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Scientific Notebook # 337: Thermal Effects on Flow KTI (TEF)

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James D Prikryl CNWRA x5467

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5/18/99 JP

Thermal Effects on Flow KTI (TEF)
20-01402-661

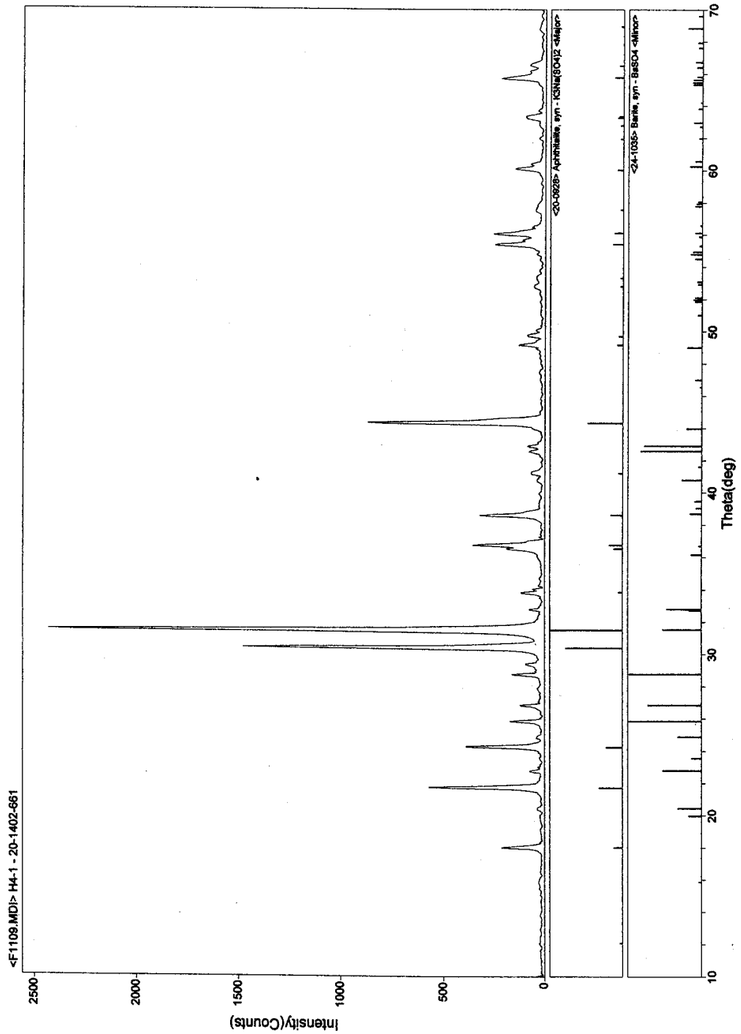
Initial entry 5/18/99 by James O. Pulsford

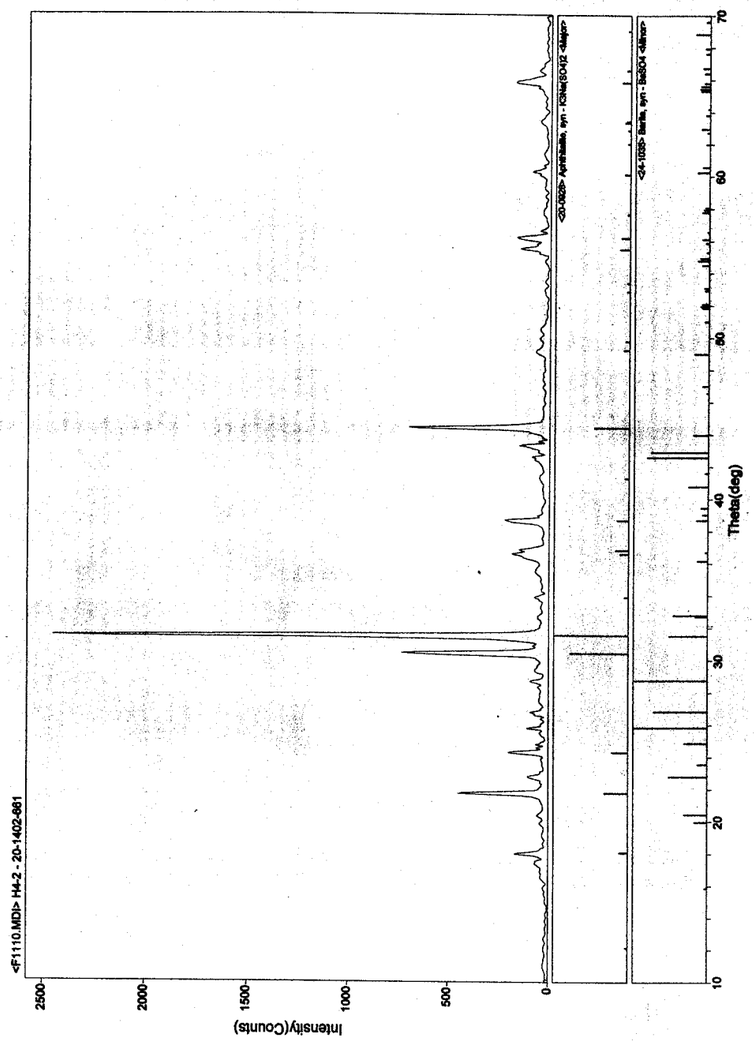
This notebook chronicles the laboratory investigation being conducted for the TEF KTI.

