Physical Property Lab
Thermal Conductivity Cookbook

Thermal conductivity (k) [W/(m/K)] is the rate (Q) at which heat flows through a material (the temperature difference ΔT over a distance Δx). These measurements along with down temperature tool measurements are used to determine geothermal heat flow. This physical property is dependent on the materials chemical composition, density, and porosity.

$$Q = k(\Delta T/\Delta x)$$

1.1 TK04 System

The TK04 Thermal Conductivity System by TeKa measures thermal conductivity using either a full space probe (VLQ – sediments) or a half space probe (HLQ – lithified sediments or hard rock samples). The full space probe uses a steady line source of heat and assumes the material is isotropic, and the temperature of the material does not change. The half space method assumes these same factors and also requires a correction since measurement is being taken on only one side of the probe.

1.2 Calibrations
No calibrations are required for this system.   Each probe is calibrated prior to leaving the factory. TK04 conducts self tests prior to each measurement cycle.

1.3 Sample Preparation

1.3.1 Sediments – Full space probe (needle - VLQ)
Full space measurements are taken on whole cores after the temperature has equilibrated at lab temperature (17ºC – 18ºC). In order for the TK04 program to begin measurements, the temperature drift should be at a minimum.

Once the number of measurements per core is determined (a common choice is one section per core, usually section 3, with the measurement taken at 75 cm), a small hole is drilled through the working half section of the core liner. The entire needle of the probe is then GENTLY inserted into the hole of the liner. Don't force the probe into the sediment as they can bend or break.

Caution: Gassy cores may explode out of the drilled hole of the liner. It is recommended that safety glasses are worn and a rag is placed around the area the hole is being drilled.

1.3.2 Lithified Sediments and Hard Rock Samples – Half space probe   (puck – HLQ)

Half space measurements are performed after the core is split. When large enough pieces of the core are available (the sample piece must be at least as long as the probe within the puck) the sample is taken out of the section (orientation is noted in order for it to be put back correctly) and a ethyfoam plug is put in its place in the liner until the sample is returned.

If the sample does not have a smooth flat surface (the probe needs to be in full contact with the sample in order for a good measurement), fine sand paper is available at the thermal conductivity station. Thermal joint compound which improves the heat flow between touching surfaces is also available but is not recommended because it can discolor the core. Before using this method, contact other scientist to inform them of the changes the could occur to the sample.

The cut surface of the sample is attached to the bottom of the probe (puck) with elastic bands or velcro. The probe and sample are left to soak in a seawater bath (a plastic container deep enough to cover both) for 15 minutes before starting measurements. The sample remains in the seawater bath during measurements in order to reduce the effect of temperature variations.

1.4 Measurements

1.4.1 Parameters
The TK04 runs on a simple DOS program. The steps to begin measuring sediments using the full space probe (needle) are:

>   The initial screen shows only **C:\TK04>**
>   At this prompt type *needle site/hole*   ex. **C:\TK04> needle 1183A**

The main menu will then appear. The parameters for *full space measurements* are included in Figure 1.

Figure 1 – TC Main Menu with Full Space Parameters

```
                        TKMEAS V 3.20
                     Implementation for ODP
                     © 1997, Teka, Berlin



Probe Number:                V00694
Data Directory:              C:\TK04\1183A        ex.. C:\TK04\sitehole
Root Name:                   11R3-               ex. core coretype section -
Serial Number Start at:      1
Number of Measurements:      3*
Heating Power [W/m]:         3*
Measuring Time [s]:          150*
Save Data? (y/n):            Y
Comments:                    75 cm               ex. measurement interval



  F1 Help                    F10 Abort                  Esc Continue
```

The steps to begin measuring sediments using the half space probe (puck) are:

> The initial screen shows only **C:\TK04>**
> At this prompt type *needle site/hole*   ex. **C:\TK04> halfsp 1183A**

The main menu will then appear. The parameters for <u>*half space measurements*</u> are included in Figure 2.

]
Figure 2 – TC Main Menu with Half Space Parameters

```
                        TKMEAS V 3.20
                     Implementation for ODP
                     © 1997, Teka, Berlin



Probe Number:                H019694
Data Directory:              C:\TK04\1183A        ex.. C:\TK04\sitehole
Root Name:                   21R3-               ex. core coretype section -
```

```
Serial Number Start at:        1
Number of Measurements:        4*
Heating Power [W/m]:           2*
Measuring Time [s]:            80*
Save Data? (y/n):              Y
Comments:                      55-70 cm              ex. measurement interval



    F1 Help                    F10 Abort                    Esc Continue
```

* parameters that are different between half and full space measurements

Use the **arrow keys** to select the parameters, and press **enter** to select the parameter to make changes. Press **enter** again to initiate changes. **Esc** will start the measurements.

