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1. Introduction

The HIU Test Standard stipulates in clause 2.23 “For each test undertaken the ambient temperature should be controlled to 20℃±5.” What are the advantages and disadvantages of a ±5℃ acceptable range in ambient temperature during testing? (compared to a tighter ±2℃ range?)

2. Concerns

A HIU during testing will lose heat to the ambient air. A wide ranger in allowable ambient air temperatures (15-25℃) potentially makes test results:

- Less reproducible?
- Inadvertently favouring poor HIU design choices?
- Giving unfair advantage to manufacturers who inadvertently have a high/low ambient temperatures during testing?

A smaller range is always better from a standardization point of view, h.owever for the industry as a whole there could be reasons against tightening the allowable variation. (to ±2°C?)

- Extra cost to test houses to regulate temperatures (especially cooling in Summer).
- Loss of available testing time, especially when testing overnight.
- Difficulty in stabilising temperature gives an incentive to ‘clean’ data.
- Increase testing costs and test duration.

We have to balance tighter acceptable variation in ambient temperature against the resultant increase in costs.

3. Tests in other industries and heating equipment

A summary of ambient temperature variation allowable in other equipment testing standards.

- *Micro-CHP* standards EN50465 and the PAS67 are ±5℃ ambient for testing.
- *Closed storage water heaters* EN 12897 and *Gas fired domestic appliances* EN 13203 are ± 2℃ ambient.

4. Particular attention needs to be given to the Keep-Warm test (stand-by test) result

The Keepwarm test is the only test in the standard that directly involves heat 'output' to the ambient (e.g., there is no space heating or hot water production, only waste heat loss being measured). This means the test result should be more susceptible to changes in ambient temperature (NOT VWART, see 5 below, but will effect primary flow volume).

5. The HIU standard is not an efficiency test

Traditional heating equipment testing standards (like those referenced) are usually efficiency tests, measuring energy out over energy in. The HIU standard however is not a direct efficiency test. The focus in the HIU standard is on having a heat-network low return temperature (*the volume-weighted average return temperature* or VWART). The reasoning is that a lower return temperature creates large gains in efficiency in the heat network equipment (either CHP or heat pump) and this outweighs the importance of efficiency gains in any individual HIU. So, in the suite of tests the focus is on lowering VWART rather than increasing HIU energy efficiency (although VWART is <u>indirectly</u> also a measure of efficiency).

Note: VWART is not <u>directly</u> an indication of efficiency as it does not measure waste heat losses. However, when the heat-network flow is constant through the HIU and the useful heat output much larger than the waste heat amount then VWART becomes correlated with efficiency of heat output.

6. Effect of ambient temperature on VWART & Volume flow

Perhaps counter-intuitively, ambient temperature has no effect on VWART. For example, let-us consider the Keepwarm test (a standby test). The HIU pulses (allows a small flow of) district circuit heat into the HIU raising the HIU body temperature. A small proportion of that heat energy won't be captured into the HIU thermal mass and instead goes back in the return flow (seen as a higher return temperature). However, whether the HIU pulses once, or a number of times in a given period, the ***average*** return temperature will be the same. In other words, a HIU that requires 100 pulses over 8 hours will have used more heat energy from the district circuit than a HIU that pulses only once, however the average return temperature will be the same value as a HIU that required 1000 pulses.

While the test VWART figure is unaffected by ambient temperature, as explained above the volume flow *will* be effected. Going back to the Keepwarm test, the lower the ambient temperature, the greater the volume flow will have to be to keep the HIU at a DHW ready temperature.

While VWART(Keepwarm) is a headline value, the *volume flow* is a variable in the subsequent series of VWART calculations; VWART(HEAT), VWART(NONHEAT) and VWART(HIU) and so ambient temperature has an effect on those. Critically, volume flow will have a large effect on VWART(HIU) through its effect on VWART(NONHEAT) and the variable V(KWM) [in particular as the Keepwarm test is so long]. Simple calculations suggest as much as a 40% variability in V(KWM) is possible for a HIU being maintained at 50℃ with the ambient being either at 15℃ or 25℃ (a temperature difference of either 25 or 35 degrees). This variability would be only 14% at +-2℃ (a temperature difference of only 28 vs 32).

We should keep in mind that waste heat loss is also a concern for dwelling overheating problems in summer and additional cost to the user. A more accurate value for this heat loss would be beneficial.

7. Ambient Temperature Sensor Placement

The HIU standard does not currently contain guidance on placement of the ambient temperature sensor. The following phrase could be added;

The ambient temperature sensor should be placed in a well-ventilated draught free area (air speed less than 0.5m/s) at a height of 1.5m from the ground and a minimum distance of 1m away from the HIU with the sensor protected against direct radiation from the test installation.

8. Recommendation

On balance, it is recommended to reduce the ambient temperature variation in the tests to ±2℃. There are worthwhile gains in test reproducibility with a tighter ambient variability however consideration should be given to allow test houses to achieve this in a practical manner as ambient temperature control can be an expensive upgrade for test labs.