This notebook is a continuation of scientific notebook ~~238~~. 222.
JP
5/18/99

5/18/99 JP

Results of XRD analysis of samples H4-1 and H4-2 are shown below.





Aphthitalite is the major phase in both samples and barite is a minor phase in both samples.

5/18/99 gp

The voltage, current, & resistance of the variable trasformer and heater were measured. The voltage & current were measured with the variable Trasformer set at 20 & 30.

Measurments at 30

Voltage - 61.2 V
Current - 1.28 Amps

Measurments at 20

Voltage - 41.4 V
Current - 0.89 Amps

The resistance of the heater is 46.9 ohms.

5/19/99 gp

Thermocouple check

Obj - check integrity of themocouples used in expirment HEAT 4.

Method - check themocouple measurments against calibrated themometer.

Equipment -
- calibrated themometer (S/N C96-784)
- Corning hot plate
- Ice
- Beaker - 2L
- Themocouples Type K insulated, type T, and Type J
- Hewlett Packard 34970A Data Logger with HP 34908A 40 channel cartridges

Procedure
1. Thmocouples were attached to the HP data logger. Thmocouples were labled K1 to K102. K1 thru K99 are type K Thmocouples. K100 is a type J thmocouple which was used to check temperature of cartridge heater in the expirment. K101 & K102 are Type T thmocouples which were used to measure adit temperatures.

(2) Water was placed in a 2L beaker + heated to near boiling. Thermocouples + the calibrated thermometer were placed in the heated water + Temperatures were recorded. The temperature of the calibrated thermometer was 96°.

Temperatures are in °C

K1	96.5	K26	95.7
K2	95.8	K27	96.2
K3	96.0	K28	95.8
K4	95.2	K29	96.5
K5	96.5	K30	96.5
K6	95.1	K31	96.0
K7	96.5	K32	95.8
K8	95.4	K33	95.7
K9	95.8	K34	96.0
K10	95.8	K35	96.6
K11	96.3	K36	96.4
K12	96.1	K37	96.8
K13	96.1	K38	94.1
K14	95.6	K39	9.9 °E+37
K15	96.1	K40	96.9
K16	95.4	K41	95.7
K17	97.0	K42	95.3
K18	93.4	K43	95.6
K19	94.8	K44	96.0
K20	95.8	K45	96.0
K21	96.2	K46	95.8
K22	9.90 °E+37	K47	95.1
K23	88.9	K48	96.4
K24	95.3	K49	95.2
K25	96.4	K50	94.5

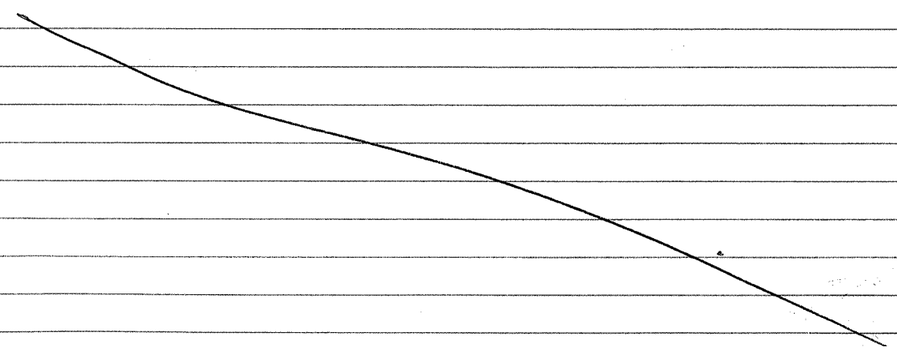
K51	95.6	K76	95.7
K52	96.2	K77	95.0
K53	95.4	K78	95.9
K54	95.8	K79	96.4
K55	96.2	K80	96.1
K56	95.4	K81	96.7
K57	95.7	K82	96.9
K58	96.1	K83	96.7
K59	95.5	K84	100.4
K60	96.4	K85	96.4
K61	95.8	K86	96.4
K62	96.1	K87	96.9
K63	95.9	K88	96.1
K64	96.0	K89	96.1
K65	96.3	K90	96.4
K66	95.3	K91	96.6
K67	95.6	K92	98.9
K68	95.6	K93	100.0
K69	95.9	K94	96.5
K70	95.5	K95	96.1
K71	95.5	K96	96.6
K72	95.7	K97	97.6
K73	95.3	K98	97.3
K74	95.9	K99	96.6
K75	95.3	K100	95.7
		K101	98.6
		K102	97.4

③ Ice water plank in a 2L beaker. Thermocouple & thermister were placed in the beaker & temperatures were recorded. The temperature of the calibrated thermometer was 0.0°C

Temperature in °C.

