

Test Module 7

Domestic Hot Water, High Temperature, Keep Warm
HOT WATER MODULE 7-DH70-KWarm

DHWM7-DH70C-KWarm

Our Mission Statement: *"To improve the performance of residential HIUs across the UK."*

Revision History

Revision number	Comments	Author	Approver	Date
VI-Rev001	Final version of test module for publication alongside the third edition of the Technical Standard for UK HIU Test Regime	Technical Committee	Steering Group	01/09/2023

1. INTRODUCTION

This document forms part of the UK Test Standard for Heat Interface Units that has been developed to assess the role and performance of HIUs in UK heat networks.

BESA Technical Standard for UK HIU Test Regime (2023) sets out the overall Test Standard requirements. In order to avoid having to repeat successful tests, the tests have been bundled into 'modules'. This sub document covers MODULE 7 that comprises a series of tests, as set out below. Readers should refer to the main test document to understand how the tests and modules fit together within the overall Test Standard.

2. SCOPE

This document covers the tests required for registration under

MODULE 7, covering HIUs supplying Domestic Hot Water, High Temperature, Keep Warm.

The module code is:

HOT WATER MODULE 7-DH70-KWarm.

This module only applies to HIUs:

TYPE 1	HI / HWI
TYPE 2	HD / HWI
TYPE 3	HD-MD / HWI
TYPE 4	HWI

Pass/fail and best practice thresholds for these HIUs are shown below.

This module can be combined with Space Heating modules M1 for a TYPE 1 HIU, M3 for a TYPE 2 HIU, or M5 for a TYPE 3 HIU.

3. TESTS TO BE CARRIED OUT

The following tests shall be carried out in this module.

DHWM7-DH70C-KWarm	HOT WATER MODULE 7-DH70-KWarm
11a	DH/70C, DHW only, 50°C DHW, variable dP
12a	DH/70C, DHW Low flow, 50°C DHW, 50kPa
12c	DH/70C, DHW Low flow, 50°C DHW, 200kPa
13a	DH/70C, DHW load test, 50°C DHW
21a	DH/70C, DHW Keep Warm, 50°C DHW
22a	DH/70C, DHW Keep Warm response time, 50°C DHW

M7.3.1 **Objective:** To explore the performance of the HIU under changing loads, as would be the case in practical operation. Key performance criteria are speed and consistency of DHW delivery to the customer; DHW staying at a safe temperature at all times; and the volume weighted average return temperature when supplying space heating or DHW.

M7.3.2 The primary differential pressure shall be dictated by the tests to be undertaken. This shall be set to either 50 kPa or 200 kPa, or will vary between the two, dependent on the test. The test rig shall control primary differential pressure to the set point $\pm 4\%$.

Note that in all plotting of graphs when reporting, dP will be converted into MPa to ensure that dP has a similar magnitude to flow rate values (in l/s) and can therefore share the same axis, with temperature on a separate axis.

M7.3.3 Load changes occur in the hot water system during the dynamic performance tests in accordance with the draw-off rates and durations detailed below. The average DHW flow rates for each 180 second flow period shall be within 5% of the target flow rates, and the time to achieve 95% of the target flow rates shall not exceed 5 seconds from the onset of the flow change.

All tests shall include the following:

