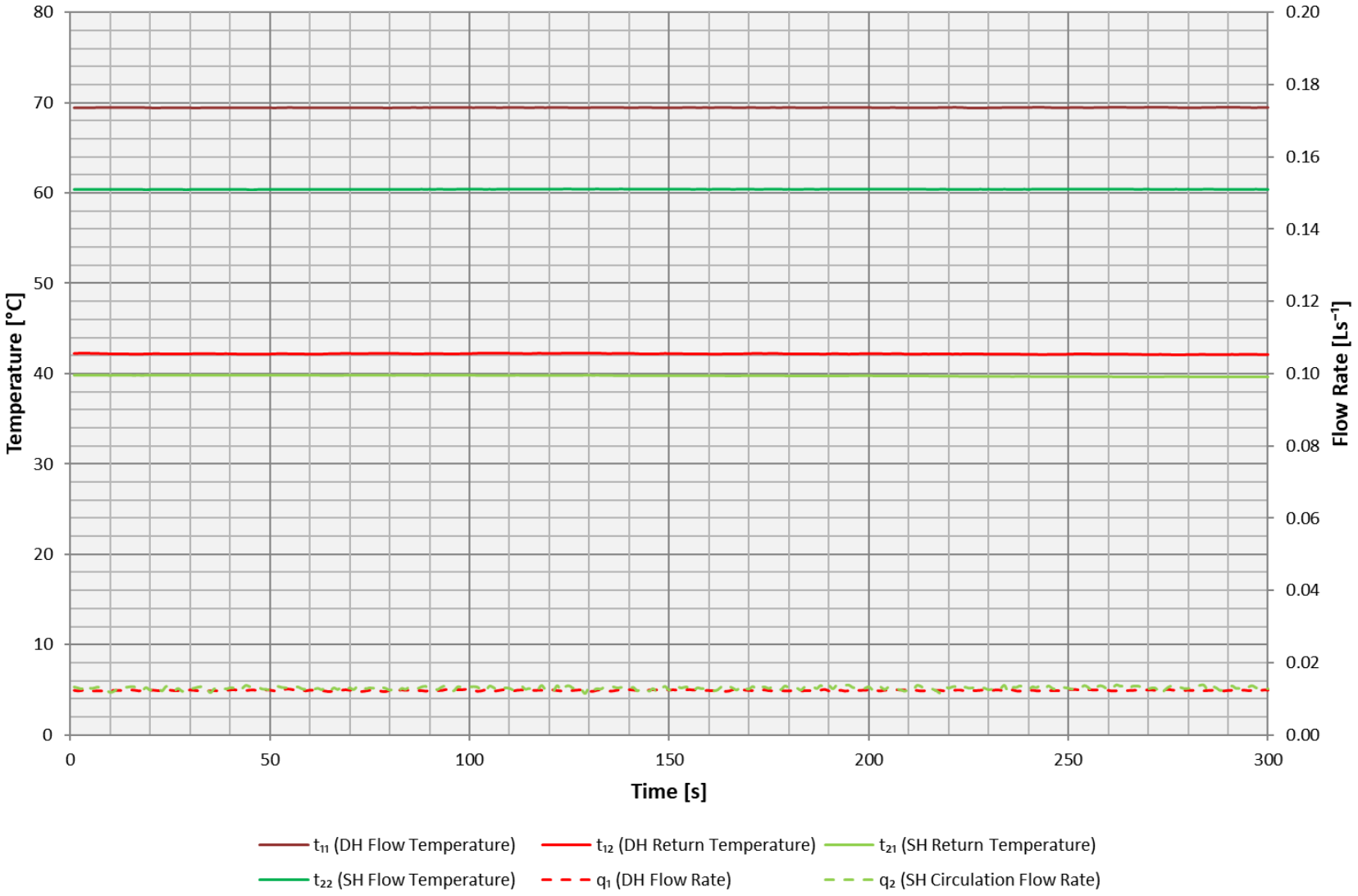

Figure 7.1 - Test 1a – Space Heating 1 kW at 70 °C

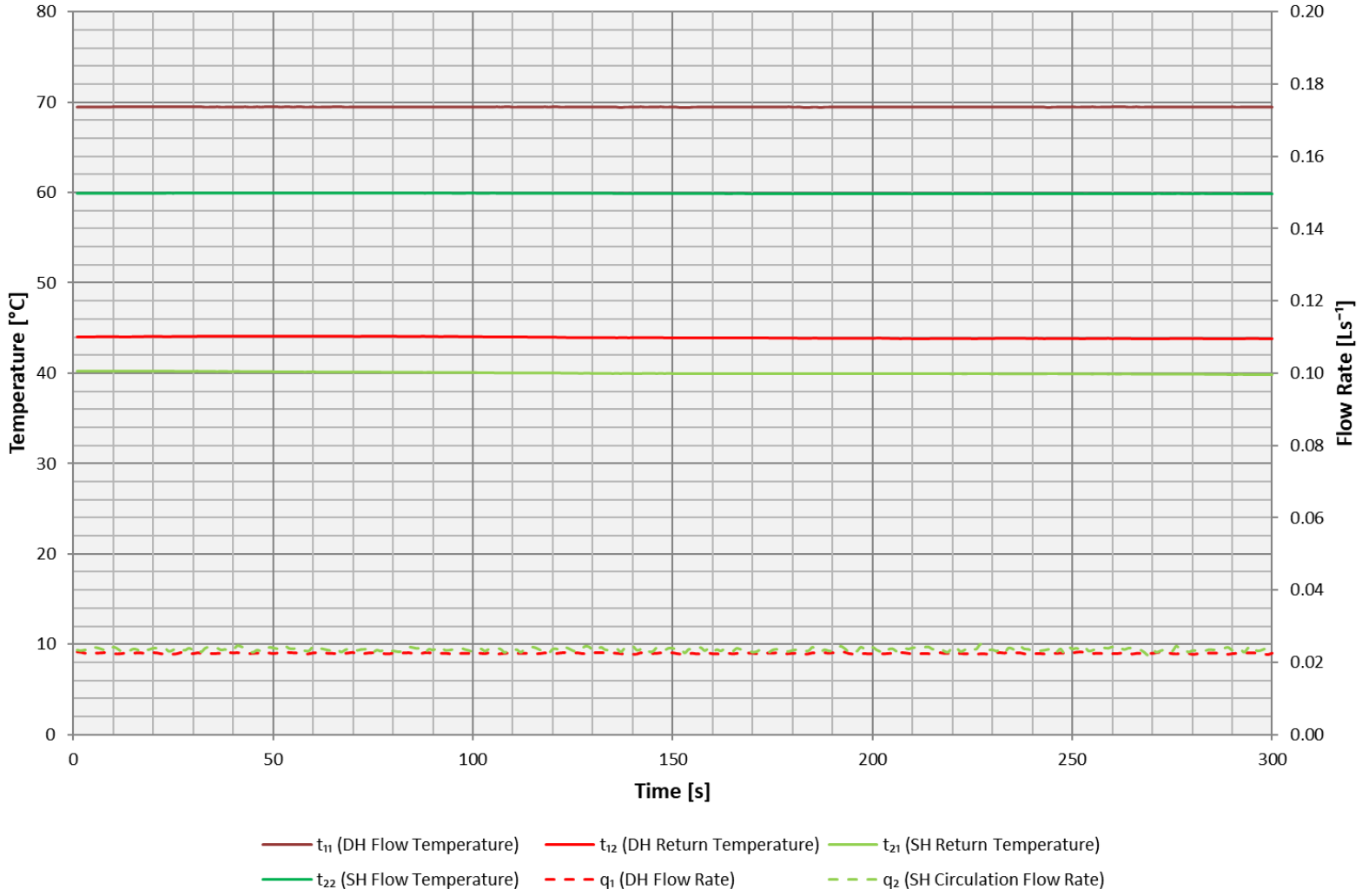

Figure 7.2 - Test 1b – Space Heating 2 kW at 70 °C

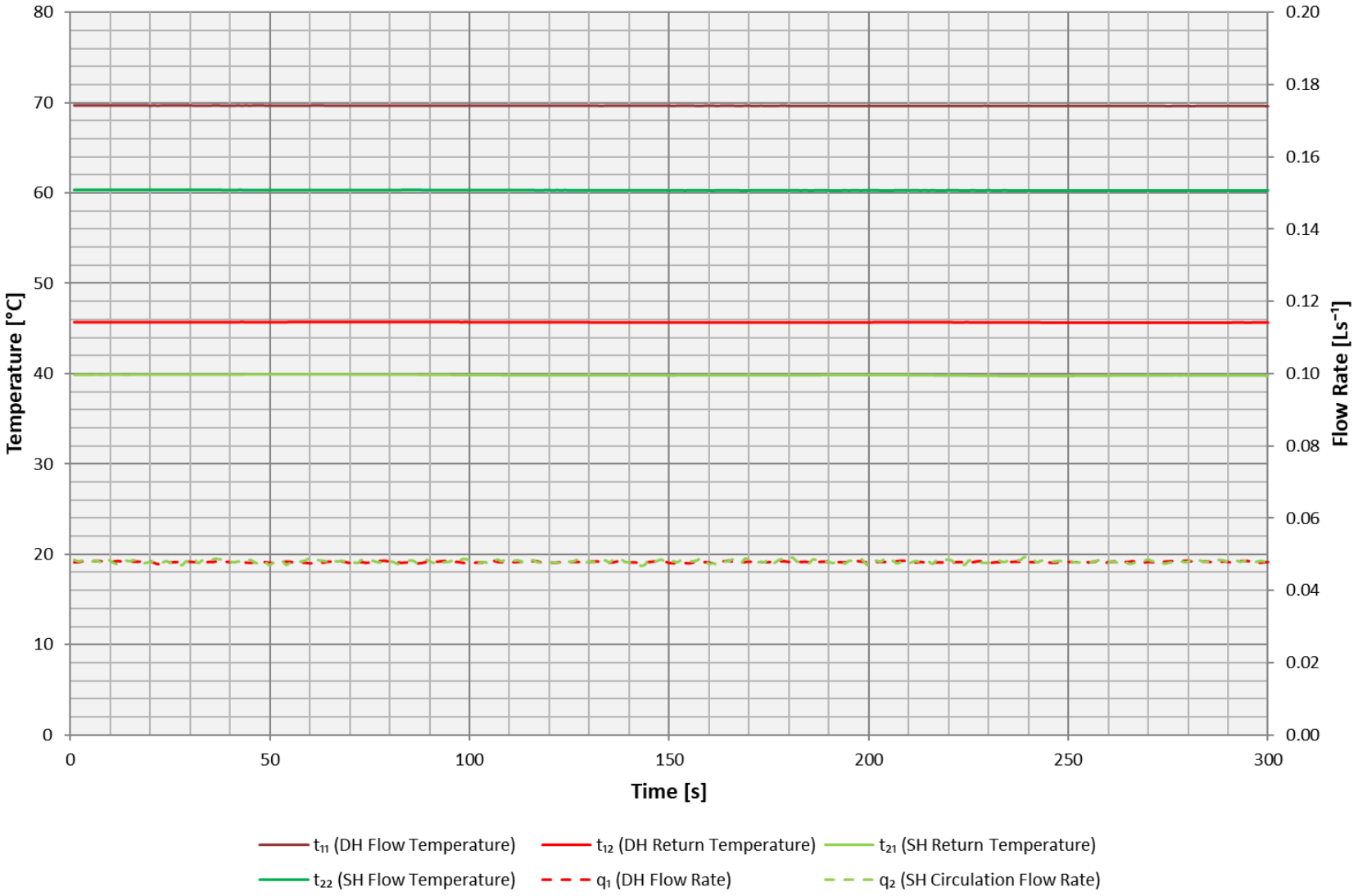

Figure 7.3 - Test 1c – Space Heating 4 kW at 70 °C

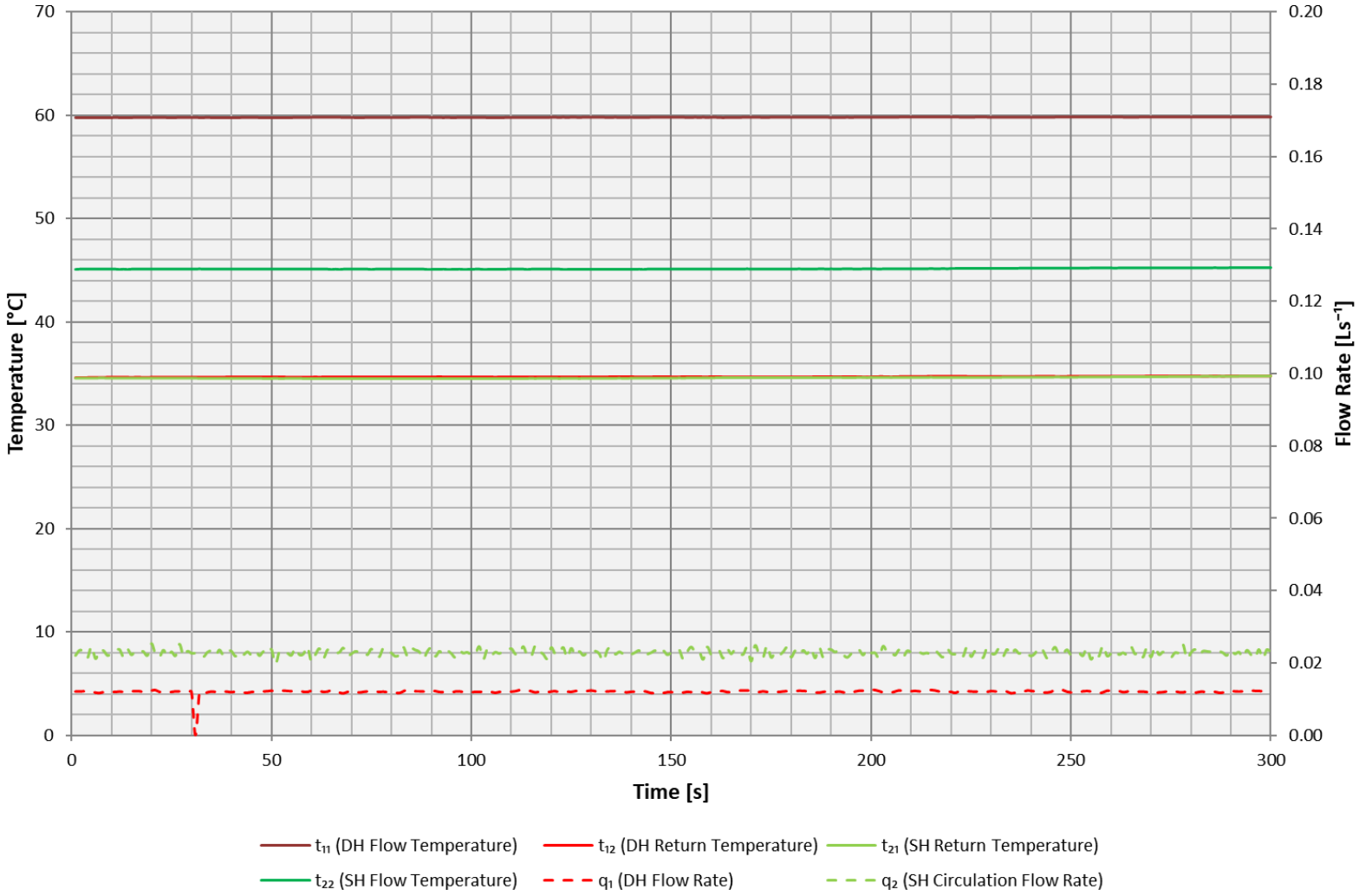

Figure 7.4 - Test 1d – Space Heating 1 kW at 60 °C

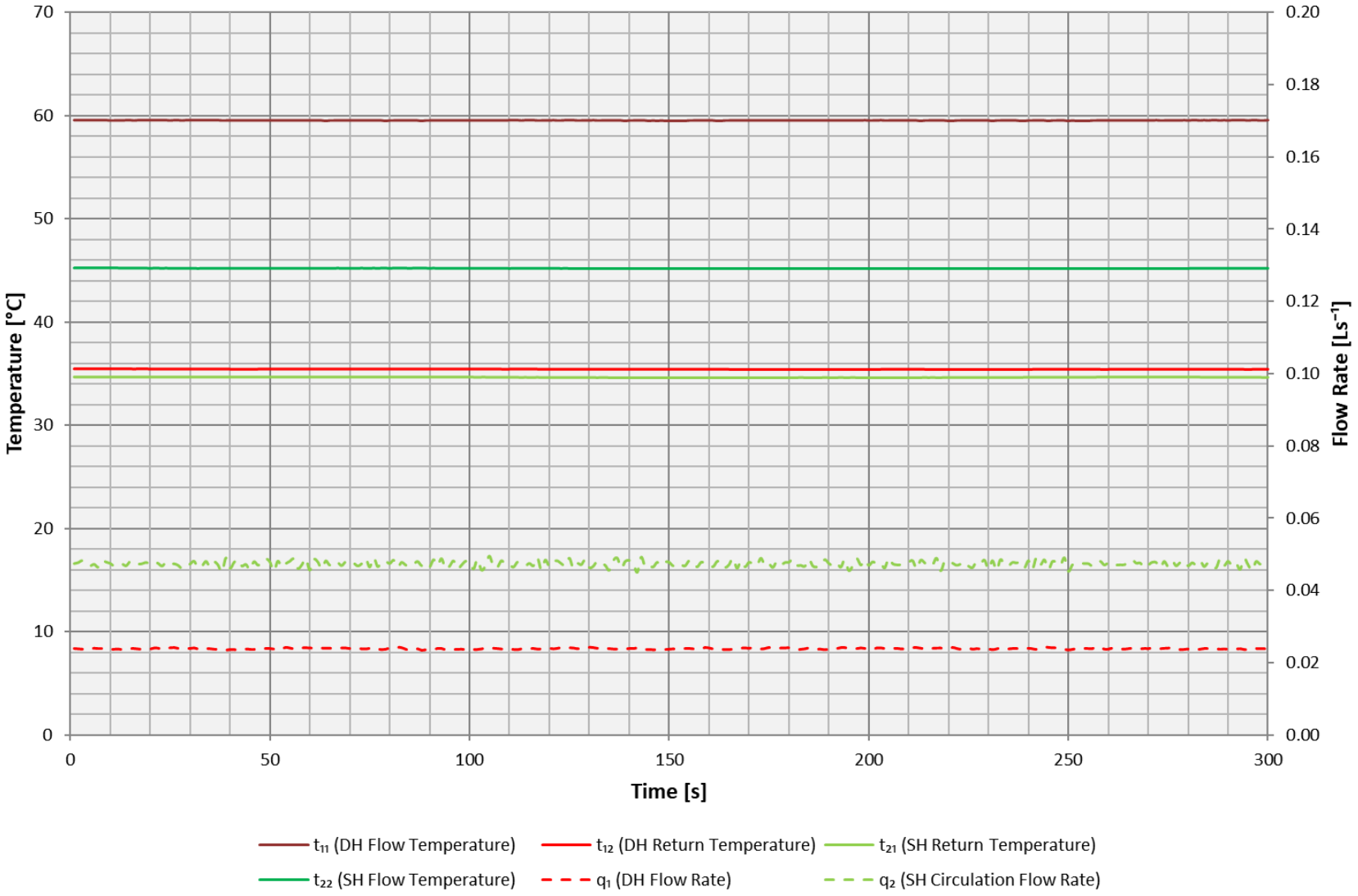

Figure 7.5 - Test 1e – Space Heating 2 kW at 60 °C

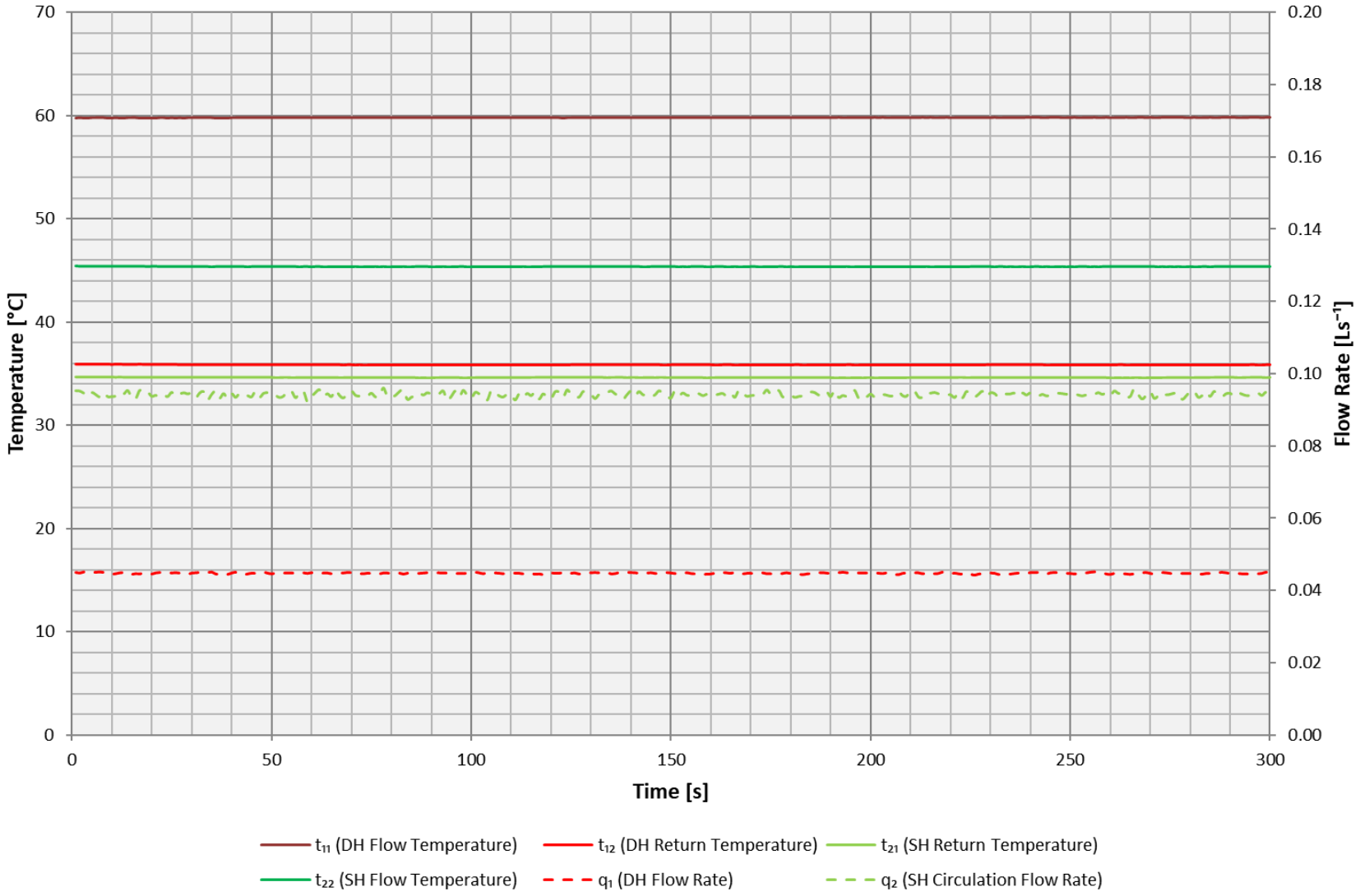

Figure 7.6 - Test 1f – Space Heating 4 kW at 60 °C

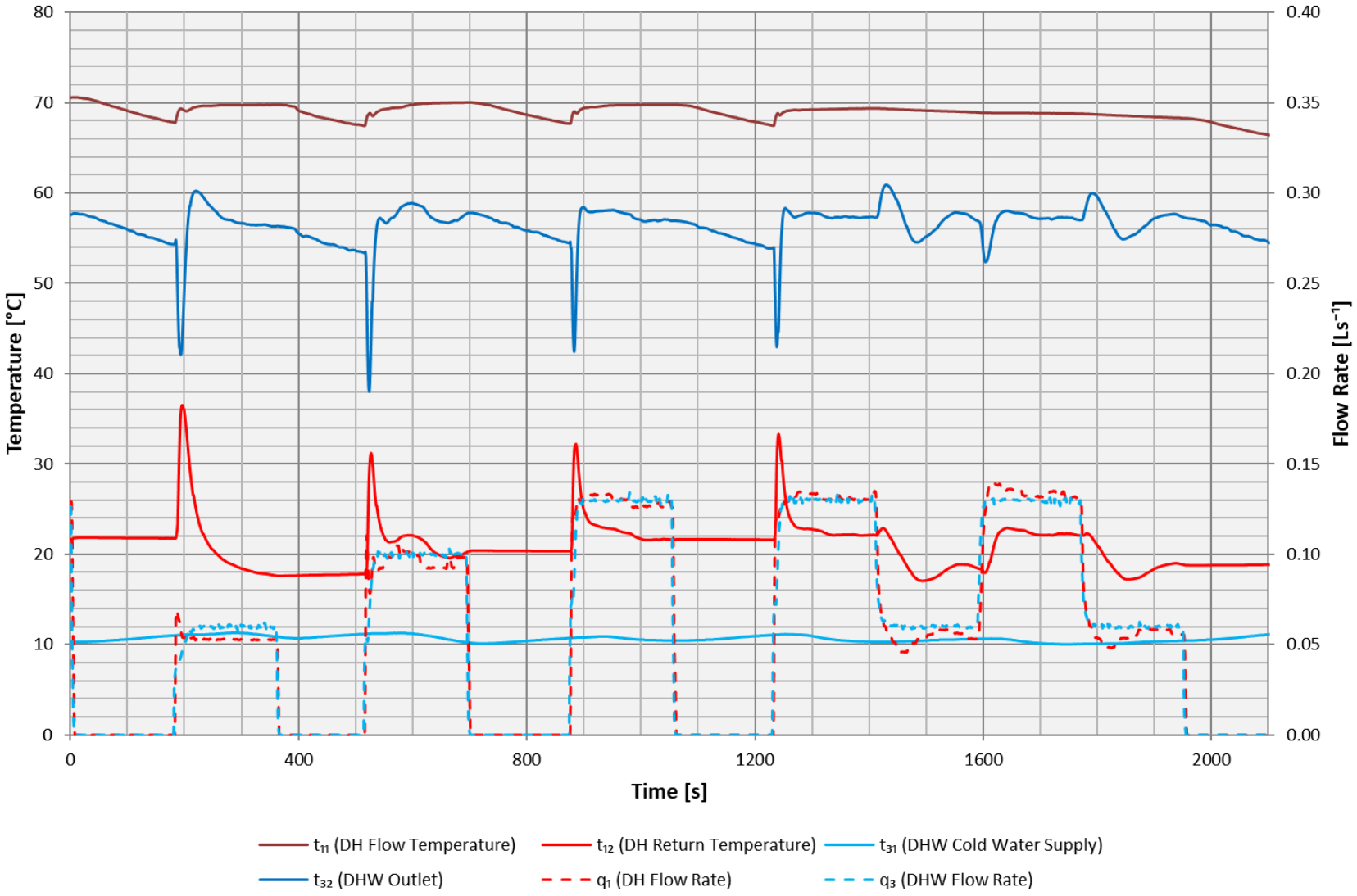

Figure 7.7 - Test 2a – DHW only at 70 °C

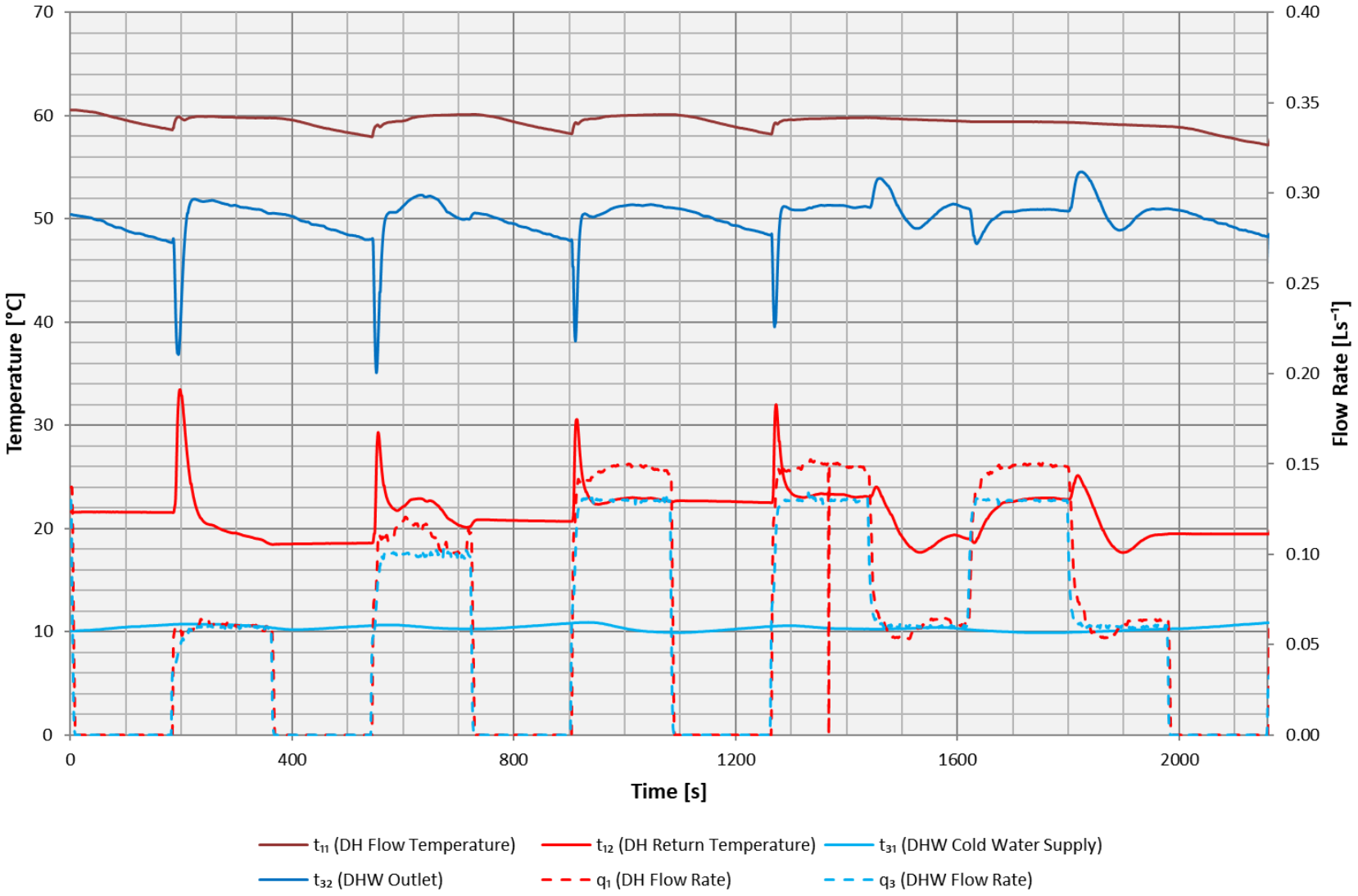

Figure 7.8 - Test 2b – DHW only at 60 °C

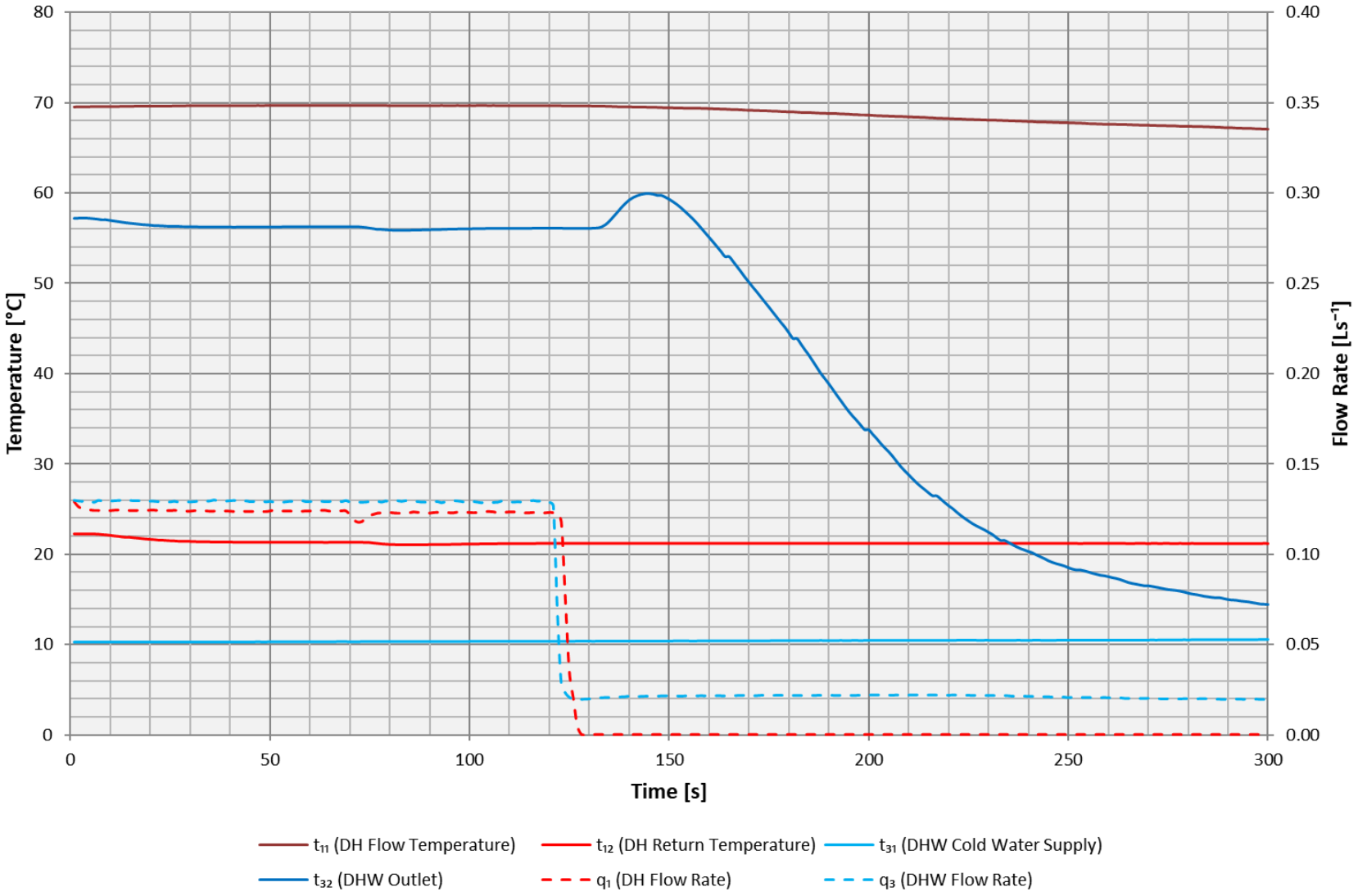

Figure 7.9 - Test 3a – Low Flow DHW at 70 °C

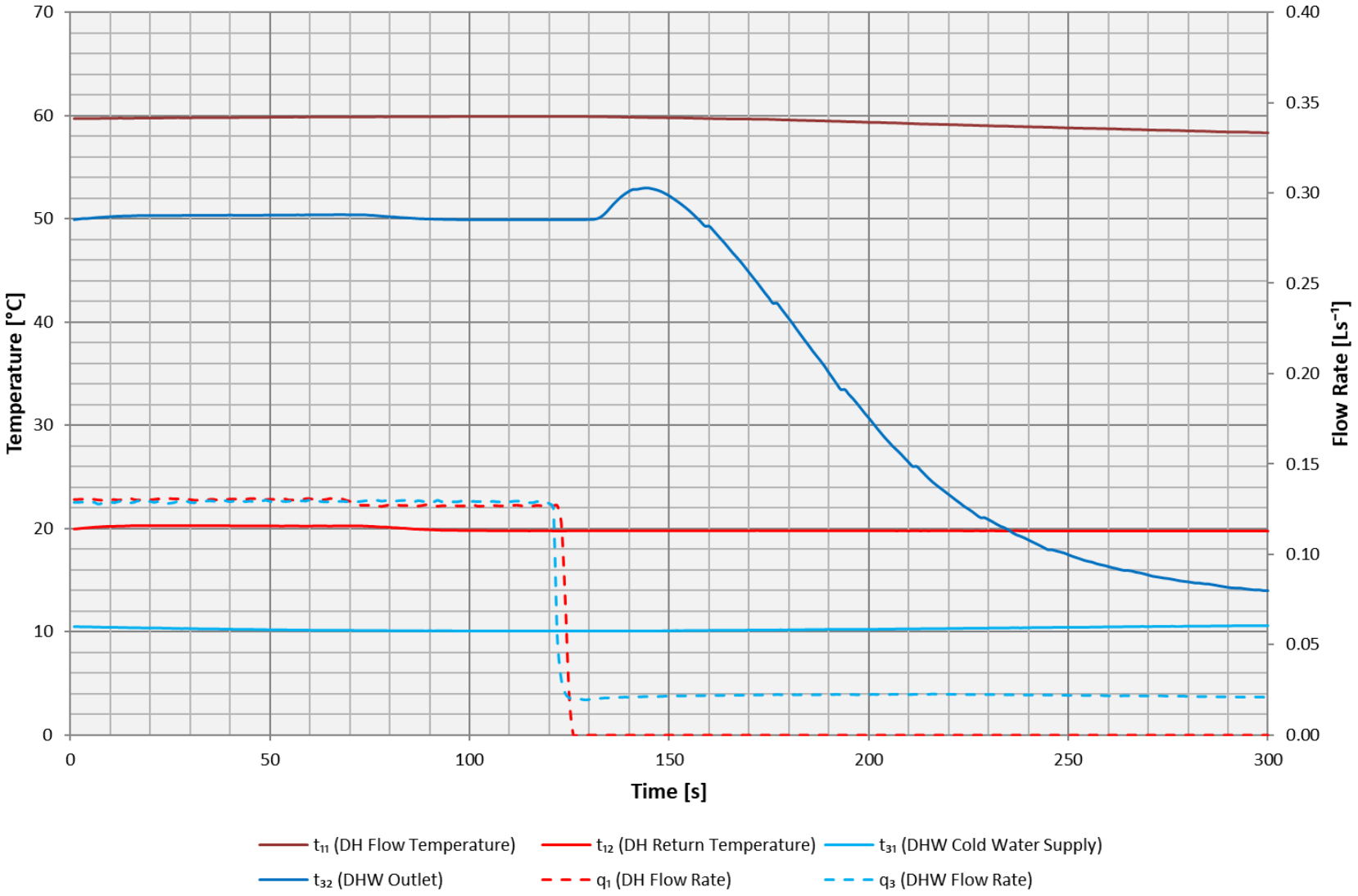

