Rhico
District Heating Products

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: TI45 UL (Ultra Lean Electronic HIU)

Serial Number: 428440300/Matr.: A202800460/1

Year of manufacture: 2020

Test carried out by BSRIA Ltd On: 2/7/22 Reference: 102787/1

	HIGH TEMP	LOW TEMP
NOTE: The VWART accuracy is in the range +/-2°C	VWART ^{0}C	VWART ^{0}C
DHW	15	16
Keep-warm	40	41
Space heating	44	37
Overall with keep warm	31	32

Pressure test		
No HIU damage	Pass	Pass

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

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

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

Keep-warm test	4a	4b
Standby heat consumption - average (Watts)	36	34
Standby electricity consumption - average (Watts)	1.9	1.9
Total HIU heat loss (DH + electrical input) (Watts)	37.9	35.9
Standby flow rate (the average flow rate) (l/hr)	4.3	6.1

DHW Response time test	5a	5b
DHW response time (Seconds)	11	14
Peak electrical heat during test (Watts)	7.4	10.4
Output		
DHW temperature not exceed 65°C for more than 10 secs	Pass	n/a
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	No	No	n/a
t12 exceeds 55°C at any point of the test	No	No	n/a
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.

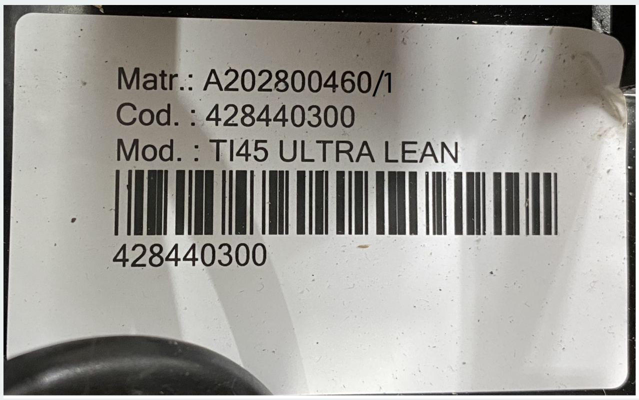

Photo of Manufacturers label and serial number.

COMPONENT DATA AND DOCUMENTATION

Component and Part No.	Manufacturer and Type	Documents submitted
Space heating heat exchanger	SWEP E8AS W-Nx10	Yes
DHW heat exchanger	ZILMET ZA315, 4 40 Plates	Yes
DHW flow meter Honeywell	C7195 -0,7-30 l/m	Yes
Check Valve on DCW inlet	Lovato code 20313113	n/a
Check Valve on filling circuit	Kramer	n/a
Temperature sensors	Brahama G 1/8"-ST06	n/a
Primary side strainer M-M ¾”	VALBRASS	n/a
Controller for DHW and Space Heating	Brahama 1961 SAT	Yes
Control valve & actuator for space heating and DHW	Jonson control M30X1,5 VA 7481-0003	Yes
Heat Meter Ista	Ultego III smart	Yes
Differential pressure control valve	Frese Optima compact DN15	No
Circulation pump	WILO pump block PARA 15/7	No
Safety valve Female 3/4”3 bar	PINTOSSI +C SPA	n/a
Air vent valve Manual 3/8”	MARVIT SPA	n/a
Digital pressure transducer	ELTEK 10.80.40.00.07	n/a
Expansion Vessel	Zilio Industries VRP204-7	n/a
Isolation valves	Arpro EPP 60 g/L	n/a
Pipes	Silmet / Feinrohren	n/a
O-rings	Teknofluor – EPDM 70	n/a
Joints and connections gasket Flat seat and nuts	-AFM34	n/a
		n/a
		n/a
		n/a
		n/a
		n/a
		n/a
		n/a

Schematic diagram and drawing showing the structure and arrangement of the HIU with dimensions and weight		Yes
Technical specification for electronic components including version of software		Yes
Installation guide		Yes
Commissioning guide		Yes
Operation guide with a function description/ description of operations and care instructions as suited to the intended user category		Yes
Declaration of Conformity for CE-marked HIUs	See Appendix C	Yes
Full parameter list for electronically controlled HIUs		Yes

HIU Marking	Comment	Info present
Model name and type no.	TI45 UL (Ultra Lean Electronic HIU)	Yes
Serial no.	428440300/Matr: A202800460/1	Yes

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

HIU Model	TI45 UL (Ultra Lean Electronic HIU)
Part No.	428440300
Software version	1961SAT.LO1.00 – C00430823_01
Test Date:	07/02/22
Test No.	102787/1

DIMENSIONAL INFORMATION	
Dimensions with casing (HxDxW) (mm)	750 x 220 x 560
Primary connections top/bottom	Bottom
Secondary HTG connections top/bottom	Bottom
Secondary BCW/DHW connections top/bottom	Bottom
Connection sizes Prim/Sec DHW/Sec HTG (mm)	3/4" male BSP
Empty weight kg** (Kg)	25
Operating weight kg** (Kg)	27.5

ELECTRICAL INFORMATION	
Power supply (230V 1 phase)	**230V 1~**
Maximum power (Watts)	70
Standby power demand (Watts)	5

HYDRAULIC INFORMATION	
Maximum primary pressure (Bar g)	16
Maximum primary temperature (°C)	85
Primary water volume (l)	1.5
Maximum secondary DHW pressure (Bar g)	10
Maximum secondary DHW temperature (°C)	58
Secondary DHW water volume (l)	1
Maximum secondary HTG pressure (Bar g)	3
Maximum secondary HTG temperature (°C)	80
Primary operating DP range min/max (kPa)	60/240

DECLARED MAXIMUM PERFORMANCE LT TEST CONDITIONS	
DHW	
Maximum DHW production at 70°C (kW)	81
Primary flow temperature (°C)	**70**
Primary return temperature (°C)	23.3
Primary flow (m3/h)	1.5
Primary $\triangle$P* (kPa)	120
Secondary in/out temperature (°C)	**10/55**
Secondary $\triangle$P (bar)	1.33
HTG	
Maximum HTG production (kW)	23.64
Primary flow temprature (°C)	**70**
Primary return temperature (°C)	56.1
Primary $\triangle$P* (bar)	1.15
Secondary in/out temperature (°C)	**40/60**
Secondary available DP at the output of HIU	47

DECLARED MAXIMUM PERFORMANCE LT TEST CONDITIONS	
DHW	
Maximum DHW production at 60ºC (kW)	63.9
Primary flow temperature (ºC)	**60**
Primary return temperature (ºC)	23.4
Primary flow (m^3/h)	1.5
Primary △P* (kPa)	118
Secondary in/out temprature (ºC)	**10/50**
Secondary △P (bar)	1.30
HTG	
Maximum HTG production (kW)	17.28
Primary flow temprature (ºC)	**60**
Primary return temperature (ºC)	49.9
Primary △P* (bar)	0.55
Secondary in/out temperature (ºC)	**35/45**
Secondary avialable DP at the output of the HIU (kPa)	13
HIU P&ID supplied by manufacturer with a legend for the components	Yes

*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 Sergio Borsati Position R&D Manager Company Rhico District Heating Products

COMMENTS/HISTORY

BESA HIU PARTIAL Test Report

TI45 UL (Ultra Lean Electronic HIU)

Carried out for

Rhico District Heating Products

Report 102787/1 (FINAL)

Compiled by Colin Judd

22 March 2022




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BESA HIU PARTIAL Test Report

TI45 UL (Ultra Lean Electronic HIU)

Carried out for:	Rhico District Heating Products Basepoint, Aviation Business Park Enterprise Close, Christchurch Dorset BH23 6NX UK
Contract:	Report 102787/1 (FINAL)
Issued by:	BSRIA Limited Old Bracknell Lane West Bracknell Berkshire RG12 7AH UK
Telephone:	+44 (0)1344 465600
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Email: bsria@bsria.co.uk
Website: www.bsria.com/uk/

QUALITY ASSURANCE

Issue	Date	Compiled by:	Approved by:	Signature
Final	*22-Mar-2022*	*Colin Judd*	*Mark Roper*	
		Senior Test Engineer	*Head of Laboratory*	

CONTENTS

FIGURES

TABLES

APPENDICES

1 INTRODUCTION

BSRIA Ltd. were commissioned by Rhico District Heating Products to carry out a test on an HIU in accordance with the UK HIU Test Regime, October 2018. This is a variant of the **TI45 Ultra Lean HIU (S/N 428440300/Matr.: A202800460)**, the results of which can be found in **BSRIA Report 101924/1**.

The modification to the **TI45 UL (Ultra Lean Electronic HIU)** compared to the previous model tested is on the domestic hot water side only. Therefore the space heating test results have been taken from the original test report **BSRIA Report 101924/1** and used in all calculations. They have been re-issued in this report.

The modification made to the unit was specification of the DHW plate heat exchanger for this variant. The retests of the DHW circuit were carried out in accordance with the UK HIU Test Regime, October 2018. The test method covers testing one HIU at a primary inlet temperature of 70°C and 60°C. The HIU was a combined low temperature hot water (LTHW) and domestic hot water (DHW) unit. This report is based on one sample of the above-mentioned product. Testing was carried out during December 2021 and January 2022. Charts of outputs obtained from this series of tests are shown in Appendix A of this report.

2 SAMPLE RECEIVED FOR TEST

The HIU received for testing was a TI45 UL (Ultra Lean Electronic HIU). This was a combined LTHW and DHW unit. The HIU was designed for both wet radiator systems and underfloor heating (UFH) systems. The test regime requires the HIU is tested at two primary inlet temperatures, 70°C for wet radiator systems and 60°C for UFH systems. Table 1 gives details of the HIU tested.

Table 1 Manufacturer supplied data

Description	Data
Model	TI45 UL (Ultra Lean Electronic HIU)
Serial Number	428440300/Matr.: A202800460/1
Year of manufacture	2020
Height	750 mm
Width	560 mm
Depth	220 mm
Total unit weight	25 kg (including cover)
Maximum DHW output	92 kW at 85°C – DHW 10°C to 55°C (manufacturer supplied data) 69 kW at 60°C – DHW 10°C to 45°C (manufacturer supplied data)
Maximum central heating output	33 kW at 85°C – Htg 50°C to 70°C (manufacturer supplied data) 9.3 kW at 55°C – Htg 33°C to 38°C (manufacturer supplied data)
Maximum primary supply temperature	85°C
Recommended minimum DP	120 kPa
Maximum working pressure primary side	16 bar
Maximum working pressure DHW side	10 bar
Safety relief valve setting secondary heating side	3 bar
Expansion vessel capacity	7 Lt
Ball valve connections	1” male flat seal connection with adaptors down to ¾“ male BSP
Safety relief valve connection	¾” Female connection
Electrical power supply voltage	230 V AC±10%
Frequency	50/60 Hz

Table 2 gives a component list for the HIU as supplied by the Client. Items in bold have been changed since the original test covered in **BSRIA Report 101924/1**.

Table 2 HIU component list

Description	Manufacturer
Software version	1961SAT.LO1.00 – C00430823_01
Space heating heat exchanger	SWEP E8AS W-Nx10
DHW heat exchanger	**Zilmet 17CA314030 No, plates 40**
DHW flowmeter	Honeywell C7195 -0,7-30 l/m'
Check Valve on DCW inlet	Lovato code 20313113
Check Valve on filling circuit	Kramer
Temperature sensors	Brahama G 1/8"-ST06
Primary side strainer	M-M ¾" – VALBRASS
Controller for DHW and Space Heating	Brahama 1961 SAT
Control valve and actuator for space heating and DHW	Jonson control M30X1,5 VA 7481-0003
Heat Meter	Ista Ultego III smart
Differential pressure control valve	Frese Optima compact DN15
Circulation pump	WILO pump block PARA 15/7
Safety valve	Female 3/4"3 bar PINTOSSI +C SPA
Air vent valve	Manual 3/8" – MARVIT SPA
Digital pressure transducer	ELTEK 10.80.40.00.07
Expansion Vessel	Zilio Industries VRP204-7
Isolation valves	Arpro EPP 60 g/L
Pipes	Silmet / Feinrohren
o-ring	Teknofluor – EPDM 70
Joints and connections gasket	Flat seat and nuts-AFM34

Figure 1 shows the TI45 UL (Ultra Lean Electronic HIU) installed in the test rig with the cover removed. A picture of the name plate is also included.

Figure 1 TI45 UL (Ultra Lean Electronic HIU), installed in the test rig

Figure 2 shows the TI45 UL (Ultra Lean Electronic HIU), installed in the test rig with the cover on.

Figure 2 TI45 UL (Ultra Lean Electronic HIU), cover on

3 APPROACH

3.1 ABBREVIATIONS

The abbreviations given in Table 3 are used throughout this report.