It is also recommended to add guidance to the HIU standard on placement of the ambient temperature sensor.

9. Appendix information

Relevant passages from the standards referenced.

7.1.3 Installation of the mCHP appliance (BS EN 50465:2015+A1:2019pg. 80)

The mCHP appliance is installed in accordance with the technical instructions in a well-ventilated, draught free room (air speed less than 0,5 m/s) which has an ambient temperature of 20 °C ± 5 K, measured at a height of 1,50 m above the floor and at a minimum distance of 3 m from the mCHP appliance, with a temperature sensor protected against radiation from the test installation.

The mCHP appliance is protected from direct solar radiation.

Wall-mounted mCHP appliances are installed on a vertical test panel of plywood, or of a material with the same thermal characteristics, in accordance with the information in the appliance instructions.

The plywood panel shall be (25 ± 1) mm thick and painted matt black; the panel dimensions are at least 50 mm greater than the corresponding dimensions of the mCHP appliance (see 7.4.1.4).

Also;

(pg. 121) 7.6.4.3 – Heat losses in standby are calculated at temperatures 30K above ambient by flowing hot water through the appliance.(how much electrical energy does it take to sustain this minus heat rig losses)

PAS67:2013

7 Test laboratory conditions adjacent to the MCG

The ambient air temperature in the test laboratory shall be 20 °C ± 5 °C. The maximum air velocity adjacent to the package shall be 0.5 m/s, except where the air velocity is inherently generated by the package. The package shall at all times be shaded from sunlight. The laboratory temperature, humidity and pressure shall be recorded hourly during the test at a height of 1.5 m and between 1 m and 3 m horizontally away from the MCG. The thermometer shall be protected from direct radiation from the MCG. The averages of each condition shall be reported in Results Table 2 (Clause **13**).

NOTE Wherever possible, relative humidity should be controlled between 50% and 70%.

Also: Standby losses are calculated from measuring the appliance outer casing temperature with the device in standby.

BS EN 13203-4:2016
EN 13203-4:2016 (E)

4 General test conditions

4.1 Reference conditions

Unless otherwise stated, the general test conditions shall be as follows:

- cold water temperature: 10°C
  - maximum average variation over the test period: ± 2 K
- cold water pressure: (2 ± 0,1) bar;
- ambient air temperature: 20°C
  - maximum average variation over the test period ± 1 K
  - maximum variation during the tests ± 2 K
- electrical supply voltage:
  - (230 ± 2) V single phase;
  - (410 ± 4) V three phase.

Christoph Zauner et al. / Energy Procedia 57 (2014) 2352 – 2359

Essentially, the storage to be tested needs to be placed in a conditioned chamber (20 +/- 2°C) with appropriate distanced to surrounding walls (Figure 3). Then the immersed electrical heater is used to heat up the water until the sensor located at T_W reaches 65 +/- 2°C. After a period of 24 hours, which is implemented in order to reach the thermal equilibrium, on has to monitor the electrical power that is necessary to keep T_W at 65 +/- 2°C as well as the ambient and water temperatures, T_{amb} and T_W. Using equation [1], the standing losses are determined for subsequent 24 hour periods until the calculated values are within 2%. The finally obtained standing loss value, *S*, is the average of these 24 hour periods.

Ambient Temperature is +-2. However this is easier as the measurement is typically done in a environmental chamber. Heat losses from hot water tanks measured at elevated temperature of 65C.

Notes:

PAS67 uses double accounting and modelling/casing measurements to calculate standby heat losses (where appliance is barely above ambient).

EN50465, 12897 use elevated temperatures of water above ambient and measure electrical energy needed to sustain that elevated temperature. This elevated temperature with 30C+ above ambient means the ±5C variation in ambient temperature is less of an effect.

En13203 measures energy input over 24hours, and these are the losses in the standby steady state. No modelling or double accounting like with PAS67. This may require the tigher variation limit of ±2±C.

It is perhaps the double accounting done in PAS67 that allows a ±5 tolerance in ambient temperature. The EN13203 asks for ±2 because it's such a simple mechanism for heat loss.

We may need to consider how other industries handle heat loss tests like this? Two types of test – during operation, where ambient temp matters less because working temperatures are higher and so the variation in delta between HIU temp and air temp is relatively smaller. And keepwarm or standby where variation in delta T is relatively more significant.

10. References

[1] **BS EN50465:2015+A1:2019** Gas appliances. Combined heat and power appliance of nominal heat input inferior or equal to 70 kW

[2] **PAS67:2013** Laboratory tests to determine the heating and electrical performance of heat-led micro-cogeneration packages primarily intended for heating dwellings

[3] **EN 12897:2016** Water supply - Specification for indirectly heated unvented (closed) storage water heaters

[4] EN 13203-4:2016 Gas-fired domestic appliances producing hot water - Part 4: Assessment of energy consumption of gas combined heat and power appliances (mCHP) producing hot water and electricity