Enertek International

International Consultants In Product Research, Design, Development & Certification

Project Number:	E4175
Project Title:	BESA Test Regime for VTherm HIU Unit
Client:	Vital Energi
Client Address	Vital Energi Headquarters Century House Roman Road Blackburn BB1 2LD
Date:	01 February 2019
Report Number:	1

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CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 BRIEF

1.1.1 Enertek international Limited (EIL), were contracted to receive, install and commission a production sample, Vital Energi vTherm on behalf of Vital Energi.

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

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

2 DEFINITIONS

2.1.1 The following definitions and abbreviations have been used within this report:

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

3 TEST OBJECT

3.1 Appliance Details

3.1.1 Details of the HIU Vital Energi vTherm appliance are given in Table 3.1. Photograph of the installed appliance is given in Figure 8-1.

3.2 Design Pressures

3.2.1 The maximum design pressures of the Vital Energi vTherm appliance are given for the primary side and the secondary side for both Space Heating and DHW in Table 3.2.

3.3 Design temperatures

3.3.1 The maximum design temperatures of the Vital Energi vTherm appliance are given for the primary side and the secondary side for both Space Heating and DHW in Table 3.3

Table 3.1 – Appliance Details

Item	Description
Manufacturer	Vital Energi
Model	Vital Energi vTherm
Serial number	44100395
Year of manufacture	2018
DHW priority	Yes

Table 3.2 – Appliance Design Pressures

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

Table 3.3 – Appliance Design Temperatures

Item	Value	Unit
Primary Side	95	°C
Secondary Side space Heating	80	°C
Secondary Side DHW	60	°C

4 TEST METHOD

4.1 Installation of Appliance

4.1.1 The appliance was installed and commissioned (as received) and as defined in the product literature provided. Testing was carried out without further adjustment other than disabling the internal space heating pump and adjusting the setting of the SH and DHW set points through the user interface on the HIU controller to suit the conditions of the HIU test rig. The HIU rig schematic is given in Figure 4-1.

4.2 Test Regime

4.2.1 The testing described in this report was carried out in accordance with the BESA test regime[1]. The Test Regime outlines a series of static and dynamic tests to determine the performance of a HIU's DHW and SH functions. The Regime outlines the test method including the reporting of the results, the performance requirements and the VWART calculations.

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

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

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

4.3 Measurement & Uncertainties

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

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

4.3.3 EIL's reported uncertainty is based on a standard uncertainty by a coverage factor K=2, providing a level of confidence of approximately 95%. The uncertainty evaluation has been carried out in accordance with UKAS requirements. The EIL equipment list and uncertainties are given in Table 8.3, Appendix B.

[1] UK HIU Test Regime Technical Specification, Rev-009 requirements, issued by the Building Engineering Services Association (BESA)

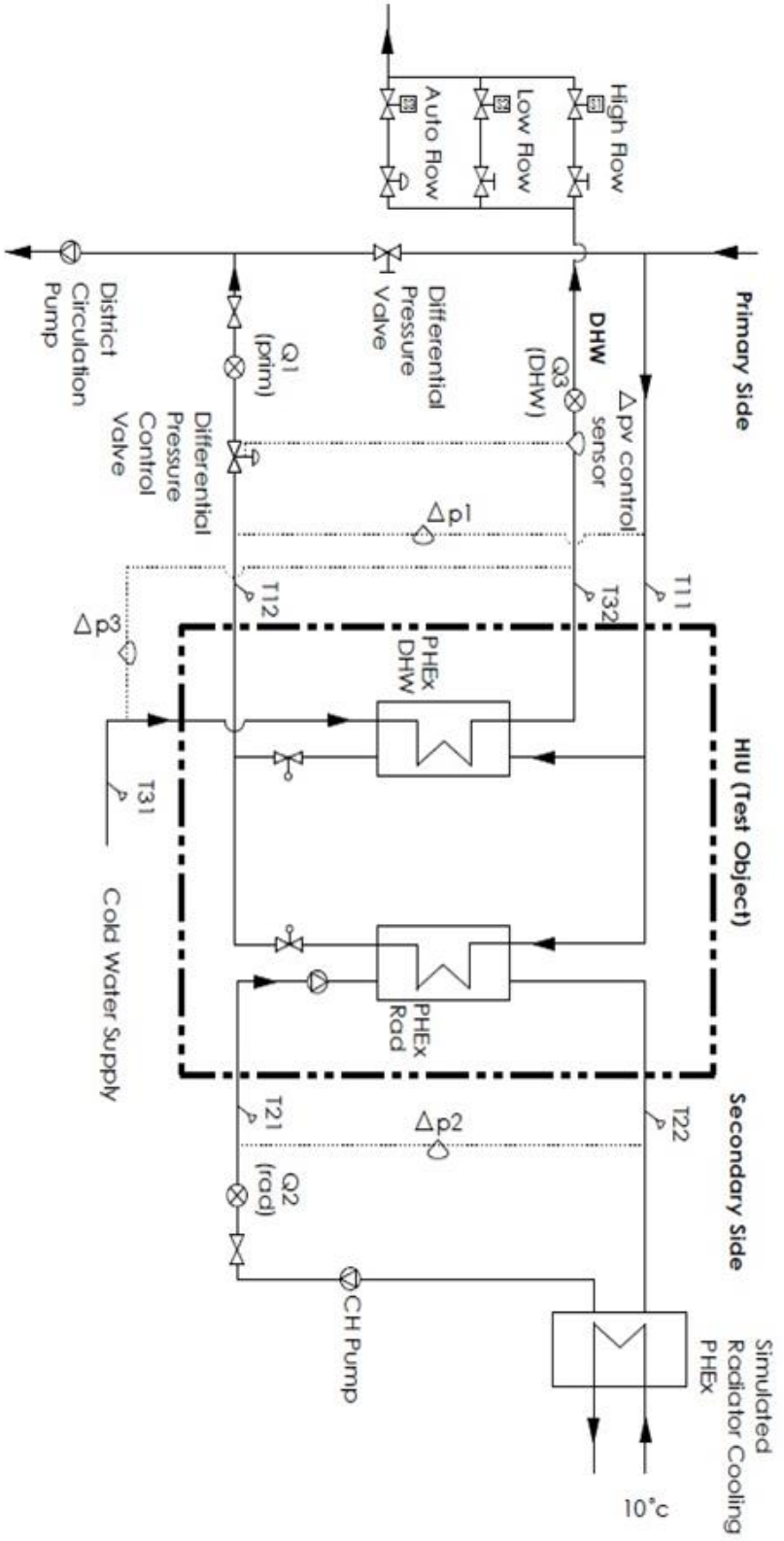

Figure 4-1 – EIL's HIU Test Rig schematic

Table 4.1 – Setup of tests (extracted from BESA Test Regime)

No	Test	static pressure on return	dP across HIU	Primary flow temp	DHW setpoint	DHW flow rate	DHW power	SH output	SH flow temp	SH 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	1.43 times rated value	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1a	Space Heating 1 kW (DH 70 °C flow)	2.5	0.5	70	55	0	0	1	60	40
1b	Space Heating 2 kW (DH 70 °C flow)	2.5	0.5	70	55	0	0	2	60	40
1c	Space Heating 4 kW (DH 70 °C flow)	2.5	0.5	70	55	0	0	4	60	40
1d	Space Heating 1 kW (DH 60 °C flow)	2.5	0.5	60	50	0	0	1	45	35
1e	Space Heating 2 kW (DH 60 °C flow)	2.5	0.5	60	50	0	0	2	45	35
1f	Space Heating 4 kW (DH 60 °C flow)	2.5	0.5	60	50	0	0	2	45	35
Dynamic tests										
2a	DHW only (DH 70 °C flow)	2.5	0.5	70	55	DHW test profile	DHW test profile	0	n/a	n/a
2b	DHW only (DH 60 °C flow)	2.5	0.5	60	50	DHW test profile	DHW test profile	0	n/a	n/a
3a	Low flow DHW (DH 70 °C flow)	2.5	0.5	70	55	0.02	Record value	0	n/a	n/a
3b	Low flow DHW (DH 60 °C flow)	2.5	0.5	60	50	0.02	Record value	0	n/a	n/a
4a	Keep-warm (DH 70 °C flow)	2.5	0.5	70	55	0	0	0	n/a	n/a
4b	Keep-warm (DH 60 °C flow)	2.5	0.5	60	50	0	0	0	n/a	n/a
5a	DHW response time (DH 70 °C flow)	2.5	0.5	70	55	0.13	Record value	0	n/a	n/a
5b	DHW response time (DH 60 °C flow)	2.5	0.5	60	50	0.13	Record value	0	n/a	n/a

Table 4.2 – Test Reporting, adapted from BESA Test Regime

Test	Description	Reporting
Static Tests		
0	Pressure Tests.	Pass/Fail as to whether HIU manages pressure test without leaks or damage.
1a	Space heating 1 kW, 60/40 °C secondary.	$\mathbf{t_{11}}$ – Primary flow temperature. $\mathbf{t_{12}}$ – Primary return temperature. Plot of key metrics over duration of test. **Note**: Outputs used as input data to 'High Temperature' Space Heating Volume Weighted Average Return Temperature calculation.
1b	Space heating 2 kW, 60/40 °C secondary.	
1c	Space heating 4 kW, 60/40 °C secondary.	
1d	Space heating 1 kW, 45/35 °C secondary.	$\mathbf{t_{11}}$ – Primary flow temperature. $\mathbf{t_{12}}$ – Primary return temperature. Plot of key metrics over duration of test. **Note**: Outputs used as input data to 'Low Temperature' Space Heating Volume Weighted Average Return Temperature calculation.
1e	Space heating 2 kW, 45/35 °C secondary.	
1f	Space heating 4 kW, 45/35 °C secondary.	
Dynamic Tests		
2a	DHW only, DH 70 °C flow; 55 °C DHW.	Pass/Fail on DHW (at $\boldsymbol{t_{32}}$) exceeding 65.0 °C (to 1 decimal point)for more than 10 consecutive seconds. 'State the maximum and minimum DHW temperatures over the period of the test when there is a DHW flow. Assessment of scaling risk as per the criteria detailed in 2.26. **Note:** Outputs used as input data to 'High Temperature' Space Heating Volume Weighted Average Return Temperature calculation. Plot $\mathbf{t_{32}}$, $\mathbf{t_{31}}$, $\mathbf{q_3}$, $\mathbf{t_{12}}$, $\mathbf{q_1}$
2b	DHW only, DH 60 °C flow; 50 °C DHW.	State the maximum and minimum DHW temperatures over the period of the test when there is a DHW flow. Plot $\mathbf{q_1}$, $\mathbf{q_3}$, $\mathbf{dp_1}$, $\mathbf{dp_3}$ **Note:** Outputs used as input data to 'Low Temperature' Domestic Hot Water Volume Weighted Average Return Temperature calculation.
3a	Low flow DHW, DH 70 °C flow; 55 °C DHW.	Pass/Fail on DHW (at $\mathbf{t_{32}}$) exceeding 65.0 °C (1 decimal place) for more than 10 consecutive seconds. Comment on ability to deliver DHW at low flow based on DHW temperature reaching at least 45.0 °C (1 decimal place) at the end of the 180 second period of low flow DHW. Comment on the ability to deliver stable DHW flow temperature (at t^{32}), defined as ability to maintain 55.0 +/- 3.0 °C (1 decimal place) during the last 60 seconds of the test. Maximum temperature achieved and +/-°C variance around 55.0 °C (1 decimal place) to be stated. 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.
3b	Low flow DHW, DH 60 °C flow; 50 °C DHW.	Comment on the ability to deliver DHW at low flow rate based on DHW temperature reaching at least 45 °C (1 decimal place) at the end of the 180 second period of low flow DHW. Comment on the ability to deliver stable DHW flow temperature (at t_{32}), defined as ability to maintain 50.0 +/-3°C (1 decimal place) to be stated. 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.
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. Plot temperature t_{10}

		Assessment of scaling risk, based on duration of temperatures in excess of 55.0 °C (1 decimal place). 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 the average primary flow rate for the duration of the test. Note: Outputs used as input data to 'High Temperature' Keep-warm Volume Weighted Average Return Temperature calculation.
4b	Keep-warm, DH 60 °C flow; 50 °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 extent and duration of temperatures in excess of 55.0 °C (1 decimal place). 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 the average primary flowrate for the duration of the test. **Note:** Outputs used as input data to 'Low Temperature' Keep-warm Volume Weighted Average Return Temperature calculation.
5a	DHW response time, DH 70 °C flow; 55 °C DHW.	Pass/Fail on DHW (at $\mathbf{t_{32}}$) exceeding 65.0 °C (1 decimal place) for more than 10 consecutive seconds. State time to achieve 45.0 °C (1 decimal place) and not subsequently drop below 42.0 °C (1 decimal place). Plot $\mathbf{t_{32}, t_{31}, t_{12}, q_1}$
5b	DHW response time, DH 60 °C flow; 50 °C DHW.	State time to achieve a DHW temperature 45.0 °C (1 decimal place) and not subsequently drop below 42.0 °C (1 decimal place). Comment on stability of DHW temperature. Plot $\mathbf{t_{32}, t_{31}, t_{12}, q_1}$ over duration of test.

