BESA HIU Test Report

IVAR-ESAT DUAL

Carried out for

I.V.A.R S.p.A

Report 101858/1

Compiled by Colin Judd

4 August 2020




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BESA HIU Test Report

IVAR-ESAT DUAL

Carried out for:	I.V.A.R S.p.A Via IV Novembre 181 25080 Prevalle Italy
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QUALITY ASSURANCE

Issue	Date	Compiled by:	Approved by:	Signature
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1 INTRODUCTION

BSRIA carried out a series of tests on one heat interface unit (HIU), the IVAR-ESAT DUAL, manufactured by I.V.A.R S.p.A. Testing was 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 June 2020. Charts of outputs obtained from this series of tests are shown in Appendix A of this report.

2 ITEM RECEIVED FOR TEST

The HIU received for testing was a I.V.A.R S.p.A IVAR-ESAT DUAL. 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 that 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	ESAT DUAL code 500429C
Serial Number	500429C20200603014
Firmware	V1.0.0
Height	771 mm
Width	488 mm
Depth	271 mm
Total unit weight	34.8 kg (including cover)
Maximum DHW output	56 kW (manufacturer supplied data)
Maximum central heating output	20 kW High Temperature (manufacturer supplied data) 12 kW Low Temperature (manufacturer supplied data)
Maximum primary supply temperature	90°C
Recommended minimum DP	0.5 bar
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	8 l
Ball valve connections	¾" Male flat seal connection
Safety relief valve connection	½" Male connection, copper discharge pipe diameter 15 x 1 mm included
Electrical power supply voltage	230 V AC±10%
Frequency	50/60 Hz

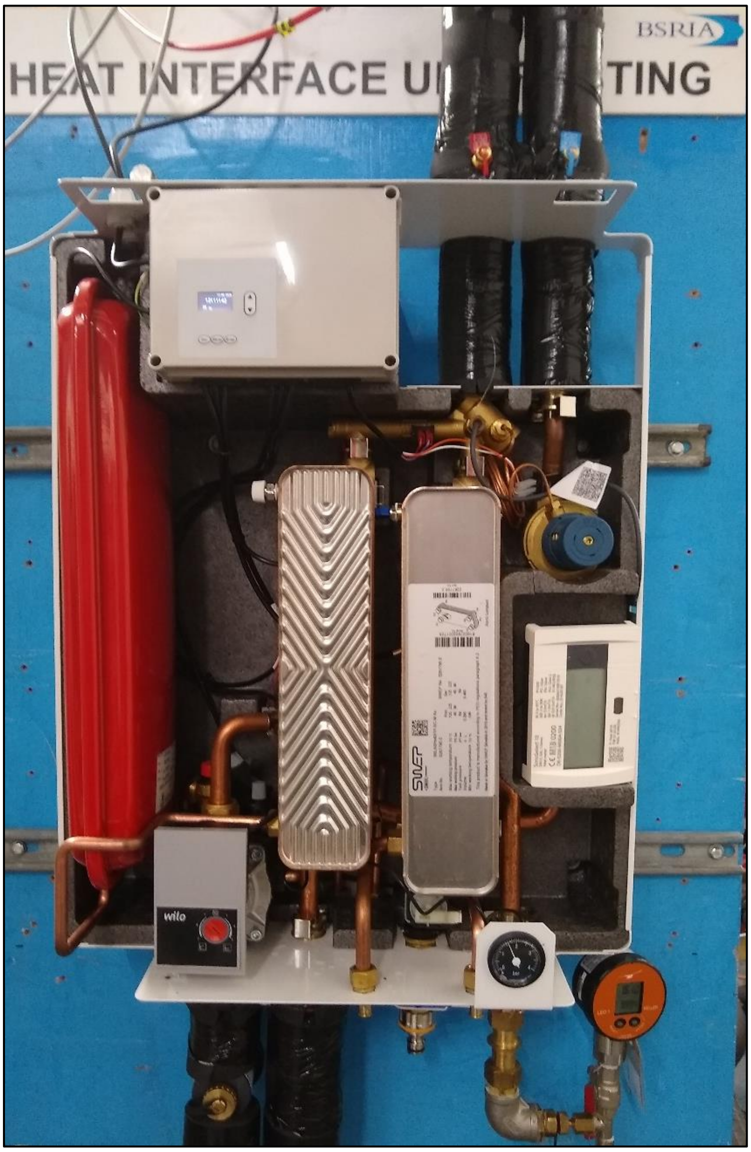
Table 2 gives a component list for the HIU as supplied by the Client.

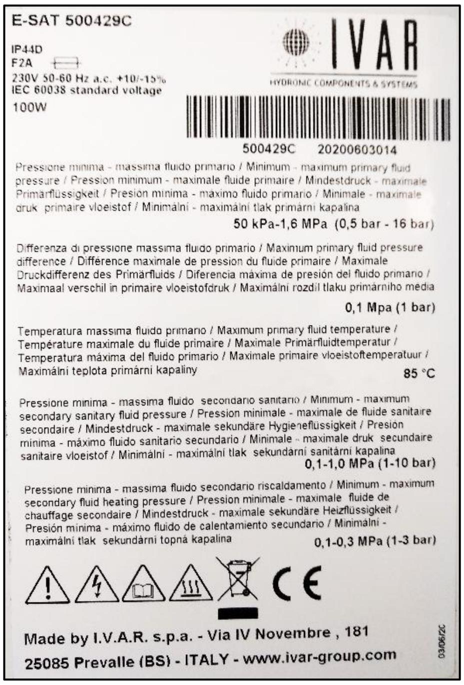
Table 2 HIU Component list

Description	Manufacturer
Space heating heat exchanger	SWEP E8ASHx22/1P-SC-S
DHW heat exchanger	SWEP B8LAS x 40/1P-SC-M
DHW flowmeter	Eltek code 10.0884.25.02
Check Valve on DCW inlet	Neoperl – DW15GF
Check Valve on filling circuit	Neoperl – DW10
Temperature sensors	Clip sensor: TRECI srl mo14del 36JB –NTC 10kOhm Beta 3435 @ 25°C Immersion sensor: TRECI srl model 95JB – NTC 10kOhm Beta 3435 @ 25°C
Primary side strainer	IVAR 500 micron
Control valve and actuator for space heating and DHW	Control valve by IVAR, stepper motor D0365 from FUGAS spa
Heat Meter	Danfoss SonoSelect 10 DN15, qp 1,5, G ¾, 110 mm
Differential pressure control valve	IVAR Equifluid G ¾ male 50-300 mbar (adjusted setting 300 mbar)
Circulation pump	WILO pump block Yonos PARA MSL12/7.0-RKA W MFR 12
Safety valve	Included in pump block
Automatic air vent valve	Included in Pump block for Space Heating circuit
Manometer	CEWAL 0-4 bar code 4005406
Expansion Vessel	Varem (8l) code C6008931K0G10000
Space heating strainer	IVAR Dirststop magnetic filter code 520049 Recommended and installed outside HIU on SH return
Pipes	Copper pipes diam. 18/1
Drain Valves	Included in Pump block for Space Heating circuit IVAR for DHW circuit and for primary circuit
Joint and connections	IVAR brass
Controller for DHW and Space Heating	IVAR code 602660 version 1.0.0

Figure 1 shows the IVAR-ESAT DUAL installed in the test rig with the cover removed. A photograph of the name plate is also included.

