Enertek International

International Consultants In Product Research, Design, Development & Certification

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Project Title:	BESA Testing
Client:	Dutypoint Ltd.
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Approval By:

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1 BRIEF

1.1.1 Enertek international Limited (EIL), were contracted to receive, install and commission a production sample, DUTY UFH 10/26 Heatmaster Bus iCover on behalf of Dutypoint Ltd.

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	kPa
Δp_2	Pressure Drop, Space heating system across HIU	kPa
Δp_3	Pressure Drop, Domestic Hot Water across HIU	kPa
$VWART_{DHW}$	DHW Volume Weighted Return Temperature	°C
$VWART_{SH}$	Space Heating Volume Weighted Return Temperature	°C
$VWART_{KWH}$	Keep Warm Volume Weighted Return Temperature	°C
$VWART_{HEAT}$	Annual Volume Weighted Return Temperature for Heating Period	°C
$VWART_{NONHEAT}$	Annual Volume Weighed Return Temperature for Non-Heating	°C
$VWART_{HIU}$	Total Annual Volume Weighted Return Temperature	°C
DHW	Domestic Hot Water	–
HIU	Heat Interface Unit	–
SH	Space Heating	–
TMV	Thermostatic mixing Valve	–

3 TEST OBJECT

3.1 Appliance Details

3.1.1 Details of the HIU DUTY UFH 10/26 Heatmaster Bus iCover 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 DUTY UFH 10/26 Heatmaster Bus iCover 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 DUTY UFH 10/26 Heatmaster Bus iCover 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	Dutypoint Ltd.
Model	DUTY UFH 10/26 Heatmaster Bus iCover
Serial number	276.2148.684BI
Year of manufacture	2018
DHW priority	Yes

Table 3.2 – Appliance Design Pressures

Item	Value	Unit
Primary Side	10.0	Bar
Secondary Side space Heating	3.0	Bar
Secondary Side DHW	10.0	Bar

Table 3.3 – Appliance Design Temperatures

Item	Value	Unit
Primary Side	90	°C
Secondary Side space Heating	85	°C
Secondary Side DHW	75	°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 Dutypoint Ltd., DUTY UFH 10/26 Heatmaster Bus iCover 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)

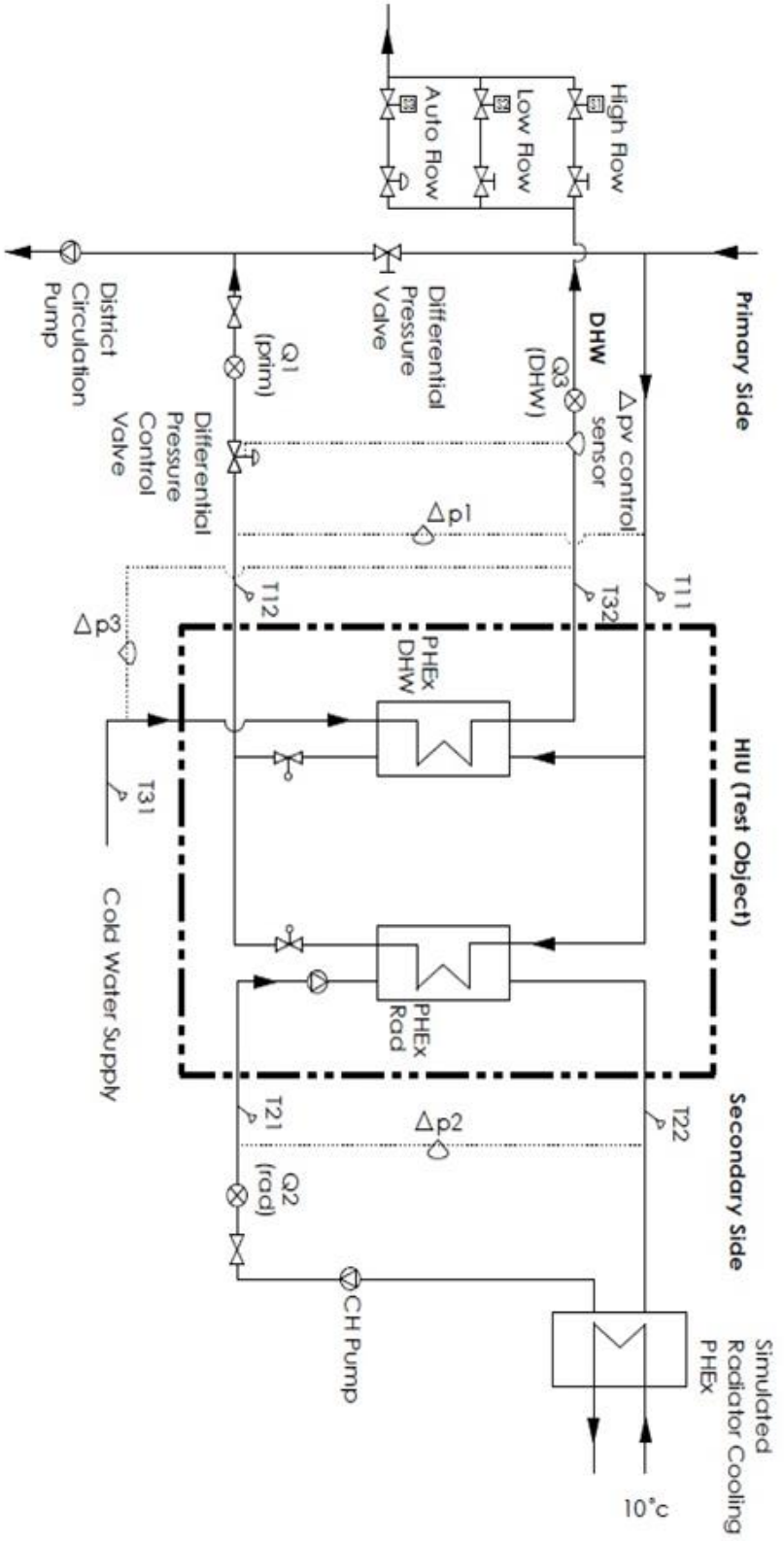

Figure 4.1 – EIL's HIU Test Rig schematic

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 $\mathbf{t_{32}}$, $\mathbf{t_{31}}$, $\mathbf{t_{12}}$, $\mathbf{q_1}$
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 $\mathbf{t_{32}}$, $\mathbf{t_{31}}$, $\mathbf{t_{12}}$, $\mathbf{q_1}$ 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	W	°C	°C	l/s	kPa	W
1a	Space Heating 1 kW (DH 70 °C flow)	69.9	65.1	0.069	1363	40.0	61.9	0.011	-0.7	1006
1b	Space Heating 2 kW (DH 70 °C flow)	69.8	64.0	0.098	2369	39.7	61.6	0.022	0.0	2017
1c	Space Heating 4 kW (DH 70 °C flow)	70.3	62.1	0.124	4297	39.8	59.9	0.047	2.1	3957
1d	Space Heating 1 kW (DH 60 °C flow)	59.7	49.1	0.020	878	35.2	45.7	0.022	0.1	973
1e	Space Heating 2 kW (DH 60 °C flow)	60.0	47.6	0.043	2209	35.1	45.8	0.046	3.0	2040
1f	Space Heating 4 kW (DH 60 °C flow)	59.9	46.0	0.070	4055	35.0	45.0	0.095	10.0	3967

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 5 seconds.

5.3.3 The maximum and minimum temperatures of t_{32} were 57.6°C and 45.6°C respectively.

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

5.4 Test 2b – DHW only at 60 °C

5.4.1 The maximum and minimum temperatures of t_{32} were 51.6°C and 42.6°C respectively.

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

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 5 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 55.6°C and 41.9°C respectively.

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

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 0 seconds throughout the duration of the test.

5.6.3 The maximum and minimum temperatures of t_{32} were 50.5°C and 46.4°C respectively.

5.6.4 The plot of the key metrics of the duration of Test 3b is displayed in Figure 7.10, Appendix.

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 not performing keep-warm cycling as the primary flow temperature, t_{11} does not vary by more than ± 3 °C during the final 3 hours of the test.

5.7.4 The appliance is not performing keep-warm cycle as no cycling was observed.

5.7.5 The average heat load on the primary side P_1 is 60 W.

5.7.6 The average primary flow q_1 over the 8 hour test was 18 l/hr.

5.7.7 The Keep warm control is non-adjustable and has a bypass pipe with a set orifice to control the keep warm flow.

5.7.8 The plot of the key metrics of the duration of Test 4a is displayed in Figure 7.11, Appendix.

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 not performing keep-warm cycling as the primary flow temperature, t_{11} does not vary by more than ± 3 °C during the final 3 hours of the test.

5.8.4 The appliance is not performing keep-warm cycle as no cycling was observed.

5.8.5 The average heat load on the primary side P_1 is 44 W.

5.8.6 The average primary flow q_1 over the 8 hour test was 17 l/hr.

5.8.7 The Keep warm control is non-adjustable and has a bypass pipe with a set orifice to control the keep warm flow.

5.8.8 The plot of the key metrics of the duration of Test 4b is displayed in Figure 7.12, Appendix.

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 5 seconds.

