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| **Technical Note** | | | **TN-031** | |
| **Test:** N/A | | | **Test no.:** N/A | |
| **Assumption:** Pass Thresholds | | | **Assumption no: N/A** | |
| **Rev: 02** | **Date: 14/8/22** | **Author: Tom Naughton** | | **Checked: Freddie Valletta** |

# Introduction

In order to ensure a minimum standard for all HIUs that pass the BESA HIU test, a number of minimum pass thresholds are proposed.

A number of the pass thresholds are retained from the previous test. However, based on a request from the BESA HIU Steering Committee, a new performance threshold based on the VWART results of the unit is also proposed.

It should be noted that the pass thresholds do not reflect any other compliance test or regime and should not be used for demonstrating compliance with any other guidance or regulations.

The following parameters have pass thresholds:

* DHW maximum temperature
* DHW scaling temperature
* Keep Warm definition
* Space heating, DHW, and Keep Warm VWARTs (all tests)

# DHW Maximum Temperature Pass Thresholds

The DHW maximum temperature pass thresholds relate to all high temperature DHW tests - 11a, 12a, 12c, 13a, 22a, 31a, and 32a.

The pass threshold for all these tests is less or equal to 1 second at a temperature measured at t32 of equal to or greater than 60 °C. For clarity, a unit will have deemed to have failed if a temperature of over 60 °C measured at t32 is recorded for more than 1 second.

The technical justifications for these pass thresholds are detailed and presented in Technical Note 8 (TN\_BESA\_HIU\_008\_Assumption\_27&28\_DynamicDHWtest-PassFailCriteriaScaldingLimits\_WE\_Rev2\_01).

# DHW Scaling Temperature Pass Thresholds

There are two DHW scaling temperature pass thresholds.

The first relates to the dynamic DHW tests 11a, 12a, 12c, 13a, 22a, 31a, 32a. The pass threshold for these tests is that the temperature measured at t12, doesn’t exceed 55 °C for more than 5 seconds during the tests.

The second relates to the Keep Warm test 21a. The pass threshold for these tests is that the temperature measured at t12, doesn’t exceed 55 °C at any point during the test.

The technical justifications for these pass thresholds are detailed and presented in Technical Note 29 (TN\_BESA\_HIU\_029\_Assumption\_68\_ScalingAssessment\_DM\_Rev1\_03).

# DHW response time test

The DHW response time pass threshold relates to the Keep Warm DHW response time tests – 22a, 22b, 32a and 32b.

The HIU must be able to provide DHW at 45 °C t32 within (equal or less than) 15 seconds.

The technical justifications for these pass thresholds are detailed and presented in Technical Note 19 (TN\_BESA\_HIU\_019\_Assumption\_44\_PerformanceRequirementsOfKWF\_GJ\_Rev1\_02).

# VWART Pass Thresholds

## Analysis

In order to determine the suitable pass VWART thresholds for the new test, analysis was carried out on the 29 HIU tests carried out since 2018.

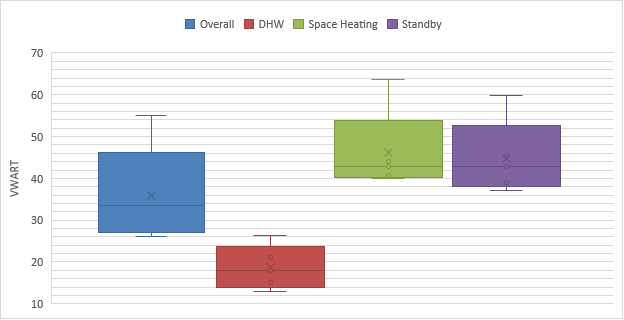


Figure 1 Overall, DHW, space heating, and Keep Warm VWART results for the 29 high temperature tests

Figure 1 above shows the highest, lowest, 25% percentile, 75% percentile and mean VWART for the overall, DHW, space heating, and Keep Warm tests. It can be seen that there is a significant variation between all tests

