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James D. Prikryl JP CNWRA x5667

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2/28/97 JP

Thermal Effects on Flow KTI

Initial entry 2/28/97 by James D. Prikryl JP

This notebook chronicles the laboratory investigations for the Thermal Effects on Flow KTI

6/12/97

This is a continuation of Notebook # 173 Randall Fedors

On 2/28/97 the 10 Apache Leap Samples were again removed from the Blue M oven so that measurements of mass could be performed. Procedures were the same as those discussed on page 152 lab notebook 173.

Sample ID	Mass (g)
1	21.472
2	16.499
3	22.868
4	19.316
5	22.272
6	26.200
7	25.151
8	19.398
9	20.801
10	25.866

Samples #1-10 were then placed back into the Blue M oven set @ 105°C.

M. Hill 2/28/97

3/4/97 JP Thermal Conductivity Experiment Run 59
Water

Parameters
Variable transformer setpoint 35
Waterbath temp setpoint 20°C
Pressure on top Al plate 5 ft lb

3/5/97 JP Results of TC expmt Run 59

Bottom Al plate Serial No	Heat Flux BTU/ft²-hr	Temp °C
96041630	15.0310	24
31	50.1750	23.9
32	—	24
33	—	24.1

Top Al plate		
95J042	45.1181	21
41	32.0194	21
39	36.2434	21.1
40	42.1510	21.1

Monitoring Thermocouples	Temp °C
1	31.7
2	23.7
3	24
4	23.8
5	24
6	24.5
7	21.1
8	21.2
9	21.0
10	21.0

3/5/97 JP Thermal Conductivity Experiment Run 60
Water

Parameter
Variable transformer setpoint 50
Temp of waterbath 20°C
Pressure on top Al plate 55 ft lb

3/6/97 JP Results of TC experiment run 60

Bottom Al plate Serial No	Heat Flux BTU/Ft²hr	Temp °C
96041630	50.2294	27.9
31	93.6221	27.8
32	—	28.1
33	—	28.1
Top Al plate		
95J042	76.1849	23.0
41	56.1383	22.9
39	61.0281	23.0
40	73.1990	23.0

Monitoring Thermocouples	Temp °C
1	40.4
2	26.3
3	27.5
4	27.5
5	27.6
6	28.7
7	22.9
8	23.1
9	23.0
10	22.8

3/6/97 JP Thermal Conductivity Experiment run 61
Water

Parameter
Variable transformer setpoint 70
Temp of waterbath 20°C
Pressure on top Al plate 55 ft lb

3/7/97 Results of TC experiment Run 61

Bottom Al plate Serial No	Heat Flux BTU/Ft²hr	Temp °C
96041630	97.0083	40.7
31	187.0770	40.5
32	—	41.0
33	—	41.0
Top Al plate		
95J042	110.9059	33.5
41	81.8540	33.4
39	91.6479	33.5
40	111.1884	33.5

Monitoring Thermocouples	Temp °C
1	57.1
2	34.3
3	39.9
4	39.5
5	39.8
6	41.7
7	33.7
8	33.7
9	33.6
10	33.6

3/7/97 Thermal Conductivity Experiment Run 62
Water

Parameter

Variable temperature setpoint	80
Waterbath temp setpoint	20°C
Pressure on top Al plate	55±16

3/10/97 Results of TC experiment Run 62

Bottom Al plate Serial No	Heat Flux BTU/Ft²-hr	Temp °C
96041630	155.1838	48.6
31	229.3427	48.3
32	–	49.0
33	–	49.0

Top Al plate

95J042	135.2298	40.4
41	103.7586	40.3
39	117.9742	40.4
40	141.0895	40.6

Monitoring Thermocouple	Temp °C
1	70.3
2	39.9
3	47.5
4	47.8
5	48.0
6	50.6
7	40.4
8	41.0
9	41.0
10	40.6

3/10/97 Thermal Conductivity Experiment Run 63
Water

Parameter

Variable temperature setpoint	100
Waterbath temperature setpoint	20°C
Pressure on top Al plate	55±16

3/11/97 Results of TC experiment Run 63

Bottom Al plate Serial No	Heat Flux BTU/Ft²-hr	Temp °C
96041631	306.0768	64.0
31	299.7980	63.4
32	–	64.5
33	–	64.5

Top Al plate

95J042	182.7046	54.0
41	158.3891	53.6
39	172.7328	53.8
40	207.0740	53.8

Monitoring Thermocouple	Temp °C
1	92.8
2	50.6
3	62.7
4	62.1
5	62.8
6	66.6
7	53.7
8	53.8
9	53.5
10	53.7

3/11/97 Thermal Conductivity Experiment Run 64
Water

Parameter

Variable transformer setpoint	90
Waterbath temp	20°C
Pressure on top Al plate	5 ft-lb

3/12/97 Results of TC experiment Run 64

Bottom Al plate Serial No	Heat Flux BTU/Ft²hr	Temp °C
96041630	203.5540	56.4
31	287.6535	56.0
32	—	56.8
33	—	55.8

Top Al plate		~~47.8~~ 3/12/97
950042	159.6835	47.8
41	137.7420	47.4
39	144.2958	47.6
40	148.6313	47.6

Monitoring Thermocouples	Temp °C
1	81.8
2	45.9
3	55.6
4	54.9
5	55.5
6	58.5
7	47.5
8	42.7
9	47.3
10	47.4

3/12/97 Thermal Conductivity Experiment Run 65
Water

Parameter

Variable transformer setpoint	60
Waterbath temp setpoint	20°C
Pressure on top Al plate	5 ft-lb

3/13/97 Results of TC experiment Run 65

Bottom Al plate Serial No	Heat Flux BTU/Ft²hr	Temp °C
96041630	88.0485	32.9
31	95.8126	32.7
32	—	33.1
33	—	33.1

Top Al plate		
950042	99.2215	27.8
01	76.9357	27.8
39	79.7061	27.8
40	89.8890	27.9

Monitoring Thermocouples	Temp °C
1	51.0
2	32.4
3	32.6
4	32.7
5	32.8
6	34.2
7	27.6
8	27.9
9	27.8
10	27.8

3/13/97 gp Thermal Conductivity Experiment Run 66
Water

Parameter

Variable temperature setpoint	42
Waterbath temp setpoint	20°c
Pressure on top Al plate	55 ft lb

3/14/97 gp Results of TC experiment Run 66

Bottom Al plate Serial No	Heat Flux BTU/Ft²h	Temp °c
96041630	51.6474	20.7
31	52.9750	20.6
32	–	20.9
33	–	20.8

Top Al plate		
95J042	57.7680	17.1
41	47.4255	17.1
39	49.5748	17.1
40	57.2408	17.3

Monitoring Thermocouples	Temp °c
1	35.5
2	25.3
3	20.6
4	20.7
5	20.8
6	21.5
7	17.1
8	17.4
9	17.2
10	17.2

3/14/97 gp Thermal Conductivity Experiment Run 67
Water

Parameter

Variable temperature setpoint	20
Waterbath temp setpoint	20°c
Pressure on top Al plate	55 ft lb

3-13-00 JP

Reassembly of bulk thermal conductivity apparatus

Obj - assemble steady-state thermal conductivity apparatus to measure the thermal properties of the Topapah Spring welded tuff (lower lithophysal unit).

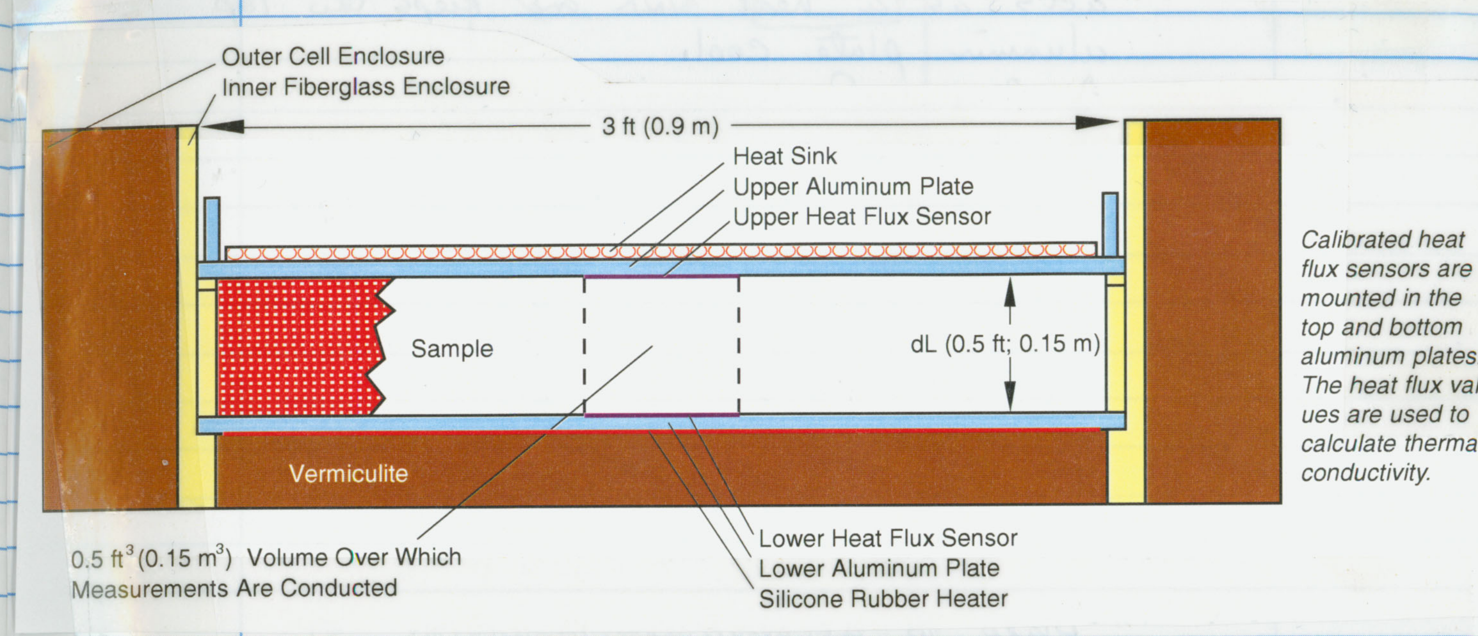
Method - measure the thermal conductivity of a 0.15 m³ (3-13-00 JP) volume of tuff centrally located within the cell.

Equipment - Materials - Supplies
- an approximate 4'x4'x2' plywood enclosure.
- an approximate 3'x3'x2' fiberglass insert
- two 3'x3'x1" aluminum plates; one plate has a welded aluminum enclosure
- coiled copper tubing and plastic tubing.
- angle iron; three 4' sections with three all thread bolts mounted in each section.
- C-clamps.
- ten type J thermocouples; 6" long
- variable transformer, 0-140V, Staco Energy Products Co.

- 3'x3' rubber silicon heater
- Hewlett Packard 34970A data aquisition meter.
- HP Benchlink Data logger software
- Exacal EX-251HT water bath from Neslab
- Neslab FTC-350 flow thru cooler
- ~~Ex~~ 3-13-00 gp
- Two heat flux sensors from RDF; S/N 27092 each sensor consists of a 6"x6" aluminum plate on which four separate heat flux sensors and four type K thermocouple have been mounted
- Topopah Spring welded tuff (lower lithophysal unit). See scientific notebook # 382 for a description of the ~~tuff~~.
- Vermiculite
- vacuum grease
- aluminum tape.
- Proto torque wrench
- aluminum foil

Assembly

① A schematic diagram of the thermal conductivity apparatus is shown below.



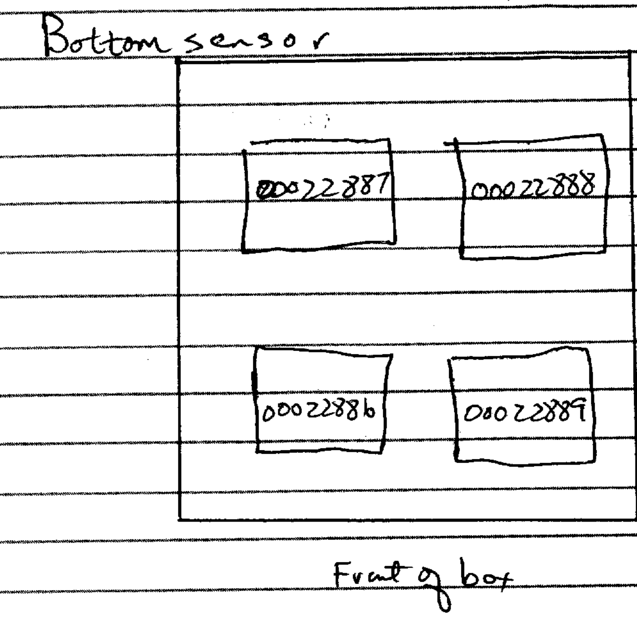
The fiberglass insert is placed inside the plywood enclosure. Space between the plywood enclosure and fiberglass insert is filled with vermiculite which acts as an insulator.
The 1" thick aluminum plates are mounted on the fiberglass enclosure about 6" (0.15 m) apart.
Crushed tuff is loaded between the aluminum plates.
The silicon rubber heater is mounted on the underside of the bottom aluminum plate and is connected to the variable transformer.
Coiled copper tubing is placed on the top of the top aluminum plate. The

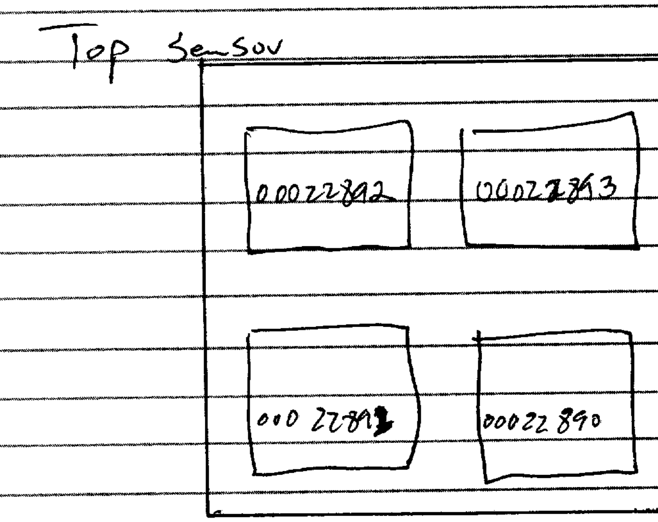
copper tubing is attached to the water bath and flow thru cooler by means of plastic tubing. The enclosure on the top aluminum plate is filled with water. This assembly acts as a heat sink and keeps the top aluminum plate cool.
A downward compression strength is applied to the top aluminum plate using the angle iron with all thread bolts. The angle iron is attached to the top of the plywood enclosure using C clamps. Pressure is applied by screwing down the bolts using a torque wrench.

(2) A 6"x6" recess has been milled into the center of each 3'x3' aluminum plate to accomodate mounting of the heat flux sensors. The sensors are mounted in the plates using aluminum tape. Vacuum grease is applied to the contact between the sensor and the aluminum plate to assure good contact.

Below are diagrams showing the orientation and serial no of each sensor in the plate. There are four sensors attached to each plate; in addition type K Thermocouples are attached at each sensor.

Calibration certificates for each sensor are also attached.





Leads for the sensors and thermocouples are run out of the cell and attached to the HP 34970A. Sensors output a voltage reading.

RdF *Specialists in Temperature Measurement*

Certificate of Calibration

TEST NUMBER 77244

RdF P/N: 27070-1/27092

Serial No: SEE BELOW

Customer:: SOUTHWEST RESEARCH INSITIUTION

Range 70°F Calibration

Item No.: N/A

AS FOUND CONDITION: IN TOLERANCE

AS LEFT CONDITION: IN TOLERANCE

PO#: X852458S

HUMIDITY: 21%

CAL DATE 02/08/00

TEMPERATURE: 72°F

NEXT RECOMMENDED DUE DATE: 02/08/01

CALIBRATION DATA

S/N. NO.	70°F
00022886	3.58
00022887	3.59
00022888	3.56
00022889	3.55
00022890	3.58
00022891	3.60
00022892	3.58
00022893	3.60

RdF Corporation
23 Elm Avenue Hudson, New Hampshire 03051-0490 Tel (800) 445-8367 (603) 882-5195 Fax
INTERNET: sensor@rdfcorp.com
ISO 9001 CERTIFIED COMPANY

RdF Corporation certifies that the articles identified below have been manufactured, inspected and/or tested under controlled conditions in compliance with the applicable specifications and drawings. Calibration instruments used at RdF are traceable to N.I.S.T.

RdF Equipment Used for Calibration	NIST Trace No.	Cal Date	Cal due
Keithley Mulitmeter Item # 2351	QA-02606-R-17332	02/24/99	02/24/00

Certified by: [signature] Date: 03/03/00

RdF Corporation
23 Elm Avenue Hudson, New Hampshire 03051-0490 Tel (800) 445-8367 (603) 882-5195 Fax (603) 882-6925
INTERNET: sensor@rdfcorp.com
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RdF *Specialists in Temperature Measurement*

CERTIFICATE OF CONFORMANCE

CUSTOMER: SOUTHWEST RESEARCH INSTITUTE

P.O. NUMBER: X852458S

RdF SALES ORDER: 77244

RdF Corporation certifies that the articles identified below have been manufactured, inspected and/or tested under controlled conditions in compliance with the applicable specifications and drawings. Calibration instruments used at RdF are traceable to N.I.S.T.

ITEM	QTY	DESCRIPTION
1	2	27092 HEAT FLUX SENSOR S/N: 00022886 THRU 00022889 00022890 THRU 00022893
2	1	LOT CHARGE FOR CERTIFICATE OF CALIBRATION

RdF Quality Assurance Representative   Date: 000303

Q-330A REV. G 11/96

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Q-116-08 REV A
Q-116-12 REV A

MICRO-FOIL™ HEAT FLUX SENSOR

CALIBRATION

RdF PART NO. 27092

SERIAL NO. 00022886

HEAT FLUX SENSOR:

Output at 70°F: 3.58 μV/BTU/ft² hr

Polarity: (For heat flow into the surface)
White - Positive (+)
Red - Negative (-)

Temperature Multiplication Factor: See Attached Graph

*Thermal Resistance: 0.01 °F/BTU/ft² hr (Typ)

*Heat Capacity: 0.03 BTU/ft² hr/°F (Typ)

Response Time: 0.60 sec (62% response to step function) (Typ)

THERMOCOUPLE:

ANSI TYPE	MATERIAL	POLARITY	COLOR
K	Chromel Alumel	Pos. (+) Neg. (-)	Yellow Red

Output per ANSI MC96.1-1975 and NBS Monograph 125

*Thermal resistance is the temperature difference between the front surface and rear mounting surface of the sensor per unit of heat flow through the sensor. Heat capacity is the amount of heat required to raise the mean temperature of the sensor 1°F. Typical values of these two properties are given primarily to indicate sensor capabilities and are required for heat flow calculations only in very rare instances.

BY: Elaine Tardif   DATE: 2-8-00

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Specialists in Temperature Measurement

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Q-116-08 REV A
Q-116-12 REV A

MICRO-FOIL™ HEAT FLUX SENSOR

CALIBRATION

RdF PART NO. 27092

SERIAL NO. 00022887

HEAT FLUX SENSOR:

Output at 70°F: 3.59 μV/BTU/ ft² hr

Polarity: (For heat flow into the surface)
White - Positive (+)
Red - Negative (-)

Temperature Multiplication Factor: See Attached Graph

*Thermal Resistance: 0.01 °F/BTU/ft² hr (Typ)

*Heat Capacity: 0.03 BTU/ft² hr/°F (Typ)

Response Time: 0.60 sec (62% response to step function) (Typ)

THERMOCOUPLE:

ANSI TYPE	MATERIAL	POLARITY	COLOR
K	Chromel Alumel	Pos. (+) Neg. (-)	Yellow Red

Output per ANSI MC96.1-1975 and NBS Monograph 125

*Thermal resistance is the temperature difference between the front surface and rear mounting surface of the sensor per unit of heat flow through the sensor. Heat capacity is the amount of heat required to raise the mean temperature of the sensor 1°F. Typical values of these two properties are given primarily to indicate sensor capabilities and are required for heat flow calculations only in very rare instances.

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MICRO-FOIL™ HEAT FLUX SENSOR

CALIBRATION

RdF PART NO. 27092

SERIAL NO. 00022888

HEAT FLUX SENSOR:

Output at 70°F: 3.56 μV/BTU/ ft² hr

Polarity: (For heat flow into the surface)
White - Positive (+)
Red - Negative (-)

Temperature Multiplication Factor: See Attached Graph

*Thermal Resistance: 0.01 °F/BTU/ft² hr (Typ)

*Heat Capacity: 0.03 BTU/ft² hr/°F (Typ)

Response Time: 0.60 sec (62% response to step function) (Typ)

THERMOCOUPLE:

ANSI TYPE	MATERIAL	POLARITY	COLOR
K	Chromel Alumel	Pos. (+) Neg. (-)	Yellow Red

Output per ANSI MC96.1-1975 and NBS Monograph 125

*Thermal resistance is the temperature difference between the front surface and rear mounting surface of the sensor per unit of heat flow through the sensor. Heat capacity is the amount of heat required to raise the mean temperature of the sensor 1°F. Typical values of these two properties are given primarily to indicate sensor capabilities and are required for heat flow calculations only in very rare instances.

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MICRO-FOIL™ HEAT FLUX SENSOR

CALIBRATION

RdF PART NO. 27092

SERIAL NO. 00022889

HEAT FLUX SENSOR:

Output at 70°F: 3.55 μV/BTU/ft² hr

Polarity: (For heat flow into the surface)
White - Positive (+)
Red - Negative (–)

Temperature Multiplication Factor: See Attached Graph

*Thermal Resistance: 0.01 °F/BTU/ft² hr (Typ)

*Heat Capacity: 0.03 BTU/ft² hr/°F (Typ)

Response Time: 0.60 sec (62% response to step function) (Typ)

THERMOCOUPLE:

ANSI TYPE	MATERIAL	POLARITY	COLOR
K	Chromel Alumel	Pos. (+) Neg. (–)	Yellow Red

Output per ANSI MC96.1-1975 and NBS Monograph 125

*Thermal resistance is the temperature difference between the front surface and rear mounting surface of the sensor per unit of heat flow through the sensor. Heat capacity is the amount of heat required to raise the mean temperature of the sensor 1°F. Typical values of these two properties are given primarily to indicate sensor capabilities and are required for heat flow calculations only in very rare instances.