Figure 7.10 - Test 3b – Low Flow DHW at 60 °C

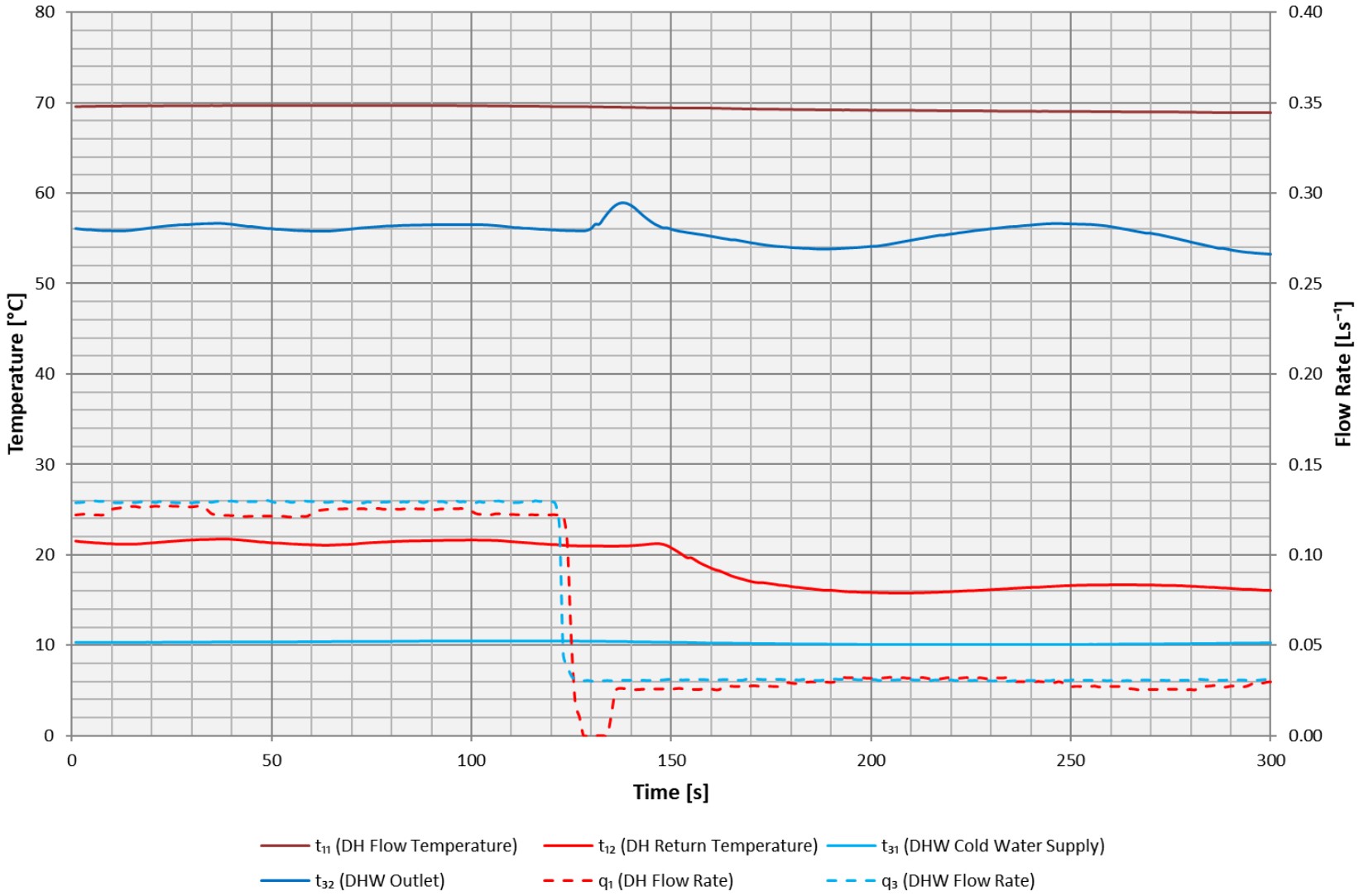

Figure 7.11 - Test 3c – Manufacturers Declared Low Flow DHW at 70 °C

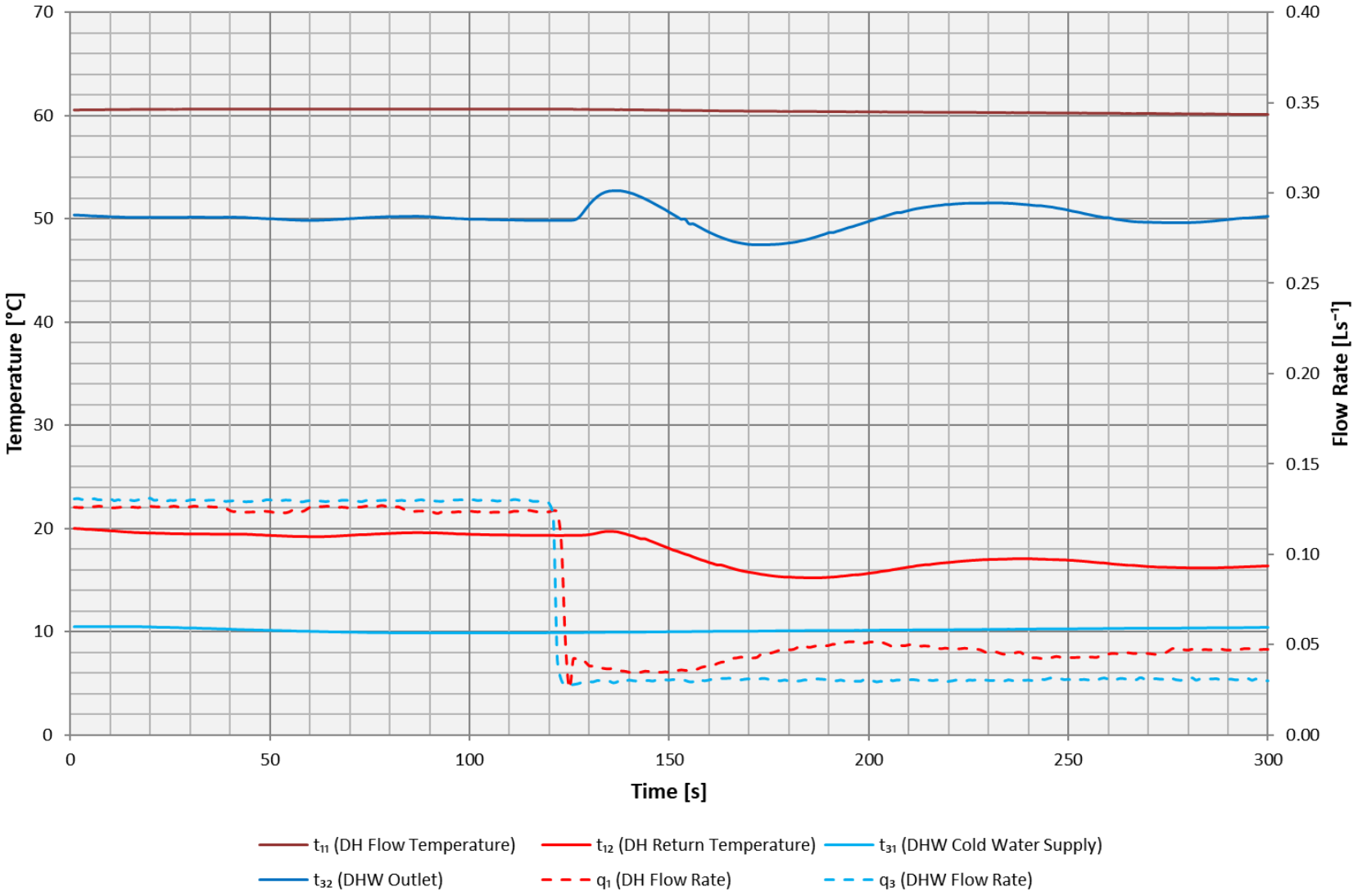

Figure 7.12 - Test 3d – Manufacturers Declared Low Flow DHW at 60 °C

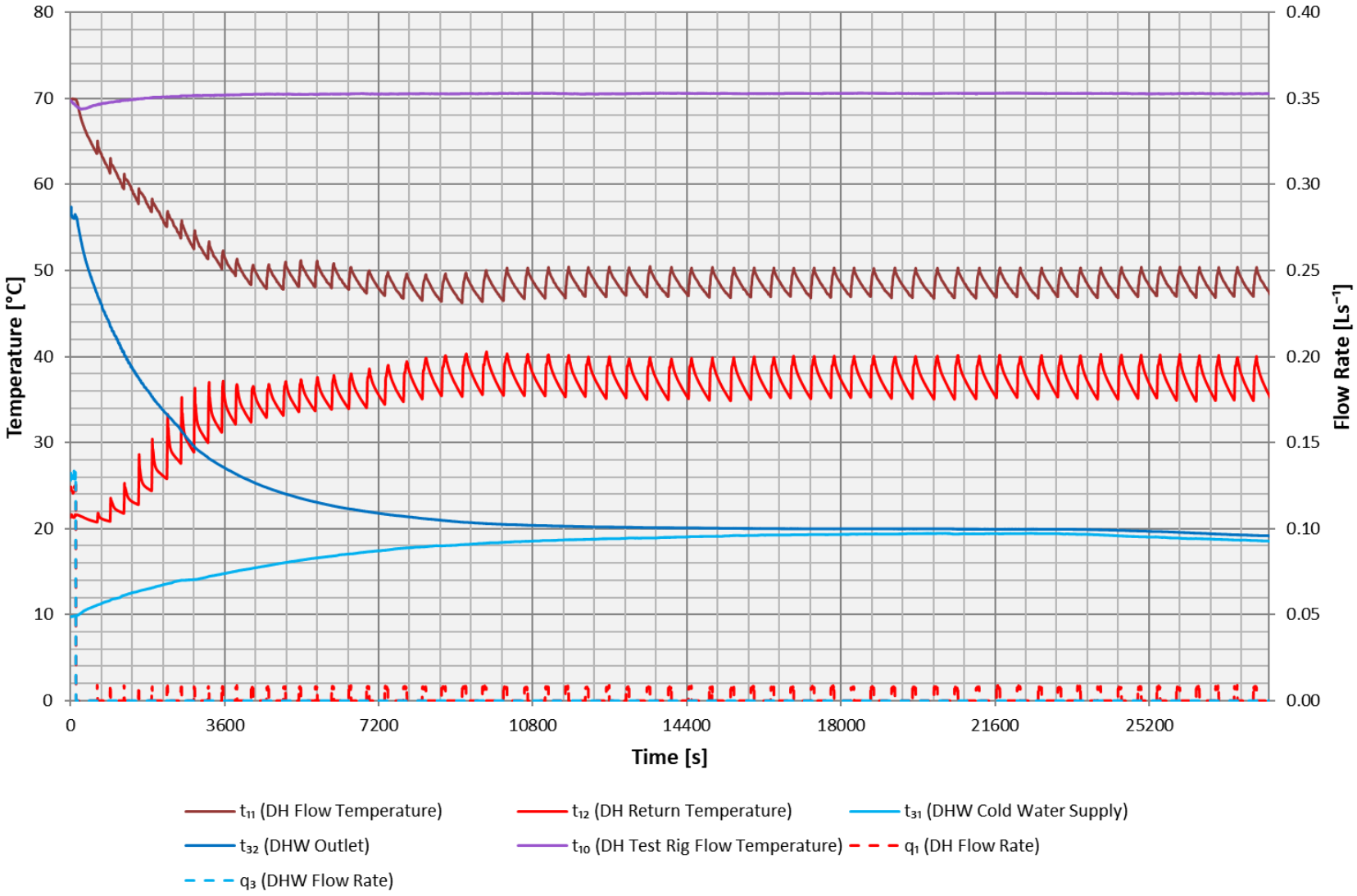

Figure 7.13 - Test 4a – Keep-Warm at 70 °C

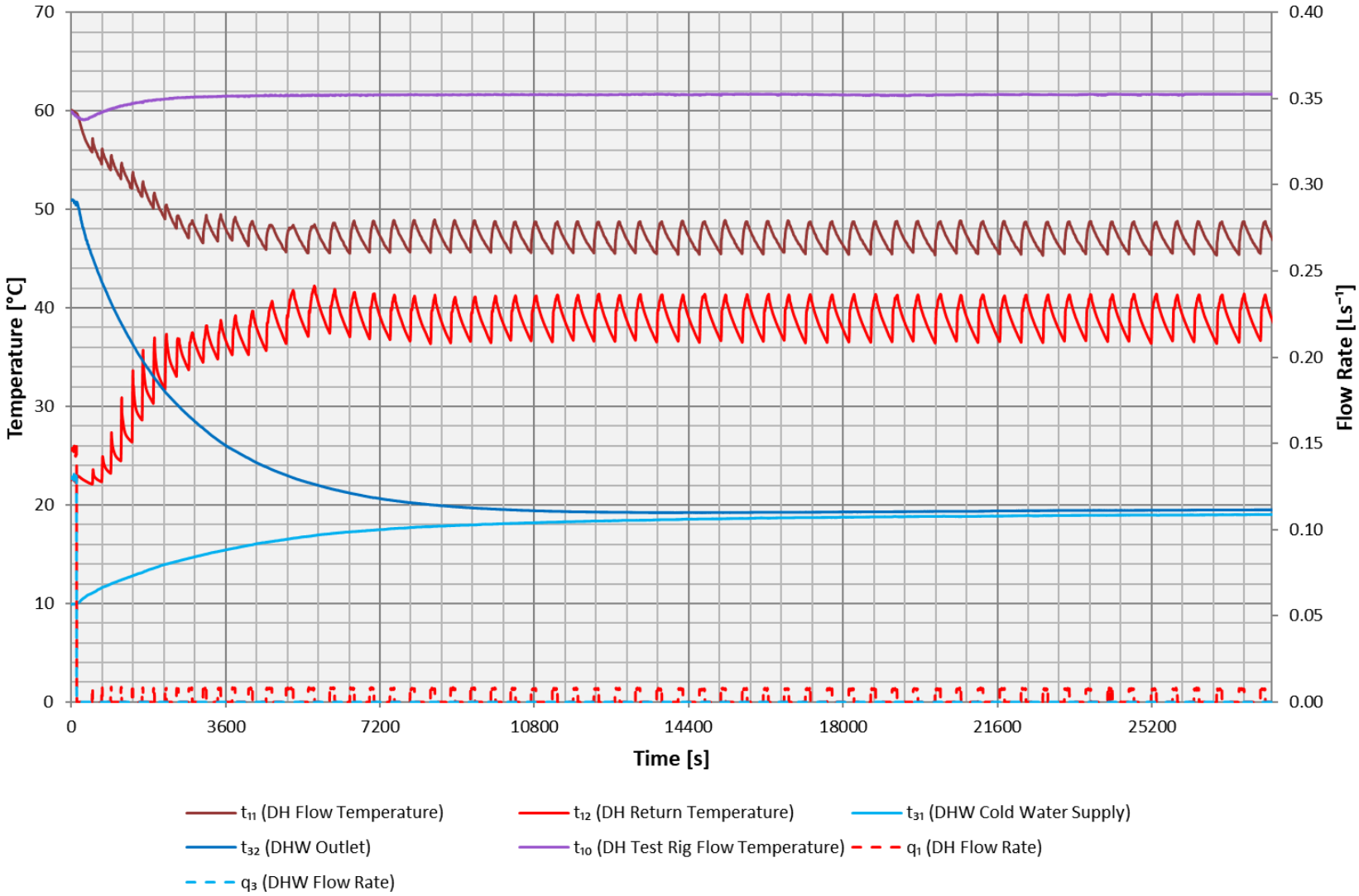

Figure 7.14 - Test 4b – Keep-Warm at 60 °C

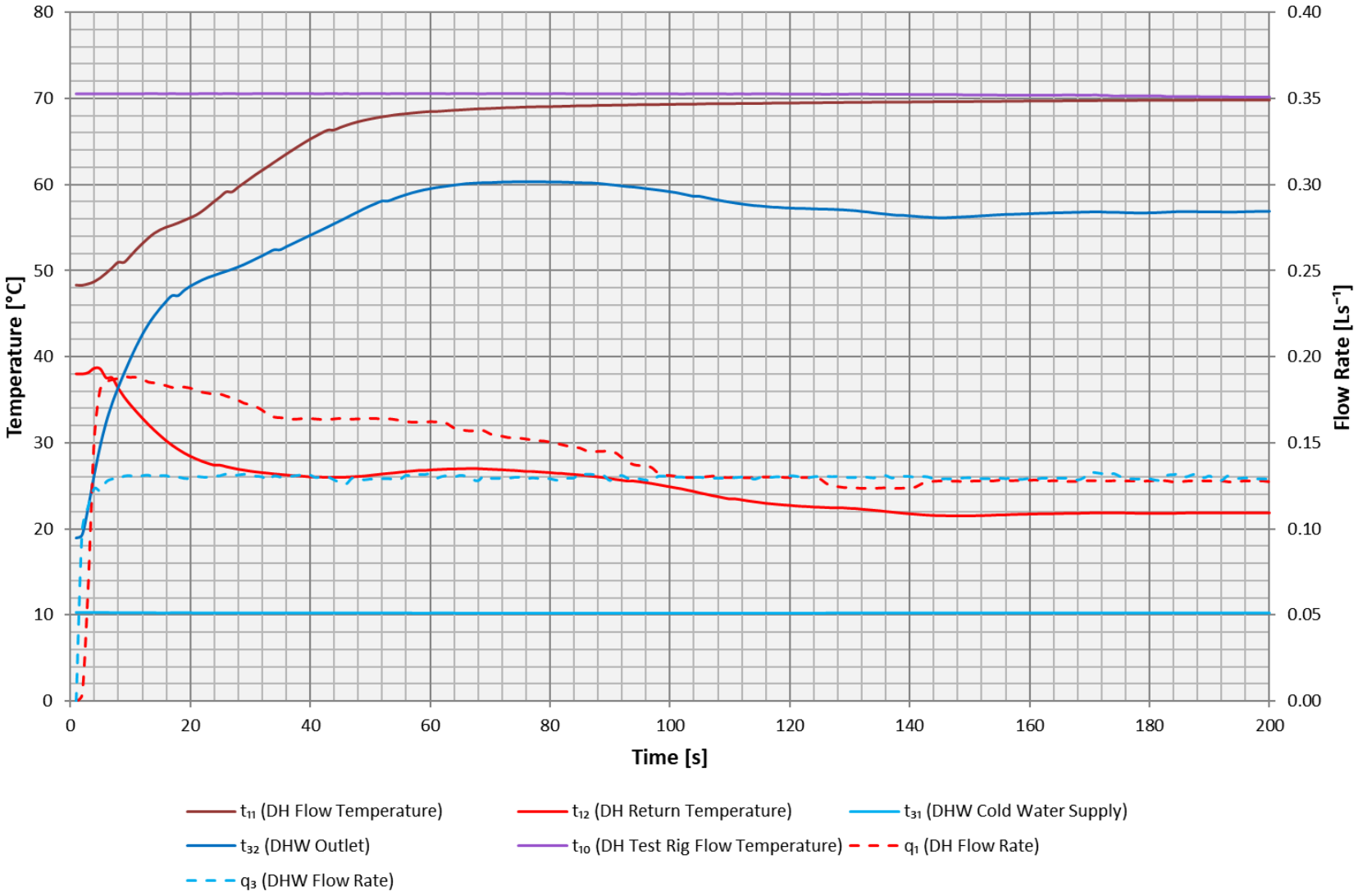

Figure 7.15 - Test 5a – DHW Response Time at 70 °C

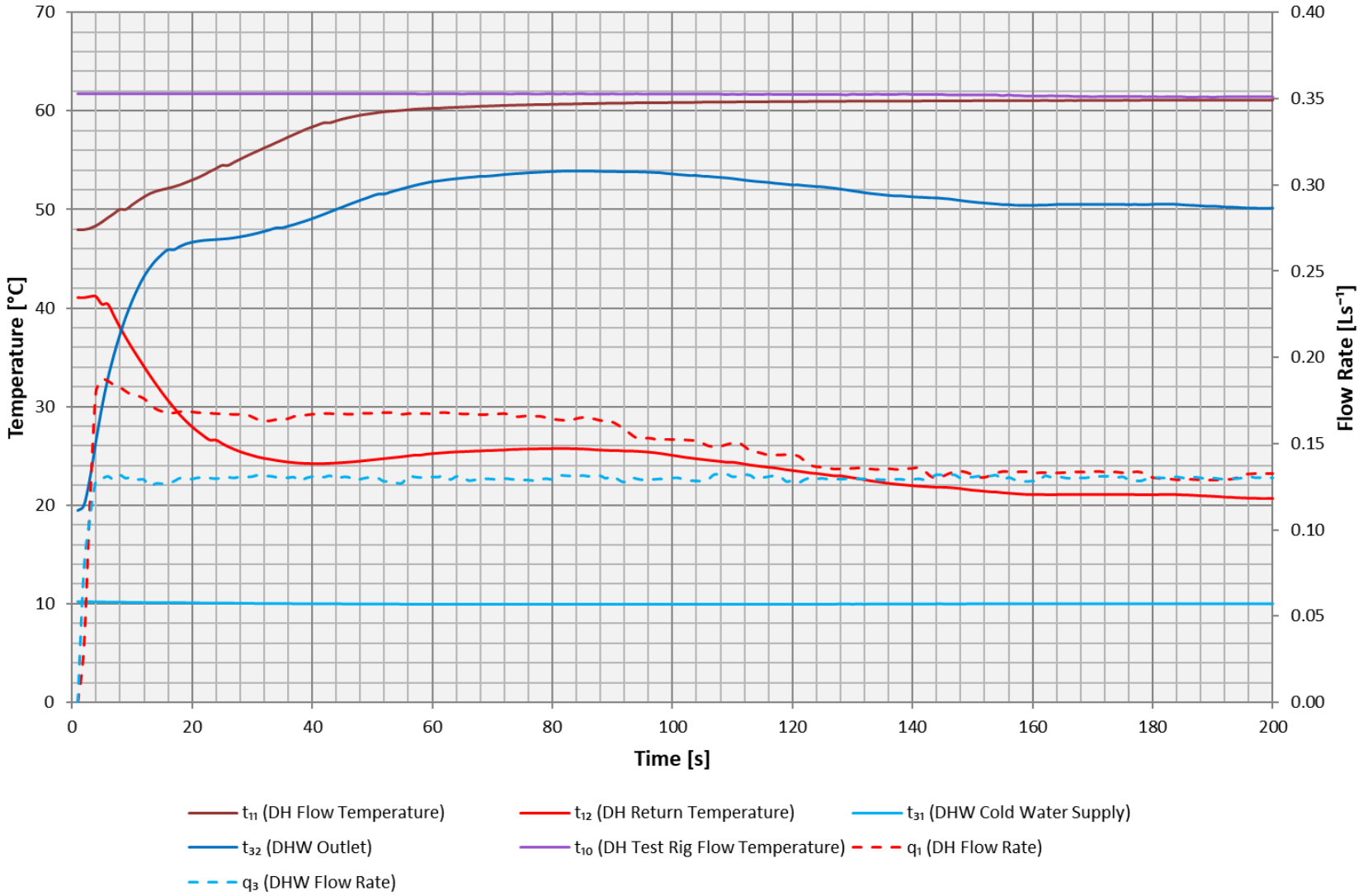

Figure 7.16 - Test 5b – DHW Response Time at 60 °C

7.2 Key Metric and VWART Summary

7.2.1 The summary tables of the key metrics and VWARTs of the tests described in this report are given in this section.

SUMMARY TABLES START ON NEXT PAGE

VWART Calculation with Keep Warm

Test carried out by Enertek International for High Temperature BESA Tests