5.9.3 The DHW response time for t_{32} to reach 45 °C (and not subsequently drop below 42 °C) was 10 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.

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 15 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 7.14, Appendix.

5.11 Overall Scaling Risk Assessment

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

Table 5.2 - Overall Scaling Risk Assessment

HIU has a TMV or TRV on the output of the DHW plate heat exchanger.	Yes	
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	Yes	No
Test Designation	**4a**	**4b**
t_{12} exceeds 50°C at any time	Yes	Yes

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	7.2%
NSH_{PROP}	Annual Non-Heating Period percentage	92.8%
$VWART_{SH}$	Space Heating Volume Weighted Return Temperature	64
$VWART_{DHW}$	DHW Volume Weighted Return Temperature	26
$VWART_{KWM}$	Keep Warm Volume Weight return Temperature	60
$VWART_{HEAT}$	Annual Volume Weighted Return Temperature For Heating Period	63
$VWART_{NONHEAT}$	Annual Volume Weighted Return Temperature For Non Heating	54
$VWART_{HIU}$	Total Annual Volume Weighted Return Temperature	55

Table 5.4 – Low Temperature VWART Calculations

Symbol	Description	Value
SH_{PROP}	Annual Heating Period percentage	7.2%
NSH_{PROP}	Annual Non-Heating Period percentage	92.8%
$VWART_{SH}$	Space Heating Volume Weighted Return Temperature	47
$VWART_{DHW}$	DHW Volume Weighted Return Temperature	26
$VWART_{KWM}$	Keep Warm Volume Weight return Temperature	52
$VWART_{HEAT}$	Annual Volume Weighted Return Temperature For Heating Period	47
$VWART_{NONHEAT}$	Annual Volume Weighted Return Temperature For Non Heating	47
$VWART_{HIU}$	Total Annual Volume Weighted Return Temperature	47