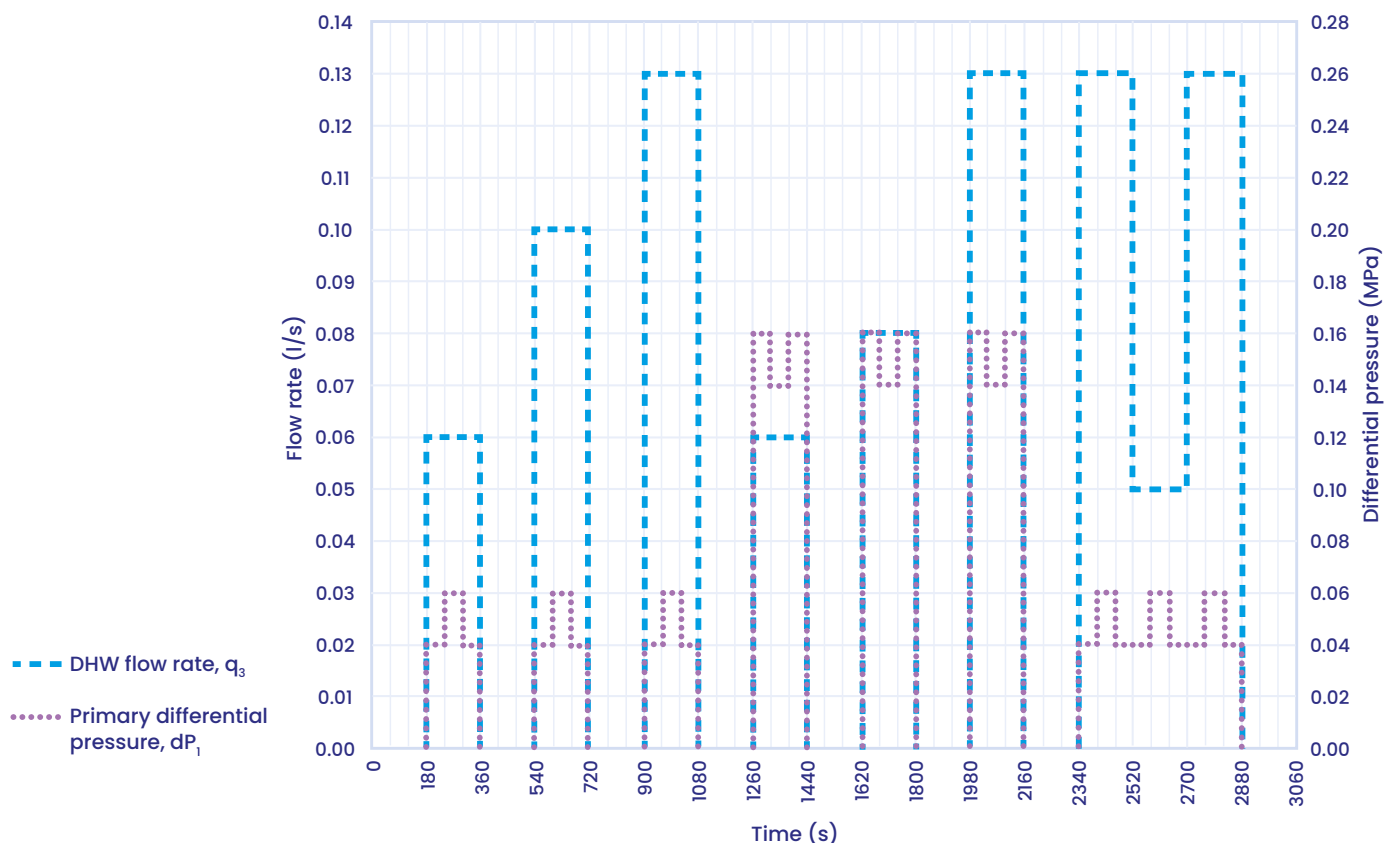
M7.3.4 **Parameter recording** – there are several sensors across the test rig as well as instantaneous power values that shall be calculated from these sensor recordings. Only some of these will be required to be reported and plotted in graphs (see Reporting box at the end of the test module sections). However, all sensors and calculated values shall be recorded for the duration of all tests and made available to the Technical Lead for analysis.

M7.3.5 **Electrical consumption** – the maximum and average electrical consumption should be measured throughout the test (in Watts $\pm 1\%$) along with the derived electrical losses. Electrical elements and other components not within the standard definition of a HIU should be recorded in the HIU list of components and added as an extra line item of measured electrical consumption. The electrical consumption values will only be reported on for the Keep-Warm and Non-Keep Warm tests (i.e. tests 21 and 31) but all values from other tests will be made available to the Technical Lead for analysis.

Test 11a – DHW dynamic performance testing at variable flow rates and differential pressures

11a	DH/70C, DHW only, 50°C DHW, variable dP
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- M7.3.6 **Objective:** To investigate the performance of the HIU when delivering DHW, at a range of flow rates and differential pressures, given a 70°C primary flow temperature. The test investigates HIU operation in terms of DHW delivery and impacts on primary heat network return temperatures.
- M7.3.7 Pass/fail on DHW temperature (t_{32}) dropping below 45.0°C (to one decimal place) for more than 5 consecutive seconds, during DHW supply, as this would impact of resident comfort.
- M7.3.8 Pass/fail on average DHW temperature (t_{32}) being 50.0°C \pm 1°C (to one decimal place) for the final 150 seconds of each of the 180 second DHW flow periods..
- M7.3.9 Pass/fail on DHW temperature (t_{32}) not being maintained at 50.0°C \pm 3°C (to one decimal place) for >150 seconds of the 180 seconds of each flow draw time. Comment should be provided on the stability of DHW flow temperature by stating the maximum and minimum DHW temperatures over the period of the test when there is a DHW flow.
- M7.3.10 Pass/fail on DHW temperature (t_{32}) exceeding 60.0°C (to one decimal place) for more than 1 second, as this poses a scalding risk. Report on the number of consecutive seconds > 55°C.
- M7.3.11 Pass/fail on primary return temperature (t_{12}) exceeding 55.0°C (to one decimal place) at any point, as this poses a scaling risk.
- M7.3.12 For this test the DHW set point shall be 50°C.
- M7.3.13 Prior to commencing the test, domestic hot water shall be drawn off at 0.13 l/s for a minimum of 120 seconds, to establish steady-state conditions. The draw-off cycles set out below shall commence immediately following this.
- M5.3.14 The dynamic test shall be carried out with varying domestic hot water draw-off rates. The draw-off cycles of domestic hot water flow rates to be used in DHW only test 11a are shown in Figure 1.
- M7.3.15 The dynamic test shall be carried out under varying primary differential pressure conditions to simulate HIUs on differing points on a network, and fluctuations likely experienced by the HIUs. The differential pressure profiles to be used in DHW only test 11a are shown in Figure 1.



