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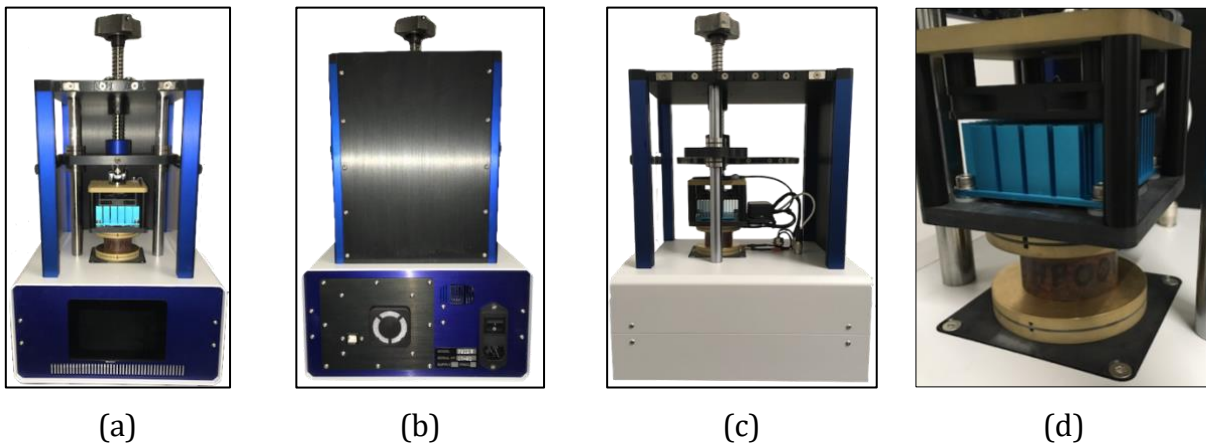
# A practical guide to thermal conductivity and specific heat capacity measurement with the PEDB Mk II

Specific to: *Serial Number 0223*  
Calibrated: *October 2023*

***If at any time the device or software does not respond in the manner described in the following pages, cease operation and contact Hot Dry Rocks for trouble shooting.***

## 1. Relevant device

This document relates to the Portable Electronic Divided Bar Mark II (PEDB Mk II) designed and manufactured by Hot Dry Rocks Pty Ltd, as shown in Figure 1.



*Figure 1. Views of the PEDB Mk II: (a) front, (b) rear, (c) side, and (d) sample in measurement position. Note that the photos do not show the communication and power cables, Perspex screens, or foam insulation.*

The PEDB Mk II holds a sample within a continuous ‘thermal stack’ between a heater and a chiller held at known constant temperatures ( $\pm 0.005^{\circ}\text{C}$ ) set by the operator. That is, the PEDB Mk II imposes a known temperature differential across the thermal stack. Software records temperatures ( $^{\circ}\text{C}$ ) at the surfaces of the heater and chiller Peltier elements, and at four points along the thermal stack ( $T_1$ ,  $T_2$ ,  $T_3$ , and  $T_4$ ; Figure 2), approximately twice each second. It also records ‘ambient’ temperature inside the measurement enclosure. Depending on the mode of operation, these records can be used to determine the thermal conductivity, specific heat capacity, or both, of the sample.

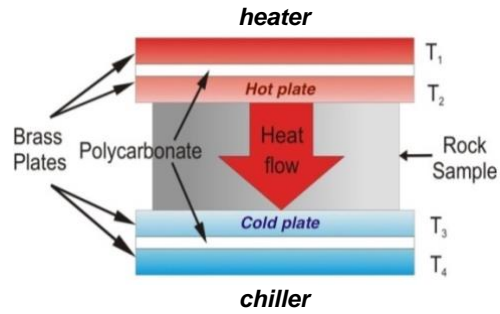


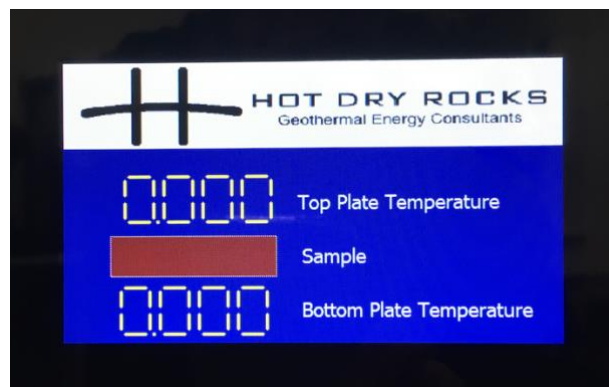
Figure 2. Schematic of the PEDB Mk II. Heater and chiller temperatures are set by the operator. The PEDB Mk II software records temperatures ( $^{\circ}\text{C}$ ) at points  $T_1$ ,  $T_2$ ,  $T_3$ , and  $T_4$ .

## 2. Set up

The PEDB Mk II will arrive ‘ready to use’ after some simple assembly. Raise the upper part of the thermal stack (Figure 1d) by turning the top knob anti-clockwise. Remove the foam disk placed between the contact plates for transport. Use the supplied IEC lead (‘kettle cord’) to connect the socket on the rear panel (red circle on Figure 3a) to a standard Australian AC power outlet. Use the supplied communications cable to connect the USB socket on the rear panel (blue circle on Figure 3a) to any USB port on a PC installed with the operating software. Switch the power on at the outlet, then turn on the PEDB Mk II using the switch on the rear panel (red arrow on Figure 3a). If operating correctly, the front panel of the PEDB Mk II will show the ‘dormant’ display (Figure 3b).