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

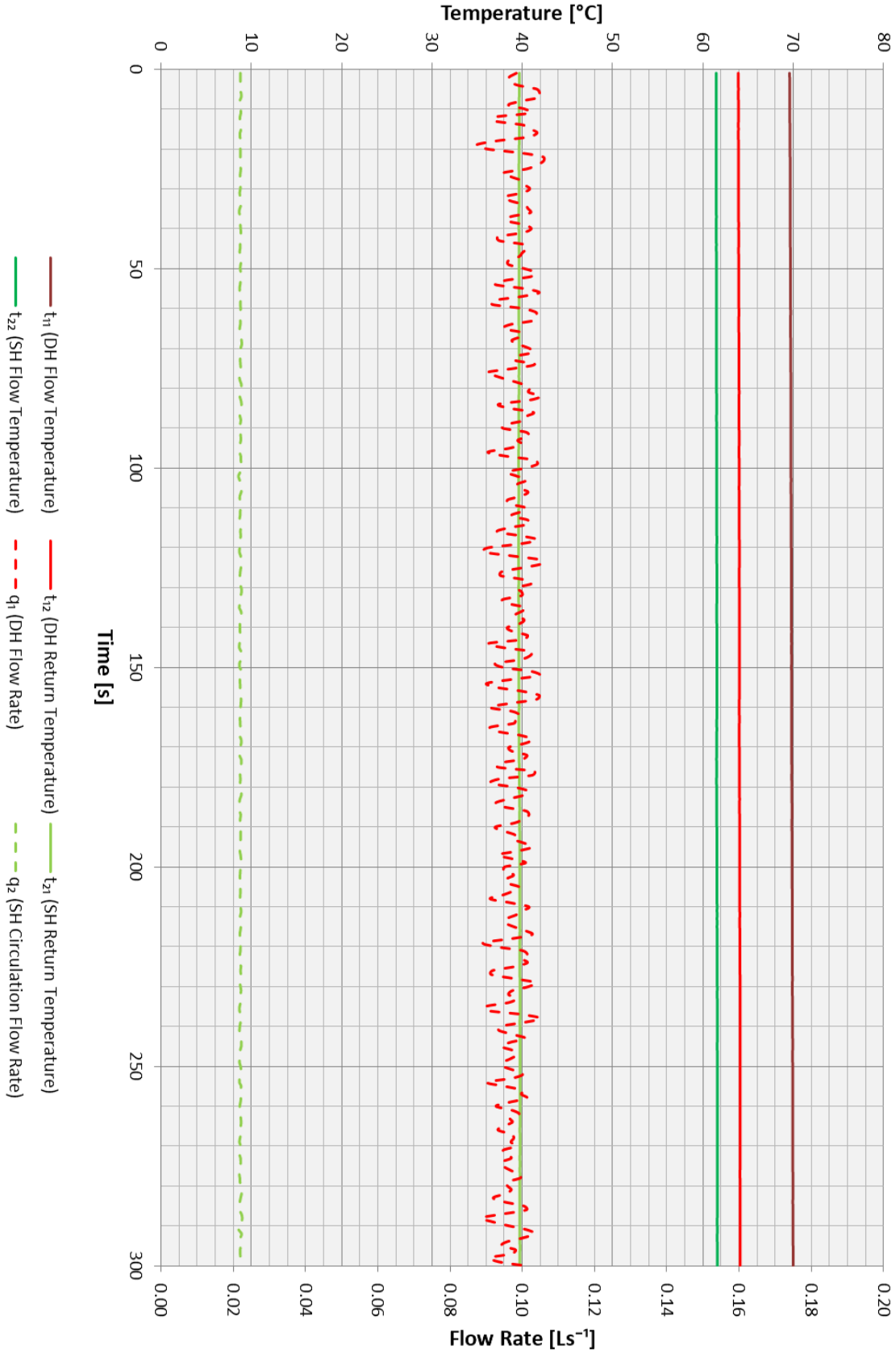

Figure 7.2 - Test 1b – Space Heating 2 kW at 70 °C

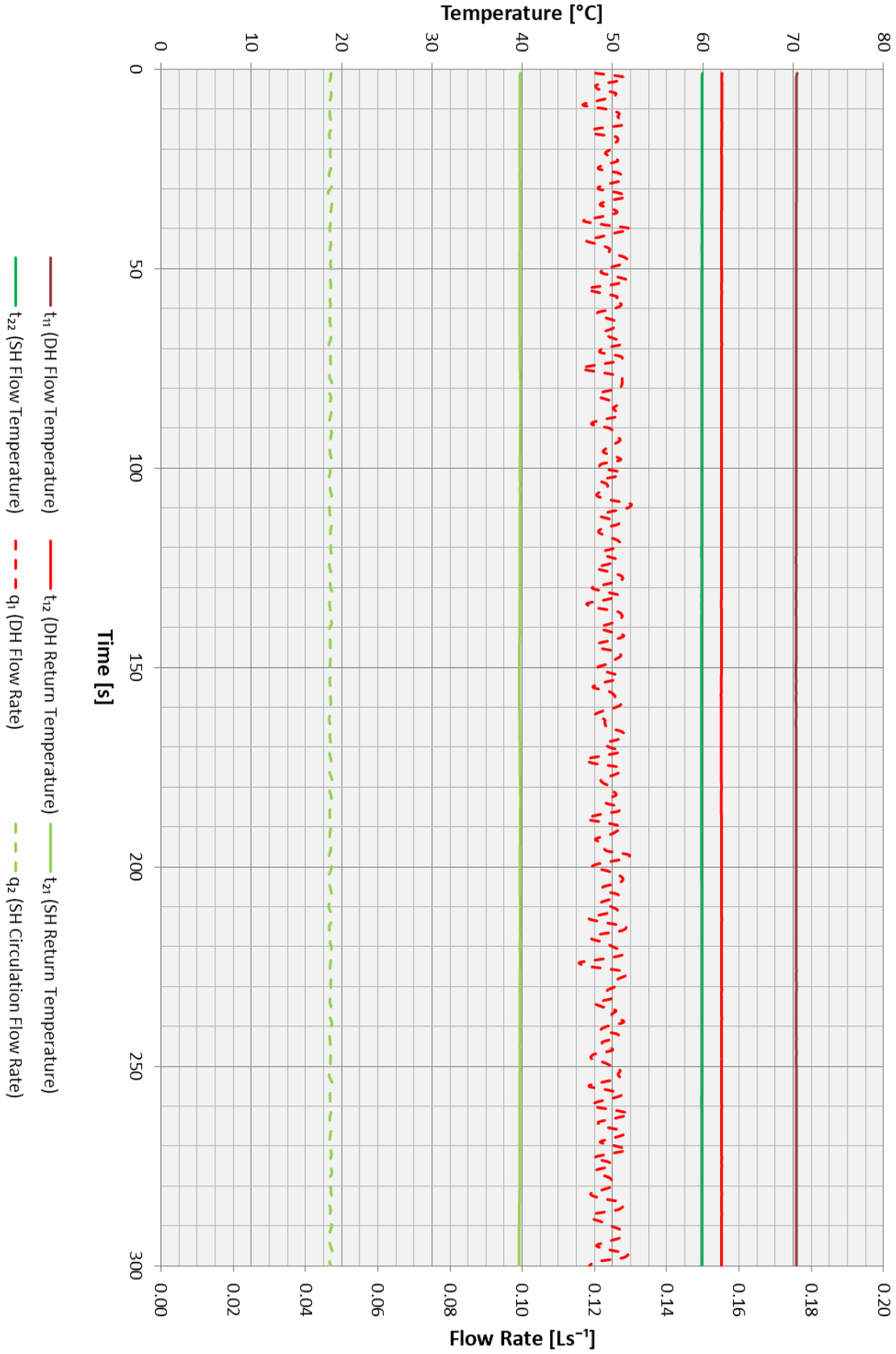

Figure 7.3 - Test 1c – Space Heating 4 kW at 70 °C

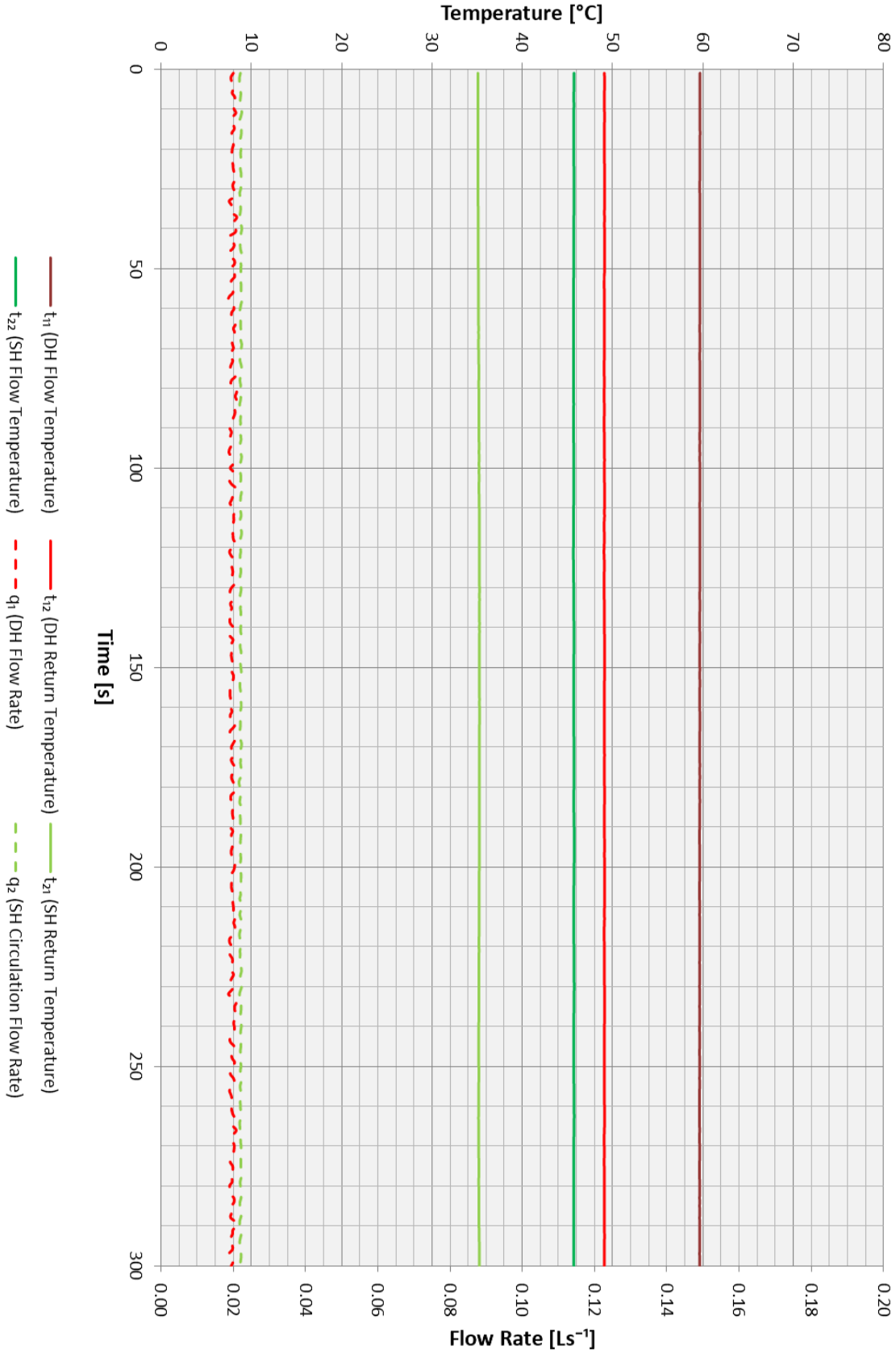

Figure 7.4 - Test 1d – Space Heating 1 kW at 60 °C

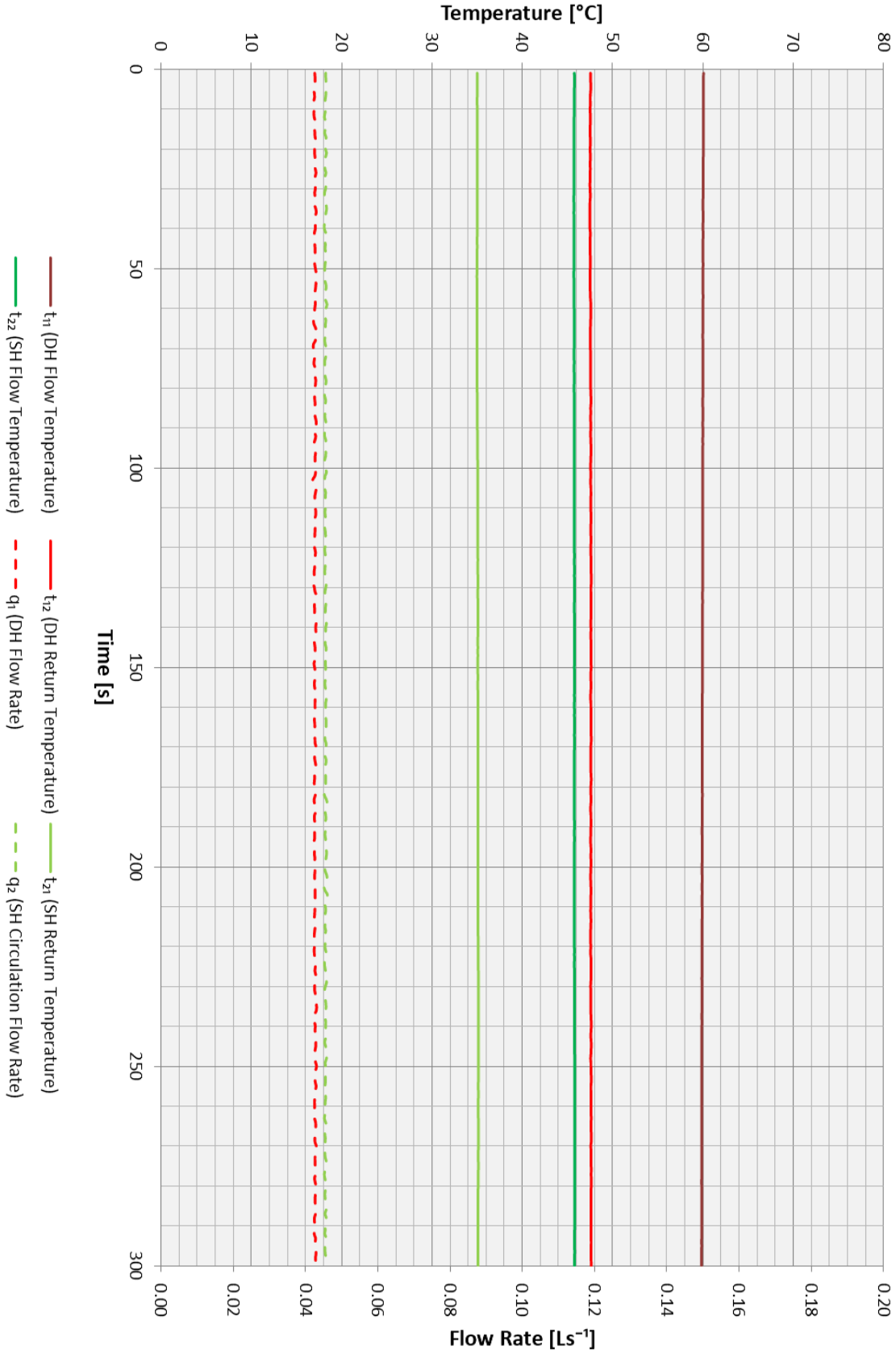

Figure 7.5 - Test 1e – Space Heating 2 kW at 60 °C

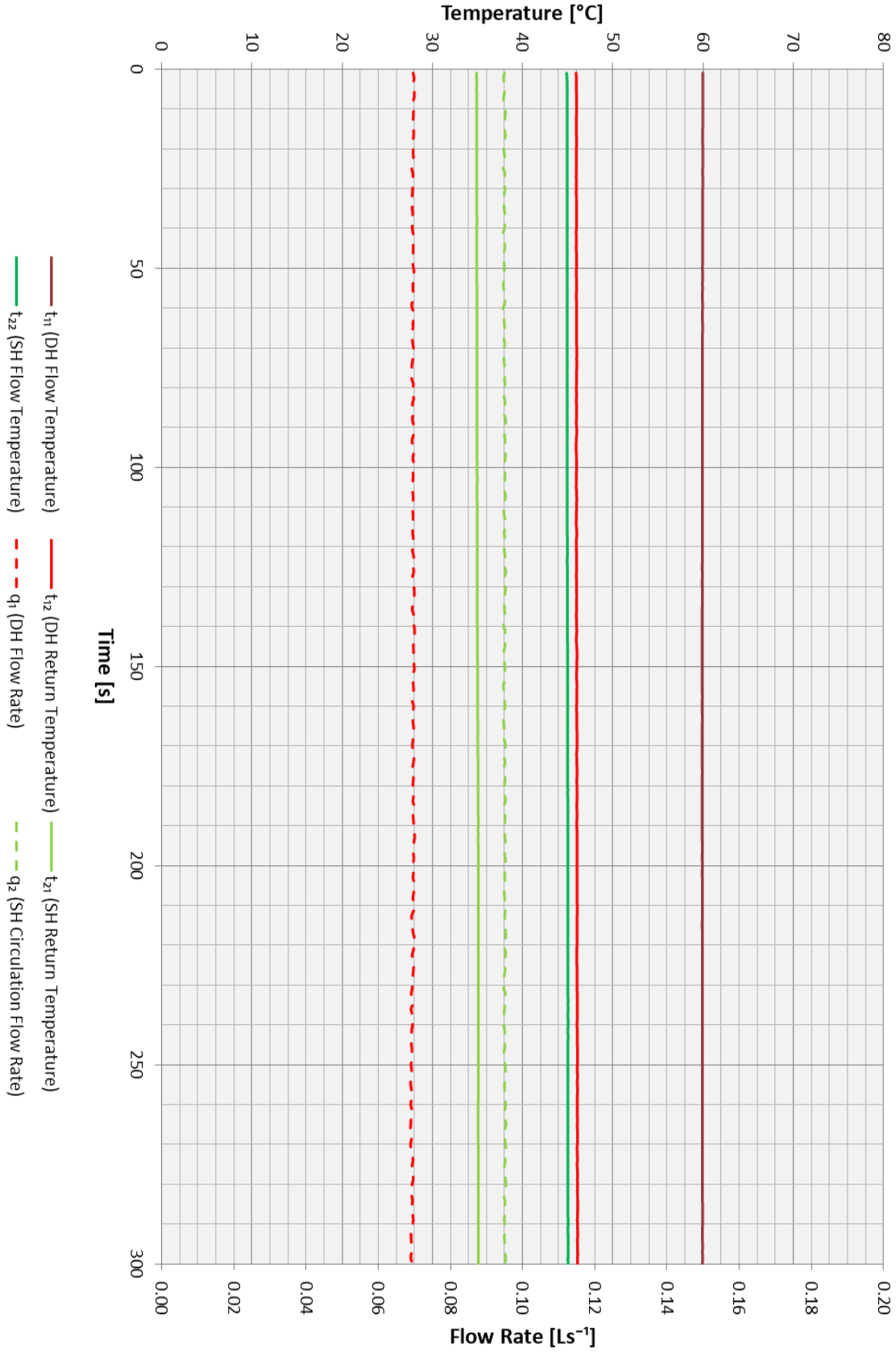

Figure 7.6 - Test 1f – Space Heating 4 kW at 60 °C