Table 3 Abbreviations used

Abbreviation	Parameter	Units
DH	District Heating	-
SH	Space Heating	-
CWS	Cold Water Supply	-
P_1	Heat load – primary side	[kW]
P_2	Heat load – space heating system	[kW]
P_3	Heat load – domestic hot water	[kW]
t_{10}	Temperature at DH supply upstream of 9m HIU supply pipework	[°C]
t_{11}	Temperature – primary side flow connection	[°C]
t_{12}	Temperature – primary side return connection	[°C]
t_{21}	Temperature – space heating system return connection	[°C]
t_{22}	Temperature – space heating system flow connection	[°C]
t_{31}	Temperature – cold water supply	[°C]
t_{32}	Temperature – domestic hot water flow from HIU	[°C]
q_1	Volume flow – primary side	[$l.s^{-1}$]
q_2	Volume flow – space heating system	[$l.s^{-1}$]
q_3	Volume flow – domestic hot water	[$l.s^{-1}$]
Δp_1	Primary pressure drop across entire HIU unit	[bar]
Δp_2	Pressure drop – space heating system across HIU	[bar]
Δp_3	Pressure drop – domestic hot water across HIU	[bar]
$VWART_{DHW}$	DHW Volume Weighted Average Return Temperature	[°C]
$VWART_{SH}$	Space Heating Volume Weighted Average Return Temperature	[°C]
$VWART_{KWM}$	Keep-warm Volume Weighted Average Return Temperature	[°C]
$VWART_{HEAT}$	Annual Volume Weighted Average Return Temperature for Heating Period	[°C]
$VWART_{NONHEAT}$	Annual Volume Weighted Average Return Temperature for Non-Heating	[°C]
$VWART_{HIU}$	Total Annual Volume Weighted Return Temperature	[°C]
SH_{PROP}	Annual Heating Period	-
NSH_{PROP}	Annual Non-Space Heating Period	-
DH	District Heating (primary) circuit	-
SH	Space Heating circuit	-
CWS	Cold Water Supply	-
DHW	Domestic Hot Water	-
TMV	Thermostatic Mixing Valve	-
TRV	Temperature Regulating Valve	-
UFH	Under Floor Heating	-

3.2 INSTRUMENTATION USED

Table 4 shows details of the instrumentation used for the tests.

Table 4 Instrumentation used

Instrument	Manufacturer	Range	Units	ID No.	Calibration Due
Keysight logging system	Keysight	-1 – 90	°C	1595 1597	03-09-22
Static pressure transducer DHW circuit – Pressure test Primary circuit for all thermal tests	Fuji Electric	0 – 10	Bar	1592	10-05-22
Static pressure transducer SH circuit – Pressure test Secondary circuit for all thermal tests	Fuji Electric	0 – 10	Bar	1593	10-05-22
Platinum Resistance Thermometers (PRTs)* Used for measuring the inlet/outlet parameters during the testing	TC Ltd	5 – 90	°C	1685	02-12-22
Platinum Resistance Thermometer (PRT)	Anville Sensors Ltd	5 – 90	°C	1685	02-12-22
Flowmeter – DH circuit Space heating tests – (1a – 1f)	Siemens	0 – 0.07	$l.s^{-1}$	2961	21-01-21**
Flowmeter – SH circuit Space heating tests – (1a – 1d)	Siemens	0 – 0.07	$l.s^{-1}$	1678	28-04-21**
Flowmeter – SH circuit Space heating tests – (1f)	Danfoss	0 – 0.2	$l.s^{-1}$	94	27-04-21**
Flowmeter – DH circuit Dynamic tests – (2a and 2b) DHW response time tests (5a & 5b)	Siemens	0 – 0.5	$l.s^{-1}$	2063	12-11-22
Flowmeter – DHW circuit Dynamic tests – (2a and 2b)	Danfoss	0 – 0.2	$l.s^{-1}$	94	10-05-22
Flowmeter – DH circuit Keep warm tests (4a & 4b)	Siemens	0 – 0.07	$l.s^{-1}$	1678	07-05-22
Flowmeter – DHW circuit Keep warm tests (4a & 4b) DHW response time tests (5a & 5b)	Danfoss	0 – 0.2	$l.s^{-1}$	94	10-05-22
Differential pressure transducer DH circuit for all tests except 4b and 5b	Fuji Electric	0 – 200	kPa	2065	08-02-22
Differential pressure transducer SH and DHW circuit for all tests except 4b and 5b DH circuit for tests 4b and 5b	Fuji Electric	0 – 200	kPa	1591	10-05-22
Differential pressure transducer DHW circuit for tests 4a and 4b	Fuji Electric	0 – 50	kPa	1583	10-05-22
Static pressure transducer Pressure test and heating/DHW circuits	Fuji Electric	0 – 30	barg	1582	14-06-22
Stopwatch	RS		Secs	2955	01-12-21
Tape measure	Stanley	1,000	mm	683	28-02-22
Voltage and power draw	Yokogawa	0-300V 0-25W	V/W	988	27-10-22

*The time constant for these temperature sensors was ≤ 1.5 s.
**These tests were carried out in July 2020.
The calibration certificates for all the instrumentation used during this series of tests are available on request from BSRIA (test@BSRIA.co.uk)

Figure 3 shows a schematic of the space heating pipework.

Figure 3 Schematic of the space heating pipework.

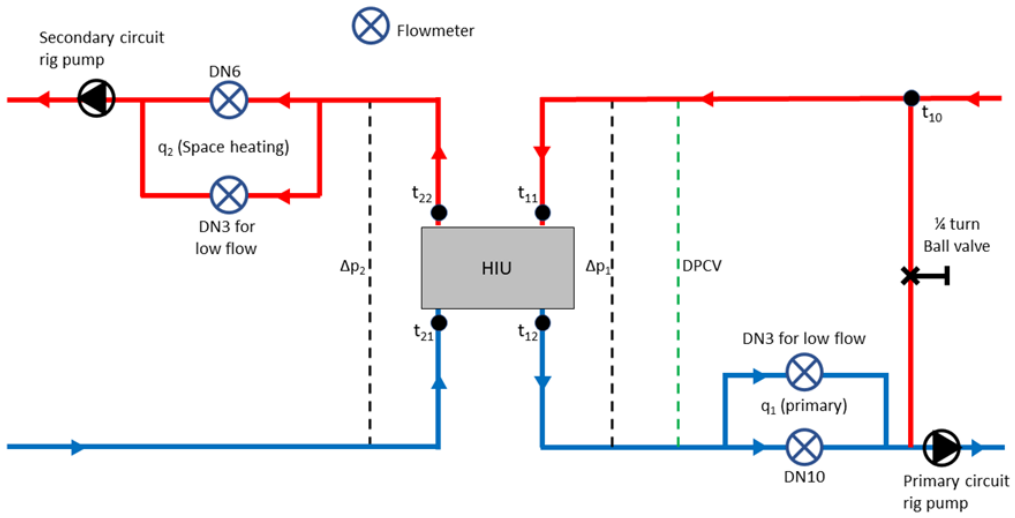
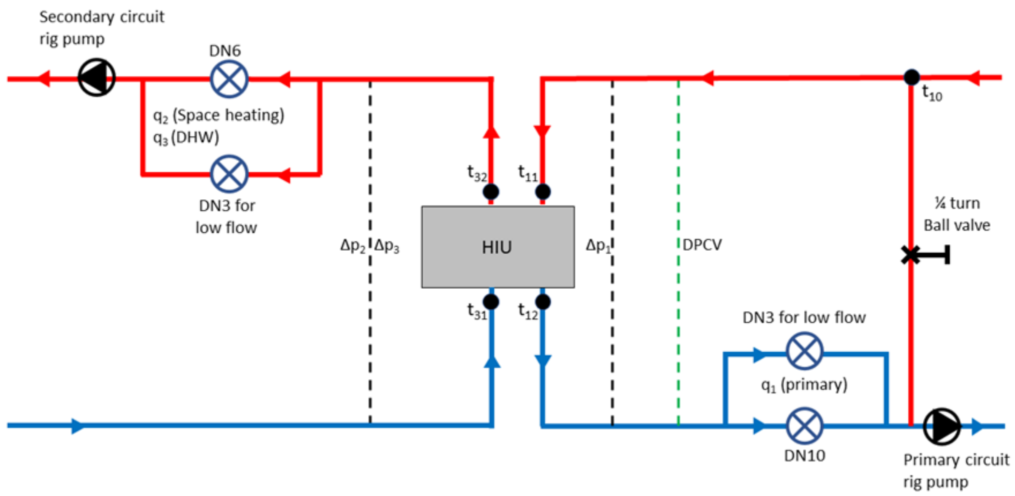


Figure 4 shows a schematic of the DHW pipework.

Figure 4 Schematic of the DHW pipework.



3.3 UNCERTAINTY BUDGET

The uncertainty of measurement given in the test regime is shown in Table 5.

Table 5 Uncertainty budget

Parameter	Required Uncertainty	BSRIA Uncertainty
Static pressure	±10 kPa	±0.65 kPa
Differential pressure, district heating	*Not supplied*	±0.06 kPa
Differential pressure, domestic hot water	±1 kPa	±0.06 kPa
Differential pressure, space heating	±1 kPa	±0.06 kPa
Temperature	±0.1°C	±0.02°C
Volume flow (≥ 0.06 l/s)	±1.5%	±0.0006 l/s
Volume flow (< 0.06 l/s)	To be specified in conjunction with each measurement	±0.0007 l/s

The uncertainty of the instrumentation used was calculated according to M3003 – The Expression of Uncertainty and Confidence in Measurement. All the instrumentation used in this series of tests was within the required uncertainty quoted above.

3.4 RANGE OF TESTS

Table 6 shows the setup of the tests as given in the test regime.

Table 6 Test setup as given in the test regime

Test No.	Test	Static pressure on return	dP across HIU	Primary flow temp	Hot water setpoint	DHW flow rate	DHW power	Space heat output	Space heat flow temp	Space heat return temp
		bar	bar	°C	°C	l/s	kW	kW	°C	°C
			dP_1	t_{11}	t_{32}	q_3	P_3	P_2	t_{22}	t_{21}
Static tests										
0a	Static pressure test (same static pressure on both flow and return connections)	1.43 times rated value		70	50	-	-	-	n/a	n/a
1a	Space Heating 1 kW	3.0	0.5	70	55	-	-	1	60	40
1b	Space Heating 2 kW	3.0	0.5	70	55	-	-	2	60	40
1c	Space Heating 4 kW	3.0	0.5	70	55	-	-	4	60	40
1d	Space Heating 1 kW	3.0	0.5	60	50	-	-	1	45	35
1e	Space Heating 2 kW	3.0	0.5	60	50	-	-	2	45	35
1f	Space Heating 4 kW	3.0	0.5	60	50	-	-	4	45	35
Dynamic tests										
2a	DHW only DH 70°C flow	3.0	0.5	70	55	see DHW test profile	see DHW test profile	-	60	-
2b	DHW only DH 60°C flow	3.0	0.5	60	50			-	45	-
3a	Low flow DHW, DH 70°C flow	3.0	0.5	70	55	0.02	Record value	-	60	-
3b	Low flow DHW, DH 60°C flow	3.0	0.5	60	50	0.02	Record value	-	45	-
4a	Keep-warm, DH 70°C flow	3.0	0.5	70	55	0	0	-	60	-
4b	Keep-warm, DH 60°C flow	3.0	0.5	60	50	0	0	-	45	-
5a	DHW response time	3.0	0.5	70	55	0.13	Record value	-	60	-
5b	DHW response time	3.0	0.5	60	50	0.13	Record value	-	45	-

Table 7 shows the reporting structure of the tests as given in the test regime. A summary of findings is shown in the right hand column, see section 4 for the full test results.

