BESA HIU Test Report

GE556Y421

Carried out for

Giacomini Ltd.

Report 100799/1

Compiled by Colin Judd

14 November 2019

This page is intentionally left blank

BESA HIU Test Report

GE556Y421

Carried out for: Giacomini Ltd.
Unit 2 Westerleigh Business Park
Goodrich Close
Yate, Bristol
BS37 5YT
UK

Contract: Report 100799/1

Issued by: BSRIA Limited
Old Bracknell Lane West
Bracknell
Berkshire
RG12 7AH
UK

Telephone: +44 (0)1344 465600

Fax: +44 (0)1344 465626

Email: bsria@bsria.co.uk
Website: www.bsria.co.uk

QUALITY ASSURANCE

Issue	Date	Compiled by:	Approved by:	Signature
Final	*14-Nov-2019*	*Colin Judd* *Senior Test Engineer*	*Tom Garrigan* *Business Manager*	

CONTENTS

FIGURES

TABLES

APPENDICES

1 INTRODUCTION

BSRIA carried out a series of tests on one heat interface unit (HIU), GE556Y421, manufactured by Giacomini Ltd. 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 August/September 2019. 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 Giacomini Ltd. GE556Y421. 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	GE556Y421
Serial Number	00062/2019
Software version	1.1.11
Height	630mm
Width	460mm
Depth	270mm
Total unit weight	26 kg (including cover)
Maximum DHW output	42 kW
Maximum central heating output	Radiators – 40kW (@ 35 kPa) UFH – 16kW (@ 65 kPa)
Maximum primary supply temperature	90°C
Recommended minimum DP	55 kPa
Maximum working pressure primary side	16 bar
Maximum working pressure DHW side	10 bar
Safety relief valve setting secondary heating side	4.5 bar
Expansion vessel capacity	6 litres
Ball valve connections	¾ “
Safety relief valve connection	½ “
Electrical power supply voltage	230 V
Frequency	50 Hz

Table 2 gives a component list for the HIU as supplied by the Client. All necessary documentation was supplied with the HIU.

Table 2 HIU Component list

Description	Part number	Manufacturer
Manual air vent	R66A	Giacomini
Pressure gauge	R225x6bar	SITEM
Check valve	R189V	Giacomini
Connections	Various PN - CW617N brass	Giacomini
Pipes 18x1	Copper	CBS
Pipe insulation	XG-09X018	Armaflex
DHW heat exchanger	E8LAS	SWEP
Insulation Hex	Trocellen	Cozzi
DHW flow sensor	VFS 1-15 l/min	Grundfos
15 l/min flow limiter	E-NT	Neoperl
Gaskets	Fasit Omnia	Morganti
Primary strainer	R74A	Giacomini
DHW control valve	SLB126	ESBE
Space Heating Control valve	SLB126	ESBE
Space Heating heat exchanger	E8LAS	SWEP
Pressure switch	XP600 - 0,8 bar	Milano Componenti
Space heating flow sensor	VFS 2-40 l/min	Grundfos
Secondary heating circulation pump	UPM3 15-70 PWM	Grundfos
Heating system epansion vessel	D.392 6 litre	Zilmet
Heating system safety valve	R140 - 4.5 bar	Giacomini
Optional heat meter	Hydrocal M3	Bmeters
Temperature sensors	TSB PT1000	Tasseron
Controller	M005	Minibems
Pump flat seals	EPDM	Morganti
Spacers for meters	CW614N brass	Giacomini

Figure 1 shows the GE556Y421 installed in the test rig with the cover removed. A photograph of the name plate is also included.

Figure 1 GE556Y421 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
Platinum Resistance Thermometers (PRTs)	Anville Sensors Ltd	-10 – 95	°C	1596	17-04-20
Static pressure transducer Primary circuit for all tests	Fuji Electric	0 – 10	Bar	1592	10-06-20
Static pressure transducer Secondary circuit for all tests	Fuji Electric	0 – 10	Bar	1593	11-06-20
ET7026 logger	IPC	-	-	1685	N/A
Platinum Resistance Thermometers (PRTs)* Used for measuring the inlet/outlet parameters during the testing	TC Ltd	1 – 90	°C	1685	05-11-19
Platinum Resistance Thermometer (PRT)	Anville Sensors Ltd	1 – 90	°C	1685	05-11-19
Flowmeter – DH circuit Space heating tests – (1a – 1f)	Siemens	0 – 0.07	$l.s^{-1}$	2961	09-01-20
Flowmeter – SH circuit Space heating tests – (1a – 1e)	Siemens	0 – 0.07	$l.s^{-1}$	1678	10-06-20
Flowmeter – SH circuit Space heating tests – (1f)	Siemens	0 – 0.2	$l.s^{-1}$	685	10-01-20
Flowmeter – DH circuit Dynamic tests – (2a, 2b, 3a,3b) DHW response time tests – (5a,5b)	Siemens	0 – 0.5	$l.s^{-1}$	1544	11-06-20
Flowmeter – DHW circuit Dynamic tests – (2b, 3b) DHW response time tests – (5a,5b)	Siemens	0 – 0.2	$l.s^{-1}$	685	10-01-20
Flowmeter – DHW circuit Dynamic tests – (2a, 3a)	Danfoss	0 – 0.2	$l.s^{-1}$	95	12-03-20
Flowmeter – DH circuit Keep warm tests (4a & 4b)	Siemens	0 – 0.07	$l.s^{-1}$	2961	09-01-20
Flowmeter – DHW circuit Keep warm tests (4a & 4b)	Siemens	0 – 0.2	$l.s^{-1}$	685	10-01-20
Differential pressure transducer Primary circuit for all tests	Fuji Electric	0 – 200	kPa	2065	07-01-20
Differential pressure transducer Secondary circuit for all tests	Fuji Electric	0 – 200	kPa	1591	10-06-20
Static pressure transducer Pressure test	Fuji Electric	0 – 30	barg	1582	25-07-20
Static pressure transducer Pressure test	Keller LEO-1	0 – 10	bar	1760	29-01-20
Stopwatch	RS	3,603.02	Secs	238	21-12-20
Tape measure	Stanley	1,000	mm	683	28-02-22

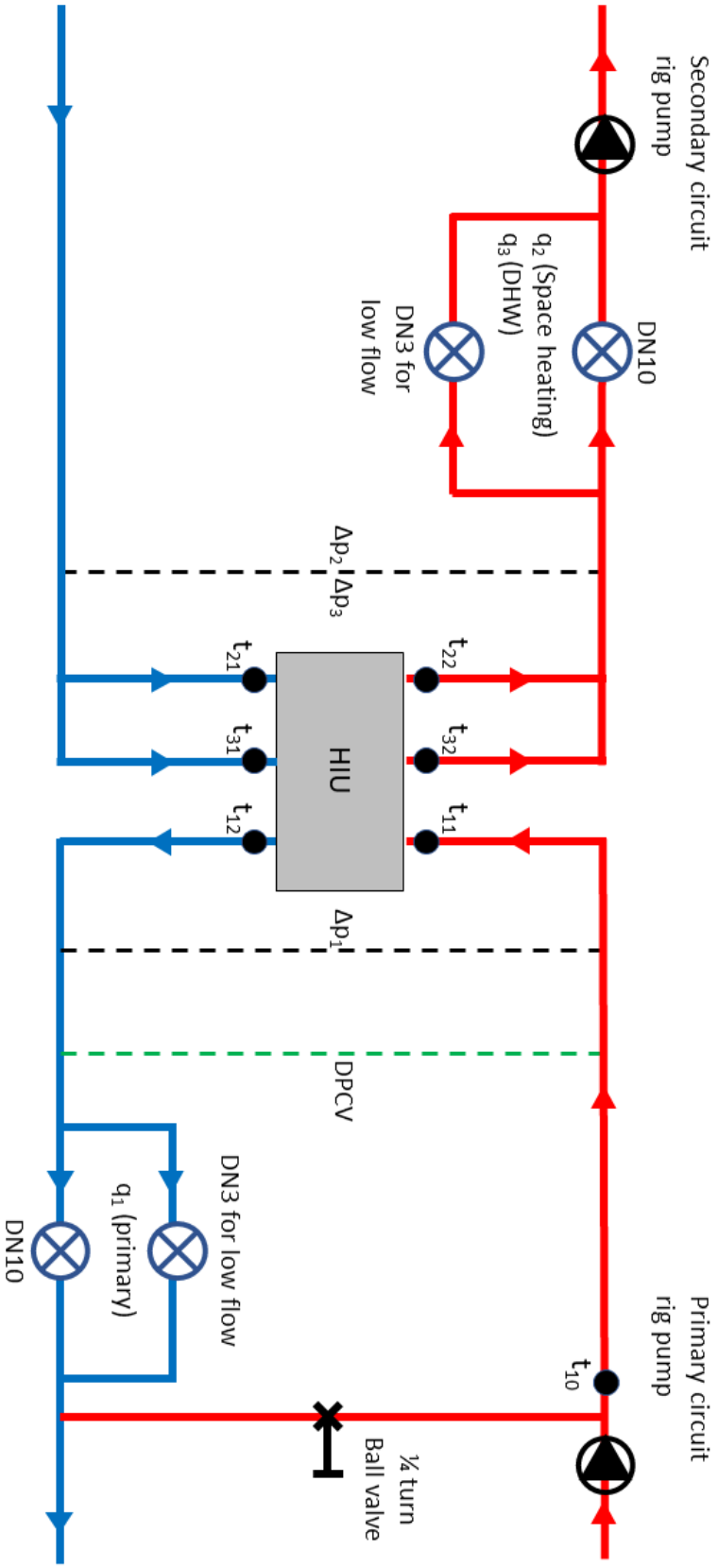
*The time constant for these temperature sensors was ≤ 1.5 s.