K1	0.14	K26	1.70
K2	0.62	K27	1.75
K3	0.91	K28	1.21
K4	0.68	K29	0.77
K5	1.73	K30	2.33
K6	0.77	K31	0.20
K7	1.77	K32	6.08
K8	2.04	K33	1.29
K9	0.18	K34	6.88
K10	6.15	K35	2.39
K11	1.56	K36	-0.70
K12	0.62	K37	-2.46
K13	1.58	K38	-1.18
K14	1.12	K39	820.64
K15	1.72	K40	-2.25
K16	1.15	K41	-0.73
K17	-2.70	K42	-0.26
K18	-0.88	K43	0.56
K19	-1.93	K44	6.53
K20	-3.71	K45	1.32
K21	2.95	K46	2.96
K22	489.44	K47	-0.68
K23	1.50	K48	12.90
K24	6.68	K49	6.32
K25	6.92	K50	-0.26

K51	-0.31	K76	1.14
K52	-0.16	K77	-0.04
K53	1.77	K78	0.74
K54	-0.73	K79	-0.91
K55	0.77	K80	-1.24
K56	-0.51	K81	0.33
K57	-0.52	K82	-0.14
K58	1.19	K83	-6.55
K59	-1.13	K84	0.71
K60	-0.94	K85	-0.40
K61	-1.13	K86	1.01
K62	1.16	K87	0.79
K63	-1.14	K88	1.38
K64	0.26	K89	1.46
K65	6.09	K90	-0.02
K66	-1.11	K91	0.25
K67	-0.81	K92	-0.59
K68	-0.64	K93	-0.78
K69	-0.64	K94	-0.63
K70	0.14	K95	0.80
K71	0.68	K96	6.95
K72	1.50	K97	0.81
K73	-0.68	K98	-0.06
K74	1.86	K99	6.88
K75	1.25	K100	0.50
		K101	-0.07
		K102	2.49



7/1/99 JP

Equilibrate and analyze water for use in next set of heater Tests.

Obj - equilibrate deionized water with Apache Leap tuff and analyze its chemistry.

Method - Rock crushed Apache leap tuff in Deionized Water for approximately 2 weeks and analyze resultant water by ICP for major and minor elements.

Materials and Equipment
- crushed Apache leap tuff
- Ultrapure Water
- 4L plastic containers
- filter paper & funnel
- plastic bottles

Procedure:
1. Place ~2 kg of tuff in 2 4L plastic containers. Label containers ALT-1 and ALT-2

(2) Add ~1300 ml of ultrapure water to each container. Enough water to completely immerse the stuff.

(3) Place container on a gyratory shaker set at 100 rpm. and let stand the water to equilibrate with the rock (~2 weeks). Leave containers open to atmosphere. (loosely capped)

8/2/99 ll (4) Filtered liquid from containers through Whatman #5 filter paper and plastic funnel into separately labeled 1-gallon Nalgene plastic containers.

Containers are labeled as ALT-1F + ALT-2F.

8/2/99 ll (5) pH measurements taken: ~10mL samples each.
sample ALT-1F = 8.29 pH
sample ALT-2F = 8.29 pH

Alkalinity measured using Hach # 24443-01 alkalinity test kit. ~5mL samples taken.
sample ALT-1F = 100 mg/L $CaCO_3$ methyl orange
sample ALT-2F = 100 mg/L $CaCO_3$ methyl orange

(6) added 6.5 mL conc. HNO_3 to each 1-liter sample bottle (approx. 0.1 M HNO_3) to preserve solution.

(7) Took three 20mL samples of ALT-1F and ALT-2F in 50mL plastic bottles for analysis by Div. 1, included two standard checks prepared as follows:
ALT-QC-1 5mL Detection Limits Std. lot no. 15-154AS pipetted with class A volumetric

(7) cont'd.
pipette and 5mL of IC drinstrument Check Std. 1 lot no. 16-20AS and 10mL Nanopure water in a 50mL plastic bottle.

ALT-QC-2 4mL of Std. lot no. 15-154AS and 6mL of Std. lot no. 16-20AS and 10mL nanopure water in a 50mL plastic bottle.

Samples labeled as follows:

3 duplicate ALT-1F samples: ALT-1F-A
ALT-1F-B
ALT-1F-C

3 duplicate ALT-2F samples: ALT-2F-A
ALT-2F-B
ALT-2F-C

2 standard checks: ALT-QC-1
ALT-QC-2

8/12/99 gp (8) Filtered remaining liquid from containers ALT-1 and ALT-2 into 500 ml plastic containers which were labeled:

ALT-1R and ALT-2R

Filtration was done using Whatman #5 filter paper and plastic funnels.

