Technical Note			TN-011
Test: Low domestic hot water flow rate			**Test no.:** 3a, 3b
Assumption: Domestic hot water flow rate			**Assumption no: 22**
Rev: 01	**Date:** 20/09/2020	**Author:** Gareth Jones	**Checked:** Martin Crane

1. Introduction

The objective of this test is 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 3 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.

This test was included from the Swedish F:103-7 test and has been in the test regime since the original SBRI funded test regime. A key driver for this low flow rate test in the Swedish test is safety. In Sweden F:103-7 testing is done at primary flow temperature of both 100˚C and 60˚C. Good substation control is required to ensure that, during low DHW flow rates, very high DHW temperatures are not produced at the tap causing serious burns.

An additional driver for this test is as a measure for resident comfort, especially given low flow rates from outlets on new build. The inability to deliver hot water from HIUs has been cited as a source of complaints from residents on heat networks where HIUs are not able to DHW at low flow rates.

In releasing the latest (Rev-009) version of the test regime, a compromise position was reached, based on HIU manufacturer feedback. In cases where the stated manufacturer minimum flow rate is above 0.02 l/s, then the manufacturer has the option of testing at both the 0.02 l/s flow rate and the stated minimum flow rate, with both sets of results to be published. In this case, the H&S requirements (maximum DHW flow temperature) must be met in both cases, otherwise the unit will fail and cannot be registered. However, inability to meet temperature stability requirements at the 0.02 l/s flow rate (or indeed, inability to generate DHW) is not taken as a failure of the test.

This technical note considers whether 0.02 l/s is an appropriate flow rate for the low flow rate test.

2. Consideration 1: Minimum flow rates for Gas Boilers

Domestic gas boilers (<70kW) typically have minimum flow rates that are significantly higher than 0.02 l/s and tests for gas boilers are conducted at higher minimum flow rates.

Note: reference flow rates required.

BS EN 625:1996

BS EN 677:1998

In the past, this has been proposed as an argument for testing HIUs at a higher minimum flow rate.

However:

(a) It has been noted that the minimum flow rates on combi boilers are becoming an issue for new dwellings with lower outlet flow rates (Environment Agency, Combination Boilers and Low Flow Fittings, 2007)
(b) Gas boilers are often paired with cylinders, to avoid such issues, particularly in higher end dwellings. This is generally not an option with HIUs, as hot water cylinders are often not considered appropriate for heat networks, due to high return temperatures are requirements for high flow temperatures.

With respect to (a), there is no reason for HIUs to be restricted to the same limitations as gas boilers, as it is technologically possible to deliver much lower flow rates from HIUs (as already demonstrated from HIUs that have passed the test). Reducing minimum burner heat outputs on combi boilers is much harder.

With respect to (b), it is clear that the BESA HIU Test Regime should cover HIUs that are appropriate to the full range of use types.

As such, making a comparison to combi gas boilers is not appropriate.

3. Consideration 2: Likely minimum flow rates in practice

In order to assess the minimum domestic hot water flow rates likely to be experienced in practice, we need to consider:

(i) Outlet flow rates
(ii) Outlet flow rates in use
(iii) DHW Flow rates given mix down:
    a. DHW delivery temperature to the outlet
    b. Cold water supply temperature

<u>Outlet flow rates</u>

There are three good sources for likely minimum outlet flow rates:

(a) The NHBC Design Guidelines
(b) Building Regulation Part G water calculator
(c) Real world specifications for new build developments

The 2019 NHBC Design Guidelines, Part 8, provide guidelines for minimum flow rates for various outlets. These are lowest in wash hand basins and at the kitchen sink, where there is a requirement to be able to deliver 0.1 l/s, at full flow, which equates to 6 l/min.

Outlet	Design flow (l/s)	Min flow (l/s)	Design flow (l/m)	Min flow (l/m)
WHB	0.15	0.1	9	6
Kitchen Sink	0.2	0.1	12	6

The Building Regulations Part G2 provides guidance on maximum consumption, in l/min for various outlets. In many cases these are *lower* than the NHBC Design Guidelines (which raises a question with respect to compliance that will not be explored in this note). There is also the provision for an "optional requirement", which only applies where a condition that the dwelling should meet the optional requirement is imposed as part of the process of granting planning permission. Where this applies, the estimated consumption of wholesome water calculated in accordance with the methodology in the water efficiency calculator, should not exceed 110 litres/person/day.

Where the optional requirement does apply, the maximum consumption allowed from WHB is 5 l/min, as per Table 2.2 (as shown below).