M7 Figure 1 - DHW profile for DHW-only test (Test 11a)

Note: The graph is for illustrative purposes only, the dP control is unlikely to be immediate in practice.

Note: The test results from Test 11a for the 0.06 l/s flow, 0.10 l/s flow and 0.13 l/s flow at 50 kPa (180 secs to 1,140 secs) and at 200 kPa (1,260 secs to 2,100 secs) shall be used for calculating the Volume Weighted Average Return Temperature for the HIU, utilising the 180 seconds at load and the 60 seconds directly preceding it for each flow rate – see Appendix C for the VWART calculation methodology. Note that the final period of varying flow rate and fluctuating differential pressure shall not be included in any VWART calculations. This period is to just test the HIU's response to changing flow rates at the most challenging (i.e. lowest) dP.

The HIU outer case shall be in place for this test.

No space heating shall be enabled during this test.

M7.3.16 Results shall be presented as a graph over time including t_{11} , t_{12} , q_1 , dP_1 , t_{31} , t_{32} , q_3 , dP_3 . The maximum and minimum values of t_{32} when there is DHW flow, the number of consecutive seconds where $t_{32} > 55^\circ\text{C}$ and the overall DHW VWART shall also be stated.

Pass/Fail Criteria

TEST 11 – DHW dynamic performance testing at variable flow rates and differential pressures

Fail if DHW temperature (t_{32}) exceeds 60.0°C (to one decimal place) for more than 1 second, as this poses a scalding risk.

Fail if primary return temperature (t_{12}) exceeds 55.0°C (to one decimal place) at any point, as this poses a scaling risk.

Fail if the VWART is above 22°C (to one decimal place).

Fail if the average DHW temperature (t_{32}) is not 50.0°C \pm 1°C (to one decimal place) for the final 150 seconds of each of the 180 second DHW flow periods.

Fail if the DHW temperature (t_{32}) is not being maintained at 50.0°C \pm 3°C (to one decimal place) for >150 seconds of each of the DHW flow periods.

Fail if the DHW temperature (t_{32}) drops below 45.0°C (to one decimal place) for more than 5 consecutive seconds, as this would impact resident comfort.

Best Practice Criteria

TEST 11 – DHW dynamic performance testing at variable flow rates and differential pressures

Best practice if the VWART is less than 17°C (to one decimal place).

Best practice if the DHW temperature (t_{32}) is being maintained at 50.0°C \pm 2°C throughout periods of DHW flow.

Best practice if the DHW temperature (t_{32}) doesn't drop below 45.0°C (to one decimal place) for more than 2 consecutive seconds

These values do not constitute part of the formal test registration process. However, they do provide targets for manufacturers and purchasers seeking to achieve the highest possible performance in the sector.

Reporting

TEST 11 – DHW dynamic performance testing at variable flow rates and differential pressures

Report on the following values for each test

Maximum and minimum values of t_{32} when there is DHW flow.

Number of consecutive seconds where $t_{32} > 55^\circ\text{C}$.

Overall DHW VWART.

Plot graph of following key metrics for each test:

t_{11} , t_{12} , q_1 , dP_1 , t_{32} , q_3 over the duration of each test.

Tests 12a, 12c – DHW low flow rate stability test

12a	DH/70C, DHW Low flow, 50°C DHW, 50 kPa
12c	DH/70C, DHW Low flow, 50°C DHW, 200 kPa

M7.3.17 **Objective:** To investigate the stability of DHW temperature at low flow rates. During operation, domestic hot water is sometimes drawn off at extremely low flow rates. Test 12 investigates the ability of the system to meet this condition by measuring the temperature at test point t₃₂ at a flow rate of 0.02 l/s.