(9) Took two approximately 20 ml aliquots from ALT-1R and ALT-2R and placed in 60 ml PP bottles for anion analysis by Div 01.

These samples were labeled as follows

ALT-1R-A
ALT-1R-B

ALT-2R-A
ALT-2R-B

(10) Prepared two standards for anion analysis by Div 01 using IC Instrument Check Standard 1 from SPEX (lot NO 16-20AS).

Standard were labeled and prepared as follows:

ALT-QC-3 — 5 ml of standard (lot 16-20AS) + 15 ml H_2O in a 60 ml PP bottle. 7.0 JR 8/12/99

ALT-QC-4 — ~~7.5~~ 13.0 ml of standard (lot 16-20AS) + ~~12.5~~ 10 ml H_2O in a 60 ml PP bottle. 8/12/99

(11) Following samples were Taken to Div 01 for anion analysis by ion chromatography.

ALT-1R-A
ALT-1R-B
ALT-2R-A
ALT-2R-B
ALT-QC-3
ALT-QC-4

Client Name/Address: BOB CHERRINGTON, CNWRA/DIV 10, BLDG. 57

SAMPLE LIST/CHAIN OF CUSTODY

Southwest Research Institute
Chemistry and Chemical Engineering Division
6220 Culebra Road
San Antonio, Texas 78238-5166

Requested Turnaround: ☐ 1 Week ☒ 2 Weeks (Normal) ☐ 3 Weeks ☐ Other:

Client Purchase Order/Other ID | Site/Zone ID | Analyses Requested | SwRI Contact:

Sample ID	Sample Collection Date (mm/dd/yy)	Sample Collection Time (mm/dd/yy)	Matrix Type	Sample Type	# of Containers	ICP for common element analysis	Anions by ion chromatography											REMARKS
ALT-QC-1	8/12/99		W	DM	1	X	X											Preservation: a = HCl to pH <2; b = HNO_3 to pH <2; c = H_2SO_4 to pH <2; d = NaOH to pH >12; e = Other (Specify)
ALT-QC-2	"		"	"	1	X	X											Project is nuclear safety related 10CFR50, Part 21, Appendix B
ALT-1R-A	"		"	"	1	X	X											
ALT-1R-B	"		"	"	1	X	X											
ALT-1R-C	"		"	"	1	X	X											
ALT-2R-A	"		"	"	1	X	X											
ALT-2R-B	"		"	"	1	X	X											
ALT-2R-C	"		"	"	1	X	X											

Matrix Types: **A** - Air, **P** - Product, **S** - Soil, **T** - Tissue, **W** - Water

Sample Types: **DM** - Dissolved Metals, **ER** - Equipment Rinsate, **FB** - Field Blank, **MSD** - Matrix Spike Duplicate, **MS** - Matrix Spike, **TB** - Trip Blank, **TM** - Total Metals, **ES** - Environmental Samples, **FD** - Field Duplicate

Relinquished by (Signature): | Received by (Signature) | Relinquished by Sampler (Signature): | Relinquished by (Signature) | Received by (Signature): | Comments:

SwRI Project No: 20.18022.667
Received by SwRI Lab (Signature): [illegible]
Samples Disposed by:
Date/Time: 8/13/99 11:20

Div 01 COC Form 01-01-001, Rev 1/97

Page ____ of ____

Client Name/Address: James D. Purtymun, CNWRA/Div 20, BldG 57

SAMPLE LIST/CHAIN OF CUSTODY

Southwest Research Institute
Chemistry and Chemical Engineering Division
6220 Culebra Road
San Antonio, Texas 78238-5166

Requested Turnaround:
- ☐ 1 Week
- ☒ 2 Weeks (Normal)
- ☐ 3 Weeks
- ☐ Other: _____

Client Purchase Order/Other ID | Site/Zone ID | Analyses Requested | SwRI Contact:

Sample ID	Sample Collection Date (mm/dd/yy)	Sample Collection Time (mm/dd/yy)	Matrix Type	Sample Type	# of Containers	Analysis (Aluminum, Antimony, Arsenic, Barium, Beryllium, Bismuth, Boron, Cadmium, Calcium, Chromium, Cobalt, Copper, Iron, Lanthanum, Lead, Lithium, Magnesium, Manganese, Molybdenum, Nickel, Palladium, Phosphorus, Potassium, Selenium, Silicon, Silver, Sodium, Strontium, Sulfur, Thallium, Thorium, Tin, Titanium, Tungsten, Uranium, Vanadium, Yttrium, Zinc, Zirconium)
ALT-1R-A	8/11/99		W	DM	1	X
ALT-1R-B					1	X
ALT-2R-A					1	X
ALT-2R-B					1	X
ALT-QC-3					1	X
ALT-QC-4					1	X

REMARKS

Preservation
a = HCl to pH <2
b = HNO_3 to pH <2
c = H_2SO_4 to pH <2
d = NaOH to pH >12
e = Other (Specify)