Figure 1 IVAR-ESAT DUAL installed in the test rig





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

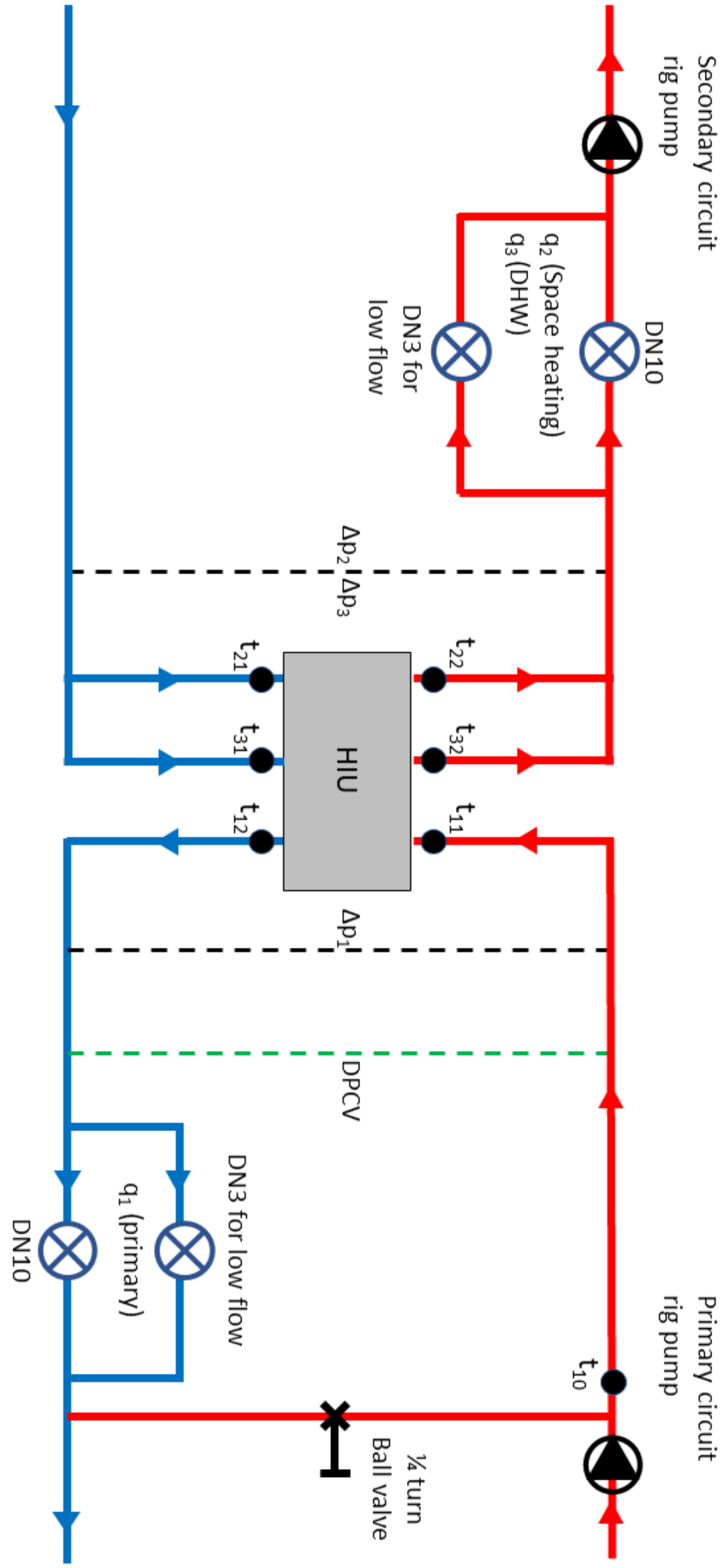
Instrument	Manufacturer	Range	Units	ID No.	Calibration Due
Keysight logging system	Keysight	N/A	N/A	1595	N/A
Static pressure transducer DHW circuit – Pressure test Primary circuit for all thermal tests	Fuji Electric	0 – 10	Bar	1592	29-04-21
Static pressure transducer SH circuit – Pressure test Secondary circuit for all thermal tests	Fuji Electric	0 – 10	Bar	1593	29-04-21
Platinum Resistance Thermometers (PRTs)* Used for measuring the inlet/outlet parameters during the testing	TC Ltd	1 – 90	°C	1685	05-11-20
Platinum Resistance Thermometer (PRT)	Anville Sensors Ltd	1 – 90	°C	1685	05-11-20
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, 2b, 3c,3d)	Siemens	0 – 0.5	$l.s^{-1}$	1545	27-04-21
Flowmeter – DHW circuit Dynamic tests – (2a, 2b, 3c,3d)	Siemens	0 – 0.2	$l.s^{-1}$	94	27-04-21
Flowmeter – DH circuit Keep warm tests (4a & 4b) DHW response time tests (5a & 5b)	Siemens	0 – 0.07	$l.s^{-1}$	2961	21-01-21
Flowmeter – DHW circuit Keep warm tests (4a & 4b) DHW response time tests (5a & 5b)	Siemens	0 – 0.5	$l.s^{-1}$	94	27-04-21
Differential pressure transducer DH circuit for tests 1a – 1f ,2a, 2b, 3a, 3b, 4a, 4b, 5a,5b	Fuji Electric	0 – 200	kPa	2065	15-01-21
Differential pressure transducer SH and DHW circuit for tests 1a – 1f ,2a, 2b, 3a, 3b, 4a, 4b, 5a,5b	Fuji Electric	0 – 200	kPa	1591	29-04-21
Differential pressure transducer Secondary circuit tests 1a – 1f ,2a, 2b, 3a, 3b, 4a, 4b, 5a,5b	Fuji Electric	0 – 600	kPa	2958	28-04-21
Static pressure transducer Pressure test	Fuji Electric	0 – 30	barg	1582	25-07-20
Digital static pressure gauge – All thermal tests	Keller	0 – 10	Barg	1760	09-03-21
Stopwatch	Micronta	3,601.03	Secs	1119	04-02-21
Tape measure	Stanley	1,000	mm	683	28-02-22
Voltage and power draw	Yokogawa	0-300V 0-25W	V/W	116	20-08-20

*The time constant for these temperature sensors is ≤ 1.5 s.

The calibration certificates for all the instrumentation used during this series of tests are available on request from BSRIA (test@BSRIA.co.uk)

Figure 2 shows a schematic of the test rig layout.

Figure 2 Schematic of the test rig layout



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	±0.72 kPa
Differential pressure, district heating	*Not supplied*	±0.08 kPa
Differential pressure, domestic hot water	±1 kPa	±0.06 kPa
Differential pressure, space heating	±1 kPa	±0.06 kPa
Temperature	±0.1°C	±0.023°C
Volume flow (≥ 0.06 l/s)	±1.5%	0.0003 l/s
Volume flow (< 0.06 l/s)	To be specified in conjunction with each measurement	0.0004 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 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.

3.5 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.

3.6 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.

3.7 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. 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.

3.8 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.

3.9 TEST SET UP

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. 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

Test	Description	Reporting	Pass/Fail
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 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.

4.1 PRESSURE TEST – 0A

The DHW circuit and the space heating circuit were pressurised to 1.5 bar (±5%). 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.

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

The following tests were carried out on the space heating circuit:

- 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 59.5°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 45.0°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 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	40.85	0.009	50.22	1.09	39.98	60.14	0.012	0.99
1b	70.01	41.64	0.017	50.07	2.00	39.99	59.98	0.023	1.89
1c	69.98	43.30	0.037	50.19	4.09	40.13	60.26	0.048	3.97
Uncertainty	±0.018	±0.018	±0.0006	0.031	±0.06	±0.018	±0.018	±0.0006	±0.06
1d	60.08	35.34	0.010	50.10	1.03	35.11	44.61	0.025	0.98
1e	60.16	35.57	0.019	50.32	1.94	35.05	45.39	0.045	1.93
1f	60.28	36.06	0.039	50.47	3.92	35.16	44.75	0.097	3.85
Uncertainty	±0.018	±0.018	±0.0006	0.031	±0.06	±0.018	±0.018	±0.0007	±0.04

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

4.3.1 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 52.5°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 62.2°C
- The minimum DHW temperature was 43.7°C
- Details of the scaling risk are given in Table 9

Result – Pass

4.3.2 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 48.0°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 54.7°C
- The minimum DHW temperature was 39.7°C

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

4.4 LOW FLOW DHW TESTS – 3A AND 3B

4.4.1 Test 3a

Test 3a 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 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 set 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 50.1°C and ranged from 55.9°C to 41.7°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 62.2°C and 32.3.0°C respectively during the 180 second test.
- Details of the scaling risk are given in Table 9

Result – Pass

4.4.2 Test 3b

Test 3b 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 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 set 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 50.7°C and ranged from 51.4°C to 48.7°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 57.3°C and 31.1°C respectively

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

4.5 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.

4.5.1 Test 4a

Test 4a 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 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 keep warm settings in the HIU control software were as follows:

T08 Yes
T09 41.0°C
T09 41.5°C
T11 40

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

Once the keep warm function had stabilised (approximately 7,000 seconds into the test), the average t_{11} temperature for the remainder of the test (21,800 seconds) was 46.0°C varying between 47.7°C and 44.3°C.

During test 4a:

- The average heat load during the 8-hour keep warm period was 28 W
- The average primary flow rate during the 8-hour keep warm period was 3.1 l/h
- The average measured voltage was 230.2 V
- The average measured electrical power draw was 2.9 W
- Details of the scaling risk are given in Table 9

4.5.2 Test 4b

Test 4b 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 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 keep warm setting in the HIU control software were as follows:

T08 Yes
T09 42.5°C
T10 43.0°C
T11 40

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

Once the keep warm function had stabilised (approximately 4,500 seconds into the test), the average t_{11} temperature for the remainder of the test (24,300 seconds) was 46.5°C varying between 48.4°C and 45.2°C.

- 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 5.3 l/h
- The average measured voltage was 230.2 V
- The average measured electrical power draw was 2.5 W
- Details of the scaling risk are given in Table 9

4.6 DHW RESPONSE TIME – 5A AND 5B

4.6.1 Test 5a

Test 5a was carried out immediately after test 4a with all the settings and conditions the same.

During test 5a:

- The DHW temperature did not exceed 65.0°C during the test
- The DHW achieved 45.0°C in 15 seconds from the first recorded non-zero DHW flow reading
- The DHW temperature did not subsequently drop below 42.0°C

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

Overall result – Pass

4.6.2 Test 5b

Test 5b was carried out immediately after test 4b with all the settings and conditions the same.

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

4.7 TOTAL SCALING RISK ASSESSMENT

The scaling risk criteria is given in section 2.26 of the test regime. Table 9 gives details of the scaling risk associated with this HIU. If any of the factors given in Table 9 occur, then there is an increased scaling risk of the DHW plate in hard water areas.