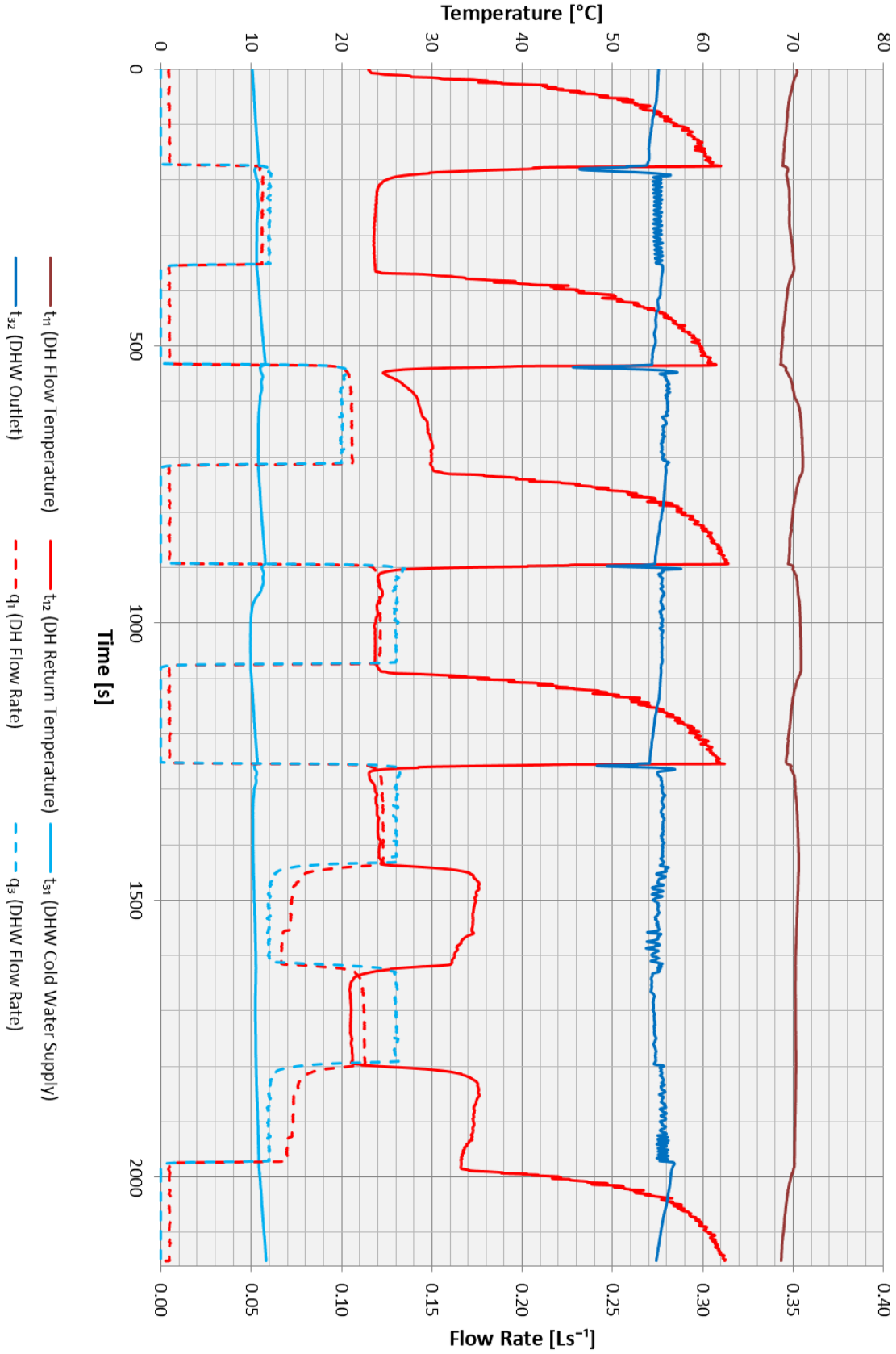

Figure 7.7 - Test 2a – DHW only at 70 °C

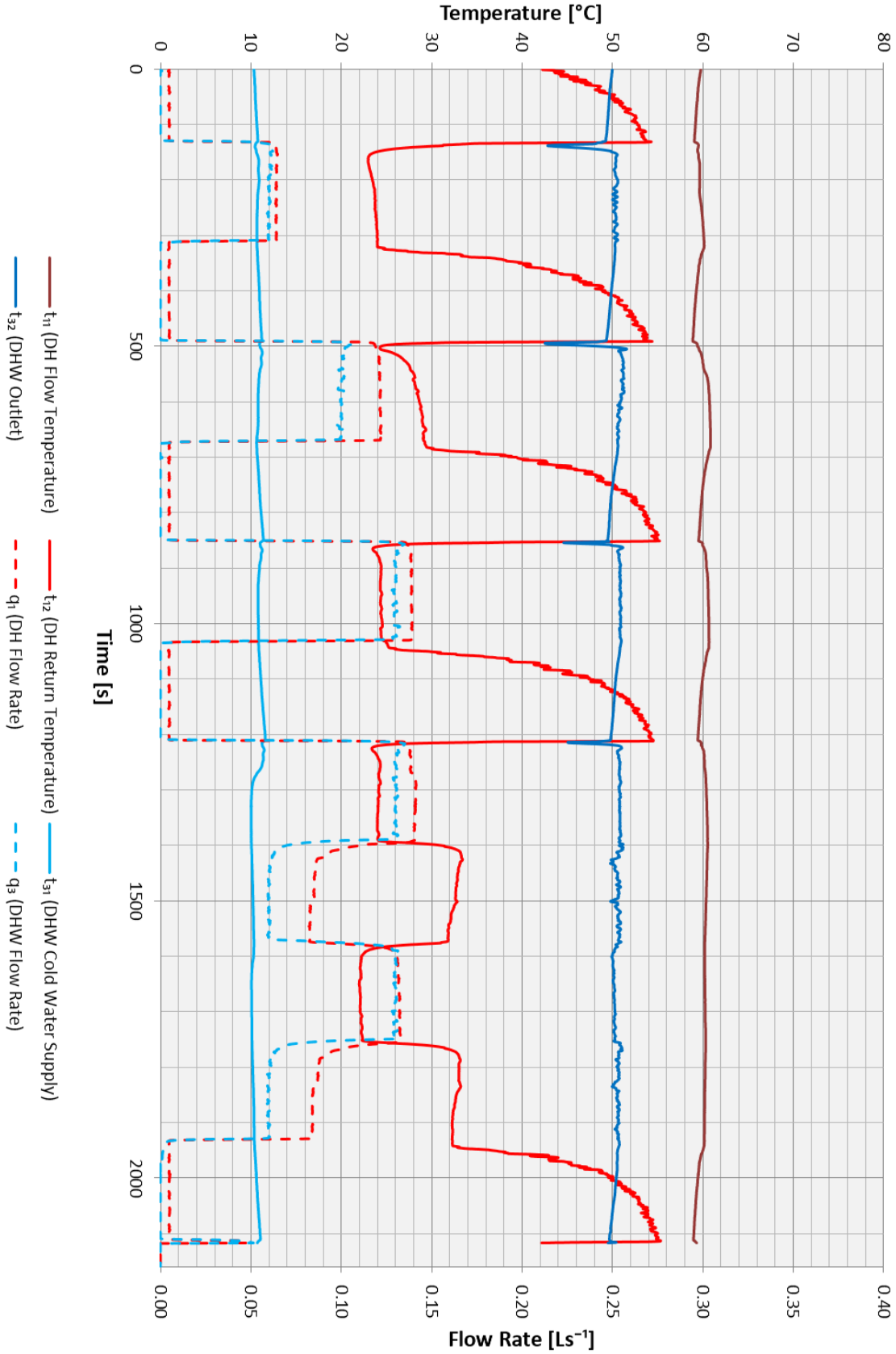

Figure 7.8 - Test 2b – DHW only at 60 °C

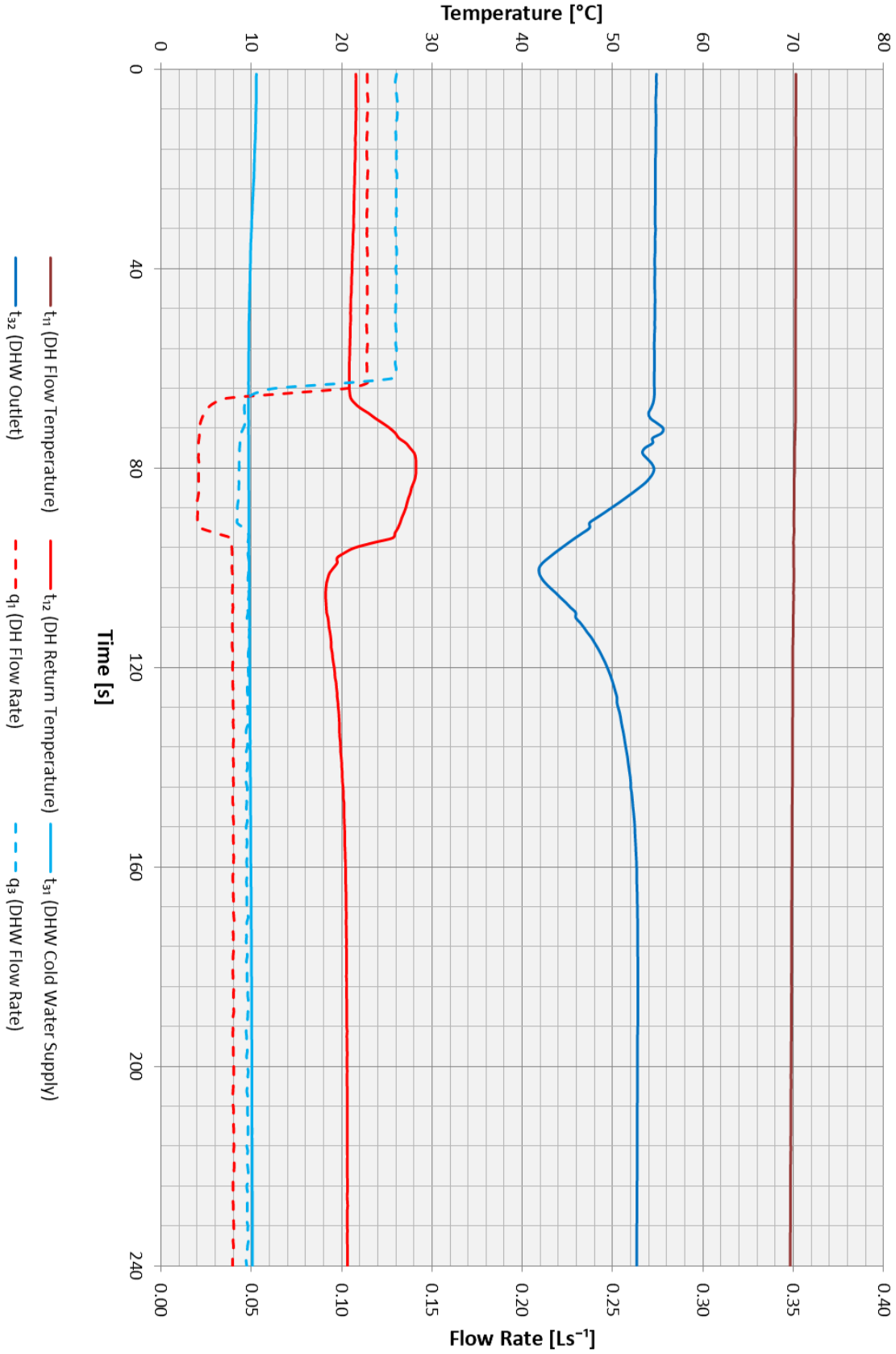

Figure 7.9 - Test 3a – Low Flow DHW at 70 °C

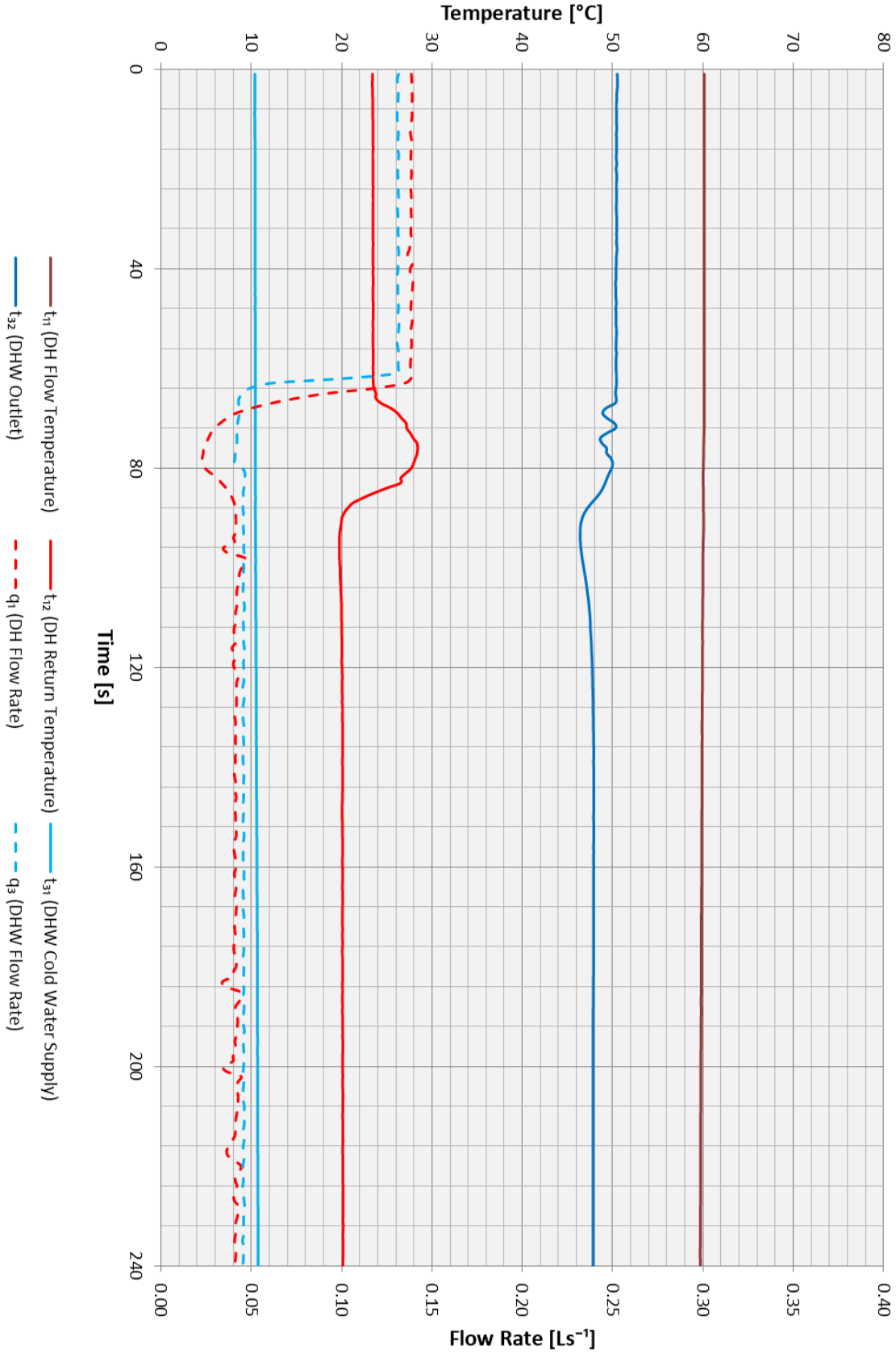

Figure 7.10 - Test 3b – Low Flow DHW at 60 °C

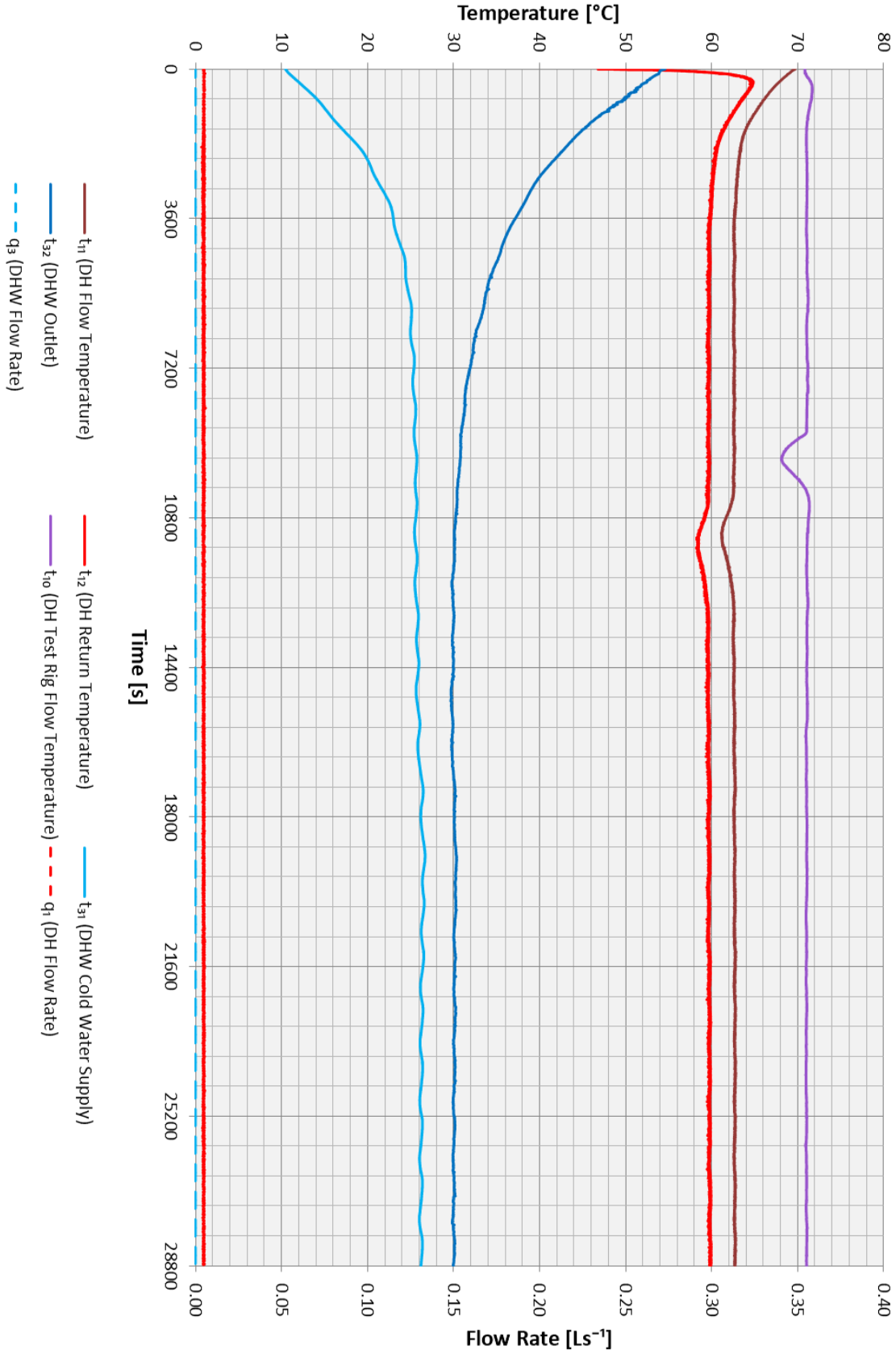

Figure 7.11 - Test 4a – Keep-warm at 70 °C

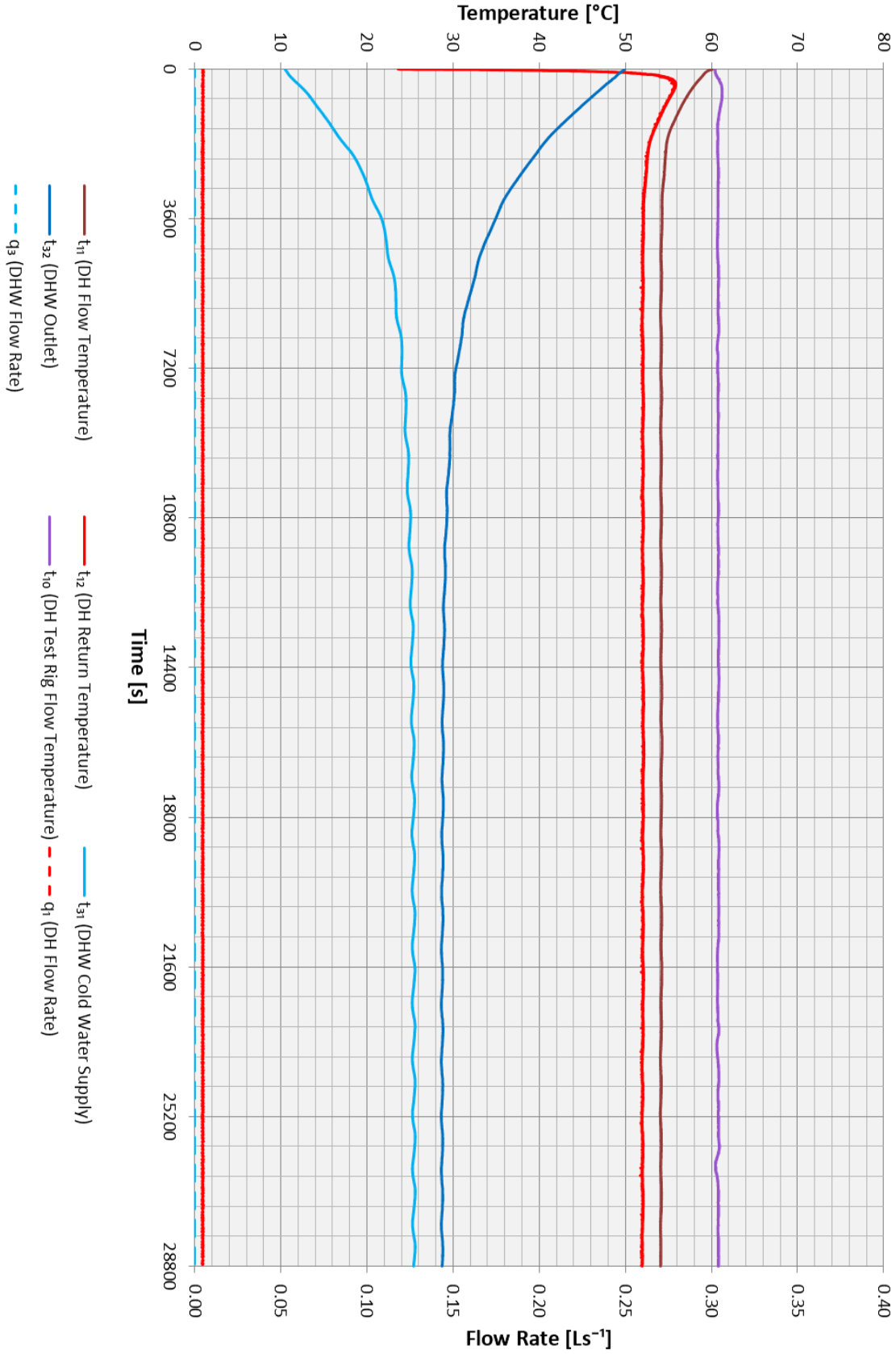