Project is nuclear related 10CFR50 Part 21 Appendix B

Questions - call Jim at x5667

Matrix Types: **A** - Air; **P** - Product; **S** - Soil; **T** - Tissue; **W** - Water

Sample Types: **DM** - Dissolved Metals; **ER** - Equipment Rinsate; **FB** - Field Blank; **MSD** - Matrix Spike Duplicate; **MS** - Matrix Spike; **TB** - Trip Blank; **TM** - Total Metals; **ES** - Environmental Samples; **FD** - Field Duplicate

Relinquished by Sampler (Signature): [signature]

Received by (Signature): [signature]

Relinquished by (Signature):

Received by (Signature)

Relinquished by (Signature)

Comments:

SwRI Project No.: 20-1402-661

Received by SwRI (Signature): [signature]

Samples Disposed by:

Date/Time: 8/12/99 1445

Div 01 COC Form 01-01-001, Rev 1/97

Page ____ of ____

9/1/99 JP

Results of the chemical analyses of waters equilibrated with Apache Leap Tuff are shown below.

SOUTHWEST RESEARCH INSTITUTE
SAMPLE ANALYSIS DATA SHEET

Sample ID: ALT-1F-A

Lab Name: Southwest Research Institute
Client: Division 20
Lab Code: SwRI
Date Received: 08/03/99
Matrix: Water
Project No.: 20-1402-661
Lab System ID: 127771
Work Order: 16186

Analysis	Sample Result (mg/L)	Detection Limit (mg/L)
Aluminum	<0.05	0.05
Antimony	<0.005	0.005
Arsenic	0.050	0.005
Barium	0.006	0.005
Beryllium	<0.005	0.005
Bismuth	<0.01	0.01
Boron	0.375	0.025
Cadmium	<0.005	0.005
Calcium	13.1	0.05
Chromium	<0.005	0.005
Cobalt	<0.005	0.005
Copper	<0.005	0.005
Iron	<0.05	0.05
Lanthanum	<0.005	0.005
Lead	<0.005	0.005
Lithium	0.015	0.005
Magnesium	4.91	0.05
Manganese	0.008	0.005
Molybdenum	0.012	0.005
Nickel	<0.005	0.005
Palladium	<0.005	0.005
Phosphorus	0.036	0.02
Potassium	0.551	0.1
Selenium	<0.005	0.005
Silicon	11.5	0.025
Silver	<0.005	0.005
Sodium	18.5	0.2
Strontium	0.093	0.005
Sulfur	1.78	0.025
Thallium	<0.01	0.01
Thorium	<0.025	0.025
Tin	<0.005	0.005
Titanium	<0.005	0.005
Tungsten	<0.025	0.025
Uranium	<0.1	0.1
Vanadium	<0.005	0.005
Yttrium	<0.005	0.005
Zinc	0.013	0.005
Zirconium	<0.005	0.005

SOUTHWEST RESEARCH INSTITUTE
SAMPLE ANALYSIS DATA SHEET

Sample ID
ALT-1F-B

Lab Name: Southwest Research Institute
Lab Code: SwRI
Matrix: Water
Lab System ID: 127772

Client: Division 20
Date Received: 08/03/99
Project No.: 20-1402-661
Work Order: 16186

Analysis	Sample Result (mg/L)	Detection Limit (mg/L)
Aluminum	<0.05	0.05
Antimony	<0.005	0.005
Arsenic	0.047	0.005
Barium	0.007	0.005
Beryllium	<0.005	0.005
Bismuth	<0.01	0.01
Boron	0.376	0.025
Cadmium	<0.005	0.005
Calcium	13.2	0.05
Chromium	<0.005	0.005
Cobalt	<0.005	0.005
Copper	<0.005	0.005
Iron	<0.05	0.05
Lanthanum	<0.005	0.005
Lead	<0.005	0.005
Lithium	0.015	0.005
Magnesium	4.93	0.05
Manganese	0.008	0.005
Molybdenum	0.014	0.005
Nickel	<0.005	0.005
Palladium	<0.005	0.005
Phosphorus	0.035	0.02
Potassium	0.521	0.1
Selenium	<0.005	0.005
Silicon	11.4	0.025
Silver	<0.005	0.005
Sodium	18.9	0.2
Strontium	0.092	0.005
Sulfur	1.76	0.025
Thallium	<0.01	0.01
Thorium	<0.025	0.025
Tin	<0.005	0.005
Titanium	<0.005	0.005
Tungsten	<0.025	0.025
Uranium	<0.1	0.1
Vanadium	<0.005	0.005
Yttrium	<0.005	0.005
Zinc	0.016	0.005
Zirconium	<0.005	0.005

SOUTHWEST RESEARCH INSTITUTE
SAMPLE ANALYSIS DATA SHEET

Sample ID
ALT-1F-C

Lab Name: Southwest Research Institute
Lab Code: SwRI
Matrix: Water
Lab System ID: 127773

