Technical Note			TN-019
Test: Domestic Hot Water response time following keep warm			**Test no.:** 5a, 5b
Assumption: Time to achieve 45°C at t32			**Assumption no: 44**
Rev: 1_02	**Date: 14/03/22**	**Author: Gareth Jones**	**Checked: Ian Robinson**

1. Introduction

The DHW response time test was developed as one of the key tests related to resident comfort within the test regime. It was initially added as a result of steering group member experience of resident complaints where there are long delivery times.

In practice, the test addresses whether the tested HIU can be considered to have a valid "keep warm" function, in that system temperatures are maintained at a level that is sufficient to enable delivery of "hot" water following a long period of standby operation.

The requirement for the period of hot water delivery (15 seconds) was set in order to enable sufficient time for hot water to be delivered from the HIU to the outlet. The threshold for "hot" was set to 45°C, as this was the point at which DHW becomes painful, so can be objectively determined as "hot" from a perceptual perspective.

Anecdotal experience was that complaints occurred when DHW delivery takes more than 45 seconds. Given average pipe lengths, the decision was made that DHW should be generated within 15 seconds in order to meet resident comfort requirements.

2. Considerations for DHW Response Time

In determining what an acceptable timeframe is for an HIU to deliver hot water of a certain temperature, the key considerations are:

(a) Whether 45°C is the correct temperature threshold
(b) What an acceptable timeframe is for the delivery of hot water to an outlet
(c) The timeframe to deliver hot water from an HIU to an outlet, given typical pipe lengths and diameters

3. Consideration (a) – DHW Temperature Threshold

The key issues with respect to hot water delivery time is what constitutes "hot" from a user perspective. As set out in HSG274, water becomes painful and can cause scalding at above 44°C. As such, from a functional perspective, water at a temperature of 45°C can be considered "hot".

This is why 45°C has been selected as the temperature threshold for the delivery of hot water to meet comfort requirements in both CP1 2020 and the CIBSE Guidance Note: DHW from instantaneous HIUs.

4. Consideration (b) – Acceptable Time Frame for DHW Delivery

This issue has been considered both within CP1 2020 and the CIBSE Guidance Note: DHW from instantaneous HIUs.

In CP1 2020, minimum requirement 3.4.17 states that *the design of hot water systems in dwellings shall ensure that hot water is delivered to the kitchen tap to achieve a minimum of 45°C with 45 seconds of turning the tap on at full flow rate.*

Likewise, one of the main conclusions of the CIBSE Guidance Note: DHW from instantaneous HIUs was that *DELIVERING instantaneous hot water to the kitchen tap at a minimum of 45°C after opening the tap to full flow demonstrates an acceptable service level for users and satisfies the requirement to limit water use.*

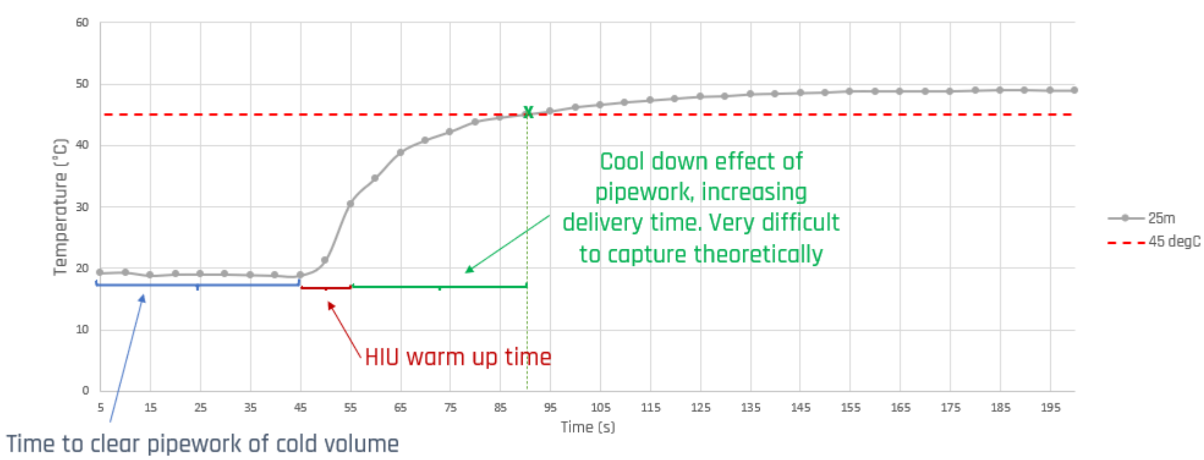
As such, the BESA test standard should ensure that HIU performance is in line with the requirement to deliver hot water to the kitchen tap within 45 seconds.