Figure 7.12 - Test 4b – Keep-warm at 60 °C

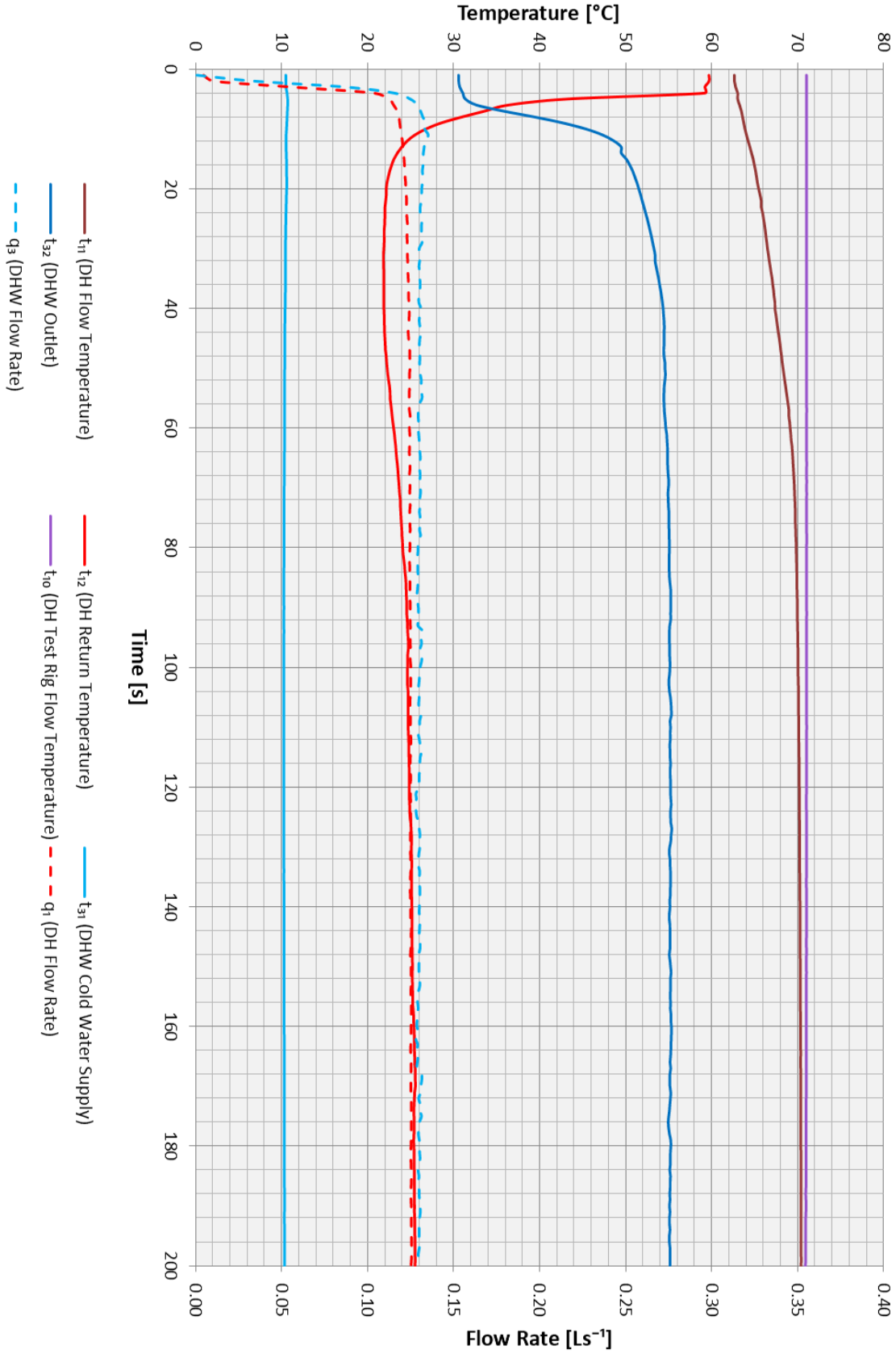

Figure 7.13 - Test 5a – DHW Response Time at 70 °C

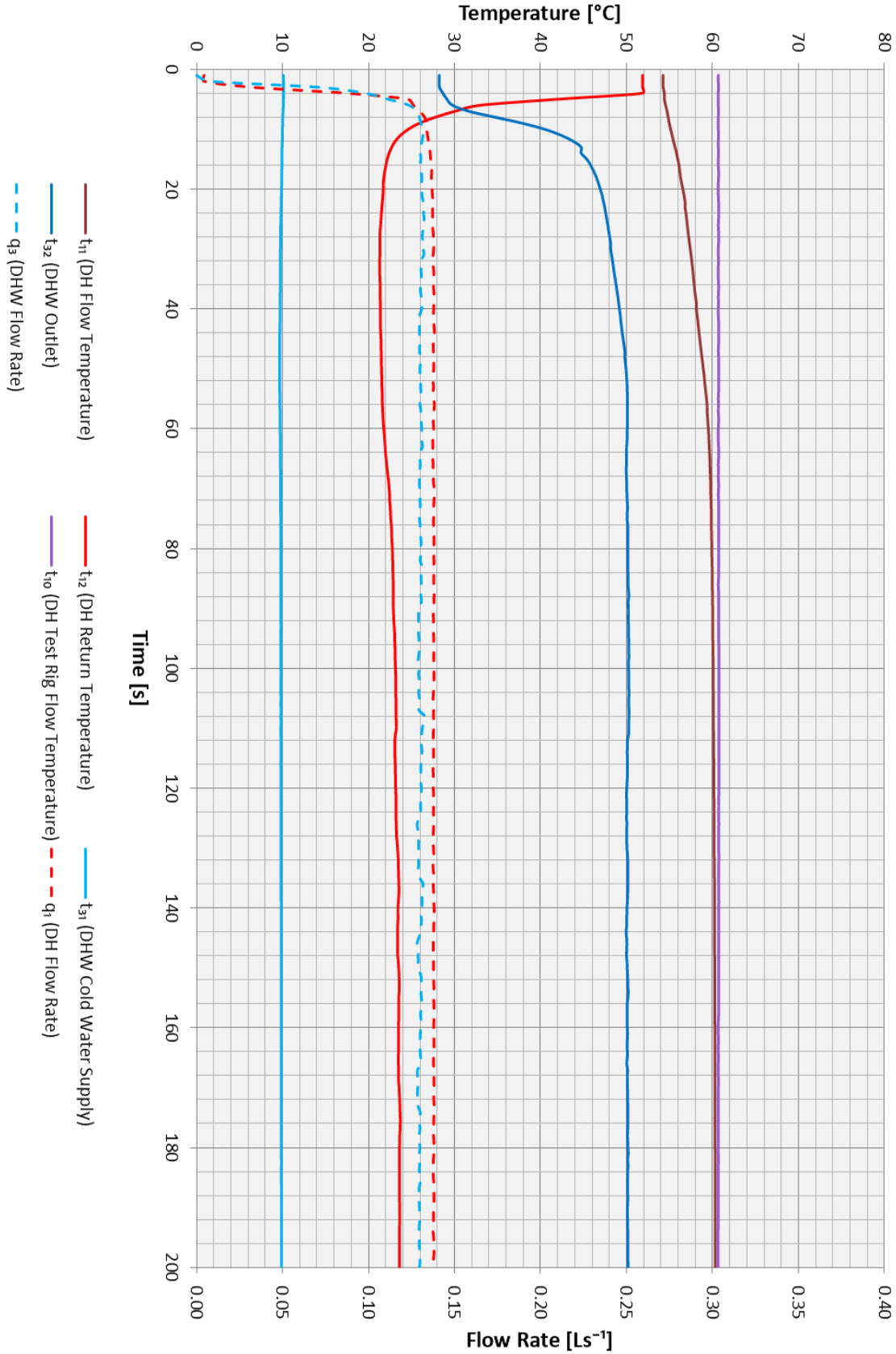

Figure 7.14 - Test 5b – DHW Response Time at 60 °C

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:		**1d**	**1e**	**1f**	**2b**	**2b**	**2b**	**2b**	**2b**	**2b**	**4b**
Ambient Temp	[°C]	21.3	21.6	21.8	18.3	18.3	18.3	18.3	18.3	18.3	19.3
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]	**49.1**	**47.6**	**46.0**	**24.4**	**35.5**	**28.2**	**39.8**	**24.8**	**36.7**	**52.2**
