REPORT

Contact person
Björn Folkeson
Energy and bioeconomy
+46 10 516 54 46
bjorn.folkeson@sp.se

Date 2016-06-27 Reference 6P04381 Page 1 (15)

Thermal Integration Ltd
8 Curzon Road
Sudbury
Suffolk CO10 2XW
Great Britain

Testing of heat interface unit – Thermal Integration

(1 appendix)

1 Assignment

SP has tested a heat interface unit (HIU, also known as a district heating substation) from Thermal Integration on behalf of Thermal Integration.

2 Test method

The test method is described in the UK HIU Test Regime Technical Specification (based on Swedish District Heating Association F:103-7), V1-Rev-009, issued by FairHeat. This will be referred to as the Test Regime throughout this document.

3 Test object

Manufacturer: Thermal Integration
Model: DATA Plus
Serial number: DQ-13488-01
Year of manufacture: 2015 (unit was modified in May 2016)
Domestic hot water priority: yes

The HIU was modified by Thermal Integration prior to the testing. The modifications made to the unit involved replacement of the heat exchanger for space heating, the heat exchanger for domestic hot water and a section of pipework. The components were replaced with other versions than the original. These changes are included in the component list, see Components.

3.1 Design pressures

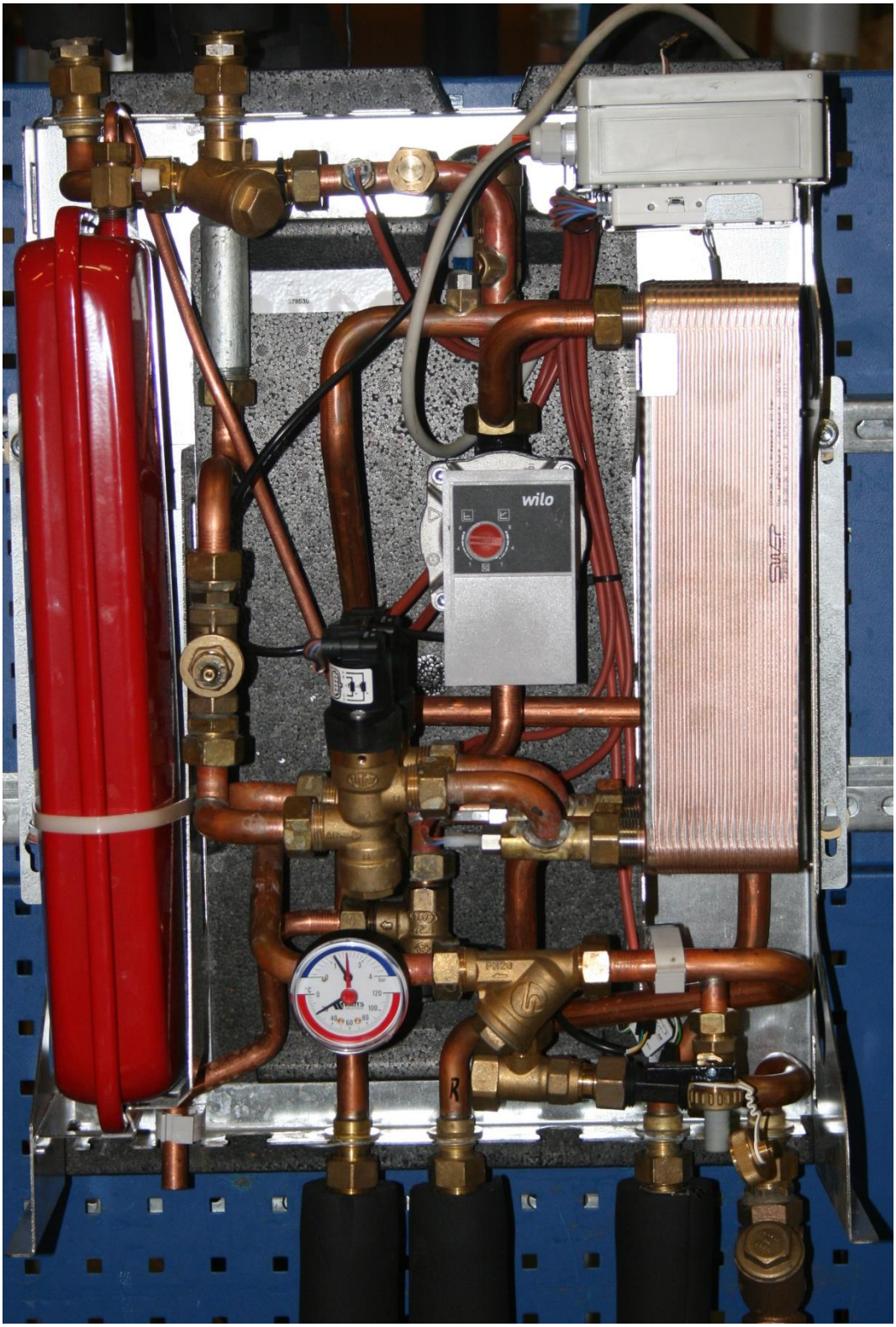
Primary side: 16 bar
Secondary side, radiator: 3.0 bar (the HIU was tested for a max. dP of 2.5 bar)
Secondary side, DHW: 10 bar

3.2 Design temperatures

Primary side: 85 °C
Secondary side, radiator: 80 °C
Secondary side, DHW: 60 °C

This document may not be reproduced other than in full, except with the prior written approval of SP.

Figure 1. The test object after testing. Insulation removed.



3.3 Components

Heat exchanger for space heating SWEP single phase – Performance heat exchanger E8LASx36, 36 plates **Control system for space heating** *Electrical shunt gate valve* Mut meccanica tovo, VDE/MLS, 24 V ac, G 3/4", k_{vs} 1.9 m^3/h, Type of motor: S **Heat exchanger for DHW** SWEP single phase – Performance Heat Exchanger E8ASx36, 36 plates **Control system for DHW** *Electrical shunt gate valve* Mut meccanica tovo, VDE/MLS, 24 V ac, G 3/4", k_{vs} 1.9 m^3/h ,Type of motor: S	**Other components** *Pump for space heating* Wilo Yonos PARA RS 15/6 RKA FS 130 *Expansion vessel* Varem, LR P 504 8 3/8" 3 bar *Safety valve* Flamco, Flopress ½" x ½" 3.0 bar *Manometer* Watts Industries

3.4 Documents pertaining to the test object

The following document has been supplied with the unit:

- *The Data HIU Installation Instructions D1 (15th October 2015)*

4 Test location and time

The testing was performed at SP, section of Energy and bioeconomy, in May 2016.

The test object arrived to SP in January 2016 with no visible damage. The unit was modified by Thermal Integration in May prior to the testing, see Test object.

5 Abbreviations

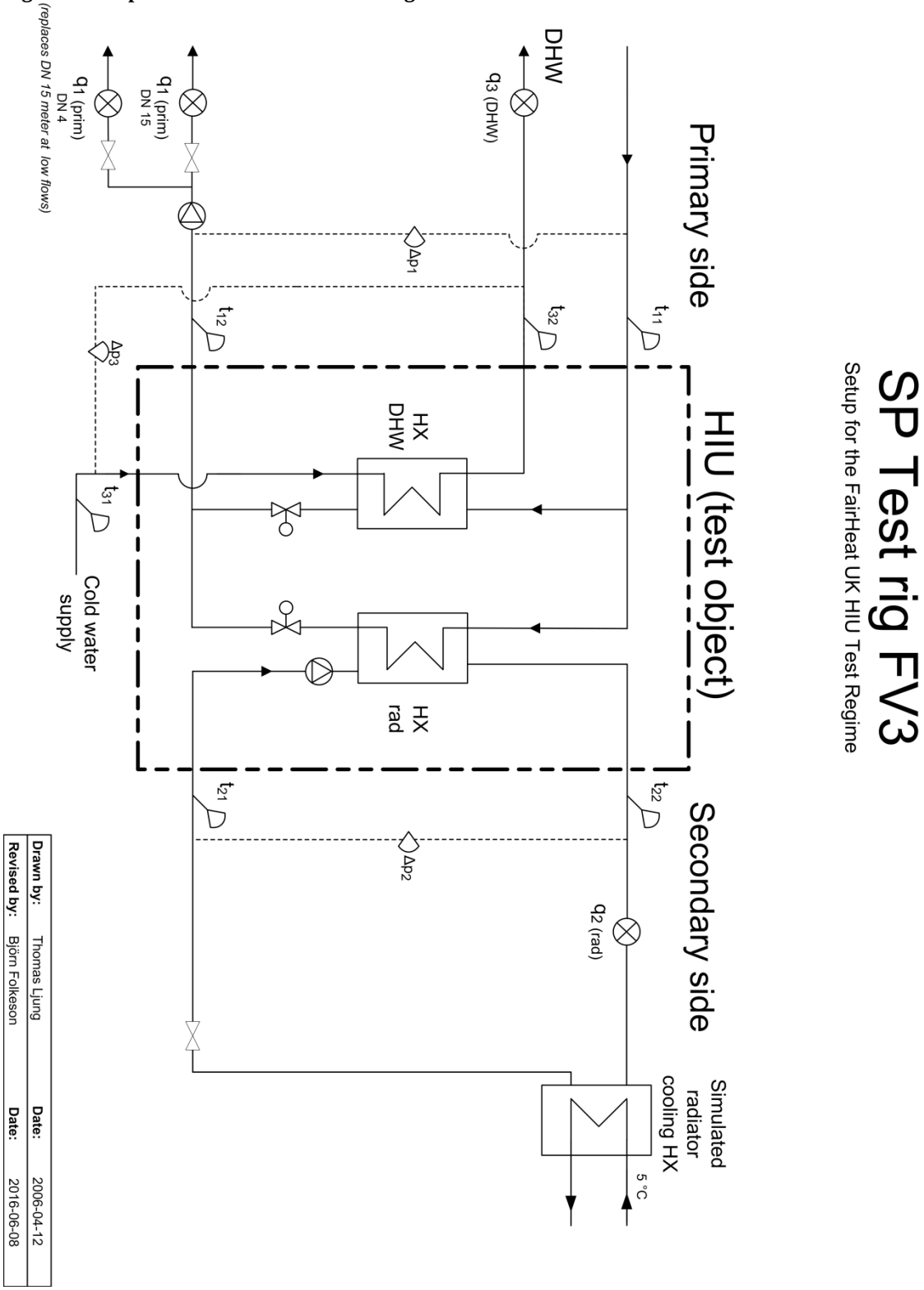
Term	Meaning (*diagram legend entry*)	
DHW	Domestic hot water	-
HIU	Heat Interface Unit	-
SH	Space heating	-
TMV	Thermostatic mixing valve	-
$\mathbf{P_1}$	Power, primary side	[kW]
$\mathbf{P_2}$	Power, space heating system	[kW]
$\mathbf{P_3}$	Power, domestic hot water	[kW]
$\mathbf{t_{11}}$	Temperature, primary side supply connection (*DH supply*)	[^{o}C]
$\mathbf{t_{12}}$	Temperature, primary side return connection (*DH return*)	[^{o}C]
$\mathbf{t_{21}}$	(Temperature, space heating system return connection (*SH return*)	[^{o}C]
$\mathbf{t_{22}}$	Temperature, space heating system supply connection (*SH supply*)	[^{o}C]
$\mathbf{t_{31}}$	Temperature, cold water (*CWS*)	[^{o}C]
$\mathbf{t_{32}}$	Temperature, domestic hot water supply connection (*DHW supply*)	[^{o}C]
$\mathbf{q_1}$	Volume flow, primary side (*DH*)	[l/s]
$\mathbf{q_2}$	Volume flow, space heating system (*SH*)	[l/s]
$\mathbf{q_3}$	Volume flow, domestic hot water (*DHW*)	[l/s]
$\Delta\mathbf{p_1}$	Primary pressure drop across entire HIU unit	[bar]
$\Delta\mathbf{p_2}$	Pressure drop, space heating system across HIU	[kPa]
$\Delta\mathbf{p_3}$	Pressure drop, domestic hot water across HIU	[kPa]

6 Test equipment

The following equipment has been used during the tests:

District heating test rig FV3	ETu-QD CB:11
Differential pressure meter	Inv. no. 202 111
Differential pressure meter	Inv. no. 202 112
Differential pressure meter	Inv. no. 202 680
Flow meter, inductive, DN 15	Inv. no. 901 997
Flow meter, inductive, DN 15	Inv. no. 202 688
Flow meter, inductive, DN 15	Inv. no. 202 686
Flow meter, inductive, DN 4	Inv. no. BX60131
Logger for measured data	Inv. no. 202 879
Pressure meter for pressure test	Inv. no. 201 378

Figure 2. Simplified schematic of the test rig used for the tests.



6.1 Collection of measurement data, static measurements

When conditions were as stable as possible measurement results were registered for at least 60 seconds. Registered static measurement test values are averages of 60 data points. Sampling rate was 1 Hz for static tests.