It should be noted that "full flow" will be restricted by Part G of the water regulations, with an overall restriction on water usage, using a water efficiency calculator. While flow rates will vary from appliance to appliance, dependent on approach and whether Optional requirements apply, a kitchen tap flow rate of 6 l/min has become standard across many new build developers, in line with the fittings approach under the Optional requirements.

5. Consideration (c) – Acceptable time to *generate* hot DHW to enable delivery within 45 seconds

The length of time to deliver DHW to an outlet is difficult to model. While it is straight forward to model the time taken to clear pipework of cold volume, there is a significant cool down effect of pipework, which increases delivery time.

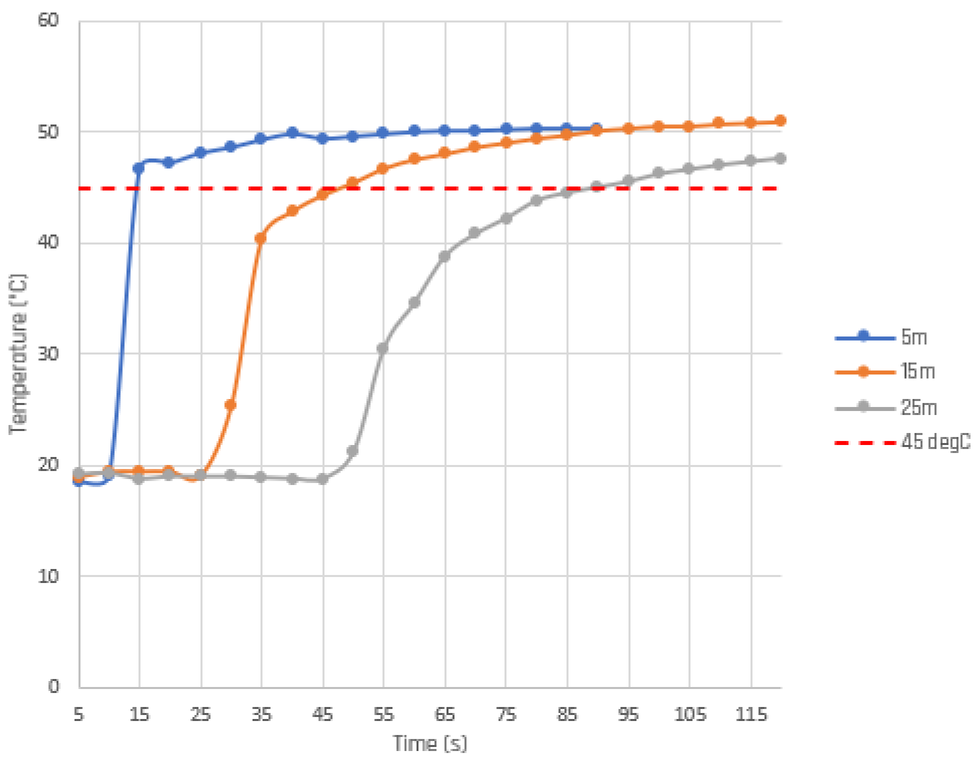
To model this, FairHeat carried out significant in situ testing of delivery times with different lengths and diameters of MCLP pipework. The figure below illustrates the impact of the cool down effect on a long run of pipework – in this case 25 meters of MCLP 14.2mm ID pipework at 6 l/min flow rate.



In this case the time for the HIU to *generate* hot water was 10 seconds. Shortening this would not have had a material impact.