Table 9 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	**Yes**	**Yes**
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**

4.8 VOLUME WEIGHTED AVERAGE RETURN TEMPERATURE

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

APPENDIX A: DATA CHARTS

Figure 3 Results for test 1a: 1kW Space heating – DH 70°C supply

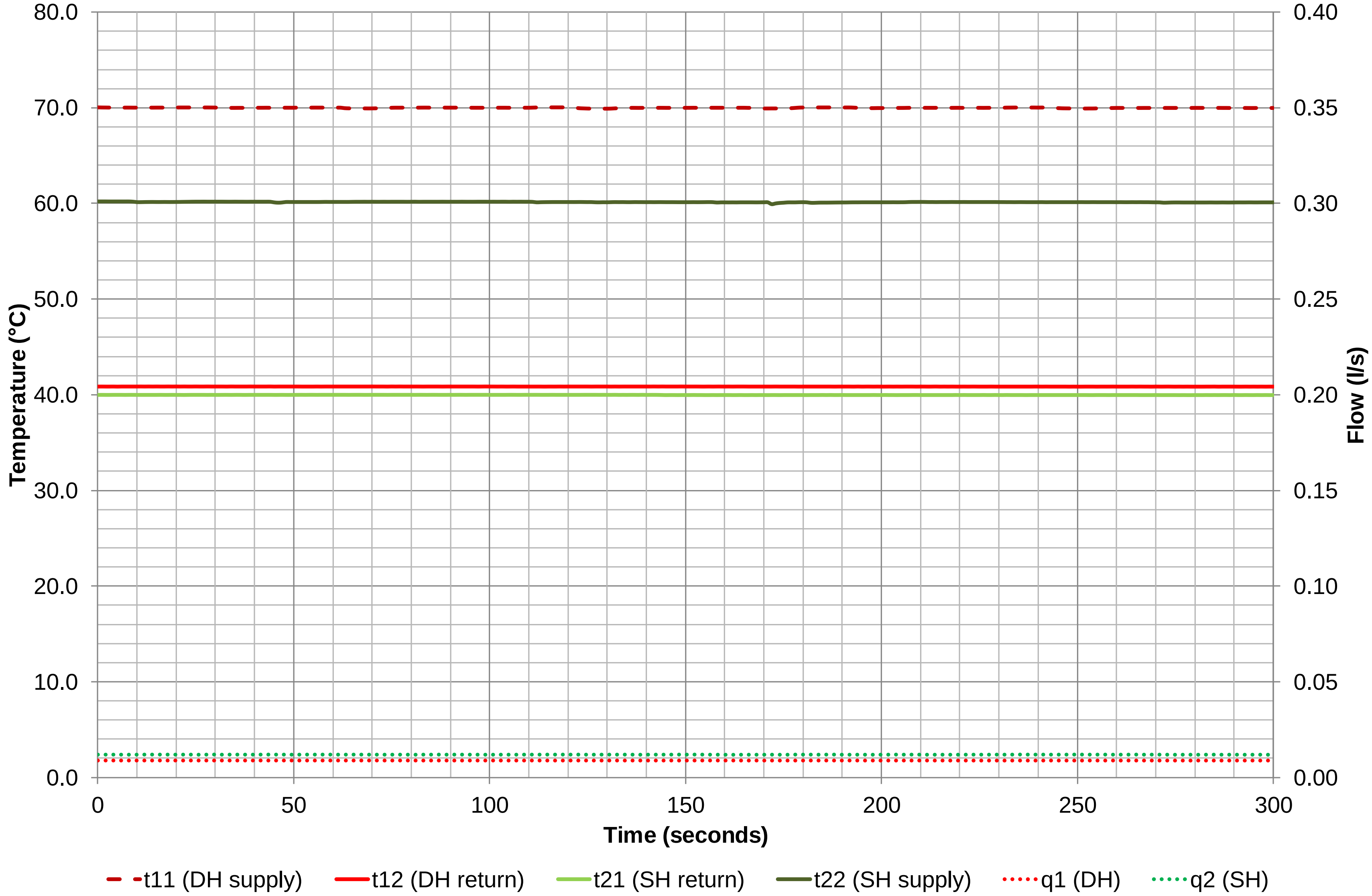


Figure 4 Results for test 1b: 2kW Space heating – DH 70°C supply

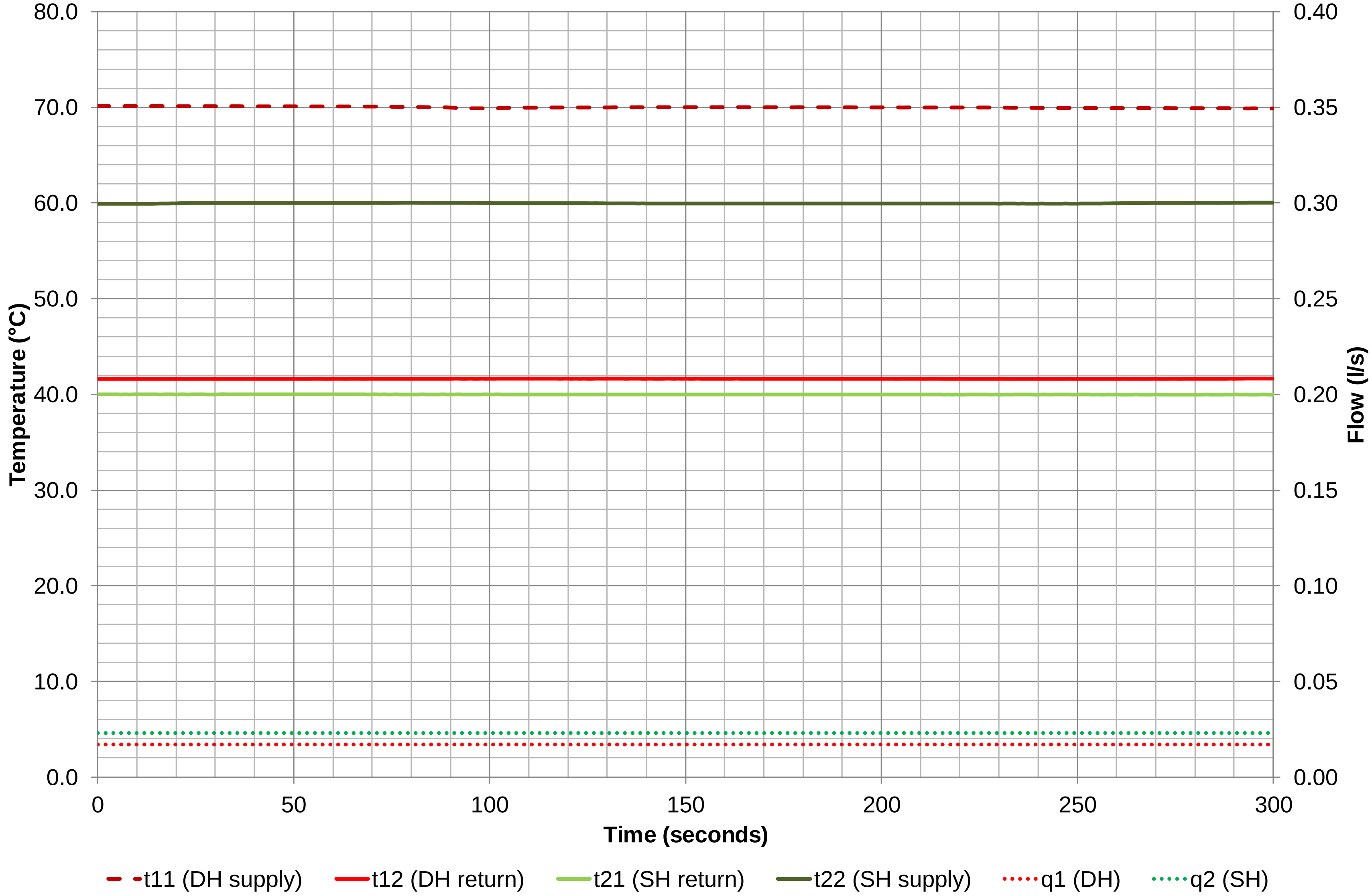


Figure 5 Results for test 1c: 4kW Space heating – DH 70°C supply

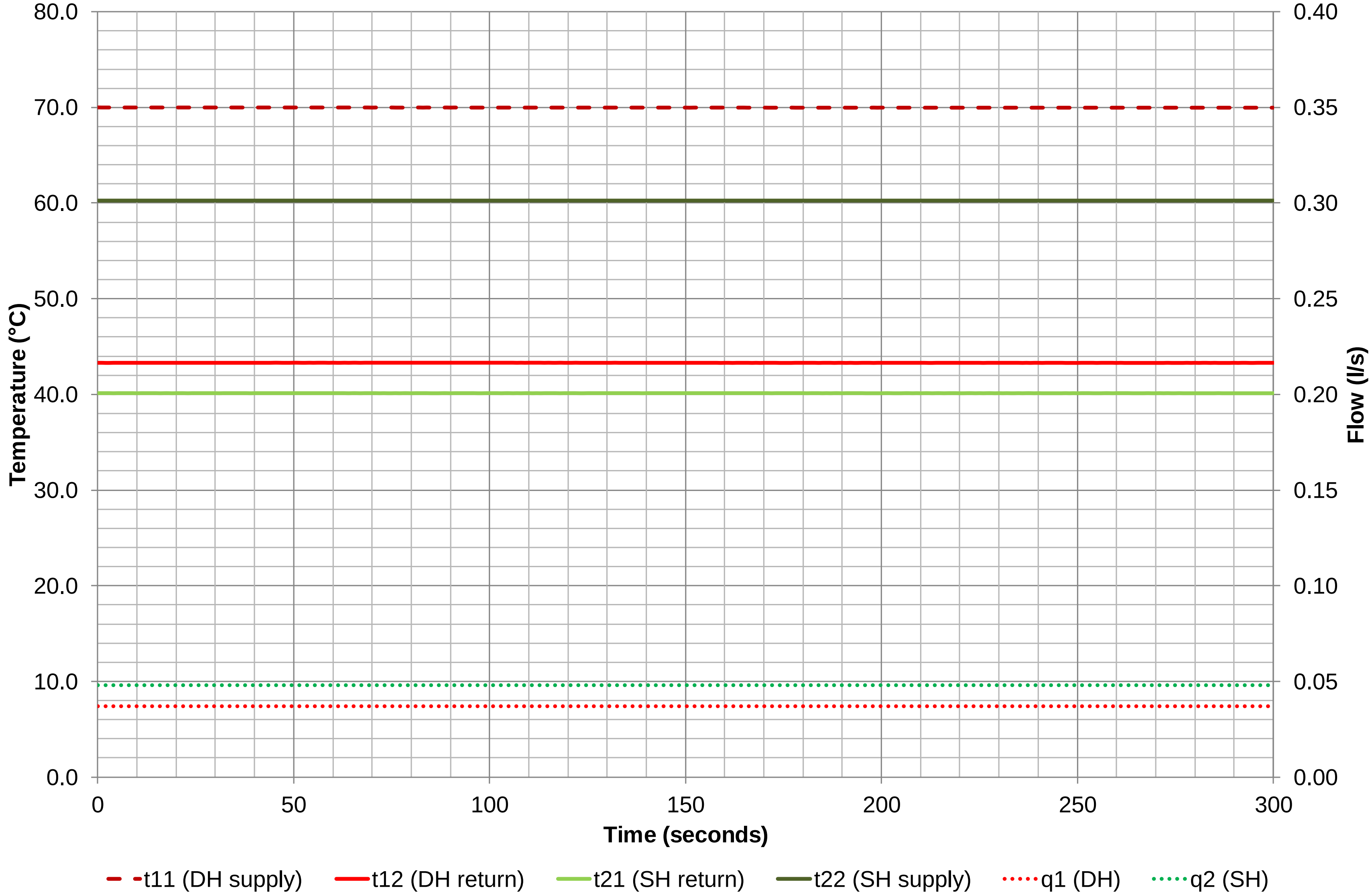


Figure 6 Results for test 1d: 1kW Space heating – DH 60°C supply

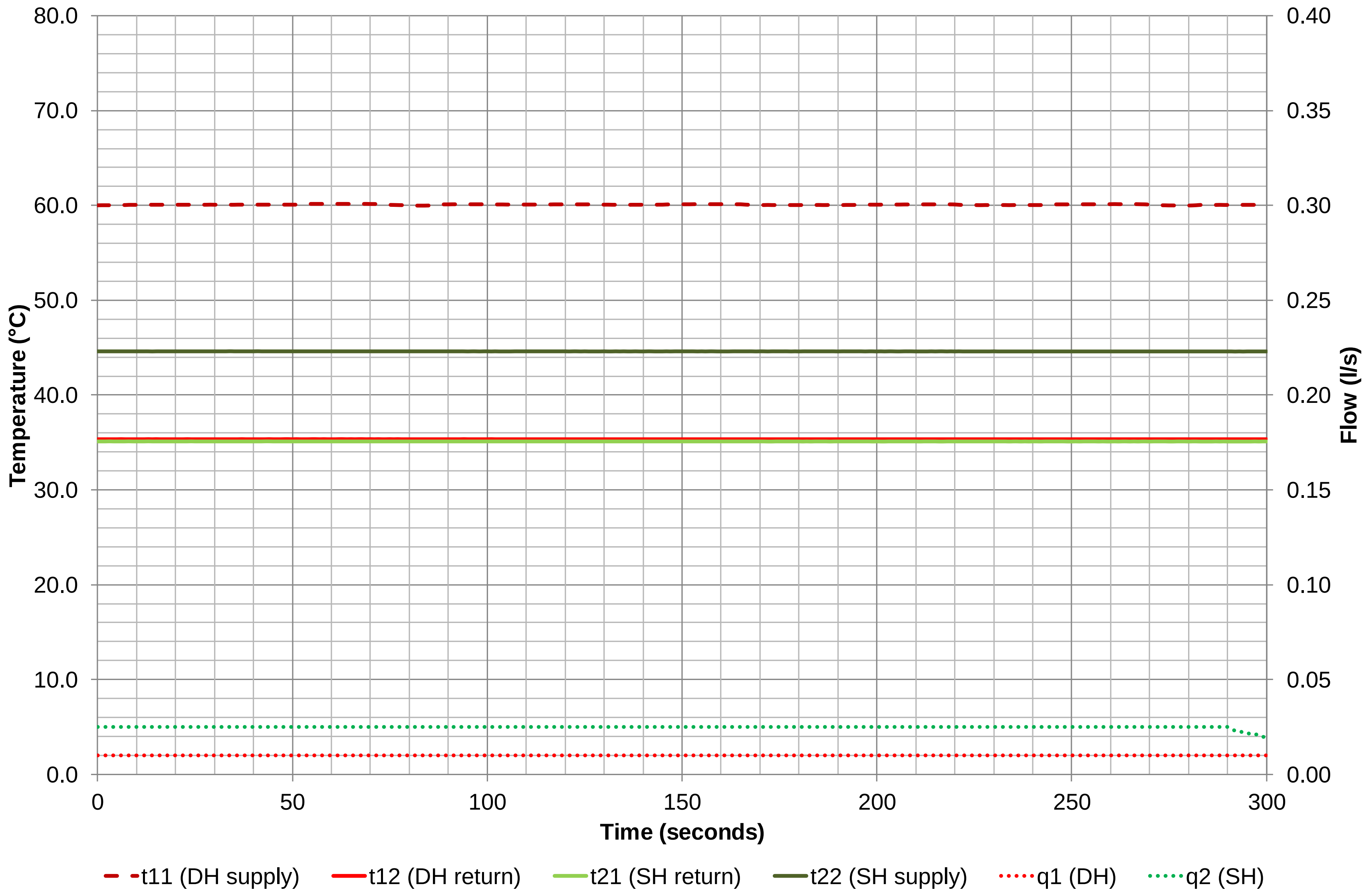


Figure 7 Results for test 1e: 2kW Space heating – DH 60°C supply