1.4.2 The TK04 Program

The program will notify you if the heating power needs to be adjusted. It will inform the user what the actual current and the desire current. In order to adjust the heating current of the probe the dial on the TK04 box must be turned (once you begin turning the dial, the actual current will begin to change) until the desired current is obtained. Press enter to start measurements.

When the measurements are complete, a black screen titled Last Results will appear with all measurements. Be sure that the Thermcon values are recorded in the log sheets once the measurements are finished!

Two data files are created for each measurement. Raw data such as the temperature, time and resistance is found within the *.dwl files. The thermal conductivity and other useful information are contained within the *.lst files. The file TC-LIST.DAT within the SiteHole directory contains all its thermal conductivity data.

> *Approximate running time of full space measurements: ~ 25 minutes*
> *Approximate running time of half space measurements: ~ 35 minutes*

1.5 Troubleshooting

If undesirable measurements are obtained or if the system starts producing strange characters (letters, symbols – it will appear as if the system is possessed):

- ✓ ensure there is a good contact between probe (needle and puck) and sample
- ✓ ensure sample temperature has equilibrated
- ✓ abort run and re-run sample

✓   change to another probe

✓   restart program and/or computer

1.6 Uploading to Janus

1.6.1 Downloading data from TK04

The data must be downloaded from the TK04 computer.

A floppy disk needs to first be formatted.

Insert a disk, then at the initial prompt C:\TK04\ > type **FORMAT A:/F:720**

Enter the directory for the site - type **CD SiteHole** ex. CD 1183A

Copy the data – type **COPY TC-LIST.DAT A:\SiteHole.DAT**

- if you need to look at the raw data before it is copied, go to the desired directory (type **CD SiteHole**), then type **DIR/W**, then **TC-LIST.dat**
- if you need to edit the data type **EDIT TC-LIST.DAT**

1.6.2 Editing for Janus

Next, go to a different PC computer and open the *.dat file (from the floppy) in Excel.

A dialogue box will ask which format, Delimited or Fixed Width, choose **FIXED WIDTH.** Click **NEXT**, then move the vertical lines to separate the data into columns. The number of columns vary depending on how you choose to separate the data.

> ** There is a lot of editing that needs to be done. Choosing well spaced columns and taking out extra characters will help in the end.*

Once the columns are set click **FINISH**. This should open the data sheet.

There are several columns of data that will not be used and therefore can be deleted at this stage. Be sure to view the entire spreadsheet before deleting and changing columns. Out of the first 6 columns you need only core number, core type, section, and measurement number (1,2,3,4). They should all be arranged in separate columns.

Columns with such headers as: LET/STD, No., Start, Length, End, Eval., "cm" (although you do you the interval which was probably placed in the comment parameter (if it wasn't it should be in the log sheets) can be deleted. After deleting the unnecessary data, you should be left with 7 columns: core, core type, section, measurement number, TC, interval (duplicate this column to use for top and bottom interval)

Next, open the Thermcon template located in *Data1/Leg 192/Prime Data/15 Thermcon/Thermcon.csv*

Table 1 – Thermal Conductivity Template

...ermal Conductivity*																
...lank line)*																
...eg	Site	Hole	Core	CT	Section	Top	Bottom	Half/Full	TC Value	Instrument	Probe #	Comment	TC1	TC2	TC3	TC4

*Thermal conductivity – This title must be present
*(blank line) this line must be left blank

Top – top of interval
Bottom – bottom of interval
Thermcon (TC) Value – average of (TC1, TC2, TC3, TC4)
Instrument – Teka
Probe Number – 594, 894, 794 – apparently the probe number column only excepts 3 digit probe numbers so you will have to put in one of the 3 known full space probes even if 19608, or 19610 was used.

Either copy the 3 lines into the top of the spreadsheet you are working with or save it as a different name (sitehole_TC.csv). Start to move the remaining data into the correct columns. You should end up with one row for each sample. Use the average function in excel to determine the Thermcon Value. Make sure all the cells have data or Janus will not accept it! Save the file as a *.csv file on both the A:\ and within the Thermcon folder in Data1.

1.6.3 Importing Data to Janus
Next open Janus and go to *Applications → Physical Properties → Transfer → Import ThermCon Data File*

Click **QUERY** and select the *.csv file you just saved on the A: ex. 1183A.csv
then click **READ FILE**.

Hopefully no errors will come up but if they do, you have to go back to Excel, correct the errors and re-save. Then go through Query and Read File again. Once the file is successfully read in, click **TRANSFER**. A message will appear telling you that the file was sent to the database.   We have been asked to include the *.dat file and *.csv file of each site in Prime Data on Data1.

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