6.2 Collection of measurement data, dynamic measurements

Sampling rate was 1 Hz for dynamic measurements.

The time constant for the temperature sensors in the measuring point t_{32} is ≤ 1.5 s and represents 63% of the final value of a momentary change of temperature from 10 to 90°C.

The time constant for the flow meter to measure the DHW flow is ≤ 0.2 s.

The pressure for the incoming cold water was 1.5 bar for the production of DHW in direct heat exchanging, except for test point 3 where the pressure was 2.5 bar.

For the control of DHW flow the test rig has two parallel coupled solenoid valves. Each solenoid valve controls a set flow.

Results are presented in chart form and are verified with numerical values.

6.3 Control systems for DHW

The tested HIU is intended for direct exchange of DHW. This means that the incoming cold water (10 ± 0.5 ºC), is heated directly in the heat exchanger to DHW temperature. The temperature of DHW in the measuring point t_{32} was measured in connection to the HIU DHW tap.

6.4 Measurement uncertainty

The measurement uncertainty has been estimated to be better than following values:

Differential pressure, primary	± 10 kPa
Differential pressure, radiator	± 1 kPa
Differential pressure, tap water	± 1 kPa
Temperature 0-100 °C	± 0.1 °C
Flow, primary (0.05-0.5 l/s)	± 1.5 %
Flow, primary (< 0.05 l/s)	± 4.0 %
Flow, radiator (0.07-0.5 l/s)	± 1.5 %
Flow, tap water (0.04-0.4 l/s)	± 1.5 %
Power (Δt=10.0 ºC)	± 2.1 %
Power (Δt=20.0 ºC)	± 1.7 %
Pressure 0-7 MPa	± 10 kPa

The measurement uncertainty has been calculated according to EA-4/16 with a coverage factor k=2.

7 Test results

The results of each test are presented as specified in the Test Regime. Refer to Table 1 for details on the reporting and to Table 2 regarding the test setup.

The test results apply only to the tested unit.

Table 1. Reporting of test results. Extract from the 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	t_{12}- primary return temperature. **Note:** t_{12} readings to be used as inputs to Space Heating Weighted Average Return Temperature
1b	Space Heating 2 kW	
1c	Space Heating 4 kW	
1d	Space Heating 4kW, at lower operating temperatures	t_{12}- primary return temperature Observations on impact of lower operating temperatures on performance.
2a	DHW performance DHW 50°C	t_{12} – primary return temperature Note where the set point needs to be adjusted to achieve the target DHW temperature. Note any variances to 40kW DHW load.
2b	DHW performance DHW 55°C	
2c	DHW performance DHW 60°C	
3	Max DHW output	t_{11} – primary flow temperature t_{12} – primary return temperature t_{32} – Temperature, DHW leaving heat exchanger P_3 – DHW load q_1 – Volume flow, primary side q_3 – Volume flow, domestic hot water
Dynamic Tests		
4a	DHW only, DH 75°C flow	Pass/Fail on DHW exceeding 65°C (at t_{32}) for more than 10 seconds. Comment on stability of DHW temperature.

		Assessment of scaling risk, based on extent and duration of temperatures in excess of 55°C. Plot of key metrics over duration of test. **Note:** Outputs used as base input data to DHW Volume Weighted Return Temperature calculation
4b	DHW only, DH 65°C flow	Pass/Fail on DHW exceeding 65°C (at t_{32}) for more than 10 seconds. Assessment of whether return temperatures remain under control at the lower flow temperature. Assessment of scaling risk, based on extent and duration of temperatures in excess of 55°C. Plot of key metrics over duration of test.
5a	DHW and space heat, 0.5 dP	Pass/Fail on DHW exceeding 65°C (at t_{32}) for more than 10 seconds. Observation of the impact of simultaneous space heating and DHW draw upon performance. Assessment of scaling risk, based on extent and duration of temperatures in excess of 55°C. Plot of key metrics over duration of test.
5b	DHW and space heat higher dP	Pass/Fail on DHW exceeding 65°C (at t_{32}) for more than 10 seconds. Observation of the impact of higher dP on performance. Plot of key metrics over duration of test.
6	Low flow DHW	Pass/Fail on DHW exceeding 65°C (at t_{32}) for more than 10 seconds. Assessment of scaling risk, based on extent and duration of temperatures in excess of 55°C. Commentary if DHW supply not stable. Plot of key metrics over duration of test.
7a	Standby	Observation on the operation of the HIU during standby. Assessment of scaling risk, based on extent and duration of temperatures in excess of 55°C. Plot of key metrics over duration of test. If cycling is observed, plot of the key metrics over the duration of a typical standby cycle. **Note:** Outputs used as base input data to Standby Volume Weighted Return Temperature calculation
7b	DHW response time	Pass/Fail on DHW exceeding 65°C (at t_{32}) for more than 10 seconds. Comment on stability of DHW temperature. Plot of key metrics over duration of test.

Table 2. Test setup. Extract from the Test Regime.

Test No	Test	static pressure	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]	dP_1 [bar]	t_{11} [°C]	t_{32} [°C]	q_3 [l/s]	P_3 [kW]	P_2 [kW]	t_{22} [°C]	t_{21} [°C]
Static tests										
0a	Static pressure test (same static pressure on both flow and return connections)	1.43 times rated value		75	55	0	0	0	n/a	n/a
0b	Differential pressure test (DH flow at higher pressure than DH return)		1.43 times rated value	75	55	0	0	0	n/a	n/a
1a	Space Heating 1 kW	3	0.5	75	55	0	0	n/a	70	40
1b	Space Heating 2 kW	3	0.5	75	55	0	0	n/a	70	40
1c	Space Heating 4 kW	3	0.5	75	55	0	0	n/a	70	40
1d	Space Heating 4kW, at lower operating temperatures	3	0.5	70	55	0	0	4	60	35
2a	DHW performance DHW 50°C	3	0.5	75	50	Record value	40	0	n/a	n/a
2b	DHW performance DHW 55°C	3	0.5	75	55	Record value	40	0	n/a	n/a
2c	DHW performance DHW 60°C	3	0.5	75	60	Record value	40	0	n/a	n/a
3	Max DHW output	3	HIU max dP	75	55	Record values achieved		0	allow DHW to drop to 10°C below setpoint	
Dynamic tests										
4a	DHW only DH 75°C flow	3	0.5	75	55	see DHW test profile	see DHW test profile	0		
4b	DHW only DH 65°C flow	3	0.5	65	55					
5a	DHW and space heat, 0.5 dP	3	0.5	75	55	see DHW test profile	see DHW test profile	4	70	40
5b	DHW and space heat higher dP	6	HIU max dP	75	55			4	70	40
6	Low flow DHW	3	0.5	75	55	0.02	Record value	0	n/a	n/a
7a	Standby	3	0.5	75	55	0	0	0	n/a	n/a
7b	DHW response time	3	0.5	75	55	0.13	Record value	0	n/a	n/a

7.1 Test 0: Pressure tests

During the static pressure test 0a, the tightness of the components on the primary side of the HIU has been checked. This has been performed by closing the primary return and pressurizing the primary flow with 22.9 bar (1.43 times the construction pressure) for 30 minutes.

During the differential pressure test 0b, the tightness of the radiator control valve and the DHW control valve has been checked. This has been performed by pressurizing the primary flow to 3.6 bar (1.43 times the maximum differential pressure) for 30 minutes with the primary return open and the radiator control valve and the DHW control valve closed.

Test requirement: The HIU is to manage the pressure tests without leaks or damage.
Result: Pass.

7.2 Test 1a-1d: Space Heating 1-4 kW

For test points 1a-1d, a space heating load of 1-4 kW was simulated using a heat exchanger on the test rig. The space heating flow and return temperatures t_{22} and t_{21} were set to 70/40 °C for test points 1a-1c and to 60/35 °C for test point 1d. The primary flow temperature t_{11} was 75 °C for test points1a-1c and 70 °C for test point 1d. The pressure in the radiator circuit was set to 1.5 bar. For further details regarding the test setup, see Table 2.

The results of the test points 1a-1d are presented in Table 3.

It should be noted that for test points 1a and 1b, both the space heating flow temperature t_{22} and primary return temperature t_{12} were not stable. The test requirement is that individual measurements are not to deviate more than ± 0.5 °C from the average during a 60 second interval. As can be seen in Figure 3 and Figure 4, however, space heating flow temperature t_{22} and primary return temperature t_{12} varied considerably more than this over the course of the test. As a result, the results for test points 1a and 1b have been averaged over a 300 second period. Results for test points 1c and 1d are averages of 60 data points. Data for a longer period is presented in Figure 3 to Figure 6.

Table 3. Test results for test points 1a-1d.

Test point	Primary				Secondary				
	t_{11} [°C]	t_{12} [°C]	q_1 [l/s]	P_1 [kW]	t_{21} [°C]	t_{22} [°C]	q_2 [l/s]	Δp_2 [kPa]	P_2 [kW]
1a[1]	74.4[2]	53.3	0.008	0.9	40.2	62.2	0.010	-[3]	0.9
1b[1]	74.6	53.3	0.021	1.7	40.3	70.8	0.014	-[3]	1.8
1c	74.6	42.9	0.030	3.9	40.2	70.3	0.032	-[3]	4.0
1d	69.7	35.8	0.027	3.8	35.3	59.4	0.039	-[3]	3.8

[1] *Due to instability, the reported values are averages from a 300 second interval.*
[2] *The primary flow temperature was below the temperature stipulated in the Test Regime.*
[3] *Not measured due to technical problems.*

7.3 Test 2a-2c: DHW performance DHW 50-60°C

For test points 2a, 2b and 2c, the DHW temperature setpoint on the HIU was adjusted to reach 50, 55 and 60 °C respectively. The primary flow temperature t_{11} was 75 °C. For further details regarding the test setup, see Table 2.

The results of the test points 2a-2c are presented in Table 4. Results are averages of 60 data points. Data for a longer period is presented in Figure 7 to Figure 9.

Table 4. Test results for test point 2a-2c.

Test point	Primary				Secondary				
	t_{11} [°C]	t_{12} [°C]	q_1 [l/s]	P_1 [kW]	t_{31} [°C]	t_{32} [°C]	q_3 [l/s]	Δp_3 [kPa]	P_3 [kW]
2a	74.7	21.0	0.177	39.7	10.2	49.8	0.243	-*	39.7
2b	75.5	23.5	0.188	40.8	10.2	55.3	0.220	-*	40.8
2c	74.7	27.6	0.204	40.1	10.2	60.2	0.196	-*	40.0

**) Not measured due to technical problems.*

The HIU was able to produce 40 kW of DHW for all three temperatures tested.

7.4 Test 3: Max DHW output

In test point 3, the maximum DHW output was tested. The primary flow temperature t_{11} was 75 °C and the hot water setpoint was 55 °C. The DHW temperature (t_{32}) was allowed to drop to 10 °C below the setpoint. For further details regarding the test setup, see Table 2.

The results of the test point 3 are presented in Table 5 and in Figure 10.

Table 5. Test results for test point 3.

Test point	Primary				Secondary				
	t_{11} [°C]	t_{12} [°C]	q_1 [l/s]	P_1 [kW]	t_{31} [°C]	t_{32} [°C]	q_3 [l/s]	Δp_3 [kPa]	P_3 [kW]
3	75.4	28.3	0.363	71.4	10.2	55.3	0.384	-*	71.2

**) Not measured due to technical problems.*

The HIU was able to produce 71.2 kW of DHW while maintaining a tap water temperature of 55.0 °C. While the Test Regime allows a 10 °C deviation from the DHW setpoint of 55 °C for the test point, no higher DHW flow could be achieved under the test point conditions (incoming cold water pressure of 2.5 bar).

7.5 Test 4a: DHW only, DH 75°C flow

In test point 4a, a dynamic test of DHW was performed according to DHW flow rates specified in the Test Regime. The primary flow temperature t_{11} was 75 °C and the hot water setpoint was 55 °C. For further details regarding the test setup, see Table 2.

The DHW temperature (t_{32}) did not exceed 65 °C during the test. The highest measured temperature in point t_{32} was 61.8 °C. Between 200 and 2160 seconds, the lowest measured temperature was 50.9 °C.

Due to a faulty component in the test rig the DHW flow rate was approx. 10 % higher than the specified flow rate in the Test Regime between approx. 1730 and 1900 seconds. Since the deviation was minor and the DHW temperature (t_{32}) was not close to exceeding 65 °C during the test it was determined that the test requirements were met.

Test requirement: The DHW temperature (t_{32}) is not to exceed 65 °C for more than 10 seconds.
Result: Pass.

The test results for test point 4a are presented in Figure 11, appendix 1.

7.6 Test 4b: DHW only, DH 65°C flow

In test point 4b, a dynamic test of DHW was performed according to DHW flow rates specified in the Test Regime. The primary flow temperature t_{11} was 65 °C and the hot water setpoint was 55 °C. For further details regarding the test setup, see Table 2.