(a)



(b)

Figure 3. (a) The power socket (red circle), USB socket (blue circle), and on/off switch (red arrow) on the rear of the PEDB Mk II. (b) The ‘dormant’ display on the front panel when the PEDB Mk II is first switched on.

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### 3. Measurement principles

#### a. Thermal conductivity

The PEDB Mk II can be used to determine the thermal conductivity of prismatic samples of arbitrary shape with a maximum horizontal dimension of 65 mm. In a perfect thermal stack with no contact resistance and no air around the sample, the thermal conductivity,  $\lambda_s$  (W/mK), of a prismatic sample of thickness,  $Z_s$  (m), is related to other parameters according to Eq 1:

$$\frac{Z_s}{\lambda_s} = R_s = \mathbf{B} \cdot \text{Delta}_T \quad \text{Eq 1}$$

Where  $R_s$  is the 'thermal resistance' of the sample and  $\mathbf{B}$  is a constant. 'Delta\_T' is a dimensionless ratio of temperatures recorded at  $T_1$ ,  $T_2$ ,  $T_3$  and  $T_4$  (Figure 2), which converges to a stationary value as the thermal stack approaches thermal equilibrium:

$$\text{Delta}_T = \frac{(T_2 - T_3)}{((T_1 - T_2) + (T_3 - T_4))} \quad \text{Eq 2}$$

In reality, the PEDB Mk II is not a perfect thermal stack. Of particular relevance is that a measurement of any sample with surface area less than the plate contact area includes a portion of air between the hot and cold plates. As well as conduction through the sample, heat is also transferred through the air by conduction, radiation and convection. Furthermore, imperfect thermal coupling between the sample and the hot and cold plates can also impede the transfer of heat through the thermal stack.

The precise relationship between  $\text{Delta}_T$  and  $\lambda_s$ , therefore, depends on sample dimensions, the temperature of the measurement, and various systematic and random errors introduced during each measurement. In practice, an empirical linear relationship unique to each PEDB Mk II is determined by calibration using a set of reference standards prior to shipping. The relationship takes the form:

$$R_{eff} = \mathbf{M}_1 \times \text{Delta}_T + \mathbf{M}_2 \quad \text{Eq 3}$$

Where  $R_{eff}$  ( $\text{m}^2\text{K}/\text{W}$ ) is the 'effective' thermal resistance between the hot and cold plates:

$$R_{eff} = \frac{Z_s}{\lambda_{eff}} \quad \text{Eq 4}$$

Where  $\lambda_{eff}$  is the 'effective' thermal conductivity of the combined sample and air calculated as an area-weighted arithmetic mean:

$$\lambda_{eff} = \lambda_s \cdot \frac{A_s}{A_p} + \lambda'_a \cdot \frac{(A_p - A_s)}{A_p} \quad \text{Eq 5}$$

Where  $A_s$  is the cross-sectional surface area of the sample which contacts the hot/cold plates, and  $A_p$  is the full surface area of the hot/cold plates ( $A_p = 3318 \text{ mm}^2$ ).  $\lambda'_a$  is the 'effective' thermal conductivity of the air surrounding a sample when the sample does not cover the full surface of the hot/cold plate.  $\lambda'_a$  encompasses heat transfer by convection as well as conduction, so is always greater than the pure thermal conductivity of air,  $\lambda_a \sim 0.026 \text{ W/mK}$ . Empirical tests by HDR have determined that  $\lambda'_a$  can be effectively approximated as a function of the thickness and temperature of the air column:

$$\lambda'_a = \lambda_a + N \cdot \frac{Z_s}{T_s} \quad \text{Eq 6}$$

Where  $Z_s$  is in units of metres, and  $T_s$  ( $^{\circ}\text{C}$ ) is the mean sample temperature at equilibrium:

$$T_S = T_2 - T_3$$

Eq 7

$N$  ( $\text{W}/\text{m}^2$ ) is an empirical constant determined during the calibration procedure.

HDR determined  $M_1$ ,  $M_2$  and  $N$  by least squares linear regression through 38 discrete data points in  $\{R_S, A_S, T_S\}$  space.  $\Delta T$  was determined at thermal equilibrium for each of eighteen cylindrical reference standards of known  $R_S$  and  $A_S$  at two different notional measurement temperatures;  $22.5^\circ\text{C}$  and  $27.5^\circ\text{C}$ . The eighteen reference standards included fourteen samples of KU1 fused silica glass, two samples of crystalline quartz, one sample of 316 stainless steel, and a copper/Perspex hollow cell filled with tap water. Calibration points were also determined with the PEDB plates pressed together (i.e.  $Z_S = 0$ ) at the two notional temperatures.

The  $R_{\text{eff}}$  vs  $\Delta T$  regression for the PEDB Mk II **Serial Number 0223** (Figure 4) demonstrates a high degree of correlation ( $r^2 = 0.9987$ ), and provides an estimate of uncertainty for values of  $R_{\text{eff}}$  ( $\text{m}^2\text{K}/\text{W}$ ) inferred from measurements of  $\Delta T$ .