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

4 APPROACH

Figure 2 shows a schematic of the test rig layout.

Figure 2 Schematic of the test rig layout.



4.1 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%	0.0012 l/s
Volume flow (< 0.06 l/s)	To be specified in conjunction with each measurement	0.0006 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.

4.2 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 (i.e. 1 second) for a minimum period of 300 seconds.

4.3 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.

4.4 TESTS 3A AND 3B

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 reduced to 0.02 l/s and logged for 180 seconds at a rate of 1 Hz.

4.5 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.

4.6 TEST 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.

4.7 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 5 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 t32) , 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 t32), 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 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. 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	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

5 TEST RESULTS

During all of 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 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 achieve 60°C in the HIU control software during the 4kw test. For tests 1d to 1f, the space heating outlet temperature was set to achieve 45°C in the HIU control software 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)	Δp_2 (kPa)	P_2 (kW)
1a	70.06	39.57	0.008	50.22	1.02	39.98	59.82	0.012	0.18	1.00
1b	69.82	39.89	0.016	50.21	2.00	39.99	59.85	0.024	0.54	1.99
1c	70.08	40.25	0.032	50.44	3.99	40.04	60.23	0.048	1.79	4.05
1d	59.82	34.78	0.010	50.34	1.05	35.00	44.55	0.024	0.51	0.96
1e	60.15	34.83	0.019	50.97	2.01	34.99	44.61	0.048	1.81	1.93
Uncertainty	±0.019	±0.018	±0.0006	0.06	±0.07	±0.019	±0.018	±0.0006	±0.054	±0.06
1f	60.10	35.03	0.038	50.87	3.98	35.09	44.88	0.096	6.74	3.93
Uncertainty	±0.018	±0.017	±0.0006	0.06	±0.05	±0.018	±0.018	±0.0013	±0.037	±0.06

Table 9 Primary/secondary duty balance

Test	DH duty (kW)	SH duty (kW)	Balance
1a	1.02	1.00	98.0%
1b	2.00	1.99	99.5%
1c	3.99	4.05	101.5%

Test	DH duty (kW)	SH duty (kW)	Balance
1d	1.05	0.96	91.4%
1e	2.01	1.93	96.0%
1f	3.98	3.93	98.7%

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 (t_{32}) was set to 55.0 (±0.5°C) 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 62.7°C
- The minimum DHW temperature was 43.3°C
- Details of the scaling risk are given in Table 10

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 (t_{32}) was set to 50.0 (±0.5°C) prior to the test.

During test 2b:

- The maximum DHW temperature was 56.1°C
- The minimum DHW temperature was 40.8°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 and the cold water supply to the DHW circuit at 10°C. The DHW outlet temperature remained at the same position, set to achieve 55.0°C (±0.5°C) prior to the test. 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 during the 180 second test
- The DHW temperature ranged from 57.0°C to 54.4°C during the last 60 seconds of the test so the results were within the stated tolerance of 55.0°C ±3°C during this time period.
- The DHW maximum and minimum outlet temperatures were 64.9°C and 54.4°C respectively during the 180 second test.
- 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 and the cold water supply to the DHW circuit at 10°C. The DHW outlet temperature remained at the same position, set to achieve 50.0°C (±0.5°C) prior to the test. 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 during the 180 second test
- The DHW temperature ranged from 52.1°C to 50.1°C during the last 60 seconds of the test 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 57.6°C and 49.7°C respectively

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. The action of the keep warm mode was deemed “non-cycling” as determined by the criteria given in the test regime for the last 3 hours of the 8-hour period.

5.5.1 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 remained at the same position, set to achieve 55.0 (±0.5°C) prior to the test.

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

During the last 3 hours of the test, the average t_{11} temperature was 47.1°C with a maximum of 49.1°C and a minimum of 45.7°C

During test 4a:

- The average heat load during the 8-hour keep warm period was 35 W
- The average primary flow rate during the 8-hour keep warm period was 3.9 l/h
- Details of the scaling risk are given in Table 10

5.5.2 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 remained at the same position, set to achieve 50.0 (±0.5°C) prior to the test.

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

During the last 3 hours of the test, the average t_{11} temperature was 47.3°C with a maximum of 49.1°C and a minimum of 46.0°C

- The average heat load during the 8-hour keep warm period was 37 W
- The average primary flow rate during the 8-hour keep warm period was 6.6 l/h
- Details of the scaling risk are given in Table 10

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.

During test 5a:

- The DHW temperature did not exceed 65.0°C during the test
- The DHW achieved 45.0°C in 14 seconds from the first recorded non-zero DHW flow reading

Result
Scaling risk factor – Pass
Achieving 45°C DHW within 15 seconds – Pass

5.6.2 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 13 seconds from the first recorded non-zero DHW flow reading

Result
Achieving 45°C DHW within 15 seconds – 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**	**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**