The DHW temperature (t_{32}) did not exceed 65 °C during the test. The highest measured temperature in point t_{32} was 58.2 °C. Between 200 and 2160 seconds, the lowest measured temperature was 52.8 °C.

Due to a faulty component in the test rig the DHW flow rate was approx. 10 % higher than the specified flow rate in the Test Regime between approx. 270 and 350 seconds and between approx. 1800 and 1950 seconds. Since the deviation was minor and the DHW temperature (t_{32}) was not close to exceeding 65 °C during the test it was determined that the test requirements were met.

Test requirement: The DHW temperature (t_{32}) is not to exceed 65 °C for more than 10 seconds.
Result: Pass.

The results of the test point 4b are presented in Figure 12, appendix 1.

7.7 Test 5a-5b: DHW and space heating

In test points 5a-5b, a dynamic test of DHW and a simultaneous static space heating load was performed according to DHW flow rates specified in the Test Regime. The primary flow temperature t_{11} was 75 °C and the hot water setpoint was 55 °C. The space heating flow and return temperatures t_{22} and t_{21} were set to 70/40 °C. Test point 5a was performed at a dP of 0.5 bar while test point 5b was performed at the maximum dP of the HIU. For further details regarding the test setup, see Table 2.

7.7.1 5a: DHW and space heating, 0.5 bar dP

The DHW temperature (t_{32}) did not exceed 65 °C during the test. The highest measured temperature in point t_{32} was 61.5 °C. Between 200 and 2160 seconds, the lowest measured temperature was 50.4 °C.

Due to a faulty component in the test rig the DHW flow rate was approx. 10 % higher than the specified flow rate in the Test Regime between approx. 1030 and 1070 seconds. Since the deviation was minor and the DHW temperature (t_{32}) was not close to exceeding 65 °C during the test it was determined that the test requirements were met.

Test requirement: The DHW temperature (t_{32}) is not to exceed 65 °C for more than 10 seconds.
Result: Pass.

The results of the test point 5a are presented in Figure 13, appendix 1.

7.7.2 5b: DHW and space heating, max dP

The maximum differential pressure of the HIU was 2.5 bar. This differential pressure was used for the test point 5b.

The DHW temperature (t_{32}) did not exceed 65 °C during the test. The highest measured temperature in point t_{32} was 60.5 °C. Between 200 and 2160 seconds, the lowest measured temperature was 50.9 °C.

Due to a faulty component in the test rig the DHW flow rate was approx. 10 % higher than the specified flow rate in the Test Regime between approx. 290 and 350 seconds. Since the deviation was minor and the DHW temperature (t_{32}) was not close to exceeding 65 °C during the test it was determined that the test requirements were met.

Test requirement: The DHW temperature (t_{32}) is not to exceed 65 °C for more than 10 seconds.
Result: Pass.

The results of the test point 5b are presented in Figure 14, appendix 1.

7.8 Test 6: Low flow DHW

In test point 6, a low DHW flow of 0.02 l/s was tested. For further details regarding the test setup, see Table 2.

The test point was run under two different HIU settings: DHW setpoint at 55 and 58 °C.

At DHW setpoint of 55 °C the DHW temperature (t_{32}) did not exceed 65 °C during the test. Due to heat losses in the test rig the primary flow temperature t_{11} was approx. 74 °C during the test. All other relevant temperatures and flows were stable, t_{32} was approx. 50 °C.

At DHW setpoint of 58 °C the DHW temperature (t_{32}) did not exceed 65 °C during the test. The primary flow temperature t_{11} was 75 °C. All relevant temperatures and flows were stable, t_{32} was approx. 56 °C.

Test requirement: The DHW temperature (t_{32}) is not to exceed 65 °C for more than 10 seconds.
Result: Pass.

The results of the test point 6 are presented in Figure 15 and 16, appendix 1.

7.9 Test 7a: Standby

In test point 7, the standby characteristics of the HIU were tested. A DHW flow of 0.13 l/s was drawn until stable conditions were reached and was then turned off. Data was then collected until stable conditions had been reached. For further details regarding the test setup, see Table 2.

The standby performance of the HIU is dependent on the standby control method used. For instance, in cases a higher DHW heat exchanger keep hot temperature setpoint is used DHW delivery is quicker while standby losses increase.

HIU standby settings: The HIU had two settings available to choose between, EcoHeat and Comfort mode.

In EcoHeat mode the HIU was set to turn off the primary flow after the DHW flow was turned off, but to allow a primary flow through the unit every 24 hours. The results of the first 55000 seconds of the test are presented in Figure 17, appendix 1. Data for a longer time period is displayed in Figure 18, appendix 1.

In Comfort mode the HIU was set to keep the DHW heat exchanger at 25 °C (adjustable), which resulted in that the HIU let through a primary flow periodically during the standby test. The results of the test are presented in Figure 19, appendix 1.

With the Comfort mode setting the primary return temperature t_{12} was maintained at 24 ± 3 °C from approx. 250 seconds until the end of the test. The primary flow was generated at approx. 75 °C. At the HIU connection, primary flow temperature t_{11} was stable at 31 ± 3 °C from approx. 43820 seconds until the end of the test. From 250 seconds until the end of the test, the average primary flow q_1 was 0.79 l/h. For the first 14400 seconds of the test after turning off the DHW flow, the average power P_1 was 33 W.

7.10 Test 7b: DHW response time

Immediately after test point 7a, test point 7b was carried out. A DHW flow of 0.13 l/s was drawn until conditions were stable. For further details regarding the test setup, see Table 2.

The DHW response time is dependent on the HIU standby settings. See Test 7a: Standby.

In EcoHeat mode the DHW temperature (t_{32}) did not exceed 65 °C during the test. After reaching 55 °C the DHW temperature (t_{32}) dropped below 52 °C. The DHW temperature (t_{32}) reached 52 °C again approx. 40 seconds after the DHW flow was started and did not drop below 52 °C thereafter.

Test requirement: The DHW temperature (t_{32}) is not to exceed 65 °C for more than 10 seconds.
Result: Pass.

The results of the test point 7b with the EcoHeat mode are presented in Figure 20, appendix 1.

In Comfort mode the DHW temperature (t_{32}) did not exceed 65 °C during the test. The DHW temperature (t_{32}) reached 55 °C approx. 27 seconds after the DHW flow was started and did not drop below 52 °C thereafter.

Test requirement: The DHW temperature (t_{32}) is not to exceed 65 °C for more than 10 seconds.
Result: Pass.

The results of the test point 7b with the Comfort mode are presented in Figure 21, appendix 1.

SP Technical Research Institute of Sweden
Energy and bioeconomy - Sustainable supply systems and plastic products

Performed by

Signed by: Björn Folkeson
Reason: I am the author of this document
Date & Time: 2016-06-28 15:00:36 +02:00

Björn Folkeson

Examined by

Signed by: Thomas Ljung
Reason: I have reviewed this document
Date & Time: 2016-06-28 12:06:33 +02:00

Thomas Ljung

Appendix

1. Diagrams

Appendix 1. Diagrams

Figure 3. Results for test point 1a: space heating 1 kw, DH 75°C flow.

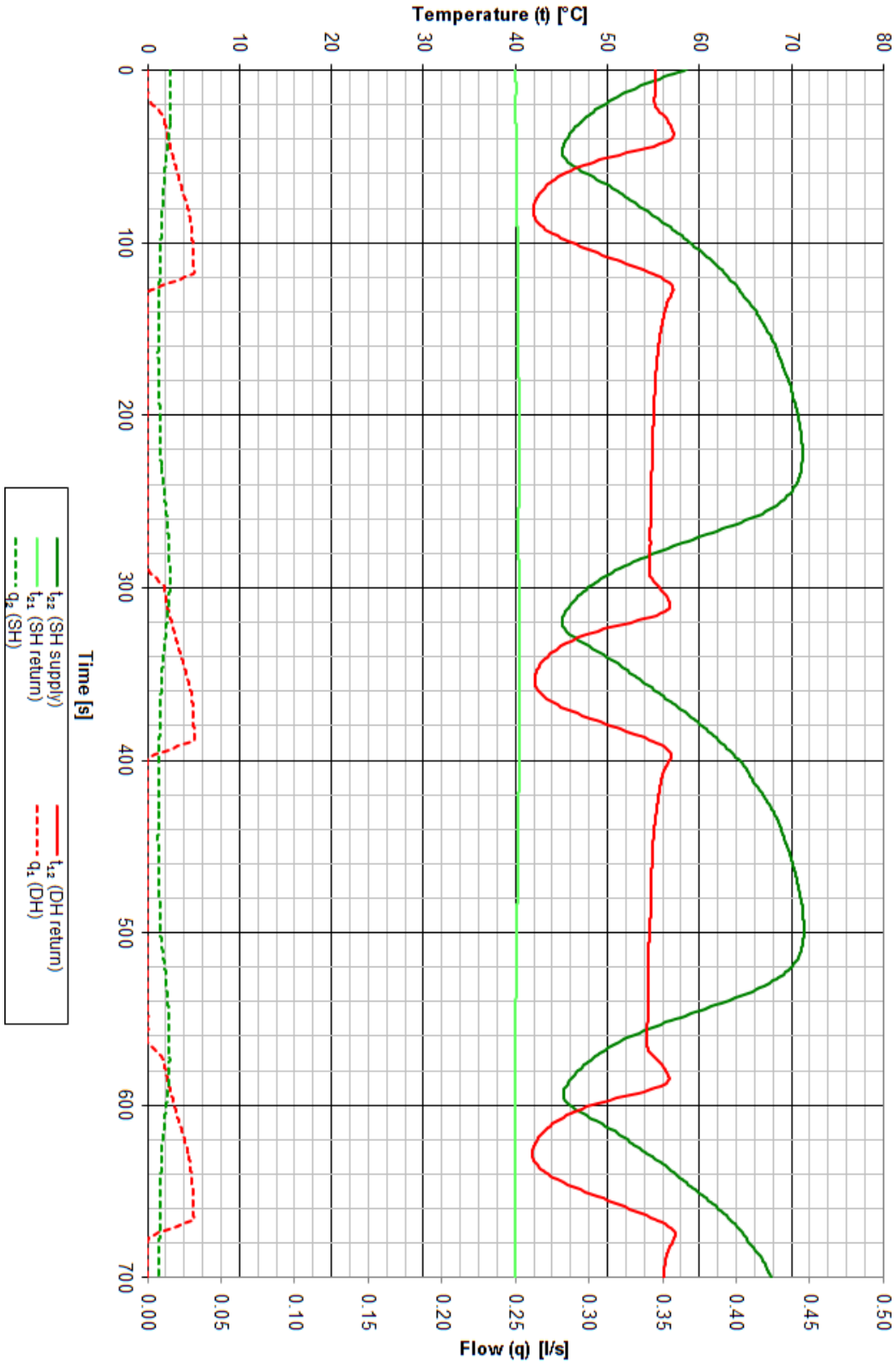


Figure 4. Results for test point 1b: space heating 2 kw, DH 75°C flow.

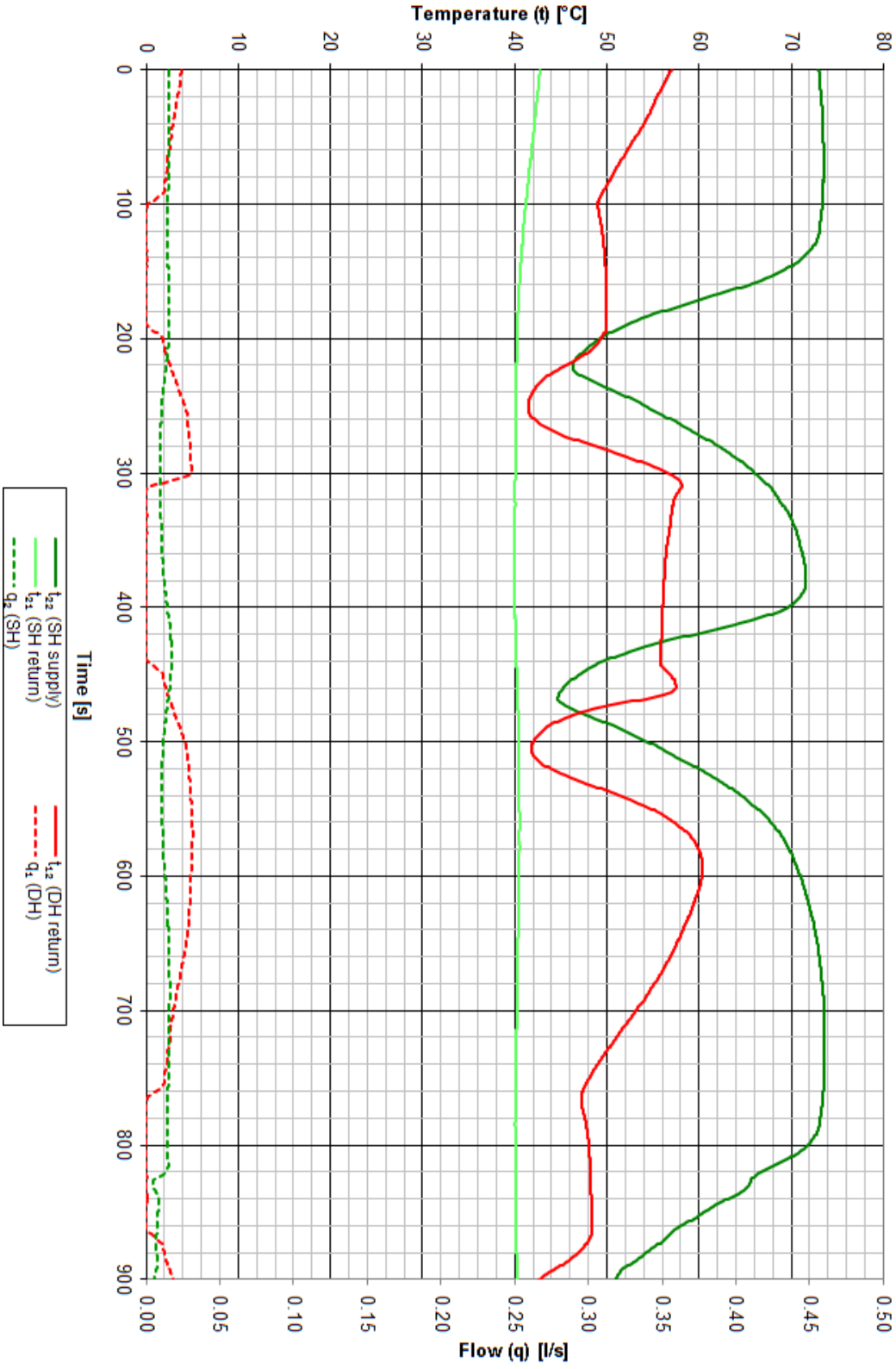


Figure 5. Results for test point 1c: space heating 4 kw, DH 75°C flow.

