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Solid wall heat losses and the potential for energy saving

Rapid measurement device test report - Summary

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1 Introduction

The Arcada/Salford University competition entry was selected from a shortlist of concepts and prototypes submitted to the competition run by BRE as part of the BEIS funded solid wall insulation research project.

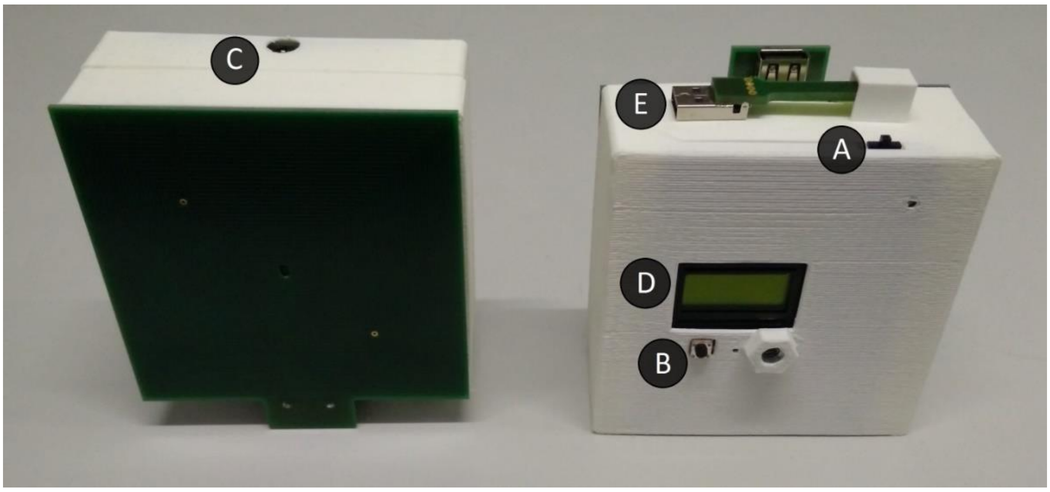

Figure 1 - Design and features of the U-value meter. Power switch (A), Reset switch (B), 3.5 mm data and charging plug (C), Display (D), Reference pin (E)

The prize for the device was a programme of testing designed primarily to assess whether it is able to meet the criteria laid out in the competition specification. This report presents the results of the testing. The keys requirements of the specification were:

- Accuracy of measurement – The tool must provide a U-value measurement that is sufficiently accurate to make its use worthwhile. Therefore, should demonstrate an accuracy of at least +/- 15%
- Speed of measurement – The tool must provide a reading within the time that an energy assessor would normally be at a dwelling i.e. not more than one hour
- The simplicity of the device and its robustness in providing repeatable and consistent measurements, all else being equal.
- Financial viability – The tool will need to be purchased by energy assessors and so a business model must be produced that is viable within this context.

Three sets of tests were conducted using the Arcada meters. The first set was conducted in a hot-box on a test panel constructed of high-density expanded polystyrene. The second set was in the hot-box on a solid brick wall. The third set of tests were conducted in the field on a wall that has been tested previously and which therefore has a known U-value.

2 Results

The graphs below show the combined results for all tests on each of the different wall types. The graphs give some indication of the spread of results and the general performance compared to the true U-value. They also show the difference between the temperature on the inside surface as measured by the devices and the external air temperature. The final graph gives an indication of performance against the speed of measurement criterion.

The first set of tests were performed in the hot-box on a homogenous test panel with low thermal mass and a U-value of 1.41 W/m²K. The delta-T was initially very high and was gradually reduced for subsequent tests. The first two tests, conducted with the higher temperature differences, can be considered ideal conditions for the devices. The stable environment, relatively high U-value, low thermal mass and large temperature gradient all contribute to a greater heat throughput which should help the accuracy of the measurement.