The test shall run on the following basis:

- Domestic hot water shall be drawn off at 0.13 l/s for a minimum of 120 seconds, then subsequently
- Domestic hot water shall be drawn off at 0.02 l/s for 180 seconds.

M7.3.18 For this test the DHW set point shall be 50°C.

Test 12a: 70°C primary flow temperature at 50 kPa

Test 12c: 70°C primary flow temperature at 200 kPa

M7.3.19 Pass/fail on DHW temperature (t_{32}) exceeding 60.0°C (to one decimal place) for more than 1 second, as this poses a scalding risk. Report on the number of consecutive seconds > 55°C.

M7.3.20 Pass/fail on primary return temperature (t_{12}) exceeding 55.0°C (to one decimal place) at any point, as this poses a scaling risk.

M7.3.21 Pass/fail on HIU maintaining stable DHW flow temperature (t_{32}) of 50 °C ±3°C (to one decimal place) for more than 60 seconds.

The HIU outer case shall be in place for these tests.

No heating shall be enabled during these tests.

M7.3.22 Results shall be presented as a graph over time including t_{11} , t_{12} , q_1 , t_{32} , q_3 . The maximum and minimum values of t_{32} when there is low DHW flow and the number of consecutive seconds where $t_{32} > 55^\circ\text{C}$ shall also be stated. Comment should be made on the following and stated in the report:

- Comment on ability to deliver DHW at low flow rate based on DHW temperature reaching at least 45.0°C (1 decimal place) at the end of the 180 second period of low flow DHW.
- Comment on ability to deliver stable DHW flow temperature (at t_{32}), defined as ability to maintain 50.0 ±3.0°C (1 decimal place) during the last 60 seconds of the test.

Pass/Fail Criteria

TEST 12 – DHW low flow rate stability test

Fail if DHW temperature (t_{32}) exceeds 60.0°C (to one decimal place) for more than 1 second, as this poses a scalding risk.

Fail if primary return temperature (t_{12}) exceeds 55.0°C (to one decimal place) at any point, as this poses a scaling risk.

Fail if DHW temperature (t_{32}) is not maintained at 50°C \pm 3°C (to one decimal place) for more than 60 seconds

Best Practice Criteria

TEST 12 – DHW low flow rate stability test

Best practice if DHW temperature (t_{32}) is maintained at 50°C \pm 2°C (to one decimal place) throughout the test for both test 12a and 12c.

These values do not constitute part of the formal test registration process. However, they do provide targets for manufacturers and purchasers seeking to achieve the highest possible performance in the sector.

Reporting

TEST 12 – DHW low flow rate stability test

Report on the following values for each test

Maximum and minimum values of t_{32} when there is low DHW flow.

Number of consecutive seconds where $t_{32} > 55^\circ\text{C}$.

Comment on ability to deliver DHW at low flow rate based on DHW temperature (t_{32}) reaching at least 45.0°C (1 decimal place) at the end of the 180 second period of low flow DHW.

Comment on ability to deliver stable DHW flow temperature (at t_{32}), defined as ability to maintain 50.0 \pm 3.0°C (1 decimal place) during the last 60 seconds of the test.

Plot graph of following key metrics for each test:

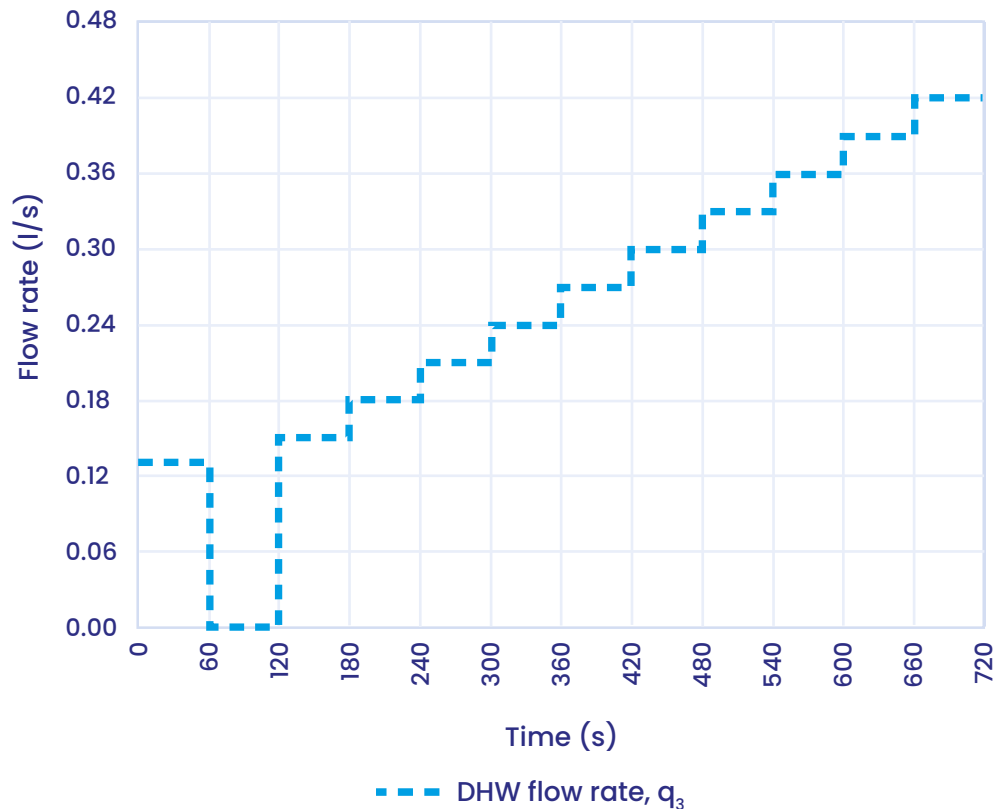
t_{11} , t_{12} , q_1 , t_{32} , q_3 over the duration of each test.