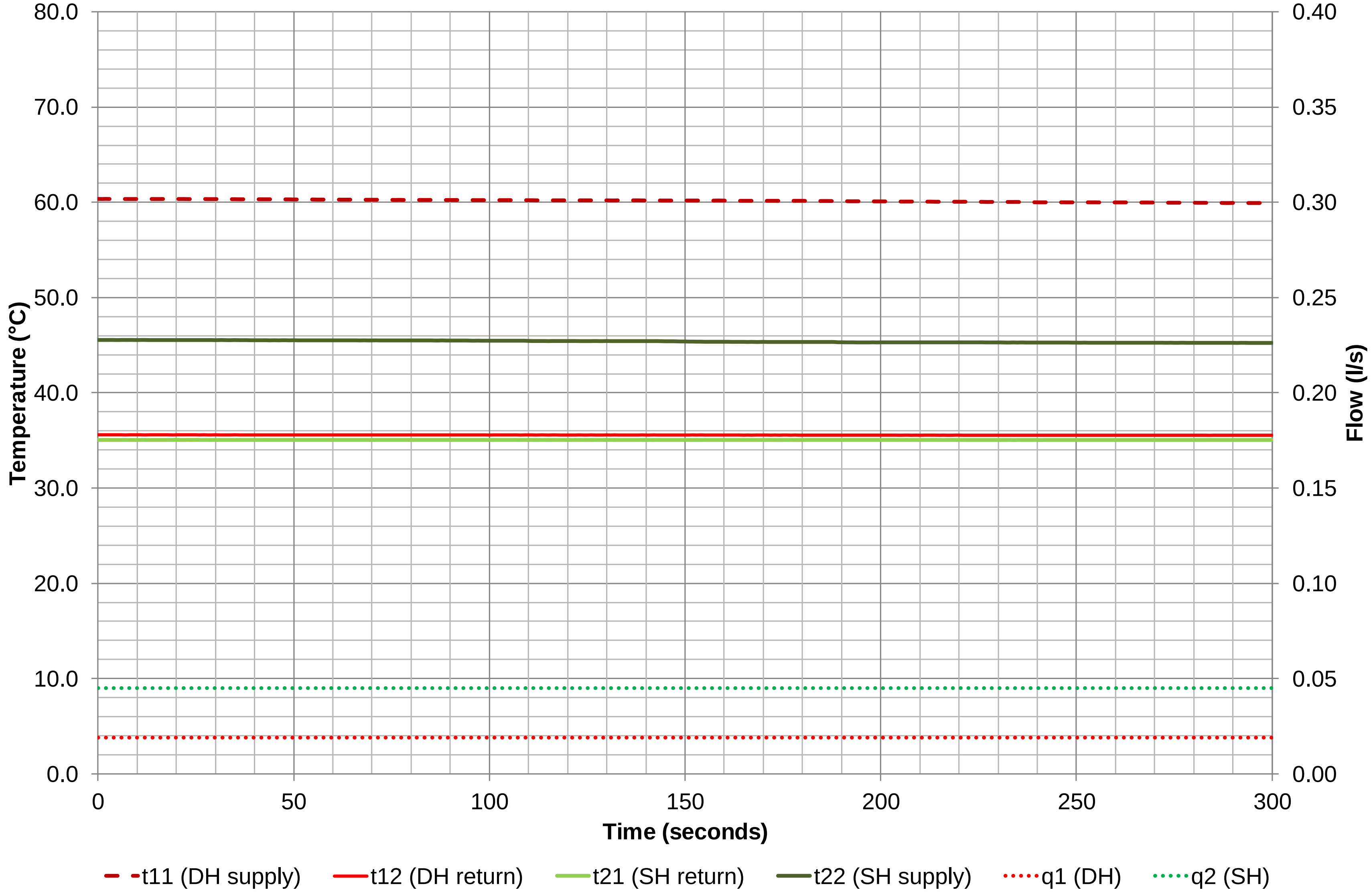


Figure 8 Results for test 1f: 4kW Space heating – DH 60°C supply

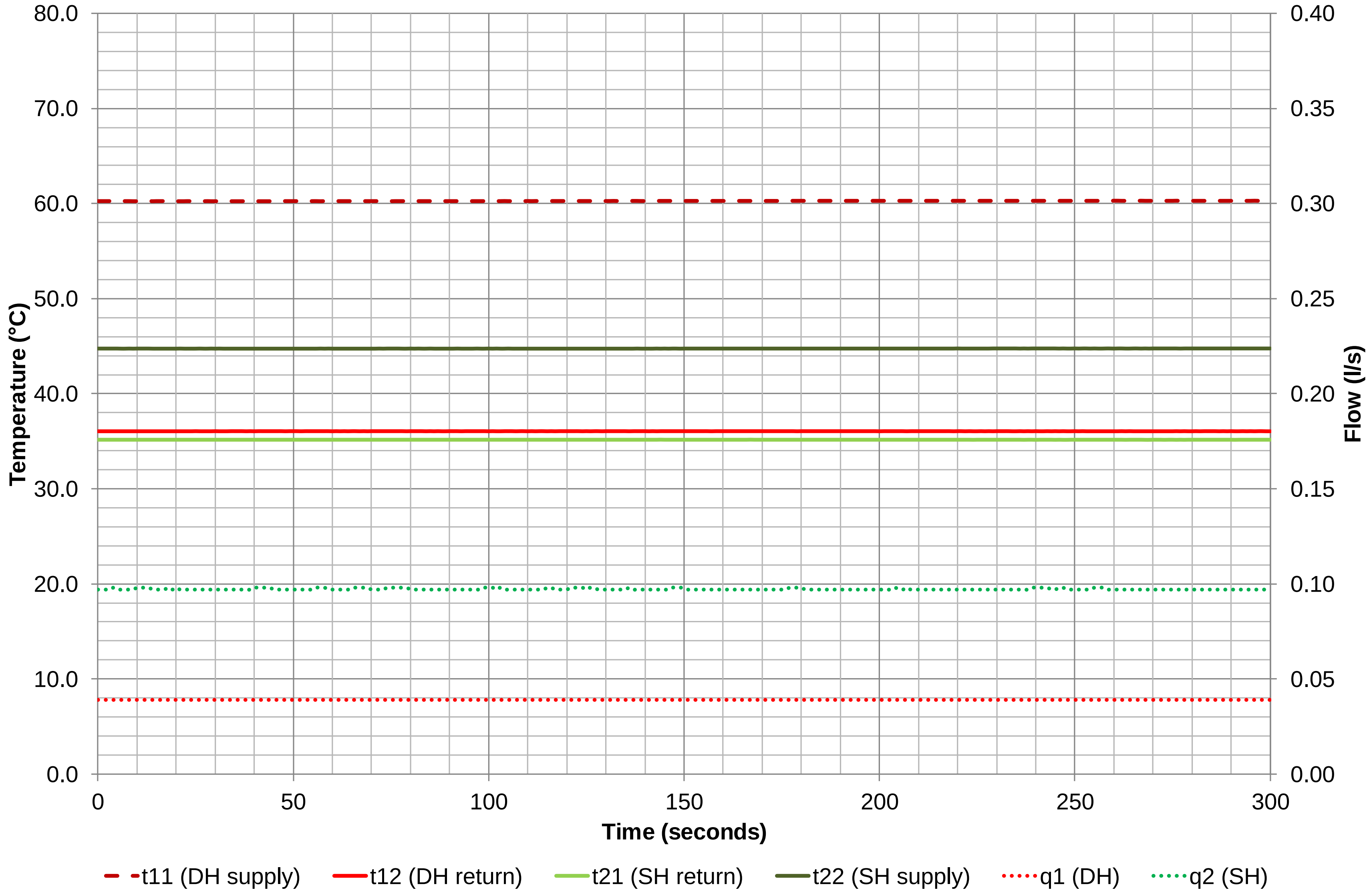


Figure 9 Results for test 2a: DHW dynamic test – DH 70°C supply

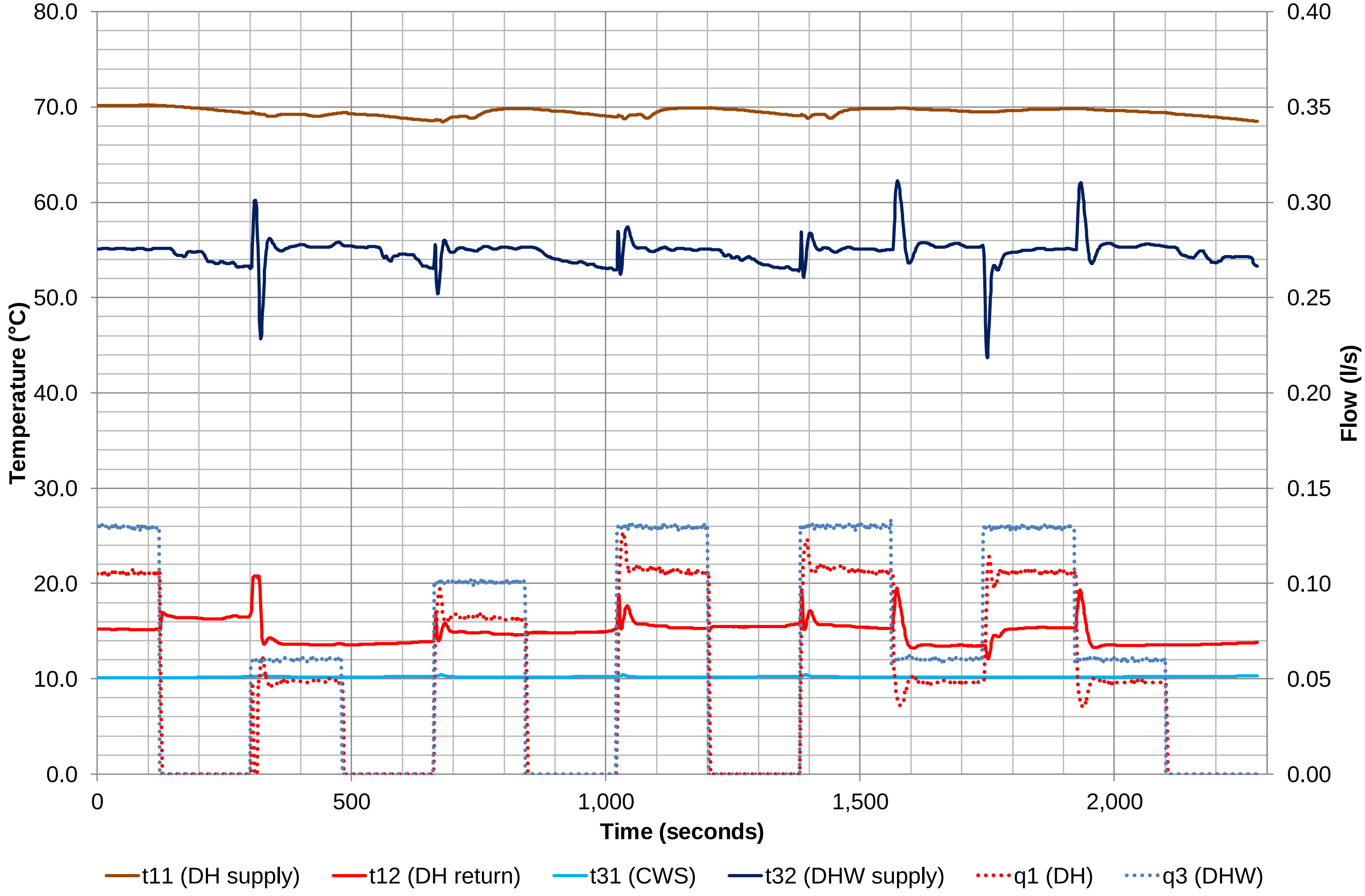


Figure 10 Results for test 2b: DHW dynamic test – DH 60°C supply

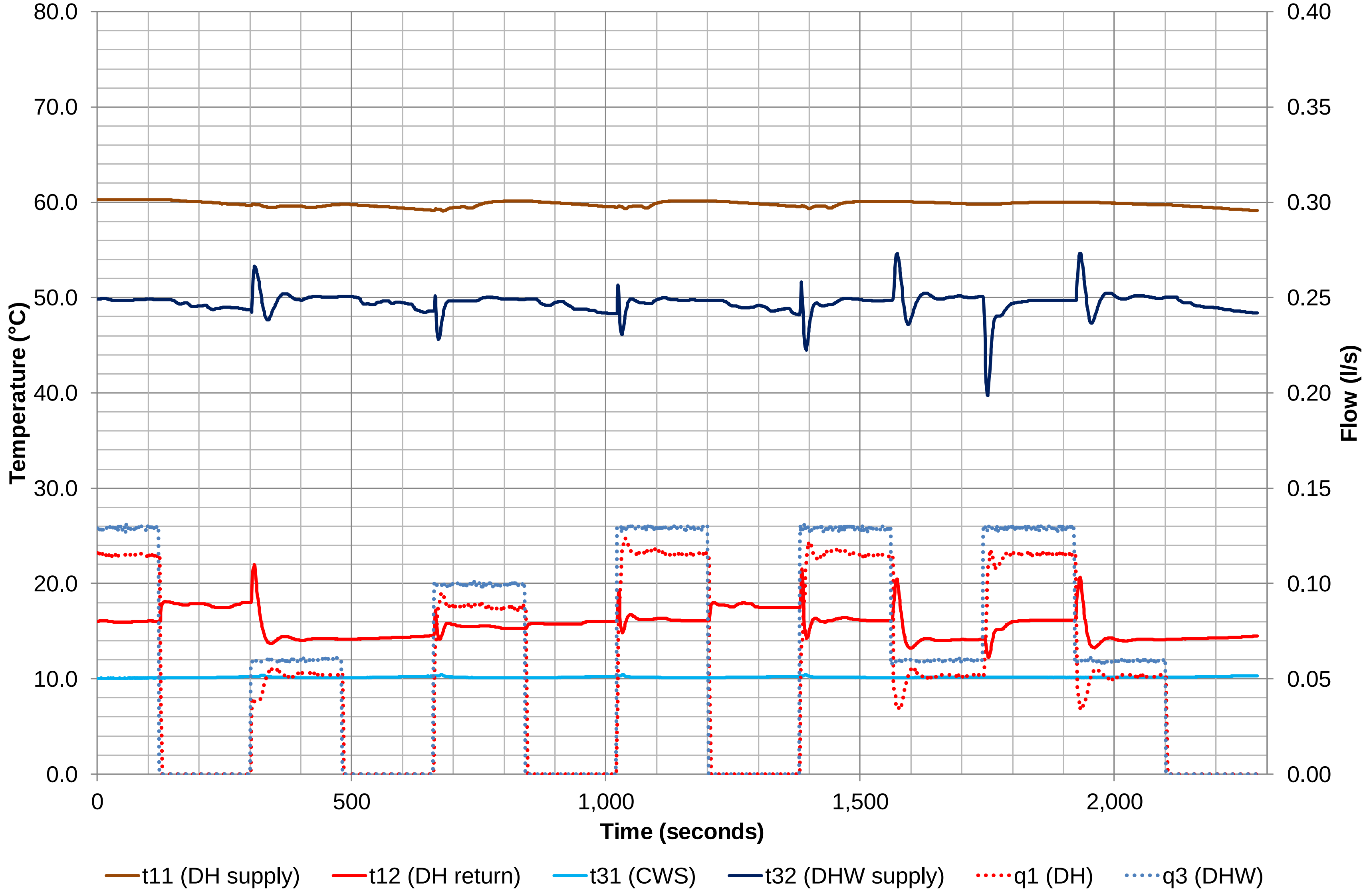


Figure 11 Results for test 3a: Low flow DHW test – DH 70°C supply

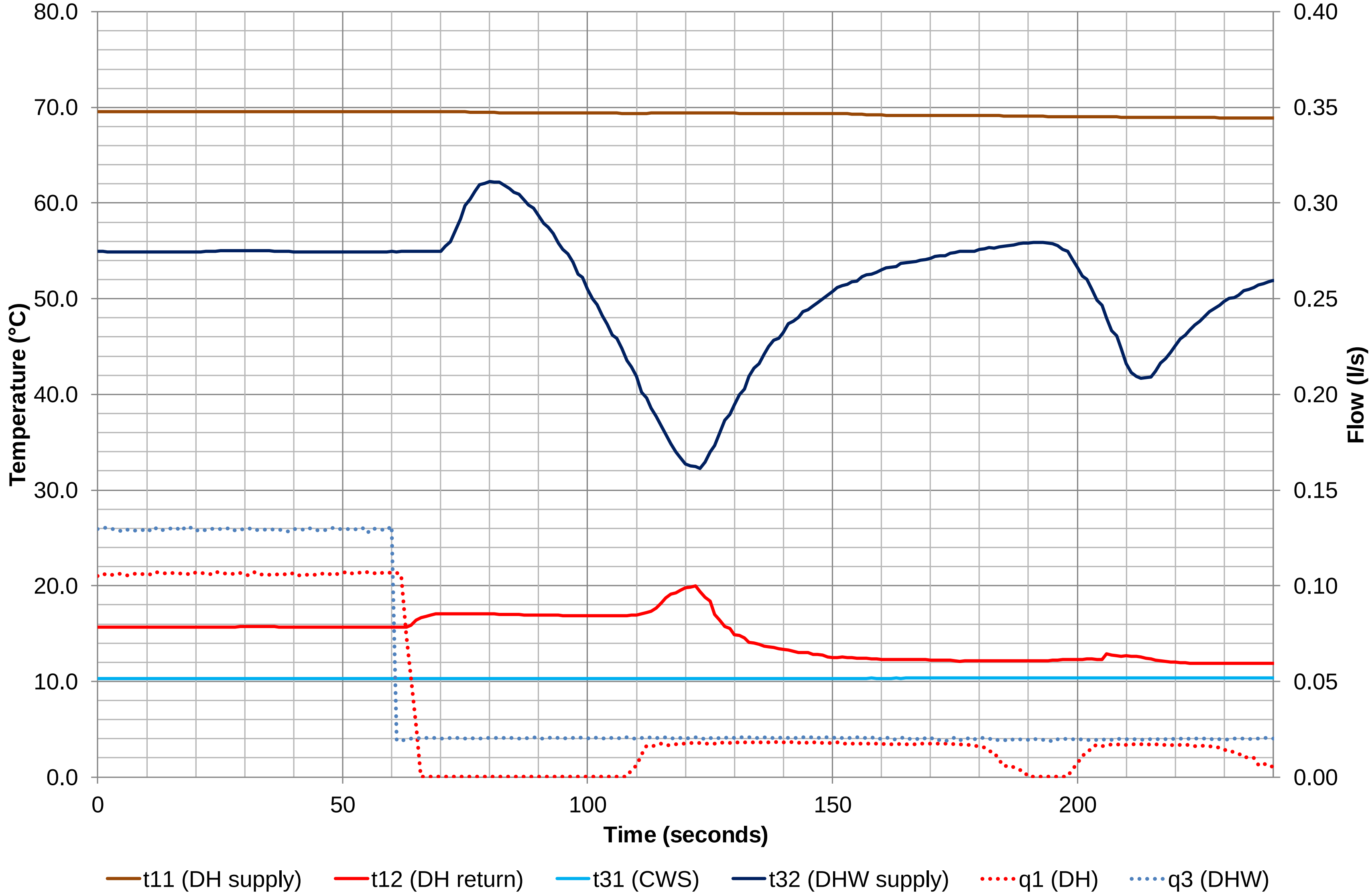


Figure 12 Results for test 3b: Low flow DHW test – DH 60°C supply

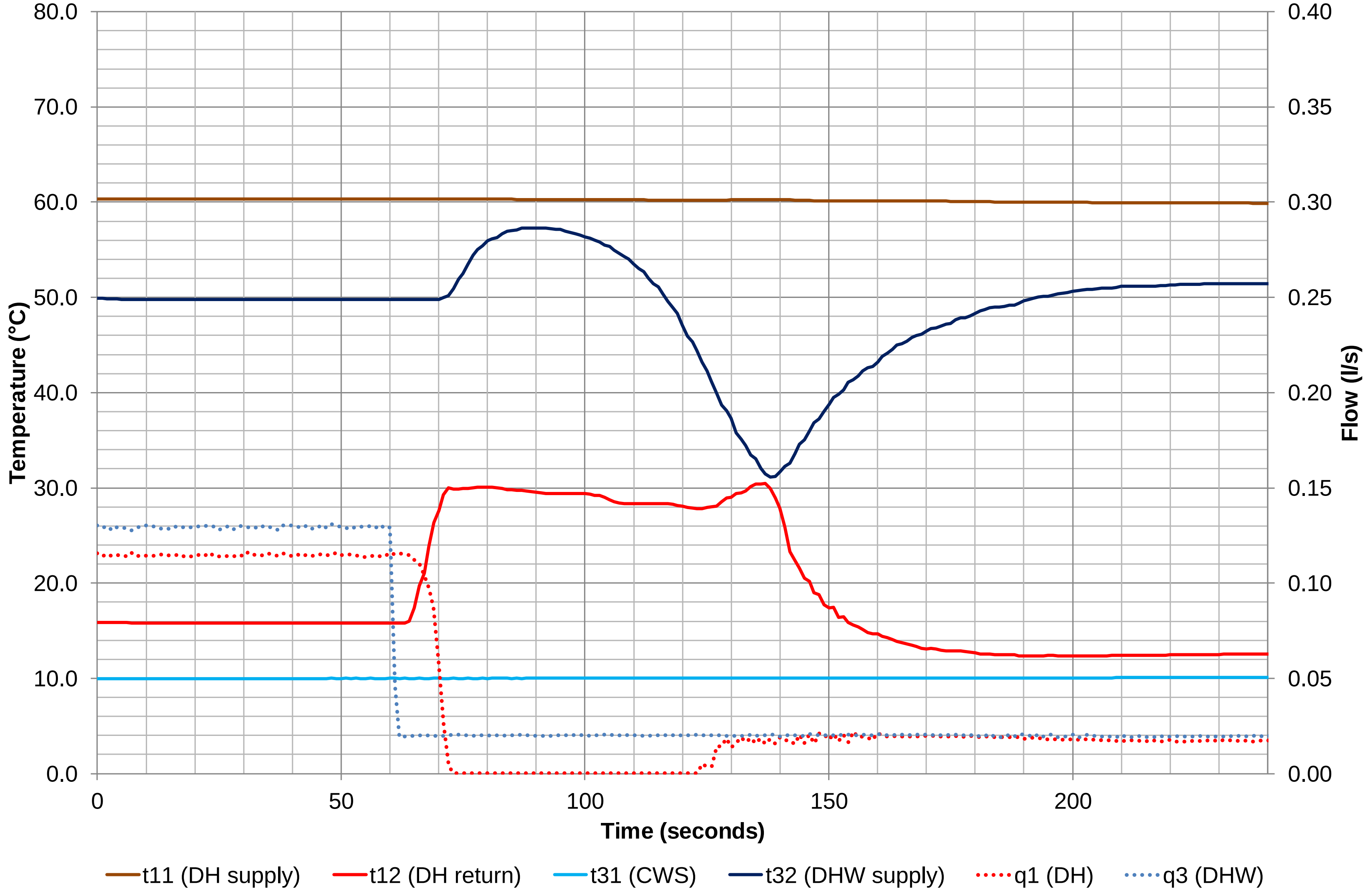


Figure 13 Results for test 4a: Keep warm test – DH 70°C supply

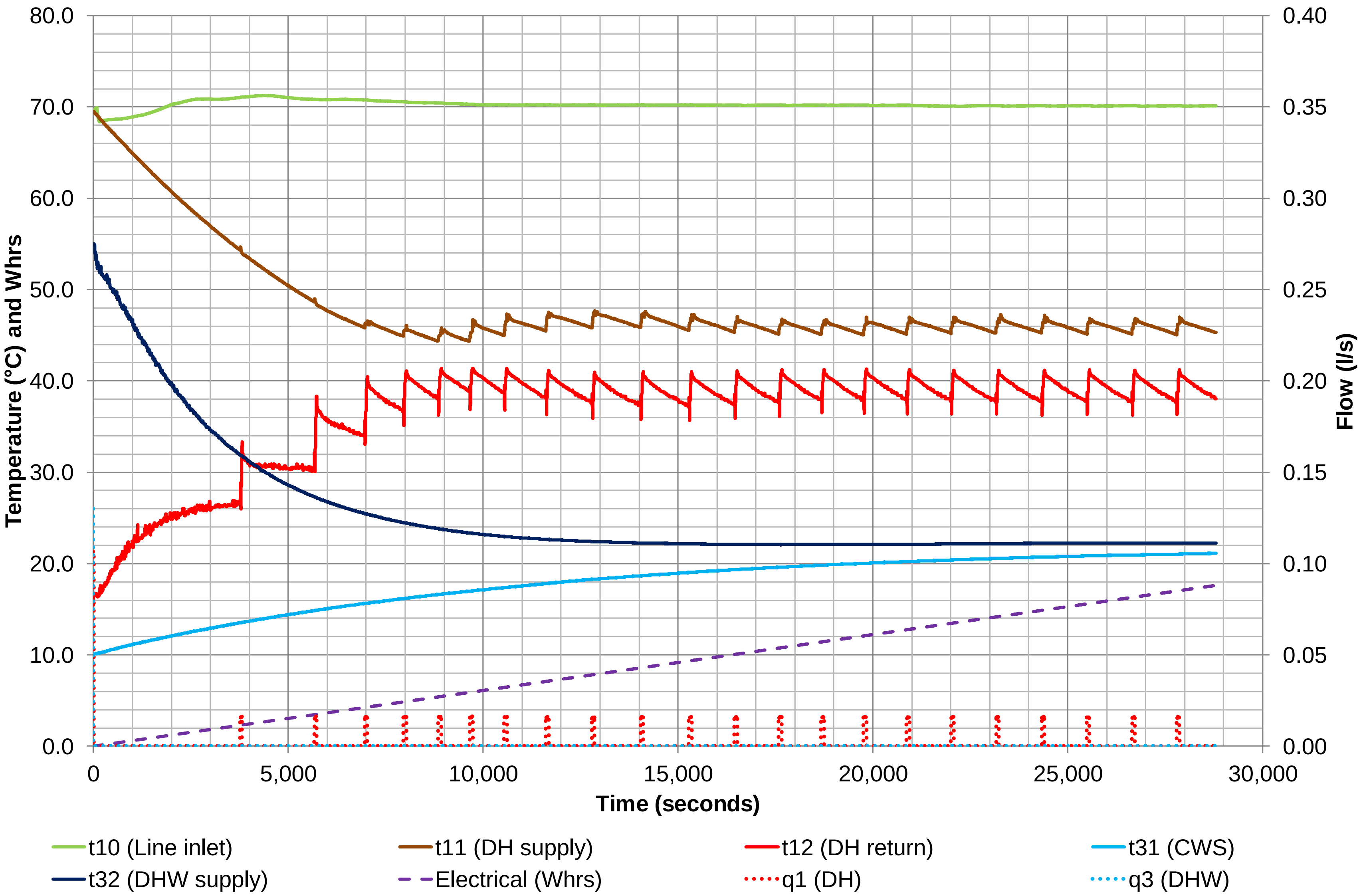


Figure 14 Results for test 4b: Keep warm test – DH 60°C supply

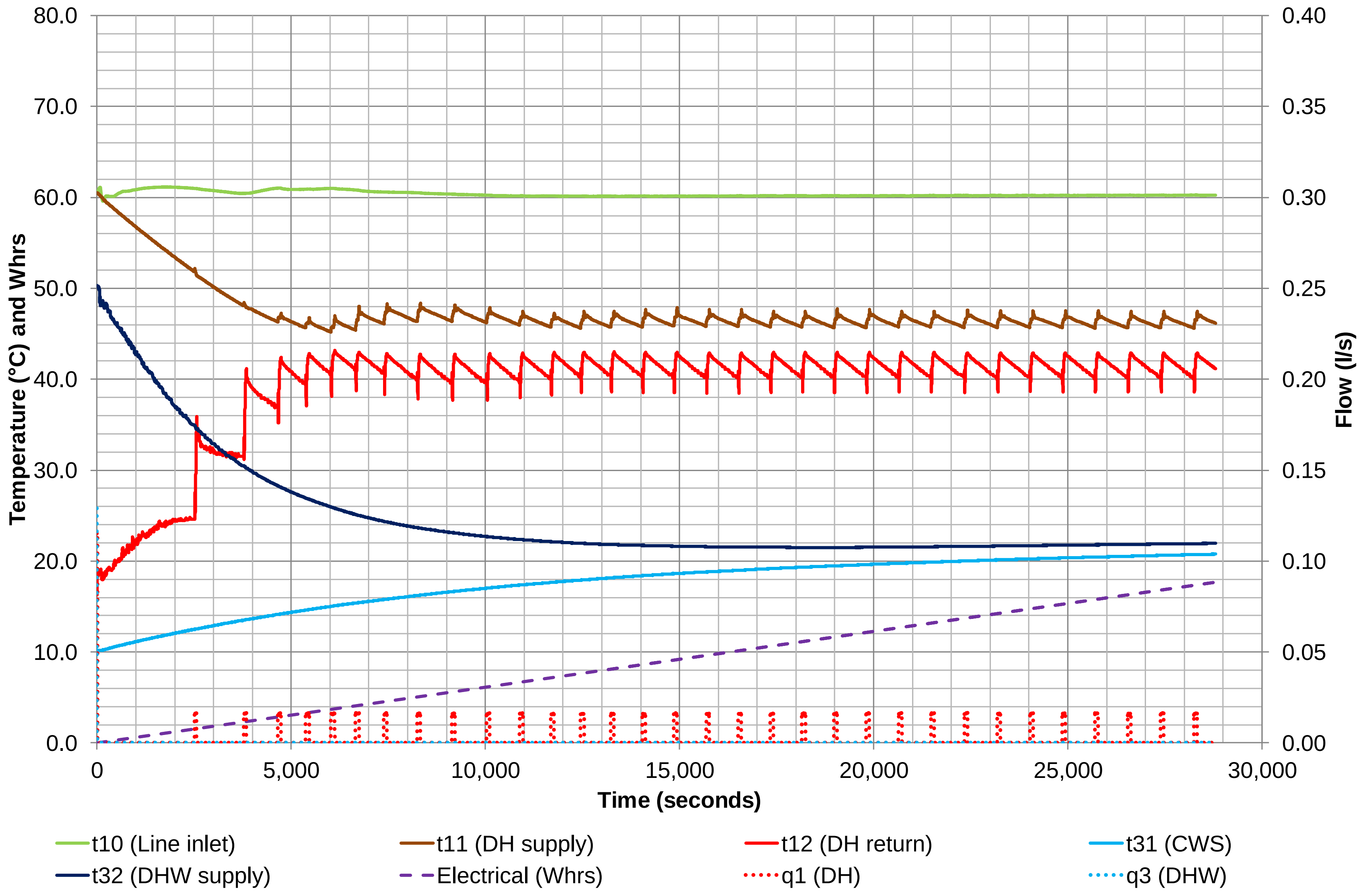