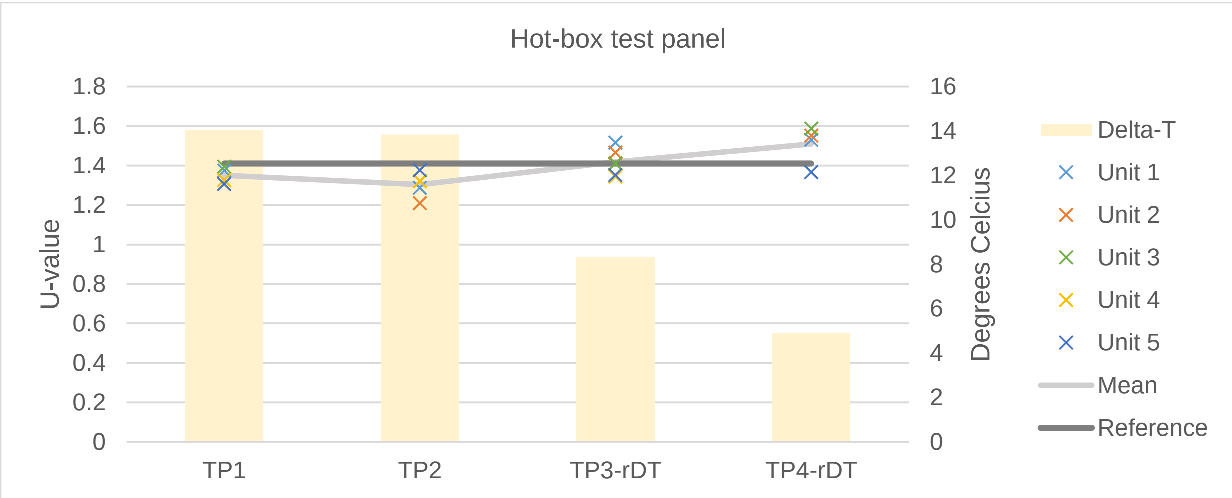

Figure 2 - Tests conducted in hot-box with test panel

The spread of results is low and the proximity to the true U-value is good. As the temperature of the cold chamber was raised; and the temperature difference therefore reduced, we see the average U-value as measured by the devices increasing. The spread of results also increases slightly.

The second set of tests was conducted in the hot-box on a solid brick wall. The cold chamber was initially set to 1.7°C to give a large delta-T. It was maintained at this level for the first two tests and then gradually increased for subsequent tests. Because of the high thermal mass of the wall, the wall was left for 72 hours after changing the cold temperature to allow the system to equalise. These conditions can be considered more idealised than they would be in reality because there would normally be the diurnal variation of external temperatures and probably also more variability in the internal temperature, for example as the heating system is timed to go on and off.

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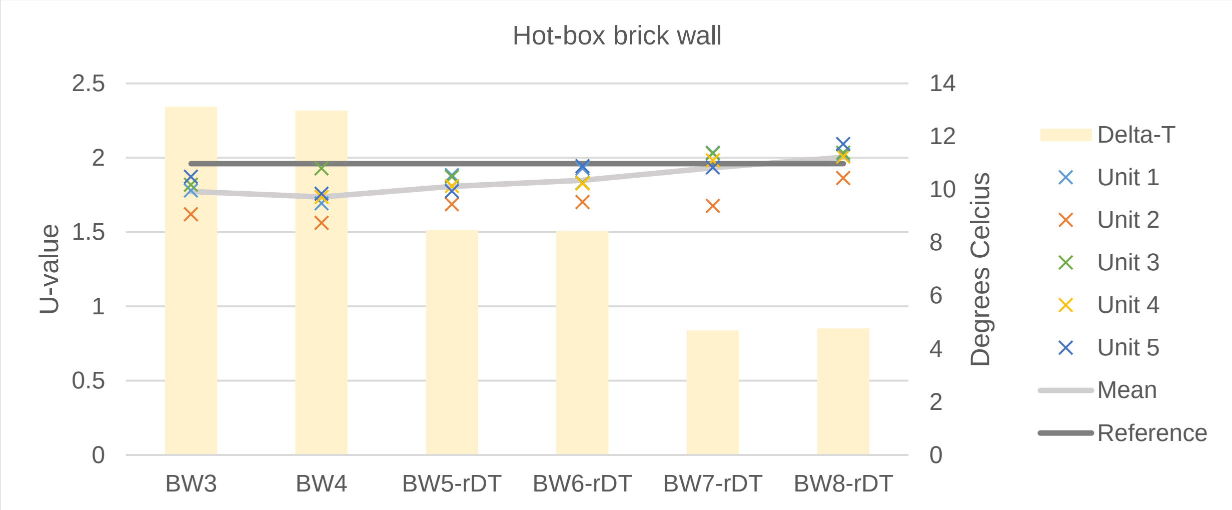