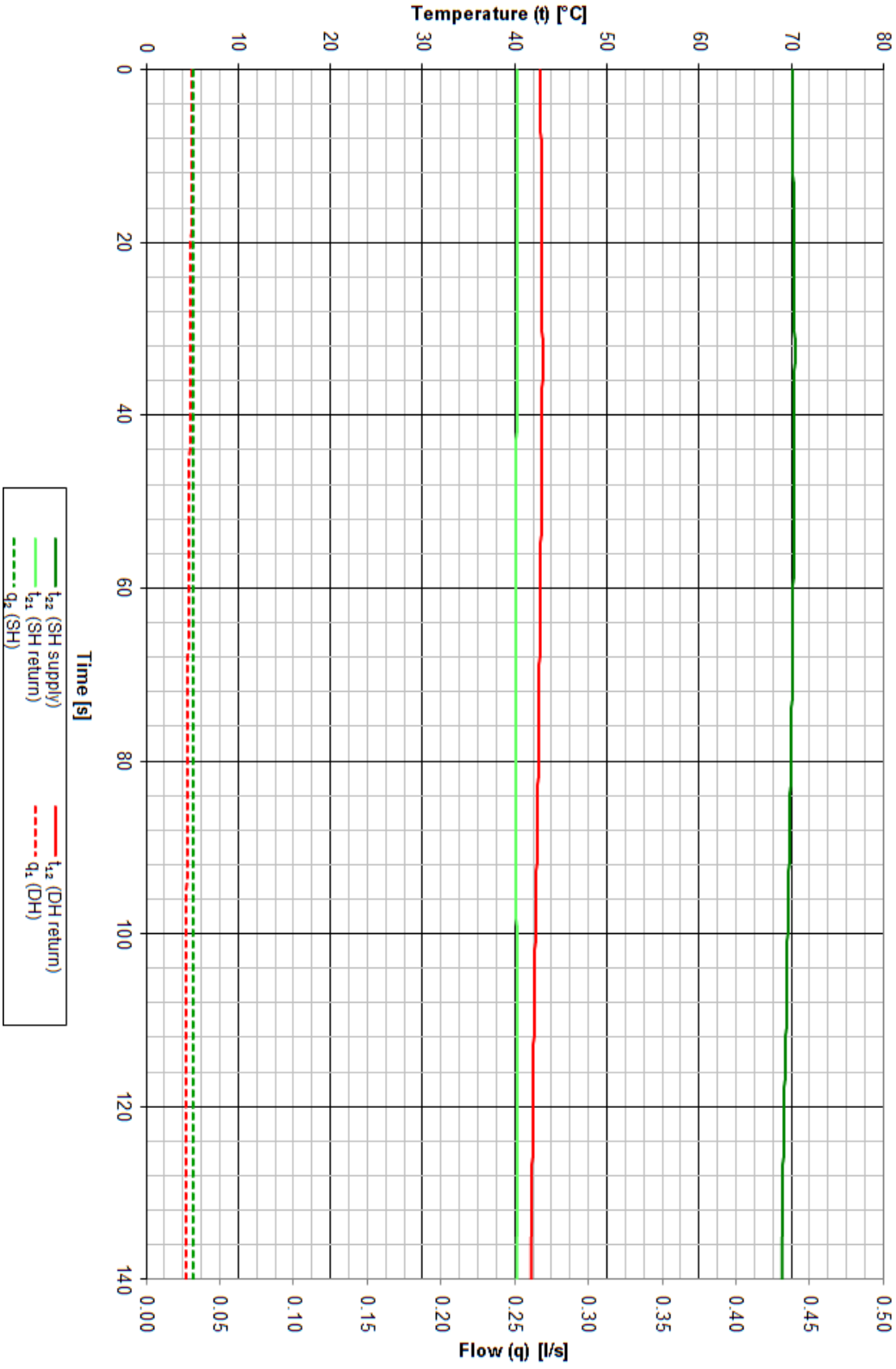


Figure 6. Results for test point 1d: space heating 4 kw, DH 70°C flow.

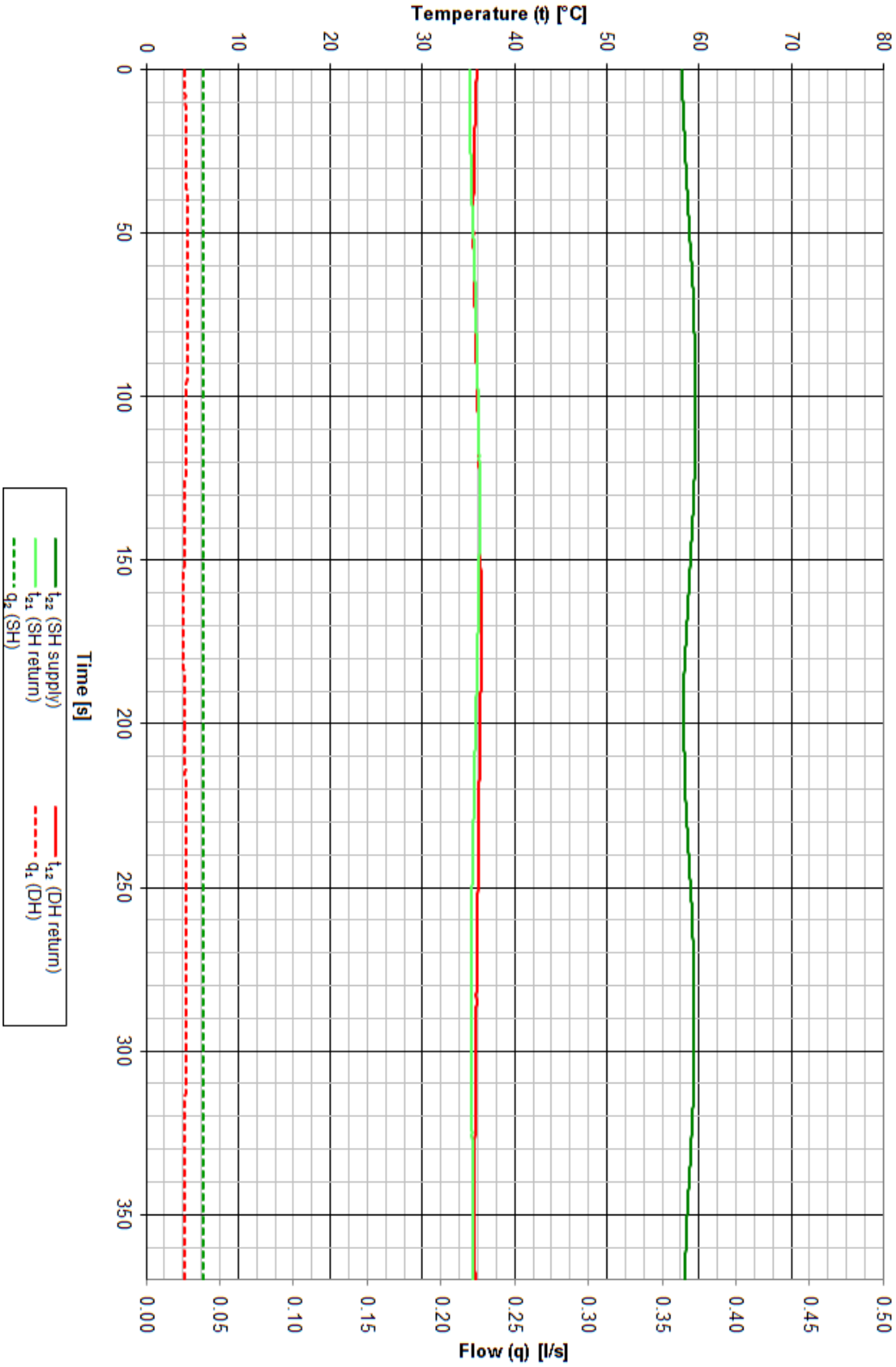


Figure 7. Results for test point 2a: DHW performance DHW 50°C.

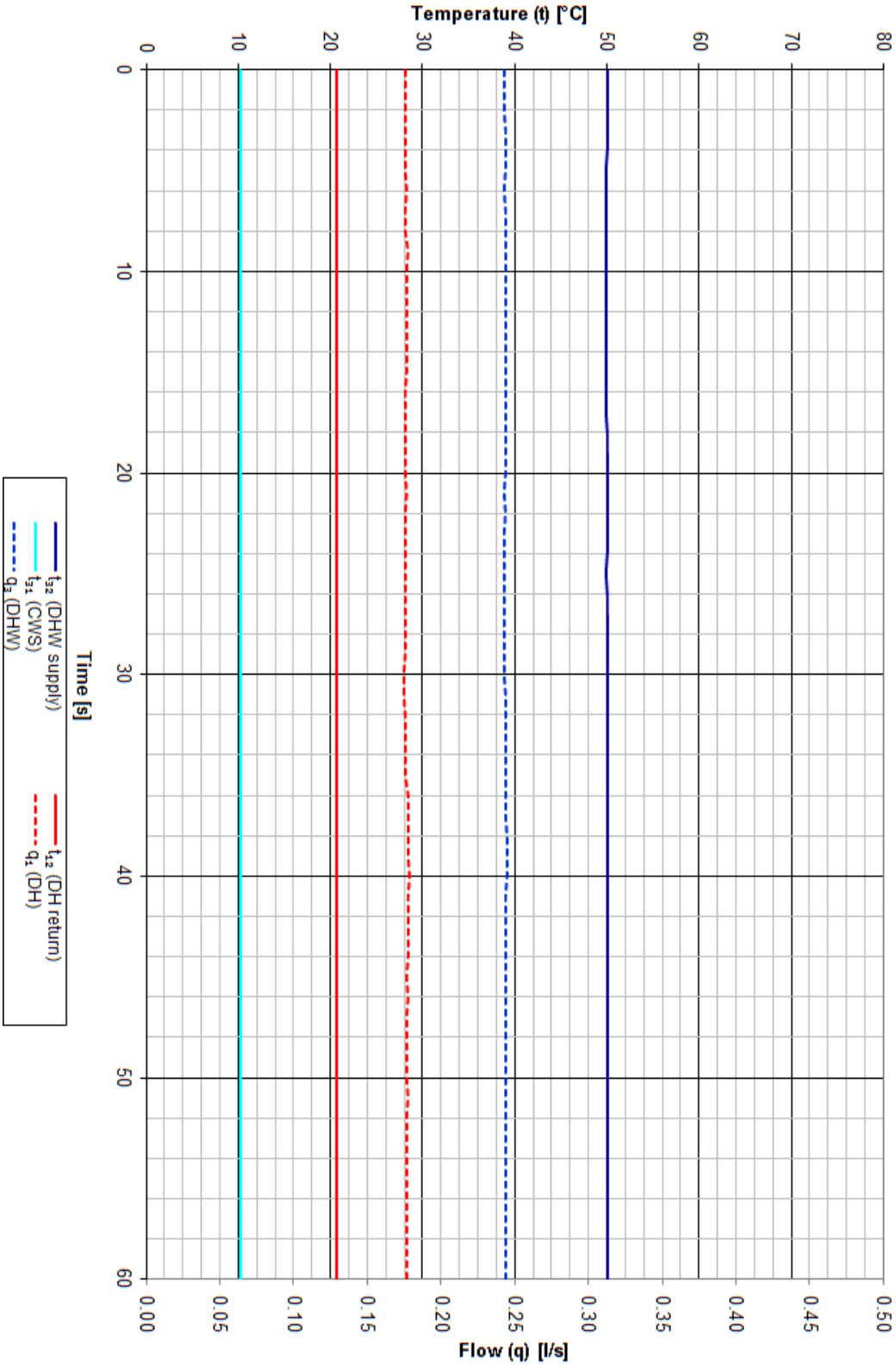


Figure 8. Results for test point 2b: DHW performance DHW 55°C.