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MICRO-FOIL™ HEAT FLUX SENSOR

CALIBRATION

RdF PART NO. 27092

SERIAL NO. 00022890

HEAT FLUX SENSOR:

Output at 70°F: 3.58 μV/BTU/ft² hr

Polarity: (For heat flow into the surface)
White - Positive (+)
Red - Negative (–)

Temperature Multiplication Factor: See Attached Graph

*Thermal Resistance: 0.01 °F/BTU/ft² hr (Typ)

*Heat Capacity: 0.03 BTU/ft² hr/°F (Typ)

Response Time: 0.60 sec (62% response to step function) (Typ)

THERMOCOUPLE:

ANSI TYPE	MATERIAL	POLARITY	COLOR
K	Chromel Alumel	Pos. (+) Neg. (–)	Yellow Red

Output per ANSI MC96.1-1975 and NBS Monograph 125

*Thermal resistance is the temperature difference between the front surface and rear mounting surface of the sensor per unit of heat flow through the sensor. Heat capacity is the amount of heat required to raise the mean temperature of the sensor 1°F. Typical values of these two properties are given primarily to indicate sensor capabilities and are required for heat flow calculations only in very rare instances.

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MICRO-FOIL™ HEAT FLUX SENSOR

CALIBRATION

RdF PART NO. 27092

SERIAL NO. 00022891

HEAT FLUX SENSOR:

Output at 70°F: 3.60 μV/BTU/ ft² hr

Polarity: (For heat flow into the surface)
White - Positive (+)
Red - Negative (-)

Temperature Multiplication Factor: See Attached Graph

*Thermal Resistance: 0.01 °F/BTU/ft² hr (Typ)

*Heat Capacity: 0.03 BTU/ft² hr/°F (Typ)

Response Time: 0.60 sec (62% response to step function) (Typ)

THERMOCOUPLE:

ANSI TYPE	MATERIAL	POLARITY	COLOR
K	Chromel Alumel	Pos. (+) Neg. (-)	Yellow Red

Output per ANSI MC96.1-1975 and NBS Monograph 125

*Thermal resistance is the temperature difference between the front surface and rear mounting surface of the sensor per unit of heat flow through the sensor. Heat capacity is the amount of heat required to raise the mean temperature of the sensor 1°F. Typical values of these two properties are given primarily to indicate sensor capabilities and are required for heat flow calculations only in very rare instances.

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MICRO-FOIL™ HEAT FLUX SENSOR

CALIBRATION

RdF PART NO. 27092

SERIAL NO. 00022892

HEAT FLUX SENSOR:

Output at 70°F: 3.58 μV/BTU/ ft² hr

Polarity: (For heat flow into the surface)
White - Positive (+)
Red - Negative (-)

Temperature Multiplication Factor: See Attached Graph

*Thermal Resistance: 0.01 °F/BTU/ft² hr (Typ)

*Heat Capacity: 0.03 BTU/ft² hr/°F (Typ)

Response Time: 0.60 sec (62% response to step function) (Typ)

THERMOCOUPLE:

ANSI TYPE	MATERIAL	POLARITY	COLOR
K	Chromel Alumel	Pos. (+) Neg. (-)	Yellow Red

Output per ANSI MC96.1-1975 and NBS Monograph 125

*Thermal resistance is the temperature difference between the front surface and rear mounting surface of the sensor per unit of heat flow through the sensor. Heat capacity is the amount of heat required to raise the mean temperature of the sensor 1°F. Typical values of these two properties are given primarily to indicate sensor capabilities and are required for heat flow calculations only in very rare instances.

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Q-116-08 REV A
Q-116-12 REV A

MICRO-FOIL™ HEAT FLUX SENSOR

CALIBRATION

RdF PART NO. 27092

SERIAL NO. 00022893

HEAT FLUX SENSOR:

Output at 70°F: 360 μV/BTU/ ft² hr

Polarity: (For heat flow into the surface)
White - Positive (+)
Red - Negative (-)

Temperature Multiplication Factor: See Attached Graph

*Thermal Resistance: 0.01 °F/BTU/ft² hr (Typ)

*Heat Capacity: 0.03 BTU/ft² hr/°F (Typ)

Response Time: 0.60 sec (62% response to step function) (Typ)

THERMOCOUPLE:

ANSI TYPE	MATERIAL	POLARITY	COLOR
K	Chromel Alumel	Pos. (+) Neg. (-)	Yellow Red

Output per ANSI MC96.1-1975 and NBS Monograph 125

*Thermal resistance is the temperature difference between the front surface and rear mounting surface of the sensor per unit of heat flow through the sensor. Heat capacity is the amount of heat required to raise the mean temperature of the sensor 1°F. Typical values of these two properties are given primarily to indicate sensor capabilities and are required for heat flow calculations only in very rare instances.

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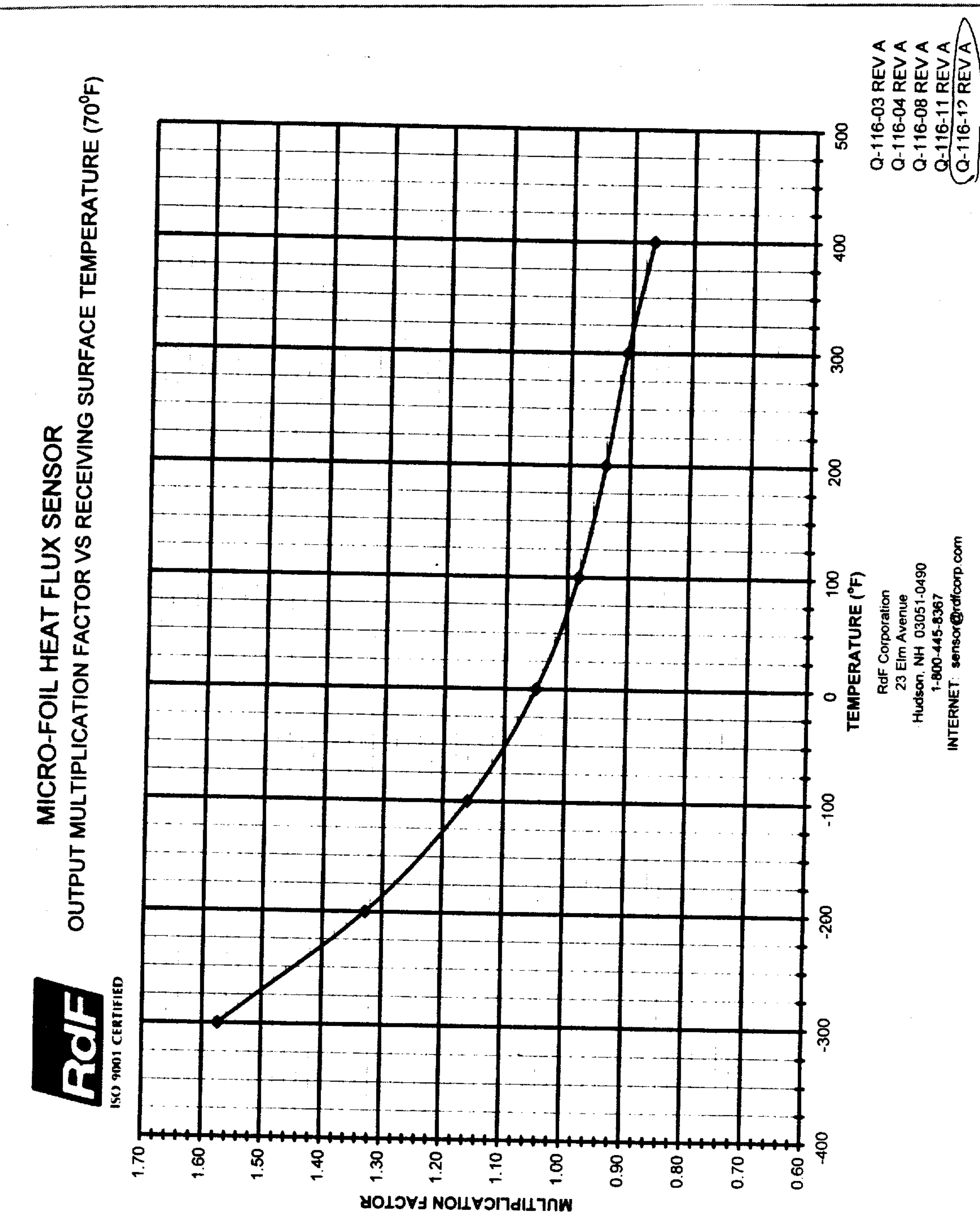
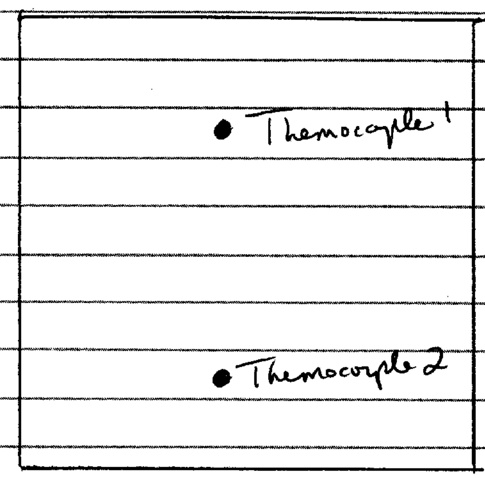
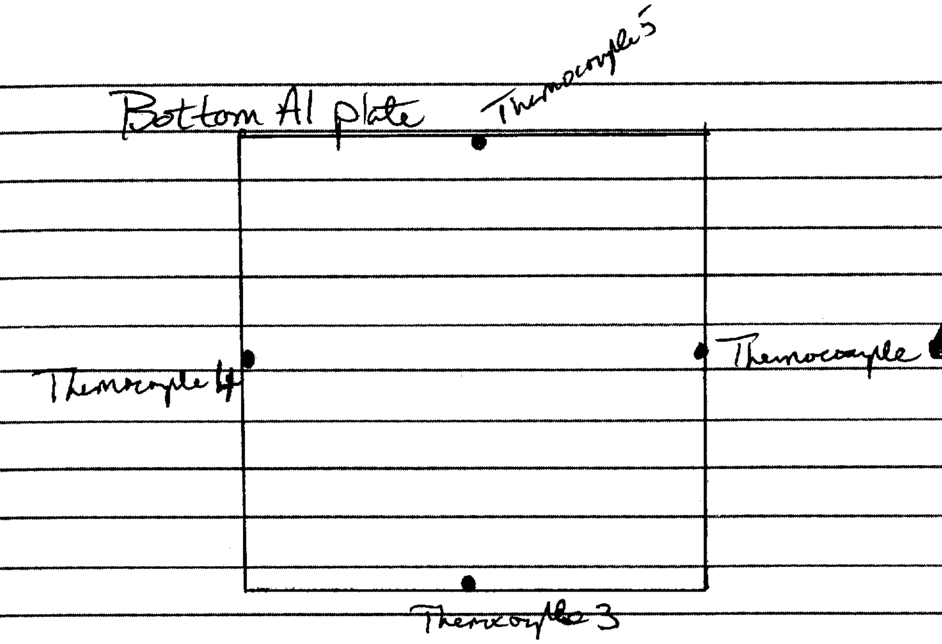


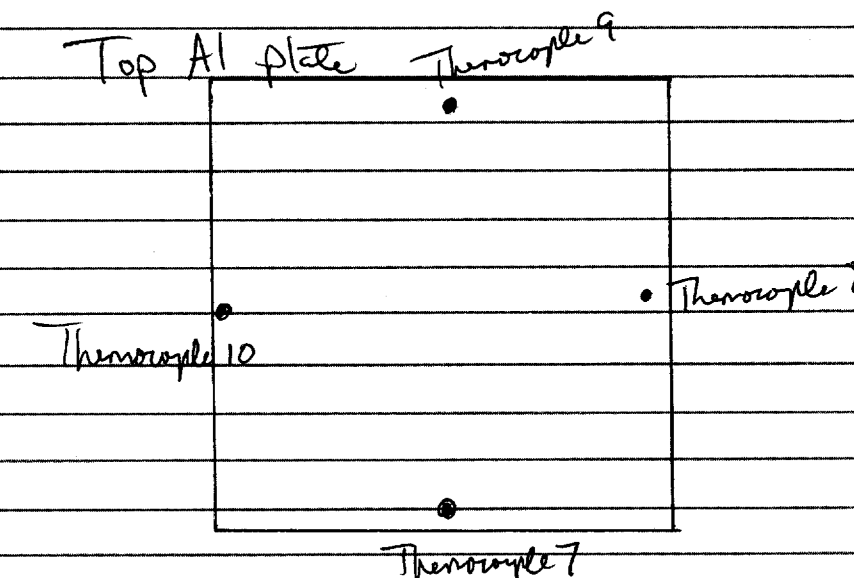
③ Two thermocouples are placed in the bottom of the box to monitor the temperature of the plywood. These thermocouples are labeled Thermocouple 1 and 2. Placement of the thermocouples is shown below.



Front of box

④ Four thermocouples are mounted in each of the top and bottom 1" aluminum plates to monitor heat distribution at the boundaries of the cell. Thermocouple placement and labels are shown in the following diagrams.





Leads for the thermocouples are attached to the HP 34970A.

⑤ Thermocouple calibration

Before the type J thermocouples in steps 3 and 4 were mounted in the apparatus they were calibrated. Following is a description of the calibration.

Equipment + Materials
- Corning hot plate
- ice
- 1L glass beaker
- calibrated thermometer S/N 1748
- HP 34970A meter

a) Thermocouples 1 thru 10 were placed in a beaker filled with ice along with the calibrated thermometer. Temperatures are recorded below.

Calibrated thermometer - 0.5°C

Thermocouple	1	- 0.3°C
"	2	- 0.6°C
"	3	- 0.1°C
"	4	- 0.1°C
"	5	- 0.3°C
"	6	- 0.1°C
"	7	- 0.9°C
"	8	- 0.8°C
"	9	- 0.4°C
"	10	- 0.2°C

b) Thermocouples 1 thru 10 were then placed in a beaker containing heated water along with the calibrated thermometer. Temperatures are recorded below.

Calibrated thermometer - 50°C

Thermocouple	1	- 49.7°C
"	2	- 50.8°C
"	3	- 48.1°C
"	4	- 49.6°C
"	5	- 51.9°C
"	6	- 51.3°C
"	7	- 50.8°C
"	8	- 50.5°C
"	9	- 49.8°C
"	10	- 50.2°C

(6) The heat flux sensors and thermocouples are attached to a HP 34970A data acquisition system (120 channel capacity). The HP34970A is computer controlled using HP Benchlink Data Logger software. The software allows the user to record & store data at prescribed scan intervals. The stored data can then be retrieved and analyzed. The list below shows the label given to each heat flux sensor and thermocouple and the channel it is connected to.

Channel #	Label
101	HF 000 22886
102	HF 000 22887
103	HF 000 22888
104	HF 000 22889
105	HF 000 22890
106	HF 000 22891
107	HF 000 22892
108	HF 000 22893
109	T 000 22886
110	T 000 22887
111	T 000 22888
112	T 000 22889
113	T 000 22890
114	T 000 22891
115	T 000 22892
116	T 000 22893

Channel #	Label
201	Thermocouple 1
202	Thermocouple 2
206	Thermocouple 3
207	Thermocouple 4
211	Thermocouple 5
212	Thermocouple 6
301	Thermocouple 7
302	Thermocouple 8
306	Thermocouple 9
307	Thermocouple 10

(7) After loading the sample into the cell, a layer of crumpled aluminum foil is placed on top of the crushed rock sample to ensure a good contact between the sample and top heat flux sensor.

The aluminum plates are temperature controlled. The silicon rubber heater attached to the bottom aluminum plate applies heat to the cell. Temperature of the heater is controlled by the variable transformer. The liquid cooled heat sink composed of the copper coil and flowthru cooler controls the temperature of the top aluminum plate.

(8) Heat flux values, the temperature difference between the upper and lower boundaries, and the sample thickness are then used to calculate thermal conductivity, K_T, using Fourier's Law:

$$K_T = Q(dL/dT) \; (BTU/hr\,ft\,^{\circ}F;\; W/m\,^{\circ}K)$$

where

- Q - heat flux ($BTU/ft^2\,hr$; W/m^2)
- dL - distance between top + bottom sensors (ft ; m)
- dT - temperature difference between top + bottom sensors ($^{\circ}F$; $^{\circ}K$)

3-15-00 JP Thermal Conductivity Measurements of Topapah Spring welded tuff using thermal conductivity cell described in pp. 13-36.

Run TSW-TC-1

Rock used - Topapah Spring welded tuff
Size - fines to ~6cm in diameter
Pretreatment - NONE

Waterbath setpoint - 5°C
Variable transformer setting - 60
Pressure on top aluminum plate - 5 ft lb
Scan interval - 15 min

Temperatures and heat flux will be monitored. When system reaches steady-state temperature + heat flux values will be recorded and thermal conductivity will be calculated.

~~3-16-00~~ 3-17-00 JP

Final readings of heat flux sensors and thermocouples are recorded on the following page for run TSW-TC-1. Data for this run is saved in an Microsoft Excel file named tsw-tc-1.xls.

Run TSw_TC_1 - Final readings

Data Grid

	Channel	Reading	Time
1	<101>HF-00022886	-284.2810 uVdc	08:12:39.764 AM
2	<102>HF-00022887	-243.2360 uVdc	08:12:39.815 AM
3	<103>HF-00022888	-284.0170 uVdc	08:12:39.866 AM
4	<104>HF-00022889	-356.7370 uVdc	08:12:39.917 AM
5	<105>HF-00022890	335.2250 uVdc	08:12:39.967 AM
6	<106>HF-00022891	259.4690 uVdc	08:12:40.018 AM
7	<107>HF-00022892	299.1950 uVdc	08:12:40.069 AM
8	<108>HF-00022893	321.8950 uVdc	08:12:40.120 AM
9	<109>T-00022886	102.9720 C	08:12:40.170 AM
10	<110>T-00022887	103.0760 C	08:12:40.209 AM
11	<111>T-00022888	102.1730 C	08:12:40.248 AM
12	<112>T-00022889	102.6540 C	08:12:40.287 AM
13	<113>T-00022890	12.34200 C	08:12:40.326 AM
14	<114>T-00022891	12.06900 C	08:12:40.365 AM
15	<115>T-00022892	12.11700 C	08:12:40.404 AM
16	<116>T-00022893	9.912000 C	08:12:40.443 AM

Data Grid

	Channel	Reading	Time
1	<201>Thermocouple 1	51.52800 C	08:12:40.484 AM
2	<202>Thermocouple	46.53700 C	08:12:40.523 AM
3	<206>Thermocouple 3	100.1670 C	08:12:40.564 AM
4	<207>Thermocouple 4	100.9050 C	08:12:40.603 AM
5	<211>Thermocouple 5	101.0700 C	08:12:40.642 AM
6	<212>Thermocouple 6	101.3770 C	08:12:40.681 AM
7	<301>Thermocouple 7	10.80700 C	08:12:40.721 AM
8	<302>Thermocouple 8	10.77900 C	08:12:40.760 AM
9	<306>Thermocouple 9	11.09900 C	08:12:40.799 AM
10	<307>Thermocouple 10	11.20300 C	08:12:40.838 AM

3-17-00 JP

Run TSw_TC_2

Rock used Topopah Springs welded tuff
Size - fines to ~6 cm in diameter
Pretreatment - none

Waterbath setpoint - 5°C
Variable transformer setpoint - 40
Pressure applied to top aluminum plate - 5 ft lb
Scan interval - 15 min

3-20-00 JP
0825

Final readings of heat flux sensors and thermocouples are recorded on the following page. Data for this run are saved in a Microsoft Excel file named tsw_tc_2.xls.

Run tsw-tc-2 final readings.

Data Grid

	Channel	Reading	Time
1	<101>HF-00022886	-136.7290 uVdc	08:13:46.569 AM
2	<102>HF-00022887	-117.7250 uVdc	08:13:46.619 AM
3	<103>HF-00022888	-142.2730 uVdc	08:13:46.671 AM
4	<104>HF-00022889	-177.3790 uVdc	08:13:46.722 AM
5	<105>HF-00022890	165.8970 uVdc	08:13:46.773 AM
6	<106>HF-00022891	130.5260 uVdc	08:13:46.823 AM
7	<107>HF-00022892	151.5110 uVdc	08:13:46.874 AM
8	<108>HF-00022893	163.3890 uVdc	08:13:46.925 AM
9	<109>T-00022886	58.85700 C	08:13:46.976 AM
10	<110>T-00022887	58.98600 C	08:13:47.015 AM
11	<111>T-00022888	58.32800 C	08:13:47.054 AM
12	<112>T-00022889	58.68800 C	08:13:47.093 AM
13	<113>T-00022890	7.237000 C	08:13:47.132 AM
14	<114>T-00022891	7.024000 C	08:13:47.171 AM
15	<115>T-00022892	7.050000 C	08:13:47.210 AM
16	<116>T-00022893	4.697000 C	08:13:47.248 AM

Data Grid

	Channel	Reading	Time
1	<201>Thermocouple 1	35.28300 C	08:13:47.289 AM
2	<202>Thermocouple 2	32.58800 C	08:13:47.328 AM
3	<206>Thermocouple 3	56.56300 C	08:13:47.367 AM
4	<207>Thermocouple 4	57.29300 C	08:13:47.405 AM
5	<211>Thermocouple 5	57.62100 C	08:13:47.444 AM
6	<212>Thermocouple 6	57.84600 C	08:13:47.483 AM
7	<301>Thermocouple 7	6.273000 C	08:13:47.524 AM
8	<302>Thermocouple 8	6.194000 C	08:13:47.563 AM
9	<306>Thermocouple 9	6.167000 C	08:13:47.602 AM
10	<307>Thermocouple 10	6.333000 C	08:13:47.641 AM

3-20-00 JP

Calculation of thermal conductivity.

The Microsoft Excel spreadsheet is used to calculate the thermal conductivity (K_T) of the bulk rock samples.

The heat flows and temperature of the sensors mounted in the top and bottom aluminum plates are input directly into the spreadsheet.

The thermal conductivity of the sample is calculated using these values.

The formulas used to calculate the thermal conductivity are shown on the following page. Input values for temperature and heat flow are from run TSW_TC_1.