Figure 3 - Tests conducted in hot-box with uninsulated brick wall

Consistent with the test panel tests, we see that the best results are achieved when the heat throughput is greatest and when this is reduced, the average measured U-value rises and deviates from the true value. The spread of results for the 5 devices is fairly good across the tests which is encouraging.

The final set of tests were conducted on a solid wall in an occupied dwelling. The wall U-value was measured using Hukseflux HFP-01 meters as 1.63 W/m^{2}K. Tests FT1 to FT5 were conducted with the original devices. Tests FT6 to FT11 were conducted with another set of instruments with updated control code. Device 15 in the second set appeared to be faulty, giving a result that was consistently much lower than the other devices. There was no obvious reason for this from visual inspection. It was considered best to exclude the readings from this device from the results and so tests FT6 to FT11 are based on a maximum of four devices.

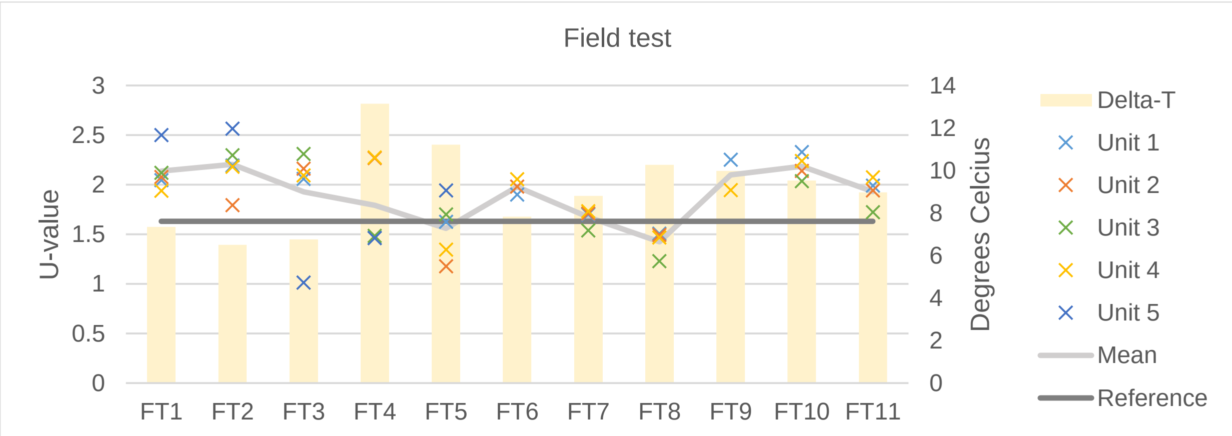

Figure 4 - Tests conducted in the field

The time taken to complete the measurement was noted and the maximum of each run was taken to be the time for that test to complete. The following graph shows this information against two targets. The first is the primary target of one hour. This is based on the typical length of time an energy assessor takes to complete a survey. This time is variable depending on many factors including the size and complexity of the dwelling. It is important that the measurement should not significantly add to the time the surveyor must spend in the dwelling. The secondary target of 90 minutes has been included as an indication of the maximum time an assessor might be expected to spend conducting the physical survey of the dwelling.

Research undertaken by GfK for the Green Deal programme (Green Deal Mystery Shopping) supports the use of these targets. The times quoted here do not include installation and removal time which would typically be 1-2 minutes per device. The results show that while the devices did not achieve the primary target of one hour, they typically completed their measurements within 90 minutes in most cases.