5 TEST RESULTS

5.1 Test 0 –Pressure Test

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

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

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

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

5.2.1 The plot of the key metrics of Tests 1a-1f for the space heating 1 - 4 kW at both 70 and 60 °C are displayed in Figure 7-1 to Figure 7-6 respectively. See Table 5.1 for summarised test results including the average primary return temperature, t_{12}.

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

Test	Description	Primary				Secondary				
		t_{11}	t_{12}	q_1	P_1	t_{21}	t_{22}	q_2	ΔP_2	P_2
		°C	°C	l/s	kW	°C	°C	l/s	kPa	kW
1a	Space Heating 1 kW (DH 70 °C flow)	70.2	39.8	0.009	1.14	40.0	60.5	0.012	1.5	1.01
1b	Space Heating 2 kW (DH 70 °C flow)	69.7	40.7	0.018	2.18	39.9	60.3	0.024	1.8	2.05
1c	Space Heating 4 kW (DH 70 °C flow)	70.4	39.9	0.035	4.05	40.4	60.2	0.048	2.9	3.98
1d	Space Heating 1 kW (DH 60 °C flow)	60.2	35.1	0.009	0.99	35.1	44.6	0.025	1.2	0.98
1e	Space Heating 2 kW (DH 60 °C flow)	59.8	34.8	0.021	2.19	34.8	45.1	0.049	1.7	2.13
1f	Space Heating 4 kW (DH 60 °C flow)	60.5	35.2	0.039	4.12	35.0	45.2	0.096	4.0	4.10

5.3 Test 2a – DHW only at 70 °C

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

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

5.3.3 The maximum and minimum temperatures of t_{32} were 59.5°C and 36.9°C respectively.

5.3.4 The plot of the key metrics of the duration of Test 2a is displayed in Figure 7-7, Appendix A.

5.4 Test 2b – DHW only at 60 °C

5.4.1 The maximum and minimum temperatures of t_{32} were 53.0°C and 36.8°C respectively.

5.4.2 The plot of the key metrics of the duration of Test 2b is displayed in Figure 7-8, Appendix A.

5.5 Test 3a – Low Flow DHW at 70 °C

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

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

5.5.3 The appliance did maintain the DHW output temperature, t_{32} at 55 ± 3 °C during the last 60 seconds of the test.

5.5.4 The maximum and minimum temperatures of t_{32} were 60.63°C and 42.38°C respectively.

5.5.5 The plot of the key metrics of the duration of Test 3a is displayed in Figure 7-9, Appendix A.

5.6 Test 3b – Low Flow DHW at 60 °C

5.6.1 The appliance did maintain the DHW output temperature, t_{32} at 50 ± 3 °C during the last 60 seconds of the test.

5.6.2 The DHW output temperature, t_{32} was in excess of 55 °C for a total of 3 seconds throughout the duration of the test.

5.6.3 The maximum and minimum temperatures of t_{32} were 55.1°C and 37.4°C respectively.

5.6.4 The plot of the key metrics of the duration of Test 3b is displayed in Figure 7-10, Appendix A.

5.7 Test 4a – Keep-warm at 70 °C

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

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

5.7.3 The appliance is performing keep-warm cycling as the primary flow temperature, t_{11} varies by more than ± 3 °C during the final 3 hours of the test.

5.7.4 The appliance is performing a keep-warm function as cycling was observed.

5.7.5 The DHW output temperature, t_{32} was in excess of 55°C for a total of 2085 seconds throughout the duration of the test.

5.7.6 The average heat load on the primary side P_1 is 30.6 W.

5.7.7 The average primary flow q_1 over the 8 hour test was 3.44 l/hr.

5.7.8 The keepwarm control was set to maintain a temperature of 49°C.

5.7.9 The plot of the key metrics of the duration of Test 4a is displayed in Figure 7-11, Appendix A.

5.8 Test 4b – Keep-warm at 60 °C

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

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

5.8.3 The appliance is performing keep-warm cycling as the primary flow temperature, t_{11} varies by more than ± 3 °C during the final 3 hours of the test.

5.8.4 The appliance is performing a keep-warm function as cycling was observed.

5.8.5 The DHW output temperature t_{32} was in excess of 55 °C for a total of 559 seconds throughout the duration of the test.

5.8.6 The average heat load on the primary side P_1 is 31.3 W.

5.8.7 The average primary flow q_1 over the 8 hour test was 4.74 l/hr.

5.8.8 The keepwarm control was set to maintain a temperature of 49°C.

5.8.9 The plot of the key metrics of the duration of Test 4b is displayed in Figure 7-12, Appendix A.

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

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

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

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

5.9.4 The plot of the key metrics of the duration of Test 5a is displayed in Figure 7-13, Appendix A.

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

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

5.10.2 The plot of the key metrics of the duration of Test 5b is displayed in Figure 7-4, Appendix A.

5.11 Overall Scaling Risk Assessment

5.11.1 If any of the below factors occur then the risk of scaling of the DHW plate in hard water areas will be increased.

Table 5.2 - Overall Scaling Risk Assessment

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

5.12 Test Summary

5.12.1 See Table 7.1 and Table 7.2, Appendix for the summary of key metrics of all the tests described in this report.

5.13 VWART Calculations

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

Table 5.3 – High Temperature VWART Calculations

Symbol	Description	Value
SH_{PROP}	Annual Heating Period percentage	0.07
NSH_{PROP}	Annual Non-Heating Period percentage	0.93
$VWART_{SH}$	Space Heating Volume Weighted Return Temperature	41.3
$VWART_{DHW}$	DHW Volume Weighted Return Temperature	13.4
$VWART_{KWM}$	Keep Warm Volume Weight return Temperature	37.6
$VWART_{HEAT}$	Annual Volume Weighted Return Temperature For Heating Period	40.3
$VWART_{NONHEAT}$	Annual Volume Weighted Return Temperature For Non Heating	27.0
$VWART_{HIU}$	Total Annual Volume Weighted Return Temperature	27.9

Table 5.4 – Low Temperature VWART Calculations

Symbol	Description	Value
SH_{PROP}	Annual Heating Period percentage	0.93
NSH_{PROP}	Annual Non-Heating Period percentage	0.07
$VWART_{SH}$	Space Heating Volume Weighted Return Temperature	35.0
$VWART_{DHW}$	DHW Volume Weighted Return Temperature	13.8
$VWART_{KWM}$	Keep Warm Volume Weight return Temperature	38.7
$VWART_{HEAT}$	Annual Volume Weighted Return Temperature For Heating Period	34.5
$VWART_{NONHEAT}$	Annual Volume Weighted Return Temperature For Non Heating	28.6
$VWART_{HIU}$	Total Annual Volume Weighted Return Temperature	29.0

6 CONCLUSIONS

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

All conclusions, opinions and interpretations indicated in this report are outside the scope of Enertek's UKAS accreditation.