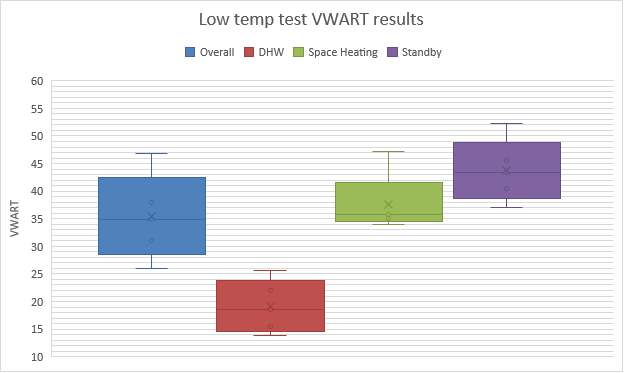


Figure 2 Overall, DHW, space heating, and Keep Warm VWART results for the 29 low temperature tests

As with the high temperature tests, it can be seen in Figure 2 that there is a significant variation in all four VWART reported values in the low temperature tests.

## Initial proposed VWART pass threshold values

# High temperature test

Based on the analysis, the following VWART pass thresholds were initially proposed for the high temperature tests. It should be noted that an HIU is considered to have failed the test if it fails any one of the four VWART results.

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter | Criteria (<=°C) | No. failed | Comment |
| DHW | 22 | 2 |  |
| Space Heating | 45 | 1 | As per CP1 guidance |
| Keep Warm | 44 | 8 |  |

Table 1 Initial proposed VWART thresholds for high temperature test based on current temperature regime

Every HIU that failed any of the individual parameters also failed the Overall test as can be seen in Figure 3 below. However, two HIUs pass all of the three independent tests (DHW, space heating and Keep Warm VWARTs).

Table

Description automatically generated

Figure 3 HIUs that would fail the proposed high temperature VWART thresholds

Overall percentage of failures for these pass thresholds would be 31% (9 of 29 units fail). It should be noted that this analysis doesn’t currently consider the impact of the new temperature regime (see Table 3).

# Low temperature test

Based on the analysis presented in Section 2, the following VWART pass thresholds were proposed for the low temperature tests.

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter | Criteria (<=°C) | No. failed | Comment |
| DHW | 23 | 4 |  |
| Space Heating | 40 | 1 | As per CP1 guidance |
| Keep Warm | 45 | 7 | Has significant impact on overall HIU performance |

Table 2 Initial proposed VWART thresholds for low temperature test based on current temperature regime

Unlike the high temperature tests, there were several HIUs that failed individual tests (DHW and Keep Warm) but passed the Overall test result.

Table

Description automatically generated

Figure 4 HIUs that would fail the proposed low temperature VWART thresholds

Overall percentage of failures for these pass thresholds would be 34% (10 of 29 units fail). It should be noted that this analysis doesn’t currently consider the impact of the new temperature regime (see Table 4).

## Final proposed VWART pass threshold values

**High temperature test**

The temperature changes proposed in for the high temperature test is a reduction in the DHW flow temperature from 55 to 50 °C and the space heating profile to change from 60/40 °C to 55/35 °C.

|  |  |  |
| --- | --- | --- |
| Criteria | Current test value (°C) | Proposed test value (°C) |
| DH flow temperature | 70 | 70 |
| DHW flow temperature | 55 | 50 |
| Space heating flow temperature | 60 | 55 |
| Space heating return temperature | 40 | 35 |

Table 3 Current and proposed temperature test values for the high temperature test

It is considered that this will have a minimal impact on the DHW VWART and an even smaller impact on the Keep Warm VWART. As there will be a larger forward approach temperature (20 °C compared with 15 °C) during the DHW test, it is likely that HIUs will perform slightly better than current tests. Therefore, it is proposed that the initial VWART pass thresholds as outlined in Table 1 are used.

Likewise with the reduction of space heating temperatures, it is expected that the reduction of VWART will scale linearly with the reduction in the return temperature, i.e. if the heating circuit return temperature drops from 40 °C to 35 °C, the primary return temperature expected will also drop by 5 °C, therefore, as above it is proposed that the initial VWART pass thresholds as outlined in Table 1 are used.