Table 7 Test reporting structure as given in the test regime

Test	Description	Reporting	Pass/Fail
		Static Tests	
0	Pressure tests	Pass/Fail as to whether HIU manages pressure test without leaks or damage.	Pass
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.	N/A
1b	Space Heating 2 kW, 60/40°C secondary		N/A
1c	Space Heating 4 kW, 60/40°C secondary		N/A
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.	N/A
1e	Space Heating 2 kW, 45/35°C secondary		N/A
1f	Space Heating 4 kW, 45/35°C secondary		N/A
		Dynamic Tests	
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 criteria detailed in 2.26. **Note:** Outputs used as input data to 'High Temperature' Domestic Hot Water Weighted Average Return Temperature calculation. Plot t_{32}, t_{31}, q_3, t_{12} q_1	Pass
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. Plot t_{32}, t_{31}, q_3, t_{12} q_1 **Note:** Outputs used as input data to 'Low Temperature' Domestic Hot Water Weighted Average Return Temperature calculation.	N/A
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 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. Assessment of scaling risk as per criteria detailed in 2.26. 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.	Pass

3b	Low flow DHW, DH 60°C flow; 50°C DHW	Comment on ability to deliver DHW at low flow rate based on DHW temperature reaching at least 45°C (one decimal place) at the end of the 180 second period of low flow DHW. Comment on ability to deliver stable DHW flow temperature (at t_{32}), defined as ability to maintain 50.0 +/-3°C (1 decimal place) during the last 60 seconds of the test. 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. Maximum temperature achieved and +/-°C variance around 50.0°C (1 decimal place) to be stated.	N/A
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. Observation on the operation of the HIU during keep-warm. Assessment of scaling risk, based on duration of temperatures in excess of 55.0°C (one decimal place). Plot temperature t10. Comment on HIU keep-warm controls options. Plot of key metrics over duration of test. State average heat load for the duration of the test. State average primary flowrate for the duration of the test. **Note:** Outputs used as input data to 'High Temperature' Keep-warm Volume Weighted Average Return Temperature calculation.	Pass
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. Assessment of scaling risk, based on duration of temperatures in excess of 55.0°C (one decimal place). Plot temperature t10. Comment on HIU keep-warm controls options. Plot of key metrics over duration of test. State average heat load for the duration of the test. State 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.	Pass
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 a DHW temperature 45.0°C (1 decimal place) and not subsequently drop below 42.0°C (1 decimal place).' Plot t_{32}, t_{31}, q_3, t_{12}, q_1 over duration of test.	Pass
5b	DHW response time, DH 60°C flow; 50°C DHW	Pass/Fail on DHW (at t_{32}). State time to achieve a DHW temperature 45.0°C (1 decimal place) and not subsequently drop below 42.0°C (1 decimal place). Plot t_{32}, t_{31}, q_3, t_{12}, q_1 over duration of test.	Pass

4 TEST PROCEDURE

The average deviation of t_{31} (CWS) during test 2a, 2b, 3a,3b, 5a and 5b remained within ±0.5°C of the stipulated 10°C as required by the test regime (see paragraph2.11 of the test regime).

4.1 TESTS 1A TO 1F

Once the rig was running, the space heating tests were allowed to stabilise at the required power output for the particular test. Once stable conditions had been achieved, the test was logged at a rate of 1 Hz for a minimum period of 300 seconds.

4.2 TESTS 2A AND 2B

Prior to the test being carried out, the rig was running at the required stable conditions for a minimum of 120 seconds. After this period, the DHW draw off test was carried out as per the flow regime specified in the test method. The flow rates were controlled using a manifold of three control valves set to the correct flows. The data was logged at a rate of 1 Hz.

4.3 TESTS 3A AND 3B

Prior to the tests being carried out, the rig was running at the required stable conditions for a minimum of 120 seconds. After this period, the DHW flow was reduced to 0.02 l/s as required by the test regime and logged for 180 seconds at a rate of 1 Hz.

4.4 TESTS 4A AND 4B

Prior to the test being carried out, the rig was running at the required stable conditions for a minimum of 120 seconds. After this period, the DHW flow was turned off and left for a minimum of 8 hours to establish “keep warm” conditions. The keep warm mode for this HIU was a trickle flow through the primary circuit. During this test, the primary flow was diverted through a DN3 flowmeter so that the trickle flow could be measured. The data was logged at a rate of 1 Hz throughout the duration of the 8-hour test period.

4.5 TESTS 5A AND 5B

These tests were carried out while the HIU was still in “keep warm” mode after the 8-hour keep warm test. With the data still being logged at a rate of 1 Hz, the DHW flow was immediately brought back to 0.13 l/s.

5 TEST RESULTS

During all the tests, the ambient temperature within the vicinity of the HIU being tested was within the tolerance of 20°C ±5°C as specified in the test regime. Charts of the key metrics for the thermal tests are given in Appendix A.

5.1 PRESSURE TEST – 0A

The DHW circuit and the space heating circuit were pressurised to 1.5 bar. The primary circuit was pressurised to 1.43 times the rated maximum static pressure of 16 bar (test pressure 22.88bar). This pressure was held for 30 minutes. After the 30-minute test period, the connections and fittings on the HIU were inspected for leaks and any signs of deformation. During the 30-minute period, there were no leaks or signs of deformation.

Result – Pass.

5.2 STATIC TESTING – 1A, 1B, 1C, 1D, 1E AND 1F

The space heating tests results in this report are taken from the original testing detailed in **BSRIA Report 101924/1**.

- 1a – DH inlet 70°C, heating return at 40°C and a flow set to achieve 1kW heating duty
- 1b – DH inlet 70°C, heating return at 40°C and a flow set to achieve 2kW heating duty
- 1c – DH inlet 70°C, heating return at 40°C and a flow set to achieve 4kW heating duty
- 1d – DH inlet 60°C, heating return at 35°C and a flow set to achieve 1kW heating duty
- 1e – DH inlet 60°C, heating return at 35°C and a flow set to achieve 2kW heating duty
- 1f – DH inlet 60°C, heating return at 35°C and a flow set to achieve 4kW heating duty

For tests 1a to 1c, the space heating outlet temperature was set to 59°C in the HIU control software to achieve 60°C (±0.5°C) during the 4kw test. The For tests 1d to 1f, the space heating outlet temperature was set to 45°C in the HIU control software to achieve 45°C (±0.5°C) during the 4kw test. Table 8 shows a summary of the results for the static tests. Table 9 shows the uncertainty of measurement for the space hearting tests.

Table 8 Results from the static tests

Test	District Heating Circuit					Space Heating Circuit			
	t_{11} (°C)	t_{12} (°C)	q_1 (l/s)	Δp_1 (kPa)	P_1 (kW)	T_{21} (°C)	T_{22} (°C)	q_2 (l/s)	P_2 (kW)
1a	69.99	42.49	0.010	50.60	1.14	39.73	61.66	0.011	0.99
1b	70.04	43.87	0.019	50.94	2.06	39.94	60.93	0.023	1.98
1c	70.10	45.28	0.039	50.70	4.01	39.99	59.77	0.048	3.90
1d	59.93	36.26	0.012	50.67	1.18	35.10	48.33	0.020	1.09
1e	60.19	35.80	0.019	50.41	1.93	35.00	43.10	0.057	1.91
1f	60.24	37.44	0.043	51.25	4.07	35.20	45.01	0.098	3.98

Table 9 Uncertainty budget for tests 1a to 1f

Test	Uncertainty Budget District Heating Circuit					Uncertainty Budget Space Heating Circuit			
	t_{11} (°C)	t_{12} (°C)	q_1 (l/s)	Δp_1 (kPa)	P_1 (kW)	T_{21} (°C)	T_{22} (°C)	q_2 (l/s)	P_2 (kW)
1a to 1e	±0.018	±0.018	±0.0006	0.031	±0.06	±0.018	±0.018	±0.0006	±0.06
1f	±0.018	±0.018	±0.0006	0.031	±0.06	±0.018	±0.018	±0.0007	±0.04

5.3 DYNAMIC TESTING OF THE HIU OPERATION – 2A AND 2B

5.3.1 Test 2a

Test 2a was carried out with the DH water temperature set to 70°C and the cold-water supply to the DHW circuit at 10°C. The DHW outlet temperature in the HIU control software was set to 58°C to achieve 55.0°C (±0.5°C) at a DHW flow rate of 0.130 l/s, prior to the test.

During test 2a:

- The DHW temperature did not exceed 65°C at any point during the test
- The maximum DHW temperature was 58.2°C
- The minimum DHW temperature was 49.9°C
- Details of the scaling risk are given in **Table 10**
- T_{31} (CWS) had an average value of 10.19°C and a standard deviation of 0.07°C

Result – Pass

5.3.2 Test 2b

Test 2b was carried out with the DH water temperature set to 60°C and the cold-water supply to the DHW circuit at 10°C. The DHW outlet temperature in the HIU control software was set to 52°C to achieve 50.0°C (±0.5°C) at a DHW flow rate of 0.130 l/s, prior to the test.

During test 2b:

- The maximum DHW temperature was 52.9°C
- The minim6um DHW temperature was 47.4°C
- T_{31} (CWS) had an average value of 10.16°C and a standard deviation of 0.06°C

Result – There is no pass/fail criteria for this test.

5.4 LOW FLOW DHW TESTS – 3A AND 3B

5.4.1 Test 3a

Test 3a was carried out with the DH water temperature set to 70°C (±0.5°C) and the cold water supply to the DHW circuit at 10°C (±0.5°C). The DHW outlet temperature setpoint remained at the same position, set to achieve 55.0 (±0.5°C) at a DHW flow rate of 0.130 l/s. The low DHW flow rate was reduced to 0.02 l/s as required by the test regime.

During test 3a:

- The DHW temperature did not exceed 65°C at any point during the test
- The HIU was able to deliver DHW above 45°C at the end of the 180 second test
- During the last 60 seconds of the test the DHW temperature averaged 53.8°C and ranged from 55.7°C to 51.6°C so the results were not within the stated tolerance of 55.0°C ±3°C during this time period.
- The DHW maximum and minimum outlet temperatures were 58.8°C and 49.3°C respectively during the 180 second test.
- T_{31} (CWS) had an average value of 10.02°C and a standard deviation of 0.04°C
- Details of the scaling risk are given in **Table 10**

Result – Pass

5.4.2 Test 3b

Test 3b was carried out with the DH water temperature set to 60°C (±0.5°C) and the cold water supply to the DHW circuit at 10°C (±0.5°C). The DHW outlet temperature setpoint remained at the same position, set to achieve 50.0 (±0.5°C) at a DHW flow rate of 0.130 l/s. The low DHW flow rate was reduced to 0.02 l/s as required by the test regime.

During test 3b:

- The HIU was able to deliver DHW above 45°C at the end of the 180 second test
- During the last 60 seconds of the test the DHW temperature averaged 48.3°C and ranged from 48.9°C to 47.6°C so the results were within the stated tolerance of 50.0°C ±3°C during this time period.
- The DHW maximum and minimum outlet temperatures were 52.6°C and 43.3°C respectively during the 180 second test.
- T_{31} (CWS) had an average value of 10.09°C and a standard deviation of 0.03°C

Result – There is no pass/fail criteria for this test.

5.5 KEEP WARM TESTS – 4A AND 4B

The keep warm function was a pulsed flow on the DH circuit as can be seen on the charts in Appendix A.

5.5.1 Test 4a

Test 4a was carried out with the DH water temperature set to 70°C (±0.5°C) and the cold water supply to the DHW circuit at 10°C (±0.5°C). The DHW outlet temperature setpoint remained at the same position, set to achieve 55.0 (±0.5°C) at a DHW flow rate of 0.130 l/s. The HIU was running at these conditions for at least 2 minutes before this test was carried out.

Once the keep warm function had stabilised (approximately 10,000 seconds into the test), the average t_{11} temperature for the remainder of the test (18,800 seconds) was 47.0°C varying between 46.1°C and 48.43°C. The average t_{12} temperature during this same period was 40.9°C varying between 39.0°C and 42.9°C.

During test 4a:

- The average heat load during the 8-hour keep warm period was 36 W
- The average primary flow rate during the 8-hour keep warm period was 4.3 l/h
- The average measured voltage was 230.2V
- The average measured electrical power draw was 1.9 W
- Details of the scaling risk are given in Table 10

Based on the results for the DHW response time during test 5a, the HIU does perform a valid keep warm operation.

5.5.2 Test 4b

Test 4b was carried out with the DH water temperature set to 60°C (±0.5°C) and the cold water supply to the DHW circuit at 10°C (±0.5°C). The DHW outlet temperature setpoint remained at the same position, set to achieve 50.0 (±0.5°C) at a DHW flow rate of 0.130 l/s. The HIU was running at these conditions for at least 2 minutes before this test was carried out.

Once the keep warm function had stabilised (approximately 12,000 seconds into the test), the average t_{11} temperature for the remainder of the test (16,800 seconds) was 46.2°C varying between 45.7°C and 47.1°C. The average t_{12} temperature during this same period was 42.6°C varying between 41.3°C and 43.7°C.

- The average heat load during the 8-hour keep warm period was 34 W
- The average primary flow rate during the 8-hour keep warm period was 6.1 l/h
- The average measured voltage was 230.0V
- The average measured electrical power draw was 1.9 W
- Details of the scaling risk are given in Table 10

Based on the results for the DHW response time during test 5b, the HIU does perform a valid keep warm operation.

5.6 DHW RESPONSE TIME – 5A AND 5B

5.6.1 Test 5a

Test 5a was carried out immediately after test 4a with all the settings and conditions the same. The DHW isolation valve was opened to achieve 0.130 l/s instantly.