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

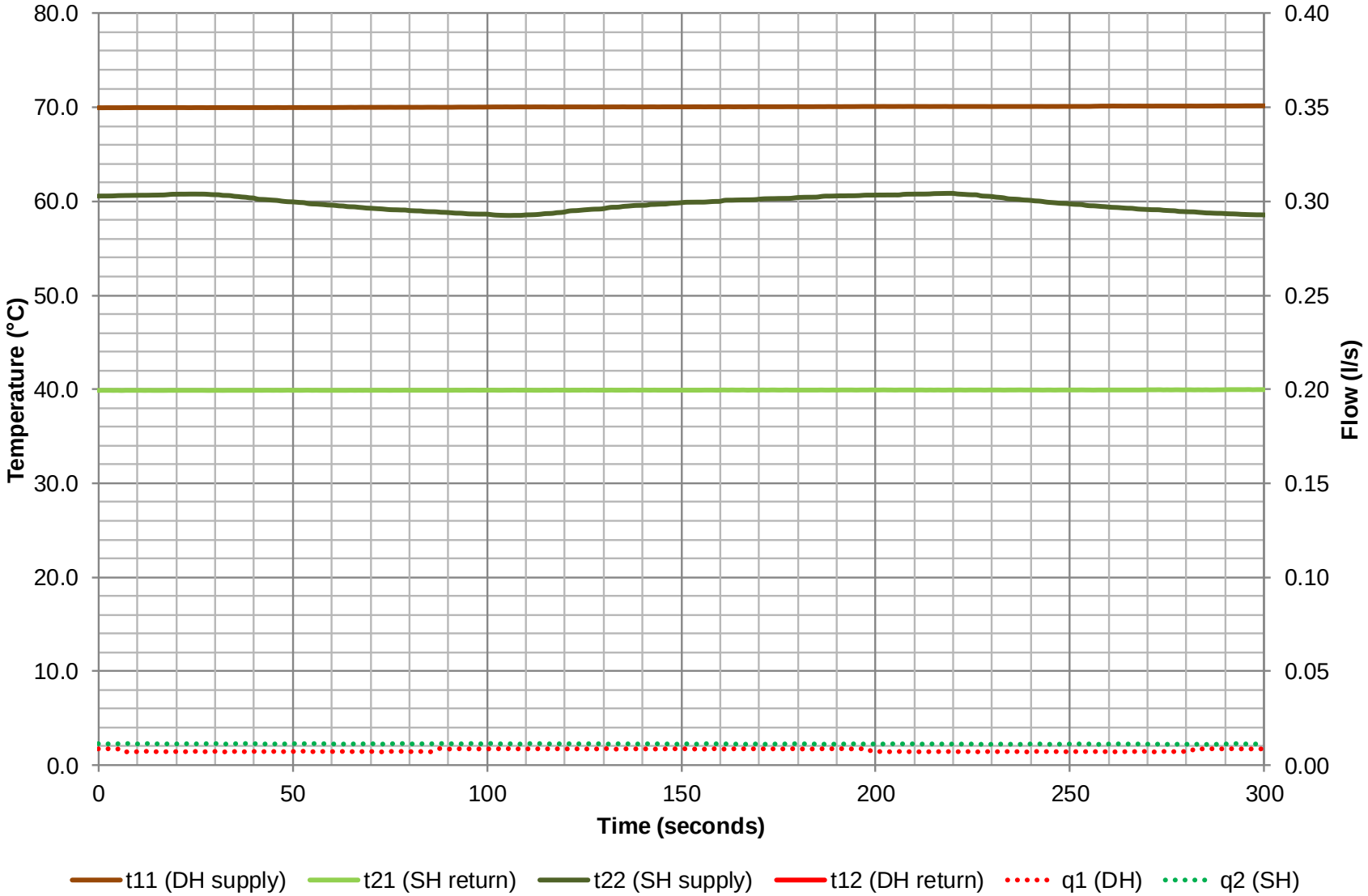


Figure 4 Results for test 1b: 2kW Space heating – DH 70°C supply

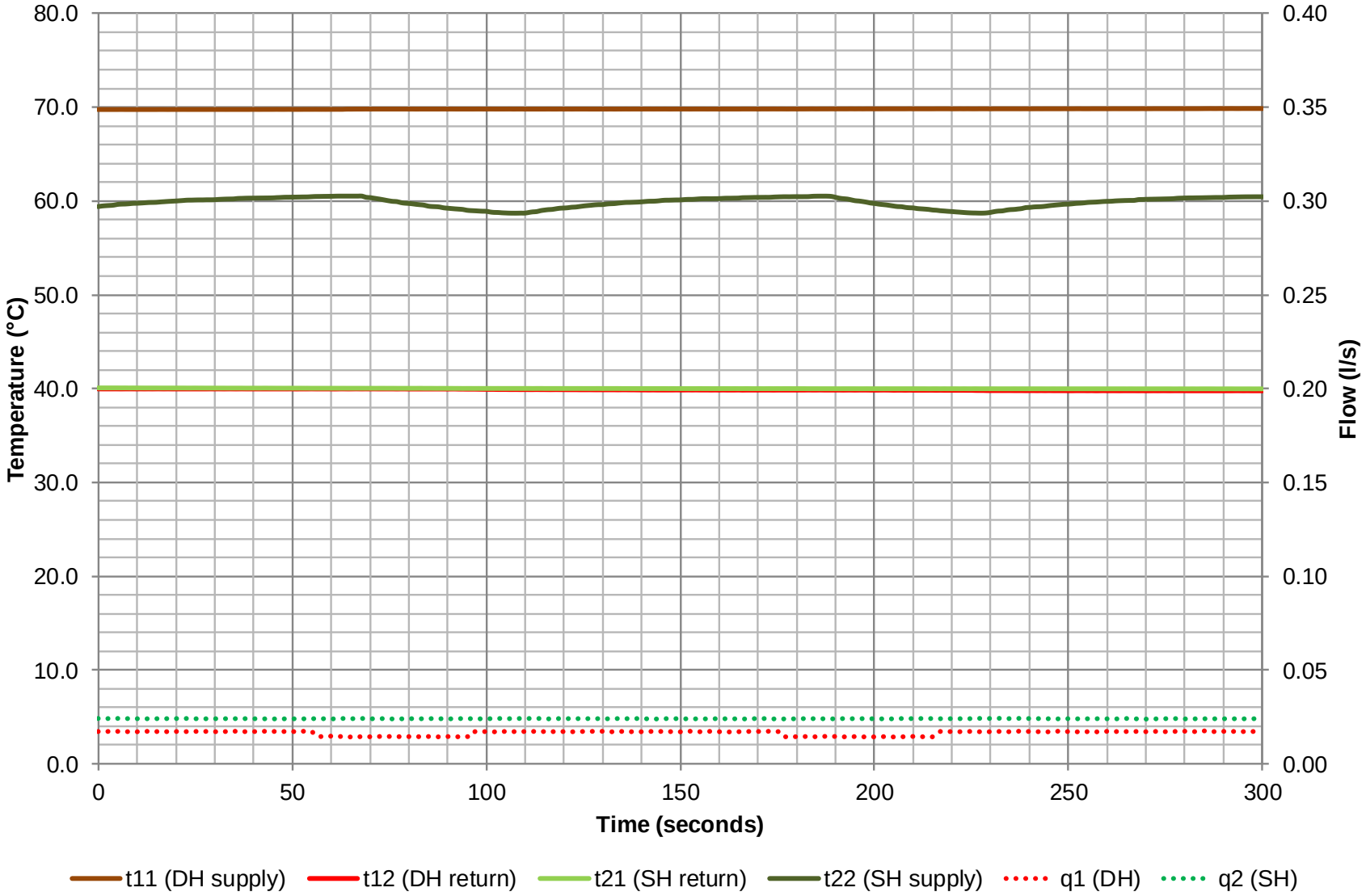


Figure 5 Results for test 1c: 4kW Space heating – DH 70°C supply

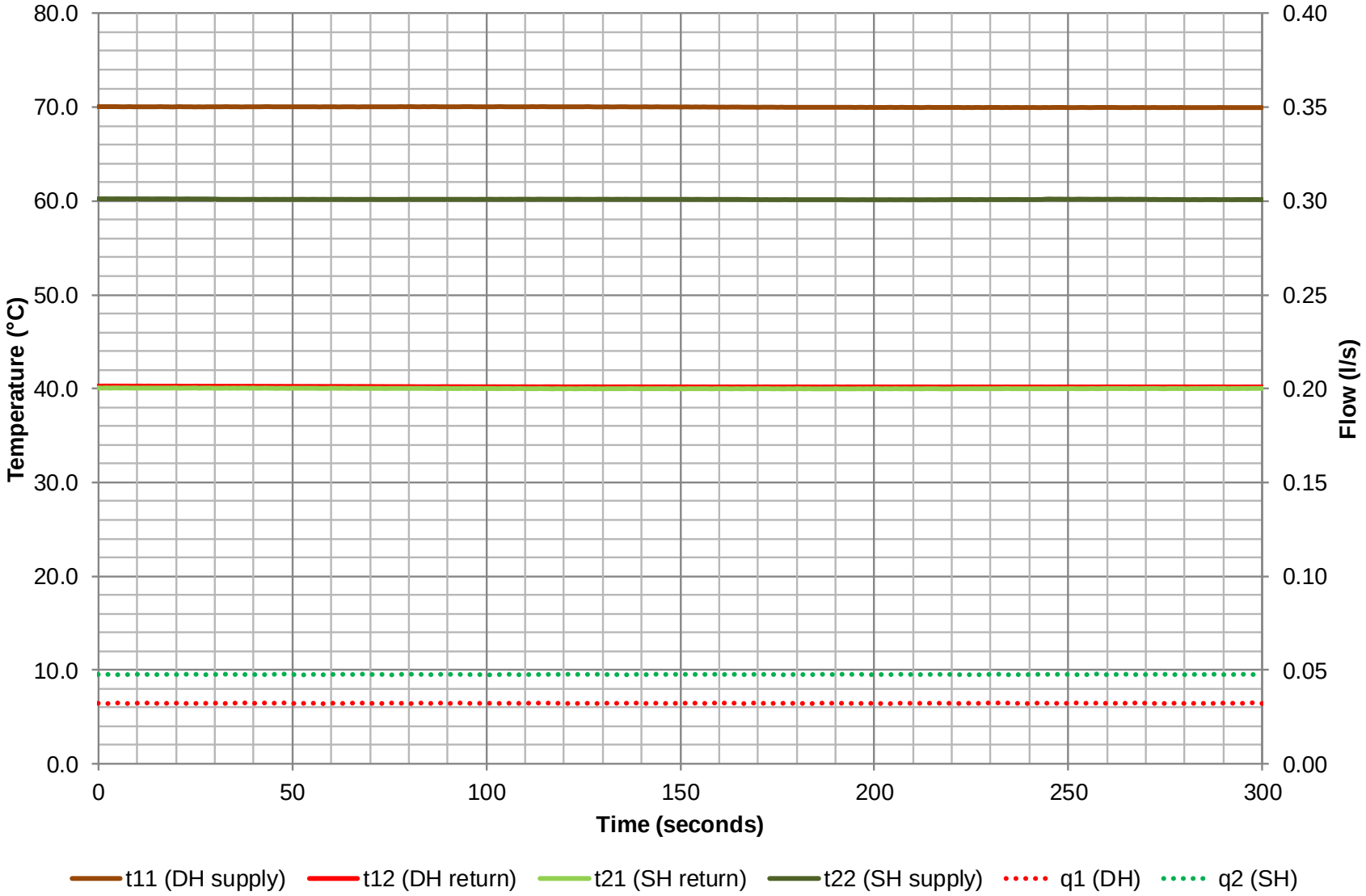


Figure 6 Results for test 1d: 1kW Space heating – DH 60°C supply

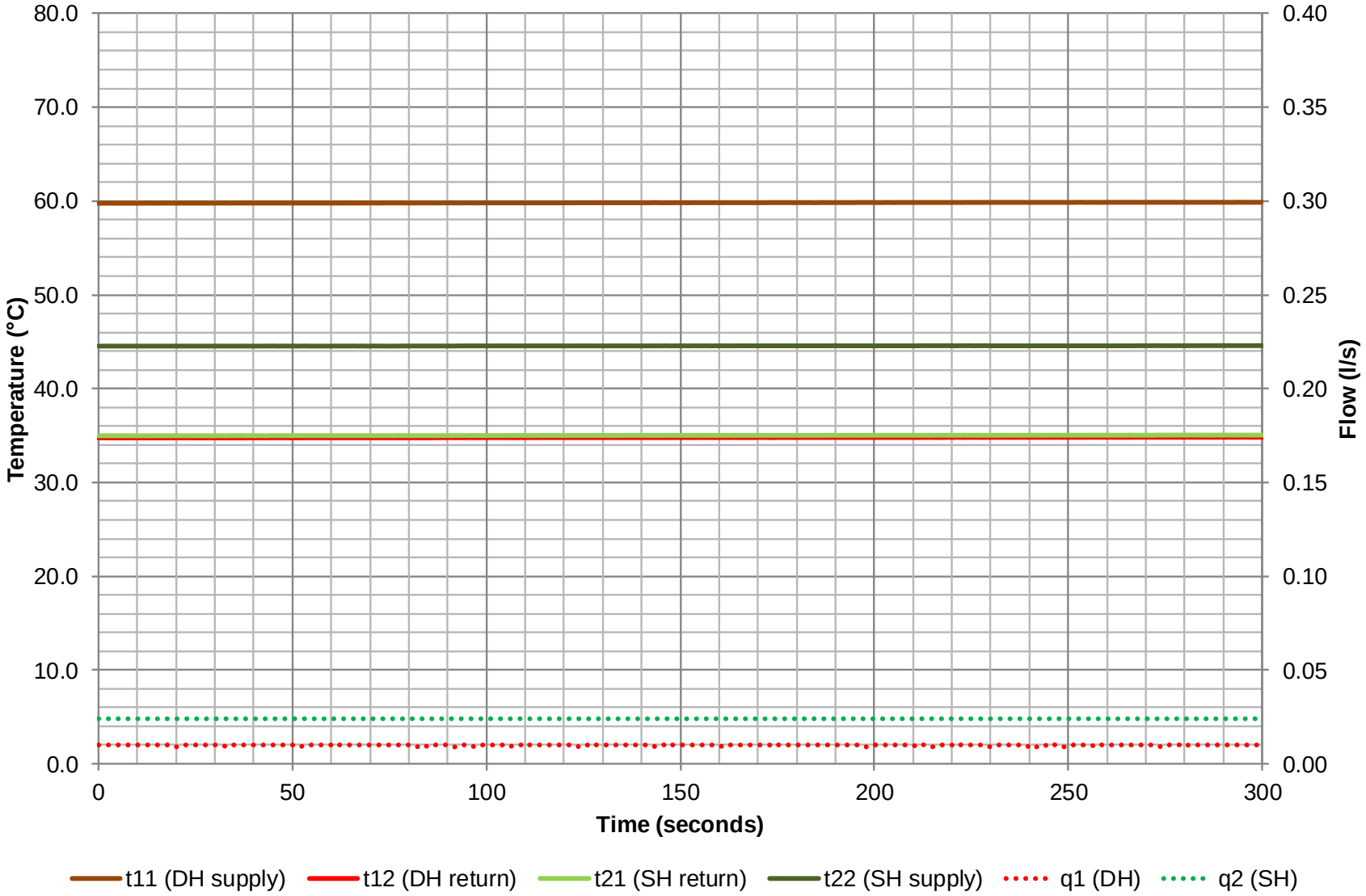


Figure 7 Results for test 1e: 2kW Space heating – DH 60°C supply

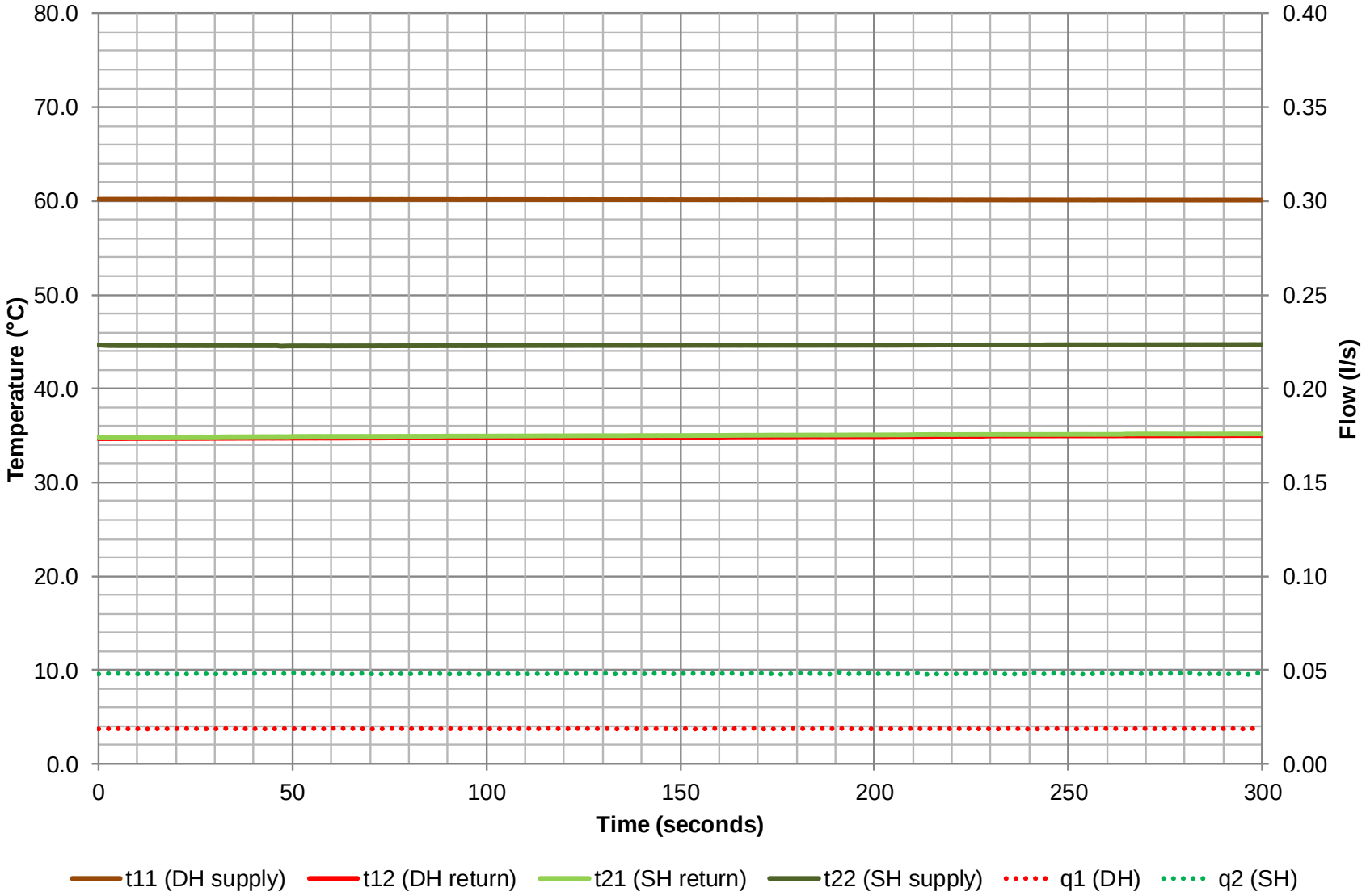


Figure 8 Results for test 1f: 4kW Space heating – DH 60°C supply

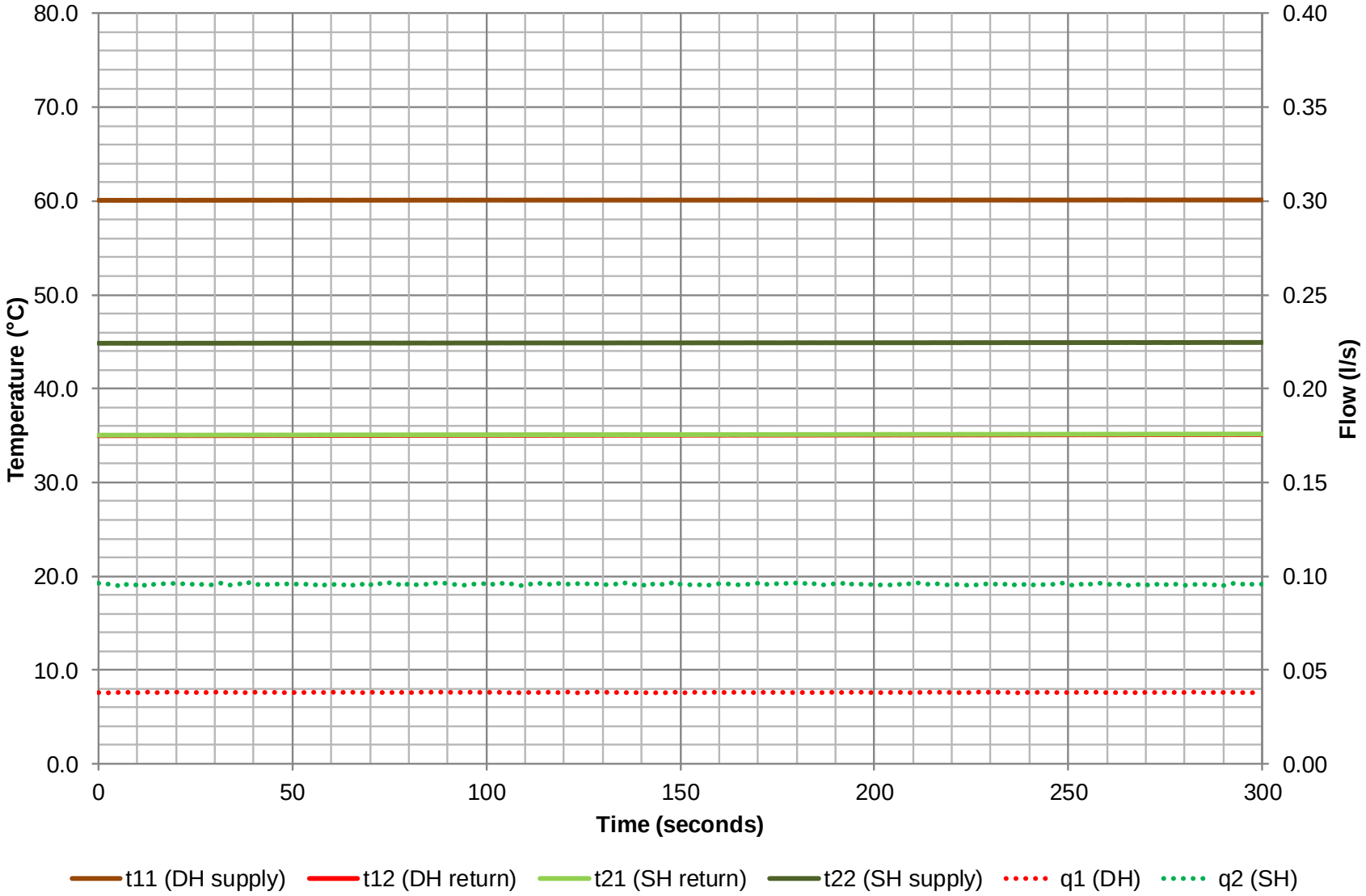


Figure 9 Results for test 2a: DHW dynamic test – DH 70°C