7 APPENDIX A

7.1 Key Metric Plots

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

GRAPHICAL PLOTS START ON NEXT PAGE

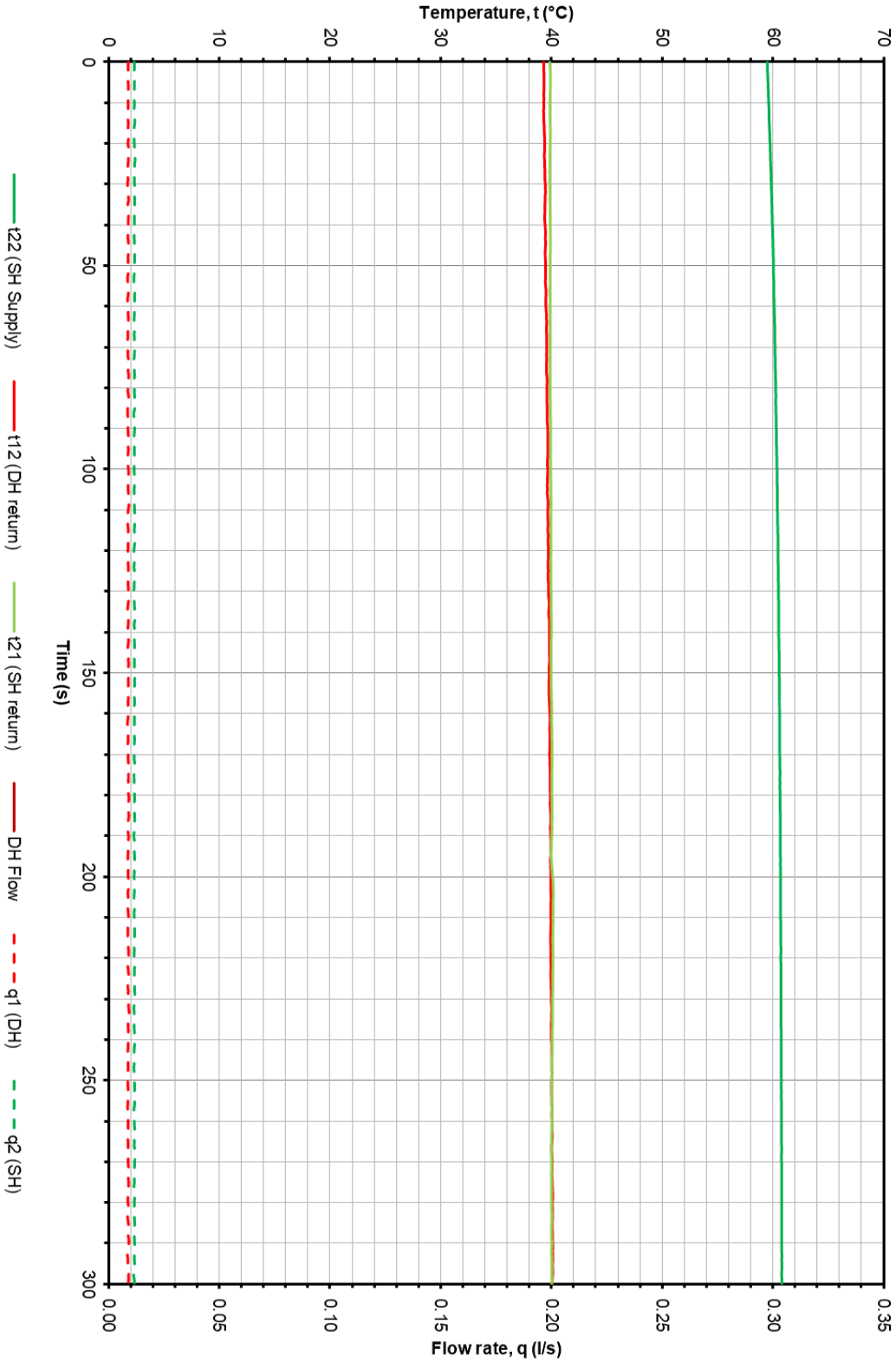

Figure 7-1 - Test 1a – Space Heating 1 kW at 70 °C

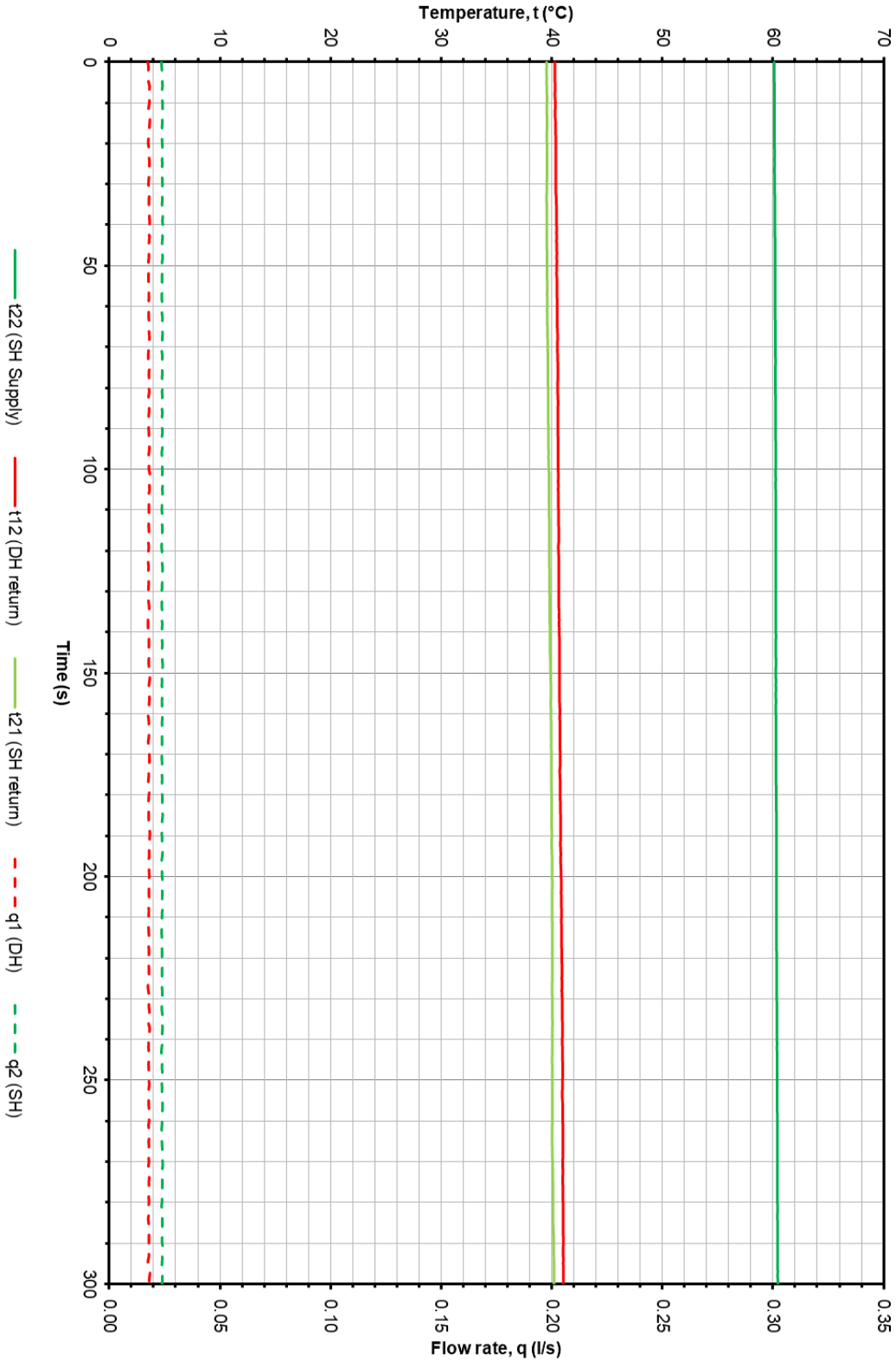

Figure 7-2 - Test 1b – Space Heating 2 kW at 70 °C

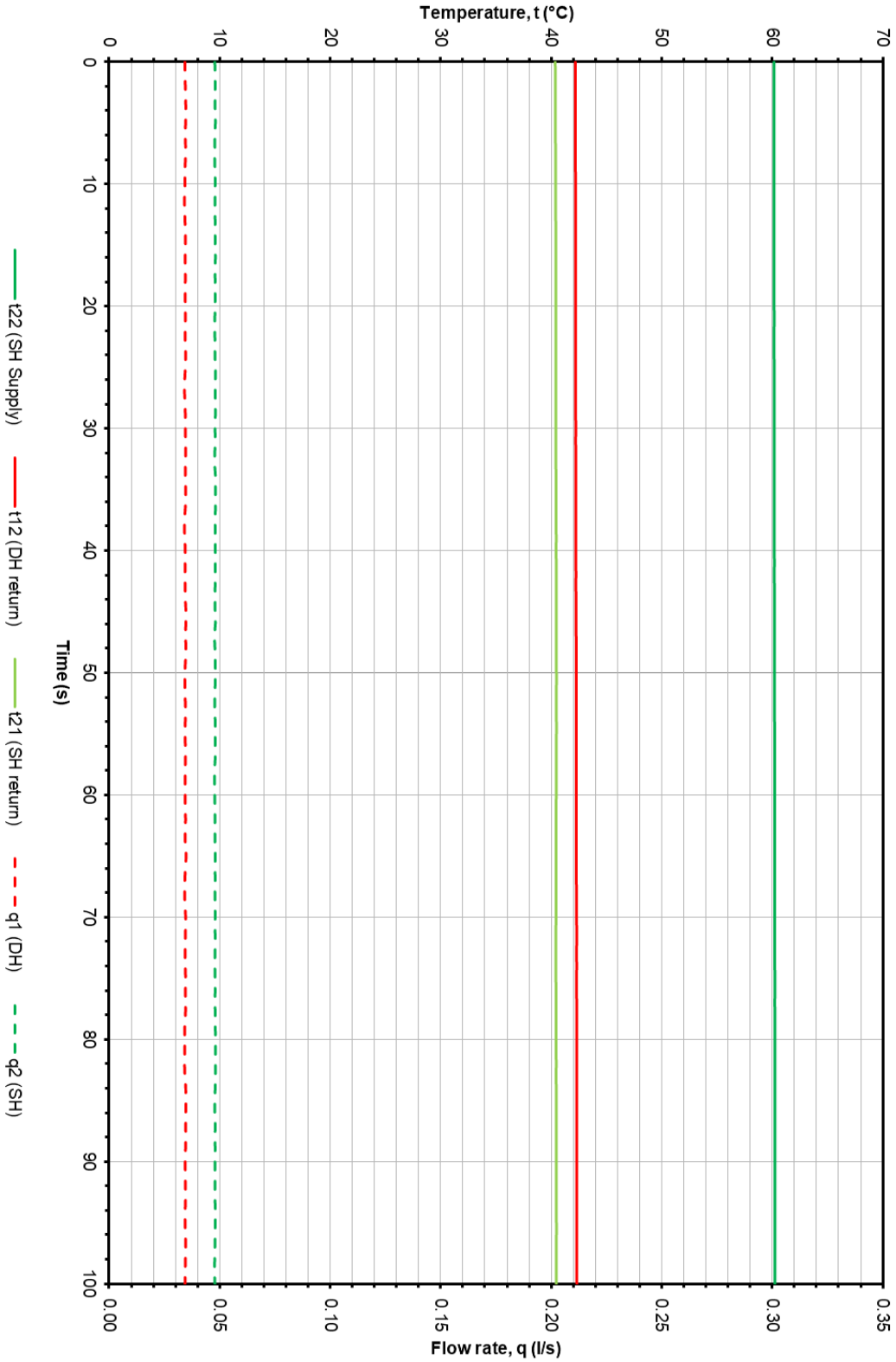

Figure 7-3 - Test 1c – Space Heating 4 kW at 70 °C

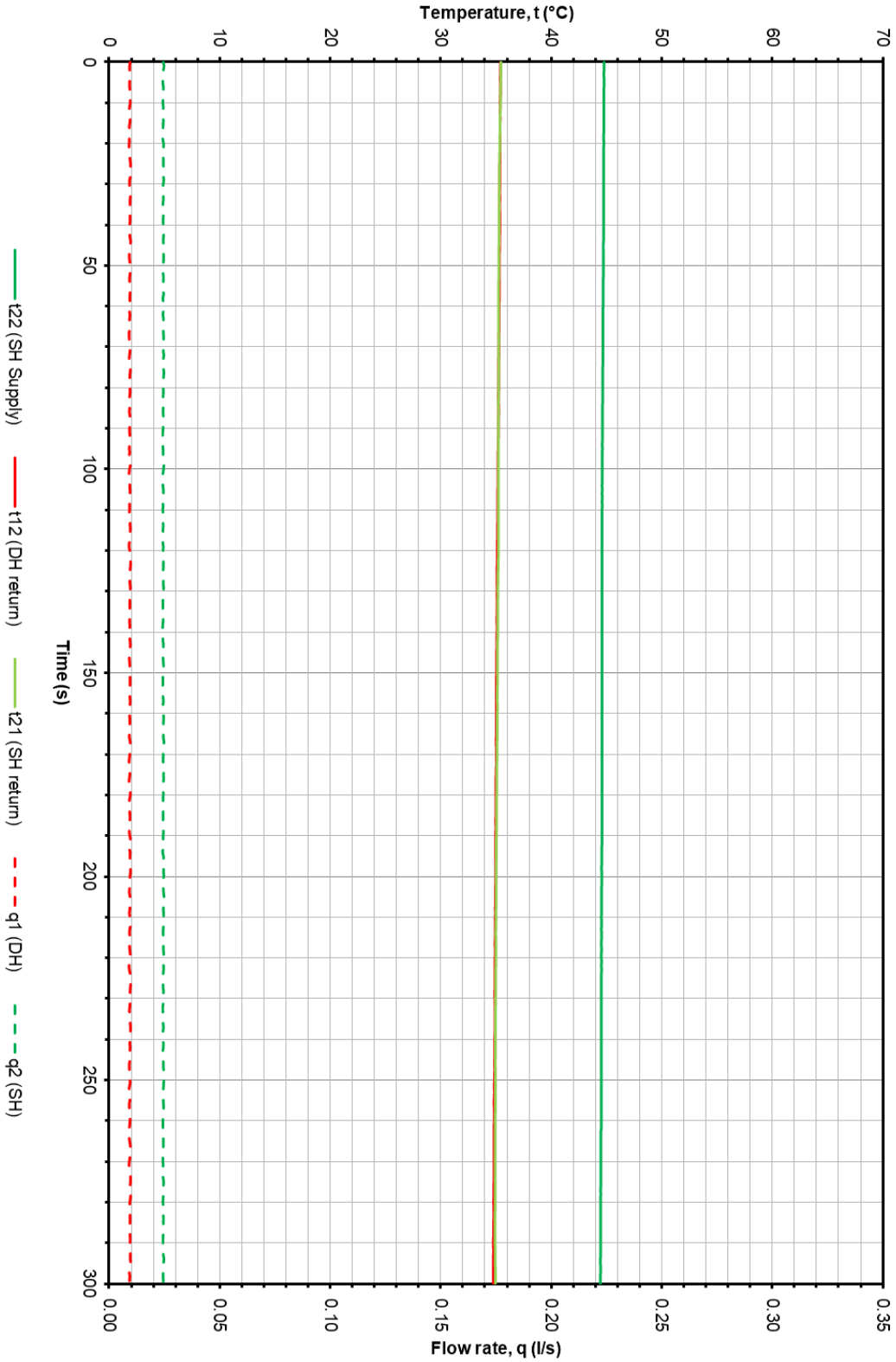

Figure 7-4 - Test 1d – Space Heating 1 kW at 60 °C

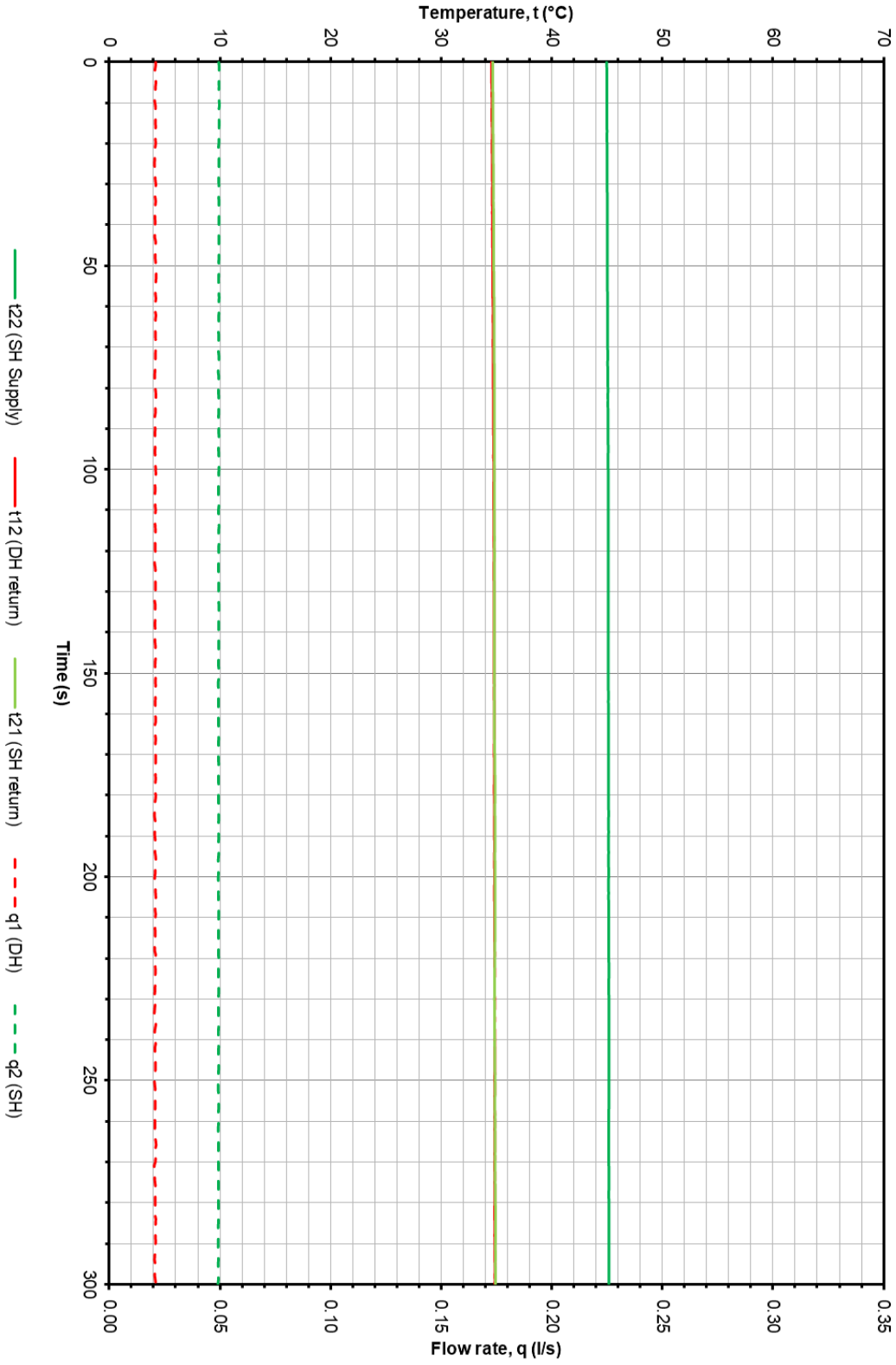

Figure 7-5 - Test 1e – Space Heating 2 kW at 60 °C

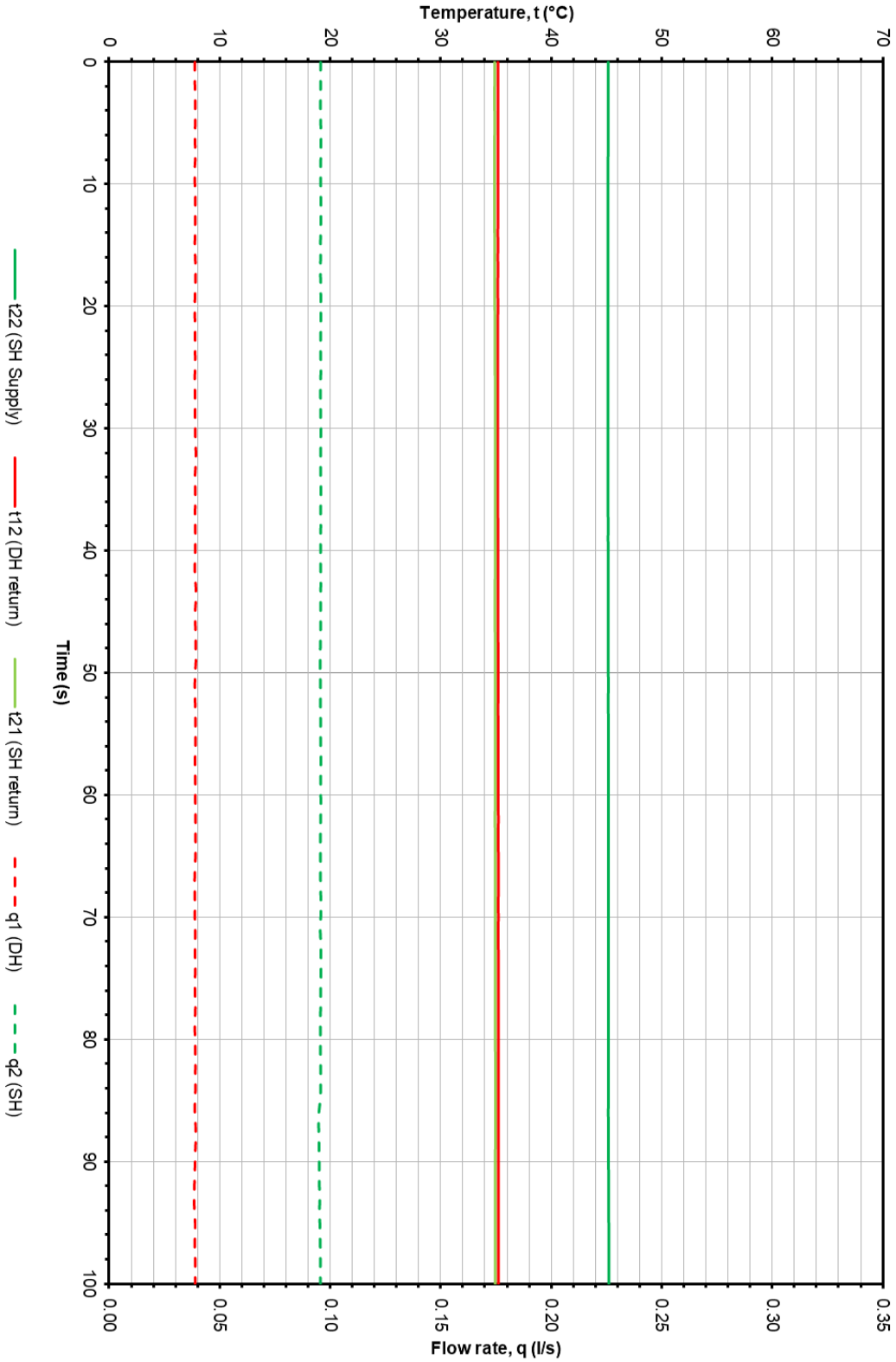

Figure 7-6 - Test 1f – Space Heating 4 kW at 60 °C

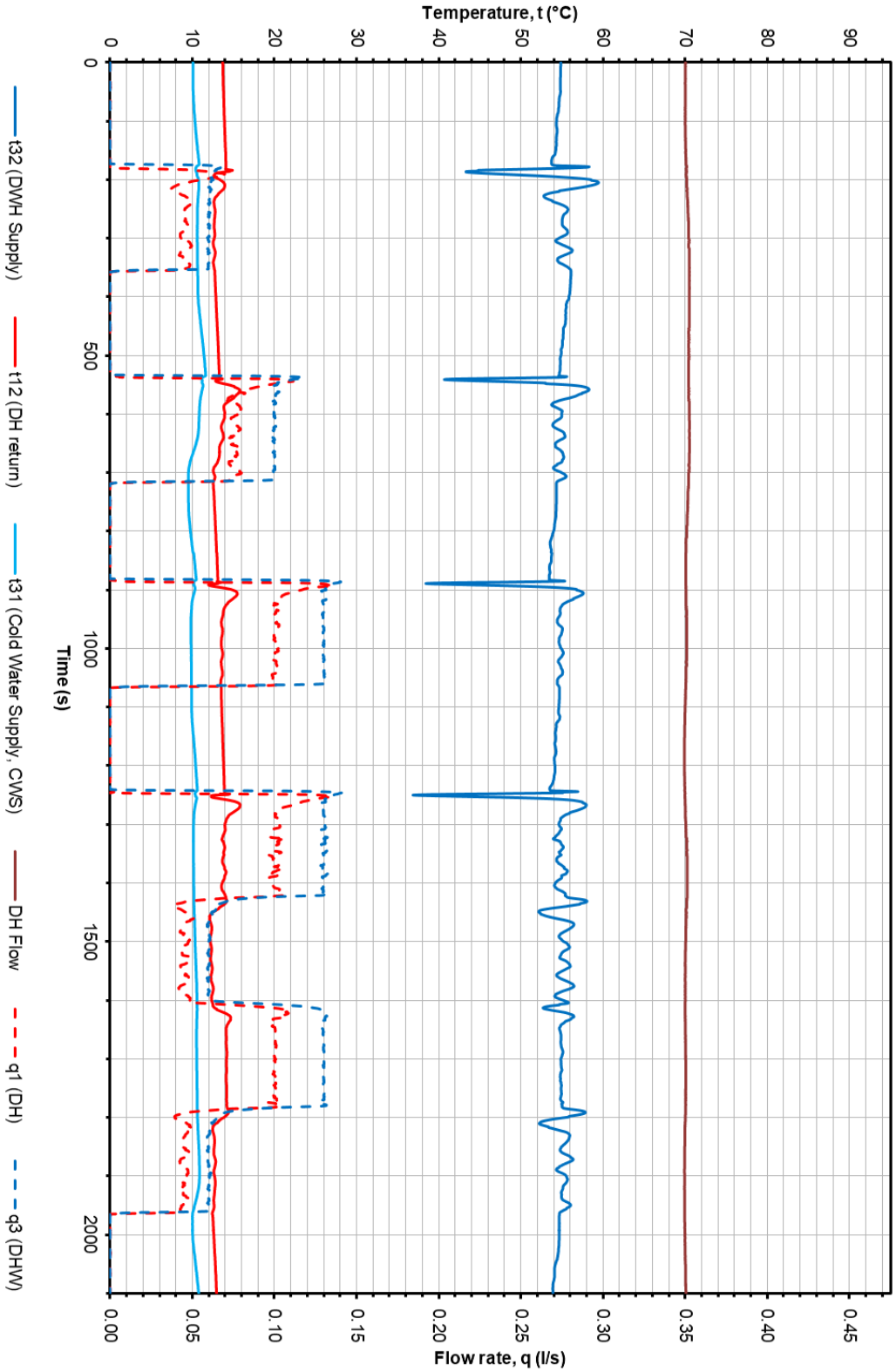

Figure 7-7 - Test 2a – DHW only at 70 °C

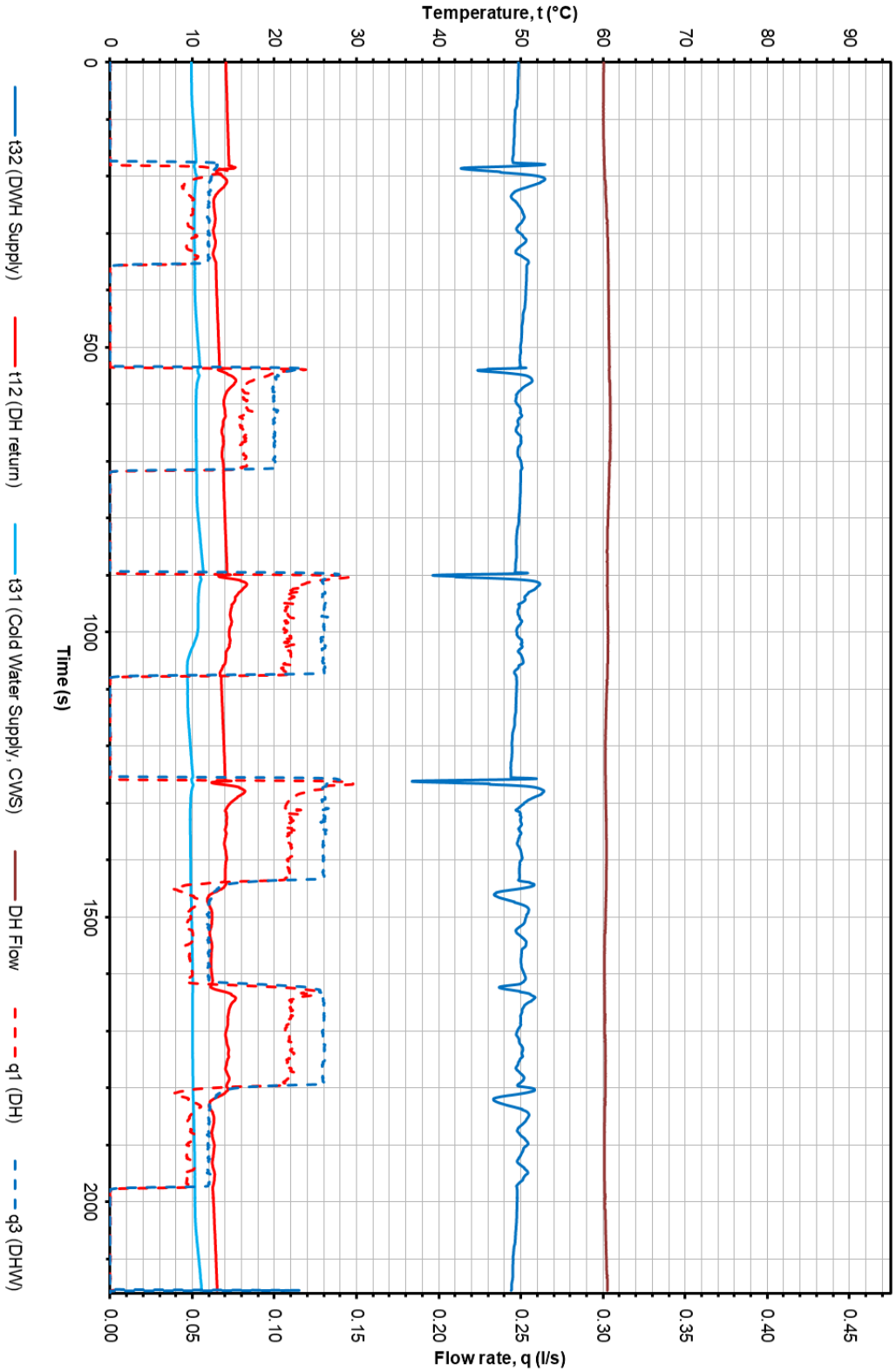

Figure 7-8 - Test 2b – DHW only at 60 °C

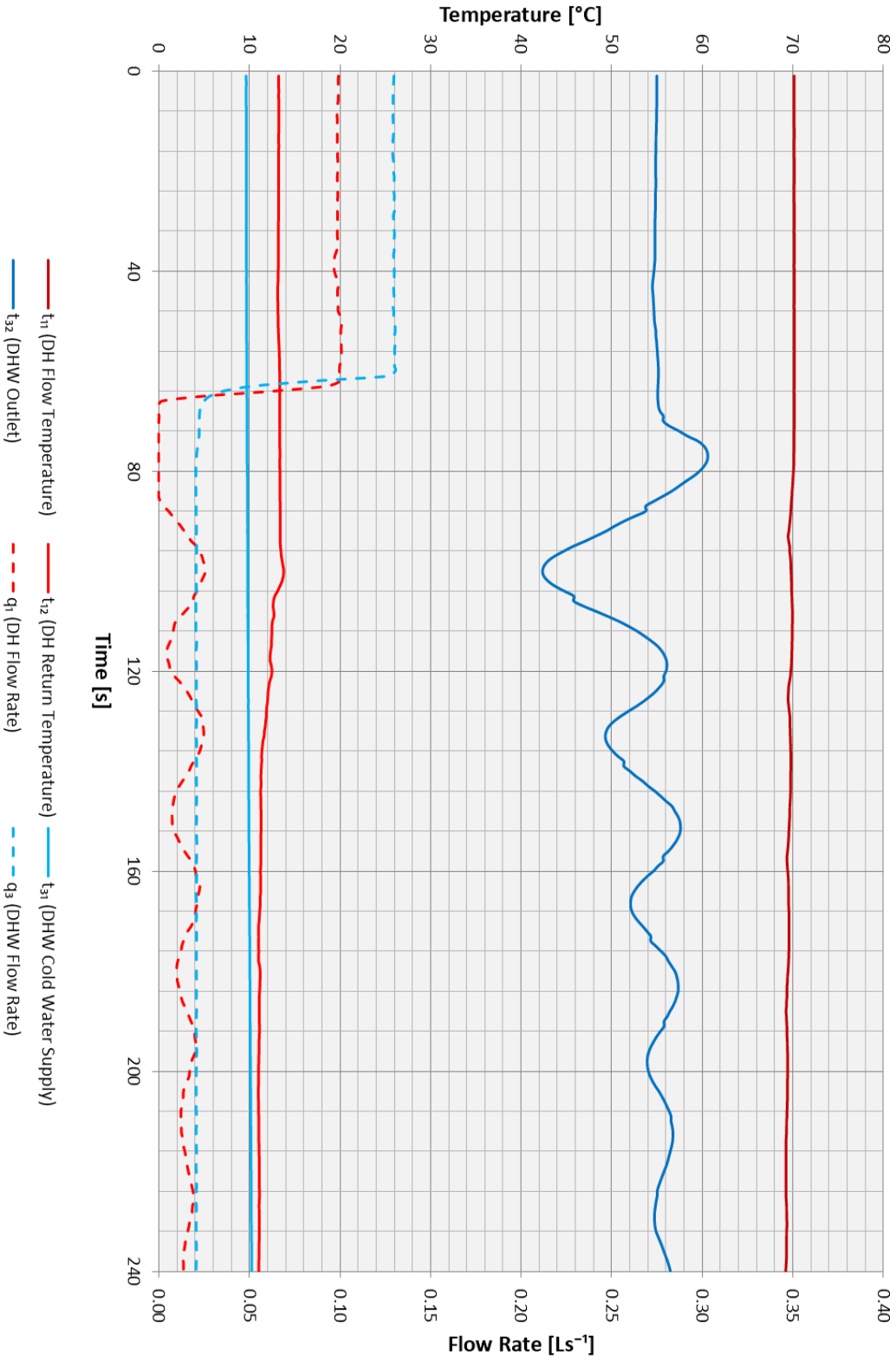

Figure 7-9 - Test 3a – Low Flow DHW at 70 °C

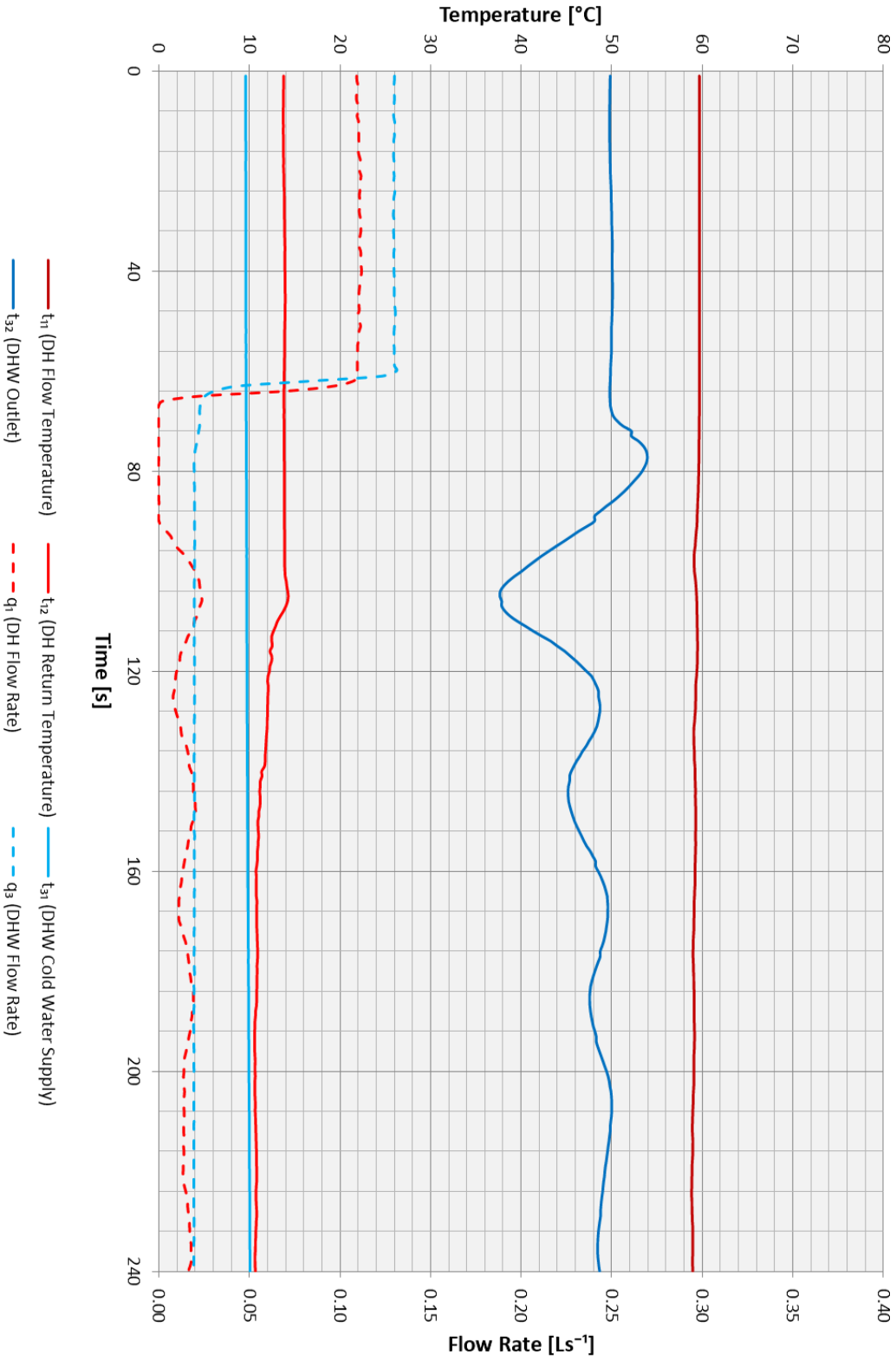

Figure 7-10 - Test 3b – Low Flow DHW at 60 °C

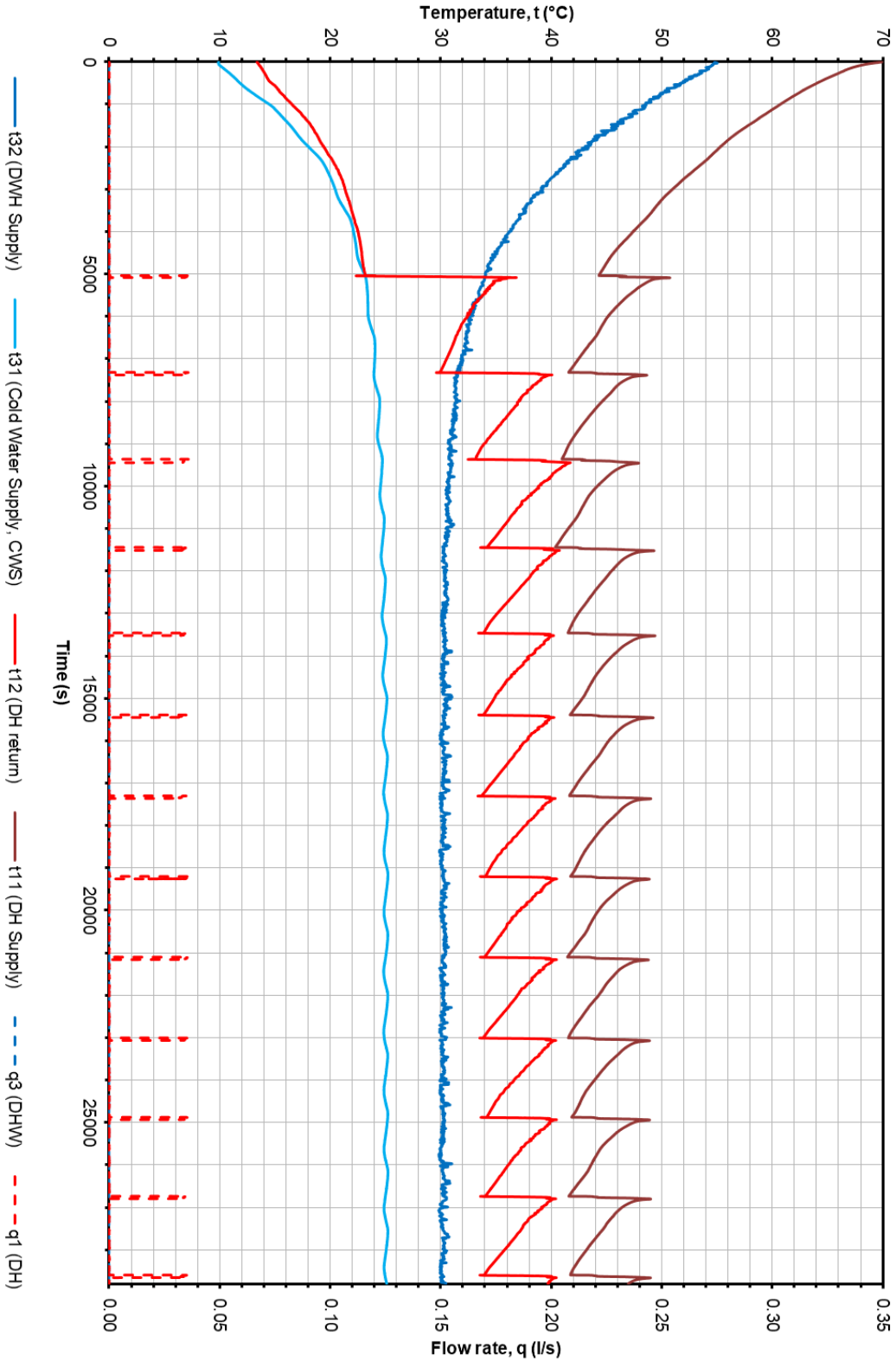

Figure 7-11 - Test 4a – Keep-warm at 70 °C

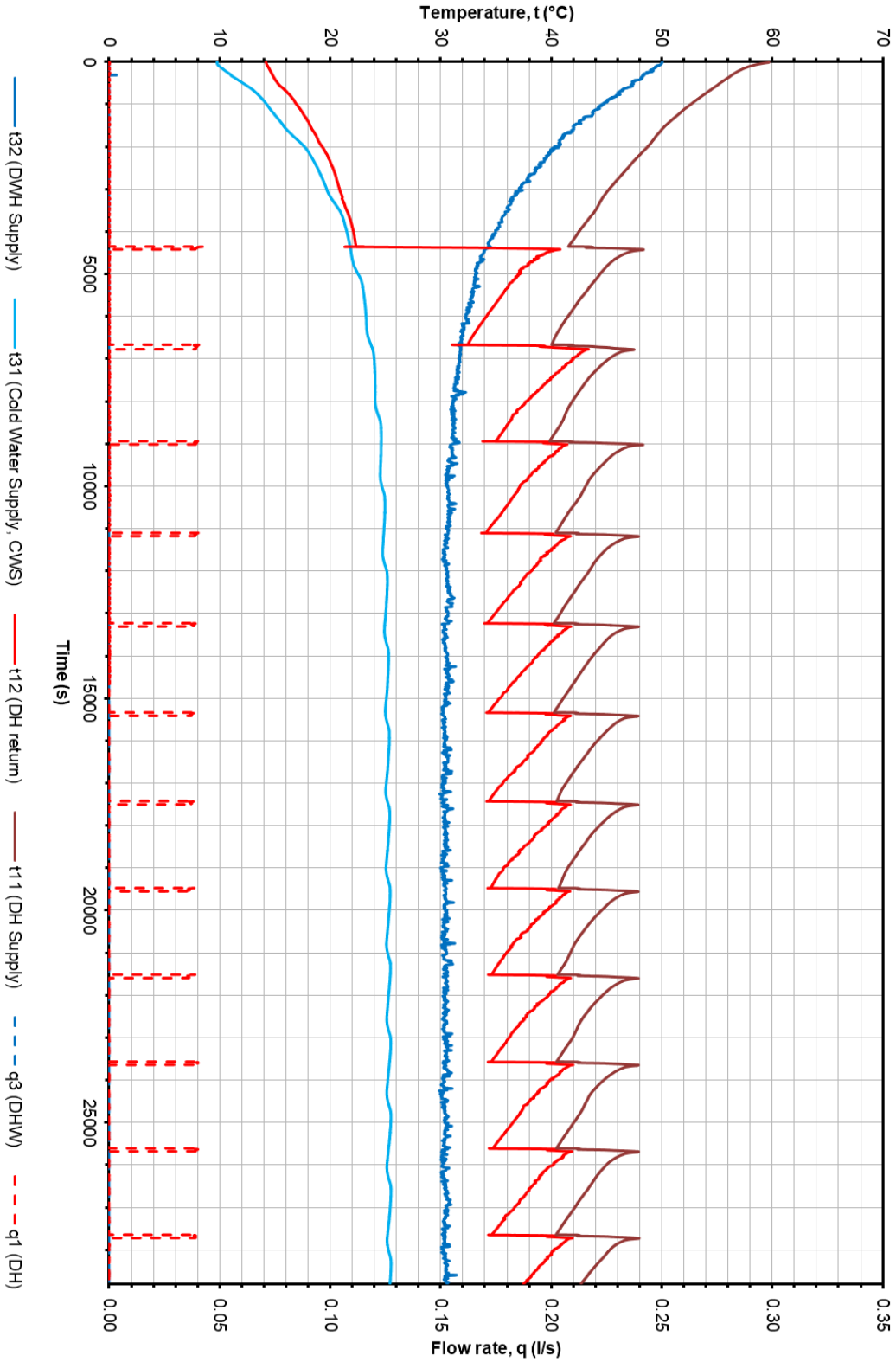