	A	B	C	D	E	F	G	H
1	**Thermal Conductivity**							
2								
3	**Run =**	TC calculation formulas						
4								
5	**Sample =**	Topapah Spring welded tuff (lower lithophysal unit)						
6								
7		$Q=K_T(dT/dL)$						
8								
9		where		Q =heat transfer per unit area (W/Ft²)				
10				K_T = thermal conductivity (W/m-K)				
11				dT = temperature difference between bottom and top sensors (K)				
12				dL = distance between bottom and top sensors (m)				
13								
14	**Sensor readings**							
15	Serial no.	Temp °C	Correct	Temp °K	Heat flow mV	Cal. constant	Heat flow	Convert to W/Ft²
16			Temp			mV/Btu/Ft²-Hr	Btu/Ft²-Hr	1Btu/Hr = 0.293W
17	Bottom							
18	00022886	103	=E40	=C18+273.2	284	3.58	=E18/F18	=G18*0.293
19	00022887	103	=E41	=C19+273.2	243	3.59	=E19/F19	=G19*0.293
20	00022888	102	=E42	=C20+273.2	284	3.56	=E20/F20	=G20*0.293
21	00022889	103	=E43	=C21+273.2	357	3.55	=E21/F21	=G21*0.293
22								
23	Top							
24	00022890	12	=E46	=C24+273.2	335	3.58	=E24/F24	=G24*0.293
25	00022891	12	=E47	=C25+273.2	259	3.6	=E25/F25	=G25*0.293
26	00022892	12	=E48	=C26+273.2	299	3.58	=E26/F26	=G26*0.293
27	00022893	10	=E49	=C27+273.2	322	3.6	=E27/F27	=G27*0.293
28								
29	Q =	=(H18+H19+H20+H21+H24+H25+H26+H27)/8	W/Ft²				=B29/0.0929	W/m²
30	dT =	=(D18+D19+D20+D21)/4-(D24+D25+D26+D27)/4	K					
31	dL =	0.5	Ft				=B31*0.3048	m
32								
33	**K_T =**	**=G29*G31/B30**	±	**=B33*SQRT((0.1*G29)/G29)^2+((0.02*B30)/B30)^2+((0.03*G31)/G31)^2**	**W/m-K**			
34								
35								
36	**Temperature correcti**							
37	Serial no.	Temp °C	Temp °F	Multiplication	Correct			
38				factor	Temp °C			
39	Bottom							
40	00022886	=B18	=((9/5)*B40)+32	0.94	=5/9*((C40*D40)-32)			
41	00022887	=B19	=((9/5)*B41)+32	0.94	=5/9*((C41*D41)-32)			
42	00022888	=B20	=((9/5)*B42)+32	0.94	=5/9*((C42*D42)-32)			
43	00022889	=B21	=((9/5)*B43)+32	0.94	=5/9*((C43*D43)-32)			
44								
45	Top							
46	00022890	=B24	=((9/5)*B46)+32	1.02	=5/9*((C46*D46)-32)			
47	00022891	=B25	=((9/5)*B47)+32	1.02	=5/9*((C47*D47)-32)			
48	00022892	=B26	=((9/5)*B48)+32	1.02	=5/9*((C48*D48)-32)			
49	00022893	=B27	=((9/5)*B49)+32	1.02	=5/9*((C49*D49)-32)			

3-20-00 Thermal conductivity calculations for runs TSw_TC_1 and TSw_TC_2 are shown on the following pages.

TSw_TC_1

Thermal Conductivity calculation using Fourier equation

Run = TSw_TC_1

Sample = Topapah Spring welded tuff (lower lithophysal unit)

$Q=K_T(dT/dL)$

where
- Q =heat transfer per unit area (W/Ft^2)
- K_T = thermal conductivity (W/m-K)
- dT = temperature difference between bottom and top sensors (K)
- dL = distance between bottom and top sensors (m)

Sensor readings

Serial no.	Temp ^{0}C	Correct Temp	Temp ^{0}K	Heat flow mV	Cal. constant mV/Btu/Ft^2-Hr	Heat flow Btu/Ft^2-Hr	Convert to W/Ft^2 1Btu/Hr = 0.293W
Bottom							
00022886	103	95.75	368.95	284	3.58	79.33	23.24
00022887	103	95.75	368.95	243	3.59	67.69	19.83
00022888	102	94.81	368.01	284	3.56	79.78	23.37
00022889	103	95.75	368.95	357	3.55	100.56	29.47
Top							
00022890	12	12.60	285.80	335	3.58	93.58	27.42
00022891	12	12.60	285.80	259	3.6	71.94	21.08
00022892	12	12.60	285.80	299	3.58	83.52	24.47
00022893	10	10.56	283.76	322	3.6	89.44	26.21

Q = 24.39 W/Ft^2 262.50 W/m^2
dT = 83.43 K
dL = 0.5 Ft 0.15 m

K_T = 0.479 ± 0.049 W/m-K

Temperature correction

Serial no.	Temp ^{0}C	Temp ^{0}F	Multiplication factor	Correct Temp ^{0}C
Bottom				
00022886	103	217.4	0.94	95.75
00022887	103	217.4	0.94	95.75
00022888	102	215.6	0.94	94.81
00022889	103	217.4	0.94	95.75
Top				
00022890	12	53.6	1.02	12.60
00022891	12	53.6	1.02	12.60
00022892	12	53.6	1.02	12.60
00022893	10	50	1.02	10.56

TSw_TC_2

Thermal Conductivity calculation using Fourier equation

Run = TSw_TC_2

Sample = Topapah Spring welded tuff (lower lithophysal unit)

$Q=K_T(dT/dL)$

where
- Q =heat transfer per unit area (W/Ft^2)
- K_T = thermal conductivity (W/m-K)
- dT = temperature difference between bottom and top sensors (K)
- dL = distance between bottom and top sensors (m)

Sensor readings

Serial no.	Temp ^{0}C	Correct Temp	Temp ^{0}K	Heat flow mV	Cal. constant mV/Btu/Ft^2-Hr	Heat flow Btu/Ft^2-Hr	Convert to W/Ft^2 1Btu/Hr = 0.293W
Bottom							
00022886	59	55.93	329.13	137	3.58	38.27	11.21
00022887	59	55.93	329.13	118	3.59	32.87	9.63
00022888	58	54.97	328.17	142	3.56	39.89	11.69
00022889	59	55.93	329.13	177	3.55	49.86	14.61
Top							
00022890	7	7.50	280.70	166	3.58	46.37	13.59
00022891	7	7.50	280.70	131	3.6	36.39	10.66
00022892	7	7.50	280.70	152	3.58	42.46	12.44
00022893	5	5.46	278.66	163	3.6	45.28	13.27

Q = 12.14 W/Ft^2 130.64 W/m^2

dT = 48.70 K

dL = 0.5 Ft   0.15 m

K_T = 0.409 ± 0.042 W/m-K

Temperature correction

Serial no.	Temp ^{0}C	Temp ^{0}F	Multiplication factor	Correct Temp ^{0}C
Bottom				
00022886	59	138.2	0.96	55.93
00022887	59	138.2	0.96	55.93
00022888	58	136.4	0.96	54.97
00022889	59	138.2	0.96	55.93
Top				
00022890	7	44.6	1.02	7.50
00022891	7	44.6	1.02	7.50
00022892	7	44.6	1.02	7.50
00022893	5	41	1.02	5.46

3-20-00 JP

Run TSw_TC_3

Rock used - Topopah Spring welded tuff
Size - Fines to ~6cm in diameter
Pretreatment - None

Waterbath setpoint - 5°C
Variable transformer setpoint - 30
Pressure applied to top aluminum plate - 5 ft-lb
Scan interval - 15 min.

3-22-00 JP
0755

Final readings of heat flux sensors + thermocouples are recorded on the following page. Data for this run are stored in a Microsoft Excel file named tsw_tc_3.xls

3-22-00 Run TSw_TC_3 Final readings
JP

Data Grid

	Channel	Reading	Time
1	<101>HF-00022886	-82.88200 uVdc	07:12:13.168 AM
2	<102>HF-00022887	-70.47600 uVdc	07:12:13.220 AM
3	<103>HF-00022888	-86.31400 uVdc	07:12:13.271 AM
4	<104>HF-00022889	-108.7500 uVdc	07:12:13.323 AM
5	<105>HF-00022890	103.3390 uVdc	07:12:13.374 AM
6	<106>HF-00022891	82.09000 uVdc	07:12:13.425 AM
7	<107>HF-00022892	94.10000 uVdc	07:12:13.476 AM
8	<108>HF-00022893	101.7550 uVdc	07:12:13.527 AM
9	<109>T-00022886	39.42800 C	07:12:13.578 AM
10	<110>T-00022887	39.56200 C	07:12:13.617 AM
11	<111>T-00022888	38.99700 C	07:12:13.656 AM
12	<112>T-00022889	39.29200 C	07:12:13.694 AM
13	<113>T-00022890	5.855000 C	07:12:13.733 AM
14	<114>T-00022891	5.669000 C	07:12:13.772 AM
15	<115>T-00022892	5.708000 C	07:12:13.811 AM
16	<116>T-00022893	3.275000 C	07:12:13.850 AM

Data Grid

	Channel	Reading	Time
1	<201>Thermocouple 1	27.29300 C	07:12:13.890 AM
2	<202>Thermocouple 2	25.88500 C	07:12:13.929 AM
3	<206>Thermocouple 3	37.36000 C	07:12:13.968 AM
4	<207>Thermocouple 4	38.06800 C	07:12:14.007 AM
5	<211>Thermocouple 5	38.42700 C	07:12:14.046 AM
6	<212>Thermocouple 6	38.64600 C	07:12:14.085 AM
7	<301>Thermocouple 7	5.563000 C	07:12:14.125 AM
8	<302>Thermocouple 8	5.081000 C	07:12:14.164 AM
9	<306>Thermocouple 9	4.827000 C	07:12:14.204 AM
10	<307>Thermocouple 10	4.965000 C	07:12:14.243 AM

3-22-00 JP
Thermal conductivity calculation for TSw-tc-3 is shown on following page.

TSw_TC_3

Thermal Conductivity calculation using Fourier equation

Run = TSw_TC_3

Sample = Topapah Spring welded tuff (lower lithophysal unit)

$Q=K_T(dT/dL)$

where
- Q = heat transfer per unit area (W/Ft^2)
- K_T = thermal conductivity (W/m-K)
- dT = temperature difference between bottom and top sensors (K)
- dL = distance between bottom and top sensors (m)

Sensor readings

Serial no.	Temp °C	Correct Temp	Temp °K	Heat flow mV	Cal. constant mV/Btu/Ft^2-Hr	Heat flow Btu/Ft^2-Hr	Convert to W/Ft^2 1Btu/Hr = 0.293W
Bottom							
00022886	39.43	37.71	310.91	82.88	3.58	23.15	6.78
00022887	39.56	37.84	311.04	70.48	3.59	19.63	5.75
00022888	39.00	37.29	310.49	86.31	3.56	24.25	7.10
00022889	39.29	37.58	310.78	108.75	3.55	30.63	8.98
Top							
00022890	5.86	6.33	279.53	103.34	3.58	28.87	8.46
00022891	5.67	6.14	279.34	82.09	3.6	22.80	6.68
00022892	5.71	6.18	279.38	94.10	3.58	26.28	7.70
00022893	3.28	3.70	276.90	101.76	3.6	28.27	8.28

Q = 7.47 W/Ft^2 80.38 W/m^2
dT = 32.02 K
dL = 0.5 Ft   0.15 m

K_T = 0.383 ± 0.040 W/m-K

Temperature correction

Serial no.	Temp °C	Temp °F	Multiplication factor	Correct Temp °C
Bottom				
00022886	39.43	102.97	0.97	37.71
00022887	39.56	103.21	0.97	37.84
00022888	39.00	102.19	0.97	37.29
00022889	39.29	102.73	0.97	37.58
Top				
00022890	5.86	42.54	1.02	6.33
00022891	5.67	42.20	1.02	6.14
00022892	5.71	42.27	1.02	6.18
00022893	3.28	37.90	1.02	3.70

3-22-00 JP

Run TSw_TC_4

Rock mat - Topopah Spring welded tuff
Size - fine to ~6cm in diameter
Pretreatment - none

Waterbath setpoint - 5°C
Variable transformer setpoint - 50
Pressure applied to top aluminum plate 5 ft-lb.
Scan interval - 20 min

3-24-00 JP
0825

Final readings of heat flux sensors and thermocouples are shown on following page. Data is saved in a Microsoft Excel file named tsw_tc_4.xls.

Thermal conductivity calculation for run tsw_tc_4 is also shown on following pages.

3-24-00 JP Run tsw_tc_4 final readings.

Data Grid

	Channel	Reading	Time
1	<01>HF-00022886	-196.3840 uVdc	07:34:57.669 AM
2	<02>HF-00022887	-162.2010 uVdc	07:34:57.720 AM
3	<03>HF-00022888	-190.1810 uVdc	07:34:57.771 AM
4	<04>HF-00022889	-244.5560 uVdc	07:34:57.823 AM
5	<05>HF-00022890	226.2110 uVdc	07:34:57.874 AM
6	<06>HF-00022891	176.1910 uVdc	07:34:57.925 AM
7	<07>HF-00022892	203.2460 uVdc	07:34:57.976 AM
8	<08>HF-00022893	217.2360 uVdc	07:34:58.026 AM
9	<09>T-00022886	77.12500 C	07:34:58.077 AM
10	<10>T-00022887	77.20600 C	07:34:58.116 AM
11	<11>T-00022888	76.40500 C	07:34:58.155 AM
12	<12>T-00022889	76.82700 C	07:34:58.194 AM
13	<13>T-00022890	9.350000 C	07:34:58.233 AM
14	<14>T-00022891	9.096000 C	07:34:58.272 AM
15	<15>T-00022892	9.128000 C	07:34:58.311 AM
16	<16>T-00022893	6.813000 C	07:34:58.350 AM

Data Grid

	Channel	Reading	Time
1	<201>Thermocouple 1	41.49000 C	07:34:58.391 AM
2	<202>Thermocouple 2	38.01200 C	07:34:58.430 AM
3	<206>Thermocouple	74.55900 C	07:34:58.468 AM
4	<207>Thermocouple 4	75.26200 C	07:34:58.507 AM
5	<211>Thermocouple 5	75.46700 C	07:34:58.546 AM
6	<212>Thermocouple 6	75.77100 C	07:34:58.585 AM
7	<301>Thermocouple 7	8.905000 C	07:34:58.625 AM
8	<302>Thermocouple 8	8.084000 C	07:34:58.664 AM
9	<306>Thermocouple 9	7.837000 C	07:34:58.703 AM
10	<307>Thermocouple 10	7.906000 C	07:34:58.742 AM

3-24-00 JP Thermal conductivity calculation TSw-TC-4.

TSw_TC_4

Thermal Conductivity calculation using Fourier equation

Run = TSw_TC_4

Sample = Topapah Spring welded tuff (lower lithophysal unit)

$Q=K_T(dT/dL)$

where
- Q = heat transfer per unit area (W/Ft^2)
- K_T = thermal conductivity (W/m-K)
- dT = temperature difference between bottom and top sensors (K)
- dL = distance between bottom and top sensors (m)

Sensor readings

Serial no.	Temp °C	Correct Temp	Temp °K	Heat flow mV	Cal. constant $mV/Btu/Ft^2$-Hr	Heat flow Btu/Ft^2-Hr	Convert to W/Ft^2 1Btu/Hr = 0.293W
Bottom							
00022886	77.13	72.38	345.58	196.38	3.58	54.86	16.07
00022887	77.21	72.46	345.66	162.20	3.59	45.18	13.24
00022888	76.41	71.70	344.90	190.18	3.56	53.42	15.65
00022889	76.83	72.10	345.30	244.56	3.55	68.89	20.18
Top							
00022890	9.35	9.89	283.09	226.21	3.58	63.19	18.51
00022891	9.91	10.46	283.66	176.19	3.6	48.94	14.34
00022892	9.13	9.67	282.87	203.25	3.58	56.77	16.63
00022893	6.81	7.30	280.50	217.24	3.6	60.34	17.68

Q = 16.54 W/Ft^2 178.04 W/m^2

dT = 62.83 K

dL = 0.5 Ft   0.15 m

K_T = 0.432 ± 0.044 W/m-K

Temperature correction

Serial no.	Temp °C	Temp °F	Multiplication factor	Correct Temp °C
Bottom				
00022886	77.13	170.83	0.95	72.38
00022887	77.21	170.97	0.95	72.46
00022888	76.41	169.53	0.95	71.70
00022889	76.83	170.29	0.95	72.10
Top				
00022890	9.35	48.83	1.02	9.89
00022891	9.91	49.83	1.02	10.46
00022892	9.13	48.43	1.02	9.67
00022893	6.81	44.26	1.02	7.30

3-24-00 JP

Run TSw-TC-5

Rock used - Topapah Spring welded tuff
Size - Same to ~6cm in diameter
Pretreatment - None

Waterbath setpoint - 5°C
Variable Transformer setpoint - 60
Pressure applied to Top aluminum plate - 5 ft-lb
Scan interval - 30 min.

3-27-00 JP
Final readings of heat flux sensors and thermocouples and thermal conductivity calculation are shown on following pages.

Data is saved in MS Excel file named tsw_tc_5.xls.

3-27-00 gp Final reading tsw_tc_5 run.

Data Grid

	Channel	Reading	Time
1	<101>HF-00022886	-279.3980 uVdc	07:20:28.233 AM
2	<102>HF-00022887	-230.4340 uVdc	07:20:28.284 AM
3	<103>HF-00022888	-266.8600 uVdc	07:20:28.335 AM
4	<104>HF-00022889	-336.0170 uVdc	07:20:28.387 AM
5	<105>HF-00022890	298.7990 uVdc	07:20:28.438 AM
6	<106>HF-00022891	233.0740 uVdc	07:20:28.489 AM
7	<107>HF-00022892	268.8400 uVdc	07:20:28.540 AM
8	<108>HF-00022893	287.7130 uVdc	07:20:28.590 AM
9	<109>T-00022886	101.6710 C	07:20:28.641 AM
10	<110>T-00022887	101.7900 C	07:20:28.680 AM
11	<111>T-00022888	100.8320 C	07:20:28.719 AM
12	<112>T-00022889	101.2620 C	07:20:28.758 AM
13	<113>T-00022890	13.93800 C	07:20:28.797 AM
14	<114>T-00022891	13.64500 C	07:20:28.836 AM
15	<115>T-00022892	13.68100 C	07:20:28.875 AM
16	<116>T-00022893	11.43900 C	07:20:28.914 AM

Data Grid

	Channel	Reading	Time
1	<201>Thermocouple 1	52.29200 C	07:20:28.955 AM
2	<202>Thermocouple 2	47.45200 C	07:20:28.994 AM
3	<206>Thermocouple 3	98.74600 C	07:20:29.033 AM
4	<207>Thermocouple 4	99.41400 C	07:20:29.072 AM
5	<211>Thermocouple 5	99.57600 C	07:20:29.111 AM
6	<212>Thermocouple 6	99.85800 C	07:20:29.149 AM
7	<301>Thermocouple 7	14.29300 C	07:20:29.190 AM
8	<302>Thermocouple 8	12.59400 C	07:20:29.229 AM
9	<306>Thermocouple 9	11.53700 C	07:20:29.268 AM
10	<307>Thermocouple 10	11.41500 C	07:20:29.307 AM

3-27-00 gp Thermal conductivity calculation TSw_TC_5

TSw_TC_5

Thermal Conductivity calculation using Fourier equation

Run = TSw_TC_5

Sample = Topapah Spring welded tuff (lower lithophysal unit)

$Q=K_T(dT/dL)$

where
- Q = heat transfer per unit area (W/Ft^2)
- K_T = thermal conductivity (W/m-K)
- dT = temperature difference between bottom and top sensors (K)
- dL = distance between bottom and top sensors (m)

Sensor readings

Serial no.	Temp ^0C	Correct Temp	Temp ^0K	Heat flow mV	Cal. constant $mV/Btu/Ft^2$-Hr	Heat flow Btu/Ft^2-Hr	Convert to W/Ft^2 1Btu/Hr = 0.293W
Bottom							
00022886	101.67	94.50	367.70	279.40	3.58	78.04	22.87
00022887	101.79	94.62	367.82	230.43	3.59	64.19	18.81
00022888	100.83	93.72	366.92	266.86	3.56	74.96	21.96
00022889	101.26	94.12	367.32	336.02	3.55	94.65	27.73
Top							
00022890	13.94	14.26	287.46	298.80	3.58	83.46	24.45
00022891	13.65	13.96	287.16	233.07	3.6	64.74	18.97
00022892	13.68	14.00	287.20	268.84	3.58	75.09	22.00
00022893	11.44	11.73	284.93	287.71	3.6	79.92	23.42

Q = 22.53 W/Ft^2 242.48 W/m^2

dT = 80.75 K

dL = 0.5 Ft   0.15 m

K_T = 0.458 ± 0.047 W/m-K

Temperature correction

Serial no.	Temp ^0C	Temp ^0F	Multiplication factor	Correct Temp ^0C
Bottom				
00022886	101.67	215.01	0.94	94.50
00022887	101.79	215.22	0.94	94.62
00022888	100.83	213.50	0.94	93.72
00022889	101.26	214.27	0.94	94.12
Top				
00022890	13.94	57.09	1.01	14.26
00022891	13.65	56.56	1.01	13.96
00022892	13.68	56.63	1.01	14.00
00022893	11.44	52.59	1.01	11.73

3-27-00 gp 0820hr

Run TSw_TC_6

Rock used - Topopah Spring welded tuff
Size - Same to ~6cm in diameter
Pretreatment - none

Waterbath setpoint 5°C
Variable transformer setpoint - 70
Pressure applied to top aluminum plate - 5 ft-lb
Scan interval - 30 min.

3-29-00 gp 0800hr
Final readings of heat flux sensors and thermal ~~Thermocouples & thermal~~ conductivity calculations are shown on following pages.

Data for run TSw_TC_6 are saved in an MS Excel file named tsw-tc-6.xls.

3-29-00 gp Final readings, run TSw_TC_6.

