

UK HIU Test Regime Technical Specification: Based on Swedish District Heating Association F:103-7e

Methodology for calculating Volume-Weighted Average Return Temperatures

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Please note that the FairHeat VWARD Calculation Model, which can be used for calculating the Volume Weighted Average Return Temperature (VWARD) of an HIU, is available at www.fairheat.com.

In order to assess overall performance of HIUs tested according to the *UK HIU Test Regime Technical Specification* published by FairHeat, a number of derived results will be calculated from the output from the tests, assuming 'standard' UK operating conditions of:

- 75°C primary flow temperature
- 55°C DHW set point
- 70°C : 40°C secondary flow and return temperatures
- 0.5 dP across the HIU

The following six derived measures will be calculated based on the outputs of the test:

- i) DHW Volume Weighted Return Temperature, $VWARD_{DHW}$
- ii) Space Heating Volume Weighted Return Temperature, $VWARD_{SH}$
- iii) Standby Volume Weighted Return Temperature, $VWARD_{SBY}$
- iv) Annual Volume Weighted Return Temperature for Heating Period, $VWARD_{HEAT}$
- v) Annual Volume Weighted Return Temperature for Non-Heating Period, $VWARD_{NONHEAT}$
- vi) Total Annual Volume Weighted Return Temperature, $VWARD_{HIU}$

These derived results will be calculated by FairHeat using the methodology set-out below.

Interpretation of test data

DHW Draw-Off

Each of the three domestic hot water draw-off events (6 l/min, 10 l/min, 13 l/min) are to be calculated between the following two data points:

- Start: First non-zero hot water flow read as recorded by q_3 .
- End: The preceding hot water flow read to the first zero read for the relevant hot water test point as recorded by q_3 .

DHW Post Draw-Off

Each of the three domestic hot water post draw-off events (6 l/min, 10 l/min, 13 l/min) are to be calculated between the following two data points:

- Start: First non-zero hot water flow read proceeding the relevant hot water test point as recorded by q_3 .
- End: 60 seconds post start point reading as recorded by q_3 .

Space Heating

Each of the three space heating load events (1 kW, 2 kW, 4 kW) are to be calculated using the entirety of the dataset.

Standby

The standby event is to be calculated between the following two data points:

- Start: First zero hot water flow read as recorded by q_3 .
- End: 28,800 seconds (8 hours) post start point reading as recorded by q_3 .

Annual Operational Distributions

DHW Draw Volumes pa

Total annual domestic hot water demand calculated as 1,470 kWh using SAP v9.92 methodology for a typical sized modern flat in London.

Distribution of low, medium and high DHW draw-off events based on analysis of EST "Measurement of Domestic Hot Water Consumption in Dwellings, 2008" data as follows:

Table 3: Domestic Hot Water Annual Demand

| Description | Flow Rate (litres/min) | Estimated Annual Demand (kWh/year) |
|-------------|------------------------|------------------------------------|
| Low | 6 | 729 |
| Medium | 10 | 297 |
| High | 13 | 444 |

DHW operating hours for each HIU (and therefore volumes) are to be calculated by dividing the respective annual kWh figures set out above, by the average actual power output measured in the test.

Post DHW Draw Volumes pa

Total annual number and average duration of low, medium and high DHW draw-off events based on analysis of EST "Measurement of Domestic Hot Water Consumption in Dwellings, 2008" data, as below:

Table 4: Domestic Hot Water Annual Events and Duration

| Description | Number of events, n (events/year) | Average Duration, d (seconds) |
|-------------|-----------------------------------|-------------------------------|
| Low | 10,000 | 30 |
| Medium | 660 | 75 |
| High | 300 | 145 |

Space Heating

Total annual space heating demand calculated as 1,450 kWh using modified SAP v9.92 methodology for an 85 unit, 6-storey residential block built to 2013 Part L Building Regulations in London. Distribution of 1 kW, 2 kW and 4 kW consumption loads based on analysis of Guru Systems data for a typical modern high-rise residential block in London as follows:

Table 5: Space Heating Annual Demand

| Space Heating Load (kW) | Estimated Annual Demand (kWh/year) |
|-------------------------|------------------------------------|
| 1 | 98 |
| 2 | 787 |
| 4 | 565 |

Space heating operating hours for each HIU (and therefore volumes), are to be calculated by dividing the respective annual kWh figures set out above, by the average actual power output measured in the test.

Standby

Standby annual operational hours defined as subtraction of DHW Draw-Off and Space Heating operation hours from total annual hours (8,760).

Volume Weighted Average Return Temperature Calculations

Please note that the FairHeat VWART Calculation Model, which can be used for calculating the Volume Weighted Average Return Temperature (VWART) of an HIU, is available at www.fairheat.com.

For all relevant test points (as outlined in 5.2.1 Interpretation of test data), the Volume Weighted Average Return Temperature (VWART) for each test is defined as follows:

$$VWART = \frac{\sum(t_{12,t} \times q_{1,t})}{\sum q_{1,t}} \quad (1)$$

where t represents each read during the test period (i.e. every second).