Test 13a – DHW maximum heat output and flow rate load test

13a DH/70C, DHW load test, 50°C DHW

- M7.3.23 **Objective:** To measure the maximum heat output (kW) and flow (l/min) DHW output that can be delivered from the HIU. The HIU shall be set to deliver 50°C and the maximum DHW power output shall be measured with a flow step change and the peak value recorded when the DHW flow temperature is above 45°C.
- M7.3.24 Pass/Fail on the HIU being unable to produce 50°C ± 1.0 °C (to one decimal place) at 0.13 l/s DHW flow during the first draw-off step.
- M7.3.25 The maximum DHW heat output rating of a HIU can indicate unit oversizing and provide information on the available DHW capacity at a useful temperature for the DHW outlets.
- M7.3.26 The test will also have a tertiary purpose of measuring the pressure loss in the DHW line across the HIU at the different flow rates.
- M7.3.27 The test includes HIU DHW heat output up to 70 kW at 50 kPa difference in primary pressure. Cold water pressure is set so that the test rig will allow a maximum pressure drop of 1 bar $\pm 5\%$ across the HIU DHW tertiary, as this is considered the maximum reasonable value without a negative impact in the DHW circuit. It is expected that the 1 bar pressure drop will be one of the limiting factors on the DHW load test. DHW tertiary pressure differential is measured for the duration of the test. The primary flow temperature for the high temperature test shall be 70°C.
- M7.3.28 The test consists of a series of hot water draws starting from 0.15 l/s and increasing in steps of 0.03 l/s up to 0.42 l/s (approx. 5 kW steps from 25 kW up to 70 kW). The HIU shall be rated at the final step where it was successful in maintaining hot water output above 45°C. The test can be carried out in the high or low primary temperature regimes with a set DHW output temperature of 50°C.
- M7.3.29 The HIU shall have the same settings as used for Test 11.
- M7.3.30 The domestic hot water draw-off rates are as follows:
- 0.13 l/s for 60 seconds (pre-heat)
 - 0.00 l/s for 60 seconds
 - 0.15 l/s for 60 seconds
 - 0.18 l/s for 60 seconds
 - 0.21 l/s for 60 seconds
 - 0.24 l/s for 60 seconds
 - 0.27 l/s for 60 seconds
 - 0.30 l/s for 60 seconds
 - 0.33 l/s for 60 seconds
 - 0.36 l/s for 60 seconds
 - 0.39 l/s for 60 seconds
 - 0.42 l/s for 60 seconds

M7.3.31 The series of DHW hot water draws are shown diagrammatically in Figure 2.



M7 Figure 2 – Domestic hot water flow rate versus time, Test 13a

M7.3.32 In the final ten seconds of each step if the average DHW temperature falls below 45°C then the test shall be stopped. Otherwise, the test shall be carried out to completion until there are no more steps.

M7.3.33 The test conditions shall be:

- The settings on the HIU shall be unchanged from Test 11a.
- 70°C primary flow temperature at 50 kPa primary differential pressure.
- The preheat stage DHW output temperature set point shall be 50°C.
- The DHW output temperature set point for each step shall be 50°C.
- The average of DHW flow rates for each step shall be within 5% of the target flow rates, and the time to achieve 95% of the target flow rates shall not exceed 5 seconds from the onset of the step change.
- DHW gauge pressure is set to 3 bar $\pm 5\%$. The average DHW cold temperature shall be 10°C ± 0.5 for the test.