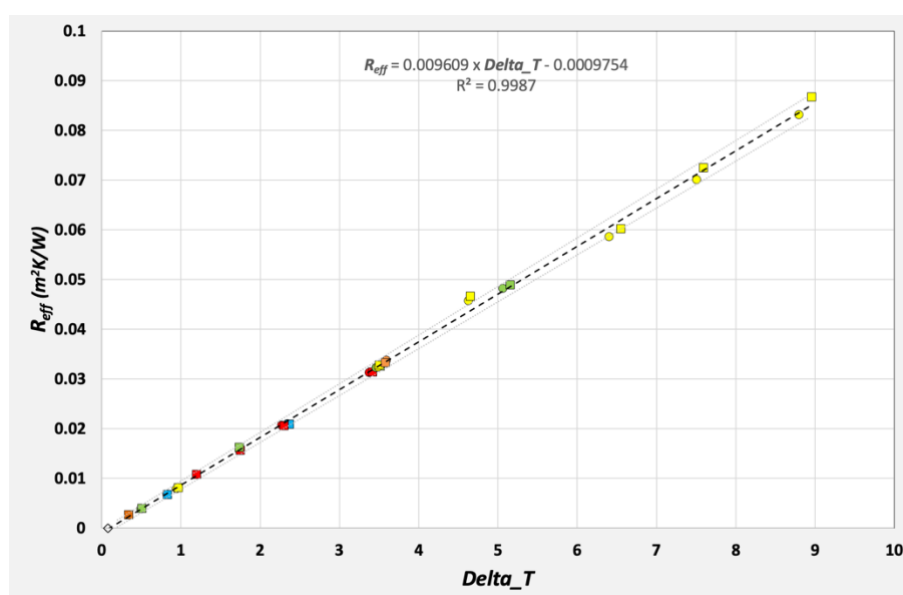


Figure 4. The PEDB Mk II **Serial Number 0223**  $R_{\text{eff}}$  vs  $\Delta T$  calibration plot. Colours represent different sample types and diameters. Round points measured at  $22.5^\circ\text{C}$ ; square points measured at  $27.5^\circ\text{C}$ . Grey lines indicate  $\pm 3\sigma$  confidence range.

Table 1 lists the values of  $M_1$ ,  $M_2$  and  $N$  derived from the regression line on Figure 4. The table also lists the absolute uncertainty ( $R_{\text{unc}}$ ) in values of  $R_{\text{eff}}$  calculated using Eq 3.

Table 1. Values of  $M_1$ ,  $M_2$  and  $N$  for the PEDB Mk II **Serial Number 0223** from least-squares linear regression through the calibration points on Figure 4, and one standard deviation confidence ranges for  $M_1$  and  $M_2$ .

	$M_1$	$M_2$	$N$
	$9.609 \times 10^{-3}$	$-9.754 \times 10^{-4}$	80
$1\sigma$	$5.780 \times 10^{-5}$	$2.277 \times 10^{-4}$	

Section 4a below gives directions for making a thermal conductivity measurement.

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### ***b. Specific heat capacity***

The PEDB Mk II can be used to determine the specific heat capacity,  $c_p$  (J/kgK), of a sample of mass,  $m_s$  (kg), by recording the change in sample temperature,  $\Delta T$  ( $^{\circ}\text{C}$ ), over a period of thermal re-equilibration.  $(T_1-T_2)$  on Figure 2 is proportional to the rate at which heat is transmitted into the sample and air by the hot plate, and  $(T_3-T_4)$  is proportional to the rate at which heat is drawn from the sample and air by the cold plate. The difference between the two at any given moment,  $\tau$  ( $^{\circ}\text{C}$ ), is proportional to the rate at which the sample and air are absorbing heat, which is in principle proportional to rate at which the sample temperature is increasing:

$$\tau = (T_1 - T_2) - (T_3 - T_4) \quad \text{Eq 8}$$

As mentioned above, however, the PEDB Mk II is not a perfect thermal stack. For example, some heat is transferred from the hot plate by convection into the air surrounding the sample; the sides of the sample exchange heat with the surrounding air; and materials such as the brass plates and foam insulation absorb and yield heat along with the sample. Furthermore, top plate and bottom plate assemblies inevitably have slightly different thermal properties. The precise relationship between  $\tau$  and  $c_p$  is, therefore, a complex function of the sample dimensions, thermal characteristics of the instrument, and systematic and random errors introduced during measurements.

To infer an empirical relationship between  $\tau$  and  $c_p$  for a specific PEDB Mk II, a parameter,  $H_t$  ( $^{\circ}\text{C}$ ), is defined to approximate the heating rate of the sample at any given time step during the measurement process:

$$H_t = (\tau_t - \tau_f) \quad \text{Eq 9}$$

Where subscripts  $t$  and  $f$  refer to intermediate and final time-steps, respectively, in a measurement record.  $H_t$  can be thought of as the ‘thermal potential’ of the PEDB Mk II to drive heat into the sample at any given time,  $t$ . Over a period of thermal re-equilibration following an increase in Heater and Chiller temperatures,  $H_t$  tends to rapidly increase for the initial 20–30 seconds, then subsequently decrease over a period of 5–20 minutes. By definition,  $H_t$  reaches a value of zero at the last record of any given heat capacity measurement (e.g. Figure 5). The integral of  $H_t$  over the full measurement period (Eq 10; Figure 6; shaded area on Figure 5) has S.I. units of kelvin-seconds (Ks) and is, in principle, proportional to the quantity of heat absorbed by the sample during the measurement:

$$\Sigma(H) = \sum_{t=0}^D (H_t) dt \quad \text{Eq 10}$$

Where  $D$  is the total number of discrete time entries in the measurement record, and  $dt$  is the discrete time step ( $\sim 0.5$  s) between successive entries.