Manufacturer:	BOSCH	Primary Flow Temperature:	70°C
Model:	Greenstar KE	DHW Setpoint:	55°C
Serial number:	5570-273-000010-7735600662	Space Heating Temperature:	60/40°C
Calculation performed by S.Broxham of Enertek on:	19/12/2021		

	VWART (°C)	Volume (m3)
DHW	22	26.5
Standby	38	31.8
Space Heating	45	60.1

	VWART with keep warm active	
Period	**VWART (°C)**	**% Time**
No Heating	31	93%
Heating	44	7%
Overall	**32**	

		Test Results							
		Power (p1) [W]	Primary flow [m³/hr]	VWART [°C]	Energy Used [kWh]	Annual Operation [Hours]	Volume [m³]	Events [Per Year]	Average duration [Seconds]
1kW Space Heating	1a	1290	0.044	42	112	87.2	3.85	-	-
2kW Space Heating	1b	2277	0.081	44	913	401.0	32.62	-	-
4kW Space Heating	1c	4604	0.172	46	632	137.2	23.64	-	-
DHW Low Flow Rate	2a	10942	0.190	22	696	66.6	12.69	-	-
DHW Medium Flow Rate	2a	18463	0.342	22	301	16.1	5.49	-	-
DHW High Flow Rate	2a	24472	0.456	23	440	18.1	8.28	-	-
DHW Post Low Flow Rate	2a	-	0.000	18	-	-	0.00	10000	30
DHW Post Medium Flow Rate	2a	-	0.000	0	-	-	0.00	660	70
DHW Post High Flow Rate	2a	-	0.000	22	-	-	0.00	300	145
DHW Keep Warm Standby	4a	-	0.004	38	396	8033.7	31.77	-	-

Table 7.1 - Key Metrics of High Temperature Package

VWART Calculation with Keep Warm

Test carried out by Enertek International for Low Temperature BESA Tests

Manufacturer: Bosch

Model: Greenstar KE

Serial number: 5570-273-000010-7735600662

Calculation performed by S.Broxham of Enertek on: 19/12/2021

Primary Flow Temperature: 60°C

DHW Setpoint: 50°C

Space Heating Temperature: 45/35°C

	VWART (°C)	Volume (m3)
DHW	20	30.8
Standby	40	48.6
Space Heating	36	57.4

	VWART with keep warm active	
Period	**VWART (°C)**	**% Time**
No Heating	32	93%
Heating	35	7%
Overall	**32**	

		Test Results							