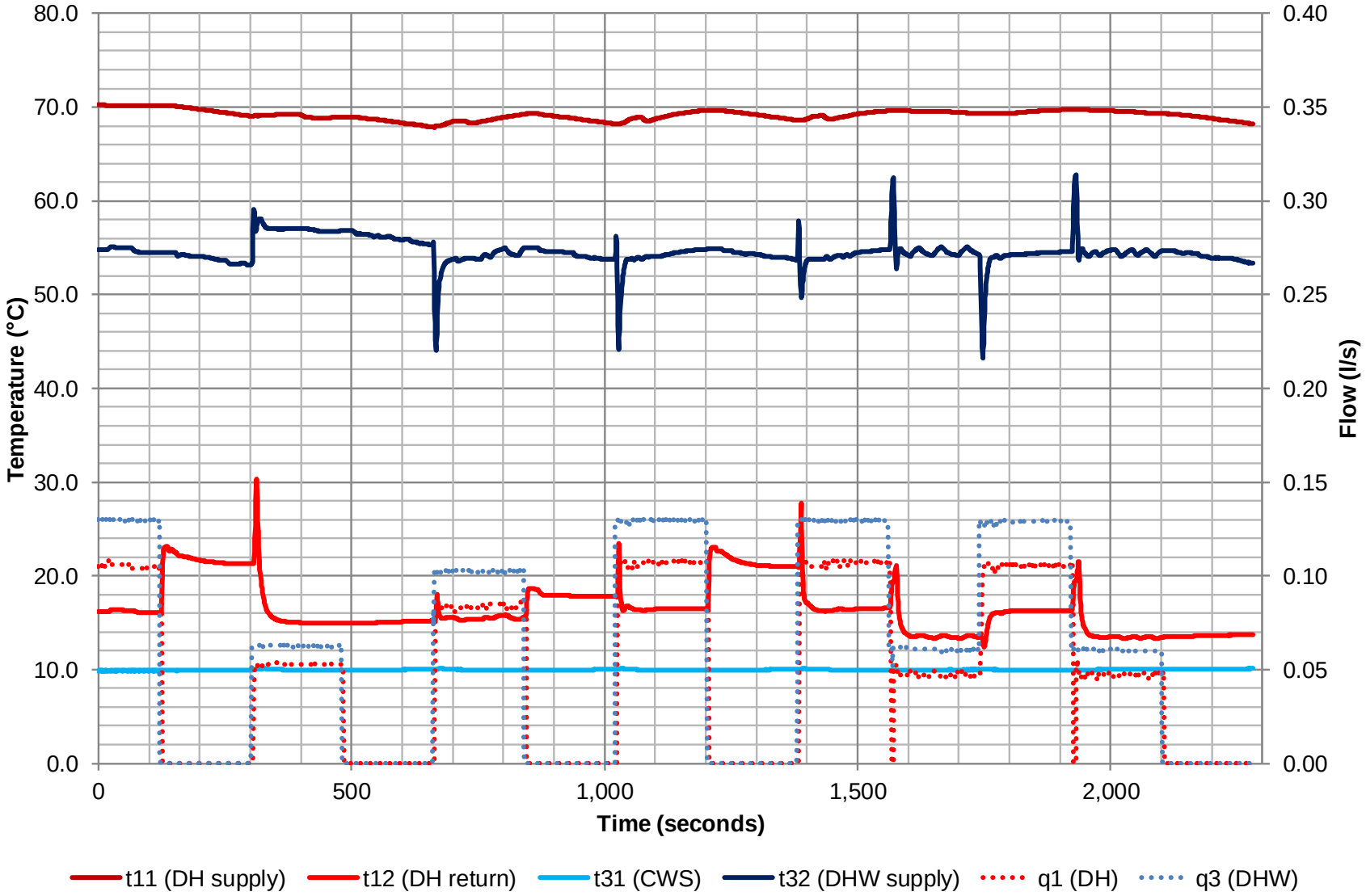


Figure 10 Results for test 2b: DHW dynamic test – DH 60°C

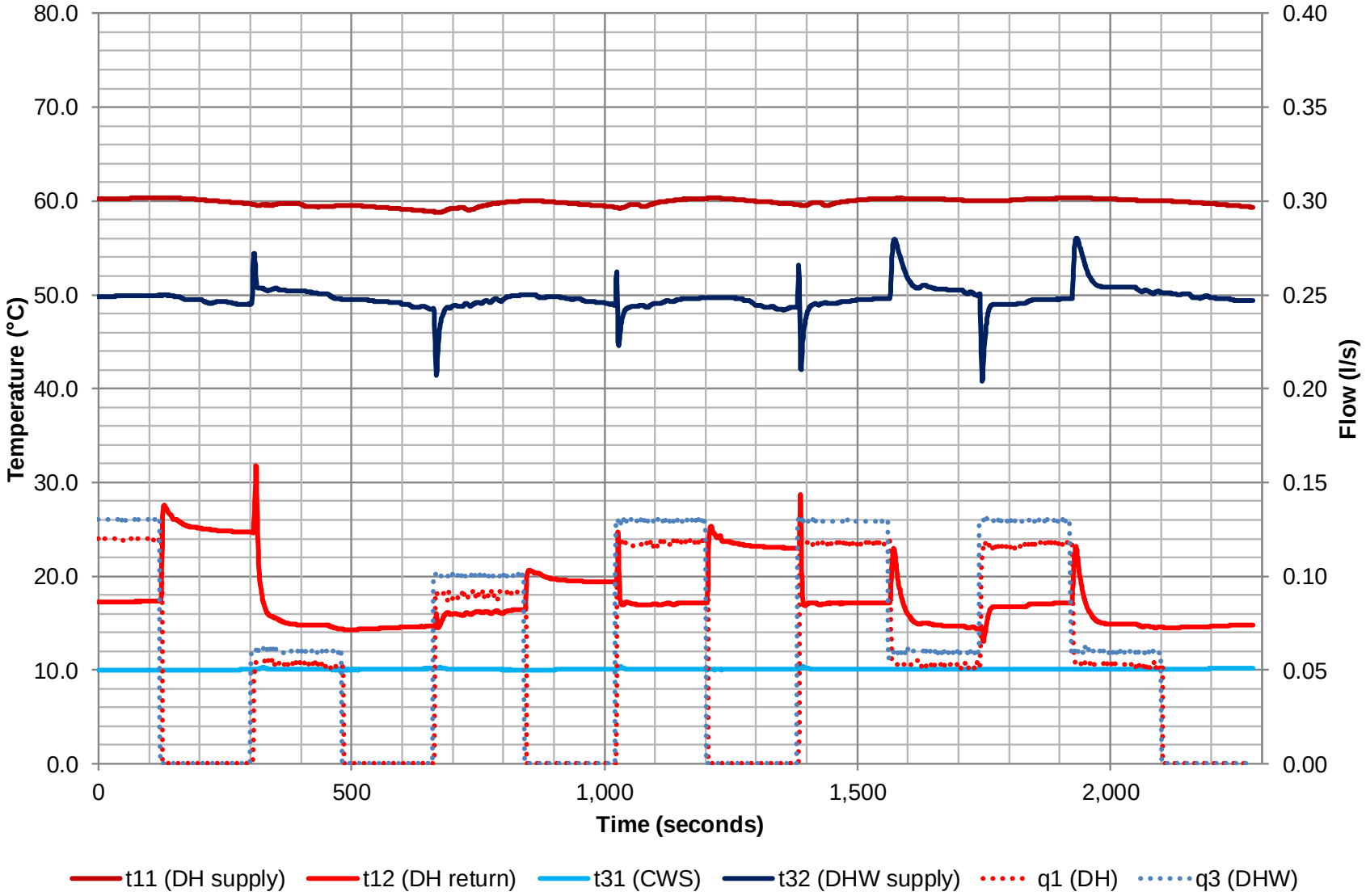


Figure 11 Results for test 3a: Low flow DHW test – DH 70°C

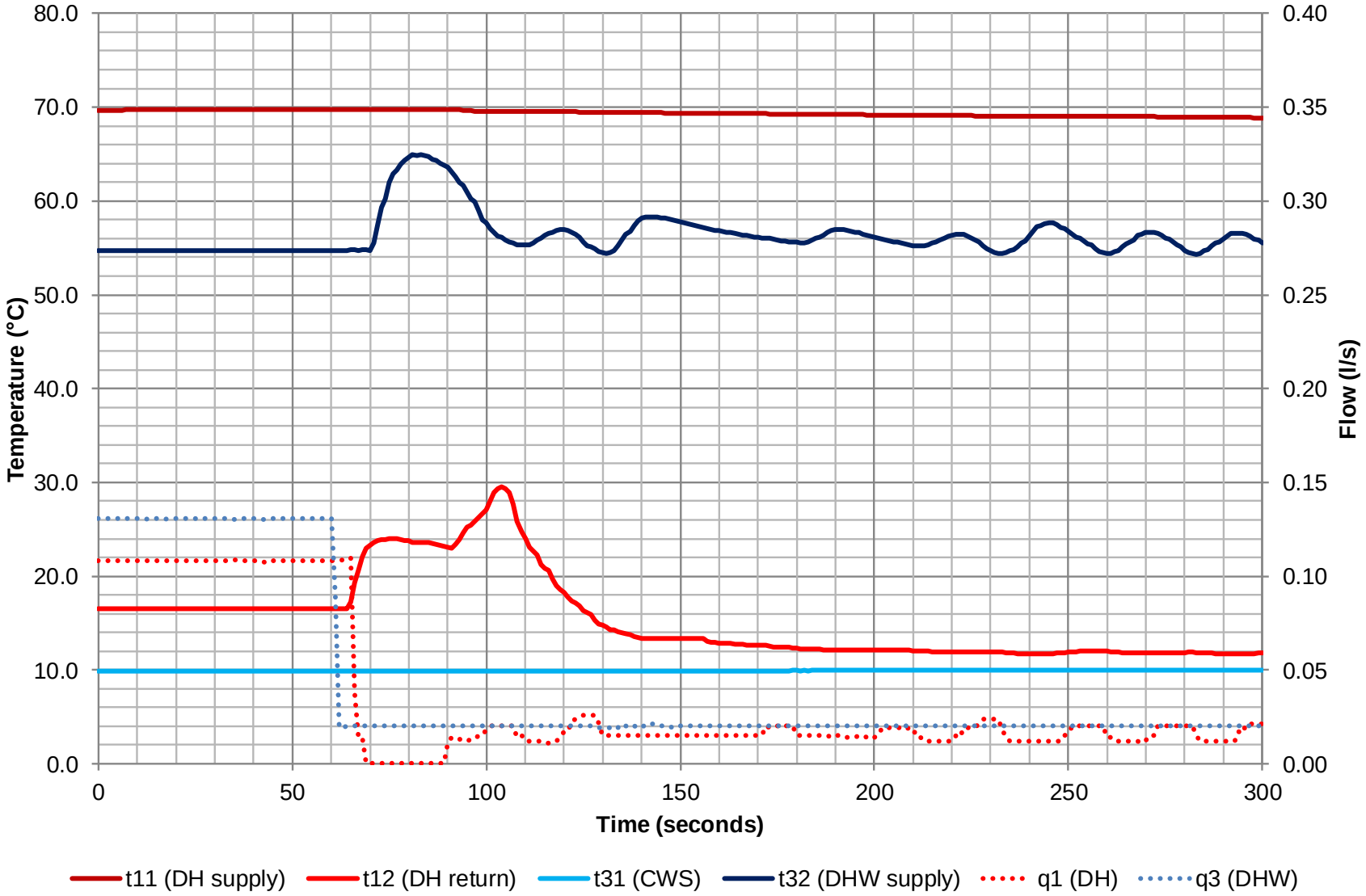


Figure 12 Results for test 3b: Low flow DHW test – DH 60°C

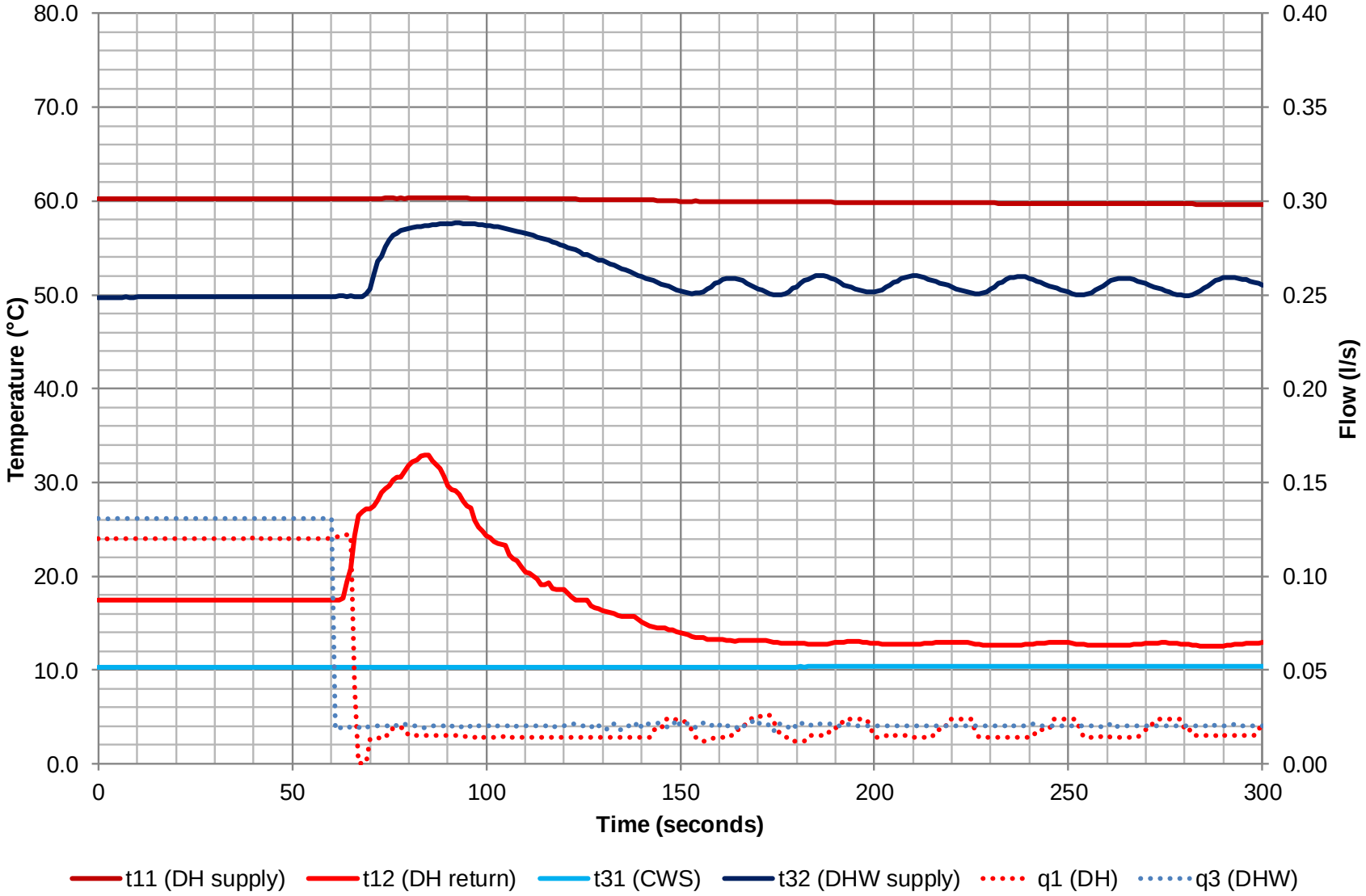


Figure 13 Results for test 4a: Keep warm test – DH 70°C supply

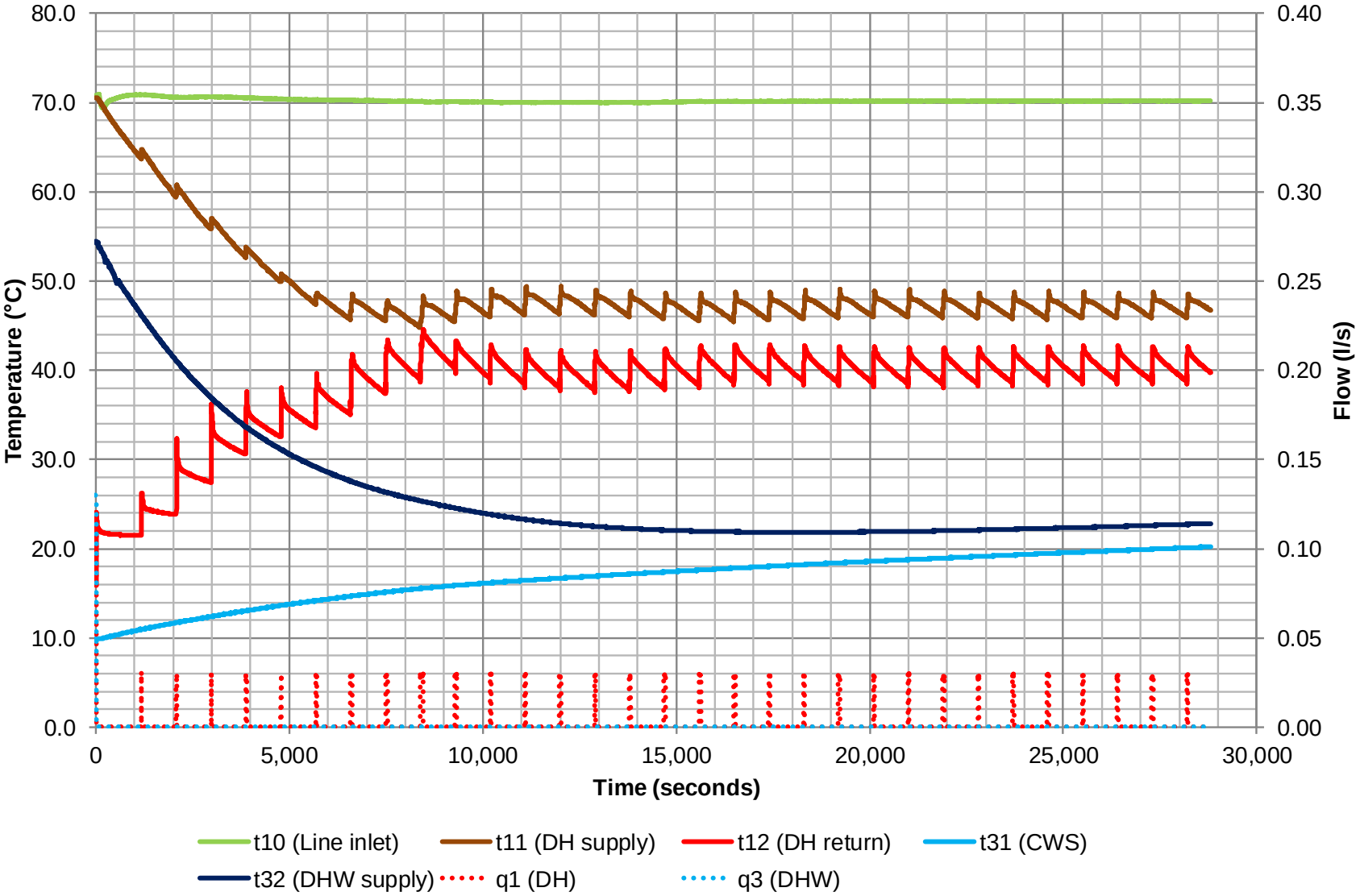


Figure 14 Results for test 4b: Keep warm test – DH 60°C supply

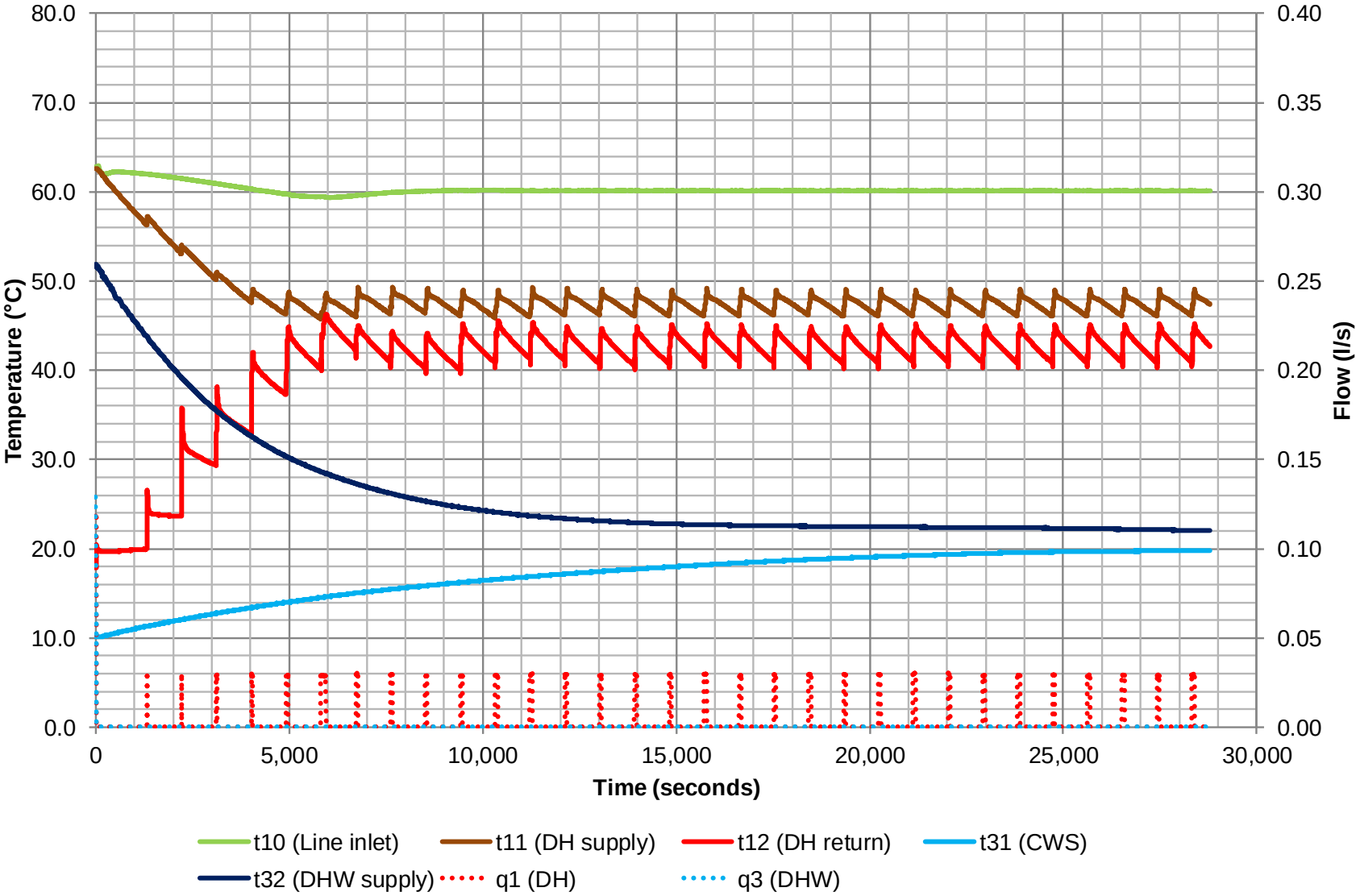


Figure 15 Results for test 5a: DHW response time – DH 70°C supply

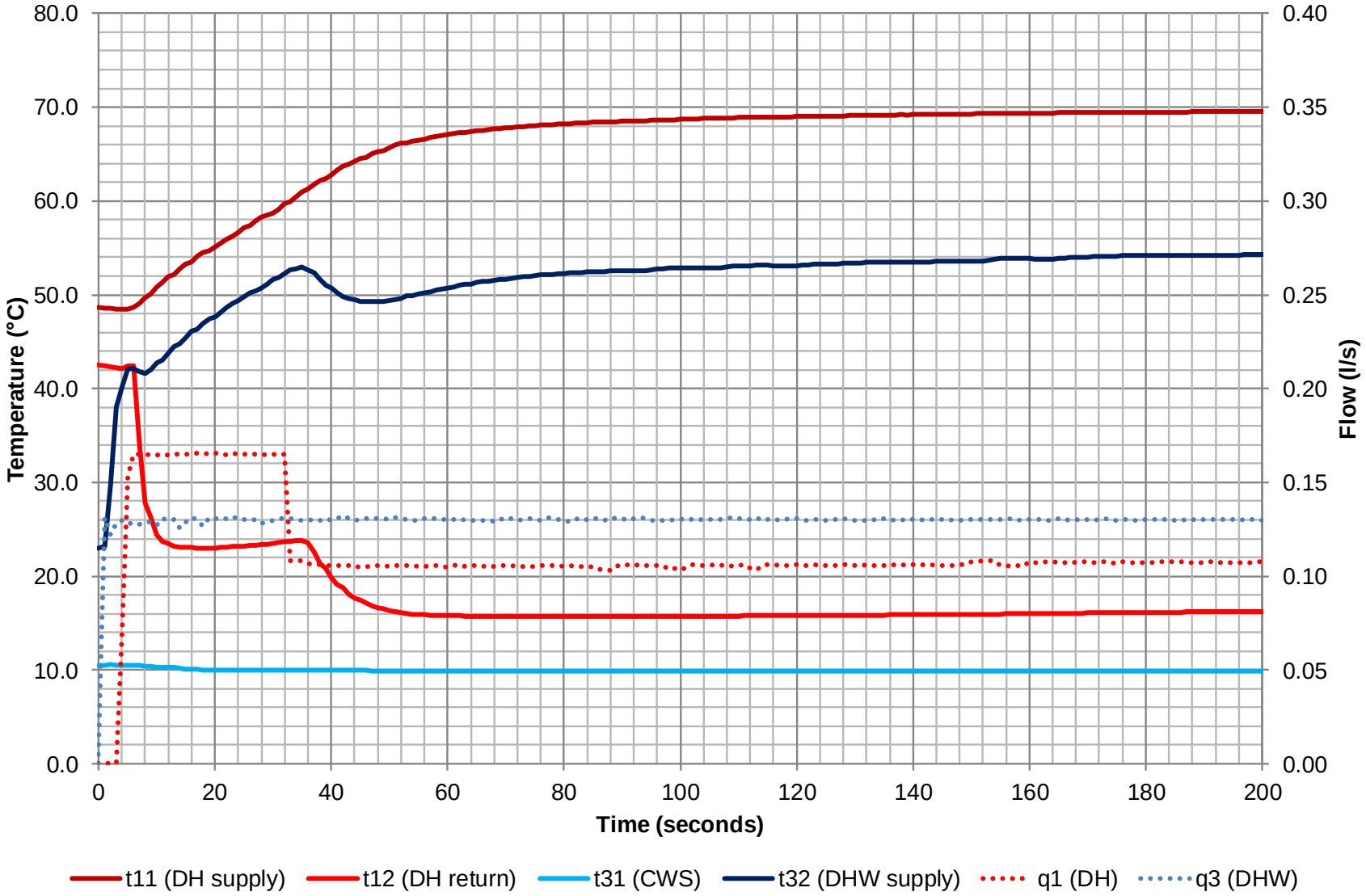
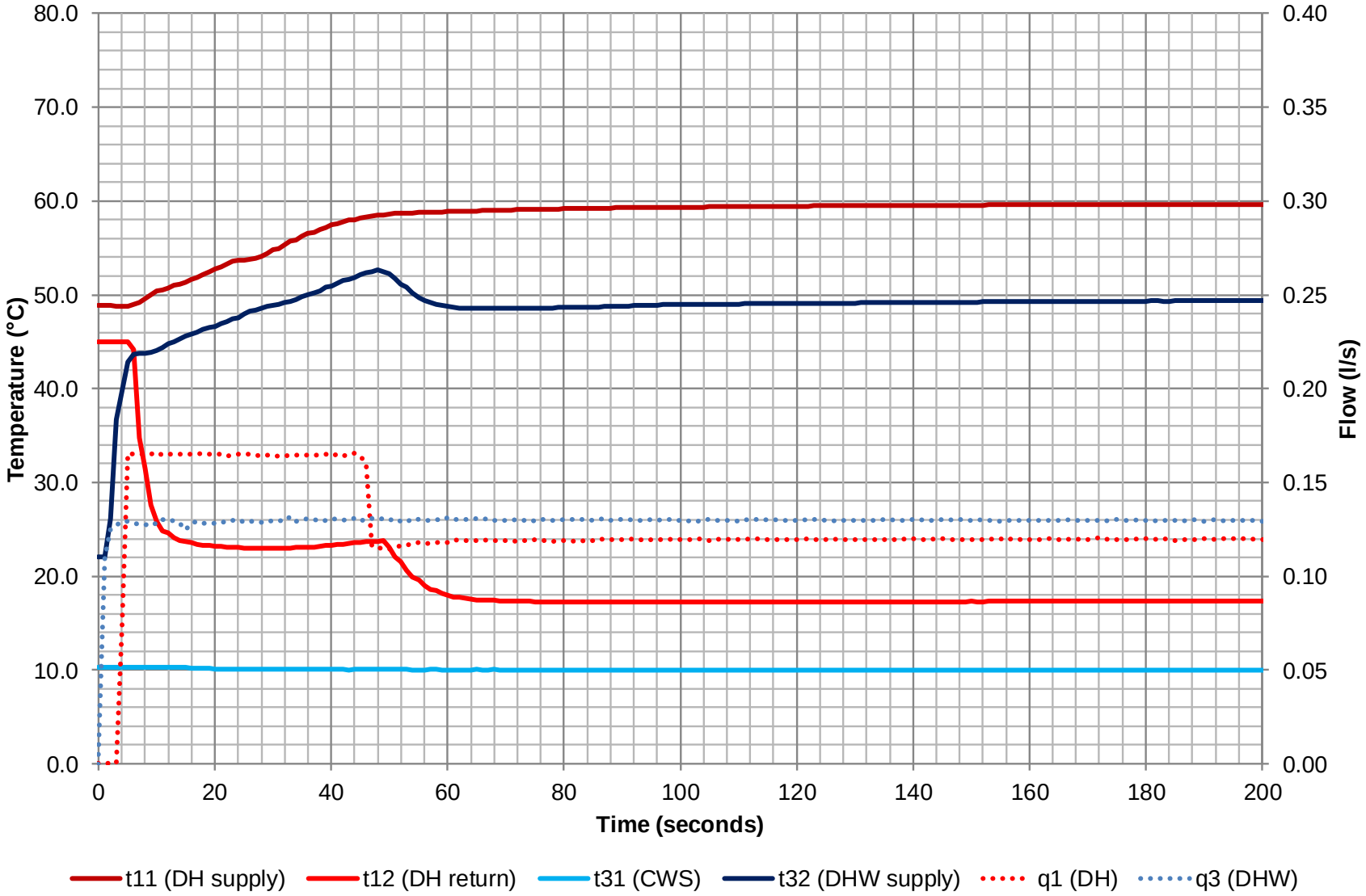