Figure 15 Results for test 5a: DHW response time – DH 70°C supply

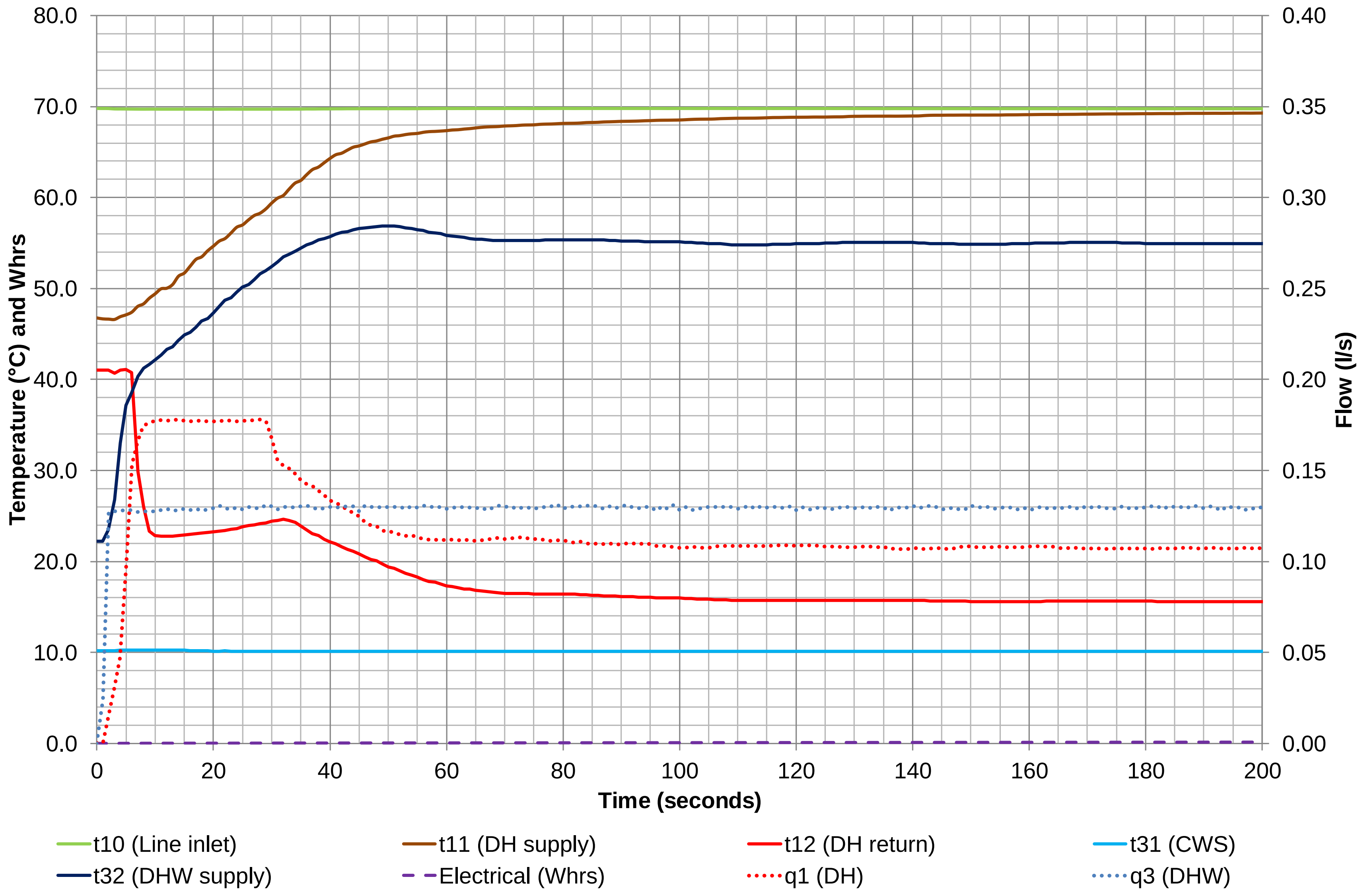
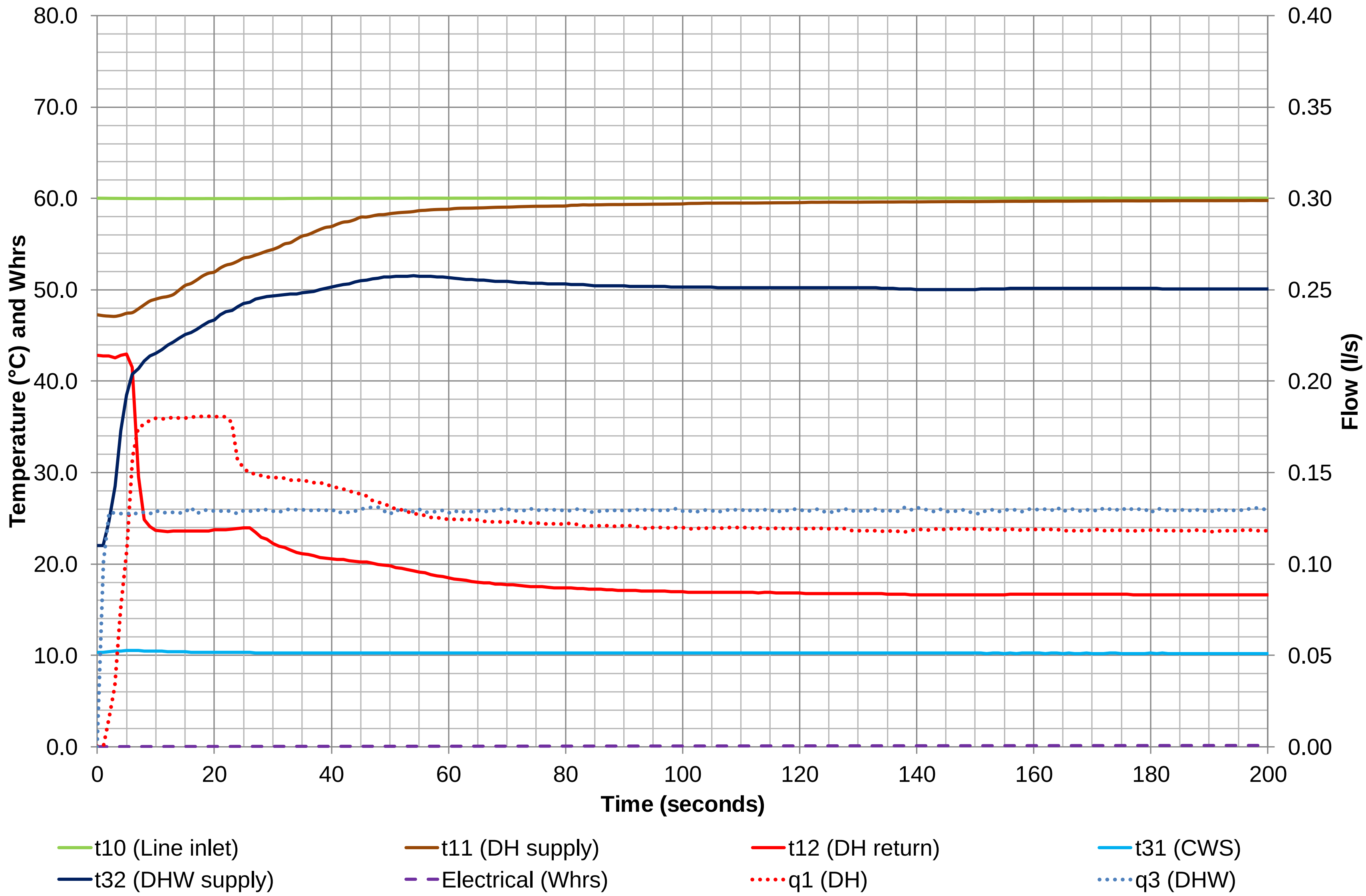


Figure 16 Results for test 5b: DHW response time – DH 60°C supply



APPENDIX B: VWART CALCULATIONS

High Temperature VWART Calculations

High Temperature VWART Calculation for I.V.A.R S.p.A HIU
Primary flow temperature = 70°C, DHW set point = 55°C, Space heating temperatures = 40°C/60°C
Test carried out by BSRIA Ltd. in June 2020, Test Reference 101858/1
Manufacturer: I.V.A.R S.p.A; Model: IVAR-ESAT Dual; Serial number: 500429C; Year of manufacture: 2019
VWART calculation prepared by Colin Judd of BSRIA Ltd. on 01 July 2020

	VWART (°C)	Volume (m^3)
DHW	15	23.8
Keep Warm	39	24.5
Space Heating	42	47.6