Data Grid

	Channel	Reading	Time
1	<01>HF-00022886	-403.3260 uVdc	07:11:43.929 AM
2	<02>HF-00022887	-330.0780 uVdc	07:11:43.980 AM
3	<03>HF-00022888	-389.8640 uVdc	07:11:44.031 AM
4	<04>HF-00022889	-472.4820 uVdc	07:11:44.081 AM
5	<05>HF-00022890	397.1230 uVdc	07:11:44.132 AM
6	<06>HF-00022891	312.2610 uVdc	07:11:44.183 AM
7	<07>HF-00022892	360.5650 uVdc	07:11:44.234 AM
8	<08>HF-00022893	383.9250 uVdc	07:11:44.285 AM
9	<09>T-00022886	131.6250 C	07:11:44.335 AM
10	<10>T-00022887	131.8180 C	07:11:44.374 AM
11	<11>T-00022888	130.7360 C	07:11:44.413 AM
12	<12>T-00022889	131.1310 C	07:11:44.452 AM
13	<13>T-00022890	17.33200 C	07:11:44.491 AM
14	<14>T-00022891	16.97600 C	07:11:44.530 AM
15	<15>T-00022892	17.00500 C	07:11:44.569 AM
16	<16>T-00022893	14.77000 C	07:11:44.608 AM

Data Grid

	Channel	Reading	Time
1	<201>Thermocouple 1	63.00400 C	07:11:44.649 AM
2	<202>Thermocouple 2	56.64400 C	07:11:44.688 AM
3	<206>Thermocouple 3	128.3040 C	07:11:44.727 AM
4	<207>Thermocouple 4	129.0620 C	07:11:44.766 AM
5	<211>Thermocouple 5	129.1870 C	07:11:44.805 AM
6	<212>Thermocouple 6	129.3920 C	07:11:44.844 AM
7	<301>Thermocouple 7	17.57600 C	07:11:44.885 AM
8	<302>Thermocouple 8	15.76700 C	07:11:44.924 AM
9	<306>Thermocouple 9	14.30400 C	07:11:44.963 AM
10	<307>Thermocouple 10	14.11800 C	07:11:45.002 AM

3-29-00 gp Thermal conductivity calculation TSw_TC_6.

TSw_TC_6

Thermal Conductivity calculation using Fourier equation

Run = TSw_TC_6

Sample = Topapah Spring welded tuff (lower lithophysal unit)

$Q=K_T(dT/dL)$

where
- Q = heat transfer per unit area (W/Ft^2)
- K_T = thermal conductivity (W/m-K)
- dT = temperature difference between bottom and top sensors (K)
- dL = distance between bottom and top sensors (m)

Sensor readings

Serial no.	Temp °C	Correct Temp	Temp °K	Heat flow mV	Cal. constant $mV/Btu/Ft^2$-Hr	Heat flow Btu/Ft^2-Hr	Convert to W/Ft^2 1Btu/Hr = 0.293W
Bottom							
00022886	131.63	119.67	392.87	403.33	3.58	112.66	33.01
00022887	131.82	119.85	393.05	330.08	3.59	91.94	26.94
00022888	130.74	118.85	392.05	389.86	3.56	109.51	32.09
00022889	131.13	119.22	392.42	472.48	3.55	133.09	39.00
Top							
00022890	17.33	17.33	290.53	397.12	3.58	110.93	32.50
00022891	16.98	16.98	290.18	312.26	3.6	86.74	25.41
00022892	17.01	17.01	290.21	360.57	3.58	100.72	29.51
00022893	14.77	14.77	287.97	383.93	3.6	106.65	31.25

Q = 31.21 W/Ft^2 — 335.99 W/m^2

dT = 102.88 K

dL = 0.5 Ft — 0.15 m

K_T = **0.498 ± 0.051 W/m-K**

Temperature correction

Serial no.	Temp °C	Temp °F	Multiplication factor	Correct Temp °C
Bottom				
00022886	131.63	268.93	0.92	119.67
00022887	131.82	269.27	0.92	119.85
00022888	130.74	267.32	0.92	118.85
00022889	131.13	268.04	0.92	119.22
Top				
00022890	17.33	63.20	1	17.33
00022891	16.98	62.56	1	16.98
00022892	17.01	62.61	1	17.01
00022893	14.77	58.59	1	14.77

3-29-00 gp 0810 hr

Run TSw_TC_7

Rock used - Topapah Spring welded tuff
Size - Sieve to ~ 6 cm in diameter
Pretreatment - none

Waterbath setpoint - 5°C
Variable transformer setpoint - 80
Pressure applied to top dummy plate - 5 ft-lb
Scan interval - 30 min.

3-31-00 gp 0800 hr

Final readings of heat flux sensors and thermocouples and thermal conductivity calculation are shown on following page.

Data for run TSw_TC_7 are saved in a MS EXCEL file named tsw-tc-7.xls.

3-31-00 JP Final readings TSw_TC_7.

Data Grid

	Channel	Reading	Time
1	<101>HF-00022886	-552.8570 uVdc	07:24:26.872 AM
2	<102>HF-00022887	-433.9440 uVdc	07:24:26.923 AM
3	<103>HF-00022888	-510.6240 uVdc	07:24:26.974 AM
4	<104>HF-00022889	-617.3940 uVdc	07:24:27.025 AM
5	<105>HF-00022890	494.7860 uVdc	07:24:27.076 AM
6	<106>HF-00022891	396.4630 uVdc	07:24:27.126 AM
7	<107>HF-00022892	442.3910 uVdc	07:24:27.177 AM
8	<108>HF-00022893	479.8730 uVdc	07:24:27.228 AM
9	<109>T-00022886	160.9100 C	07:24:27.279 AM
10	<110>T-00022887	161.2260 C	07:24:27.318 AM
11	<111>T-00022888	160.1260 C	07:24:27.357 AM
12	<112>T-00022889	160.4410 C	07:24:27.396 AM
13	<113>T-00022890	22.51400 C	07:24:27.434 AM
14	<114>T-00022891	22.14900 C	07:24:27.473 AM
15	<115>T-00022892	22.14100 C	07:24:27.512 AM
16	<116>T-00022893	19.95000 C	07:24:27.551 AM

Data Grid

	Channel	Reading	Time
1	<201>Thermocouple 1	75.53500 C	07:24:27.591 AM
2	<202>Thermocouple 2	68.43300 C	07:24:27.631 AM
3	<206>Thermocouple 3	157.5730 C	07:24:27.670 AM
4	<207>Thermocouple 4	158.3990 C	07:24:27.708 AM
5	<211>Thermocouple 5	158.6270 C	07:24:27.747 AM
6	<212>Thermocouple 6	158.7210 C	07:24:27.787 AM
7	<301>Thermocouple 7	22.69500 C	07:24:27.827 AM
8	<302>Thermocouple 8	20.69000 C	07:24:27.866 AM
9	<306>Thermocouple 9	18.96100 C	07:24:27.905 AM
10	<307>Thermocouple 10	18.79400 C	07:24:27.944 AM

3-31-00 JP Thermal conductivity calculation TSw_TC_7

TSw_TC_7

Thermal Conductivity calculation using Fourier equation

Run = TSw_TC_7

Sample = Topapah Spring welded tuff (lower lithophysal unit)

$Q=K_T(dT/dL)$

where
- Q = heat transfer per unit area (W/Ft^2)
- K_T = thermal conductivity (W/m-K)
- dT = temperature difference between bottom and top sensors (K)
- dL = distance between bottom and top sensors (m)

Sensor readings

Serial no.	Temp °C	Correct Temp	Temp °K	Heat flow mV	Cal. constant mV/Btu/Ft²-Hr	Heat flow Btu/Ft²-Hr	Convert to W/Ft² 1Btu/Hr = 0.293W
Bottom							
00022886	160.91	143.04	416.24	552.86	3.58	154.43	45.25
00022887	161.23	143.33	416.53	433.94	3.59	120.88	35.42
00022888	160.13	142.34	415.54	510.62	3.56	143.43	42.03
00022889	160.44	142.62	415.82	617.39	3.55	173.91	50.96
Top							
00022890	22.51	22.51	295.71	494.79	3.58	138.21	40.50
00022891	22.15	22.15	295.35	396.46	3.6	110.13	32.27
00022892	22.14	22.14	295.34	442.39	3.58	123.57	36.21
00022893	19.95	19.95	293.15	479.87	3.6	133.30	39.06

Q = 40.21 W/Ft^2 — 432.82 W/m^2

dT = 121.14 K

dL = 0.5 Ft — 0.15 m

K_T = 0.545 ± 0.056 W/m-K

Temperature correction

Serial no.	Temp °C	Temp °F	Multiplication factor	Correct Temp °C
Bottom				
00022886	160.91	321.64	0.9	143.04
00022887	161.23	322.21	0.9	143.33
00022888	160.13	320.23	0.9	142.34
00022889	160.44	320.79	0.9	142.62
Top				
00022890	22.51	72.53	1	22.51
00022891	22.15	71.87	1	22.15
00022892	22.14	71.85	1	22.14
00022893	19.95	67.91	1	19.95

3-31-00 JP
0810hr

Run TSw-TC-8

Rock used - Topopah Spring welded tuff
Size - fines to ~6mm in diameter
Pretreatment - none.

~~Waterbath setpoint - 20°C~~ JP 3-31-00 1400hr
Variable transformer setpoint - ~~80~~ 40
Pressure to top alumi plate - 5 ft lb.
Scan Interval - 30 min.

4-3-00 JP 0800hr

Final readings of heat flux sensors and thermocouples and thermal conductivity calculation is shown on following page.

Data for run TSw-TC-8 are saved in an MS Excel file named tsw-tc-8.xls.

4-3-00 JP Final readings TSw-TC-8

Data Grid

	Channel	Reading	Time
1	<101>HF-00022886	-133.0340 uVdc	07:46:53.507 AM
2	<102>HF-00022887	-102.9430 uVdc	07:46:53.558 AM
3	<103>HF-00022888	-129.3390 uVdc	07:46:53.609 AM
4	<104>HF-00022889	-159.4300 uVdc	07:46:53.660 AM
5	<105>HF-00022890	142.2730 uVdc	07:46:53.711 AM
6	<106>HF-00022891	116.8010 uVdc	07:46:53.761 AM
7	<107>HF-00022892	126.6990 uVdc	07:46:53.812 AM
8	<108>HF-00022893	139.8970 uVdc	07:46:53.863 AM
9	<109>T-00022886	67.91300 C	07:46:53.914 AM
10	<110>T-00022887	68.08800 C	07:46:53.953 AM
11	<111>T-00022888	67.50000 C	07:46:53.992 AM
12	<112>T-00022889	67.75800 C	07:46:54.031 AM
13	<113>T-00022890	23.68700 C	07:46:54.070 AM
14	<114>T-00022891	23.50200 C	07:46:54.109 AM
15	<115>T-00022892	23.51400 C	07:46:54.148 AM
16	<116>T-00022893	21.16000 C	07:46:54.187 AM

Data Grid

	Channel	Reading	Time
1	<201>Thermocouple 1	35.88400 C	07:46:54.228 AM
2	<202>Thermocouple 2	33.38900 C	07:46:54.266 AM
3	<206>Thermocouple 3	65.62400 C	07:46:54.305 AM
4	<207>Thermocouple 4	66.33200 C	07:46:54.344 AM
5	<211>Thermocouple 5	66.67400 C	07:46:54.384 AM
6	<212>Thermocouple 6	66.89200 C	07:46:54.422 AM
7	<301>Thermocouple 7	24.43200 C	07:46:54.463 AM
8	<302>Thermocouple 8	23.84100 C	07:46:54.502 AM
9	<306>Thermocouple 9	21.21800 C	07:46:54.541 AM
10	<307>Thermocouple 10	20.65400 C	07:46:54.580 AM

4-3-00 JP Thermal Conductivity calculation TSw-TC-8.

TSw_TC_8

Thermal Conductivity calculation using Fourier equation

Run = TSw_TC_8

Sample = Topapah Spring welded tuff (lower lithophysal unit)

$Q=K_T(dT/dL)$

where
- Q = heat transfer per unit area (W/Ft^2)
- K_T = thermal conductivity (W/m-K)
- dT = temperature difference between bottom and top sensors (K)
- dL = distance between bottom and top sensors (m)

Sensor readings

Serial no.	Temp ^0C	Correct Temp	Temp ^0K	Heat flow mV	Cal. constant $mV/Btu/Ft^2$-Hr	Heat flow Btu/Ft^2-Hr	Convert to W/Ft^2 1Btu/Hr = 0.293W
Bottom							
00022886	67.91	64.49	337.69	133.03	3.58	37.16	10.89
00022887	68.09	64.65	337.85	102.94	3.59	28.67	8.40
00022888	67.50	64.09	337.29	129.34	3.56	36.33	10.65
00022889	67.76	64.34	337.54	159.43	3.55	44.91	13.16
Top							
00022890	23.69	23.69	296.89	142.27	3.58	39.74	11.64
00022891	23.50	23.50	296.70	116.80	3.6	32.44	9.51
00022892	23.51	23.51	296.71	126.70	3.58	35.39	10.37
00022893	21.16	21.16	294.36	139.90	3.6	38.86	11.39

Q = 10.75 W/Ft^2 115.71 W/m^2

dT = 41.43 K

dL = 0.5 Ft   0.15 m

K_T = 0.426 ± 0.044 W/m-K

Temperature correction

Serial no.	Temp ^0C	Temp ^0F	Multiplication factor	Correct Temp ^0C
Bottom				
00022886	67.91	154.24	0.96	64.49
00022887	68.09	154.56	0.96	64.65
00022888	67.50	153.50	0.96	64.09
00022889	67.76	153.96	0.96	64.34
Top				
00022890	23.69	74.64	1	23.69
00022891	23.50	74.30	1	23.50
00022892	23.51	74.33	1	23.51
00022893	21.16	70.09	1	21.16

4-3-00 JP 0815 hr

Run TSw TC_9

Rock used - Topapah Spring welded tuff
Size - fines to ~6cm in diameter
Pretreatment - none

Waterbath setpoint - 20°C
Variable transformer setpoint - ~~30~~ 25 JP 4-3-00 1430 hr
Pressure on top aluminum plate - 5 ft lb
Scan Interval - 30 min.

4-4-00 JP 1300 hr

Final readings of heat flux sensors and thermocouple and thermal conductivity calculation is shown on following pages.

Data for run TSw_TC-9 are stored in a MS Excel file named tsw-tc.9.xls.

4-4-00 JP 1310hr Final readings TSw_TC-9.

Data Grid

	Channel	Reading	Time
1	<101>HF-00022886	-58.99400 uVdc	11:05:01.553 AM
2	<102>HF-00022887	-47.64400 uVdc	11:05:01.604 AM
3	<103>HF-00022888	-58.33400 uVdc	11:05:01.654 AM
4	<104>HF-00022889	-72.19200 uVdc	11:05:01.705 AM
5	<105>HF-00022890	70.74000 uVdc	11:05:01.756 AM
6	<106>HF-00022891	59.12600 uVdc	11:05:01.807 AM
7	<107>HF-00022892	64.80100 uVdc	11:05:01.857 AM
8	<108>HF-00022893	69.94800 uVdc	11:05:01.908 AM
9	<109>T-00022886	41.62100 C	11:05:01.959 AM
10	<110>T-00022887	41.76300 C	11:05:01.998 AM
11	<111>T-00022888	41.30100 C	11:05:02.040 AM
12	<112>T-00022889	41.51100 C	11:05:02.079 AM
13	<113>T-00022890	18.68800 C	11:05:02.118 AM
14	<114>T-00022891	18.58200 C	11:05:02.157 AM
15	<115>T-00022892	18.57500 C	11:05:02.196 AM
16	<116>T-00022893	16.12600 C	11:05:02.235 AM

Data Grid

	Channel	Reading	Time
1	<201>Thermocouple 1	26.58900 C	11:05:02.275 AM
2	<202>Thermocouple 2	25.61500 C	11:05:02.314 AM
3	<206>Thermocouple 3	39.54200 C	11:05:02.353 AM
4	<207>Thermocouple 4	40.23200 C	11:05:02.392 AM
5	<211>Thermocouple 5	40.60200 C	11:05:02.431 AM
6	<212>Thermocouple 6	40.81100 C	11:05:02.470 AM
7	<301>Thermocouple 7	19.30100 C	11:05:02.511 AM
8	<302>Thermocouple 8	18.84800 C	11:05:02.550 AM
9	<306>Thermocouple 9	16.69300 C	11:05:02.589 AM
10	<307>Thermocouple 10	16.34300 C	11:05:02.628 AM

4-4-00 JP 1310hr Thermal conductivity calculation TSw_TC-9.

TSw_TC_9

Thermal Conductivity calculation using Fourier equation

Run = TSw_TC_9

Sample = Topapah Spring welded tuff (lower lithophysal unit)

$Q=K_T(dT/dL)$

where
- Q = heat transfer per unit area (W/Ft^2)
- K_T = thermal conductivity (W/m-K)
- dT = temperature difference between bottom and top sensors (K)
- dL = distance between bottom and top sensors (m)

Sensor readings

Serial no.	Temp ^0C	Correct Temp	Temp ^0K	Heat flow mV	Cal. constant $mV/Btu/Ft^2$-Hr	Heat flow Btu/Ft^2-Hr	Convert to W/Ft^2 1Btu/Hr = 0.293W
Bottom							
00022886	41.62	39.84	313.04	58.99	3.58	16.48	4.83
00022887	41.76	39.98	313.18	47.64	3.59	13.27	3.89
00022888	41.30	39.53	312.73	58.33	3.56	16.39	4.80
00022889	41.51	39.73	312.93	72.19	3.55	20.34	5.96
Top							
00022890	18.69	18.69	291.89	70.74	3.58	19.76	5.79
00022891	18.58	18.58	291.78	59.13	3.6	16.42	4.81
00022892	18.58	18.58	291.78	64.80	3.58	18.10	5.30
00022893	16.13	16.13	289.33	69.95	3.6	19.43	5.69

Q = 5.13 W/Ft^2 55.27 W/m^2

dT = 21.78 K

dL = 0.5 Ft 0.15 m

K_T = 0.387 ± 0.040 W/m-K

Temperature correction

Serial no.	Temp ^0C	Temp ^0F	Multiplication factor	Correct Temp ^0C
Bottom				
00022886	41.62	106.92	0.97	39.84
00022887	41.76	107.17	0.97	39.98
00022888	41.30	106.34	0.97	39.53
00022889	41.51	106.72	0.97	39.73
Top				
00022890	18.69	65.64	1	18.69
00022891	18.58	65.45	1	18.58
00022892	18.58	65.44	1	18.58
00022893	16.13	61.03	1	16.13

4-4-00 JP 1310 hr

Run TSw-TC-10

Rock used - Topopah Spring welded tuff
Size - Sieve to ~6 cm in diameter
~~Pretreatment~~ - None

Waterbath setpoint - 20°C
Variable Transformer setpoint - 55
Pressure on top plate - 5 ft lb.
Scan Interval - 30 min

4-5-00 JP 1330 hr.

Final readings of heat flux sensors, thermocouples & thermal conductivity calculation for TSw-TC-10 is shown on following pages.

Data are saved in a MS Excel file named tsw-tc-10.xls

4-5-00 JP Final readings TSw-TC-10.

Data Grid

	Channel	Reading	Time
1	<101>HF-00022886	-241.5200 uVdc	11:30:21.843 AM
2	<102>HF-00022887	-183.9780 uVdc	11:30:21.894 AM
3	<103>HF-00022888	-225.8150 uVdc	11:30:21.945 AM
4	<104>HF-00022889	-279.5300 uVdc	11:30:21.996 AM
5	<105>HF-00022890	231.0940 uVdc	11:30:22.046 AM
6	<106>HF-00022891	187.8050 uVdc	11:30:22.097 AM
7	<107>HF-00022892	204.3020 uVdc	11:30:22.148 AM
8	<108>HF-00022893	226.7390 uVdc	11:30:22.199 AM
9	<109>T-00022886	93.01600 C	11:30:22.249 AM
10	<110>T-00022887	93.20400 C	11:30:22.288 AM
11	<111>T-00022888	92.46800 C	11:30:22.327 AM
12	<112>T-00022889	92.74300 C	11:30:22.366 AM
13	<113>T-00022890	20.88900 C	11:30:22.405 AM
14	<114>T-00022891	20.66500 C	11:30:22.445 AM
15	<115>T-00022892	20.66000 C	11:30:22.484 AM
16	<116>T-00022893	18.32000 C	11:30:22.522 AM

Data Grid

	Channel	Reading	Time
1	<201>Thermocouple 1	46.82000 C	11:30:22.563 AM
2	<202>Thermocouple 2	42.55300 C	11:30:22.602 AM
3	<206>Thermocouple 3	90.40300 C	11:30:22.641 AM
4	<207>Thermocouple 4	91.10500 C	11:30:22.680 AM
5	<211>Thermocouple 5	91.40000 C	11:30:22.719 AM
6	<212>Thermocouple 6	91.56900 C	11:30:22.757 AM
7	<301>Thermocouple 7	21.30500 C	11:30:22.798 AM
8	<302>Thermocouple 8	20.37100 C	11:30:22.837 AM
9	<306>Thermocouple 9	18.12300 C	11:30:22.876 AM
10	<307>Thermocouple 10	17.71600 C	11:30:22.915 AM

4-5-00 gp Thermal Conductivity calculation TSw_TC_10.

TSw_TC_10

Thermal Conductivity calculation using Fourier equation

Run = TSw_TC_10

Sample = Topapah Spring welded tuff (lower lithophysal unit)

$Q=K_T(dT/dL)$

where
- Q = heat transfer per unit area (W/Ft^2)
- K_T = thermal conductivity (W/m-K)
- dT = temperature difference between bottom and top sensors (K)
- dL = distance between bottom and top sensors (m)

Sensor readings

Serial no.	Temp °C	Correct Temp	Temp °K	Heat flow mV	Cal. constant $mV/Btu/Ft^2$-Hr	Heat flow Btu/Ft^2-Hr	Convert to W/Ft^2 1Btu/Hr = 0.293W
Bottom							
00022886	93.02	86.37	359.57	241.52	3.58	67.46	19.77
00022887	93.20	86.55	359.75	183.98	3.59	51.25	15.02
00022888	92.47	85.85	359.05	225.82	3.56	63.43	18.59
00022889	92.74	86.11	359.31	279.53	3.55	78.74	23.07
Top							
00022890	20.89	20.89	294.09	231.09	3.58	64.55	18.91
00022891	20.67	20.67	293.87	187.81	3.6	52.17	15.29
00022892	20.66	20.66	293.86	204.30	3.58	57.07	16.72
00022893	18.32	18.32	291.52	226.74	3.6	62.98	18.45

Q = 18.23 W/Ft^2 — 196.20 W/m^2

dT = 66.09 K

dL = 0.5 Ft — 0.15 m

K_T = 0.452 ± 0.047 W/m-K

Temperature correction

Serial no.	Temp °C	Temp °F	Multiplication factor	Correct Temp °C
Bottom				
00022886	93.02	199.43	0.94	86.37
00022887	93.20	199.77	0.94	86.55
00022888	92.47	198.44	0.94	85.85
00022889	92.74	198.94	0.94	86.11
Top				
00022890	20.89	69.60	1	20.89
00022891	20.67	69.20	1	20.67
00022892	20.66	69.19	1	20.66
00022893	18.32	64.98	1	18.32

4-5-00 gp 1330 hr

Run TSw_TC_11

Rock used - Topapah Spring welded tuff
Size - 5mm to ~6cm in diameter
Pretreatment - none

Waterbath setpoint 20°C
Variable transformer setpoint - 70
Pressure on top plate 5 ft lb
Scan interval - 30 min.