Client: Division 20
Date Received: 08/03/99
Project No.: 20-1402-661
Work Order: 16186

Analysis	Sample Result (mg/L)	Detection Limit (mg/L)
Aluminum	<0.05	0.05
Antimony	<0.005	0.005
Arsenic	0.047	0.005
Barium	0.009	0.005
Beryllium	<0.005	0.005
Bismuth	<0.01	0.01
Boron	0.381	0.025
Cadmium	<0.005	0.005
Calcium	13.1	0.05
Chromium	<0.005	0.005
Cobalt	<0.005	0.005
Copper	<0.005	0.005
Iron	<0.05	0.05
Lanthanum	<0.005	0.005
Lead	<0.005	0.005
Lithium	0.015	0.005
Magnesium	4.93	0.05
Manganese	0.009	0.005
Molybdenum	0.012	0.005
Nickel	<0.005	0.005
Palladium	<0.005	0.005
Phosphorus	0.043	0.02
Potassium	0.454	0.1
Selenium	<0.005	0.005
Silicon	11.5	0.025
Silver	<0.005	0.005
Sodium	18.7	0.2
Strontium	0.094	0.005
Sulfur	1.80	0.025
Thallium	<0.01	0.01
Thorium	<0.025	0.025
Tin	<0.005	0.005
Titanium	<0.005	0.005
Tungsten	<0.025	0.025
Uranium	<0.1	0.1
Vanadium	<0.005	0.005
Yttrium	<0.005	0.005
Zinc	0.014	0.005
Zirconium	<0.005	0.005

SOUTHWEST RESEARCH INSTITUTE
SAMPLE ANALYSIS DATA SHEET

Sample ID: ALT-2F-A

Lab Name: Southwest Research Institute
Lab Code: SwRI
Matrix: Water
Lab System ID: 127774

Client: Division 20
Date Received: 08/03/99
Project No.: 20-1402-661
Work Order: 16186

Analysis	Sample Result (mg/L)	Detection Limit (mg/L)
Aluminum	<0.05	0.05
Antimony	<0.005	0.005
Arsenic	0.039	0.005
Barium	0.008	0.005
Beryllium	<0.005	0.005
Bismuth	<0.01	0.01
Boron	0.346	0.025
Cadmium	<0.005	0.005
Calcium	12.2	0.05
Chromium	<0.005	0.005
Cobalt	<0.005	0.005
Copper	<0.005	0.005
Iron	<0.05	0.05
Lanthanum	<0.005	0.005
Lead	<0.005	0.005
Lithium	0.014	0.005
Magnesium	4.61	0.05
Manganese	<0.005	0.005
Molybdenum	0.031	0.005
Nickel	<0.005	0.005
Palladium	<0.005	0.005
Phosphorus	<0.02	0.02
Potassium	0.492	0.1
Selenium	<0.005	0.005
Silicon	11.7	0.025
Silver	<0.005	0.005
Sodium	18.8	0.2
Strontium	0.087	0.005
Sulfur	1.66	0.025
Thallium	<0.01	0.01
Thorium	<0.025	0.025
Tin	<0.005	0.005
Titanium	<0.005	0.005
Tungsten	<0.025	0.025
Uranium	<0.1	0.1
Vanadium	<0.005	0.005
Yttrium	<0.005	0.005
Zinc	0.018	0.005
Zirconium	<0.005	0.005

SOUTHWEST RESEARCH INSTITUTE
SAMPLE ANALYSIS DATA SHEET

Sample ID: ALT-2F-B

Lab Name: Southwest Research Institute
Lab Code: SwRI
Matrix: Water
Lab System ID: 127775

Client: Division 20
Date Received: 08/03/99
Project No.: 20-1402-661
Work Order: 16186

Analysis	Sample Result (mg/L)	Detection Limit (mg/L)
Aluminum	<0.05	0.05
Antimony	<0.005	0.005
Arsenic	0.040	0.005
Barium	0.007	0.005
Beryllium	<0.005	0.005
Bismuth	<0.01	0.01
Boron	0.347	0.025
Cadmium	<0.005	0.005
Calcium	12.2	0.05
Chromium	<0.005	0.005
Cobalt	<0.005	0.005
Copper	<0.005	0.005
Iron	<0.05	0.05
Lanthanum	<0.005	0.005
Lead	<0.005	0.005
Lithium	0.014	0.005
Magnesium	4.62	0.05
Manganese	<0.005	0.005
Molybdenum	0.029	0.005
Nickel	<0.005	0.005
Palladium	<0.005	0.005
Phosphorus	<0.02	0.02
Potassium	0.467	0.1
Selenium	<0.005	0.005
Silicon	11.6	0.025
Silver	<0.005	0.005
Sodium	18.9	0.2
Strontium	0.087	0.005
Sulfur	1.67	0.025
Thallium	<0.01	0.01
Thorium	<0.025	0.025
Tin	<0.005	0.005
Titanium	<0.005	0.005
Tungsten	<0.025	0.025
Uranium	<0.1	0.1
Vanadium	<0.005	0.005
Yttrium	<0.005	0.005
Zinc	0.015	0.005
Zirconium	<0.005	0.005