h	[hrs]	100.7	385.8	142.4	74.2	-	17.9	-	20.7	-	8018.3
Annual Primary Volume	[m^3]	7.2	59.3	35.7	16.9	0.4	7.7	0.1	10.2	0.1	137.5
P_1	[W]	878	2209	4055	9365	488	16146	420	20457	476	44
P_2	[W]	973	2040	3967	-	-	-	-	-	-	-
P_3	[W]	-	-	-	9830	153	16552	127	21479	123	-
t_{11}	[°C]	59.7	60.0	59.9	59.7	59.8	60.4	60.5	60.5	60.4	54.4
t_{12}	[°C]	**49.1**	**47.6**	**46.0**	**24.8**	**35.4**	**28.5**	**39.8**	**25.2**	**36.6**	**52.2**
t_{21}	[°C]	35.2	35.1	35.0	-	-	-	-	-	-	-
t_{22}	[°C]	45.7	45.8	45.0	-	-	-	-	-	-	-
t_{31}	[°C]	-	-	-	10.7	10.8	10.9	10.8	10.9	11.0	24.0
t_{32}	[°C]	-	-	-	50.0	50.2	50.6	50.4	50.7	50.7	30.9
q_1	[Ls^{-1}]	0.020	0.043	0.070	0.063	0.005	0.120	0.005	0.137	0.005	0.005
q_2	[Ls^{-1}]	0.022	0.046	0.095	-	-	-	-	-	-	-
q_3	[Ls^{-1}]	-	-	-	0.060	0.000	0.100	0.000	0.129	0.000	0.00
Δp_1	[kPa]	55.0	53.1	50.3	51.9	57.6	50.8	57.4	46.3	57.3	59.7
Δp_2	[kPa]	0.1	3.0	10.0	-	-	-	-	-	-	-
Δp_3	[kPa]	-	-	-	32.0	4.4	33.6	4.3	39.4	4.3	-