The issue is that there is a significant interaction between the diameter of the pipework and delivery time. If we were to assume a standard approach using 14.2mm ID pipework, with a 6 l/min flow rate (as shown below), then with a 10 second generation time for the HIU (in this case in practice), this would suggest a maximum length of pipework of <15m. Lengths in excess of 15m are seen relatively frequently in modern builds. This would tend to suggest that 10 seconds would be the maximum time for generation.

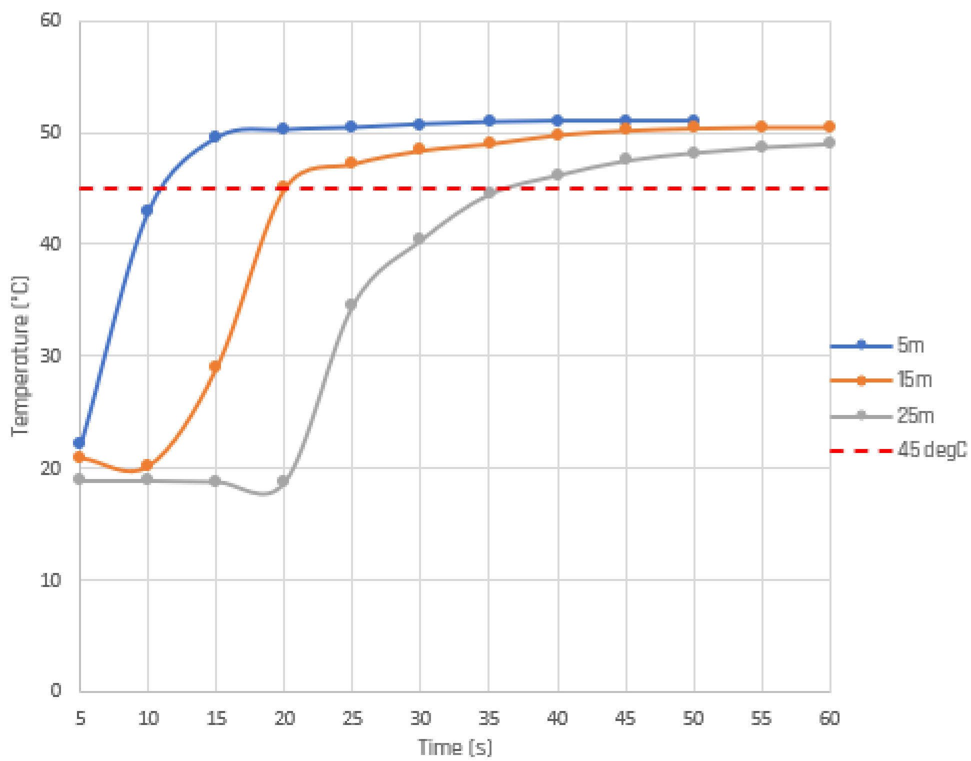
<u>Temperature over time for different lengths of MCLP 14.2mm I.D. at 6 l/min flow rate</u>



Conversely, if we assume that there will be a change in approach, with a shift to manifold systems and a reduction in DHW pipe diameters, then HIU generation times could be longer. The figure below shows DHW delivery temperature vs time, given an 8.8mm I.D. pipe, from a manifold, at 6 l/min, given a 10 second HIU generation time. As can be seen, the DHW was able to be delivered in c.37 seconds with a 25-meter pipe length. Which is toward the upper length that could be expected to be seen in a modern dwelling. As such, given a 15 second generation period, DHW would still be able to be delivered within 45 seconds.

As a side note: there was no audible different of noise between pipe diameters or pipe lengths during tests.

Temperature over time for different lengths of MCLP 8.8mm I.D. pipework at 6 l/min flow rate



In summary, theoretical calculations of the time taken to deliver DHW are difficult. However, if a 'standard' approach to pipe sizing for DHW is maintained, then consideration should be made for reducing HIU DHW generation time requirements, as it will be difficult to respect the 45°C with 45 seconds requirement in many instances were generation times to be 15 seconds.