SOUTHWEST RESEARCH INSTITUTE
SAMPLE ANALYSIS DATA SHEET

Sample ID: ALT-2F-C

Lab Name: Southwest Research Institute
Lab Code: SwRI
Matrix: Water
Lab System ID: 127776

Client: Division 20
Date Received: 08/03/99
Project No.: 20-1402-661
Work Order: 16186

Analysis	Sample Result (mg/L)	Detection Limit (mg/L)
Aluminum	<0.05	0.05
Antimony	<0.005	0.005
Arsenic	0.037	0.005
Barium	0.007	0.005
Beryllium	<0.005	0.005
Bismuth	<0.01	0.01
Boron	0.346	0.025
Cadmium	<0.005	0.005
Calcium	12.4	0.05
Chromium	<0.005	0.005
Cobalt	<0.005	0.005
Copper	<0.005	0.005
Iron	<0.05	0.05
Lanthanum	<0.005	0.005
Lead	<0.005	0.005
Lithium	0.014	0.005
Magnesium	4.60	0.05
Manganese	<0.005	0.005
Molybdenum	0.030	0.005
Nickel	<0.005	0.005
Palladium	<0.005	0.005
Phosphorus	<0.02	0.02
Potassium	0.526	0.1
Selenium	<0.005	0.005
Silicon	11.6	0.025
Silver	<0.005	0.005
Sodium	18.9	0.2
Strontium	0.087	0.005
Sulfur	1.67	0.025
Thallium	<0.01	0.01
Thorium	<0.025	0.025
Tin	<0.005	0.005
Titanium	<0.005	0.005
Tungsten	<0.025	0.025
Uranium	<0.1	0.1
Vanadium	<0.005	0.005
Yttrium	<0.005	0.005
Zinc	0.034	0.005
Zirconium	<0.005	0.005

SOUTHWEST RESEARCH INSTITUTE
SAMPLE ANALYSIS DATA SHEET

Sample ID: ATL-QC-2

Lab Name: Southwest Research Institute
Lab Code: SwRI
Matrix: Water
Lab System ID: 127770

Client: Division 20
Date Received: 08/03/99
Project No.: 20-1402-661
Work Order: 16186

Analysis	Sample Result (mg/L)	Detection Limit (mg/L)
Aluminum	4.02	0.05
Antimony	1.20	0.005
Arsenic	0.204	0.005
Barium	3.79	0.005
Beryllium	0.099	0.005
Bismuth	<0.01	0.01
Boron	<0.025	0.025
Cadmium	0.095	0.005
Calcium	100	0.05
Chromium	0.191	0.005
Cobalt	0.945	0.005
Copper	0.491	0.005
Iron	1.92	0.05
Lanthanum	<0.005	0.005
Lead	0.059	0.005
Lithium	<0.005	0.005
Magnesium	98.1	0.05
Manganese	0.278	0.005
Molybdenum	<0.005	0.005
Nickel	0.755	0.005
Palladium	<0.005	0.005
Phosphorus	14.7	0.02
Potassium	148	0.1
Selenium	0.103	0.005
Silicon	<0.025	0.025
Silver	0.114	0.005
Sodium	119	0.2
Strontium	<0.005	0.005
Sulfur	15.4	0.025
Thallium	0.216	0.01
Thorium	<0.025	0.025
Tin	<0.005	0.005
Titanium	<0.005	0.005
Tungsten	<0.025	0.025
Uranium	<0.1	0.1
Vanadium	0.971	0.005
Yttrium	<0.005	0.005
Zinc	0.386	0.005
Zirconium	<0.005	0.005

SOUTHWEST RESEARCH INSTITUTE
SAMPLE ANALYSIS DATA SHEET

Sample ID: ALT-QC-1

Lab Name: Southwest Research Institute
Lab Code: SwRI
Matrix: Water
Lab System ID: 127769

Client: Division 20
Date Received: 08/03/99
Project No.: 20-1402-661
Work Order: 16186