Figure 16 Results for test 5b: DHW response time – DH 60°C supply



APPENDIX B: VWART CALCULATIONS

High Temperature VWART Calculations

High Temperature VWART Calculation for Giacomini UK Ltd. 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 September 2019, Test Reference 100799/1
Manufacturer: Giacomini UK Ltd.; Model: GE55 6Y421; Serial number: 00062/2019; Year of manufacture: 2019
VWART calculation prepared by Colin Judd of BSRIA Ltd. on 22 October 2019

	VWART (°C)	Volume (m^3)
DHW	16	24.1
Keep warm	40	31.5
Space heating	40	42.2

	VWART with keep warm active	
Period	VWART (°C)	% Time
No heating	30	93%
Heating	39	7%
Overall	30	

	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	12164	0.184	16.0	0.009	14.95
Medium	18572	0.294	15.5	0.021	15.76
High	23739	0.375	16.6	0.027	16.81

DHW draw volumes per annum		
Energy (kWh)	Time (hours)	Volume (m^3)
729	59.93	11.046
297	15.99	4.703
444	18.70	7.011

Post DHW draw volumes per annum		
Events	Avg duration (seconds)	Volume (m^3)
10000	30	0.750
660	75	0.286
300	145	0.324

Keep warm test results	
Primary flow (m^3/hr)	Return temp (°C)
0.0039	40.2

Keep warm volumes per annum	
Time (hours)	Volume (m^3)
8032	31.458

	Space heating test results		
	Power (W)	Primary flow (m^3/hr)	Return temp (°C)
1 kW	995	0.029	39.6
2 kW	1992	0.059	39.9
4 kW	4043	0.116	40.3

Space heating volumes per annum		
Energy (kWh)	Time (hours)	Volume (m^3)