M7.3.34 Pass/fail on DHW temperature (t_{32}) exceeding 60.0°C (to one decimal place) for more than 1 second, as this poses a scalding risk. Report on the number of consecutive seconds > 55°C.

M7.3.35 Pass/fail on primary return temperature (t_{12}) exceeding 55.0°C (to one decimal place) at any point, as this poses a scaling risk.

The HIU outer case shall be in place for this test.

No space heating shall be enabled during this test

M7.3.36 Results shall be presented in two forms:

- A table including mean average values of t_{11} , t_{12} , q_1 , H_1 , t_{31} , t_{32} , q_3 , dP_3 , H_3 for the last ten seconds of every step. The load test result shall be reported as the maximum DHW heat output, XX kW, and flow rate, YY l/s, when producing minimum DHW at 45°C or above, and the recorded DHW line pressure drop across the HIU, xx KPa, at this flow rate (up to a flow rate of 0.42 l/s, equivalent to 70 kW). The number of consecutive seconds where $t_{32} > 55^\circ\text{C}$ shall also be stated.
- A graph over time including t_{11} , t_{12} , q_1 , t_{32} , q_3 , dP_3 , H_3 .

Pass/Fail Criteria

TEST 13 – DHW maximum heat output and flow rate load test

Fail if DHW (at t_{32}) is less than $50^\circ\text{C} \pm 1.0^\circ\text{C}$ (to one decimal place) at 0.13 l/s flow rate, as the HIU must be able to produce DHW to the target temperature at a moderate load.

Fail if DHW temperature (t_{32}) exceeds 60.0°C (to one decimal place) for more than 1 second, as this poses a scalding risk.

Fail if primary return temperature (t_{12}) exceeds 55.0°C (to one decimal place) at any point, as this poses a scaling risk.

Reporting

TEST 13 – DHW maximum heat output and flow rate load test

Report on the following values for each test

A table including mean average values of t_{11} , t_{12} , q_1 , H_1 , t_{31} , t_{32} , q_3 , dP_3 , H_3 for the last ten seconds of every step.

The maximum DHW heat output, xx kW, and flow rate, xx l/s, when producing minimum DHW at 45°C or above, and the recorded DHW line pressure drop across the HIU, xx KPa, at this flow rate (up to a flow rate of 0.42 l/s, equivalent to 70 kW).

Number of consecutive seconds where $t_{32} > 55^\circ\text{C}$.

Plot graph of following key metrics for each test:

t_{11} , t_{12} , q_1 , t_{32} , q_3 , dP_3 , H_3 over the duration of each test.

Test 21a – DHW no-load characteristics of units in 'Keep Warm' mode

21a	DH/70C, DHW Keep Warm, 50°C DHW
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- M7.3.37 **Objective:** To establish HIU performance during periods of no load, when operating in Keep Warm mode.
- M7.3.38 The Keep Warm Mode test set up and rig operation is based on the HIU Keep Warm Reference building, see Appendix D in the main test document.
- M7.3.39 During those times of the year when no space heating is required, or at times when no domestic hot water is being drawn off, various types of temperature-holding functions come into operation in order to ensure that domestic hot water will be quickly available. Test 21a investigates how this Keep Warm function operates and the impact on the primary heat network.
- M7.3.40 For HIUs that can enable/disable their Keep Warm function, HIUs undergoing "Keep Warm on" modules, Keep Warm shall be enabled at all times and operation/set up detailed and recorded.
- M7.3.41 The settings shall be such that:
- HIU primary supply temperatures (t_{p1}) shall be maintained at or above 39.0°C (to one decimal place) at all times to ensure that the HIU is able to deliver DHW at any point.
 - 45°C DHW delivery temperature (t_{32}) shall be achieved within 15 seconds in the DHW response time Test 22a.

For HIUs with a range of Keep Warm options, the settings shall be recorded.

- M7.3.42 With no space heating load, draw off domestic hot water at a rate of 0.1 l/s for a minimum of 120 seconds to establish steady state conditions and then turn off the hot water. Measure the primary flow rate and the primary flow and return temperatures for a period of at least 8 hours after the initial hot water draw-off has been completed.
- M7.3.43 The heat consumed by the HIU over the first 8 hours of the test period shall be used as a measure of the Keep Warm heat losses from each HIU. The HIU case shall be fitted for this test to allow a representative estimate of Keep Warm losses to be made.
- Test 21a: 70°C primary source temperature (t_{p0}); 50°C DHW flow temperature (t_{32}).

Note: The test results from Test 21a shall be used for calculating the Volume Weighted Average Return Temperatures for the HIUs – see Appendix C in the main test document for the VWARD calculation methodology.