During test 5a:

- The DHW temperature did not exceed 65.0°C during the test
- The DHW achieved 45.0°C in 11 seconds from the first recorded non-zero DHW flow reading
- The DHW temperature did not subsequently drop below 42.0°C

Not exceeding 65.0°C during the test – Pass
Achieving 45°C DHW within 15 seconds – Pass
DHW temperature not subsequently dropping below 42.0°C – Pass

Overall result – Pass

5.6.2 Test 5b

Test 5b was carried out immediately after test 4b with all the settings and conditions the same. The DHW isolation valve was opened to achieve 0.130 l/s instantly.

During test 5b:

- The DHW achieved 45.0°C in 14 seconds from the first recorded non-zero DHW flow reading
- The DHW temperature did not subsequently drop below 42.0°C

Achieving 45°C DHW within 15 seconds – Pass
DHW temperature not subsequently dropping below 42.0°C – Pass

Overall result – Pass

5.7 TOTAL SCALING RISK ASSESSMENT

The scaling risk criteria is given in section 2.26 of the test regime. Table 10 gives details of the scaling risk associated with this HIU. If any of the factors given in Table 10 occur, then there is an increased scaling risk of the DHW plate in hard water areas.

Table 10 Total scaling risk assessment

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

5.8 VOLUME WEIGHTED AVERAGE RETURN TEMPERATURE

The Volume Weighted Average Return Temperature (VWART) results are given in Appendix B.