	VWART with keep warm active	
Period	VWART (°C)	% Time
No Heating	27	92%
Heating	41	8%
Overall	28	

	DHW draw test results			Post DHW draw (60 seconds)	
	Power (W)	Primary flow (m^3/hr)	Return temp (°C)	Primary flow (m^3/hr)	Return temp (°C)
Low	10992	0.167	14.1	0.006	13.64
Medium	18435	0.293	14.8	0.015	14.63
High	23885	0.381	15.7	0.015	15.30

	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	66.32	11.058	10000	30	0.536
Medium	297	16.11	4.721	660	75	0.212
High	444	18.59	7.091	300	145	0.177

Keep warm test results	
Primary flow (m^3/hr)	Return temp (°C)
0.0031	38.6

Keep warm volumes per annum	
Time (hours)	Volume (m^3)
8002	24.492

	Space heating test results		
	Power (W)	Primary flow (m^3/hr)	Return temp (°C)
1kW	995	0.032	40.9
2kW	1890	0.061	41.6
4kW	3973	0.133	43.3

	Space heating volumes per annum		
	Energy (kWh)	Time (hours)	Volume (m^3)
1kW	98	98.53	3.193
2kW	787	416.40	25.484
4kW	565	142.22	18.943

Low Temperature VWART Calculations

Low Temperature VWART Calculation for I.V.A.R S.p.A HIU
Primary flow temperature = 60°C, DHW set point = 50°C, Space heating temperatures = 35°C/45°C
Test carried out by BSRIA Ltd. in June 2020, Test Reference 101858/1
Manufacturer: I.V.A.R S.p.A; Model: IVAR-ESAT Dual; Serial number: 500429C; Year of manufacture: 2019
VWART calculation prepared by Colin Judd of BSRIA Ltd. on 01 July 2020

	VWART (°C)	Volume (m^3)
DHW	15	28.9
Keep Warm	41	42.1
Space Heating	36	52.1

	VWART with keep warm active	
Period	VWART (°C)	% Time
No Heating	31	93%
Heating	35	7%
Overall	31	

	DHW draw test results			Post DHW draw (60 seconds)	
	Power (W)	Primary flow (m^3/hr)	Return temp (°C)	Primary flow (m^3/hr)	Return temp (°C)
Low	9750	0.180	14.6	0.006	14.18
Medium	16024	0.312	15.4	0.015	15.28
High	20852	0.409	16.2	0.020	16.32

	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	74.77	13.453	10000	30	0.516
Medium	297	18.53	5.777	660	75	0.206
High	444	21.29	8.713	300	145	0.237

Keep warm test results	
Primary flow (m^3/hr)	Return temp (°C)
0.0053	41.0

Keep warm volumes per annum	
Time (hours)	Volume (m^3)
7990	42.106

	Space heating test results		
	Power (W)	Primary flow (m^3/hr)	Return temp (°C)
1kW	978	0.036	35.3
2kW	1926	0.068	35.6
4kW	3857	0.140	36.1

	Space heating volumes per annum		
	Energy (kWh)	Time (hours)	Volume (m^3)
1kW	98	100.18	3.607
2kW	787	408.69	27.954
4kW	565	146.49	20.567