M7.3.44 The HIU shall have overall energy losses of not more than 1.0 kWh/day, to 3 decimal places (typically losses should be below 0.7 kWh/day).

During the 8 hour Keep Warm test, the electrical energy consumption shall be measured and recorded to establish a mean average energy consumption. This shall include both the electrical energy used during standby operation as well as any electrical energy that is contributing to the Keep Warm function.

Together with the thermal heat losses, the electrical energy consumption shall be combined to give an overall energy loss value in standby mode. This shall be calculated to give an average overall energy loss per day as follows:

$$((W_{\text{thermal}} + W_{\text{electrical}}) \times 24) / 1000 = \text{kWh/day}$$

This value shall be reported along with W_{thermal} and $W_{\text{electrical}}$ as separate mean average consumption values.

Note that the purpose of this calculation is to establish the overall energy loss from the HIU (when in standby mode) only. When using this average overall energy loss per day value in calculations (which will be reported in SAP), designers should note that electrical consumption has a higher cost and carbon impact than heat.

M7.3.45 For this test the DHW set point shall be 50°C.

M7.3.46 For this test the primary differential pressure (dP_1) shall be 50 kPa.

M7.3.47 Pass/fail on primary return temperature (t_{12}) exceeding 55.0°C (to one decimal place) at any point, as this poses a scaling risk.

The HIU outer case shall be in place for this test.

No heating shall be enabled during this test.

M7.3.48 Results shall be presented as a graph over time including t_{10} , t_{11} , t_{12} , q_1 , t_{31} , t_{32} . The graph shall start at time = 0 s at the first instance when $q_3 = 0$ l/s. The overall keep warm VwART and mean average values of q_1 , H_1 , $W_{\text{electrical}}$, W_{thermal} and the overall energy loss per day, over the duration of each test shall be stated. Comment should be made on the following and stated in the report:

- Keep Warm operation/set up fully detailed
- Comment on whether the keep warm operation is valid (based on Test 22 response time criteria)
- Comment on whether the keep warm undergoes cycling (i.e. t_{11} varies by more than ± 3 °C during the final 3 hours of the test)

Pass/Fail Criteria

TEST 21 – DHW no-load characteristics of units in 'Keep Warm' mode

Fail if V_{WART} is above 44°C (to one decimal place).

Fail if primary return temperature (t_{12}) exceeds 55.0°C (to one decimal place) at any point, as this poses a scaling risk.

Fail if the primary supply temperature to the HIU (t_{11}) drops to below 39°C.

Fail if the HIU overall energy losses are greater than 1.0 kWh/day (to three decimal places).

Fail if the Test 22a DHW temperature response time test fails (i.e. the HIU Keep Warm operation is not a valid Keep Warm).

Best Practice Criteria

TEST 21 – DHW no-load characteristics of units in 'Keep Warm' mode

V_{WART} is below 38°C (to one decimal place)

HIU overall energy losses are less than 0.7 kWh/day (to three decimal places)

These values do not constitute part of the formal test registration process. However, they do provide targets for manufacturers and purchasers seeking to achieve the highest possible performance in the sector.

Reporting

TEST 21 – DHW no-load characteristics of units in 'Keep Warm' mode

Report on the following values for each test

Mean average values of q_1 , H_1 , $W_{\text{electrical}}$, W_{thermal} and the overall energy loss per day, over the duration of each test.

Test Keep Warm operation and set up fully detailed.

Comment on whether the keep warm operation is valid (based on Test 22a response time criteria).

Comment on whether the keep warm undergoes cycling (i.e. t_{11} varies by more than $\pm 3^\circ\text{C}$ during the final 3 hours of the test).

Overall Keep Warm V_{WART}.

Plot graph of following key metrics for each test:

t_{10} , t_{11} , t_{12} , q_1 , t_{31} , t_{32} over the duration for each test starting from time = 0 s at the first instance when $q_3 = 0 \text{ l/s}$.