APPENDIX A: DATA CHARTS

Figure 5 Results for test 1a: 1kW Space heating – DH 70°C supply

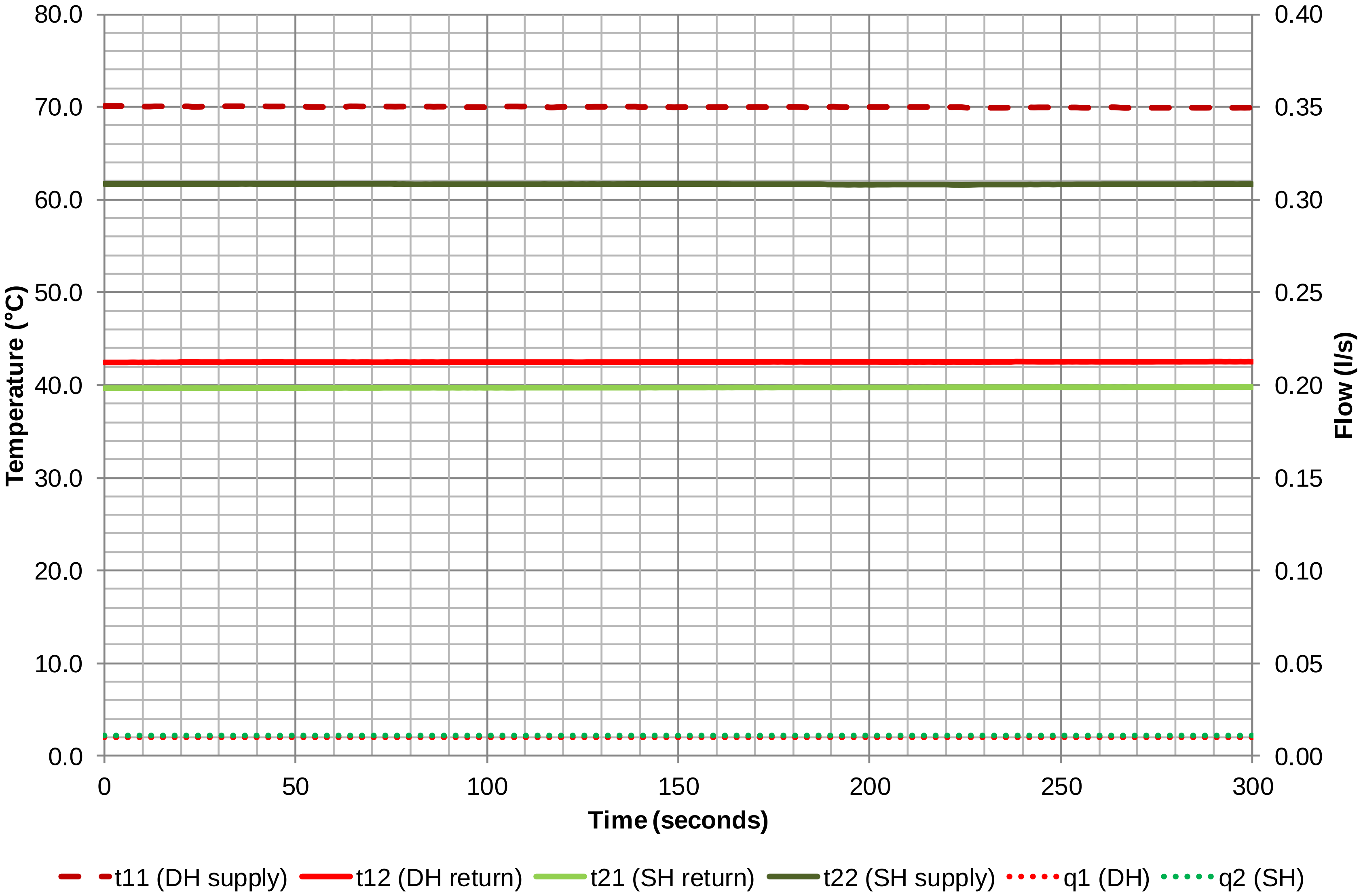


Figure 6 Results for test 1b: 2kW Space heating – DH 70°C supply

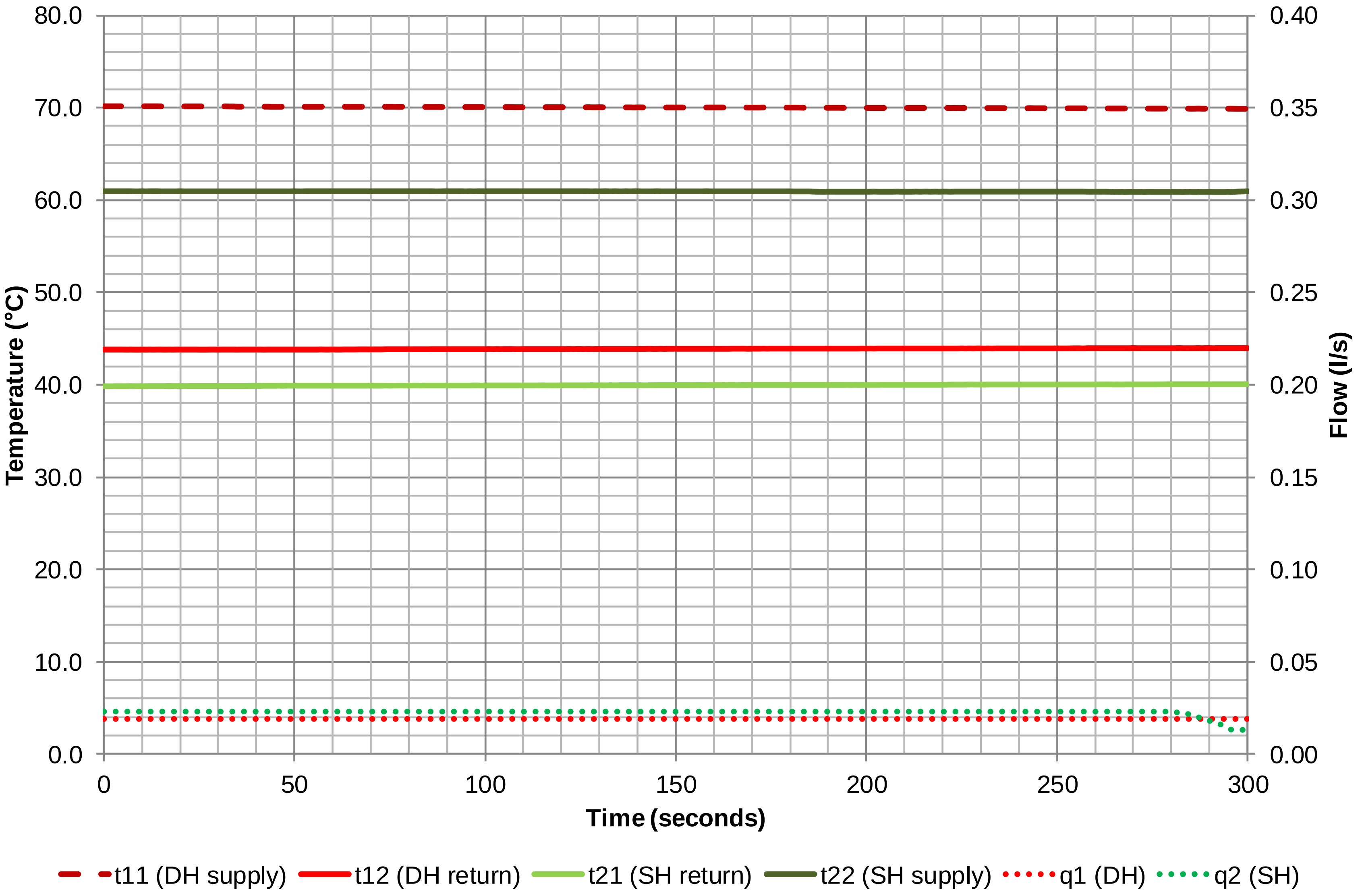


Figure 7 Results for test 1c: 4kW Space heating – DH 70°C supply

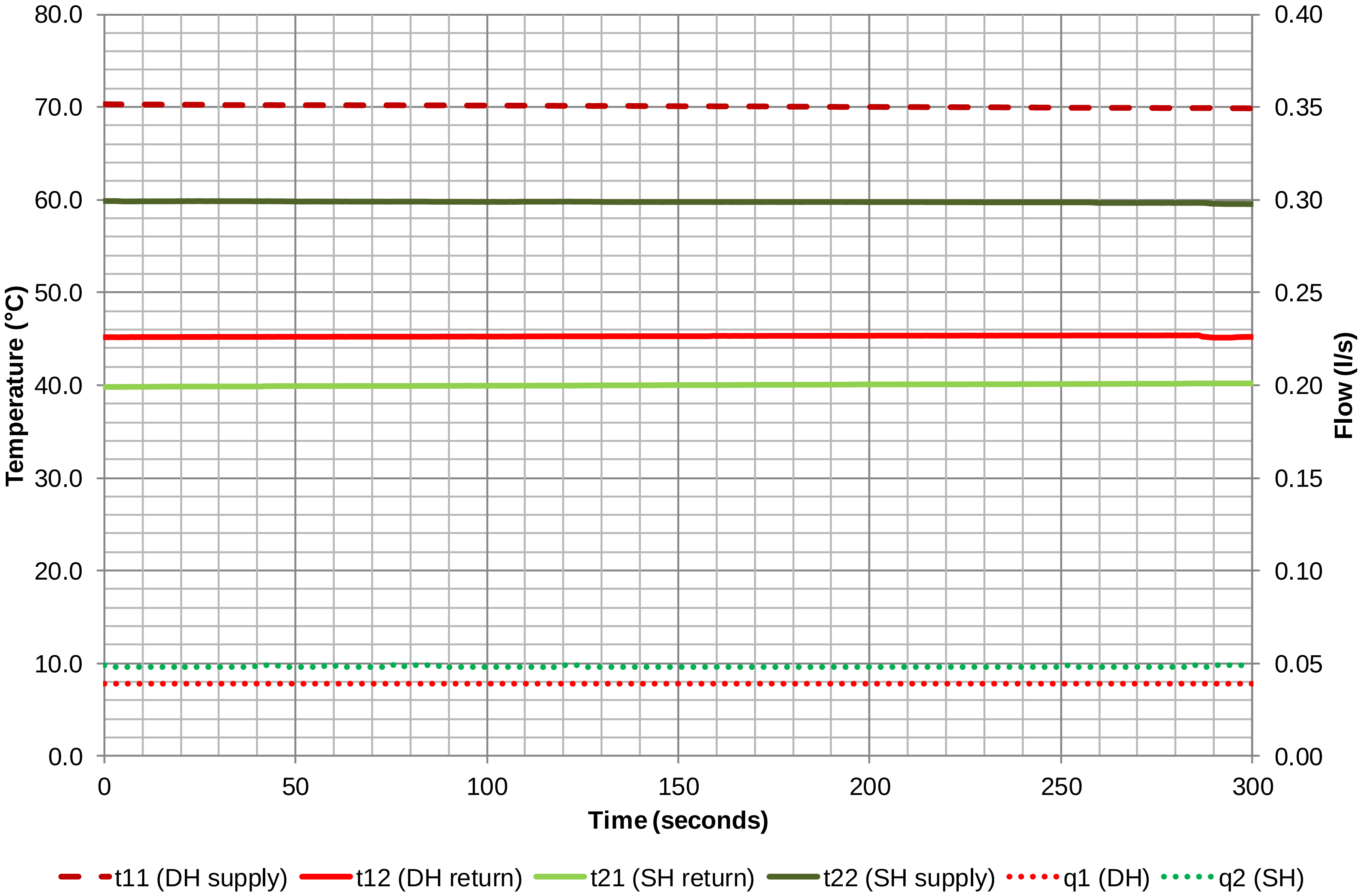


Figure 8 Results for test 1d: 1kW Space heating – DH 60°C supply

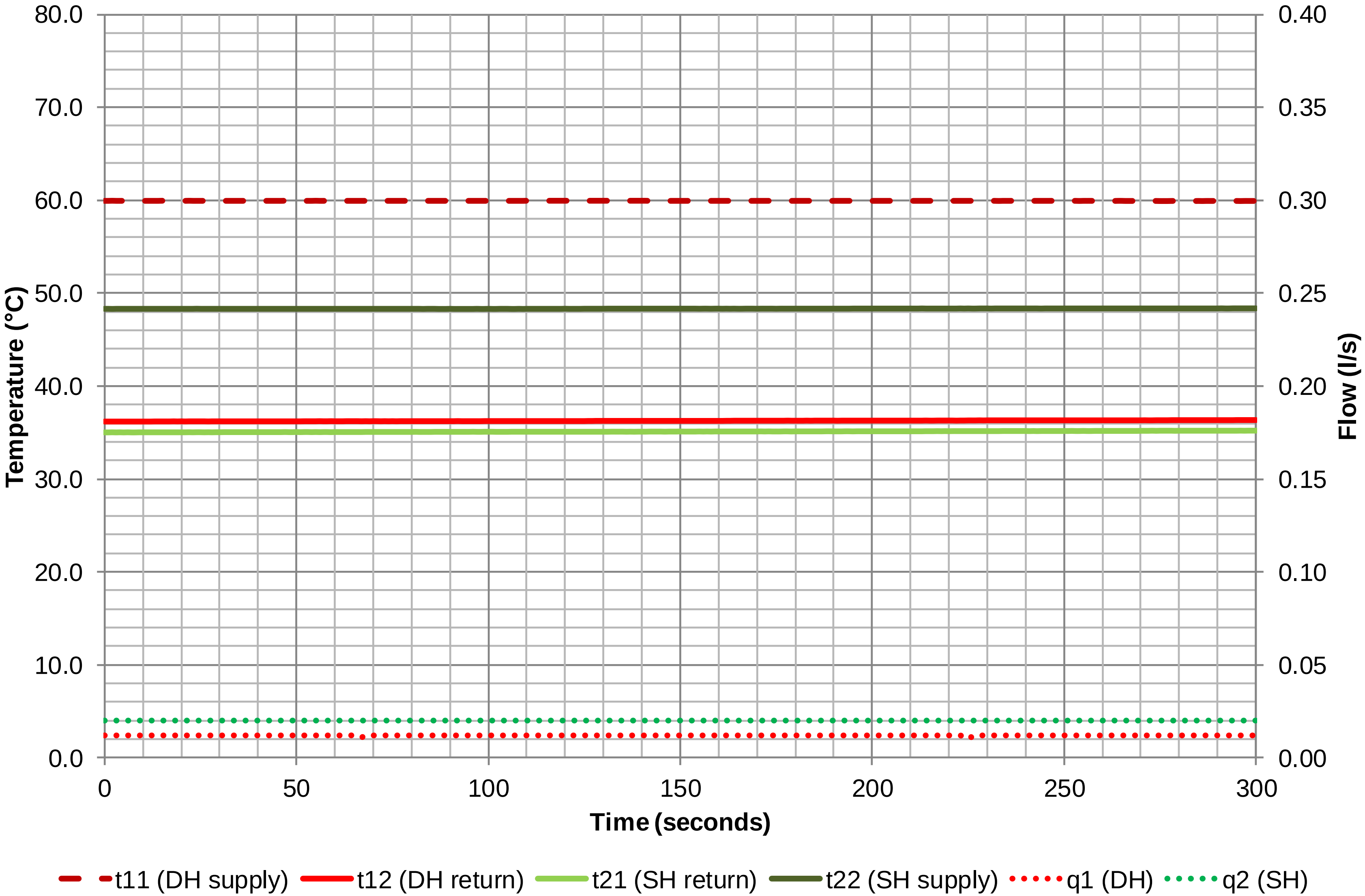


Figure 9 Results for test 1e: 2kW Space heating –DH 60°C supply

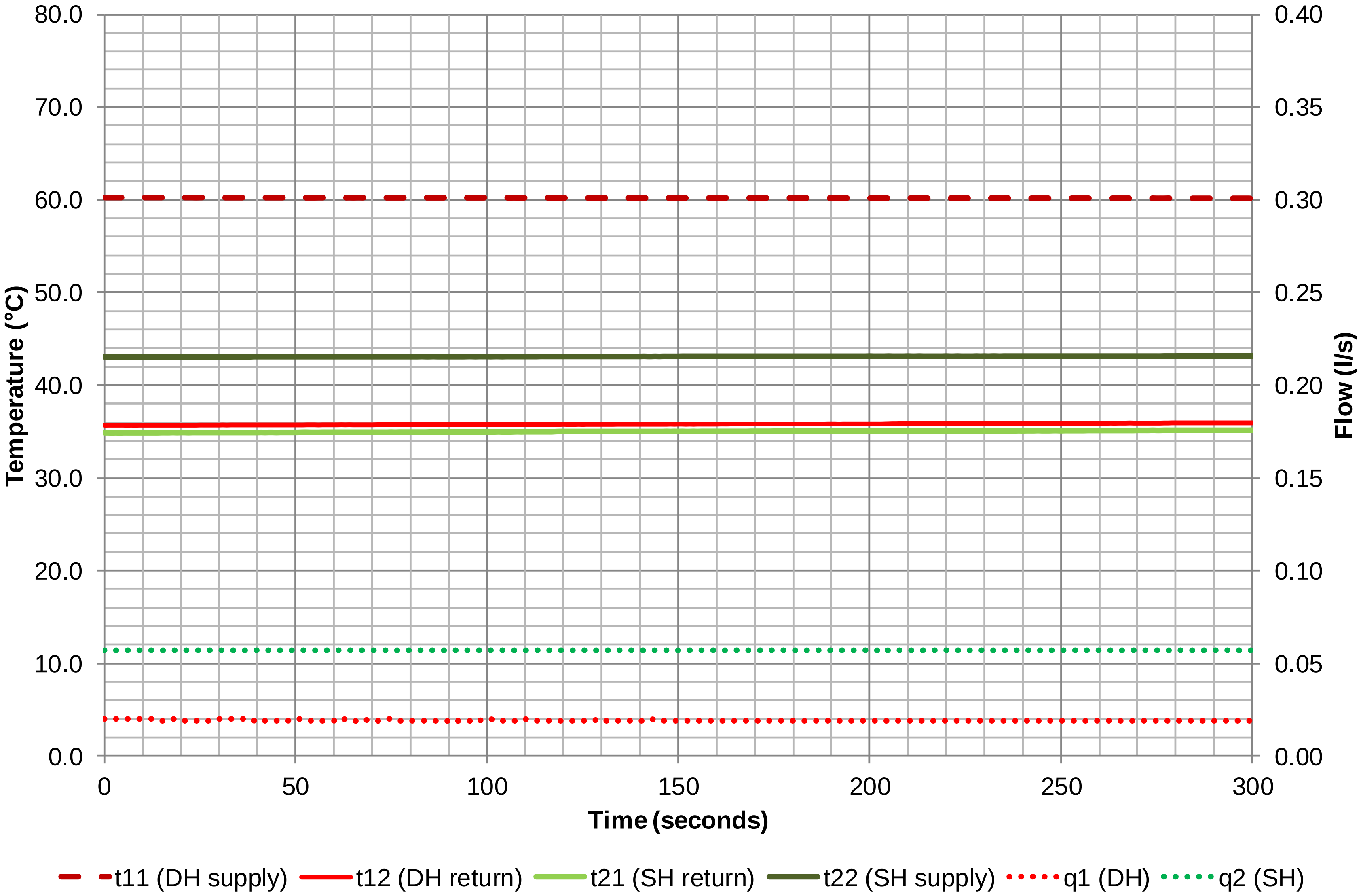


Figure 10 Results for test 1f: 4kW Space heating – DH 60°C supply

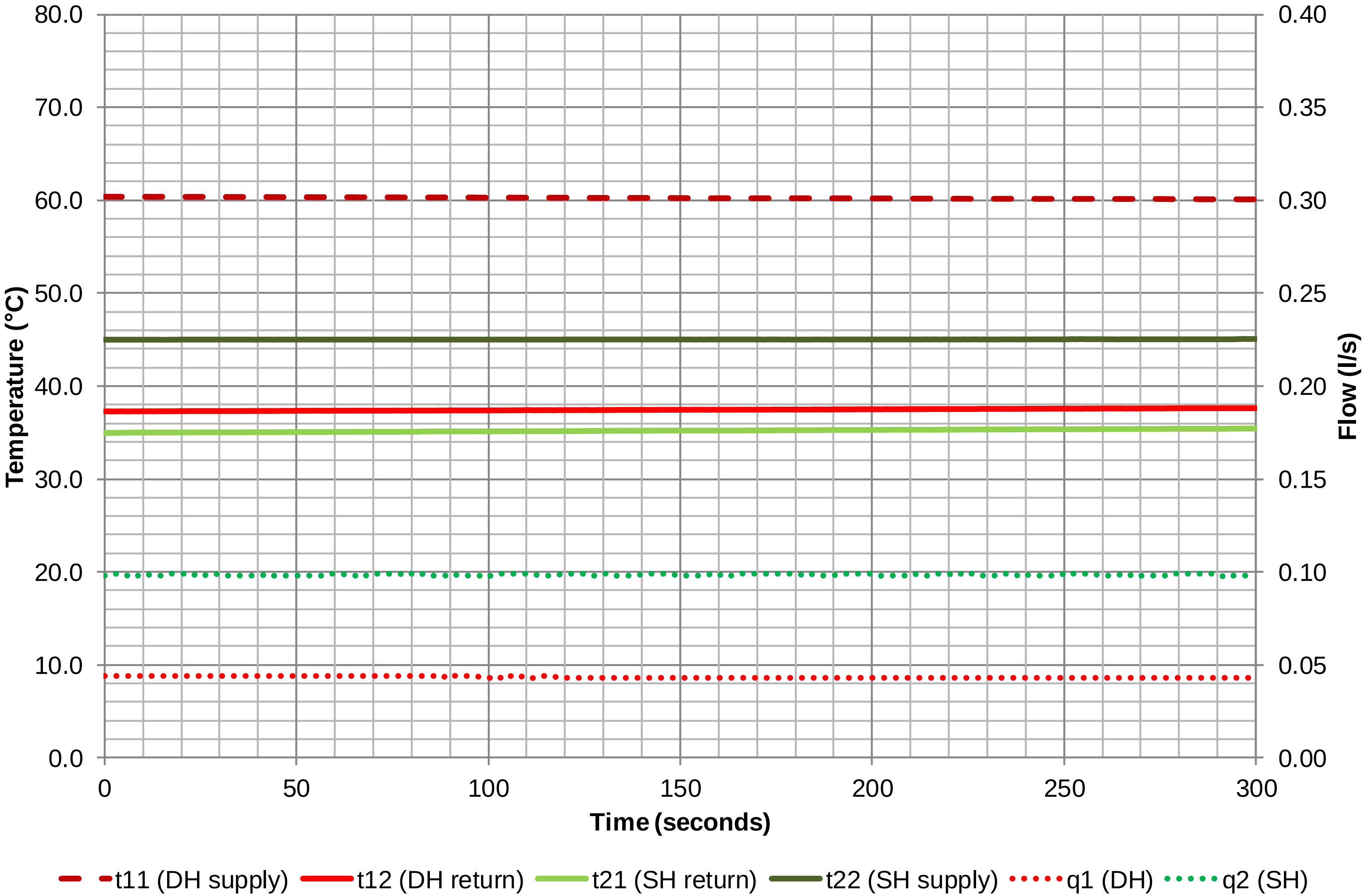


Figure 11 Results for test 2a: DHW dynamic test – DH 70°C supply

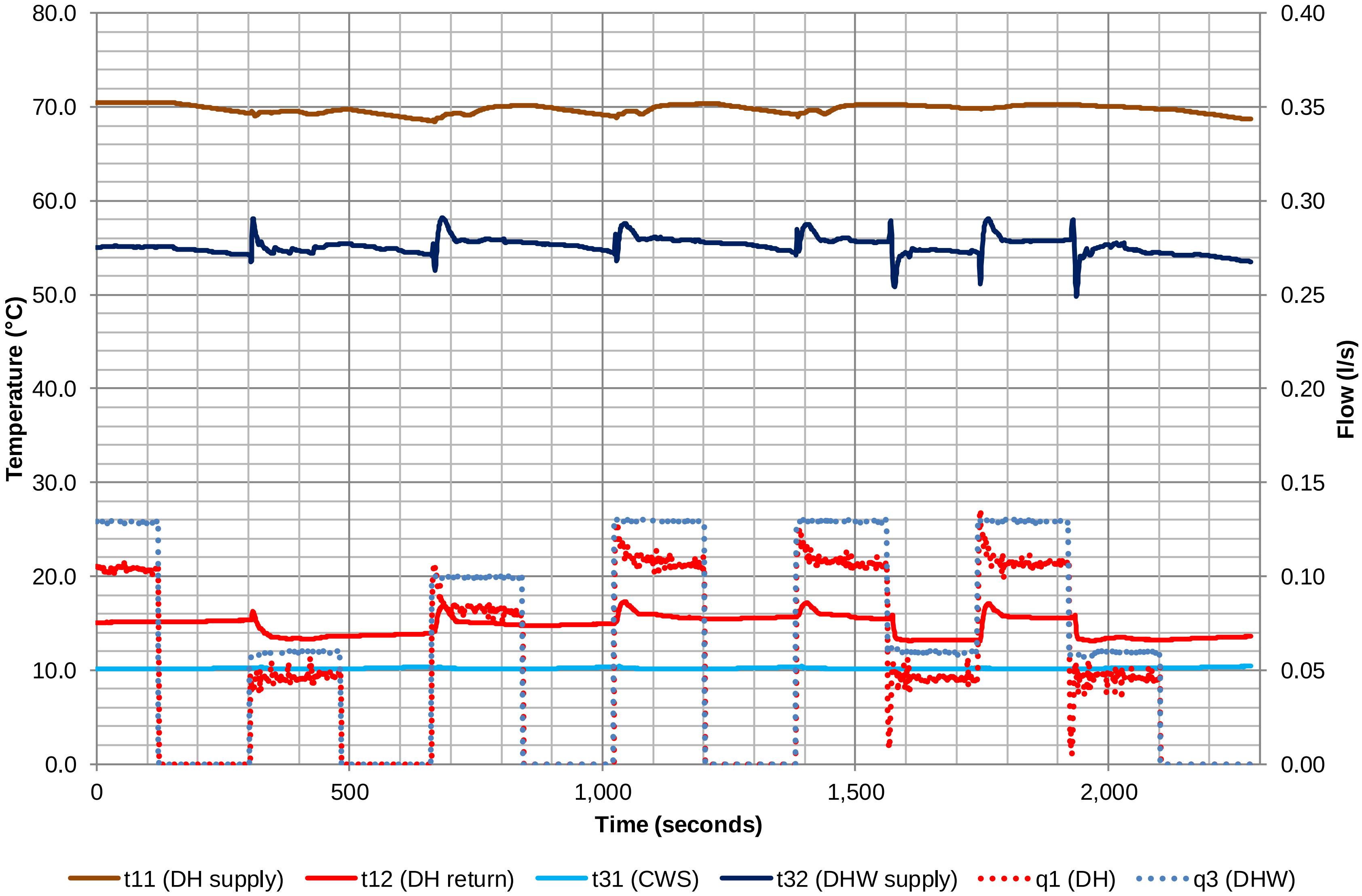


Figure 12 Results for test 2b: DHW dynamic test – DH 60°C supply

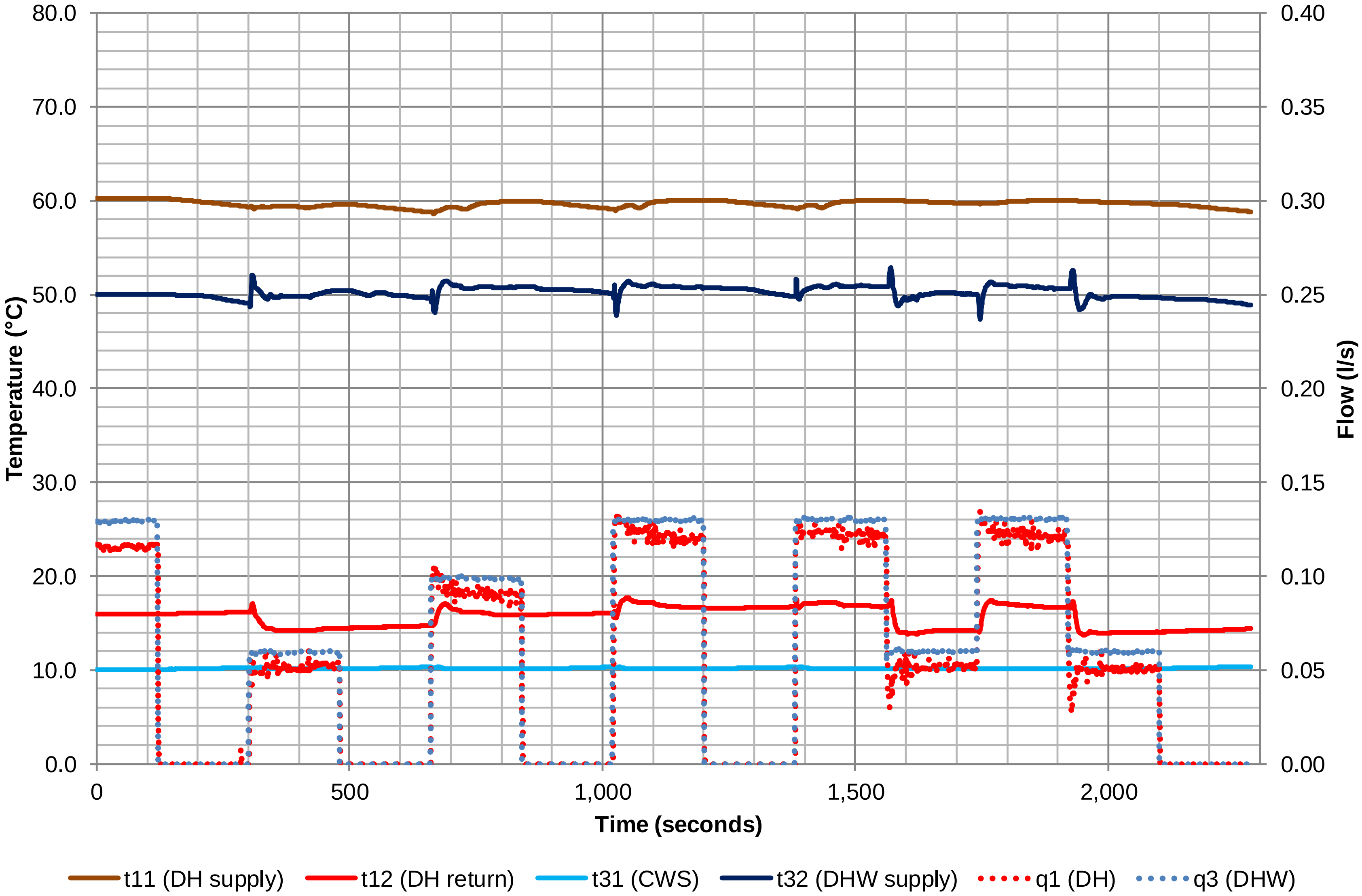


Figure 13 Results for test 3a: Low flow DHW test – DH 70°C supply

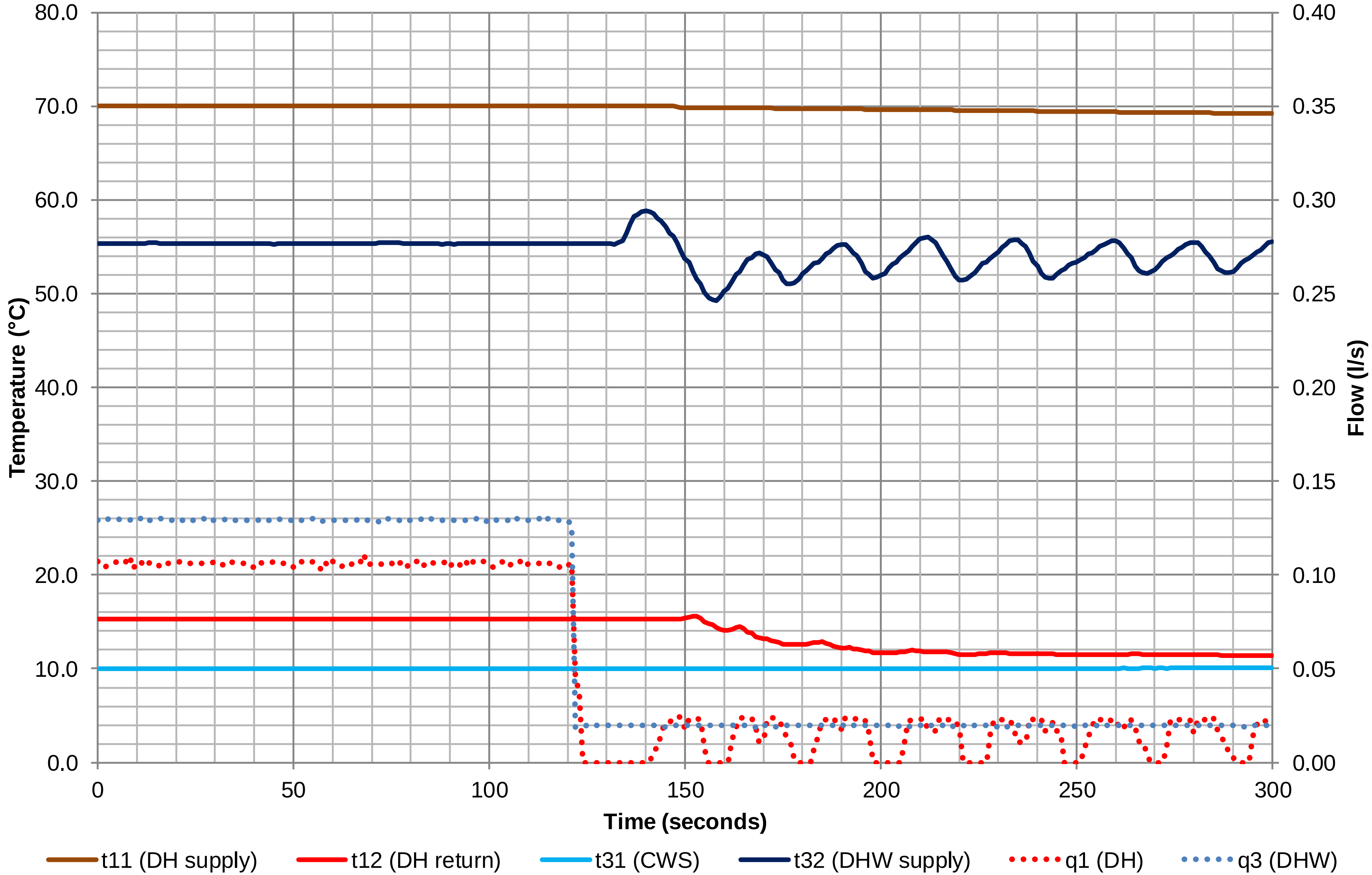


Figure 14 Results for test 3b: Low flow DHW test – DH 60°C supply

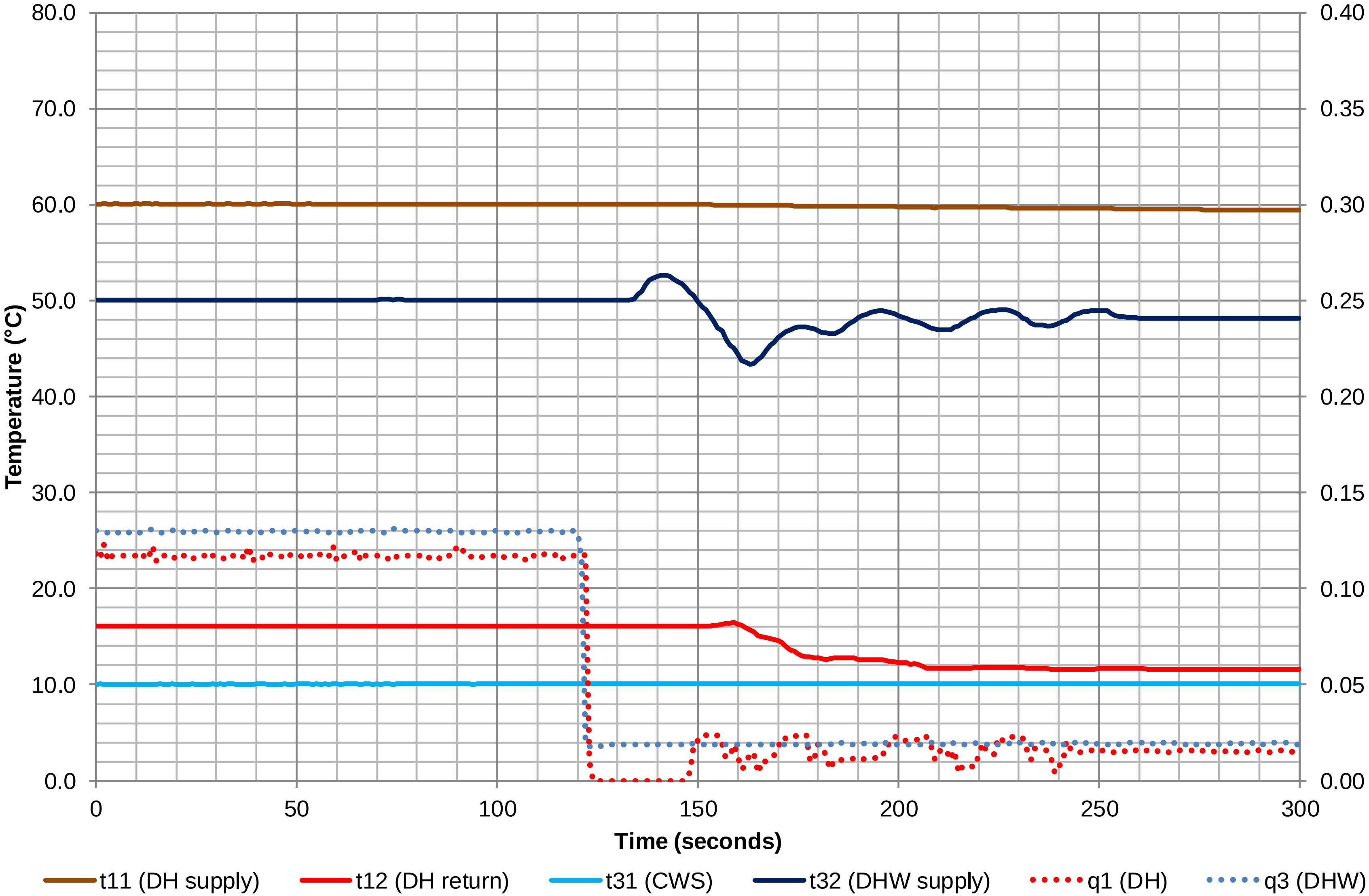


Figure 15 Results for test 4a: Keep warm test – DH 70°C supply

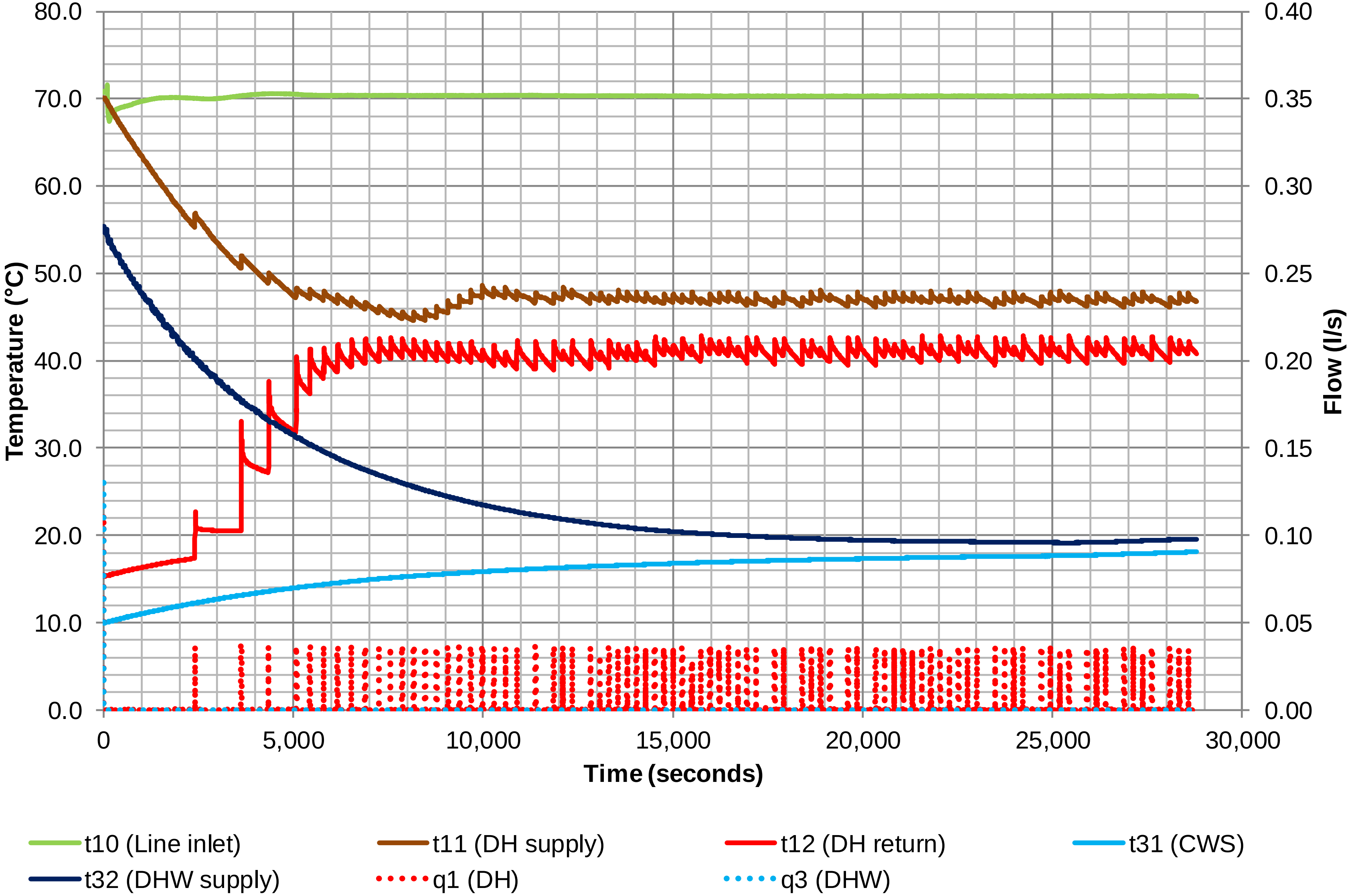


Figure 16 Results for test 4b: Keep warm test – DH 60°C supply

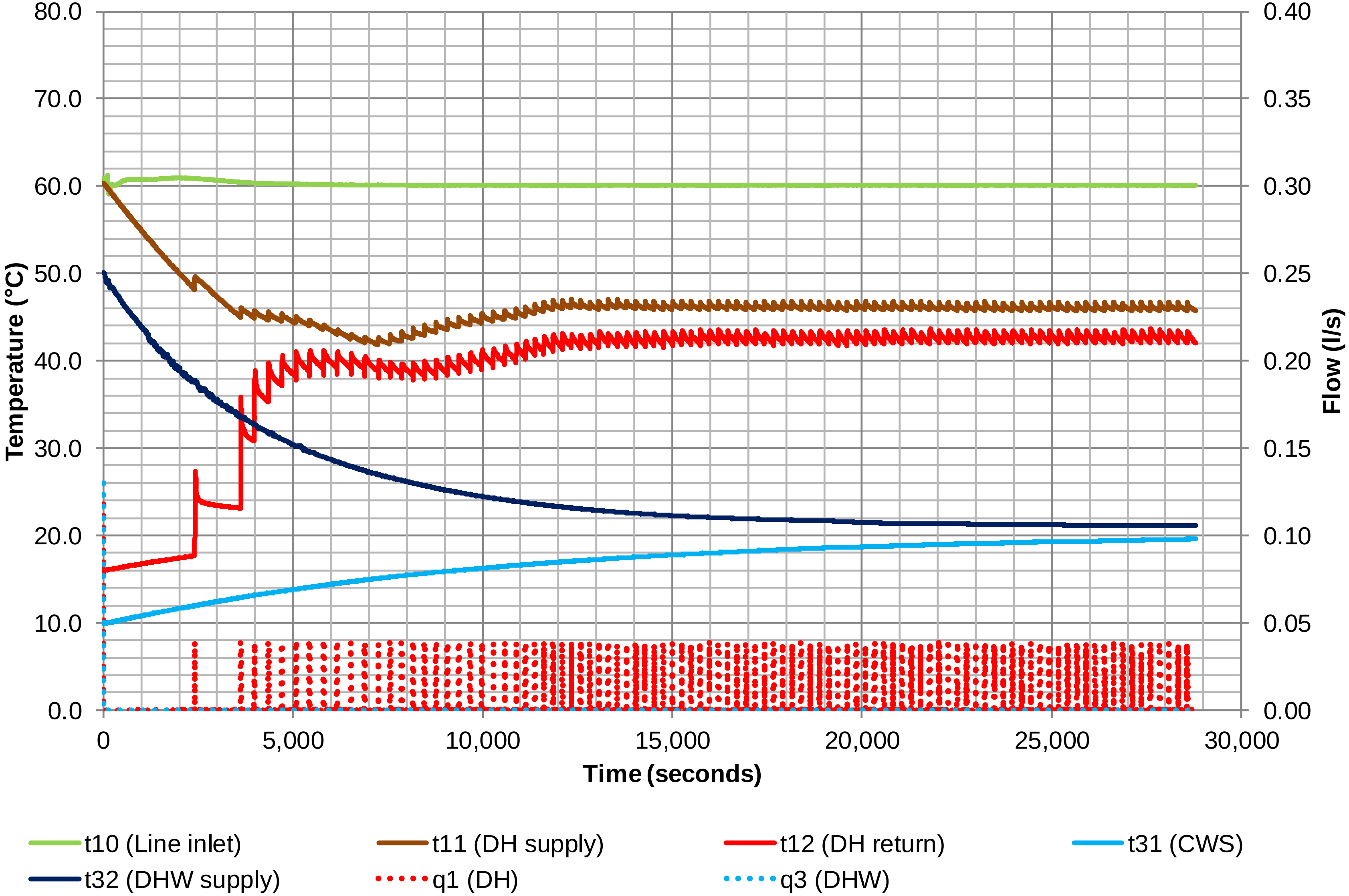


Figure 17 Results for test 5a: DHW response time – DH 70°C supply

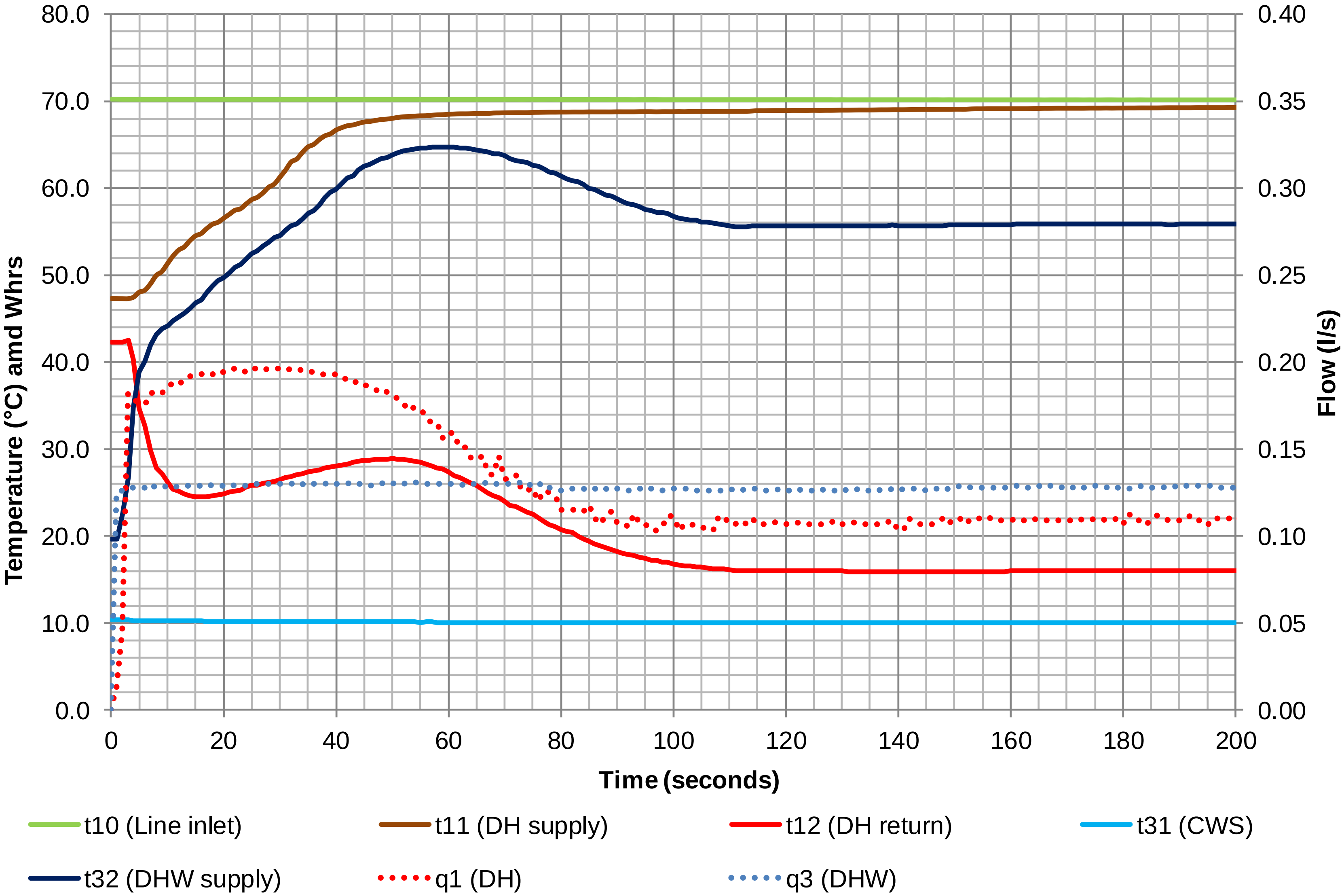
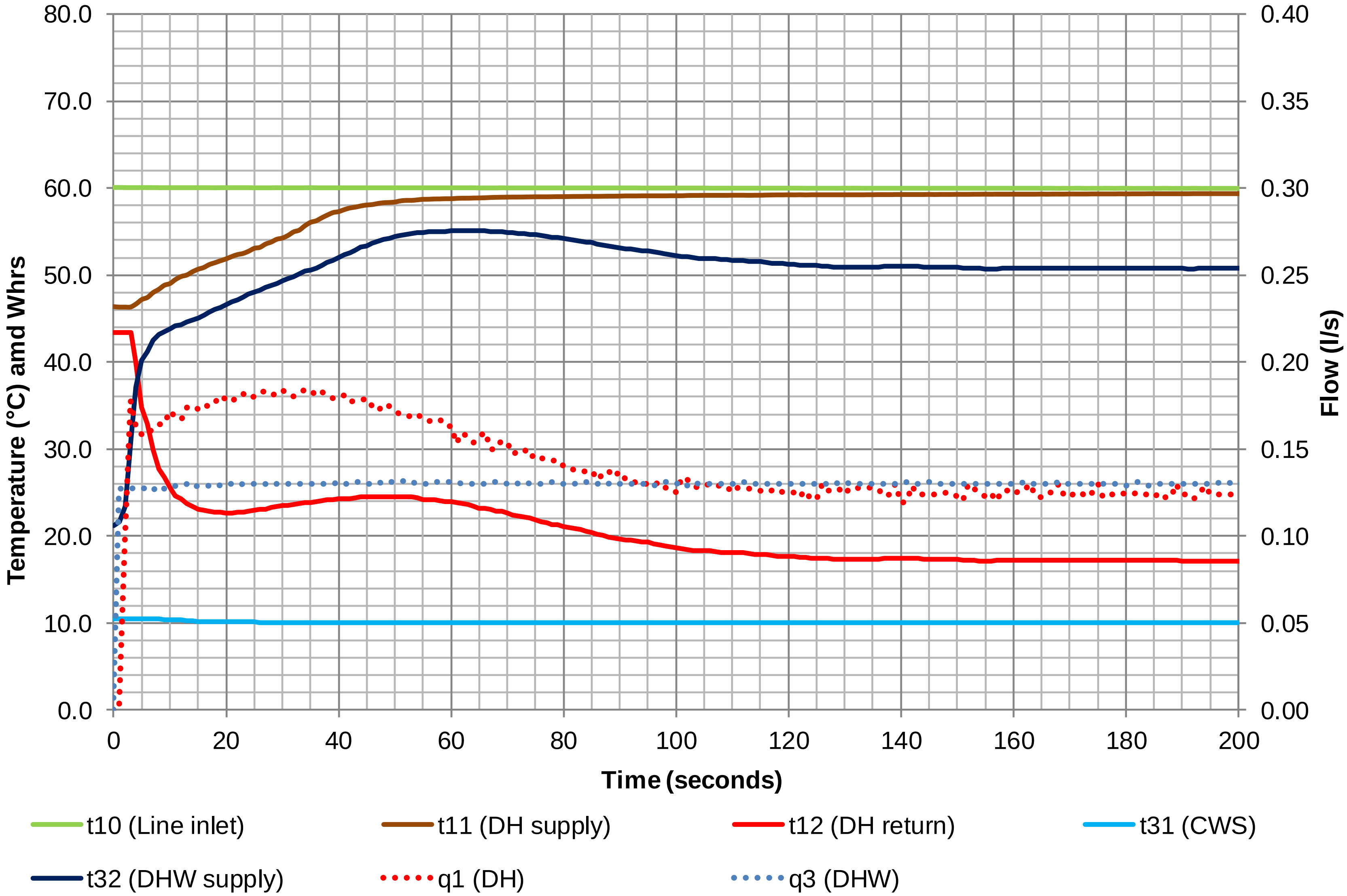


Figure 18 Results for test 5b: DHW response time – DH 60°C supply



APPENDIX B: VWART CALCULATIONS

High Temperature VWART Calculations

High Temperature VWART Calculation for Rhico District Heating Products
Primary flow temperature = 70°C, DHW set point = 55°C, Space heating temperatures = 40°C/60°C