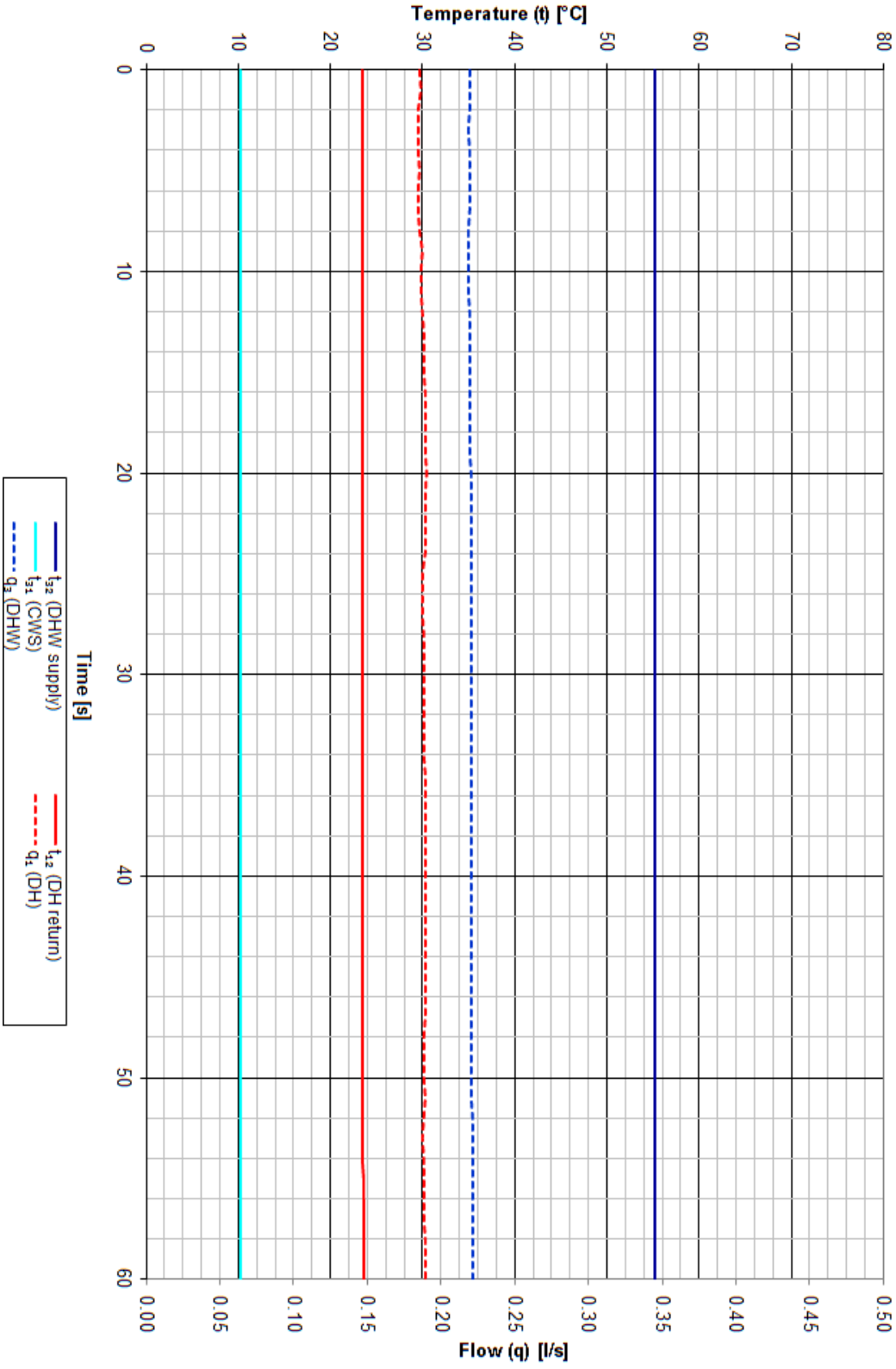


Figure 9. Results for test point 2c: DHW performance DHW 60°C.

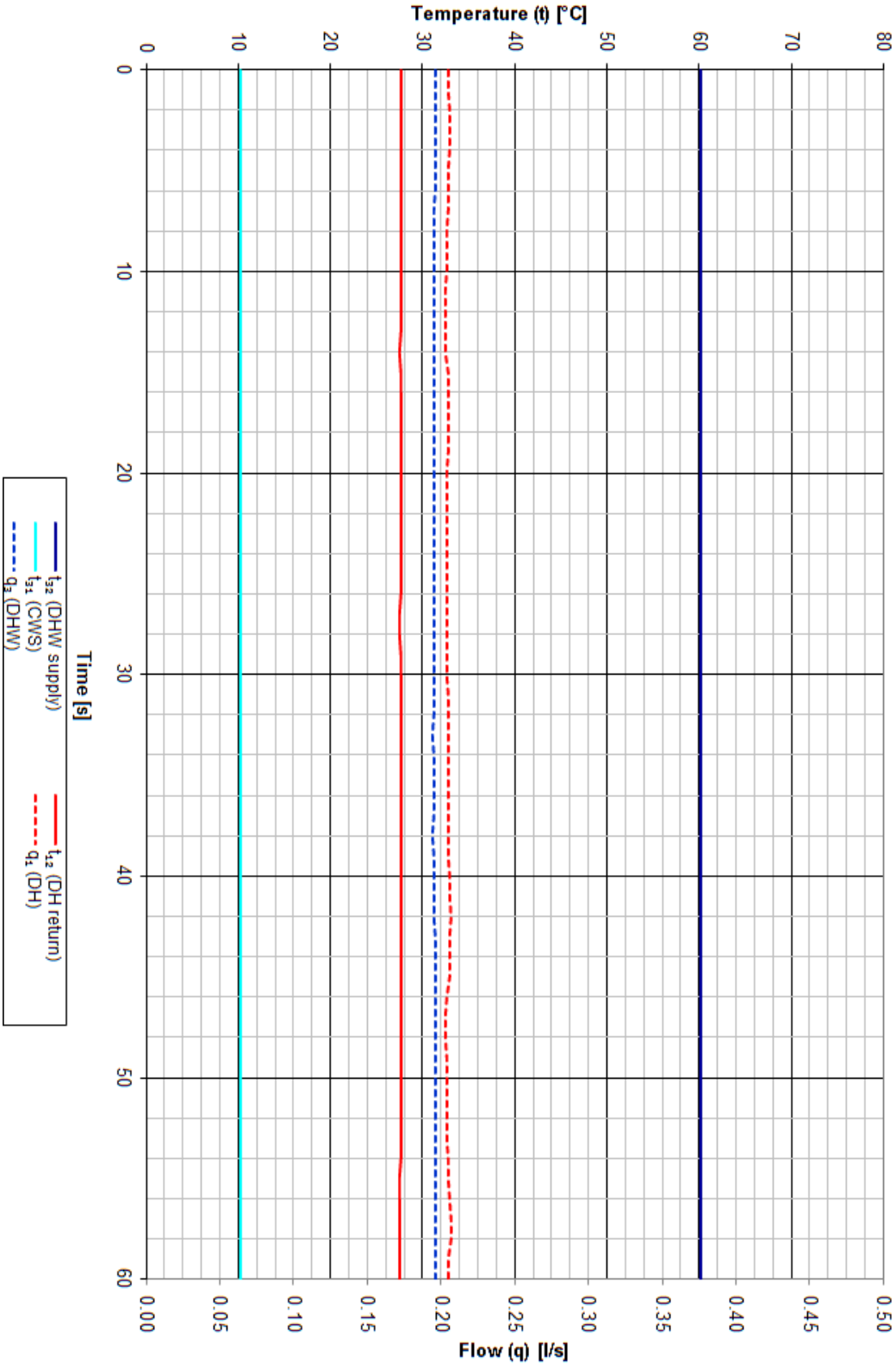


Figure 10. Results for test point 3: Max DHW output.

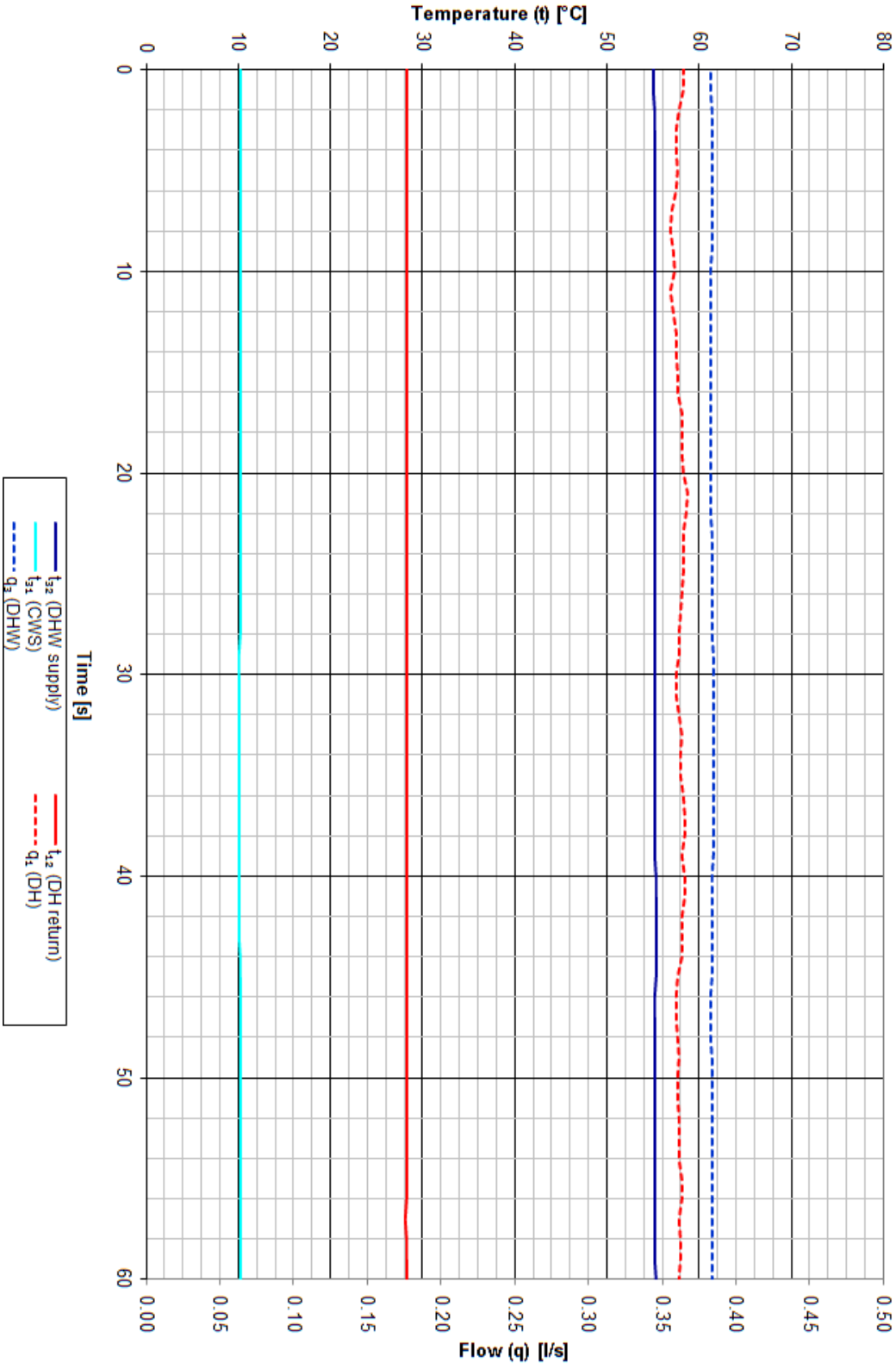


Figure 11. Results for test point 4a: DHW only, DH 75°C flow.