Figure 7-12 - Test 4b – Keep-warm at 60 °C

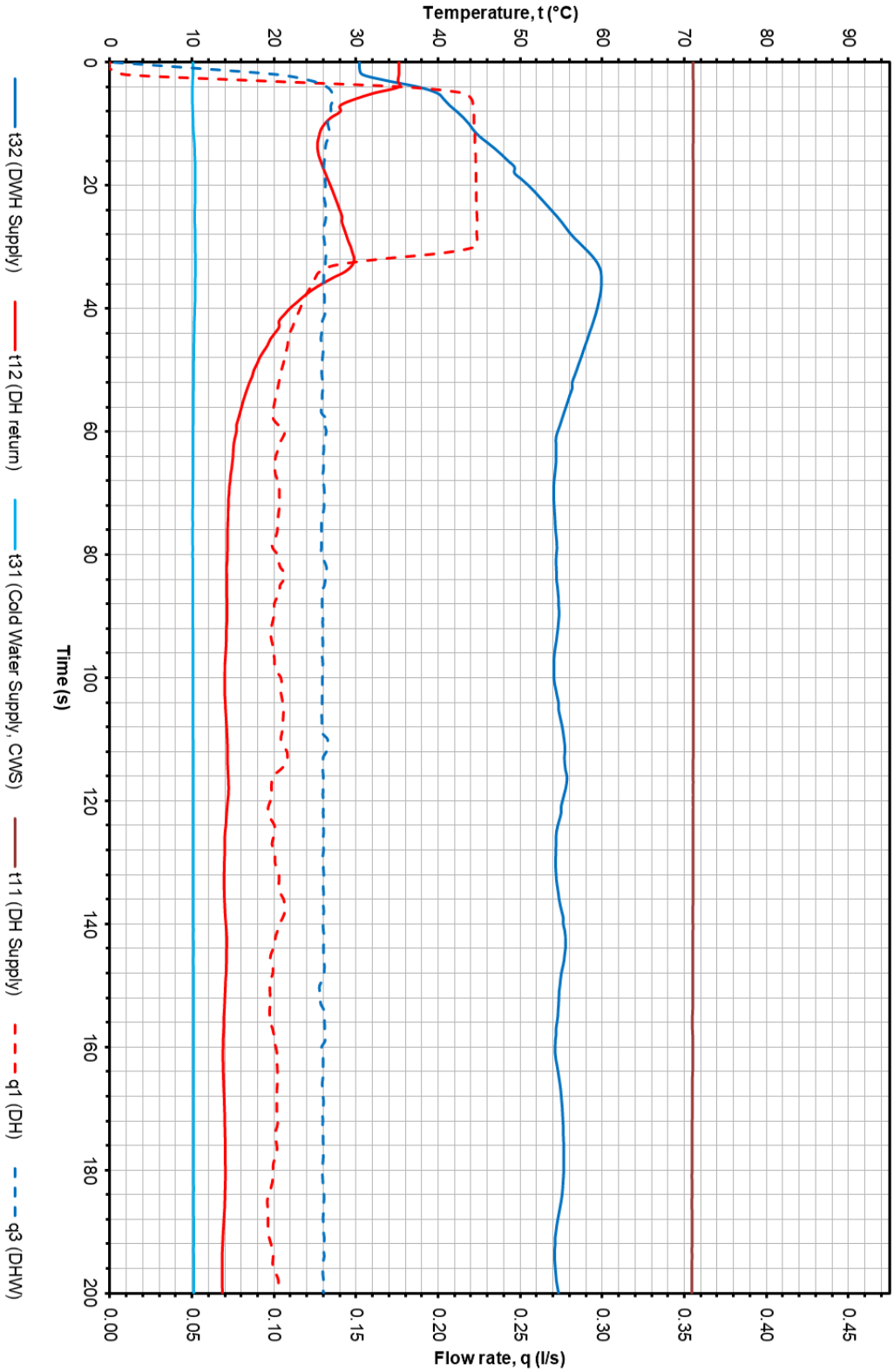

Figure 7-13 - Test 5a – DHW Response Time at 70 °C

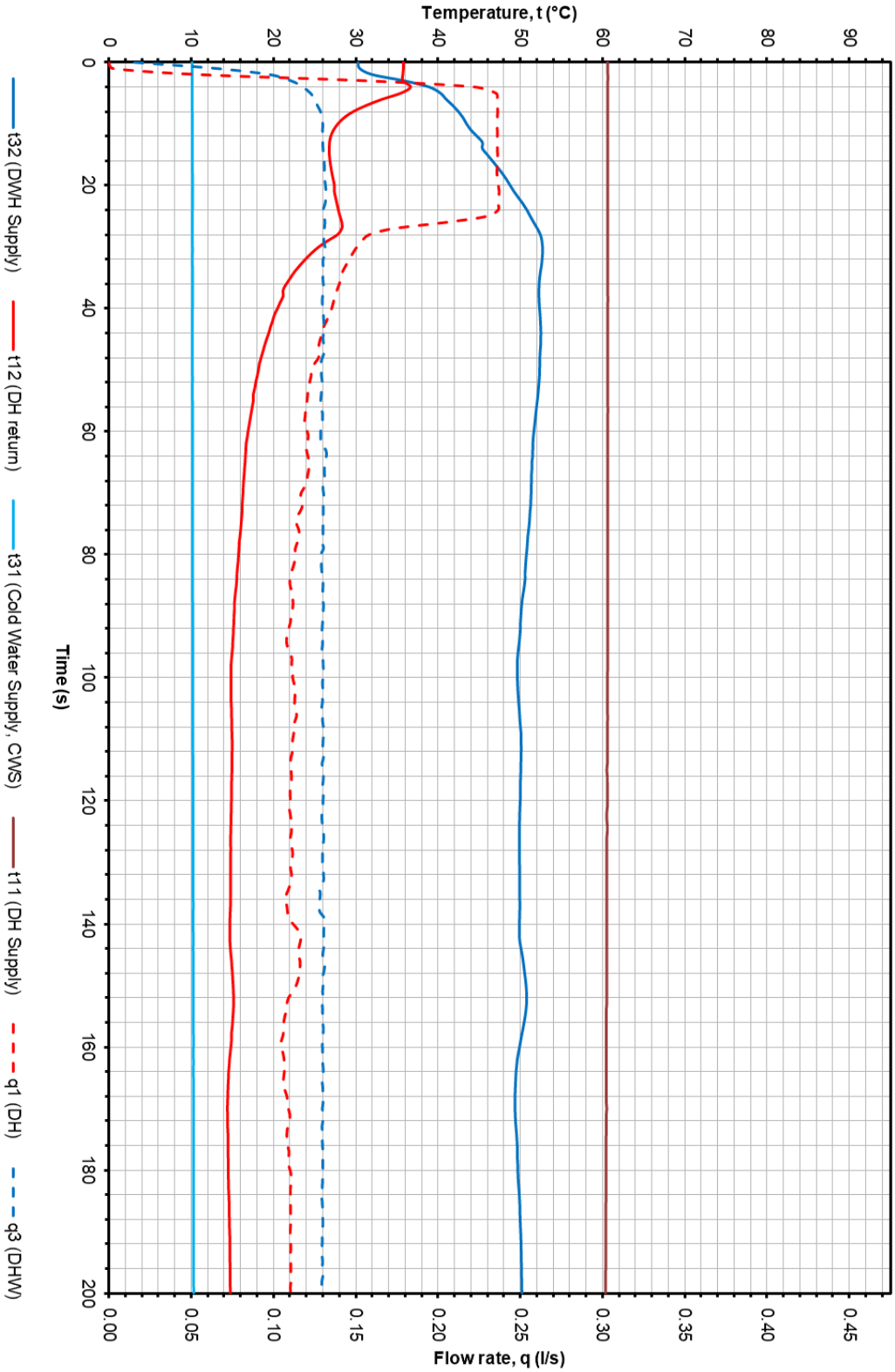

Figure 7-14 - Test 5b – DHW Response Time at 60 °C

7.2 Key Metric and VWART Summary

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

SUMMARY TABLES START ON NEXT PAGE

Table 7.1 - Key metrics of Low Temperature Package

Parameter \ Test	UNITS	SH 1kW	SH 2kW	SH 4kW	DHW Low Flow	DHW Post Low Flow	DHW Med Flow	DHW Post Med Flow	DHW High Flow	DHW Post High Flow	Keep Warm
	Test Number:	**1a**	**1b**	**1c**	**2a**	**2a**	**2a**	**2a**	**2a**	**2a**	**4a**
Ambient Temp	[°C]	20.4	20.2	20.1	20.3	21.1	20.5	20.6	20.2	20.1	20.4
VWART Type	[°C]	$VWART_{1a}$	$VWART_{1b}$	$VWART_{1c}$	$VWART_{DH\ LF}$	$VWART_{DH\ PLF}$	$VWART_{DH\ MF}$	$VWART_{DH\ PMF}$	$VWART_{DH\ HF}$	$VWART_{DH\ PHF}$	$VWART_{KWM}$
VWART value	[°C]	**39.8**	**40.7**	**42.3**	**12.9**	**12.8**	**13.7**	**12.7**	**13.8**	**13.6**	**37.6**
h	[hrs]	97.3	384.0	142.1	65.2	-	16.1	-	18.3	-	8037.1
Annual Primary Vol, V	[m^3]	3.15	24.84	17.65	10.62	0.00	4.43	0.00	6.61	0.00	27.66