Test carried out by BSRIA Ltd. in December 2021/February 2022, Test Reference 102787/1
Manufacturer: Rhico District Heating Products; Model: TI45 UL (Ultra Lean Electronic HIU); Serial number: 428440300/Matr.: A202800460/1; Year of manufacture: 2020
VWART calculation prepared by Colin Judd of BSRIA Ltd. on 28 January 2022

	VWART (°C)	Volume (m^3)
DHW	15	22.8
Keep Warm	40	34.6
Space Heating	44	50.6

	VWART with keep warm active	
Period	VWART (°C)	% Time
No Heating	30	93%
Heating	43	7%
Overall	31	

	DHW draw test results			Post DHW draw (60 Seconds)	
	Power (W)	Primary Flow (m^3/hr)	Return Temp (VWART) (°C)	Primary Flow (m^3/hr)	Return Temp (VWART) (°C)
Low	11074	0.166	13.7	0.002	13.58
Medium	18880	0.299	15.2	0.004	14.73
High	24655	0.390	15.9	0.002	15.47

	DHW draw volumes per annum			Post DHW draw volumes per annum		
	Energy (kWh)	Time (Hours)	Volume (m^3)	Events	Avg duration (Seconds)	Volume (m^3)
Low	729	65.83	10.901	10000	30	0.138
Medium	297	15.73	4.696	660	75	0.059
High	444	18.01	7.022	300	145	0.022

Keep warm test results	
Primary Flow (m^3/hr)	Return Temp (VWART) (°C)
0.0043	40.2

Keep Warm volumes per annum	
Time (Hours)	Volume (m^3)
8024	34.588

	Space Heating Test Results			Space Heating volumes per annum		
	Power (W)	Primary Flow (m^3/hr)	Return Temp (VWART) (°C)	Energy (kWh)	Time (Hours)	Volume (m^3)
1kW	1009	0.036	42.5	98	97.16	3.498
2kW	1984	0.068	43.9	787	396.70	27.134
4kW	3974	0.140	45.3	565	142.17	19.961

Low Temperature VWART Calculations

Low Temperature VWART Calculation for Rhico District Heating Products
Primary flow temperature = 60°C, DHW set point = 50°C, Space heating temperatures = 35°C/45°C
Test carried out by BSRIA Ltd. in December 2021/February 2022, Test Reference 102787/1
Manufacturer: Rhico District Heating Products; Model: TI45 UL (Ultra Lean Electronic HIU); Serial number: 428440300/Matr.: A202800460/1; Year of manufacture: 2020