As  $\Sigma(H)$  converges to a stationary value during a measurement, so too does the change in sample temperature:

$$\Delta T = T_{sf} - T_{s0} \quad \text{Eq 11}$$

Where  $T_{sf}$  and  $T_{s0}$  are the final and initial sample temperatures, respectively.

$\Sigma(H)/\Delta T$  has units of time and is, in principle, proportional to the bulk heat capacity of the sample,  $C_s = c_p \times m_s$  J/K. In practice, the unique empirical relationship between  $\Sigma(H)/\Delta T$  and  $C_s$  for each PEDB Mk II is determined by calibration using a set of reference standards prior to shipping. The relationship takes the form:

$$C_s = \mathbf{U}_1[\Sigma(H)/\Delta T]^2 + \mathbf{U}_2[\Sigma(H)/\Delta T] + \mathbf{U}_3 \quad \text{Eq 12}$$

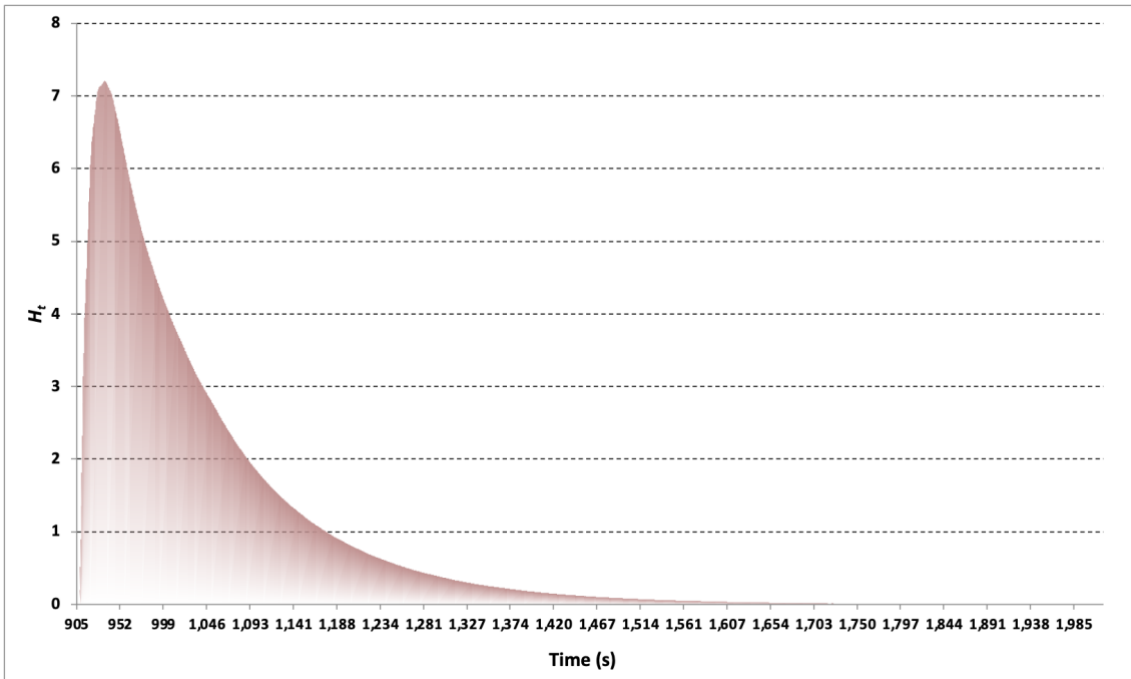


Figure 5. A record of  $H_t$  (Eq 9) over a re-equilibration period of 18.5 minutes (1110 s). The shaded area =  $\Sigma(H)$  from Eq 10.