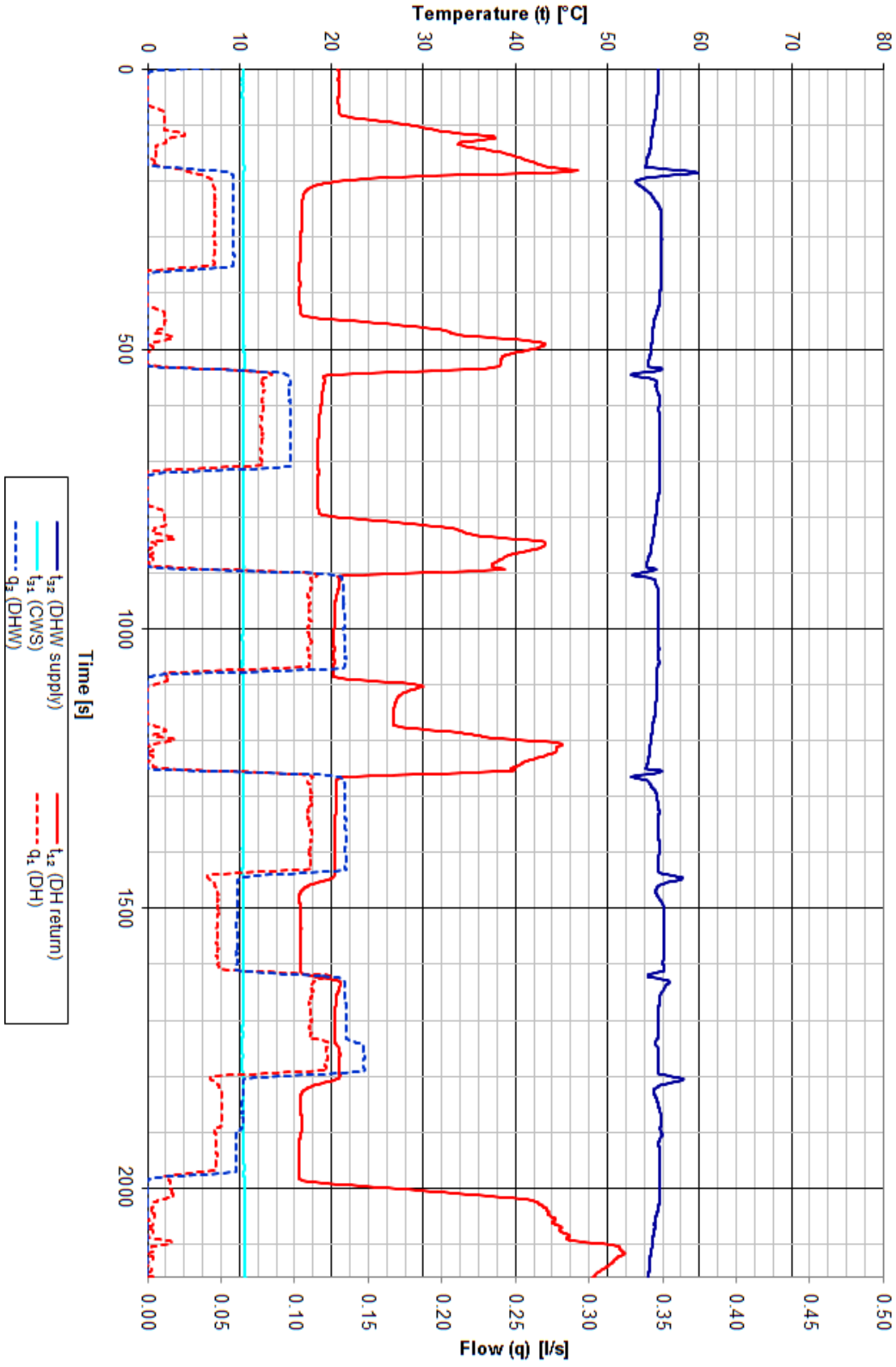


Figure 12. Results for test point 4b: DHW only, DH 65°C flow.

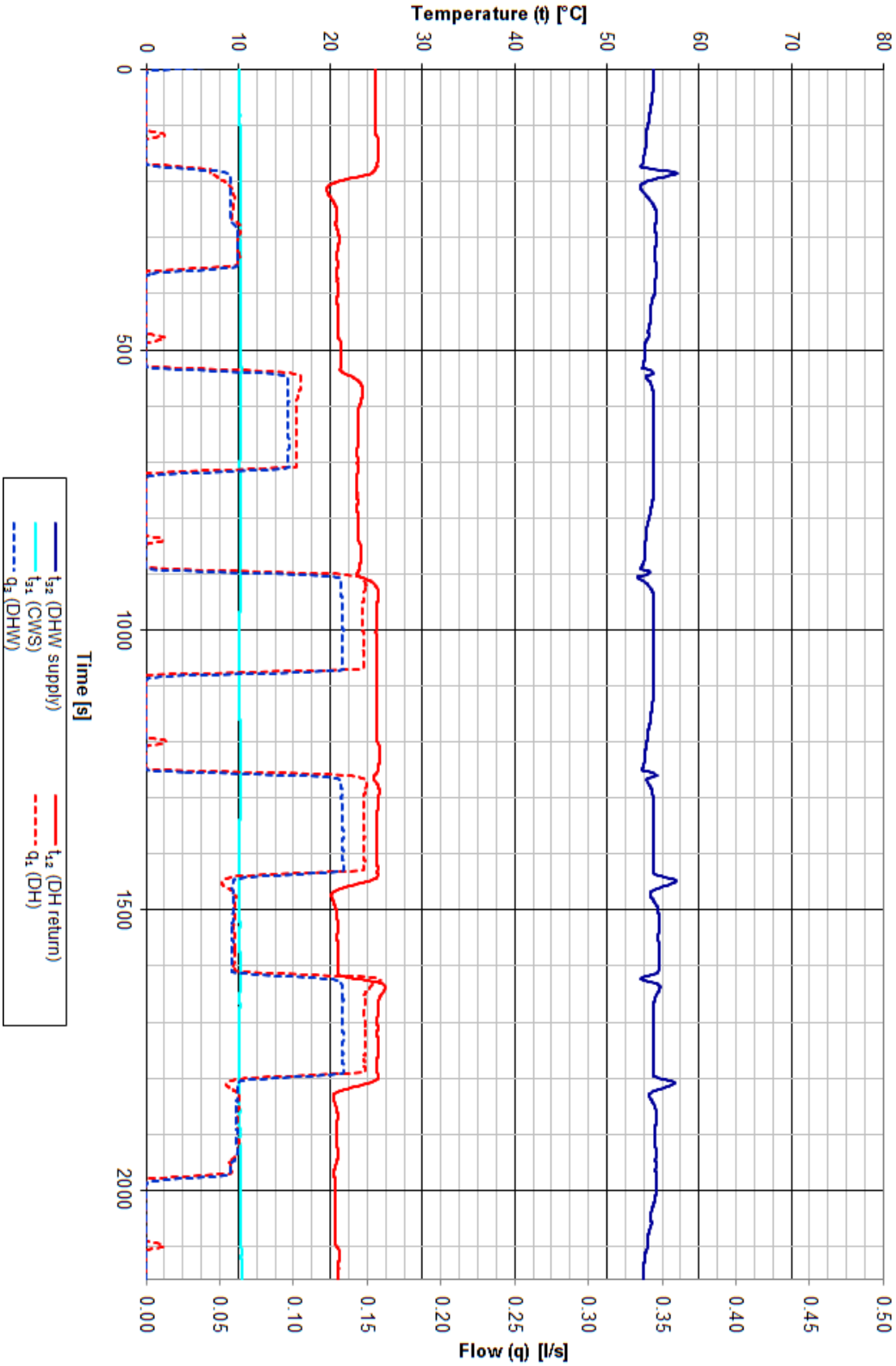


Figure 13. Results for test point 5a: DHW and space heating, 0.5 bar dP

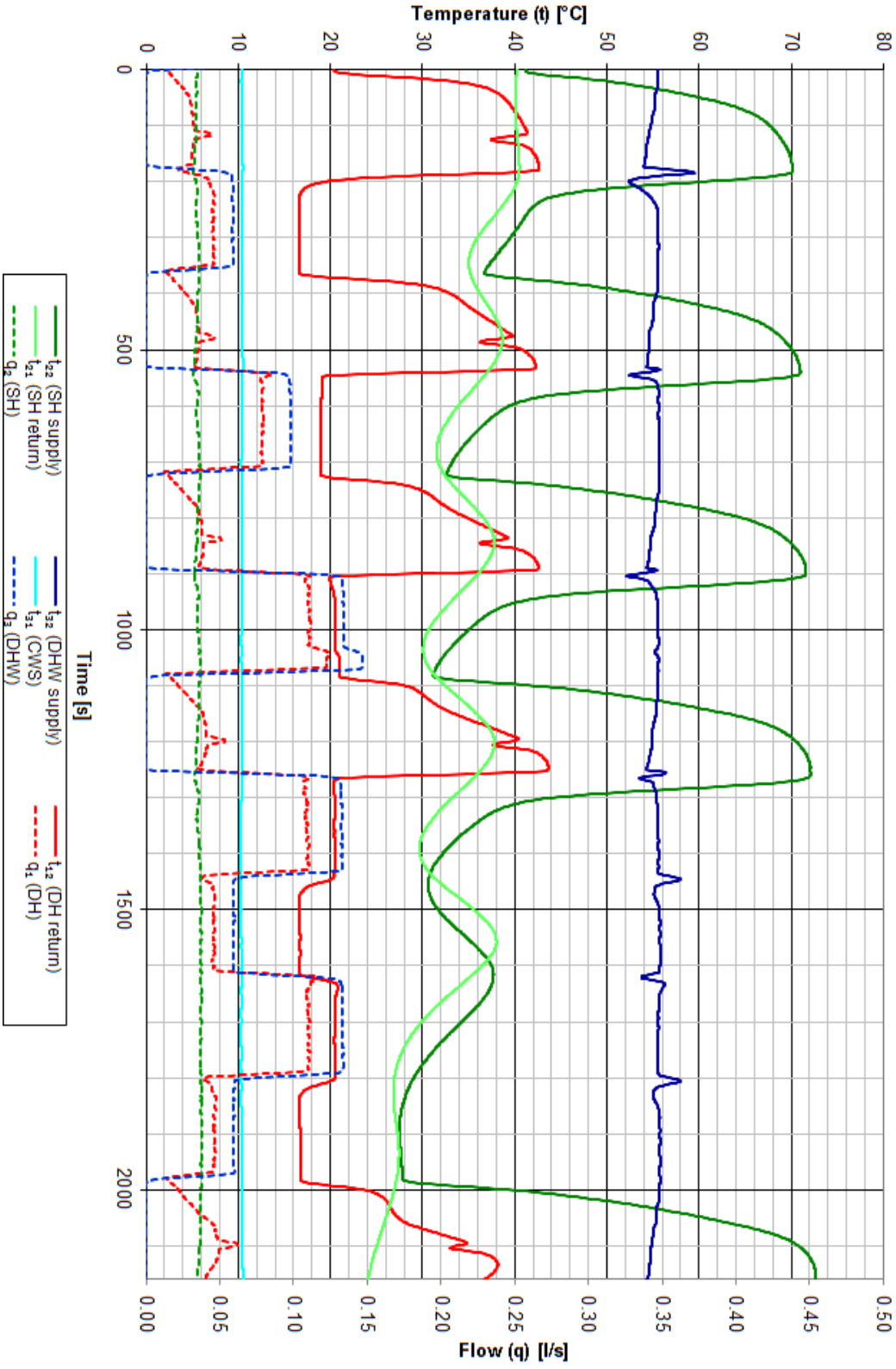


Figure 14. Results for test point 5b: DHW and space heating, max dP.