4-6-00 gp 1450 hr.

Final readings of heat flux sensor, thermocouples + thermal conductivity calculation for TSw_TC_11 is shown on following pages.

Data are stored in a MS Excel file named tsw-tc-11.xls

4-6-00 gp Final readings TSw_TC_11

Data Grid			
	Channel	Reading	Time
1	<101>HF-00022886	-394.3510 uVdc	12:58:30.584 PM
2	<102>HF-00022887	-293.1240 uVdc	12:58:30.635 PM
3	<103>HF-00022888	-348.6870 uVdc	12:58:30.686 PM
4	<104>HF-00022889	-436.7160 uVdc	12:58:30.737 PM
5	<105>HF-00022890	362.9400 uVdc	12:58:30.788 PM
6	<106>HF-00022891	296.2910 uVdc	12:58:30.839 PM
7	<107>HF-00022892	320.1790 uVdc	12:58:30.890 PM
8	<108>HF-00022893	354.2300 uVdc	12:58:30.940 PM
9	<109>T-00022886	129.5170 C	12:58:30.991 PM
10	<110>T-00022887	129.6830 C	12:58:31.030 PM
11	<111>T-00022888	128.7170 C	12:58:31.069 PM
12	<112>T-00022889	129.0930 C	12:58:31.108 PM
13	<113>T-00022890	22.79600 C	12:58:31.147 PM
14	<114>T-00022891	22.51300 C	12:58:31.186 PM
15	<115>T-00022892	22.48600 C	12:58:31.226 PM
16	<116>T-00022893	20.27100 C	12:58:31.265 PM

Data Grid			
	Channel	Reading	Time
1	<201>Thermocouple 1	61.90900 C	12:58:31.305 PM
2	<202>Thermocouple 2	55.84000 C	12:58:31.344 PM
3	<206>Thermocouple 3	126.2220 C	12:58:31.383 PM
4	<207>Thermocouple 4	126.9980 C	12:58:31.422 PM
5	<211>Thermocouple 5	127.1370 C	12:58:31.461 PM
6	<212>Thermocouple 6	127.3490 C	12:58:31.500 PM
7	<301>Thermocouple 7	23.09000 C	12:58:31.540 PM
8	<302>Thermocouple 8	21.81100 C	12:58:31.579 PM
9	<306>Thermocouple 9	19.73900 C	12:58:31.618 PM
10	<307>Thermocouple 10	19.23600 C	12:58:31.657 PM

4-6-00 gp Thermal Conductivity TSw_TC_11.

TSw_TC_11

Thermal Conductivity calculation using Fourier equation

Run = TSw_TC_11

Sample = Topapah Spring welded tuff (lower lithophysal unit)

$Q=K_T(dT/dL)$

where
- Q =heat transfer per unit area (W/Ft^2)
- K_T = thermal conductivity (W/m-K)
- dT = temperature difference between bottom and top sensors (K)
- dL = distance between bottom and top sensors (m)

Sensor readings

Serial no.	Temp ^{0}C	Correct Temp	Temp ^{0}K	Heat flow mV	Cal. constant mV/Btu/Ft^2-Hr	Heat flow Btu/Ft^2-Hr	Convert to W/Ft^2 1Btu/Hr = 0.293W
Bottom							
00022886	129.52	119.21	392.41	394.35	3.58	110.15	32.28
00022887	129.68	119.36	392.56	293.12	3.59	81.65	23.92
00022888	128.72	118.46	391.66	348.69	3.56	97.95	28.70
00022889	129.09	118.81	392.01	436.72	3.55	123.02	36.04
Top							
00022890	22.80	22.80	296.00	362.94	3.58	101.38	29.70
00022891	22.51	22.51	295.71	296.29	3.6	82.30	24.11
00022892	22.49	22.49	295.69	320.18	3.58	89.44	26.20
00022893	20.27	20.27	293.47	354.23	3.6	98.40	28.83

Q = 28.72 W/Ft^2 309.20 W/m^2

dT = 96.94 K

dL = 0.5 Ft   0.15 m

K_T = **0.486 ± 0.050 W/m-K**

Temperature correction

Serial no.	Temp ^{0}C	Temp ^{0}F	Multiplication factor	Correct Temp ^{0}C
Bottom				
00022886	129.52	265.13	0.93	119.21
00022887	129.68	265.43	0.93	119.36
00022888	128.72	263.69	0.93	118.46
00022889	129.09	264.37	0.93	118.81
Top				
00022890	22.80	73.03	1	22.80
00022891	22.51	72.52	1	22.51
00022892	22.49	72.47	1	22.49
00022893	20.27	68.49	1	20.27

4-6-00 JP 1500 hrs.

Run TSw_TC_12

Rockwell - Topopah Spring welded tuff
Size - 5mm to ~16cm in diameter
Pretreated - None

Waterbath setpoint -20°C
Variable transformer setpoint - 85
Pressure on top plate 554 lb
Scan Interval - 30 min.

4-7-00 JP 1600 hr

Final readings of heat flux sensors, thermocouples + thermal conductivity calculated for TSw_TC_12 are shown on following pages.

Data are saved in file tsw-tc-12.xls.

4-7-00 JP Final readings TSw_TC_12

Data Grid

	Channel	Reading	Time
1	<101>HF-00022886	-621.6180 uVdc	02:15:40.248 PM
2	<102>HF-00022887	-473.1420 uVdc	02:15:40.299 PM
3	<103>HF-00022888	-550.3490 uVdc	02:15:40.350 PM
4	<104>HF-00022889	-660.6830 uVdc	02:15:40.401 PM
5	<105>HF-00022890	532.9280 uVdc	02:15:40.451 PM
6	<106>HF-00022891	435.6600 uVdc	02:15:40.502 PM
7	<107>HF-00022892	470.2380 uVdc	02:15:40.553 PM
8	<108>HF-00022893	517.4870 uVdc	02:15:40.604 PM
9	<109>T-00022886	173.9240 C	02:15:40.654 PM
10	<110>T-00022887	174.2630 C	02:15:40.693 PM
11	<111>T-00022888	173.1570 C	02:15:40.732 PM
12	<112>T-00022889	173.4440 C	02:15:40.771 PM
13	<113>T-00022890	24.99800 C	02:15:40.810 PM
14	<114>T-00022891	24.59400 C	02:15:40.849 PM
15	<115>T-00022892	24.55700 C	02:15:40.888 PM
16	<116>T-00022893	22.46400 C	02:15:40.927 PM

Data Grid

	Channel	Reading	Time
1	<201>Thermocouple 1	79.43700 C	02:15:40.968 PM
2	<202>Thermocouple 2	71.34500 C	02:15:41.007 PM
3	<206>Thermocouple 3	170.5320 C	02:15:41.046 PM
4	<207>Thermocouple 4	171.4180 C	02:15:41.089 PM
5	<211>Thermocouple 5	171.6390 C	02:15:41.128 PM
6	<212>Thermocouple 6	171.7020 C	02:15:41.167 PM
7	<301>Thermocouple 7	25.36900 C	02:15:41.207 PM
8	<302>Thermocouple 8	23.15000 C	02:15:41.246 PM
9	<306>Thermocouple 9	21.26900 C	02:15:41.285 PM
10	<307>Thermocouple 10	20.68200 C	02:15:41.324 PM

4-7-00 gp Thermal conductivity TSw_TC_12

TSw_TC_12

Thermal Conductivity calculation using Fourier equation

Run = TSw_TC_12

Sample = Topapah Spring welded tuff (lower lithophysal unit)

$Q=K_T(dT/dL)$

where
- Q = heat transfer per unit area (W/Ft^2)
- K_T = thermal conductivity (W/m-K)
- dT = temperature difference between bottom and top sensors (K)
- dL = distance between bottom and top sensors (m)

Sensor readings

Serial no.	Temp ^0C	Correct Temp	Temp ^0K	Heat flow mV	Cal. constant $mV/Btu/Ft^2$-Hr	Heat flow Btu/Ft^2-Hr	Convert to W/Ft^2 1Btu/Hr = 0.293W
Bottom							
00022886	173.92	152.84	426.04	621.62	3.58	173.64	50.88
00022887	174.26	153.14	426.34	473.14	3.59	131.79	38.62
00022888	173.16	152.15	425.35	550.35	3.56	154.59	45.30
00022889	173.44	152.41	425.61	660.68	3.55	186.11	54.53
Top							
00022890	25.00	25.00	298.20	532.93	3.58	148.86	43.62
00022891	24.59	24.59	297.79	435.66	3.6	121.02	35.46
00022892	24.56	24.56	297.76	470.24	3.58	131.35	38.49
00022893	22.46	22.46	295.66	517.49	3.6	143.75	42.12

Q = 43.62 W/Ft^2 469.58 W/m^2

dT = 128.48 K

dL = 0.5 Ft   0.15 m

K_T = **0.557 ± 0.057 W/m-K**

Temperature correction

Serial no.	Temp ^0C	Temp ^0F	Multiplication factor	Correct Temp ^0C
Bottom				
00022886	173.92	345.06	0.89	152.84
00022887	174.26	345.67	0.89	153.14
00022888	173.16	343.68	0.89	152.15
00022889	173.44	344.20	0.89	152.41
Top				
00022890	25.00	77.00	1	25.00
00022891	24.59	76.27	1	24.59
00022892	24.56	76.20	1	24.56
00022893	22.46	72.44	1	22.46

7/5/00 JP

Thermal conductivity of glass plate fracture model assembly.

Obj - assemble steady-state thermal conductivity apparatus to measure the thermal properties of the glass plate fracture model apparatus (see scientific notebook # p.

Method - measure heat flux through the glass plate model apparatus.

Equipment - Materials - Supplies
Most of equipment & materials are listed on p13 and 14. with the addition of the following.

- 4 single heat flux sensors from RdF (S/N 00067902 thru 00069905)
- Fiberglass insulation
- Kevlar insulation
- glass plate fracture assembly
  - 2 15"x15"x1" lexan sheets
  - 2 15"x12"x3/8" annealed glass plate; one side of each plate sandblasted to grit size of 4.
  - 1 15"x12"x1/4" aluminum sheet
  - 1 15"x12"x1/8" kevlar

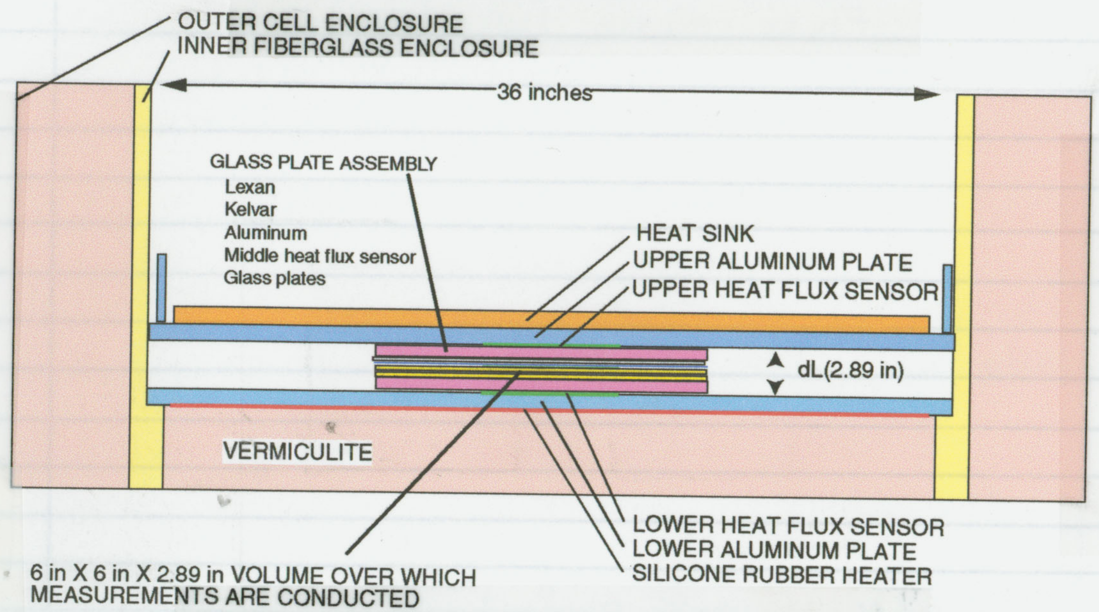
- Hewlett Packard 3458A multimeter
- Fluke Hydra Data Logger.

Assembly

The thermal conductivity apparatus was assembled as explained on p15-36 with the following modifications

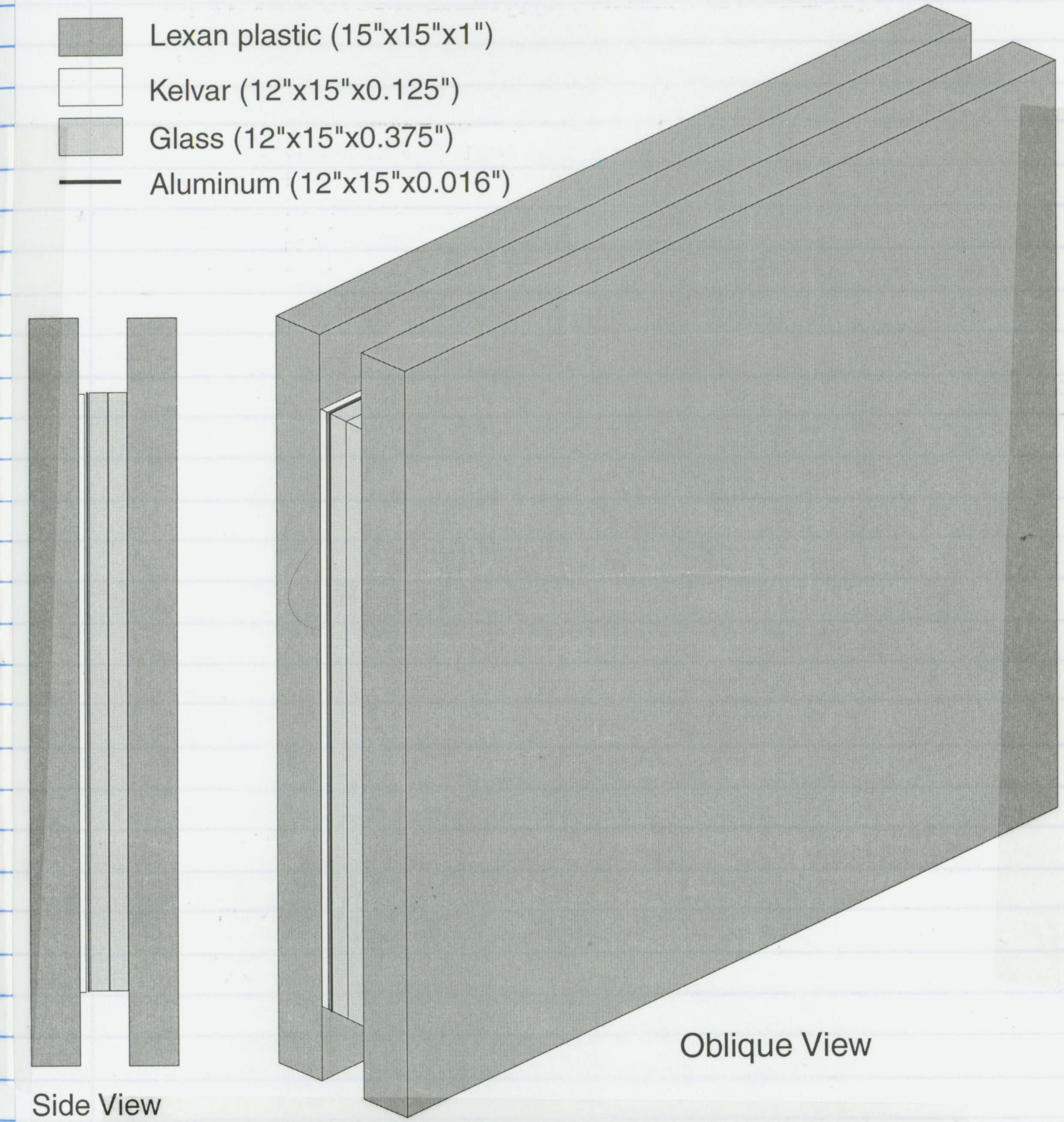
1. The fiberglass insert was removed to accomodate the smaller size of the glass plate assembly.

A schematic diagram of the modified apparatus containing that glass plate sample assembly is shown ~~below~~ JP 7/5/00 on the following page.

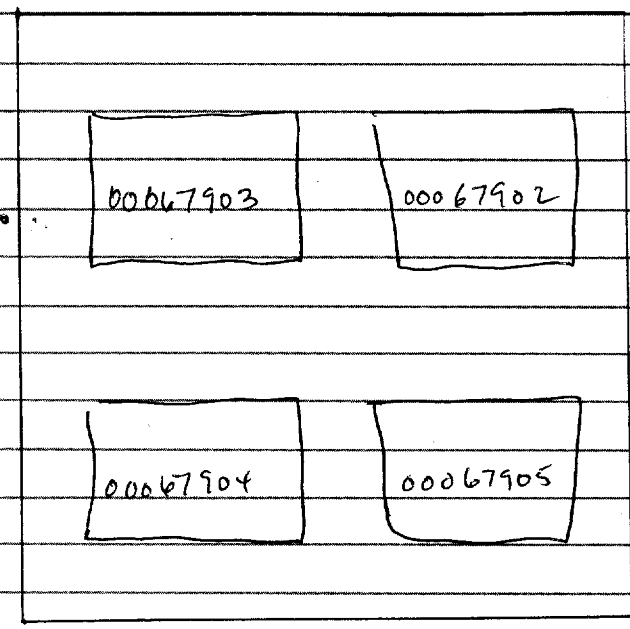


A schematic of the glass plate fracture model assembly is shown on the following page.

For the thermal conductivity measurement of the glass plate assembly, 4 additional single heat flux sensors were placed between the aluminum sheet and adjacent glass plate. This allowed for measurement of heat flux and temperature in the middle of the assembly. The sensors were placed in a 6" x 6" volume in the middle of the assembly, similar to the sensors at the top + bottom of the enclosure.



Below is a diagram showing the location of serial no of each heat flux sensor mounted in the middle of the glass plate assembly.



Front of box

Type K thermocouples are also attached to each sensor.

Calibration certificate for each additional sensor is attached on the following pages.

RdF
ISO 9001 CERTIFIED

RdF Corporation
23 Elm Avenue
Hudson, New Hampshire 03051-0490
Tele: (603) 882-5195 1-800-445-8367
Fax: (603) 882-6925
E-mail: sensor@rdfcorp.com

Q-116-08 REV A
Q-116-12 REV A

MICRO-FOIL™ HEAT FLUX SENSOR

CALIBRATION

RdF PART NO. 27070-1

SERIAL NO. 00067902

HEAT FLUX SENSOR:

Output at 70°F: 3.70 μV/BTU/ft² hr

Polarity: (For heat flow into the surface)
White - Positive (+)
Red - Negative (-)

Temperature Multiplication Factor: See Attached Graph

*Thermal Resistance: 0.01 °F/BTU/ft² hr (Typ)

*Heat Capacity: 0.03 BTU/ft² hr/°F (Typ)

Response Time: 0.60 sec (62% response to step function) (Typ)

THERMOCOUPLE:

ANSI TYPE	MATERIAL	POLARITY	COLOR
K	Chromel Alumel	Pos. (+) Neg. (-)	Yellow Red

Output per ANSI MC96.1-1975 and NBS Monograph 125

*Thermal resistance is the temperature difference between the front surface and rear mounting surface of the sensor per unit of heat flow through the sensor. Heat capacity is the amount of heat required to raise the mean temperature of the sensor 1°F. Typical values of these two properties are given primarily to indicate sensor capabilities and are required for heat flow calculations only in very rare instances.

BY: Elaine Tardiff DATE: 6-29-00

RdF Corporation
Specialists in Temperature Measurement

RdF
ISO 9001 CERTIFIED

RdF Corporation
23 Elm Avenue
Hudson, New Hampshire 03051-0490
Tele: (603) 882-5195 1-800-445-8367
Fax: (603) 882-6925
E-mail: sensor@rdfcorp.com

Q-116-08 REV A
Q-116-12 REV A

MICRO-FOIL™ HEAT FLUX SENSOR

CALIBRATION

RdF PART NO. 27070-1

SERIAL NO: 00067903

HEAT FLUX SENSOR:

Output at 70°F: 3·66 μV/BTU/ ft² hr

Polarity: (For heat flow into the surface)
White - Positive (+)
Red - Negative (-)

Temperature Multiplication Factor: See Attached Graph

*Thermal Resistance: 0·01 °F/BTU/ft² hr (Typ)

*Heat Capacity: 0·03 BTU/ft² hr/°F (Typ)

Response Time: 0·60 sec (62% response to step function) (Typ)

THERMOCOUPLE:

ANSI TYPE	MATERIAL	POLARITY	COLOR
K	Chromel Alumel	Pos. (+) Neg. (-)	Yellow Red

Output per ANSI MC96.1-1975 and NBS Monograph 125

*Thermal resistance is the temperature difference between the front surface and rear mounting surface of the sensor per unit of heat flow through the sensor. Heat capacity is the amount of heat required to raise the mean temperature of the sensor 1°F. Typical values of these two properties are given primarily to indicate sensor capabilities and are required for heat flow calculations only in very rare instances.

BY: Elaine Tardiff DATE: 6-29-00

RdF Corporation
Specialists in Temperature Measurement

RdF
ISO 9001 CERTIFIED

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Q-116-08 REV A
Q-116-12 REV A

MICRO-FOIL™ HEAT FLUX SENSOR

CALIBRATION

RdF PART NO. 27070-1

SERIAL NO. 00067904

HEAT FLUX SENSOR:

Output at 70°F: 366 μV/BTU/ ft² hr

Polarity: (For heat flow into the surface)
White - Positive (+)
Red - Negative (-)

Temperature Multiplication Factor: See Attached Graph

*Thermal Resistance: 0·01 °F/BTU/ft² hr (Typ)

*Heat Capacity: 0·03 BTU/ft² hr/°F (Typ)

Response Time: 0·60 sec (62% response to step function) (Typ)

THERMOCOUPLE:

ANSI TYPE	MATERIAL	POLARITY	COLOR
K	Chromel Alumel	Pos. (+) Neg. (-)	Yellow Red

Output per ANSI MC96.1-1975 and NBS Monograph 125

*Thermal resistance is the temperature difference between the front surface and rear mounting surface of the sensor per unit of heat flow through the sensor. Heat capacity is the amount of heat required to raise the mean temperature of the sensor 1°F. Typical values of these two properties are given primarily to indicate sensor capabilities and are required for heat flow calculations only in very rare instances.