Table 7.2 - key metrics of High Temperature Package

Test / Parameter	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]	22.9	21.0	21.1	18.4	18.4	18.4	18.4	18.4	18.4	18.5
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]	**65.1**	**64.0**	**62.1**	**25.4**	**39.6**	**29.1**	**43.9**	**24.7**	**40.2**	**59.9**
h	[hrs]	97.4	390.1	142.8	66.4	-	16.0	-	18.3	-	8028.9
Annual Primary Volume	[m^3]	24.1	137.7	63.8	13.3	0.4	6.0	0.1	7.9	0.1	140.2
P_1	[W]	1363	2369	4297	10282	593	17998	532	22943	594	60
P_2	[W]	1006	2017	3957	-	-	-	-	-	-	-
P_3	[W]	-	-	-	10971	0	18555	0	24228	0	-
t_{11}	[°C]	69.9	69.8	70.3	69.6	69.6	70.5	70.6	70.6	70.4	62.8
t_{12}	[°C]	**65.1**	**64.0**	**62.1**	**25.8**	**39.5**	**29.5**	**43.8**	**25.3**	**40.2**	**59.9**
t_{21}	[°C]	40.0	39.7	39.8	-	-	-	-	-	-	-
t_{22}	[°C]	61.9	61.6	59.9	-	-	-	-	-	-	-
t_{31}	[°C]	-	-	-	10.7	10.8	11.0	10.9	10.4	10.1	24.9
t_{32}	[°C]	-	-	-	54.7	55.4	55.5	55.8	55.4	55.3	32.5
q_1	[Ls^{-1}]	0.069	0.098	0.124	0.056	0.005	0.104	0.005	0.119	0.005	0.005
q_2	[Ls^{-1}]	0.011	0.022	0.047	-	-	-	-	-	-	-
q_3	[Ls^{-1}]	-	-	-	0.060	0.000	0.099	0.000	0.129	0.000	0.00
Δp_1	[kPa]	55.5	53.2	50.9	54.3	59.0	51.3	59.6	50.3	56.7	60.8
Δp_2	[kPa]	-0.7	0.0	2.1	-	-	-	-	-	-	-
Δp_3	[kPa]	-	-	-	30.4	2.2	32.8	2.6	38.3	2.4	-

Table 7.3 – Low Temperature VWART calculations

	VWART [°C]	Volume [m³]
$VWART_{DHW}$	26	35.35
$VWART_{KWM}$	52	137.46
$VWART_{SH}$	47	102.21
	VWART [°C]	Time [%]
$VWART_{NONHEAT}$	47	92.8%
$VWART_{HEAT}$	47	7.2%
$VWART_{OVERALL}$	47	

Table 7.4 – High Temperature VWART calculations

	VWART [°C]	Volume [m³]
$VWART_{DHW}$	26	27.66
$VWART_{KWM}$	60	140.18
$VWART_{SH}$	64	225.56
	VWART [°C]	Time [%]
$VWART_{NONHEAT}$	54	92.8%
$VWART_{HEAT}$	63	7.2%
$VWART_{OVERALL}$	55	

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	N	Danfoss XB06H-1-10
2	Domestic Hot Water Heat Exchanger	N	Danfoss XB06H-1-26
3	Controller for Space Heating	N	Taconova 009599
4	Control Valve and Actuator for Space Heating	Y – "009603" (Valve) Y – "NovaDrive NC-NO_d"	FAR 3088 Taconova Novadrive
5	Space Heating Strainer	Y – "009600"	ITAP 192 ¾"
6	Controller for Domestic Hot Water	Y – "TacoControl Pro_e"	Taconova TacocontrolPro
7	Control Valve and Actuator for Domestic Hot Water	Y – "NovaMix_High-Capacity_d"	Taconova Novamix High Capacity
8	Temperature Sensors	N	-
9	Domestic Hot Water Isolating Valve	Y – "008815"	ITAP
10	Primary Side Strainer	Y – "009600"	ITAP 192 ¾"
11	Drain Valves	Y – "005567e"	Taconova
12	Vent Valves	Y – "TacoVent_Vent_d"	Taconova TacoVent
13	Circulation Pump set with AAV & PRV	Y – "ES2 C 60_datasheet_EN"	Taco pump
14	Heat Meter	Y – „datasheet_SensoStar_U_en_2017_09_19"	Engelmann SensoStar U
15	Domestic Hot Water Flow Sensor	N	-
16	Pipes	Y – "009618"	1.4404 (X2CrNiMo17-12-2)
17	Connections	Y – "009514"	Taconova 009514
18	Joints	Y – "008906"	Taconova
19	Gaskets	N	Centellen WS3820
20	Expansion Vessel	Y – "009605"	Cimm Expansionsgefäss RP 350x440x98
21	Insulation	Y – "ArmaflexXG_ProductRange_EN"	Armaflex XG plates 9mm Armaflex XG tube ø18x9.0mm
22	Pressure Sensors	N	-
A1	'O' Ring	N	lavelgomma EPDM 70shore
A2	Commissioning guide.	N	
A3	Operation guides with a function description / description of operation and care instructions as suited to the intended user category.	Y – "DOC-HIUOM1801"	
A4	Declaration of Conformity for CE-marked HIUs.	Y – "hiu-certificate-of-conformity"	
A5	Full parameter list for electrically controlled HIUs.	N/A	
A6	Maximum primary static operating differential pressure.	4 bar	
A7	Deactivation procedure of the internal SH pump.	By room thermostat – see "ES-1024"	
	Model name and type number	HIU Duty RAD 10/26	
	Serial number	PA xy	

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

DUTY UFH 10/26 Heatmaster Bus iCover	
Appliance Serial Number	PA xy
Space Heating Heat Exchanger	Danfoss XB06H-1-10
Domestic Hot Water Heat Exchanger	Danfoss XB06H-1-26
Controller for Space Heating	Taconova 009599
Control Valve & Actuator for Space Heating	Valve: 009603 FAR 3088 NovaDrive NC 230V (pdf), Taconova Novadrive
Controller for Domestic Hot Water	TacoControl Pro_e.pdf
Temperature Sensors	-
Domestic Hot Water Isolating valve	008815 ITAP
Primary Side Strainer	009600 ITAP 192 ¾"
Circulation Pump	Taconova ES2 C 60
Heat Meter	Engelmann SensoStar U
Domestic Hot Water Flow Sensor	-
Pipes	1.4404 (X2CrNiMo17-12-2)
Connections	Taconova 009514
`O` Rings	lavelgomma EPDM 70shore
Gaskets	Centellen WS3820
Expansion Vessel	Cimm RP 350x440x98
Pressure Sensors	-
Insulation	ArmaflexXG_ProductRange_EN.pdf

8.3 Appliance Photographs

Figure 8.1 – Photograph of appliance with case off

Figure 8.2 – Photograph of appliance with case on

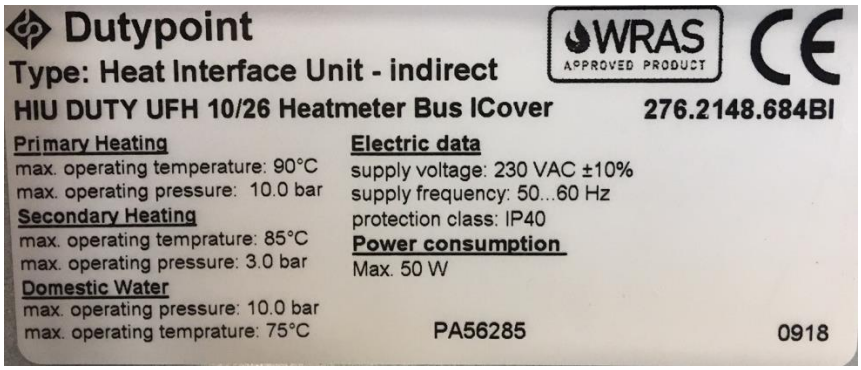

Figure 8-3 – Data Label

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	Space heating results for test 1b was duplicated for 1c – amended. Change of graph plots.
3	Change to BESA SH test method, SH tests repeated and report updated.
4	VWART figures now declared with no decimal places as requested by BESA

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