		Power (p1) [W]	Primary flow [m³/hr]	VWART [°C]	Energy Used [kWh]	Annual Operation [Hours]	Volume [m³]	Events [Per Year]	Average duration [Seconds]
1kW Space Heating	1d	1224	0.044	35	119	96.9	4.24	-	-
2kW Space Heating	1e	2411	0.086	35	906	375.6	32.23	-	-
4kW Space Heating	1f	4483	0.161	36	584	130.2	20.97	-	-
DHW Low Flow Rate	2b	9649	0.193	19	695	75.6	14.60	-	-
DHW Medium Flow Rate	2b	16186	0.352	20	298	18.3	6.47	-	-
DHW High Flow Rate	2b	20970	0.459	21	442	21.2	9.71	-	-
DHW Post Low Flow Rate	2b	-	0.000	0	-	-	0.00	10000	30
DHW Post Medium Flow Rate	2b	-	0.000	0	-	-	0.00	660	70
DHW Post High Flow Rate	2b	-	0.000	0	-	-	0.00	300	145
DHW Keep Warm Standby	4b	-	0.006	40	460	8042.3	48.62	-	-

Table 7.2 - Key Metrics of Low Temperature Package

8 APPENDIX B

8.1 Appliance Documentation

8.1.1 The details of the appliance documentation are given in Table 8.1 below.