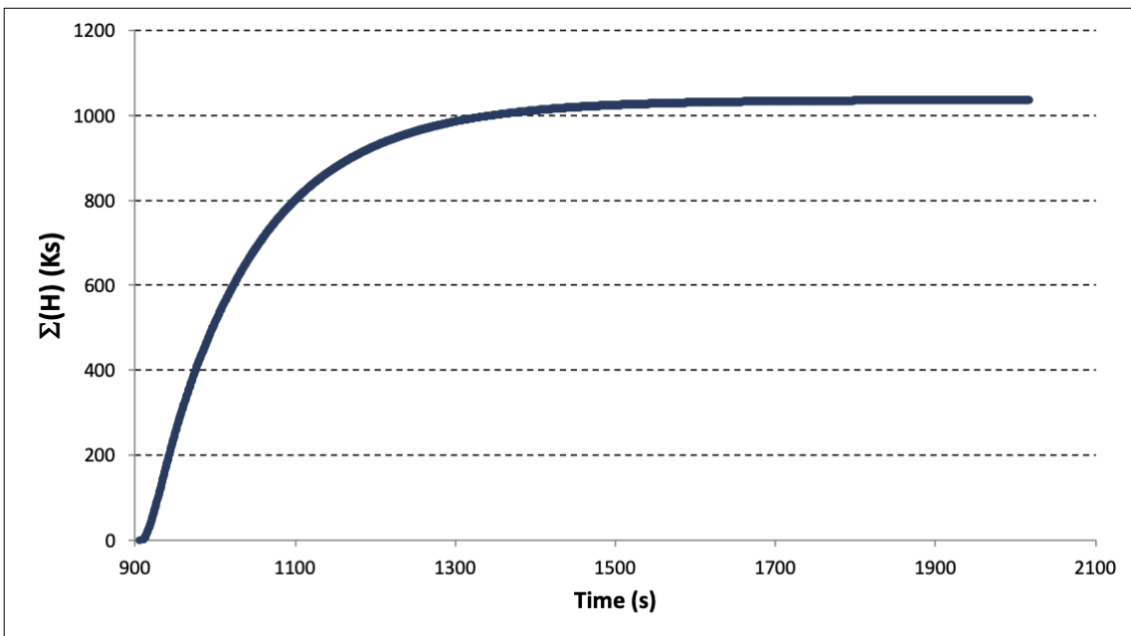


Figure 6. Cumulative integral of  $H_t$  over time for the record shown on Figure 5. The integral reached a stationary value  $\Sigma(H) = 1036$  Ks. During this measurement, the mean sample temperature increased by  $4.95^\circ\text{C}$ , giving a value of  $\Sigma(H)/\Delta T = 209.3$  seconds.

HDR determined  $U_1$ ,  $U_2$  and  $U_3$  for the PEDB Mk II **Serial Number 0223** for a notional rise in sample temperature from 22.5°C to 27.5°C by regression through 19 discrete calibration points in  $\{C_p, m_S\}$  space (Figure 7). The calibration samples comprised 14 cylindrical prisms of different thicknesses and diameters of KU1 fused silica glass, two prisms of crystalline quartz, one prism of 316 stainless steel, one hollow copper/Perspex cell filled with water, and one measurement with the PEDB plates pressed together. The regression demonstrates a high degree of correlation ( $r^2 = 0.9995$ ), and provides an estimate of uncertainty for values of  $C_S$  (J/K) inferred from measurements of  $\Sigma(H)/\Delta T$ .

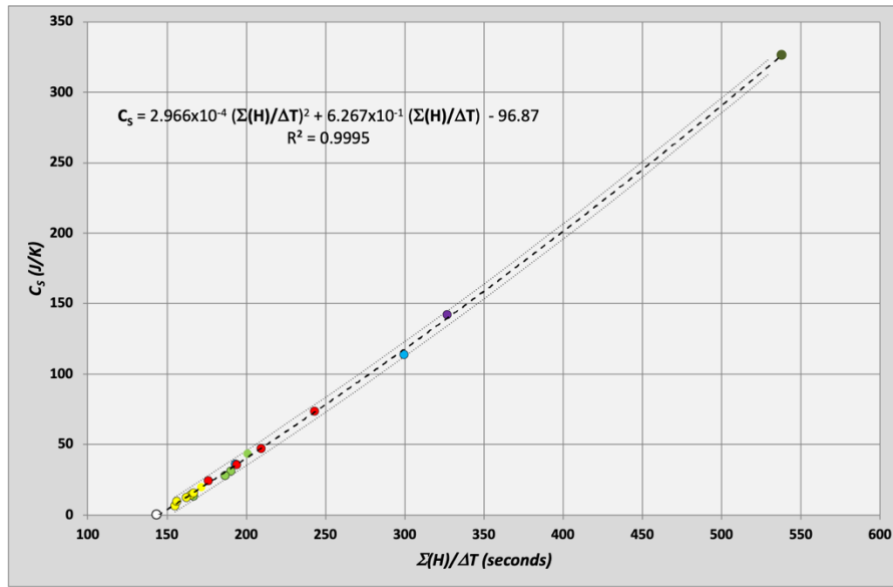


Figure 7. The PEDB Mk II **Serial Number 0223** heat capacity calibration for a notional rise in sample temperature from 22.5°C to 27.5°C. Different coloured points represent different prism diameters and material types. Grey lines indicate  $\pm 3\sigma$  confidence range.

Table 2 lists the values of  $U_1$ ,  $U_2$  and  $U_3$  derived from the regression line on Figure 7, and one standard deviation uncertainty magnitude ( $C_{unc}$ ) for values of  $C_S$  calculated using Eq 12.

Table 2. Values of  $U_1$ ,  $U_2$  and  $U_3$  for the PEDB Mk II **Serial Number 0223** from least-squares regression through the calibration points, and the uncertainty in values of  $C_S$  calculated using these values

$U_1$	$U_2$	$U_3$	$C_{unc}$ (J/K)
$2.966 \times 10^{-4}$	$6.267 \times 10^{-1}$	-96.87	$\pm 1.77$

Section 4b below gives directions for making a specific heat capacity measurement.