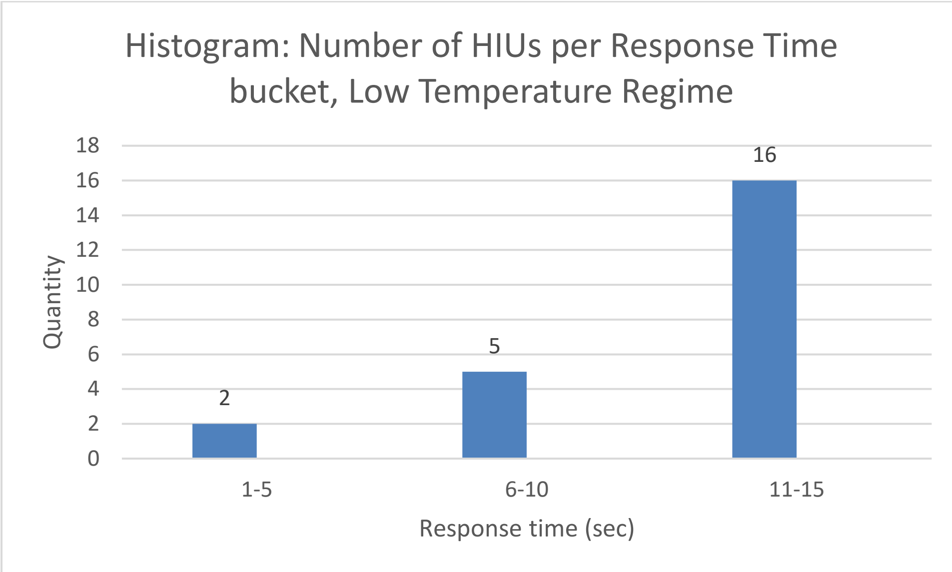
However, if a revised approach is taken, with smaller pipework, then generation of hot water within 15 seconds from the HIU should still enable acceptable service levels.

As a general point, the lower the generation time the better with respect to service levels.

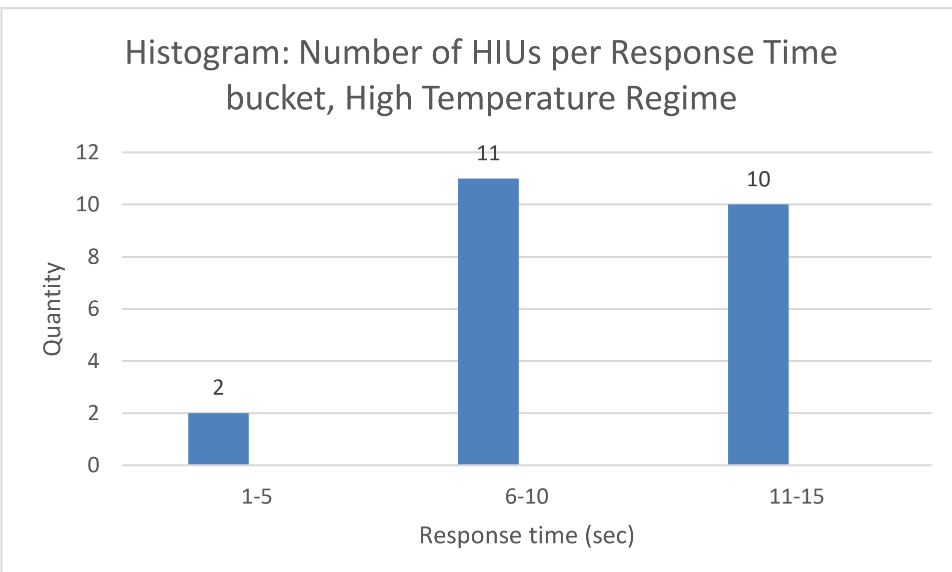
6. Consideration 4 – Time taken for HIUs to generate DHW at 45°C

The final consideration is the ability of HIUs on the market to generate DHW faster than 15 seconds.

When considering those HIUs tested against the low temperature regime, the average response time was 11.3 seconds. However, the mode was 15 seconds, with 16 HIUs in the 11-15 second bracket, as shown in the histogram below.