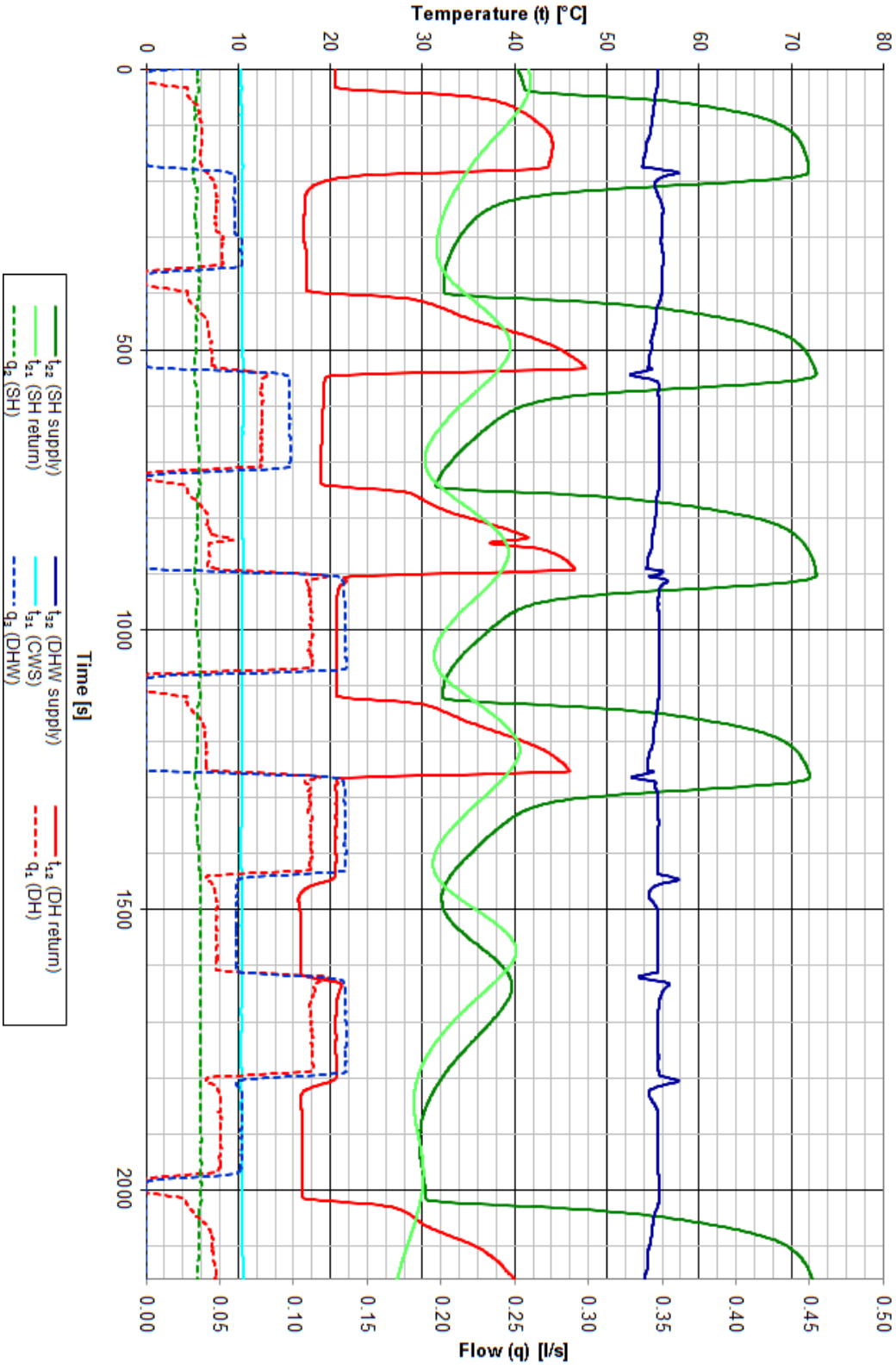


Figure 15. Results for test point 6: Low flow DHW with HIU DHW setpoint at 55 °C.

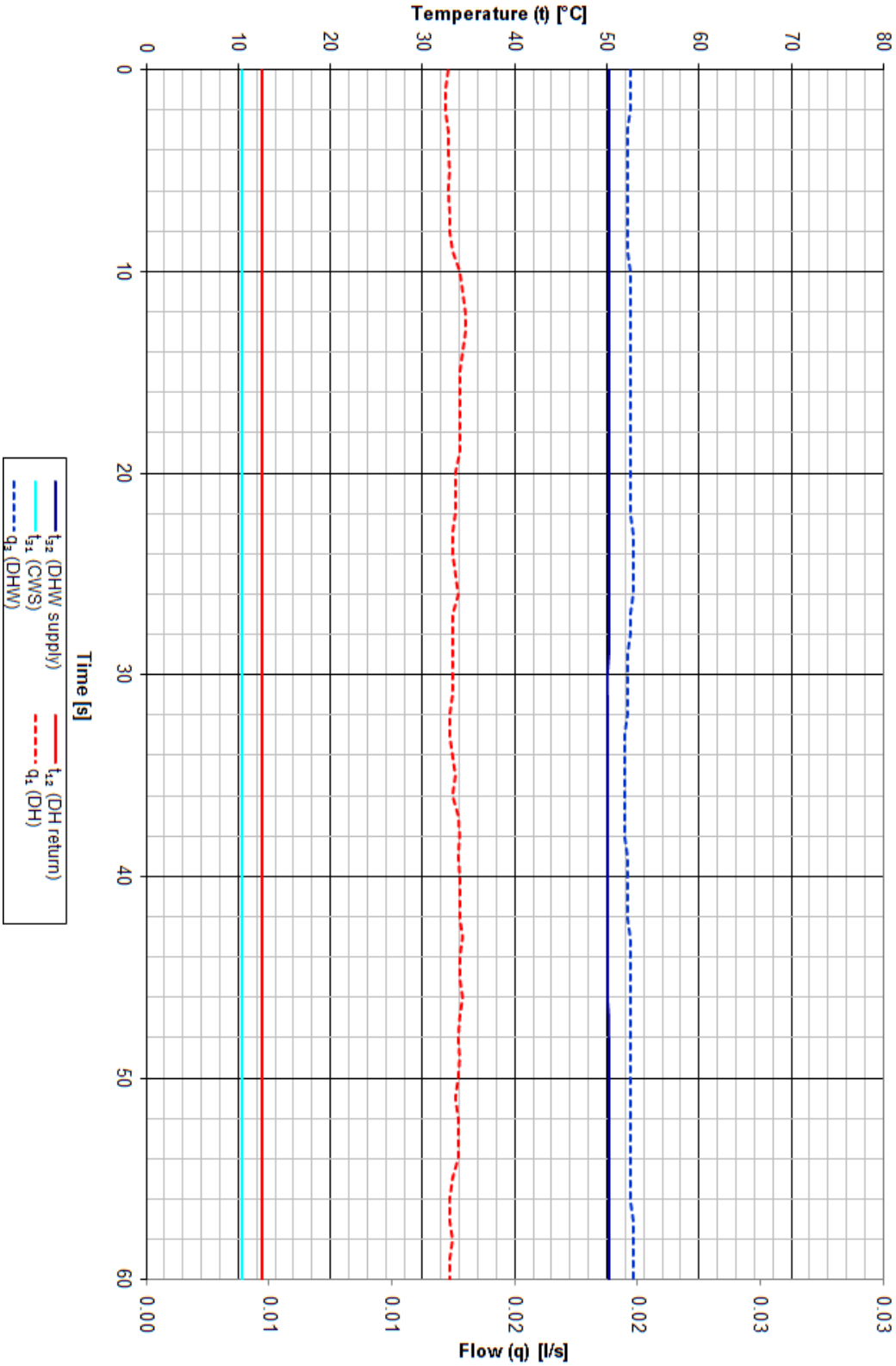


Figure 16. Results for test point 6: Low flow DHW with HIU DHW setpoint at 58 °C.

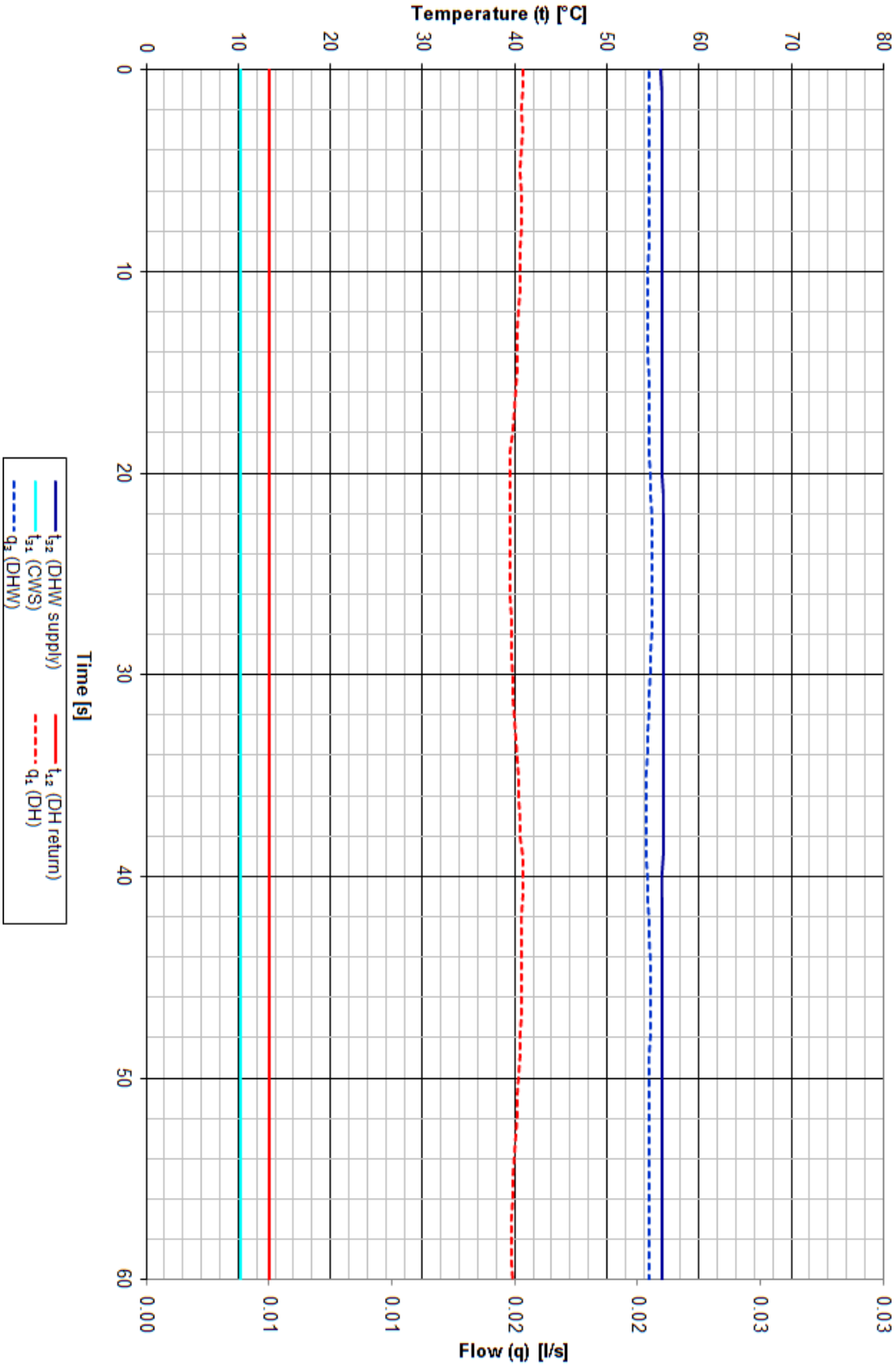


Figure 17. Results for test point 7a: Standby (EcoHeat mode).

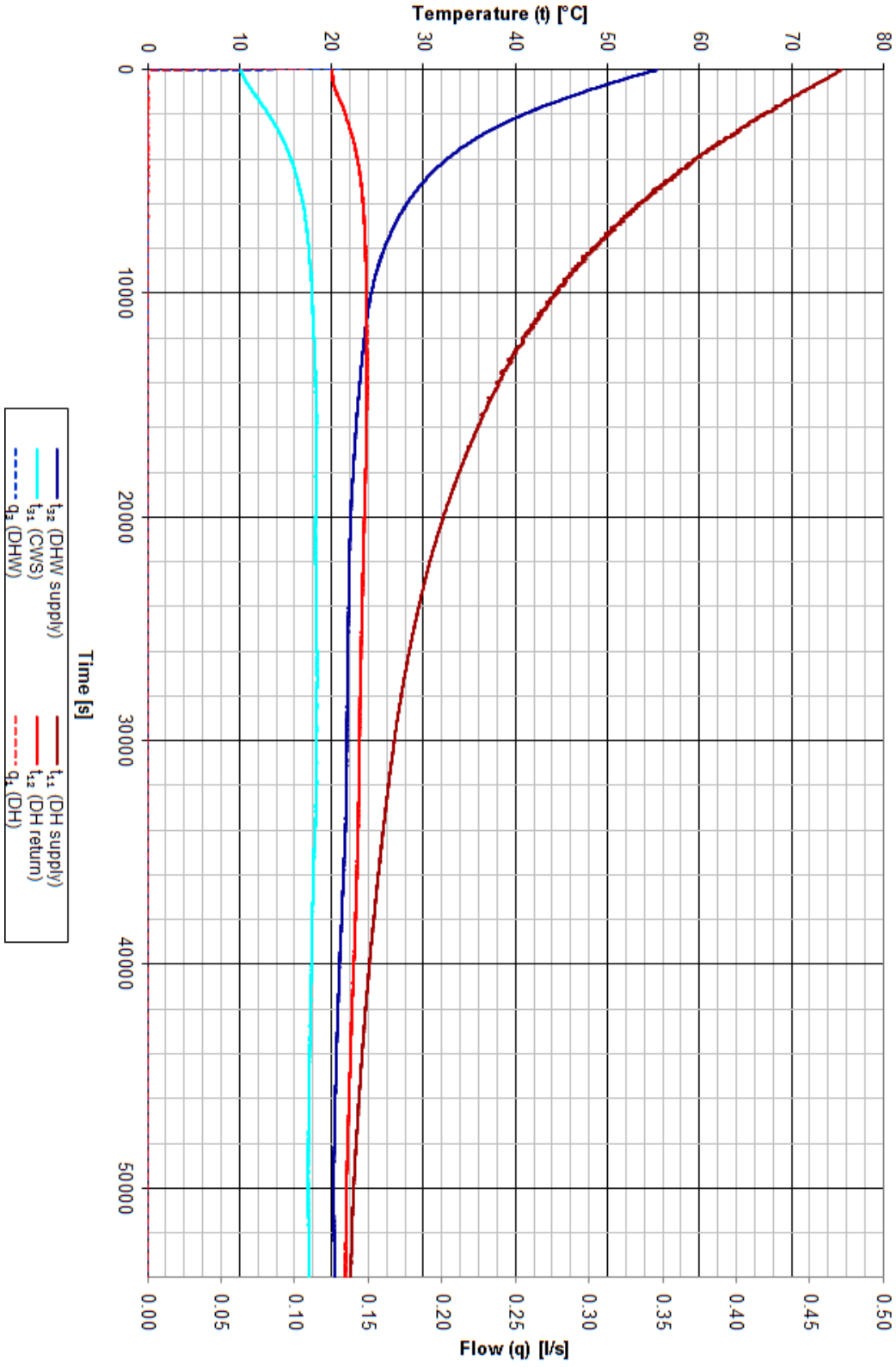


Figure 18. Results for test point 7a: Standby (EcoHeat mode) over a longer time interval.