Domestic Hot Water

The DHW VWART consists of the HIU performance during draw-off and for 60 seconds post draw-off in order to account for any delay in the DHW primary valve closing.

Therefore, six calculations in total must be carried out, three during DHW draw-off (Table 3) and three post DHW draw-off (Table 4).

Regarding DHW draw-off, for each of the three tests described in Table 3, the following calculations should be made for the total test period as outlined in 5.2.1:

- arithmetic mean of domestic hot water power (P_3), $\overline{P_3}$
- arithmetic mean of primary volume flow rate (q_1), $\overline{q_1}$
- VWART as defined by equation (1)

The annual hours of operation for each of the three tests is then calculated as follows:

$$\text{Annual hours of operation, } h = \frac{\text{Estimated Annual Demand (from Table 3)}}{\overline{P_3}} \quad (2)$$

The annual primary volume of each test is then calculated using (2) as follows:

$$V = \overline{q_1} \times h \quad (3)$$

Regarding post DHW draw-off, for each of the three tests described in Table 4, the annual primary volume can be calculated as follows:

$$V = n \times \left(\frac{d}{3600} \right) \times \overline{q_1} \quad (4)$$

Note that, in this context, $\overline{q_1}$ relates to the arithmetic mean of the primary volume flow rate during the 60 seconds post DHW draw-off for each of the three tests as outlined in 5.2.1.

The total DHW annual primary volume is defined as:

$$V_{DHW} = (3) + (4) \quad (5)$$

The Domestic Hot Water Vwart ($V_{wart_{DHW}}$) can then be calculated by summing the product of the Vwart and annual primary volume, V for each of the six tests and then dividing by the sum of the annual primary volumes, V for all of the six tests.

$$V_{wart_{DHW}} = \frac{\sum(V_{wart_{\text{each test}}} \times V_{\text{each test}})}{\sum V_{\text{all tests}}} \quad (6)$$

Space Heating

For each of the three tests described in Table 5, the following calculations should be made for the total test period as outlined in 5.2.1:

- arithmetic mean of domestic space heating power (P_2), $\overline{P_2}$
- arithmetic mean of primary volume flow rate (q_1), $\overline{q_1}$
- Vwart as defined by equation (1)

The annual hours of operation for each of the three tests is then calculated as follows:

$$\text{Annual hours of operation, } h = \frac{\text{Estimated Annual Demand (from Table 5)}}{\overline{P_2}} \quad (7)$$

The annual primary volume of each test is then calculated using equation (3) and is referred to as V_{SH} .

The Space Heating Vwart, $V_{wart_{SH}}$, can then be calculated by summing the product of the Vwart and annual primary volume, V, for each of the three tests and then dividing by the sum of the annual primary volumes, V, for all of the three tests. See equation (6).

Standby

For the single standby test, the annual hours of operation is calculated as follows:

$$\begin{aligned} \text{Annual hours of operation, } h &= 8760 \\ &- \left(\sum h \text{ for all DHW draw off tests} + \sum h \text{ for all space heating tests} \right) \end{aligned} \quad (8)$$

Note that the Standby Annual hours of operation calculation does not include the annual hours of operation for the three DHW Post Draw-Off tests.

The annual primary volume, V , is then calculated using equation (3) and is referred to as V_{SBY} .

The Standby V_{WART} is calculated as per equation (1) for the total test period as outlined in 5.2.1 and is referred to as $VWART_{SBY}$.

Overall

In order to calculate the overall V_{WART} for the HIU, the Annual Heating Period and Annual Non-Heating Periods must be defined.

Regarding the Annual Heating Period, SH_{PROP} , the proportion of the year estimated to require space heating equates to the sum of hours calculated for the three space heating tests in equation (7) divided by the number of hours in a year as shown in the following equation:

$$\text{Annual Heating Period, } SH_{PROP} = \frac{\sum h \text{ for all space heating tests}}{8760} \quad (9)$$

The Annual Heating Period $VWART_{HEAT}$ is then calculated as follows:

$$VWART_{HEAT} = \frac{((VWART_{DHW} \times V_{DHW}) + (VWART_{SBY} \times V_{SBY})) \times SH_{PROP} + (VWART_{SH} \times V_{SH})}{(V_{DHW} + V_{SBY}) \times SH_{PROP} + V_{SH}} \quad (10)$$

Regarding the Annual Non-Heating Period, NSH_{PROP} , the proportion of the year when there is no heating load is calculated as follows:

$$\text{Annual Non – Heating Period, } NSH_{PROP} = 1 - SH_{PROP} \quad (11)$$

The Annual Non-Heating Period $VWART_{NONHEAT}$ is then calculated as follows:

$$VWART_{NONHEAT} = \frac{(VWART_{DHW} \times V_{DHW}) + (VWART_{SBY} \times V_{SBY})}{(V_{DHW} + V_{SBY})} \quad (12)$$

Finally, the Overall HIU V_{WART}, $VWART_{HIU}$, is calculated as follows:

$$VWART_{HIU} = (VWART_{NONHEAT} \times NSH_{PROP}) + (VWART_{HEAT} \times SH_{PROP}) \quad (13)$$