#### 4. Preparing and mounting a sample for measurement

Sample preparation is the same for both thermal conductivity and specific heat capacity measurements. Prepare a prism with flat sub-parallel faces to fit wholly within the area of the PEDB Mk II hot/cold plates (i.e. maximum horizontal dimension  $\leq 65$  mm). Figure 4 indicates that a sample is within the calibration range for thermal conductivity during a measurement if  $\Delta T < 9$ , and Figure 7 indicates a measurement is within calibration range for specific heat capacity if  $\Sigma(H)/\Delta T < 525$  s. Results can be determined beyond the formal calibration range, but with progressively decreasing confidence. In general, bulkier samples yield higher confidence results. As a 'rule-of-thumb', **optimal sample thickness is  $\sim 5\phi$  cm**, where  $\phi$  is the proportion of hot/cold plate surface area covered by the sample. For example, samples covering half the hot/cold plate surface should optimally be 20–30 mm thick.

A sample can be mounted in the PEDB Mk II at any time regardless of whether the PEDB Mk II is switched off, in 'dormant' mode, or in full communication with the operating software (see Section 5 below). Measure and record the **thickness, surface area**<sup>1</sup> and **mass** of the sample before mounting it. Pairs of 'jigsaw' style foam insulation are provided at 5 mm thicknesses from 25 mm to 50 mm (Figure 8). These are to encase the sample and restrict air circulation during a measurement without impeding the plates from closing. 'Cut-out' sections of one set of teeth fit around the wires at the rear of the sample. Choose the insulation with thickness closest to, but less than, the sample thickness plus 20 mm (e.g. choose 35 mm insulation for a 19.4 mm thick sample, and 40 mm insulation for a 20.6 mm thick sample).



Figure 8. 'Jigsaw' insulation at 5 mm thickness intervals from 25 mm to 50 mm. Note that the 'cropped' teeth always go to the rear of the thermal stack to fit around the sensor wires.

<sup>1</sup> This means the surface area in contact with each hot/cold plate, or the sample volume divided by its thickness.

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To mount a sample in the PEDB Mk II for a thermal conductivity and/or specific heat capacity measurement:

1. Apply a thin layer of petroleum jelly, water-based jelly, thermal contact paste, or other viscous compound<sup>2</sup> to both flat faces of the sample (Video 1);
2. Press the sample firmly onto the bottom plate to eliminate air from between the sample and the bottom plate (Video 2);
3. Wind the top plate down onto the sample while holding the sample in the centre of the bottom plate (Video 3);
4. Gently oscillate and rock the top plate around its pivot point while increasing the clamping pressure to eliminate air from between the top plate and sample. Ensure the sample makes full contact with the top plate and remains centred (Video 3);
5. The clamp is torque-limited. Tighten until it reaches its limit (i.e. the knob 'clicks' when turned further; Video 4);
6. Fit the appropriate pair of 'jigsaw' insulation foam securely around the sample and contact plates. The cropped teeth fit around the sensor wires at the rear (Video 5). Ensure the teeth are locked together at front and rear.
7. Lower the three side shield windows (Video 6).

## 5. Making measurements

Switch on the PEDB Mk II and run the operating software (instructions provided elsewhere.) If properly configured, real time Heater and Chiller temperatures should display on the front panel of the PEDB Mk II (Figure 9) and chart in the user interface of the PC. It is recommended to run the PEDB Mk II for at least 30 minutes to stabilise the electronics to normal operating temperature before making a measurement.

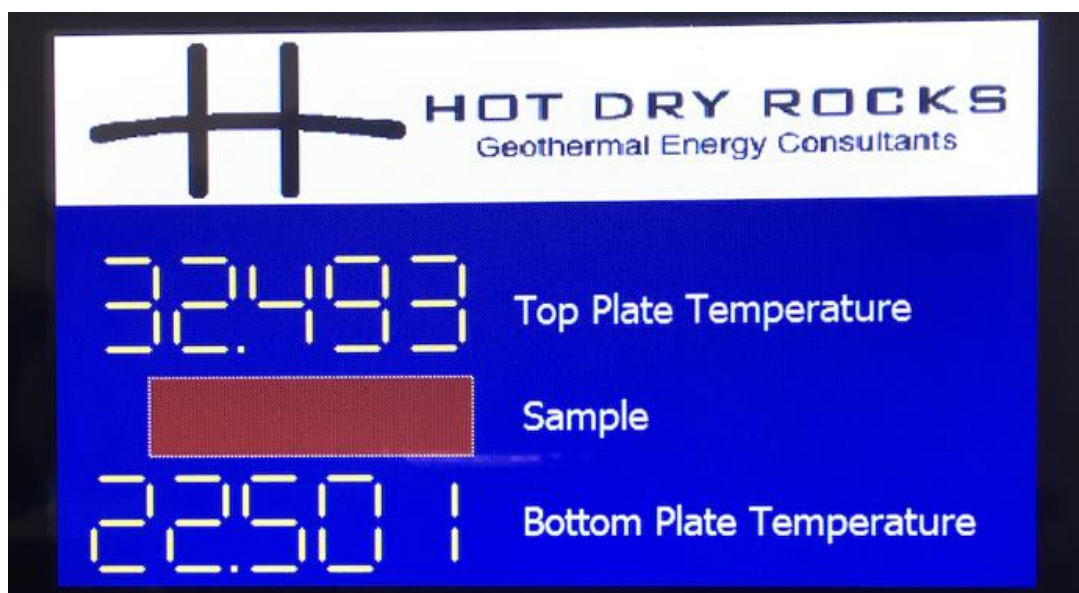


Figure 9. Display on the front panel of the PEDB Mk II when in full communication with the operating software.