BY: Elaine Tardiff DATE: 6-29-00

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Q-116-08 REV A
Q-116-12 REV A

MICRO-FOIL™ HEAT FLUX SENSOR

CALIBRATION

RdF PART NO. 27070-1

SERIAL NO. 00067905

HEAT FLUX SENSOR:

Output at 70°F: 3.45 µV/BTU/ft² hr

Polarity: (For heat flow into the surface)
White - Positive (+)
Red - Negative (-)

Temperature Multiplication Factor: See Attached Graph

*Thermal Resistance: 0.01 °F/BTU/ft² hr (Typ)

*Heat Capacity: 0.03 BTU/ft² hr/°F (Typ)

Response Time: 0.60 sec (62% response to step function) (Typ)

THERMOCOUPLE:

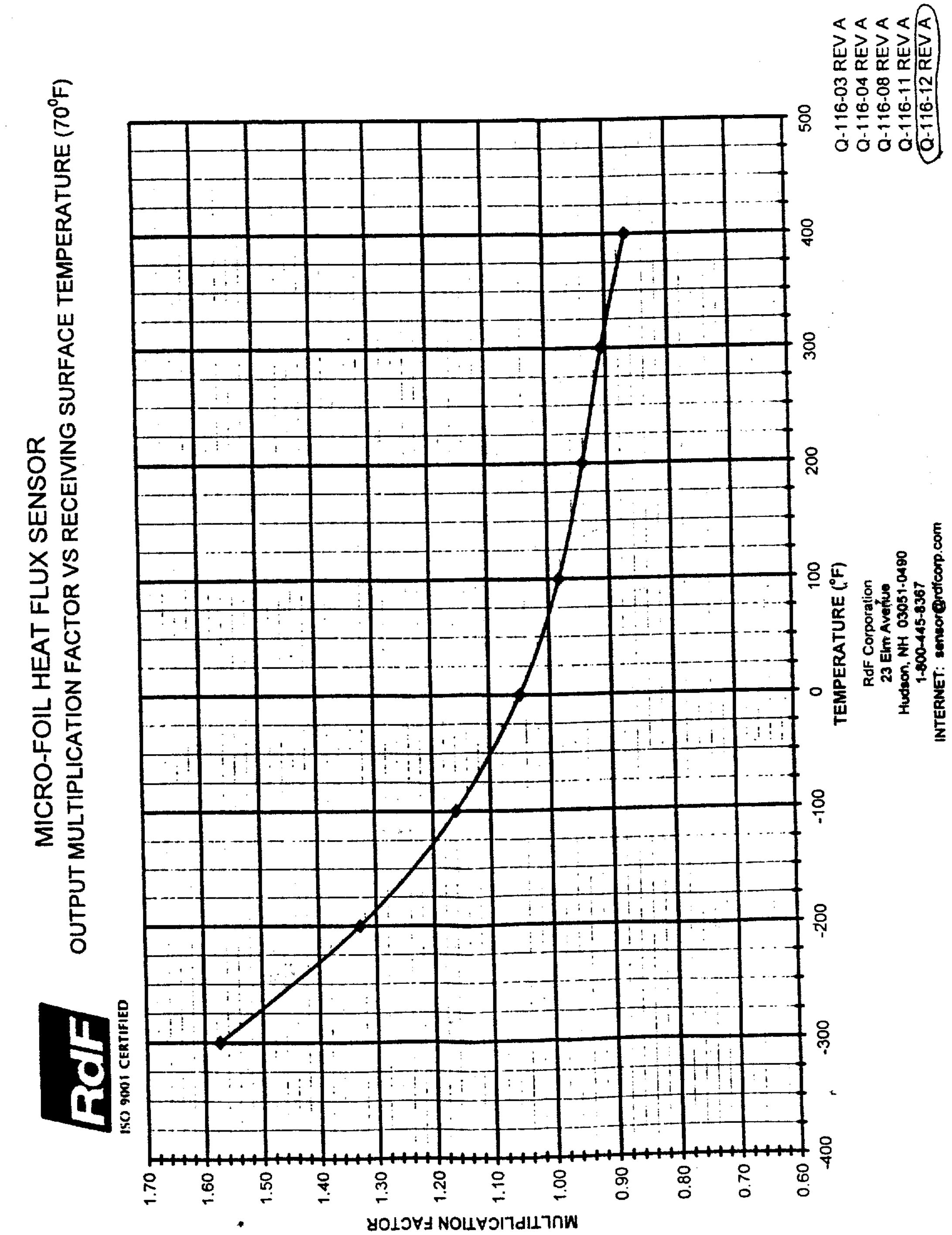
ANSI TYPE	MATERIAL	POLARITY	COLOR
K	Chromel Alumel	Pos. (+) Neg. (-)	Yellow Red

Output per ANSI MC96.1-1975 and NBS Monograph 125

*Thermal resistance is the temperature difference between the front surface and rear mounting surface of the sensor per unit of heat flow through the sensor. Heat capacity is the amount of heat required to raise the mean temperature of the sensor 1°F. Typical values of these two properties are given primarily to indicate sensor capabilities and are required for heat flow calculations only in very rare instances.

BY: Elaine Tardif DATE: 6-29-00

RdF Corporation
Specialists in Temperature Measurement



A Hewlett Packard 3458A multimeter was used to read heat flux of each heat flux sensor in microvolts.

Thermocouple temperatures were read via Fluke Hydra Data Logger.

After loading the glass plate assembly into the cell the remaining space was filled with fiberglass insulation to reduce heat loss from the system.

Heat flux values and temperature differences between the top, middle, and bottom sensors, and sample thickness are used to calculate thermal conductivity, K_t, using Fourier's Law (see p. 36).

7/7/00 JP Thermal Conductivity measurements of glass plate fracture model assembly.

Run FINGER-TC-1

Waterbath setpoint 5°C
Variable transformer setting 60
Pressure on top Al plate 35 ft lb

Temperatures and heat flux are monitored and when system reaches equilibrium temperature & heat flux values are recorded & thermal conductivity is calculated by inputting the values into an MS Excel spreadsheet ~~which can~~ JP 7/7/00 JP

Thermal conductivity calculations for Run FINGER-TC-1 is shown on the following page.

FINGER_TC_1
~~TSw_TC_1~~ JP 7/11/00

Thermal Conductivity calculation using Fourier equation

Run = FINGER_TC_1

Sample = Glass plate fracture model assembly

$Q=K_T(dT/dL)$

where
- Q = heat transfer per unit area (W/Ft²)
- K_T = thermal conductivity (W/m-K)
- dT = temperature difference between bottom and top sensors (K)
- dL = distance between bottom and top sensors (m)

Sensor readings

Serial no.	Temp °C	Correct Temp	Temp °K	Heat flow mV	Cal. constant mV/Btu/Ft²-Hr	Heat flow Btu/Ft²-Hr	Convert to W/Ft² 1Btu/Hr = 0.293W
Bottom							
00022886	98.5	91.52	364.72	251	3.58	70.11	20.54
00022887	98.5	91.52	364.72	237	3.59	66.02	19.34
00022888	98.1	91.15	364.35	250	3.56	70.22	20.58
00022889	98.4	91.43	364.63	221	3.55	62.25	18.24
Middle							
00067902	51.8	49.71	322.91	199	3.7	53.78	15.76
00067903	51.5	49.42	322.62	192	3.66	52.46	15.37
00067904	51.3	49.23	322.43	180	3.66	49.18	14.41
00067905	51.4	49.32	322.52	196	3.45	56.81	16.65
Top							
00022890	8.5	9.03	282.23	226	3.58	63.13	18.50
00022891	8.4	8.92	282.12	237	3.6	65.83	19.29
00022892	8.5	9.03	282.23	237	3.58	66.20	19.40
00022893	8.6	9.13	282.33	242	3.6	67.22	19.70
Total							
Q =	19.45	W/Ft²				209.34	W/m²
dT =	82.38	K					
dL =	0.24	Ft				0.07	m
K_T =	**0.186**	±	**0.020**	**W/m-K**			
Front							
Q =	17.38	W/Ft²				187.11	W/m²
dT =	40.40	K					
dL =	0.15	Ft				0.04	m
K_T =	**0.206**	±	**0.022**	**W/m-K**			
Back							
Q =	17.61	W/Ft²				189.57	W/m²
dT =	41.98	K					
dL =	0.10	Ft				0.03	m
K_T =	**0.131**	±	**0.014**	**W/m-K**			

Temperature correction

Serial no.	Temp °C	Temp °F	Multiplication factor	Correct Temp °C
Bottom				
00022886	98.5	209.3	0.94	91.52
00022887	98.5	209.3	0.94	91.52
00022888	98.1	208.58	0.94	91.15
00022889	98.4	209.12	0.94	91.43
Middle				
00067902	51.8	125.24	0.97	49.71
00067903	51.5	124.7	0.97	49.42
00067904	51.3	124.34	0.97	49.23
00067905	51.4	124.52	0.97	49.32
Top				
00022890	8.5	47.3	1.02	9.03
00022891	8.4	47.12	1.02	8.92
00022892	8.5	47.3	1.02	9.03
00022893	8.6	47.48	1.02	9.13

7/11/00

Run Finger_TC_2

Waterbath setpoint 5°C
Variable temperature setpoint 50
Pressure on top Al plate 3 ft.lb.

Thermal Conductivity calculation for Finger_TC_2 is shown on following page.

Finger_TC_2

Thermal Conductivity calculation using Fourier equation

Run = FINGER_TC_2

Sample = Glass plate fracture model assembly

$Q=K_T(dT/dL)$

where

- Q = heat transfer per unit area (W/Ft^2)
- K_T = thermal conductivity (W/m-K)
- dT = temperature difference between bottom and top sensors (K)
- dL = distance between bottom and top sensors (m)

Sensor readings

Serial no.	Temp °C	Correct Temp	Temp °K	Heat flow mV	Cal. constant mV/Btu/Ft²-Hr	Heat flow Btu/Ft²-Hr	Convert to W/Ft² 1Btu/Hr = 0.293W
Bottom							
00022886	75.3	71.58	344.78	182	3.58	50.84	14.90
00022887	75.3	71.58	344.78	169	3.59	47.08	13.79
00022888	74.9	71.19	344.39	178	3.56	50.00	14.65
00022889	75.2	71.48	344.68	162	3.55	45.63	13.37
Middle							
00067902	40.1	38.94	312.14	149	3.7	40.27	11.80
00067903	39.9	38.75	311.95	142	3.66	38.80	11.37
00067904	39.7	38.55	311.75	131	3.66	35.79	10.49
00067905	39.8	38.65	311.85	145	3.45	42.03	12.31
Top							
00022890	7.7	8.21	281.41	174	3.58	48.60	14.24
00022891	7.7	8.21	281.41	177	3.6	49.17	14.41
00022892	7.7	8.21	281.41	179	3.58	50.00	14.65
00022893	7.7	8.21	281.41	180	3.6	50.00	14.65

Total						
Q =	14.33	W/Ft^2			154.27	W/m^2
dT =	63.25	K				
dL =	0.24	Ft			0.07	m
K_T =	**0.178**	±	**0.019**	**W/m-K**		
Front						
Q =	12.99	W/Ft^2			139.82	W/m^2
dT =	30.51	K				
dL =	0.15	Ft			0.04	m
K_T =	**0.204**	±	**0.022**	**W/m-K**		
Back						
Q =	12.83	W/Ft^2			138.16	W/m^2
dT =	32.73	K				
dL =	0.10	Ft			0.03	m
K_T =	**0.122**	±	**0.014**	**W/m-K**		

Temperature correction

Serial no.	Temp °C	Temp °F	Multiplication factor	Correct Temp °C
Bottom				
00022886	75.3	167.54	0.96	71.58
00022887	75.3	167.54	0.96	71.58
00022888	74.9	166.82	0.96	71.19
00022889	75.2	167.36	0.96	71.48
Middle				
00067902	40.1	104.18	0.98	38.94
00067903	39.9	103.82	0.98	38.75
00067904	39.7	103.46	0.98	38.55
00067905	39.8	103.64	0.98	38.65
Top				
00022890	7.7	45.86	1.02	8.21
00022891	7.7	45.86	1.02	8.21
00022892	7.7	45.86	1.02	8.21
00022893	7.7	45.86	1.02	8.21

7/12/00

Run Finger_TC_3

Waterbath setpoint 5°c
Variable transformer setpoint 40
Pressure on Top Al plate 3 ft lb

Thermal conductivity calculation for Finger_TC_3 is shown on following page

Finger_TC_3

Thermal Conductivity calculation using Fourier equation

Run = FINGER_TC_3

Sample = Glass plate fracture model assembly

$Q=K_T(dT/dL)$

where
- Q =heat transfer per unit area (W/Ft^2)
- K_T = thermal conductivity (W/m-K)
- dT = temperature difference between bottom and top sensors (K)
- dL = distance between bottom and top sensors (m)

Sensor readings

Serial no.	Temp °C	Correct Temp	Temp °K	Heat flow mV	Cal. constant mV/Btu/Ft²-Hr	Heat flow Btu/Ft²-Hr	Convert to W/Ft² 1Btu/Hr = 0.293W
Bottom							
00022886	59.6	56.50	329.70	129	3.58	36.03	10.56
00022887	59.6	56.50	329.70	122	3.59	33.98	9.96
00022888	59.3	56.22	329.42	134	3.56	37.64	11.03
00022889	59.6	56.50	329.70	120	3.55	33.80	9.90
Middle							
00067902	32.5	31.49	304.69	116	3.7	31.35	9.19
00067903	32.4	31.40	304.60	111	3.66	30.33	8.89
00067904	32.2	31.20	304.40	99	3.66	27.05	7.93
00067905	32.2	31.20	304.40	109	3.45	31.59	9.26
Top							
00022890	7	7.50	280.70	138	3.58	38.55	11.29
00022891	7.1	7.60	280.80	158	3.6	43.89	12.86
00022892	7	7.50	280.70	143	3.58	39.94	11.70
00022893	7.1	7.60	280.80	142	3.6	39.44	11.56

Total					
Q =	11.11	W/Ft²		119.57	W/m²
dT =	48.89	K			
dL =	0.24	Ft		0.07	m
K_T =	**0.179**	±	**0.019 W/m-K**		
Front					
Q =	10.33	W/Ft²		111.23	W/m²
dT =	23.78	K			
dL =	0.15	Ft		0.04	m
K_T =	**0.208**	±	**0.022 W/m-K**		
Back					
Q =	9.59	W/Ft²		103.21	W/m²
dT =	25.11	K			
dL =	0.10	Ft		0.03	m
K_T =	**0.119**	±	**0.013 W/m-K**		

Temperature correction

Serial no.	Temp °C	Temp °F	Multiplication factor	Correct Temp °C
Bottom				
00022886	59.6	139.28	0.96	56.50
00022887	59.6	139.28	0.96	56.50
00022888	59.3	138.74	0.96	56.22
00022889	59.6	139.28	0.96	56.50
Middle				
00067902	32.5	90.5	0.98	31.49
00067903	32.4	90.32	0.98	31.40
00067904	32.2	89.96	0.98	31.20
00067905	32.2	89.96	0.98	31.20
Top				
00022890	7	44.6	1.02	7.50
00022891	7.1	44.78	1.02	7.60
00022892	7	44.6	1.02	7.50
00022893	7.1	44.78	1.02	7.60

7/13/00 JP

Run Finger TC_4

Waterbath setpoint 5°c
Variable transformer setpoint 30
Pressure on top Al plate 3 ft lb

Thermal conductivity calculation for Finger TC_4 is shown on the following page.

Finger_TC_4

Thermal Conductivity calculation using Fourier equation

Run = FINGER_TC_4

Sample = Glass plate fracture model assembly

$Q=K_T(dT/dL)$

where
Q = heat transfer per unit area (W/Ft^2)
K_T = thermal conductivity (W/m-K)
dT = temperature difference between bottom and top sensors (K)
dL = distance between bottom and top sensors (m)

Sensor readings

Serial no.	Temp ^0C	Correct Temp	Temp ^0K	Heat flow mV	Cal. constant $mV/Btu/Ft^2$-Hr	Heat flow Btu/Ft^2-Hr	Convert to W/Ft^2 1Btu/Hr = 0.293W
Bottom							
00022886	42.6	40.79	313.99	84	3.58	23.46	6.87
00022887	42.6	40.79	313.99	80	3.59	22.28	6.53
00022888	42.4	40.59	313.79	89	3.56	25.00	7.33
00022889	42.5	40.69	313.89	79	3.55	22.25	6.52
Middle							
00067902	23.9	23.48	296.68	79	3.7	21.35	6.26
00067903	23.9	23.48	296.68	76	3.66	20.77	6.08
00067904	23.7	23.29	296.49	67	3.66	18.31	5.36
00067905	23.7	23.29	296.49	74	3.45	21.45	6.28
Top							
00022890	6.5	6.99	280.19	97	3.58	27.09	7.94
00022891	6.5	6.99	280.19	111	3.6	30.83	9.03
00022892	6.5	6.99	280.19	98	3.58	27.37	8.02
00022893	6.5	6.99	280.19	98	3.6	27.22	7.98

Total

Q =	7.53	W/Ft^2	81.03	W/m^2
dT =	33.73	K		
dL =	0.24	Ft	0.07	m
K_T =	**0.176**	±	**0.019**	**W/m-K**

Front

Q =	7.12	W/Ft^2	76.64	W/m^2
dT =	16.40	K		
dL =	0.15	Ft	0.04	m
K_T =	**0.208**	±	**0.022**	**W/m-K**

Back

Q =	6.40	W/Ft^2	68.94	W/m^2
dT =	17.33	K		
dL =	0.10	Ft	0.03	m
K_T =	**0.115**	±	**0.013**	**W/m-K**

Temperature correction

Serial no.	Temp ^0C	Temp ^0F	Multiplication factor	Correct Temp ^0C
Bottom				
00022886	42.6	108.68	0.97	40.79
00022887	42.6	108.68	0.97	40.79
00022888	42.4	108.32	0.97	40.59
00022889	42.5	108.5	0.97	40.69
Middle				
00067902	23.9	75.02	0.99	23.48
00067903	23.9	75.02	0.99	23.48
00067904	23.7	74.66	0.99	23.29
00067905	23.7	74.66	0.99	23.29
Top				
00022890	6.5	43.7	1.02	6.99
00022891	6.5	43.7	1.02	6.99
00022892	6.5	43.7	1.02	6.99
00022893	6.5	43.7	1.02	6.99

7/12/00 JP

Run Finger TC_5

Waterbath setpoint - 25°C
Variable Transformer setpoint - 30
Pressure on top Al plate - 3 ft lb

Thermal conductivity calculation for Finger TC_5 is shown on next page.

Finger_TC_5

Thermal Conductivity calculation using Fourier equation

Run = FINGER_TC_5

Sample = Glass plate fracture model assembly

$Q=K_T(dT/dL)$

where
- Q = heat transfer per unit area (W/Ft^2)
- K_T = thermal conductivity (W/m-K)
- dT = temperature difference between bottom and top sensors (K)
- dL = distance between bottom and top sensors (m)

Sensor readings

Serial no.	Temp °C	Correct Temp	Temp °K	Heat flow mV	Cal. constant mV/Btu/Ft²-Hr	Heat flow Btu/Ft²-Hr	Convert to W/Ft² 1Btu/Hr = 0.293W
Bottom							
00022886	48.1	46.12	319.32	58	3.58	16.20	4.75
00022887	48.1	46.12	319.32	55	3.59	15.32	4.49
00022888	48	46.03	319.23	62	3.56	17.42	5.10
00022889	48.1	46.12	319.32	54	3.55	15.21	4.46
Middle							
00067902	35.9	34.83	308.03	53	3.7	14.32	4.20
00067903	35.8	34.73	307.93	52	3.66	14.21	4.16
00067904	35.7	34.63	307.83	47	3.66	12.84	3.76
00067905	35.7	34.63	307.83	51	3.45	14.78	4.33
Top							
00022890	24.5	24.50	297.70	64	3.58	17.88	5.24
00022891	24.5	24.50	297.70	74	3.6	20.56	6.02
00022892	24.5	24.50	297.70	65	3.58	18.16	5.32
00022893	24.5	24.50	297.70	64	3.6	17.78	5.21

Total

Q =	5.07 W/Ft²		54.61 W/m²	
dT =	21.60 K			
dL =	0.24 Ft		0.07 m	
K_T =	**0.185 ±**	**0.020 W/m-K**		

Front

Q =	4.78 W/Ft²		51.46 W/m²	
dT =	10.20 K			
dL =	0.15 Ft		0.04 m	
K_T =	**0.224 ±**	**0.024 W/m-K**		

Back

Q =	4.41 W/Ft²		47.43 W/m²	
dT =	11.40 K			
dL =	0.10 Ft		0.03 m	
K_T =	**0.121 ±**	**0.013 W/m-K**		

Temperature correction

Serial no.	Temp °C	Temp °F	Multiplication factor	Correct Temp °C
Bottom				
00022886	48.1	118.58	0.97	46.12
00022887	48.1	118.58	0.97	46.12
00022888	48	118.4	0.97	46.03
00022889	48.1	118.58	0.97	46.12
Middle				
00067902	35.9	96.62	0.98	34.83
00067903	35.8	96.44	0.98	34.73
00067904	35.7	96.26	0.98	34.63
00067905	35.7	96.26	0.98	34.63
Top				
00022890	24.5	76.1	1	24.50
00022891	24.5	76.1	1	24.50
00022892	24.5	76.1	1	24.50
00022893	24.5	76.1	1	24.50

7/18/00 gp

Run Finger_TC-6

Waterbath setpoint - 25°C
Variable temp unit setpoint - 40
Pressure on top Al plate - 3 ft-lb

Thermal conductivity calculation for Finger_TC-6 is shown on next page.