Table 8.1 – Documentation Supplied

	Component:	Document Submitted (Y/N):	Manufacturer and Type:
1	Space Heating Heat Exchanger	Y	SWEP,Copper brazed
2	Domestic Hot Water Heat Exchanger	Y	SWEP,Copper brazed
3	Controller for Space Heating	Y	Braga, Control board
4	Control Valve and Actuator for Space Heating	Y	ESBE Actuator
5	Space Heating Strainer	Y	N/A
6	Controller for Domestic Hot Water	Y	Braga, Control board
7	Control Valve and Actuator for Domestic Hot Water	Y	ESBE Actuator
8	Temperature Sensors	Y	Exa-thermametrics
9	Domestic Hot Water Isolating Valve	Y	Altecnic
10	Primary Side Strainer	Y	Italfim SPA
11	Drain Valves	Y	Orkli
12	Vent Valves	Y	Novasfer
13	Circulation Pump set with AAV & PRV	Y	Grundfos
14	Heat Meter	Y	Sontex 749 Mbus
15	Domestic Hot Water Flow Sensor	Y	Saginomiya
16	Pipes	Y	Bosch, Stainless steel
17	Connections	Y	Altecnic
18	Joints	Y	Altecnic
19	Gaskets	Y	Altecnic
20	Expansion Vessel	Y	Zilmet
21	Insulation	Y	Synprodo
22	Pressure Sensors	Y	Wika pressure gauge
A1	'O' Ring	Y	Altecnic
A2	Commissioning Guide	Y	Installation manual
A3	Operation Guides with a Function Description / Description of Operation and Care Instructions as Suited to the Intended User Category.	Y	Owner's manual
A4	Declaration of Conformity for CE-Marked HIUs.	Y	
A5	Full Parameter List for Electrically Controlled HIUs.	Y	Installation manual
A6	Maximum Primary Static Operating Differential Pressure.	Y	Installation manual
A7	Deactivation Procedure of the Internal SH Pump.	Y	Installation manual
	Model Name and Type Number	Y	Greenstar HIU KE with heat meter.
	Software Version / Date of Issue	Y	NF51.05; Power 230V / 50Hz - January 2022
	Serial Number	Y	5570-273-000010-7735600662

8.2 Appliance Photographs

Figure 8.1 – Photograph of Appliance [Case Fitted]