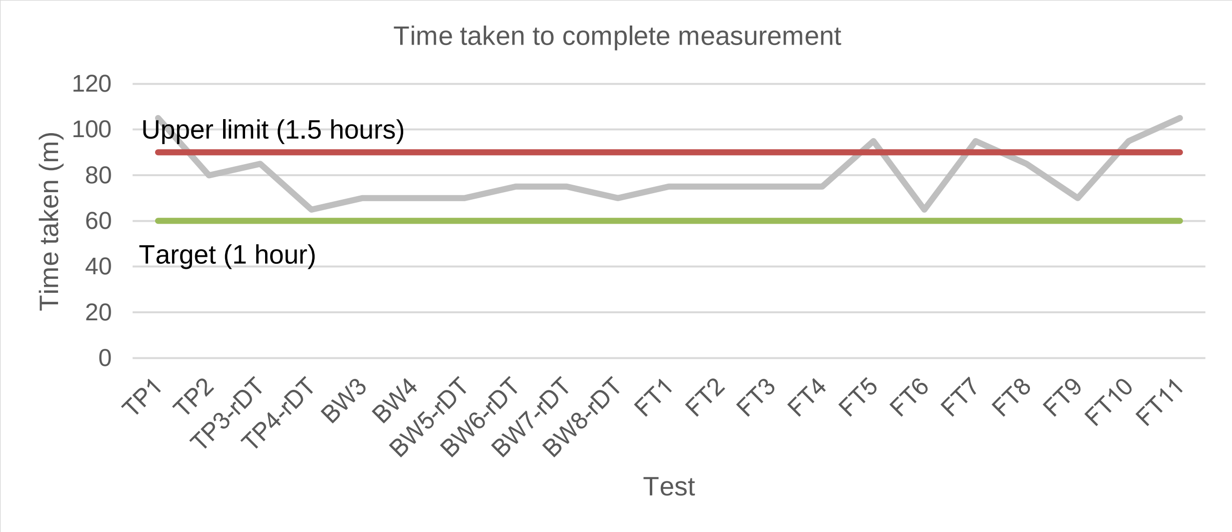

Figure 5 - Time taken for devices to complete measurement

In summary, the tests showed that in controlled environmental conditions, the meters were able to measure U-values within 10% of the reference value (this is the average of five devices used simultaneously). Therefore, it can be said that in these conditions the meters met or exceeded the requirement for accuracy. In the field tests, with uncontrolled variation of internal and external temperatures, the meters measured within 15% of the reference value in just under half of the tests. Discussion of the initial test results with Arcada highlighted the importance of the walls being in a steady thermal state such as would be achieved when the internal and external temperatures are constant. Following these discussions, the internal and external temperatures were measured during the subsequent tests (FT6 to FT11). Updates to the method statement and documentation have been made by Arcada to account for this requirement. This, combined with improvements to the design and manufacturing process have led to improvements in the accuracy and repeatability of measurements that can be verified following similar field tests to those conducted here.

The devices typically took longer than one hour to complete their measurement; especially when the installation and removal time is taken into account. While this means that the time to complete measurement exceeds the primary target set in the competition, it is close enough not to be a major cause for concern. Improvements to the design and manufacturing process made since the tests have led to improvements in this area.

The devices appeared simple and robust enough to use. The first set of meters given to us by Arcada produced quite a wide spread of results which would raise questions about repeatability. The second set of meters used appeared to show a much tighter distribution. This was encouraging for repeatability and BRE would recommend more real-world testing of the latest generation of meters to confirm this.

The financial viability of the devices is highly dependent on the scale and method of manufacture. Tested prototypes were manually assembled. Subsequent development work conducted at Arcada, including a redesign of the electronics, has been targeted at industrial assembly of the electronics components which should result in reduction of unit cost and improved uniformity of the product. Other applications, in particular for other wall types such as cavity walls, would significantly enhance the potential market.

Report Ends