Table 2.2 **Maximum fittings consumption optional requirement level**

Water fitting	Maximum consumption
WC	4/2.6 litres dual flush
Shower	8 l/min
Bath	170 litres
Basin taps	5 l/min
Sink taps	6 l/min

This optional requirement is often stipulated as a planning requirement, particularly in those localities where heat networks are more prevalent (e.g. London).

It should be further noted that these are *maximum* flow rates and many developers will make trade-offs in flow rate between appliances when using the water calculator (Appendix A to Part G). As a consequence, WHB and sink flow rates may be lowered significantly below the maximum rates – e.g. to enable a higher shower flow rate.

It should be recognised that there is a general trend to lower flow rates in the industry. The Bathroom Manufacturers Association published a number of water calculator scenarios, with different flow rates.

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Strategy, Code level	Fittings-based, Code level 3/4	Fittings-based, Code level 3/4	Fittings-based, Code level 3/4	Fittings-based, Code level 3/4	Fittings-based, Code level 5/6	Recycling-based, Code level 5/6
WC	4 (single flush)	4/2.6 (dual flush)	5/3 (dual flush)	6/4 (dual-flush toilet)	4/2.6 (dual flush)	6 (supplied by greywater)
Taps (excluding kitchen taps)	4	5	4	4	1.6	3
Bath	180	155	180	180	155	155
Shower	8	8	8	8	6	7
Kitchen sink taps	6	8	6	6	3	4

Although this table makes reference to “Code levels”, which were related to the Code for Sustainable Homes, the scenarios shown are using the Part G water calculator and are representative of different strategies that are widely seen in the market.

As can be seen, 5 of the 6 scenarios have WHB flow rates that are at or below 4 l/min.

This is representative of the real situation in the market, as the author is aware a large number of developments (i.e. where FairHeat is carrying out Acceptance Testing) where WHB outlet flow rates are between 3 l/min and 4 l/min.

Outlet Flow Rates in Use

It should be noted that the flow rate values cited above are the *maximum* values for the outlets, when fully open. In practice, residents will rarely open taps fully during use – particularly in WHBs and kitchen sinks.

- During hand washing, it is entirely possible that a resident would open a tap at 40%-50%.
- During manual dish washing, residents often partially fill the sink with hot water, then close the tap to a trickle to enable a rinse of dishes before being put into a rack.

If we consider 40% of 4 l/min for hand washing, this equates to 1.6 l/min. This would be a mixed down flow, to enable washing.

Conversely 20% of flow (for a trickle) at a 6 l/min kitchen sink would equate to 1.2 l/min.

DHW Delivery Flow Rates Given Mix Down

The flow rates considered above are the flow rates *from* the tap, once there has been a mix down. In order to calculate the likely flow rates, we need to take into consideration both the DHW delivery temperature and the CWS temperature.

- For DHW temperature, we can use 50°C, as per Assumptions 17 and 18.
- For CWS temperature, we need to consider the variation in temperature over the course of the year, as this will impact upon the DHW supply required. Based on the figures in Table 4 of the SAP CONSP:08[3] the range in expected CWS temperature is 11˚C on average in winter to 21˚C on average in summer.

Tables 1 and 2 below shows the required DHW supply flow rate in l/s for different % tap opening, given different cold water supply temperatures. As can be seen, a WHB with a outlet flow of 4 l/min operating at 40%-50% of maximum flow, which could be considered to be within the range of normal use, would have a flow rate of c.0.02 l/min.

Conversely, with a 3 l/min outlet flow rate, opening the tap 40%-50% would require a rate of between 0.1 l/s to 0.2 l/s dependent on the time of year, with lower flow rates in the summer months.

With respect to the manual dishwashing case, described above, where the tap is reduced to a trickle for rinsing, it can be expected that this will be at maximum temperature. As such, a 20% trickle flow for a 6 l/min kitchen tap would equate to 1.2 l/min of hot water supply, which is 0.02 l/s.

Table 1: DHW supply flow rate (l/s and l/min), given 4 l/m outlet flow rate, by % tap opening and CWS temp

	DHW supply flow rate l/s		DHW supply flow rate l/min	
	CWS temp		CWS temp	
Tap % Open	11˚C	21˚C	11˚C	21˚C
100%	0.050	0.044	2.97	2.62
80%	0.040	0.035	2.38	2.10
60%	0.030	0.026	1.78	1.57
50%	0.025	0.022	1.49	1.31
40%	0.020	0.017	1.19	1.05
30%	0.015	0.013	0.89	0.79
20%	0.010	0.009	0.59	0.52

Table 2: DHW supply flow rate (l/s and l/min), given 3 l/m outlet flow rate, by % tap opening and CWS temp

	DHW supply flow rate l/s		DHW supply flow rate l/min	
	CWS temp		CWS temp	
Tap % Open	11˚C	21˚C	11˚C	21˚C
100%	0.037	0.033	2.23	1.97
80%	0.030	0.026	1.78	1.57
60%	0.022	0.020	1.34	1.18
50%	0.019	0.016	1.12	0.98
40%	0.015	0.013	0.89	0.79
30%	0.011	0.010	0.67	0.59
20%	0.007	0.007	0.45	0.39

4. Consideration 4: Resident Feedback

The inability to deliver DHW at low flow rates is a source of resident complaint. The author has had direct experience of this, with residents showing that "the boiler doesn't work" when they are rinsing dishes – with a demonstration given of the rinsing technique described above.