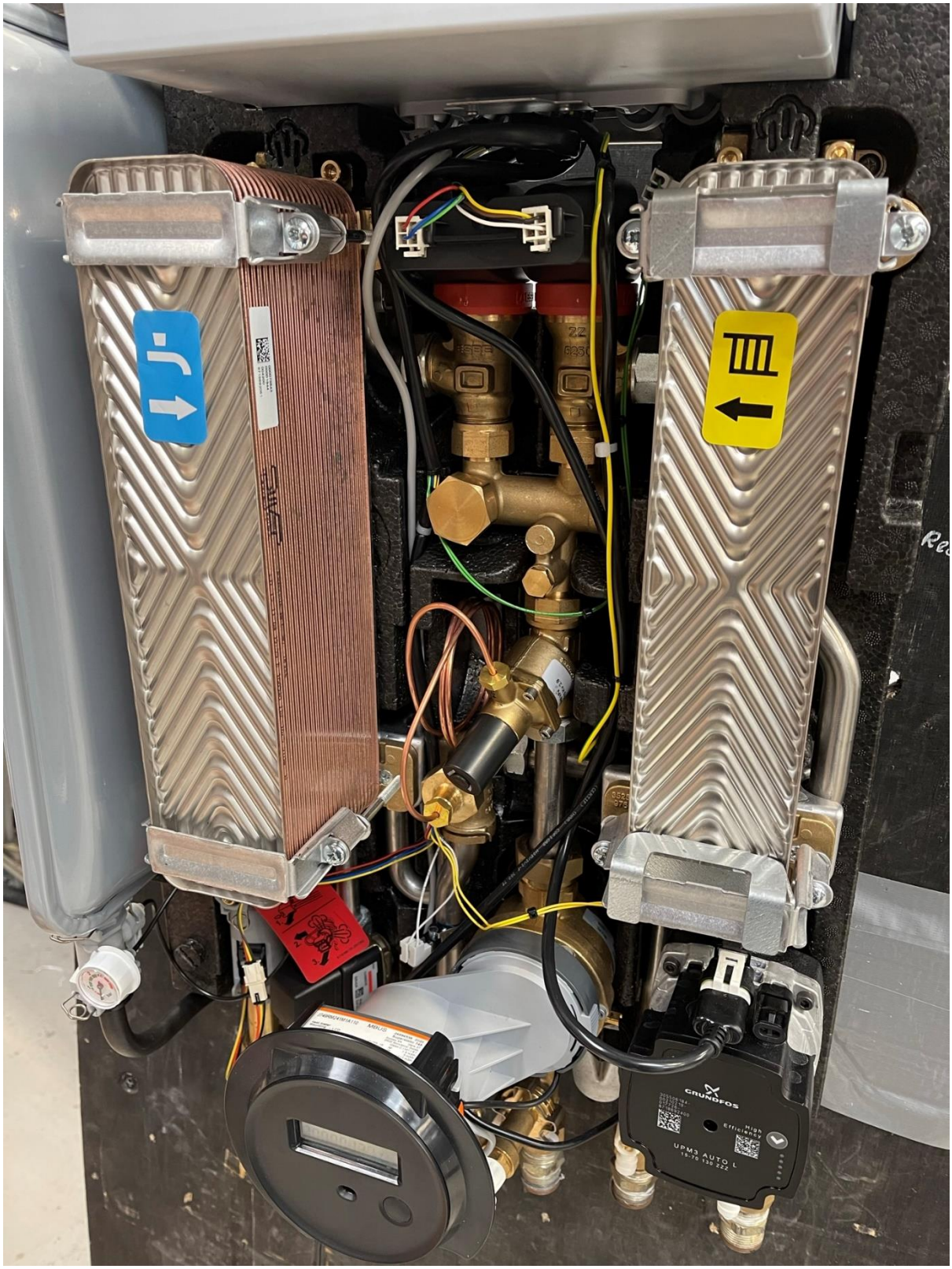

Figure 8.2 – Photograph of Appliance [Case Removed]

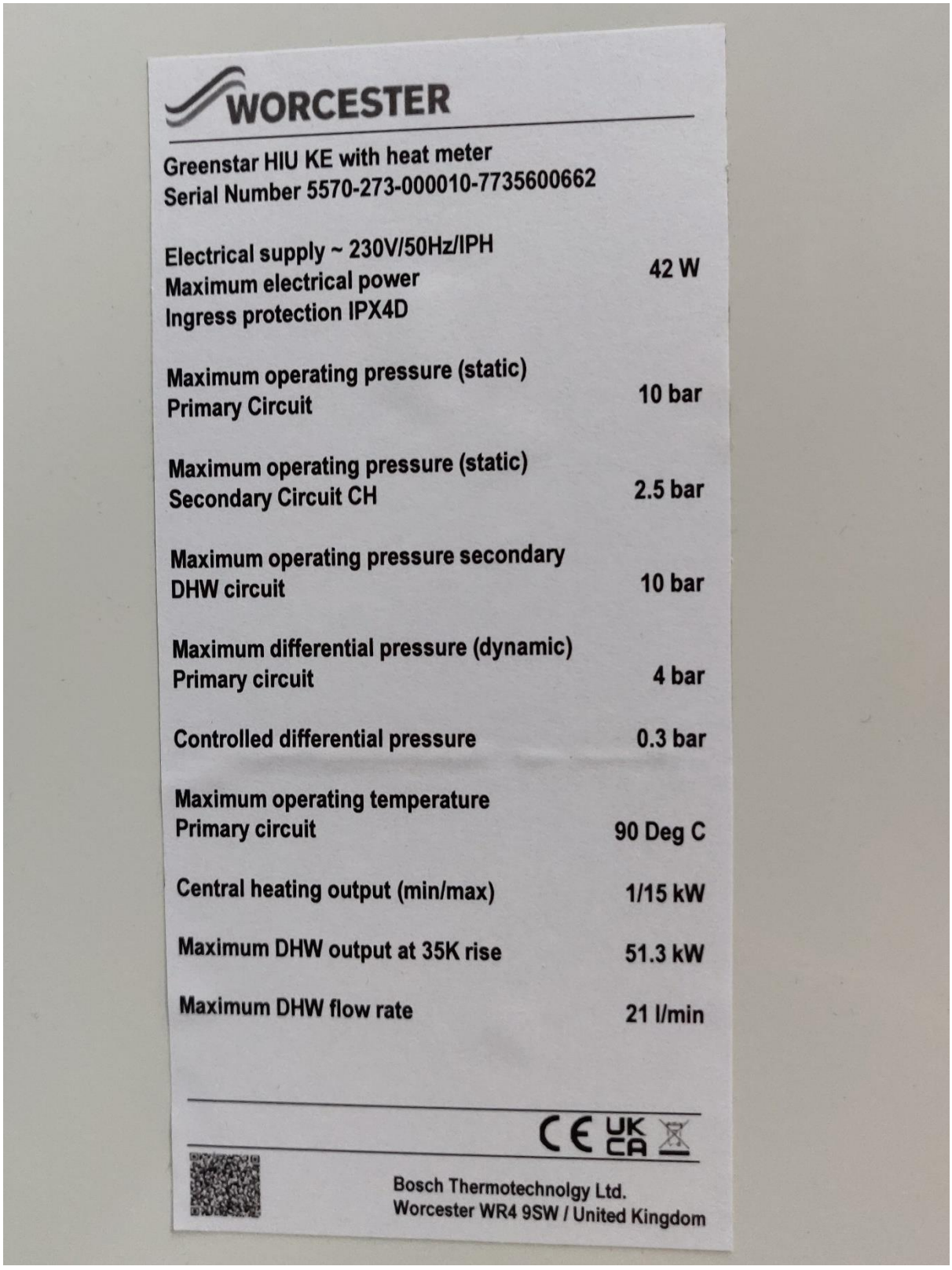

Figure 8.3 – Appliance Data Label

8.3 Calibrations and Uncertainties

8.3.1 A list of equipment, their calibrations and uncertainties are given in table 8.8 below.

Table 8.2 - EIL Equipment Calibration and Uncertainties

Equipment Name	ID Number	Calibration Certificate	Measurement Uncertainty K=2 $\frac{U}{\sqrt{20}}$	Units	Calibration Date	Calibration Due
Flow Meter [Primary Flow Rate]	FM 601	K48376FW1S2	±0.0004	l/s	07/07/2021	07/2022
Flow Meter [DHW Flow Rate]	FM 602	K48378FW	±0.00305	l/s	07/07/2021	07/2022
Flow Meter [SH Flow Rate]	FM 603	K48377FW	±0.04871	l/s	06/07/2021	07/2022
Flow Meter [DHW Flow Rate]	FM 605	K48375FW	±0.00576	l/s	05/07/2021	07/2022
Pressure Transducer [Primary Supply]	PT 086	K48379P	±6.91	kPa	05/07/2021	07/2022
Pressure Transducer [Primary Return]	PT 085	K48384P	±8.54	kPa	05/07/2021	07/2022
Pressure Transducer [DHW Output Pressure]	PT 083	K48380P	±21.27	kPa	05/07/2021	07/2022
Pressure Transducer [DHW Cold Water Supply]	PT 084	K48383P2	±9.21	kPa	20/07/2021	07/2022
Pressure Transducer [SH Flow]	PT 087	K48382P	±7.10	kPa	05/07/2021	07/2022
Pressure Transducer [SH Return]	PT 088	K48381P	±15.24	kPa	05/07/2021	07/2022
PRT Probe [Primary Supply Temp]	PRT 4709	443851	±0.6	°C	10/07/2021	07/2022
PRT Probe [Primary Return Temp]	PRT 4708	443851	±0.6	°C	10/07/2021	07/2022
PRT Probe [DHW Output Temp]	PRT 4711	443852	±0.6	°C	10/07/2021	07/2022
PRT Probe [Cold Water Supply Temp]	PRT 4710	443852	±1.91	°C	10/07/2021	07/2022
PRT Probe [SH Supply Temp]	PRT 4707	443851	±0.57	°C	10/07/2021	07/2022
PRT Probe [SH Return Temp]	PRT 4706	443851	±1.06	°C	10/07/2021	07/2022

Equipment Name	ID Number	Calibration Certificate	Measurement Uncertainty K=2 $\frac{U}{\sqrt{20}}$	Units	Calibration Date	Calibration Due
Pressure Transducer [Static Pressure Test]	PT 090	U100553-19	±50	kPa	21/11/2019	10/2022
Power Meter [Electrical Consumption]	PM1022	U103585-20	±1.03	W	28/07/2021	08/2022
Software	VERSION – LabVIEW, Version 5, Service pack 1					

Report Issue No	Reason for Report Update
1	Original Issue 31/01/2022
2	Photo of internal HIU updated. 02/03/2022

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