VWART calculation prepared by Colin Judd of BSRIA Ltd. on 08 February 2022

	VWART (°C)	Volume (m^3)
DHW	16	28.7
Keep Warm	41	49.3
Space Heating	37	53.8

	VWART with keep warm active	
Period	VWART (°C)	% Time
No Heating	32	93%
Heating	36	7%
Overall	32	

	DHW draw test results			Post DHW draw (60 Seconds)	
	Power (W)	Primary Flow (m^3/hr)	Return Temp (VWART) (°C)	Primary Flow (m^3/hr)	Return Temp (VWART) (°C)
Low	9807	0.183	14.5	0.003	14.46
Medium	16672	0.330	16.1	0.003	15.86
High	21893	0.437	16.9	0.006	16.61

DHW draw volumes per annum		
Energy (kWh)	Time (Hours)	Volume (m^3)
729	74.33	13.580
297	17.81	5.873
444	20.28	8.857

Post DHW draw volumes per annum		
Events	Avg duration (Seconds)	Volume (m^3)
10000	30	0.251
660	75	0.043
300	145	0.073

Keep warm test results	
Primary Flow (m^3/hr)	Return Temp (VWART) (°C)
0.0061	41.2

Keep Warm volumes per annum	
Time (Hours)	Volume (m^3)
8011	49.256

	Space Heating Test Results		
	Power (W)	Primary Flow (m^3/hr)	Return Temp (VWART) (°C)
1kW	1106	0.043	36.3
2kW	1930	0.069	35.8
4kW	4038	0.156	37.4

Space Heating volumes per annum		
Energy (kWh)	Time (Hours)	Volume (m^3)
98	88.64	3.825
787	407.72	28.117
565	139.93	21.839

APPENDIX C: CERTIFICATE OF CONFORMITY SUPPLIED BY THE CLIENT

LOVATO
Smart Energy Solutions

Declaration of Conformity EU

Produttore: Lovato S.P.A

Indirizzo: Via Selva 4/A, 37040 Gazzolo d'Arcole (VR)

D E C L A R E S

on its own responsibility that the **TI45 Ultra Lean** equipment is constructed in accordance with the directives:

- 2014/30 /UE (direttiva EMC)
- 2014/35/UE (direttiva LVD)
- 2011/65/UE (direttiva RoHS2)

The company Lovato S.p.A. also declares that the following standards have been applied for the design and construction verification of the equipment:

- EN61010-1:2010/A1:2019