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<sup>2</sup> The choice of compound for the contact surfaces is to some extent subjective. The goal is to apply the least amount of compound to achieve optimal thermal contact between the sample and hot/cold plates. Petroleum or water-based jelly suits highly polished, smooth and flat surfaces, but thermal paste is often more appropriate to fill gaps on the contact plane for rougher, granular, or not perfectly flat surfaces.

### a. Thermal conductivity measurement

The thermal conductivity calibration coefficients in Table 1 were generated using two different 10°C temperature differentials: Heater / Chiller temperatures of 27.5°C / 17.5°C, and 32.5°C / 22.5°C. While the calibration coefficients should give reliable results for other 10°C temperature differentials, HDR has not validated results for differentials greater than or less than 10°C. Therefore, it is recommended to use one or both of the calibration temperature settings to measure thermal conductivity with the PEDB Mk II unless and until the reliability of results from other settings is confirmed.

To make a thermal conductivity measurement:

1. Enter the chosen Heater and Chiller temperatures into the 'Heater' and 'Chiller' fields on the software interface (Figure 10) and press 'Set Temperatures'.
2. Enter the mass, surface area and thickness of the sample into the relevant fields<sup>3</sup>.
3. Select your preferred data storage directory using the 'Save Dir.' field, and assign a filename for the sample in the 'Filename' field. Note that several files might be generated for the same sample. Files subsequent to the initial file will have the same name with an appended timestamp.
4. Click the 'Start Recording' button on the software interface to start recording data.

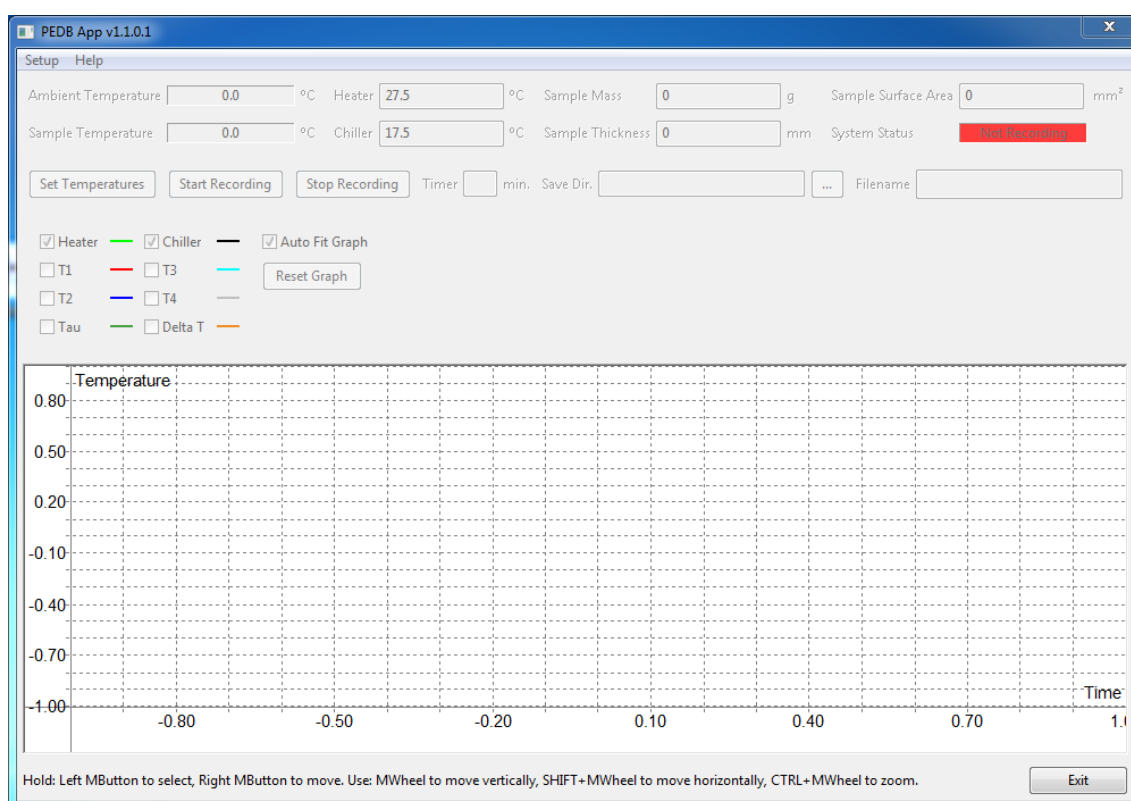


Figure 10. The software interface upon installation, showing the data entry fields and chart selection check boxes.

<sup>3</sup> While these fields do not currently influence the measurement, they are recorded in the measurement data file to assist with subsequent processing. Future software development will incorporate values in these field into real-time, on-screen thermal conductivity and specific heat capacity displays.