Test 22a – DHW response time in 'Keep Warm' mode

22a DH/70°C, DHW Keep Warm response time, 50°C DHW

- M7.3.49 **Objective:** To investigate DHW delivery time after a period of at least 8 hours Keep Warm only operation. This tests if the HIU can supply domestic hot water within an acceptable time of turning on the tap, which is a basic comfort requirement.
- M7.3.50 Immediately after testing the no-load characteristics for Test 21a, steady-state conditions, without domestic hot water draw-off or space heating load, will have been established. At this point, DHW shall be drawn off at 0.1 l/s. The time taken for the DHW, t_{32} , to achieve 45°C while not dropping below a temperature of 42°C, thereafter, shall be recorded and stated in the report. The time is taken from the first DHW flow reading above 0.001 l/s as recorded by q_3 . In order for the HIU to be considered as providing a Keep Warm facility for the purpose of this test, the HIU must pass this response time test.
- M7.3.51 For this test, the HIU's Keep Warm function will have been enabled during the previous no-load test and the operation/set up of Keep Warm configuration detailed and recorded.
- M7.3.52 The HIU's service connection is represented by the connection hoses from the test rig, which is consistent for all HIUs tested (as detailed in Section 6 and Appendix B in the main test document).
- M7.3.53 A plot of key metrics over the duration of test shall be included in the report.
- M7.3.54 It should be noted that certain HIUs have a Keep Warm cycle, with significant fluctuations in primary temperature (t_{11}) dependent on the stage of the cycle. As primary temperature has a significant impact on DHW response time, it is important that Test 22a is not conducted when primary temperatures are highest.
- M7.3.55 For HIUs that cycle during Keep Warm with a cycle period of greater than 5 minutes, Test 22a shall be timed to start at the three-quarter point of the Keep Warm cycle (i.e. 75% of the cycle time after the primary flow rate has ceased).
- M7.3.56 The start of the Keep Warm cycle is defined as the time at which the primary flow temperature, t_{11} , is at the highest temperature in the cycle.
- M7.3.57 An HIU is considered to be performing a Keep Warm cycling when the primary flow temperature, t_{11} , varies by more than $\pm 3^\circ\text{C}$ during the final 3 hours of the test.
- M7.3.58 For this test the DHW set point shall be 50°C.
- M7.3.59 For this test, the primary differential pressure (dP_1) shall be 50 kPa.
- M7.3.60 Cold-water supply temperature (t_{31}) shall reach $10^\circ\text{C} \pm 3^\circ\text{C}$ within 3 seconds of DHW flow.
- M7.3.61 Pass/fail on DHW temperature (t_{32}) exceeding 60.0°C (to one decimal place) for more than 1 second, as this poses a scalding risk. Report on the number of consecutive seconds $> 55^\circ\text{C}$.
- M7.3.62 Pass/fail on primary return temperature (t_{12}) exceeding 55.0°C (to one decimal place) at any point, as this poses a scaling risk.

The HIU outer case shall be in place for this test.

No heating shall be enabled during this test.

M7.3.63 Results shall be presented as a graph over time including t_{10} , t_{11} , t_{12} , q_1 , t_{31} , t_{32} , q_3 . The graph shall start at time = -5 s with $t = 0$ s at the first instance when $q_3 \neq 0$ l/s. The mean average values of q_1 over the duration of each test, the time taken for t_{32} to reach 45.0°C and not subsequently drop below 42.0°C and the number of consecutive seconds where $t_{32} > 55^\circ\text{C}$ shall be stated. Comment should be made as to whether the keep warm operation is valid (based on the response time criteria).

Pass/Fail Criteria

TEST 22 – DHW response time in ‘Keep Warm’ mode

Fail if the DHW response time takes more than 15 seconds to reach 45.0°C (to one decimal place) at t_{32} while not dropping below 42.0°C (to one decimal place) thereafter.

Fail if DHW temperature (t_{32}) exceeds 60.0°C (to one decimal place) for more than 1 second, as this poses a scalding risk.

Fail if primary return temperature (t_{12}) exceeds 55.0°C (to one decimal place) at any point, as this poses a scaling risk.

Best Practice Criteria

TEST 22 – DHW response time in ‘Keep Warm’ mode

Best practice if DHW response time at t_{32} is less than 10 seconds.

These values do not constitute part of the formal test registration process. However, they do provide targets for manufacturers and purchasers seeking to achieve the highest possible performance in the sector.

Reporting

TEST 22 – DHW response time in ‘Keep Warm’ mode

Report on the following values for each test

Time taken for t_{32} to reach 45.0°C (1 decimal place) and not subsequently drop below 42.0°C (1 decimal place).

Comment on whether the keep warm operation is valid (based on response time criteria above).

Mean average values of q_1 over the duration of each test.

Number of consecutive seconds where $t_{32} > 55^\circ\text{C}$.

Plot graph of following key metrics for each test:

t_{10} , t_{11} , t_{12} , q_1 , t_{31} , t_{32} , q_3 over the duration for each test, starting from time = -5 s with $t = 0$ s at the first instance when $q_3 \neq 0$ l/s.

The time taken for t_{32} to reach 45.0°C (1 decimal place) and not subsequently drop below 42.0°C (1 decimal place) should be indicated on the graph using a vertical line from this point and intersecting the time axis.

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