P_1	[W]	1143	2183	4051	10520	3.0	17652	2.8	23219	8.0	30.6
P_2	[W]	1007	2050	3977	-	-	-	-	-	-	-
P_3	[W]	-	-	-	11180	0.0	18457	0.0	24219	0.0	-
t_{11}	[°C]	70.2	69.7	70.4	68.4	68.1	68.8	68.9	69.1	68.8	45.9
t_{12}	[°C]	**39.8**	**40.7**	**42.3**	**13.0**	**12.8**	**13.7**	**12.7**	**13.8**	**13.6**	**33.5**
t_{21}	[°C]	40.0	39.9	40.4	29.0	29.1	29.0	28.9	28.6	28.4	26.2
t_{22}	[°C]	60.5	60.3	60.2	34.5	34.2	33.6	33.3	32.7	32.3	27.7
t_{31}	[°C]	-	-	-	10.7	10.7	10.6	9.6	10.0	9.9	-
t_{32}	[°C]	31.3	35.3	41.4	54.8	55.9	54.6	54.3	54.6	54.7	32.7
q1	[l/s]	0.009	0.018	0.035	0.045	0.000	0.077	0.000	0.100	0.000	0.001
q_2	[l/s]	0.012	0.024	0.048	-	-	-	-	-	-	-
q_3	[l/s]	-	-	-	0.060	0.000	0.100	0.000	0.130	0.000	-
Δp_1	[kPa]	51.5	50.7	49.1	49.7	83.2	49.6	83.1	49.6	82.9	147.8
Δp_2	[kPa]	1.5	1.8	2.9	-	-	-	-	-	-	-
Δp_3	[kPa]	-	-	-	8.3	2.0	12.8	1.9	17.4	1.3	-

Table 7.2 - Key metrics of High Temperature Package

Parameter \ Test	UNITS	SH 1kW	SH 2kW	SH 4kW	DHW Low Flow	DHW Post Low Flow	DHW Med Flow	DHW Post Med Flow	DHW High Flow	DHW Post High Flow	Keep Warm
	Test Number:	1a	1b	1c	2a	2a	2a	2a	2a	2a	4a
Ambient Temp	[°C]	20.2	19.9	20.0	19.6	19.5	19.9	20.2	20.2	20.1	20.9