5. A new '.csv' ASCII file is created in the designated directory. The file includes header lines with a time stamp; the sample mass, thickness and surface area as entered at Step 2 above; 11 column header labels; then lines of data recorded at approximately half-second time intervals. The eleven columns of data are:
  - Time (s) since recording started,
  - Ambient temperature (°C),
  - Heater and Chiller temperatures as recorded by the sensors,
  - $T_1, T_2, T_3$  and  $T_4$  (°C) as recorded by the sensors,
  - $\Delta T$  calculated according to Eq 2,
  - Approximate sample temperature  $(T_2 + T_3)/2$ , and
  - Tau ( $\tau$ ) calculated according to Eq 8.
6. 'Ambient Temperature' and 'Sample Temperature' are displayed in real time at the top left of the software interface (Figure 10). Other parameters can be charted in real time as time-series—singly or in any combination—by toggling the relevant check boxes.
7. Log continuously until ' $\Delta T$ ' reaches equilibration, as judged by the user from the time-series chart. Alternatively record for a given time (e.g. 20 mins) which the user can pre-set in the 'Timer' field before commencing recording.
8. Finalise the log file at any time by clicking 'Stop Recording' to close the current data file but continue monitoring, or 'Exit' to close the file and put the PEDB Mk II into 'dormant' mode (Figure 3b).
9. Locate the relevant '.csv' data file in the designated directory (*hint: it will have the Filename as entered in the user interface, perhaps with a timestamp suffix indicating when the measurement began.*)
10. HDR recommends copying the file to another location for further processing.
11. Open the file using (for example) Microsoft Excel.
12. Calculate the average value of ' $\Delta T$ ' (column 9) over the final 60 seconds (~120 rows) of the record.
13. Calculate  $R_{eff} \pm R_{unc}$  from  $\Delta T$  and the values in Table 1 using Eq 3.
14. Calculate  $\lambda_{eff} \pm \lambda_{eff\_unc}$  from  $R_{eff}$  and sample thickness ( $z_s$ ) using Eq 4; and from  $\lambda_{eff\_unc} = \lambda_{eff} * R_{unc}/R_{eff}$ .
15. Calculate  $\lambda'_a$  from Eq 6.
16. Derive  $\lambda_s$  from  $\lambda_{eff}$ , sample surface contact area ( $A_s$  mm<sup>2</sup>), hot/cold plate surface area ( $A_p = 3318$  mm<sup>2</sup>) and  $\lambda'_a$  by rearranging Eq 5:
 
$$\lambda_s = \left[ \frac{A_p}{A_s} \right] \left[ \lambda_{eff} - \lambda'_a \cdot \frac{(A_p - A_s)}{A_p} \right]$$
17. Calculate  $\lambda_{unc} = \lambda_s \left[ \frac{\lambda_{eff\_unc}}{\lambda_{eff} - \lambda'_a \cdot \frac{(A_p - A_s)}{A_p}} \right]$
18. Measured sample thermal conductivity =  $\lambda_s \pm \lambda_{unc}$

## **b. Specific heat capacity**

1. Follow instructions 1–7 in Section 5a (above) to achieve thermal equilibrium, with recommended 10°C temperature differential: heater = 27.5°C, chiller = 17.5°C.
2. After confirming that ' $\tau$ ' has equilibrated to a constant value (*Hint: monitor ' $\tau$ ' on the user interface chart*), simultaneously increase the temperature of the Heater and Chiller by (recommended) 5°C by entering 32.5°C and 22.5°C into the respective fields

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on the software interface and pressing 'Set Temperatures'. 'Tau' will spike over the ensuing 20–30 seconds.

3. Continue recording until 'Tau' again decays to a constant value.
4. Finalise the log file by clicking 'Stop Recording' to prepare for a new sample, or 'Exit' to close the program and put the PEDB Mk II into 'dormant' mode (Figure 3b).
5. Locate the relevant '.csv' file in the designated directory (*hint: it will have the Filename as entered in the user interface, with a timestamp suffix indicating the time at which the Heater and Chiller temperatures were increased by 5°C*).
6. HDR recommends copying the file to another location for further processing.
7. Open the file using (for example) Microsoft Excel. It will have the same file structure as described in Step 5a5 above.
8. The tenth and eleventh columns of the file are 'Sample T' and 'Tau', respectively. These correlate to  $T_s$  in Eq 7 and  $\tau$  in Eq 8, respectively.
9. Add a twelfth column to the spreadsheet to calculate  $H_t$  for each row according to Eq 9;
10. Sum the values in column 12 and multiply by the average time step ( $dt$ ) to determine  $\Sigma(H)$  according to Eq 10.
11. Determine  $\Delta T$  from the first and last values in column 9 ('Sample T') according to Eq 11.
12. Calculate  $C_S \pm C_{unc}$  using Eq 12 and the coefficients from Table 2;
13. Calculate  $c_p$  from  $C_S$  and the sample mass:  $c_p = C_S/m_S$ .
14. Calculate  $C_{unc}$ , the uncertainty in  $c_p$ , from  $C_{unc} = c_p * C_{unc}/C_S$ .
15. Measured sample specific heat capacity =  $c_p \pm C_{unc}$ .

## 6. After a measurement

To remove a sample from the PEDB Mk II:

1. Raise the three side windows.
2. Remove both pieces of foam insulation from around the sample.
3. Gently oscillate and push the sample sideways while loosening the clamp. Samples can stick firmly to the contact plates so exercise caution to protect samples, plates and hands from damage.
4. Slide the sample free from the plates.
5. Clean both plates with a dry rag, tissue paper or similar, taking care not to damage the wires at the rear of the plates.
6. The PEDB Mk II is now ready for the next sample.