Finger_TC_6

Thermal Conductivity calculation using Fourier equation

Run = FINGER_TC_6

Sample = Glass plate fracture model assembly

$Q=K_T(dT/dL)$

where
- Q = heat transfer per unit area (W/Ft^2)
- K_T = thermal conductivity (W/m-K)
- dT = temperature difference between bottom and top sensors (K)
- dL = distance between bottom and top sensors (m)

Sensor readings

Serial no.	Temp °C	Correct Temp	Temp °K	Heat flow mV	Cal. constant $mV/Btu/Ft^2$-Hr	Heat flow Btu/Ft^2-Hr	Convert to W/Ft^2 1Btu/Hr = 0.293W
Bottom							
00022886	62.2	59.00	332.20	96	3.58	26.82	7.86
00022887	62.2	59.00	332.20	92	3.59	25.63	7.51
00022888	61.9	58.71	331.91	99	3.56	27.81	8.15
00022889	62.1	58.90	332.10	88	3.55	24.79	7.26
Middle							
00067902	42.9	41.69	314.89	84	3.7	22.70	6.65
00067903	42.9	41.69	314.89	83	3.66	22.68	6.64
00067904	42.7	41.49	314.69	76	3.66	20.77	6.08
00067905	42.7	41.49	314.69	83	3.45	24.06	7.05
Top							
00022890	25.3	24.87	298.07	99	3.58	27.65	8.10
00022891	25.3	24.87	298.07	115	3.6	31.94	9.36
00022892	25.3	24.87	298.07	103	3.58	28.77	8.43
00022893	25.3	24.87	298.07	100	3.6	27.78	8.14

Total					
Q =	8.10	W/Ft^2		87.20	W/m^2
dT =	34.04	K			
dL =	0.24	Ft		0.07	m
K_T =	**0.187**	±	**0.020** W/m-K		
Front					
Q =	7.56	W/Ft^2		81.35	W/m^2
dT =	16.72	K			
dL =	0.15	Ft		0.04	m
K_T =	**0.216**	±	**0.023** W/m-K		
Back					
Q =	7.15	W/Ft^2		76.97	W/m^2
dT =	17.32	K			
dL =	0.10	Ft		0.03	m
K_T =	**0.129**	±	**0.014** W/m-K		

Temperature correction

Serial no.	Temp °C	Temp °F	Multiplication factor	Correct Temp °C
Bottom				
00022886	62.2	143.96	0.96	59.00
00022887	62.2	143.96	0.96	59.00
00022888	61.9	143.42	0.96	58.71
00022889	62.1	143.78	0.96	58.90
Middle				
00067902	42.9	109.22	0.98	41.69
00067903	42.9	109.22	0.98	41.69
00067904	42.7	108.86	0.98	41.49
00067905	42.7	108.86	0.98	41.49
Top				
00022890	25.3	77.54	0.99	24.87
00022891	25.3	77.54	0.99	24.87
00022892	25.3	77.54	0.99	24.87
00022893	25.3	77.54	0.99	24.87

7/19/00 JP

Run Finger_TC-7

Waterbath temp setpoint - 25°c
Variable Temperature setpoint - 50
Pressure on top Al plate - 3 ft lb

Thermal conductivity calculation for Finger_TC-7 is shown on next page

Finger_TC_7

Thermal Conductivity calculation using Fourier equation

Run = FINGER_TC_7

Sample = Glass plate fracture model assembly

$Q=K_T(dT/dL)$

where
- Q = heat transfer per unit area (W/Ft^2)
- K_T = thermal conductivity (W/m-K)
- dT = temperature difference between bottom and top sensors (K)
- dL = distance between bottom and top sensors (m)

Sensor readings

Serial no.	Temp °C	Correct Temp	Temp °K	Heat flow mV	Cal. constant mV/Btu/Ft²-Hr	Heat flow Btu/Ft²-Hr	Convert to W/Ft² 1Btu/Hr = 0.293W
Bottom							
00022886	82.4	77.39	350.59	156	3.58	43.58	12.77
00022887	82.4	77.39	350.59	145	3.59	40.39	11.83
00022888	82	77.01	350.21	151	3.56	42.42	12.43
00022889	82.3	77.30	350.50	141	3.55	39.72	11.64
Middle							
00067902	53.4	51.26	324.46	130	3.7	35.14	10.29
00067903	53.2	51.07	324.27	127	3.66	34.70	10.17
00067904	53	50.88	324.08	124	3.66	33.88	9.93
00067905	53	48.75	321.95	128	3.45	37.10	10.87
Top							
00022890	26.3	25.86	299.06	155	3.58	43.30	12.69
00022891	26.3	25.86	299.06	177	3.6	49.17	14.41
00022892	26.3	25.86	299.06	158	3.58	44.13	12.93
00022893	26.3	25.86	299.06	157	3.6	43.61	12.78

Total					
Q =	12.68	W/Ft²		136.53	W/m²
dT =	51.41	K			
dL =	0.24	Ft		0.07	m
K_T =	**0.194**	±	**0.021**	**W/m-K**	
Front					
Q =	11.76	W/Ft²		126.56	W/m²
dT =	24.63	K			
dL =	0.15	Ft		0.04	m
K_T =	**0.228**	±	**0.024**	**W/m-K**	
Back					
Q =	11.24	W/Ft²		121.00	W/m²
dT =	26.78	K			
dL =	0.10	Ft		0.03	m
K_T =	**0.131**	±	**0.014**	**W/m-K**	

Temperature correction

Serial no.	Temp °C	Temp °F	Multiplication factor	Correct Temp °C
Bottom				
00022886	82.4	180.32	0.95	77.39
00022887	82.4	180.32	0.95	77.39
00022888	82	179.6	0.95	77.01
00022889	82.3	180.14	0.95	77.30
Middle				
00067902	53.4	128.12	0.97	51.26
00067903	53.2	127.76	0.97	51.07
00067904	53	127.4	0.97	50.88
00067905	53	127.4	0.94	48.75
Top				
00022890	26.3	79.34	0.99	25.86
00022891	26.3	79.34	0.99	25.86
00022892	26.3	79.34	0.99	25.86
00022893	26.3	79.34	0.99	25.86

7/20/00 JP

Run Finger_TC_8

Waterbath setpoint 23°C
Variable temp wire setpoint 60
Pressure on top Al plate 35 lb

Thermal conductivity calculation for Finger_TC-8 is shown on next page.

Finger_TC_8

Thermal Conductivity calculation using Fourier equation

Run = FINGER_TC_8

Sample = Glass plate fracture model assembly

$Q=K_T(dT/dL)$

where
- Q = heat transfer per unit area (W/Ft^2)
- K_T = thermal conductivity (W/m-K)
- dT = temperature difference between bottom and top sensors (K)
- dL = distance between bottom and top sensors (m)

Sensor readings

Serial no.	Temp °C	Correct Temp	Temp °K	Heat flow mV	Cal. constant mV/Btu/Ft²-Hr	Heat flow Btu/Ft²-Hr	Convert to W/Ft² 1Btu/Hr = 0.293W
Bottom							
00022886	103.4	96.13	369.33	234	3.58	65.36	19.15
00022887	103.3	96.04	369.24	221	3.59	61.56	18.04
00022888	102.9	95.66	368.86	225	3.56	63.20	18.52
00022889	103.3	96.04	369.24	208	3.55	58.59	17.17
Middle							
00067902	61.8	58.62	331.82	189	3.7	51.08	14.97
00067903	61.5	58.33	331.53	182	3.66	49.73	14.57
00067904	61.3	58.14	331.34	182	3.66	49.73	14.57
00067905	61.4	58.23	331.43	186	3.45	53.91	15.80
Top							
00022890	22.8	22.80	296.00	220	3.58	61.45	18.01
00022891	22.8	22.80	296.00	251	3.6	69.72	20.43
00022892	22.8	22.80	296.00	225	3.58	62.85	18.41
00022893	22.9	22.90	296.10	228	3.6	63.33	18.56

Total

Q =	18.53	W/Ft²		199.52	W/m²
dT =	73.14	K			
dL =	0.24	Ft		0.07	m
K_T =	**0.200**	±	**0.021**	**W/m-K**	

Front

Q =	16.91	W/Ft²		182.06	W/m²
dT =	35.50	K			
dL =	0.15	Ft		0.04	m
K_T =	**0.228**	±	**0.024**	**W/m-K**	

Back

Q =	16.60	W/Ft²		178.66	W/m²
dT =	37.64	K			
dL =	0.10	Ft		0.03	m
K_T =	**0.137**	±	**0.015**	**W/m-K**	

Temperature correction

Serial no.	Temp °C	Temp °F	Multiplication factor	Correct Temp °C
Bottom				
00022886	103.4	218.12	0.94	96.13
00022887	103.3	217.94	0.94	96.04
00022888	102.9	217.22	0.94	95.66
00022889	103.3	217.94	0.94	96.04
Middle				
00067902	61.8	143.24	0.96	58.62
00067903	61.5	142.7	0.96	58.33
00067904	61.3	142.34	0.96	58.14
00067905	61.4	142.52	0.96	58.23
Top				
00022890	22.8	73.04	1	22.80
00022891	22.8	73.04	1	22.80
00022892	22.8	73.04	1	22.80
00022893	22.9	73.22	1	22.90

7/28/00 JP

Thermal conductivity of single 3/8" glass plate

Obj - measure thermal conductivity of single 3/8" glass plate used in the glass plate fracture model assembly

Method - measure heat flux through glass plate.

Equipment - Materials - Supplies
Most equipment & materials are listed on p13 & 14. With the addition of the following

- 12" x 15" x 3/8" annealed glass plate
- Hewlett Packard 3458A Multimeter
- Fluke Hydra Data loggers

Assembly.

The thermal conductivity apparatus was assembled as outlined on p15-36 with the following modifications.

① The fiberglass insert was removed to accomodate the smaller size of the glass plates.

② A Hewlett Packard 3458A multimeter was used to read heat flux of each sensor in ~~microvolts~~. Thermocouple temperatures were read using a Fluke Hydra Data logger.

③ A 12" x 15" x 3/8" glass plate was placed in the center of the cell. Additional 12" x 15" x 3/8" glass plates were placed around the center plate to reduce heat loss from the system.

7/28/00 JP

Thermal conductivity measurements of 12" x 15" x 3/8" glass plate

Run Finger_TC-9

Waterbath setpoint 20°C
Variable transformer setpoint 80
Pressure on top Al plate 75 lb.

Thermal conductivity calculation for Finger_TC-9 is shown on right page.

Finger_TC_9

Thermal Conductivity calculation using Fourier equation

Run = Finger_TC_9

Sample = Annealed glass plate

$Q=K_T(dT/dL)$

where
Q =heat transfer per unit area (W/Ft²)
K_T = thermal conductivity (W/m-K)
dT = temperature difference between bottom and top sensors (K)
dL = distance between bottom and top sensors (m)

Sensor readings

Serial no.	Temp °C	Correct Temp	Temp °K	Heat flow mV	Cal. constant mV/Btu/Ft²-Hr	Heat flow Btu/Ft²-Hr	Convert to W/Ft² 1Btu/Hr = 0.293W
Bottom							
	47.30	45.35	318.55	947.00	3.58	264.53	77.51
00022887	46.90	44.96	318.16	1075.00	3.59	299.44	87.74
00022888	46.80	44.86	318.06	1133.00	3.56	318.26	93.25
00022889	47.00	45.06	318.26	921.00	3.55	259.44	76.01
Top							
00022890	27.60	27.15	300.35	817.00	3.58	228.21	66.87
00022891	27.80	27.34	300.54	854.00	3.6	237.22	69.51
00022892	27.70	27.25	300.45	985.00	3.58	275.14	80.62
00022893	27.80	27.34	300.54	955.00	3.6	265.28	77.73

Q =	78.65	W/Ft²	846.64	W/m²
dT =	17.79	K		
dL =	0.032	Ft	0.01	m
K_T =	0.464 ±	0.048 W/m-K		

Temperature correction

Serial no.	Temp °C	Temp °F	Multiplication factor	Correct Temp °C
Bottom				
00022886	47.30	117.14	0.97	45.35
00022887	46.90	116.42	0.97	44.96
00022888	46.80	116.24	0.97	44.86
00022889	47.00	116.60	0.97	45.06
Top				
00022890	27.60	81.68	0.99	27.15
00022891	27.80	82.04	0.99	27.34
00022892	27.70	81.86	0.99	27.25
00022893	27.80	82.04	0.99	27.34

7/28/00 JP

The following modification was made to the glass plate sample so that a thicker sample could be measured.

Sample thickness was increased by stacking 4 12"x 15"x 3/8" glass plates on top of each other.

7/31/00 JP

Run Finger_TC_10

Waterbath setpoint 25°C
Variable transformer setpoint 60
Pressure on top Al plate 10 ft lb

Thermal conductivity calculation for Finger_TC_10 is shown on following page.

Finger_TC_10

Thermal Conductivity calculation using Fourier equation

Run = Finger_TC_10

Sample = Annealed glass plate

$Q=K_T(dT/dL)$

where
- Q =heat transfer per unit area (W/Ft^2)
- K_T = thermal conductivity (W/m-K)
- dT = temperature difference between bottom and top sensors (K)
- dL = distance between bottom and top sensors (m)

Sensor readings

Serial no.	Temp °C	Correct Temp	Temp °K	Heat flow mV	Cal. constant mV/Btu/Ft²-Hr	Heat flow Btu/Ft²-Hr	Convert to W/Ft² 1Btu/Hr = 0.293W
Bottom							
00022886	64.40	61.11	334.31	793.00	3.58	221.51	64.90
00022887	64.30	61.02	334.22	704.00	3.59	196.10	57.46
00022888	64.10	60.82	334.02	884.00	3.56	248.31	72.76
00022889	64.20	60.92	334.12	837.00	3.55	235.77	69.08
Top							
00022890	26.60	26.16	299.36	880.00	3.58	245.81	72.02
00022891	26.70	26.26	299.46	828.00	3.6	230.00	67.39
00022892	26.50	26.06	299.26	805.00	3.58	224.86	65.88
00022893	26.70	26.26	299.46	853.00	3.6	236.94	69.42

Q =	67.36 W/Ft^2		725.13 W/m^2
dT =	34.79 K		
dL =	0.125 Ft		0.04 m
K_T =	**0.794** ±	**0.081** W/m-K	

Temperature correction

Serial no.	Temp °C	Temp °F	Multiplication factor	Correct Temp °C
Bottom				
00022886	64.40	147.92	0.96	61.11
00022887	64.30	147.74	0.96	61.02
00022888	64.10	147.38	0.96	60.82
00022889	64.20	147.56	0.96	60.92
Top				
00022890	26.60	79.88	0.99	26.16
00022891	26.70	80.06	0.99	26.26
00022892	26.50	79.70	0.99	26.06
00022893	26.70	80.06	0.99	26.26

8/1/00 JP

Finger TC_11

Waterbath setpoint 25°C
Variable temperature setpoint 80
Pressure on top Al plate 10 ft lb.

Thermal conductivity calculation for Finger TC11 is shown on next page.

Finger_TC_11

Thermal Conductivity calculation using Fourier equation

Run = Finger_TC_11

Sample = Annealed glass plate

$Q=K_T(dT/dL)$

where
- Q = heat transfer per unit area (W/Ft^2)
- K_T = thermal conductivity (W/m-K)
- dT = temperature difference between bottom and top sensors (K)
- dL = distance between bottom and top sensors (m)

Sensor readings

Serial no.	Temp °C	Correct Temp	Temp °K	Heat flow mV	Cal. constant $mV/Btu/Ft^2$-Hr	Heat flow Btu/Ft^2-Hr	Convert to W/Ft^2 1Btu/Hr = 0.293W
Bottom							
00022886	90.80	86.46	359.66	1363.00	3.58	380.73	111.55
00022887	90.60	86.26	359.46	1217.00	3.59	339.00	99.33
00022888	90.30	85.98	359.18	1494.00	3.56	419.66	122.96
00022889	90.60	86.26	359.46	1439.00	3.55	405.35	118.77
Top							
00022890	29.40	28.93	302.13	1468.00	3.58	410.06	120.15
00022891	29.80	29.32	302.52	1400.00	3.6	388.89	113.94
00022892	29.50	29.03	302.23	1360.00	3.58	379.89	111.31
00022893	29.70	29.23	302.43	1424.00	3.6	395.56	115.90

Q =	114.24 W/Ft^2		1229.69 W/m^2
dT =	57.11 K		
dL =	0.125 Ft		0.04 m
K_T =	**0.820** ±	**0.083 W/m-K**	

Temperature correction

Serial no.	Temp °C	Temp °F	Multiplication factor	Correct Temp °C
Bottom				
00022886	90.80	195.44	0.96	86.46
00022887	90.60	195.08	0.96	86.26
00022888	90.30	194.54	0.96	85.98
00022889	90.60	195.08	0.96	86.26
Top				
00022890	29.40	84.92	0.99	28.93
00022891	29.80	85.64	0.99	29.32
00022892	29.50	85.10	0.99	29.03
00022893	29.70	85.46	0.99	29.23

8/2/00 JP

Finger_TC_12

Waterbath setpoint 25°C
Variable temperature setpoint 90
Pressure on top Al plate 10 ft lb

Thermal conductivity calculation for Finger_TC_12 is shown on next page.

Finger_TC_12

Thermal Conductivity calculation using Fourier equation

Run = Finger_TC_12

Sample = Annealed glass plate

$Q=K_T(dT/dL)$

where
- Q = heat transfer per unit area (W/Ft^2)
- K_T = thermal conductivity (W/m-K)
- dT = temperature difference between bottom and top sensors (K)
- dL = distance between bottom and top sensors (m)

Sensor readings

Serial no.	Temp °C	Correct Temp	Temp °K	Heat flow mV	Cal. constant mV/Btu/Ft^2-Hr	Heat flow Btu/Ft^2-Hr	Convert to W/Ft^2 1Btu/Hr = 0.293W
Bottom							
00022886	107.10	99.61	372.81	1740.00	3.58	486.03	142.41
00022887	106.90	99.42	372.62	1568.00	3.59	436.77	127.97
00022888	106.50	99.04	372.24	1901.00	3.56	533.99	156.46
00022889	106.80	99.33	372.53	1833.00	3.55	516.34	151.29
Top							
00022890	31.30	30.32	303.52	1823.00	3.58	509.22	149.20
00022891	31.80	30.81	304.01	1767.00	3.6	490.83	143.81
00022892	31.40	30.42	303.62	1707.00	3.58	476.82	139.71
00022893	31.70	30.71	303.91	1763.00	3.6	489.72	143.49

Q = 144.29 W/Ft^2 1553.20 W/m^2
dT = 68.79 K
dL = 0.125 Ft 0.04 m

K_T = 0.860 ± **0.087** W/m-K

Temperature correction

Serial no.	Temp °C	Temp °F	Multiplication factor	Correct Temp °C
Bottom				
00022886	107.10	224.78	0.94	99.61
00022887	106.90	224.42	0.94	99.42
00022888	106.50	223.70	0.94	99.04
00022889	106.80	224.24	0.94	99.33
Top				
00022890	31.30	88.34	0.98	30.32
00022891	31.80	89.24	0.98	30.81
00022892	31.40	88.52	0.98	30.42
00022893	31.70	89.06	0.98	30.71

8/3/00 JP

Finger_TC_13

Waterbath setpoint 25°C
Variable temperature setpoint 100
Pressure on top Al plate 10 ft lb

Thermal conductivity calculation for Finger_TC_13 is shown next page

Finger_TC_13

Thermal Conductivity calculation using Fourier equation

Run = Finger_TC_13

Sample = Annealed glass plate

$Q=K_T(dT/dL)$

where
Q =heat transfer per unit area (W/Ft^2)
K_T = thermal conductivity (W/m-K)
dT = temperature difference between bottom and top sensors (K)
dL = distance between bottom and top sensors (m)

Sensor readings

Serial no.	Temp ^0C	Correct Temp	Temp ^0K	Heat flow mV	Cal. constant $mV/Btu/Ft^2$-Hr	Heat flow Btu/Ft^2-Hr	Convert to W/Ft^2 1Btu/Hr = 0.293W
Bottom							
00022886	121.50	111.75	384.95	2227.00	3.58	622.07	182.27
00022887	121.20	111.47	384.67	2023.00	3.59	563.51	165.11
00022888	120.70	111.01	384.21	2426.00	3.56	681.46	199.67
00022889	121.10	111.38	384.58	2349.00	3.55	661.69	193.88
Top							
00022890	26.00	25.56	298.76	2313.00	3.58	646.09	189.30
00022891	26.70	26.26	299.46	2215.00	3.6	615.28	180.28
00022892	26.40	25.96	299.16	2158.00	3.58	602.79	176.62
00022893	26.70	26.26	299.46	2228.00	3.6	618.89	181.33

Q =	183.56 W/Ft^2		1975.85	W/m^2
dT =	85.39 K			
dL =	0.125 Ft		0.04	m
K_T =	0.882 ±	0.089 W/m-K		

Temperature correction

Serial no.	Temp ^0C	Temp ^0F	Multiplication factor	Correct Temp ^0C
Bottom				
00022886	121.50	250.70	0.93	111.75
00022887	121.20	250.16	0.93	111.47
00022888	120.70	249.26	0.93	111.01
00022889	121.10	249.98	0.93	111.38
Top				
00022890	26.00	78.80	0.99	25.56
00022891	26.70	80.06	0.99	26.26
00022892	26.40	79.52	0.99	25.96
00022893	26.70	80.06	0.99	26.26

8/4/00 JP

Finger_TC_14

Waterbath setpoint 25°C
Variable Transformer setpoint 110
Pressure on top Al plate 10 5± lb

Thermal conductivity calculation for Finger_TC_14 is shown on next page.

Finger_TC_14

Thermal Conductivity calculation using Fourier equation

Run = Finger_TC_14

Sample = Annealed glass plate

$Q=K_T(dT/dL)$

where
- Q = heat transfer per unit area (W/Ft^2)
- K_T = thermal conductivity (W/m-K)
- dT = temperature difference between bottom and top sensors (K)
- dL = distance between bottom and top sensors (m)

Sensor readings

Serial no.	Temp °C	Correct Temp	Temp °K	Heat flow mV	Cal. constant mV/Btu/Ft²-Hr	Heat flow Btu/Ft²-Hr	Convert to W/Ft² 1Btu/Hr = 0.293W
Bottom							
00022886	141.80	129.03	402.23	2697.00	3.58	753.35	220.73
00022887	141.50	128.76	401.96	2463.00	3.59	686.07	201.02
00022888	140.80	128.11	401.31	2922.00	3.56	820.79	240.49
00022889	141.30	128.57	401.77	2854.00	3.55	803.94	235.56
Top							
00022890	30.20	29.72	302.92	2747.00	3.58	767.32	224.82
00022891	31.00	30.51	303.71	2640.00	3.6	733.33	214.87
00022892	30.80	30.31	303.51	2585.00	3.58	722.07	211.57
00022893	31.10	30.61	303.81	2648.00	3.6	735.56	215.52

Q = 220.57 W/Ft^2 2374.29 W/m^2

dT = 98.33 K

dL = 0.125 Ft   0.04 m

K_T = 0.920 ± 0.093 W/m-K

Temperature correction

Serial no.	Temp °C	Temp °F	Multiplication factor	Correct Temp °C
Bottom				
00022886	141.80	287.24	0.92	129.03
00022887	141.50	286.70	0.92	128.76
00022888	140.80	285.44	0.92	128.11
00022889	141.30	286.34	0.92	128.57
Top				
00022890	30.20	86.36	0.99	29.72
00022891	31.00	87.80	0.99	30.51
00022892	30.80	87.44	0.99	30.31
00022893	31.10	87.98	0.99	30.61

8/5/00 gg

Finger_TC_15

Waterbath setpoint 25°C
Variable transformer setpoint 120
Pressure on top Al plate 10 ft lb.