VWART Type	[°C]	$VWART_{1a}$	$VWART_{1b}$	$VWART_{1c}$	$VWART_{DH\ LF}$	$VWART_{DH\ PLF}$	$VWART_{DH\ MF}$	$VWART_{DH\ PMF}$	$VWART_{DH\ HF}$	$VWART_{DH\ PHF}$	$VWART_{KWM}$
VWART value	[°C]	**35.1**	**34.8**	**35.2**	**13.0**	**12.9**	**14.0**	**13.9**	**14.7**	**13.6**	**38.7**
h	[hrs]	100.5	369.4	137.8	72.7	-	18.0	-	20.8	-	8040.8
Annual Primary Vol, V	[m^3]	3.42	27.71	19.35	12.74	0.02	5.37	0.00	8.07	0.00	38.11
P_1	[W]	994	2185	4116	9371	11.4	15783	14.7	20427	21.1	31.3
P_2	[W]	975	2131	4100	-	-	-	-	-	-	-
P_3	[W]	-	-	-	10026	0.0	16477	0.0	21380	0.0	-
t_{11}	[°C]	60.2	59.8	60.5	59.0	58.8	59.5	59.8	59.9	59.7	44.0
t_{12}	[°C]	**35.1**	**34.8**	**35.2**	**13.1**	**13.0**	**14.0**	**13.9**	**14.7**	**13.6**	**34.9**
t_{21}	[°C]	35.1	34.8	35.0	30.5	30.4	30.2	30.1	30.2	30.1	26.3
t_{22}	[°C]	44.6	45.1	45.2	37.4	37.1	36.2	35.7	35.1	34.9	27.0
t_{31}	[°C]	-	-	-	10.3	10.3	10.5	10.6	10.4	9.5	-
t_{32}	[°C]	31.4	33.1	33.5	50.0	50.7	49.8	50.0	49.8	49.5	32.3
q1	[l/s]	0.009	0.021	0.039	0.049	0.000	0.083	0.000	0.108	0.000	0.001
q_2	[l/s]	0.025	0.049	0.096	-	-	-	-	-	-	-
q_3	[l/s]	-	-	-	0.060	0.000	0.100	0.000	0.130	0.000	-
Δp_1	[kPa]	54.3	51.7	48.7	50.3	69.6	50.2	69.2	50.1	70.3	137.4