**Low temperature test**

There is only one temperature changed proposed in the low temperature test. However, this is much more significant than the high temperature test changes as it is a reduction in the primary flow temperature. This will have a significant impact on the DHW VWART as the forward approach temperature is being reduced from 10 °C to 5°C. It is expected that DH primary return temperatures will be higher for the same HIU and DHW plate heat exchanger (PHE).

|  |  |  |
| --- | --- | --- |
| Criteria | Current test value (°C) | Proposed test value (°C) |
| DH flow temperature | 60 | 55 |
| DHW flow temperature | 50 | 50 |
| Space heating flow temperature | 45 | 45 |
| Space heating return temperature | 35 | 35 |

Table 4 Current and proposed temperature test values for the low temperature test

In order to estimate the impact of the temperature change, SWEP provided the theoretical return temperatures for two common HIU plates at the three DHW power level tests (approximately 8, 15 and 20 kW). It is understood that other major PHE manufacturers have comparable performance.

|  |  |  |  |
| --- | --- | --- | --- |
| Heat Load (kW) | DH Flow Temp (°C | Return Temp (°C) | Increase in DH Return Temp (°C) |
| 8 | 60 | 14.82 | 3.95 |
| 55 | 18.77 |
| 15 | 60 | 17.73 | 4.94 |
| 55 | 22.67 |
| 20 | 60 | 19.31 | 5.38 |
| 55 | 24.69 |

Table 5 Calculated return temperatures for SWEP E8LASN-Wx20 PHE at 50 °C secondary flow temperature (provided by SWEP)

From a selection of previous tests, the approximate impact that each heat load test has on the final DHW VWART is approximately:

* 8 kW – 50%
* 15 kW – 20%
* 20 kW – 30%

Therefore, the approximate impact of reducing the primary DH flow temperature from 60 °C to 55 °C on the DHW VWART for this specific PHE would be a **4.6 °C** increase.

A second PHE which has a higher performance and is used on several HIUs that have been tested under the existing BESA HIU test regime was also modelled.

|  |  |  |  |
| --- | --- | --- | --- |
| Heat Load (kW) | DH Flow Temp (°C | Return Temp (°C) | Increase in DH Return Temp (°C) |
| 8 | 60 | 11.84 | 2.45 |
| 55 | 14.29 |
| 15 | 60 | 13.89 | 3.64 |
| 55 | 17.53 |
| 20 | 60 | 15.19 | 4.06 |
| 55 | 19.25 |

Table 6 Calculated return temperatures for SWEP E8LASN-Wx40 PHE at 50 °C secondary flow temperature (provided by SWEP)

The SWEP E8LASN-Wx40 PHE results in much lower return temperatures under all conditions and a smaller increase in return temperature when compared with the first plate heat exchanger (SWEP E8LASN-Wx20).

The approximate impact of reducing the primary DH flow temperature from 60 °C to 55 °C on the DHW VWART for this specific PHE would be a **3.2 °C** increase.

Considering these two modelled PHE, it is recommended that the VWART increase is 4 °C, which would result in a DHW VWART from 23 °C to 27 °C (see Table 2).

Regarding the other VWARTs:

* Space Heating – the selected VWART is already extremely permissive (based on CP1 2020) and the vast majority of HIUs do not have issue with achieving the 40 °C target. The reduction in primary DH flow temperature also have a much smaller impact as the forward approach temperature is still 10 °C (55 °C / 45 °C).
* Keep Warm – the reduction in primary DH flow temperature is likely to have a comparatively small impact on the VWART. Due to the lower DH flow temperature, the DH return temperature is expected to be lower, but a greater volume of water will be required to maintain the PHE temperature.

## Recommendation

The following values are recommended as the VWART pass thresholds for the proposed low and high temperature tests.

Due to the significant changes to the testing parameters and Overall VWART calculation methodology, an Overall VWART is not currently proposed. This will be reviewed and implemented in future test regimes.

**High Temperature test**

|  |  |
| --- | --- |
| Parameter | Criteria (<=°C) |
| DHW | 22 |
| Space Heating | 40 |
| Keep Warm | 44 |

**Low Temperature test**

|  |  |
| --- | --- |
| Parameter | Criteria (<=°C) |
| DHW | 27 |
| Space Heating | 40 |
| Keep Warm | 45 |