98	98.51	2.808
787	394.99	23.191
565	139.74	16.178

Low Temperature VWART Calculations

Low Temperature VWART Calculation for Giacomini UK Ltd. 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 September 2019, Test Reference 100799/1
Manufacturer: Giacomini UK Ltd.; Model: GE55 6Y421; Serial number: 00062/2019; Year of manufacture: 2019
VWART calculation prepared by Colin Judd of BSRIA Ltd. on 27 September 2019

	VWART (°C)	Volume (m^3)
DHW	16	29.5
Keep warm	43	52.7
Space heating	35	51.2

	VWART with keep warm active	
Period	VWART (°C)	% Time
No heating	33	93%
Heating	35	7%
Overall	33	

	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	10070	0.186	15.9	0.009	14.33
Medium	16212	0.319	16.0	0.026	17.00
High	21003	0.415	17.2	0.029	17.83

DHW draw volumes per annum		
Energy (kWh)	Time (hours)	Volume (m^3)
729	72.39	13.431
297	18.32	5.847
444	21.14	8.777

Post DHW draw volumes per annum		
Events	Avg duration (seconds)	Volume (m^3)
10000	30	0.780
660	75	0.360
300	145	0.352

Keep warm test results	
Primary flow (m^3/hr)	Return temp (°C)
0.0066	42.9

Keep warm volumes per annum	
Time (hours)	Volume (m^3)
7994	52.726

	Space heating test results		
	Power (W)	Primary flow (m^3/hr)	Return temp (°C)
1 kW	958	0.036	34.8
2 kW	1930	0.068	34.8
4 kW	3915	0.137	35.0

Space heating volumes per annum		
Energy (kWh)	Time (hours)	Volume (m^3)
98	102.32	3.646
787	407.68	27.846
565	144.30	19.741