Δp_2	[kPa]	1.2	1.7	4.0	-	-	-	-	-	-	-
Δp_3	[kPa]	-	-	-	8.6	2.7	13.3	2.3	18.4	2.4	-

Table 7.3 – Low Temperature VWART calculations

VWART Calculation with Keep Warm

Test carried out by Enertek International for HIGH Temperature BESA Tests

Manufacturer: ; Model: ; Serial number: ;

VWART calculation prepared by BW of Enertek International on 12/09/2018

	VWART (°C)	Volume (m3)
DHW	13.8	26.2
Standby	38.7	38.1
Space Heating	35.0	50.5

VWART with keep warm active

Period	VWART (°C)	% Time
No Heating	28.5	93%
Heating	34.5	7%
Overall	**29.0**	

	DHW Draw test results			Post DHW Draw (60 seconds)		DHW Draw Volumes pa			Post DWH Draw Volumes pa		
	Power (W)	Primary flow (m^3/hr)	VWART (°C)	Primary flow (m^3/hr)	VWART (°C)	kWh pa	Hours	Volume pa (m^3)	Events pa	Average duration	Volume pa (m^3)
Low	10026	0.175	13.0	0.000	12.9	729	72.71	12.74	10000	30	0.02
Medium	16477	0.298	14.0	0.000	13.9	297	18.03	5.37	660	75	0.00
High	21380	0.389	14.7	0.000	13.6	444	20.77	8.07	300	145	0.00

	Standy test results		Standby Volumes pa	
	Primary flow (m^3/hr)	VWART (°C)	Hours	Volume pa (m^3)
Standby	0.004739	38.7	8,041	38.10611164