- EN 55014-1:2017-04
- EN 55014-2:2015-04
- EN 60335-1:2019-10

The technical documentation proving compliance with legal requirements is kept at our premises in Gazzolo d'Arcole, Via Selva 4/a.

Il rappresentante legale

Lovato Michele

Gazzolo d'Arcole
data 18/01/2021

Dichiarazione n. 005

Declaration of Incorporation for partly completed machinery
Machinery Directive 2006/42/CE, Annex II., B

Manufacturer: *Lovato S.P.A*
Address: *Via Selva 4/A, 37040 Gazzolo d'Arcole (VR)*

Name and address of the person authorised to compile the relevant technical documentation.

Name : *Lovato S.P.A.*
Address: *Via Selva 4/A, 37040 Gazzolo d'Arcole (VR)*
Declares with the present document that the partly completed machinery:

HEATING INTERFACE UNIT TI45 Ultra Lean

- The following essential requirement to the Machinery directive(2006/42/CE) are applied and fulfilled:1.1,1.1.2,1.1.3,1.1.5,1.1.6,1.2.1,1.2.2,1.2.3,1.2.4,1.2.4.1, 1.2.4.2,1.2.4.3,1.2.5,1.2.6,1.3.1,1.3.2,1.3.3,1.3.4,1.3.6,1.4.1,1.4.2,1.4.2.1,1.5.1, 1.5.5,1.6.1,1.6.5,1.7.3.

- The relevant technical documentation is compiled in accordance with Part B of Annex VII; the documentation or part of it will be sent per post or by e-mail, in response to the specified request by the competent national authorities.

- This partly completed machinery is in compliance with the following CE Directive: 2006/95CE, 2004/108CE

- Electrical safety test is carried out according to the standard EN60335-1

And also declares that the partly completed machinery must not be put into service until the final machinery into which it is to be incorporated has been declared in conformity, where appropriate, with the Machinery Directive 2006/42/CE.

LOVATO S.p.A.
Lovato Michele
Chief Executive Officer

Gazzolo d'Arcole
data 01/03/2020

Dichiarazione n. 005