This has particularly been experienced across multiple sites, particularly with one make of HIU that was not able to deliver DHW at a flow rate of below approx. 2 l/min.

As such, the inability to deliver hot water at low flow rates is an issue has a negative impact on residents and, anecdotally, is a source of resident dissatisfaction (noting that the author has had direct experience of this feedback).

It should be acknowledged, however, that a literature search was unable to identify any referenceable third party studies that deal with this issue.

5. Consideration 5: HIUs able to deliver stable DHW at 0.02 l/s

Part of the push back against the low flow test from the market was a claim that electronic HIUs were not able to meet the low flow requirements.

However, in reviewing the statistics from tests to date, it would appear that this is not the case.

Table 3 below shows the number of electronic and mechanical HIUs that were able to deliver stable DHW temperature at low flow on test 3A (55˚C DHW, 70˚C DH) and test 3B (50˚C DHW, 60˚C DH). As can be seen, the majority of HIUs were able to deliver stable DHW at 1.2 l/min (0.02 l/s) under on both tests.

However, the number of electronic HIUs able to deliver stable DHW temperatures under the high temperature regime (Test 3A) is approximately half. This would indicate that even more are likely to fail at higher DH flow temperatures.

With respect to mechanical HIUs, 5 out of 7 were able to deliver stable DHW on each of the two tests.

Table 3: Number of HIUs that are able to deliver stable DHW at 0.02 l/s, by HIU type (BESA HIU Tests)

	Electronic		Mechanical	
	3A	3B	3A	3B
Yes	9	15	5	5
No	10	4	2	2
Total	19	19	7	7

As such, it would appear that there is no technical impediment to HIUs being able to deliver stable DHW at low flows, but that there are a number of HIUs that are currently not able to deliver stable temperatures which are being registered against the BESA HIU Test Regime.

6. Conclusions

As part of a drive to water efficiency, there is a general trend in the direction of low flow outlets. Building Regulations Part G optional requirements are required under planning by a large number of councils, which imposes a maximum flow rate of 5 l/min on WHB taps. However, flow rates seen in practice are often lower than this, at 3 – 4 l/min (in order to have higher flow rates on other outlets such as showers).

Given that: (a) there is a mix down to deliver hot water (e.g. to 40˚C) and (b) residents will typically not operate outlets at full flow, this means that flow rates for hot water supply will be much lower than this.

The inability for residents to receive hot water in part load conditions (e.g. reduced flow from a kitchen tap) is a source of complaint. This is a reasonable position.

It should be reasonably expected by a resident that hot water would be able to be delivered when a WHB outlet is opened to 40-50% of full flow.

Furthermore, given the use case for rinsing, residents may well expect a much reduced flow (e.g. 20%) during manual handwashing.

Based on likely outlet flow rates and usage scenarios, the 0.02 l/s (1.2 l/min) flow rate currently used in the test would appear to be an appropriate flow rate for testing.

Most HIUs tested to date are able to deliver stable DHW at this rate and there are no technical barriers to doing so.

7. Recommendation

The recommendation is to retain 0.02 l/s as the flow rate for the low test.

Furthermore, as there would appear to be no technical impediment to achieving this, it is recommended that consideration be given to removing the option for testing at a higher flow rate (as stated by manufacturer).

This is one of the few tests for resident comfort and it has been an area of resident complaints historically. Furthermore, given the timeframes associated with this test (and the fact that it has been flagged for a number of years now), it is arguable that the industry has had sufficient time to adjust.

This is an issue that should be reviewed within the context of setting minimum standards and/or pass/fail for the BESA HIU Test Standard.

8. References

1. Combination Boilers and Low Flow Fittings, 2007. Nick Grant, Elemental Solutions. Report commissioned by the Environmental Agency.

2. The Building Regulations 2010, Part G, Sanitation, hot water safety and water efficiency. 2015 edition, with 2016 amendments.

3. SAP Supporting Document: Consultation Paper: CONSP:08. Amendments to SAP’s hot water methodology. Issue 1.0. Underlying data from EST study.