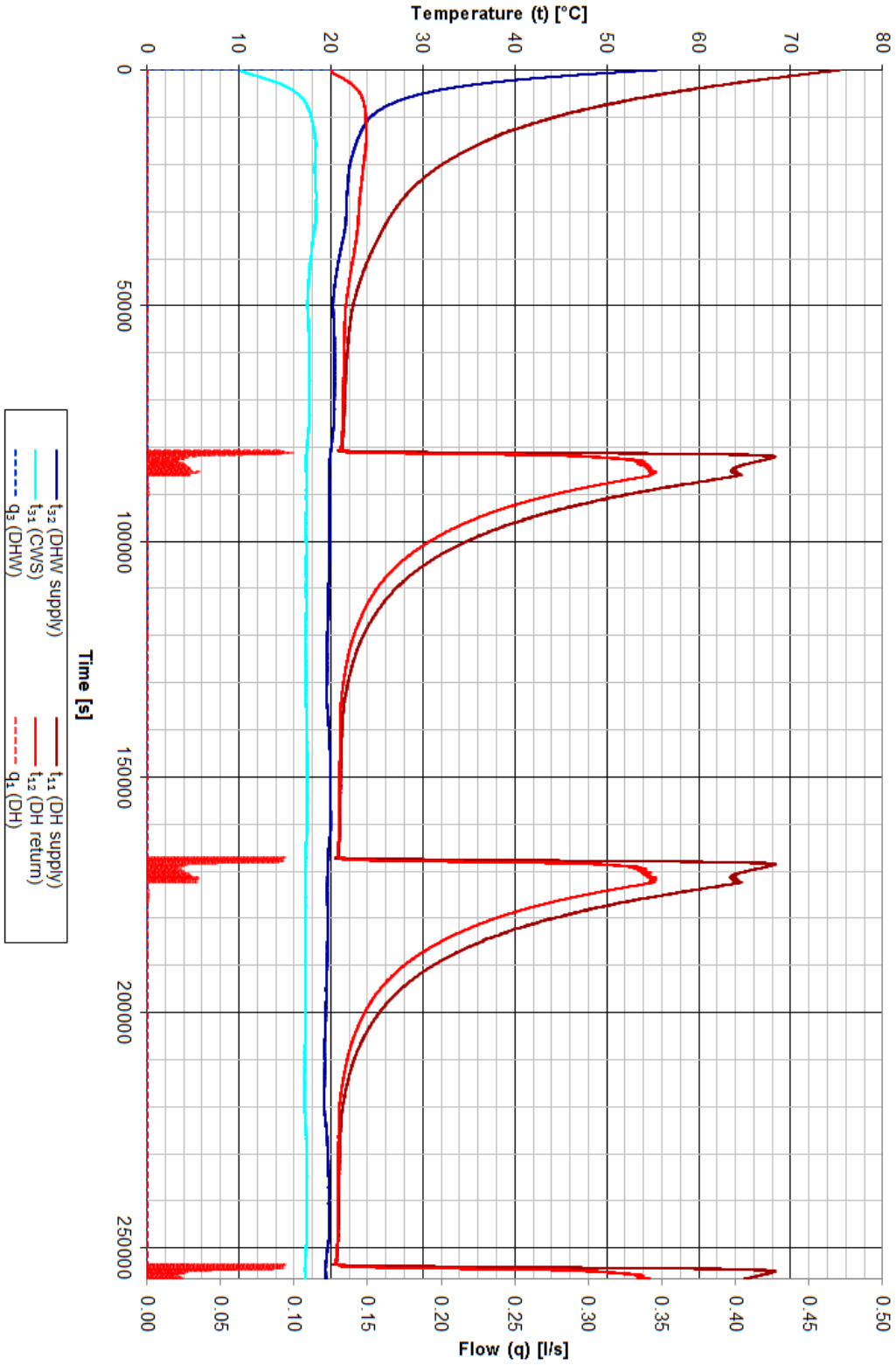


Figure 19. Results for test point 7a: Standby (Comfort mode).

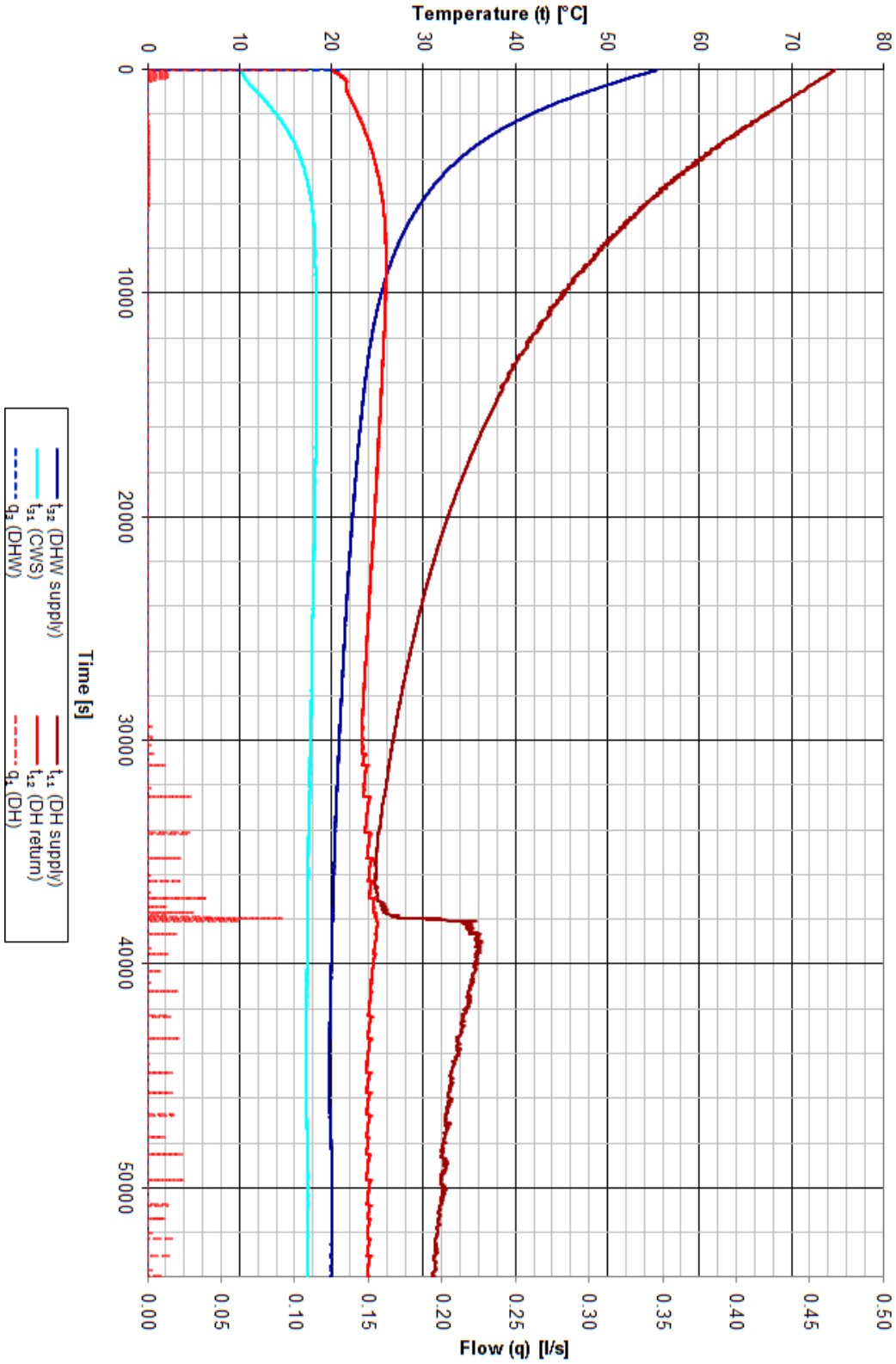


Figure 20. Results for test point 7b: DHW response time (EcoHeat mode).

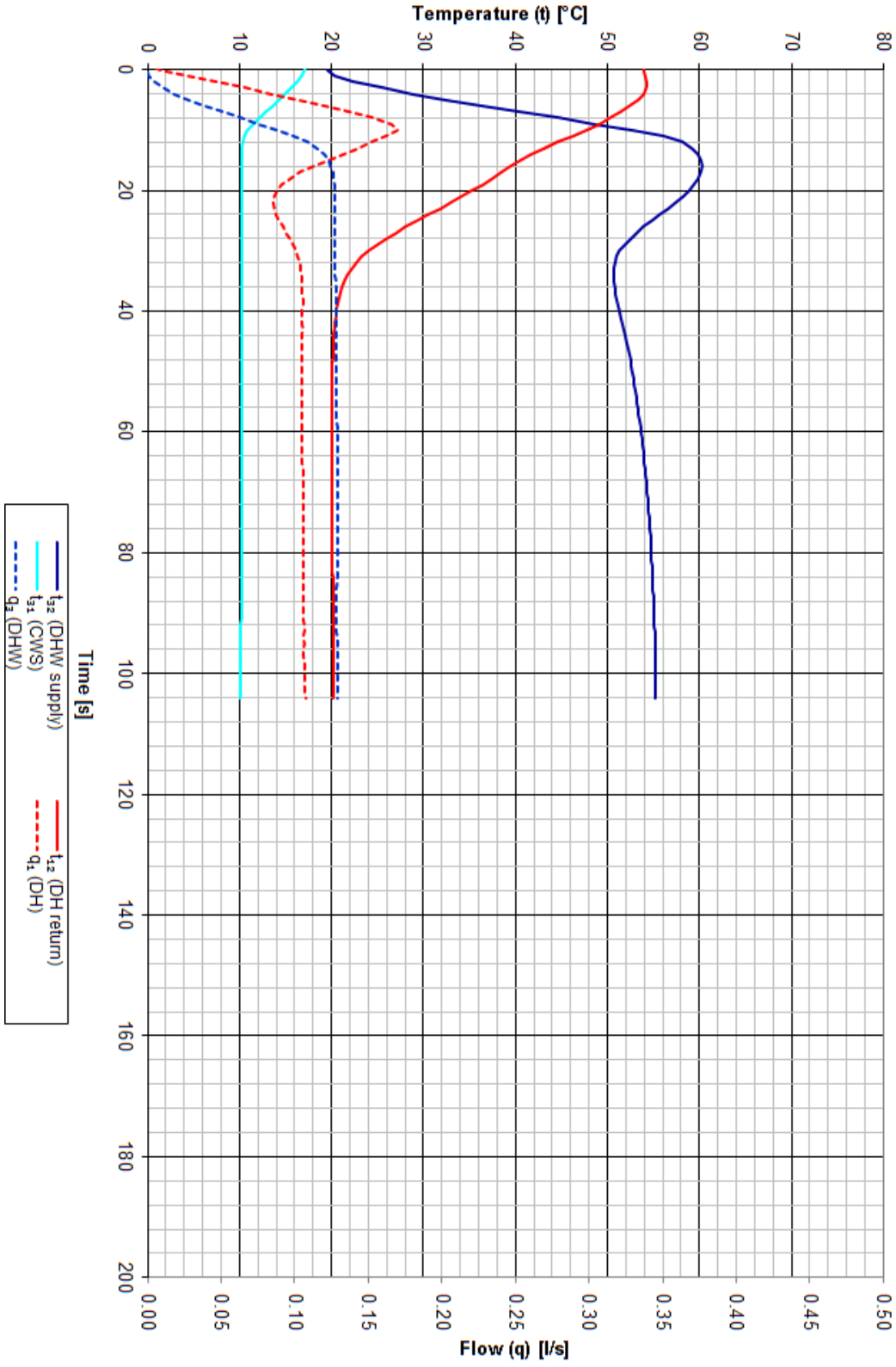


Figure 21. Results for test point 7b: DHW response time (Comfort mode).