	Space Heating test results			Space Heating Volumes pa		
	Power (W)	Primary flow (m^3/hr)	VWART (°C)	kWh pa	Hours	Volume pa (m^3)
1kWp	975	0.034	35.1	98	100.50	3.42
2kWp	2131	0.075	34.8	787	369.35	27.71
4kWp	4100	0.140	35.2	565	137.82	19.35

Table 7.4 – High Temperature VWART calculations

VWART Calculation with Keep Warm

Test carried out by Enertek International for HIGH Temperature BESA Tests

Manufacturer: ; Model: ; Serial number: ;

VWART calculation prepared by BW of Enertek International on 12/09/2018

	VWART (°C)	Volume (m3)
DHW	13.4	21.7
Standby	37.6	27.7
Space Heating	41.3	45.6

VWART with keep warm active

Period	VWART (°C)	% Time
No Heating	27.0	93%
Heating	40.3	7%
Overall	**27.9**	

	DHW Draw test results			Post DHW Draw (60 seconds)	
	Power (W)	Primary flow (m^3/hr)	VWART (°C)	Primary flow (m^3/hr)	VWART (°C)
Low	11180	0.163	12.9	0.000	12.8
Medium	18457	0.275	13.7	0.000	12.7
High	24219	0.361	13.8	0.000	13.6

DHW Draw Volumes pa		
kWh pa	Hours	Volume pa (m^3)
729	65.20	10.62
297	16.09	4.43
444	18.33	6.61

Post DWH Draw Volumes pa		
Events pa	Average duration	Volume pa (m^3)
10000	30	0.00
660	75	0.00
300	145	0.00

	Standy test results	
	Primary flow (m^3/hr)	VWART (°C)
Standby	0.003441	37.6

Standby Volumes pa	
Hours	Volume pa (m^3)
8,037	27.65926863

	Space Heating test results		
	Power (W)	Primary flow (m^3/hr)	VWART (°C)
1kWp	1007	0.032	39.8
2kWp	2050	0.065	40.7
4kWp	3977	0.124	42.3

Space Heating Volumes pa		
kWh pa	Hours	Volume pa (m^3)
98	97.28	3.15
787	383.96	24.84
565	142.06	17.65

8 APPENDIX B

8.1 Appliance Documentation

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

Table 8.1 – Documentation Supplied

	Component:	Document Submitted (Y/N):	Manufacturer and type:
1	Space Heating Heat Exchanger	Y	SWEP E8 AS
2	Domestic Hot Water Heat Exchanger	Y	SWEP E8 LAS
3	Controller for Space Heating	Y	Emerson PCB PX427 V. D6
4	Control Valve and Actuator for Space Heating	Y	Belimo C215QP-D PICV / Belimo CQ230A actuator
5	Space Heating Strainer	Y	R0402S05 Y Pattern Brass Strainer with 0.5mm filter
6	Controller for Domestic Hot Water	Y	Emerson PCB PX427 V. D6
7	Control Valve and Actuator for Domestic Hot Water	Y	Frese DN20 Compact / Frese 5V Step Motor
8	Temperature Sensors	Y	Belimo 01CT-1LH
9	Domestic Hot Water Isolating Valve	Y	Bonomi PN40 DN20 Ball Valve
10	Primary Side Strainer	Y	T Pattern Brass Strainer with 0.5mm filter
11	Drain Valves	Y	Tongsheng Brass Co. ½" PN16
12	Vent Valves	-	-
13	Circulation Pump	Y	Grundfos UPM3 15-70, 130 Auto
14	Heat Meter	Y	Sharky 775
15	Domestic Hot Water Flow Sensor	Y	Honeywell C7195B
16	Pipes	Y	SS 304 – Primary & Heating / SS 316L MCW & DHW
17	Connections	Y	KVM Various Brass
18	Joints	Y	KVM Various Brass
19	Gaskets	Y	Non-WRAS Approved: Klingersil C-4500 fibre washer WRAS Approved: Hecker Werke Centellen HD 3822 fibre washer
20	Heating System Expansion Vessel	Y	CIMM RP220x550 10 Litre
21	Insulation	Y	ARPRO 5135 EPP Casing
22	Pressure Sensors	-	-
23	ON / OFF Control Valve and Actuator	Y	Belimo C420Q-K DN20 PN25 / Belimo CQK230A-T actuator
24	Brass Pockets for Temperature Sensors	Y	Belimo A-22P-A18
25	Heating System Safety Valve	Y	LK Armatur 510
	Mains Cold Water Shock Absorber	Y	Caleffi Antishock 58965
	Manometer and Thermometer	Y	Cewal Combined Pressure and Temperature Gauge
	Heating System Filling Loop	Y	Caleffi Robofil 3006
	Mains Cold Water Check Valve	Y	Altecnic ALT-SCV020

	Component:	Document Submitted (Y/N):	Manufacturer and type:
A1	Commissioning guide.	-	-
A2	Operation guides with a function description / description of operation and care instructions as suited to the intended user category.	-	-
A3	Declaration of Conformity for CE-marked HIUs.	Y	-
A4	Full parameter list for electrically controlled HIUs.	-	-
A5	Maximum primary static operating differential pressure.	350kPa (3.5 bar)	-
A6	Deactivation procedure of the internal SH pump.	Y	-
	Model name and type number	vTherm	5kW Heating / 50kW Domestic Hot Water
	Serial number	44100395	

8.2 Appliance Components

8.2.1 Details of the main appliance components are given in Table 8.2.

Table 8.2 – Appliance Components details

Vital Energi vTherm	
Appliance Serial Number	44100395
Space Heating Heat Exchanger	SWEP E8 AS * 24
Domestic Hot Water (DHW) Heat Exchanger	SWEP E8 LAS * 44
Controller for Space Heating & DHW	PX427 Software Version D6
Control Valve & Actuator for Space Heating	Belimo C215QP-D PICV DN15 PN25 / Belimo CQ230A actuator
Space Heating Strainer	Strainer 0.5mm
Control Valve & Actuator for DHW	Frese OPTIMA Compact PICV High 5.0 DN15 PN16 / Frese OPTIMA Actuator
Temperature Sensors	Belimo 01ST-1L3
Domestic Hot Water Isolating valve	Bonomi PN40 DN20 Ball Valve
Primary Side Strainer	Strainer 0.5mm
Control Valve & Actuator for HIU On/Off, (NC)	Belimo C420Q-K DN20 PN25 / Belimo CQK230A-T actuator
Drain Valves	Tongsheng Brass Co. ½" PN16
Circulation Pump	Grundfos pump UPM3 15-70, 130 Auto
Heat Meter	Sharky 775 heat meter DN15
Domestic Hot Water Flow Sensor	Honeywell C7195B DN20
Pipes	SS 304 – Primary & Heating / SS 316 MCW & DHW
Connections	Brass
Gaskets	Non-WRAS Approved: Klingersil C-4500 fibre washer WRAS Approved: Hecker Werke Centellen HD 3822 fibre washer
Heating System Safety Valve	LK Armatur 510
Heating System Expansion Vessel	CIMM RP220x550 10 Litre
Mains Cold Water Shock Absorber	Caleffi Antishock 58965
Manometer and Thermometer	Cewal Combined Pressure and Temperature Gauge
Heating System Filling Loop	Caleffi Robofil 3006
Mains Cold Water Check Valve	Altecnic ALT-SCV020
Insulation	ARPRO 5135 EPP Casing

8.3 Appliance Photographs

Figure 8-1 – Photograph of appliance with case off

Figure 8-2 – Photograph of Appliance with Case On

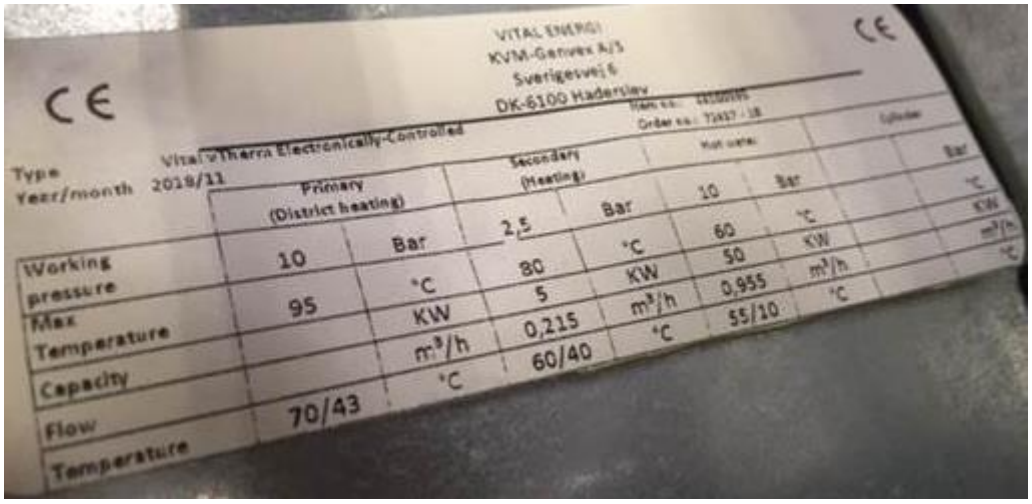

Figure 8-3 – Data Label

8.4 Calibrations and uncertainties

8.4.1 A list of equipment, their calibrations and uncertainties are given in Table 8.3 below.

Table 8.3 - EIL Equipment Calibration and Uncertainties

Equipment Name	ID Number	Calibration Certificate	Measurement Uncertainty K=2 $\frac{U}{\sqrt{20}}$	Units	Calibration Date	Calibration Due
Primary Flow Rate (Badger Flow Meter)	FM 601	U92491-18	±0.0004	l/s	23-05-2018	23/05/2019
DHW Flow Rate (Badger Flow Meter)	FM 602	U92511-18	±0.00305	l/s	24-05-2018	24/05/2019
SH Flow Rate (Badger Flow Meter)	FM 603	U92467-18	±0.04871	l/s	22-05-2018	22/05/2019
DHW Output Pressure Transducer	PT 083	K41129P	±7.73	kPa	22-05-2018	22/05/2019
Cold Water Supply Pressure Transducer	PT 084	K41130P	±7.31	kPa	22-05-2018	22/05/2019
Primary Return Pressure Transducer	PT 085	K41131P	±7.88	kPa	22-05-2018	22/05/2019
Primary Supply Pressure Transducer	PT 086	K41132P	±6.82	kPa	22-05-2018	22/05/2019
SH Flow Pressure Transducer	PT 087	K41127P	±7.26	kPa	22-05-2018	22/05/2019
SH Return Pressure Transducer	PT 088	K41128P	±7.30	kPa	22-05-2018	22/05/2019
SH Return Temp (HIU Inlet)	PRT 4608	EIL 433000	±0.5	°C	19/07/2018	19/07/2019
Primary Supply Temp	PRT 4611	EIL 432360	±0.4	°C	16/05/2018	16/05/2019
Primary Return Temp	PRT 4612	EIL 432360	±0.4	°C	16/05/2018	16/05/2019
SH Supply Temp (HIU outlet)	PRT 4613	EIL 432360	±0.4	°C	16/05/2018	16/05/2019
DHW Output Temp	PRT 4615	EIL 432360	±0.4	°C	16/05/2018	16/05/2019
Cold Water Supply Temp	PRT 4705	EIL 432360	±2.2	°C	16/05/2018	16/05/2019
Software	VERSION – LabVIEW, Version 5 , Service pack 1					

Report Issue No	Reason for Report Update
1	Original Issue.
2	Figure List updated to remove error. Cross reference link for figures repaired.
3	Modified as requested by BESA. Scaling Risk Assessment Added. Test Plots Modified. Data Badge and Serial Number Added.
4	Table 8.1 completed.
5	VWART summary screenshot updated.

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