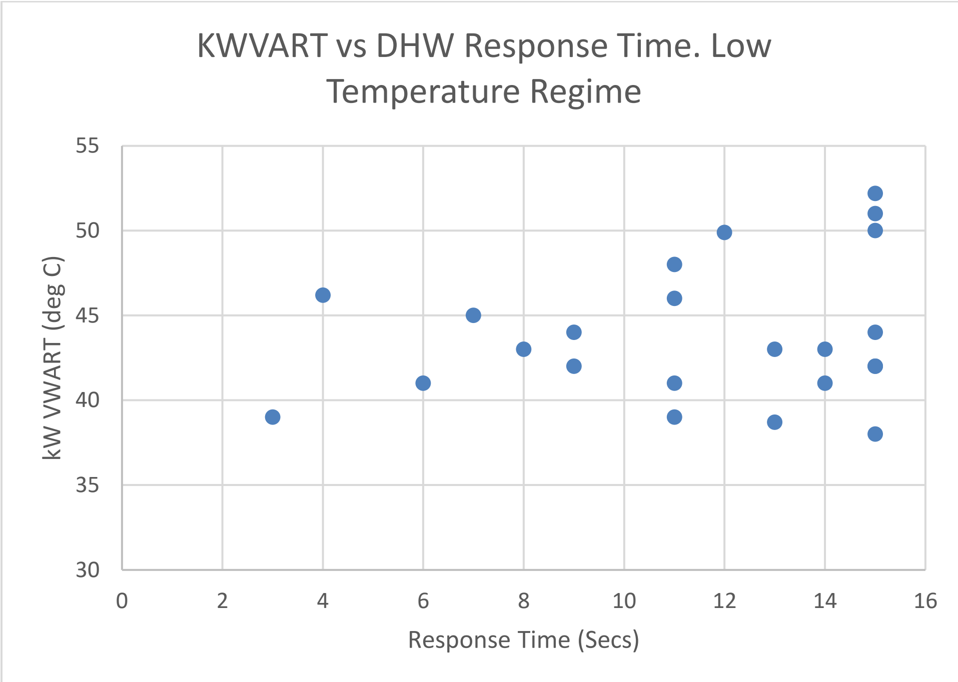


For the High Temperature regime response times were slightly better, with an average response time of 10.3 seconds, and the majority of HIUs generating 45°C hot water in 10 seconds or below.



Given the number of HIUs with high generation times (i.e. 15 seconds) under the Low Temperature regime, a question is whether manufacturers are trying to minimise their Keep Warm return temperatures at the expense of longer generation times, particularly as these are all electronic HIUs.

However, when plotting Keep Warm VWART vs DHW return times, there was no clear trend in the data to suggest that this was the case.



As such, there would be some concern that some of the HIUs on the market would struggle to achieve a more rapid DHW response time, if this was the case.

7. Conclusions

Retaining 45°C as the threshold for DHW generation temperature as part of the response time test remains appropriate, as does the objective to permit delivery of DHW within with 45 seconds.

It is not entirely clear what the upper threshold for HIU generation time should be, to enable DHW to be delivered within 45 seconds. However, there is some concern that the target would be missed for longer lengths pipework, particularly if a more 'traditional' approach is taken to DHW pipe sizing.

As a general matter, reducing HIU generation time will improve delivery times. For this to make a meaningful difference, it would make sense to reduce significantly – e.g. to 10 seconds.

However, from the data it would appear that a significant proportion of HIUs on the market would struggle to meet this requirement, particularly on the low temperature regime.

8. Recommendation

Retain 45°C within 15 seconds for the moment, with a soft signal to the market that this is likely to be reduced to 10 seconds in the next iteration of the test regime, in order to give manufacturers sufficient time to make changes to their units.

Communicate the need to reduce DHW pipe sizing, as this has a more significant potential to reduce delivery times than HIU generation time at the moment.

9. References

[1] CIBSE/ADE (2020) H*eat Networks: Code of Practice for the UK*. CIBSE CP1 2020

[2] CIBSE Guidance Note: Domestic hot water temperatures from instantaneous heat interface units

[3] HSE (2014) *Legionnaires' Disease: Technical Guidance. Part 2: The control of legionella bacteria in hot and cold water systems* HSG274.