Thermal conductivity calculation for Finger_TC_15 is shown on next page.

Finger_TC_15

Thermal Conductivity calculation using Fourier equation

Run = Finger_TC_15

Sample = Annealed glass plate

$Q = K_T(dT/dL)$

where
- Q = heat transfer per unit area (W/Ft^2)
- K_T = thermal conductivity (W/m-K)
- dT = temperature difference between bottom and top sensors (K)
- dL = distance between bottom and top sensors (m)

Sensor readings

Serial no.	Temp °C	Correct Temp	Temp °K	Heat flow mV	Cal. constant mV/Btu/Ft²-Hr	Heat flow Btu/Ft²-Hr	Convert to W/Ft² 1Btu/Hr = 0.293W
Bottom							
00022886	161.00	143.12	416.32	3180.00	3.58	888.27	260.26
00022887	160.30	142.49	415.69	2920.00	3.59	813.37	238.32
00022888	159.50	141.77	414.97	3431.00	3.56	963.76	282.38
00022889	160.00	142.22	415.42	3368.00	3.55	948.73	277.98
Top							
00022890	34.00	32.96	306.16	3187.00	3.58	890.22	260.84
00022891	34.90	33.85	307.05	3066.00	3.6	851.67	249.54
00022892	34.70	33.65	306.85	3005.00	3.58	839.39	245.94
00022893	35.00	33.94	307.14	3067.00	3.6	851.94	249.62

Q = 258.11 W/Ft^2 2778.36 W/m^2
dT = 108.80 K
dL = 0.125 Ft   0.04 m

K_T = 0.973 ± 0.099 W/m-K

Temperature correction

Serial no.	Temp °C	Temp °F	Multiplication factor	Correct Temp °C
Bottom				
00022886	161.00	321.80	0.9	143.12
00022887	160.30	320.54	0.9	142.49
00022888	159.50	319.10	0.9	141.77
00022889	160.00	320.00	0.9	142.22
Top				
00022890	34.00	93.20	0.98	32.96
00022891	34.90	94.82	0.98	33.85
00022892	34.70	94.46	0.98	33.65
00022893	35.00	95.00	0.98	33.94

8/7/00 JP

Finger_TC_16

Waterbath setpoint 25°C
Variable transformer setpoint 130
Pressure on top Al plate 10 ft lb.

Thermal conductivity calculation for Finger_TC_16 is shown on next page.

Finger_TC_16

Thermal Conductivity calculation using Fourier equation

Run = Finger_TC_16

Sample = Annealed glass plate

$Q=K_T(dT/dL)$

where
- Q = heat transfer per unit area (W/Ft^2)
- K_T = thermal conductivity (W/m-K)
- dT = temperature difference between bottom and top sensors (K)
- dL = distance between bottom and top sensors (m)

Sensor readings

Serial no.	Temp ^{0}C	Correct Temp	Temp ^{0}K	Heat flow mV	Cal. constant mV/Btu/Ft^2-Hr	Heat flow Btu/Ft^2-Hr	Convert to W/Ft^2 1Btu/Hr = 0.293W
Bottom							
00022886	180.40	156.62	429.82	3697.00	3.58	1032.68	302.58
00022887	179.70	156.00	429.20	3418.00	3.59	952.09	278.96
00022888	178.80	155.21	428.41	3965.00	3.56	1113.76	326.33
00022889	179.30	155.65	428.85	3921.00	3.55	1104.51	323.62
Top							
00022890	39.00	37.86	311.06	3600.00	3.58	1005.59	294.64
00022891	40.10	38.94	312.14	3528.00	3.6	980.00	287.14
00022892	39.50	38.35	311.55	3433.00	3.58	958.94	280.97
00022893	40.00	38.84	312.04	3477.00	3.6	965.83	282.99

Q = 297.15 W/Ft^2 3198.64 W/m^2

dT = 117.37 K

dL = 0.125 Ft 0.04 m

K_T = 1.038 ± 0.105 W/m-K

Temperature correction

Serial no.	Temp ^{0}C	Temp ^{0}F	Multiplication factor	Correct Temp ^{0}C
Bottom				
00022886	180.40	356.72	0.88	156.62
00022887	179.70	355.46	0.88	156.00
00022888	178.80	353.84	0.88	155.21
00022889	179.30	354.74	0.88	155.65
Top				
00022890	39.00	102.20	0.98	37.86
00022891	40.10	104.18	0.98	38.94
00022892	39.50	103.10	0.98	38.35
00022893	40.00	104.00	0.98	38.84

8/7/00 JP

Measurement of heat flow thru glass plate with roughened surfaces.

Obj - measure heat flow thru an assembly composed of two 3/8" x 12" x 15" glass plates. One side of each glass plate has been sandblasted to roughen the surface. The glass plates were assembled with the roughened surfaces ~~touching~~ - like the glass plate in the glass plate/lexan furniture assembly.

Method - measure heat flow via the thermal conductivity apparatus

Materials + Supplies
Most equipment & materials are listed on p13 + 14. With addition of the following

- 12" x 15" x 3/8" annealed glass plate with one side sandblasted ~~to a~~ JP 8/7/00 ~~grit size of~~ at a distance of 80 inch with extra fine grit. JP 8/7/00
- Hewlett Packard 3458A multimeter
- Fluke Hydra Data logger.

Assembly

The thermal conductivity apparatus was assembled as outlined on p 15-36 with the following modifications.

① The fiberglass insert was removed to accomodate the smaller sample size.

② A Hewlett Packard 3458A multimeter was used to read heat flux of each sensor in mV. Thermocouple temperatures were read via Fluke Hydra Data Logger

③ Glass plates were placed in center of cell. A layer of fiberglass insulation was placed around the sample to reduce heat loss from the system

④ A layer of fiberglass insulation was placed on top of the top Al plate to reduce heat loss. Temperature of top Al plate was not controlled by waterbath.

8/9/00

Measurements.

Finger_TC_17

Variable transformer setpoint 100
Pressure on top Al plate 7 ft lb.

Heat flow and thermal conductivity calculation for Finger_TC_17 is shown on next page.

Finger_TC_17

Thermal Conductivity calculation using Fourier equation

Run = Finger_TC_17

Sample = Annealed glass plate

$Q=K_T(dT/dL)$

where
- Q = heat transfer per unit area (W/Ft^2)
- K_T = thermal conductivity (W/m-K)
- dT = temperature difference between bottom and top sensors (K)
- dL = distance between bottom and top sensors (m)

Sensor readings

Serial no.	Temp °C	Correct Temp	Temp °K	Heat flow mV	Cal. constant mV/Btu/Ft²-Hr	Heat flow Btu/Ft²-Hr	Convert to W/Ft² 1Btu/Hr = 0.293W
Bottom							
00022886	174.20	153.08	426.28	1780.00	3.58	497.21	145.68
00022887	174.40	153.26	426.46	1558.00	3.59	433.98	127.16
00022888	174.10	152.99	426.19	1769.00	3.56	496.91	145.59
00022889	173.90	152.82	426.02	1890.00	3.55	532.39	155.99
Top							
00022890	129.40	119.10	392.30	1840.00	3.58	513.97	150.59
00022891	129.90	119.56	392.76	1800.00	3.6	500.00	146.50
00022892	129.50	119.19	392.39	1746.00	3.58	487.71	142.90
00022893	129.70	119.38	392.58	1844.00	3.6	512.22	150.08

Q = 145.56 W/Ft^2 — 1566.87 W/m^2

dT = 33.73 K

dL = 0.0625 Ft — 0.02 m

K_T = **0.885** ± **0.090** W/m-K

Temperature correction

Serial no.	Temp °C	Temp °F	Multiplication factor	Correct Temp °C
Bottom				
00022886	174.20	345.56	0.89	153.08
00022887	174.40	345.92	0.89	153.26
00022888	174.10	345.38	0.89	152.99
00022889	173.90	345.02	0.89	152.82
Top				
00022890	129.40	264.92	0.93	119.10
00022891	129.90	265.82	0.93	119.56
00022892	129.50	265.10	0.93	119.19
00022893	129.70	265.46	0.93	119.38

8/9/00 JP

Thermal conductivity calculation for Finger_TC_17 was redone using a different correction factor for temperature for the top plate. The factor was changed from 0.93 to 0.92.

The redone calculation is shown on the following page.

Finger_TC_17

Thermal Conductivity calculation using Fourier equation

Run = Finger_TC_17

Sample = Annealed glass plate

$Q=K_T(dT/dL)$

where
- Q =heat transfer per unit area (W/Ft²)
- K_T = thermal conductivity (W/m-K)
- dT = temperature difference between bottom and top sensors (K)
- dL = distance between bottom and top sensors (m)

Sensor readings

Serial no.	Temp °C	Correct Temp	Temp °K	Heat flow mV	Cal. constant mV/Btu/Ft²-Hr	Heat flow Btu/Ft²-Hr	Convert to W/Ft² 1Btu/Hr = 0.293W
Bottom							
00022886	174.20	153.08	426.28	1780.00	3.58	497.21	145.68
00022887	174.40	153.26	426.46	1558.00	3.59	433.98	127.16
00022888	174.10	152.99	426.19	1769.00	3.56	496.91	145.59
00022889	173.90	152.82	426.02	1890.00	3.55	532.39	155.99
Top							
00022890	129.40	117.63	390.83	1840.00	3.58	513.97	150.59
00022891	129.90	118.09	391.29	1800.00	3.6	500.00	146.50
00022892	129.50	117.72	390.92	1746.00	3.58	487.71	142.90
00022893	129.70	117.90	391.10	1844.00	3.6	512.22	150.08

Q = 145.56 W/Ft² 1566.87 W/m²

dT = 35.21 K

dL = 0.0625 Ft 0.02 m

K_T = **0.848** ± **0.086 W/m-K**

Temperature correction

Serial no.	Temp °C	Temp °F	Multiplication factor	Correct Temp °C	
Bottom					
00022886	174.20	345.56	0.89	153.08	153.04
00022887	174.40	345.92	0.89	153.26	
00022888	174.10	345.38	0.89	152.99	
00022889	173.90	345.02	0.89	152.82	
Top					
00022890	129.40	264.92	0.92	117.63	117.83
00022891	129.90	265.82	0.92	118.09	
00022892	129.50	265.10	0.92	117.72	
00022893	129.70	265.46	0.92	117.90	

8/10/00 gp

Finger_TC_18

Variable transformer setting 90
Pressure on top Al plate 3 ft lb.

Heat flow + thermal conductivity calculations for Finger_TC_18 are shown on next page.

Finger_TC_18

Thermal Conductivity calculation using Fourier equation

Run = Finger_TC_18

Sample = Annealed glass plate

$Q=K_T(dT/dL)$

where
Q =heat transfer per unit area (W/Ft^2)
K_T = thermal conductivity (W/m-K)
dT = temperature difference between bottom and top sensors (K)
dL = distance between bottom and top sensors (m)

Sensor readings

Serial no.	Temp ^{0}C	Correct Temp	Temp ^{0}K	Heat flow mV	Cal. constant mV/Btu/Ft^2-Hr	Heat flow Btu/Ft^2-Hr	Convert to W/Ft^2 1Btu/Hr = 0.293W
Bottom							
00022886	161.40	143.48	416.68	1446.00	3.58	403.91	118.35
00022887	161.60	143.66	416.86	1259.00	3.59	350.70	102.75
00022888	161.10	143.21	416.41	1482.00	3.56	416.29	121.97
00022889	160.90	143.03	416.23	1601.00	3.55	450.99	132.14
Top							
00022890	122.70	112.87	386.07	1576.00	3.58	440.22	128.99
00022891	123.00	113.15	386.35	1501.00	3.6	416.94	122.16
00022892	122.90	113.05	386.25	1440.00	3.58	402.23	117.85
00022893	122.80	112.96	386.16	1558.00	3.6	432.78	126.80

Q =	121.38 W/Ft^2			1306.54 W/m^2
dT =	30.34 K			
dL =	0.0625 Ft			0.02 m
K_T =	**0.820** ±	**0.083** W/m-K		

Temperature correction

Serial no.	Temp ^{0}C	Temp ^{0}F	Multiplication factor	Correct Temp ^{0}C
Bottom				
00022886	161.40	322.52	0.9	143.48
00022887	161.60	322.88	0.9	143.66
00022888	161.10	321.98	0.9	143.21
00022889	160.90	321.62	0.9	143.03
Top				
00022890	122.70	252.86	0.93	112.87
00022891	123.00	253.40	0.93	113.15
00022892	122.90	253.22	0.93	113.05
00022893	122.80	253.04	0.93	112.96

8/11/00 JJP

Finger_TC_19

Variable transformer setting 80
Pressure on top Al plate 3 Stick

Heat flow + thermal conductivity calculation are shown on next page.

Finger_TC_19

Thermal Conductivity calculation using Fourier equation

Run = Finger_TC_19

Sample = Annealed glass plate

$Q=K_T(dT/dL)$

where
Q =heat transfer per unit area (W/Ft^2)
K_T = thermal conductivity (W/m-K)
dT = temperature difference between bottom and top sensors (K)
dL = distance between bottom and top sensors (m)

Sensor readings

Serial no.	Temp °C	Correct Temp	Temp °K	Heat flow mV	Cal. constant mV/Btu/Ft²-Hr	Heat flow Btu/Ft²-Hr	Convert to W/Ft² 1Btu/Hr = 0.293W
Bottom							
00022886	138.80	124.71	397.91	1146.00	3.58	320.11	93.79
00022887	139.00	124.89	398.09	993.00	3.59	276.60	81.04
00022888	138.60	124.53	397.73	1176.00	3.56	330.34	96.79
00022889	138.40	124.34	397.54	1269.00	3.55	357.46	104.74
Top							
00022890	106.40	98.95	372.15	1262.00	3.58	352.51	103.29
00022891	106.60	99.14	372.34	1199.00	3.6	333.06	97.59
00022892	106.50	99.04	372.24	1142.00	3.58	318.99	93.47
00022893	106.50	99.04	372.24	1242.00	3.6	345.00	101.09

Q =	96.47 W/Ft²		1038.46	W/m²
dT =	25.57 K			
dL =	0.0625 Ft		0.02	m
K_T =	**0.774 ±**	0.079 W/m-K		

Temperature correction

Serial no.	Temp °C	Temp °F	Multiplication factor	Correct Temp °C
Bottom				
00022886	138.80	281.84	0.91	124.71
00022887	139.00	282.20	0.91	124.89
00022888	138.60	281.48	0.91	124.53
00022889	138.40	281.12	0.91	124.34
Top				
00022890	106.40	223.52	0.94	98.95
00022891	106.60	223.88	0.94	99.14
00022892	106.50	223.70	0.94	99.04
00022893	106.50	223.70	0.94	99.04

8/14/00 JP

Finger_TC_20

Variable transformer setpoint 70
Pressure on top Al plate 35 lb

Heat flow + thermal conductivity calculation are shown on next page for Finger_TC_20

Finger_TC_20

Thermal Conductivity calculation using Fourier equation

Run = Finger_TC_20

Sample = Annealed glass plate

$Q=K_T(dT/dL)$

where
- Q = heat transfer per unit area (W/Ft^2)
- K_T = thermal conductivity (W/m-K)
- dT = temperature difference between bottom and top sensors (K)
- dL = distance between bottom and top sensors (m)

Sensor readings

Serial no.	Temp °C	Correct Temp	Temp °K	Heat flow mV	Cal. constant mV/Btu/Ft²-Hr	Heat flow Btu/Ft²-Hr	Convert to W/Ft² 1Btu/Hr = 0.293W
Bottom							
00022886	115.60	106.26	379.46	877.00	3.58	244.97	71.78
00022887	115.80	106.45	379.65	758.00	3.59	211.14	61.86
00022888	115.40	106.08	379.28	903.00	3.56	253.65	74.32
00022889	115.30	105.98	379.18	974.00	3.55	274.37	80.39
Top							
00022890	89.60	84.23	357.43	975.00	3.58	272.35	79.80
00022891	89.70	84.33	357.53	925.00	3.6	256.94	75.28
00022892	89.60	84.23	357.43	879.00	3.58	245.53	71.94
00022893	89.70	84.33	357.53	960.00	3.6	266.67	78.13

Q =	74.19	W/Ft^2	798.58	W/m^2
dT =	21.92	K		
dL =	0.0625	Ft	0.02	m

K_T = **0.694** ± **0.071** W/m-K

Temperature correction

Serial no.	Temp °C	Temp °F	Multiplication factor	Correct Temp °C	
Bottom					
00022886	115.60	240.08	0.93	106.26	106.19
00022887	115.80	240.44	0.93	106.45	
00022888	115.40	239.72	0.93	106.08	
00022889	115.30	239.54	0.93	105.98	
Top					
00022890	89.60	193.28	0.95	84.23	84.28
00022891	89.70	193.46	0.95	84.33	
00022892	89.60	193.28	0.95	84.23	
00022893	89.70	193.46	0.95	84.33	

8/15/00 JB

Finger TC-21

Variable transformer setpoint 110
Pressure on top Al plate 35±1b

Heat flow + thermal conductivity calculation are shown on next page
See Finger TC-21.

Finger_TC_21

Thermal Conductivity calculation using Fourier equation

Run = Finger_TC_21

Sample = Annealed glass plate

$Q=K_T(dT/dL)$

where
- Q = heat transfer per unit area (W/Ft²)
- K_T = thermal conductivity (W/m-K)
- dT = temperature difference between bottom and top sensors (K)
- dL = distance between bottom and top sensors (m)

Sensor readings

Serial no.	Temp °C	Correct Temp	Temp °K	Heat flow mV	Cal. constant mV/Btu/Ft²-Hr	Heat flow Btu/Ft²-Hr	Convert to W/Ft² 1Btu/Hr = 0.293W
Bottom							
00022886	202.30	171.49	444.69	2121.00	3.58	592.46	173.59
00022887	202.60	171.75	444.95	1846.00	3.59	514.21	150.66
00022888	202.00	171.23	444.43	2138.00	3.56	600.56	175.96
00022889	201.70	170.97	444.17	2294.00	3.55	646.20	189.34
Top							
00022890	151.30	134.39	407.59	2246.00	3.58	627.37	183.82
00022891	151.70	134.75	407.95	2161.00	3.6	600.28	175.88
00022892	151.40	134.48	407.68	2062.00	3.58	575.98	168.76
00022893	151.50	134.57	407.77	2223.00	3.6	617.50	180.93

Q = 174.87 W/Ft² — 1882.33 W/m²
dT = 36.81 K
dL = 0.0625 Ft — 0.02 m

K_T = 0.974 ± 0.099 W/m-K

Temperature correction

Serial no.	Temp °C	Temp °F	Multiplication factor	Correct Temp °C	
Bottom					
00022886	202.30	396.14	0.86	171.49	171.36
00022887	202.60	396.68	0.86	171.75	
00022888	202.00	395.60	0.86	171.23	
00022889	201.70	395.06	0.86	170.97	
Top					
00022890	151.30	304.34	0.9	134.39	134.55
00022891	151.70	305.06	0.9	134.75	
00022892	151.40	304.52	0.9	134.48	
00022893	151.50	304.70	0.9	134.57	

8/16/00 JP

Finger TC_22

Variable Transformer setpoint - 120
Pressure on top Al plate - 3 ft-lb

Heat flow and thermal conductivity calculation for Finger_TC_22 are shown on next page.

Finger_TC_22

Thermal Conductivity calculation using Fourier equation

Run = Finger_TC_22

Sample = Annealed glass plate

$Q=K_T(dT/dL)$

where
- Q = heat transfer per unit area (W/Ft^2)
- K_T = thermal conductivity (W/m-K)
- dT = temperature difference between bottom and top sensors (K)
- dL = distance between bottom and top sensors (m)

Sensor readings

Serial no.	Temp ^0C	Correct Temp	Temp ^0K	Heat flow mV	Cal. constant $mV/Btu/Ft^2$-Hr	Heat flow Btu/Ft^2-Hr	Convert to W/Ft^2 1Btu/Hr = 0.293W
Bottom							
00022886	234.00	196.23	469.43	1785.00	3.58	498.60	146.09
00022887	234.50	196.66	469.86	2300.00	3.59	640.67	187.72
00022888	234.20	196.40	469.60	2372.00	3.56	666.29	195.22
00022889	233.50	195.81	469.01	3240.00	3.55	912.68	267.41
Top							
00022890	177.70	154.24	427.44	2738.00	3.58	764.80	224.09
00022891	178.00	154.51	427.71	2700.00	3.6	750.00	219.75
00022892	177.80	154.33	427.53	2602.00	3.58	726.82	212.96
00022893	177.80	154.33	427.53	2707.00	3.6	751.94	220.32

Q =	209.19	W/Ft^2	2251.83	W/m^2
dT =	41.92	K		
dL =	0.0625	Ft	0.02	m

K_T = 1.023 ± 0.104 W/m-K

Temperature correction

Serial no.	Temp ^0C	Temp ^0F	Multiplication factor	Correct Temp ^0C	
Bottom					
00022886	234.00	453.20	0.85	196.23	196.28
00022887	234.50	454.10	0.85	196.66	
00022888	234.20	453.56	0.85	196.40	
00022889	233.50	452.30	0.85	195.81	
Top					
00022890	177.70	351.86	0.88	154.24	154.35
00022891	178.00	352.40	0.88	154.51	
00022892	177.80	352.04	0.88	154.33	
00022893	177.80	352.04	0.88	154.33	

Final Entry:

I have reviewed this scientific notebook and find it in agreement with QAP-001. There is sufficient information regarding methods used for conducting tests, acquiring and analyzing data so that another qualified individual could repeat the activity.

E. C. Percy

9/26/2001