Analysis	Sample Result (mg/L)	Detection Limit (mg/L)
Aluminum	5.09	0.05
Antimony	1.50	0.005
Arsenic	0.252	0.005
Barium	4.72	0.005
Beryllium	0.123	0.005
Bismuth	<0.01	0.01
Boron	<0.025	0.025
Cadmium	0.117	0.005
Calcium	125	0.05
Chromium	0.236	0.005
Cobalt	1.17	0.005
Copper	0.619	0.005
Iron	2.37	0.05
Lanthanum	<0.005	0.005
Lead	0.072	0.005
Lithium	<0.005	0.005
Magnesium	123	0.05
Manganese	0.344	0.005
Molybdenum	<0.005	0.005
Nickel	0.935	0.005
Palladium	<0.005	0.005
Phosphorus	12.2	0.02
Potassium	165	0.1
Selenium	0.129	0.005
Silicon	<0.025	0.025
Silver	0.140	0.005
Sodium	140	0.2
Strontium	<0.005	0.005
Sulfur	12.8	0.025
Thallium	0.262	0.01
Thorium	<0.025	0.025
Tin	<0.005	0.005
Titanium	<0.005	0.005
Tungsten	<0.025	0.025
Uranium	<0.1	0.1
Vanadium	1.21	0.005
Yttrium	<0.005	0.005
Zinc	0.489	0.005
Zirconium	<0.005	0.005

SOUTHWEST RESEARCH INSTITUTE
SAMPLE ANALYSIS DATA SHEET

Sample ID: ALT-1R-A

Lab Name: Southwest Research Institute
Lab Code: SwRI
Matrix: Water
Lab System ID: 128165

Client: Division 20
Date Received: 08/12/99
Project No.: 20-1402-661
Work Order: 16236

Analysis	Sample Result (mg/L)	Detection Limit (mg/L)
Bromide	<0.1	0.1
Chloride	2.44	0.1
Fluoride	0.131	0.1
Nitrate-N	1.72	0.1
Nitrite-N	<0.1	0.1
Phosphate-P	<0.1	0.1
Sulfate	5.61	0.1

SOUTHWEST RESEARCH INSTITUTE
SAMPLE ANALYSIS DATA SHEET

Sample ID: ALT-1R-B

Lab Name: Southwest Research Institute
Lab Code: SwRI
Matrix: Water
Lab System ID: 128166

Client: Division 20
Date Received: 08/12/99
Project No.: 20-1402-661
Work Order: 16236

Analysis	Sample Result (mg/L)	Detection Limit (mg/L)
Bromide	<0.1	0.1
Chloride	2.37	0.1
Fluoride	0.128	0.1
Nitrate-N	1.92	0.1
Nitrite-N	<0.1	0.1
Phosphate-P	<0.1	0.1
Sulfate	5.25	0.1

SOUTHWEST RESEARCH INSTITUTE
SAMPLE ANALYSIS DATA SHEET

Sample ID: ALT-2R-B

Lab Name: Southwest Research Institute
Lab Code: SwRI
Matrix: Water
Lab System ID: 128168

Client: Division 20
Date Received: 08/12/99
Project No.: 20-1402-661
Work Order: 16236

Analysis	Sample Result (mg/L)	Detection Limit (mg/L)
Bromide	<0.1	0.1
Chloride	2.35	0.1
Fluoride	0.124	0.1
Nitrate-N	1.85	0.1
Nitrite-N	<0.1	0.1
Phosphate-P	<0.1	0.1
Sulfate	4.85	0.1

SOUTHWEST RESEARCH INSTITUTE
SAMPLE ANALYSIS DATA SHEET

Sample ID: ALT-2R-A

Lab Name: Southwest Research Institute
Lab Code: SwRI
Matrix: Water
Lab System ID: 128167

Client: Division 20
Date Received: 08/12/99
Project No.: 20-1402-661
Work Order: 16236

Analysis	Sample Result (mg/L)	Detection Limit (mg/L)
Bromide	<0.1	0.1
Chloride	2.41	0.1
Fluoride	0.126	0.1
Nitrate-N	2.04	0.1
Nitrite-N	<0.1	0.1
Phosphate-P	<0.1	0.1
Sulfate	4.87	0.1

SOUTHWEST RESEARCH INSTITUTE
SAMPLE ANALYSIS DATA SHEET

Sample ID: ALT-QC-3

Lab Name: Southwest Research Institute
Lab Code: SwRI
Matrix: Water
Lab System ID: 128169

Client: Division 20
Date Received: 08/12/99
Project No.: 20-1402-661
Work Order: 16236

Analysis	Sample Result (mg/L)	Detection Limit (mg/L)
Bromide	<0.1	0.1
Chloride	7.40	0.1
Fluoride	4.85	0.1
Nitrate-N	5.61	0.1
Nitrite-N	<0.1	0.1
Phosphate-P	12.2	0.1
Sulfate	36.9	0.1

SOUTHWEST RESEARCH INSTITUTE
SAMPLE ANALYSIS DATA SHEET

Sample ID: ALT-QC-4

Lab Name: Southwest Research Institute
Lab Code: SwRI
Matrix: Water
Lab System ID: 128170

Client: Division 20
Date Received: 08/12/99
Project No.: 20-1402-661
Work Order: 16236

Analysis	Sample Result (mg/L)	Detection Limit (mg/L)
Bromide	<0.1	0.1
Chloride	10.5	0.1
Fluoride	6.95	0.1
Nitrate-N	7.91	0.1
Nitrite-N	<0.1	0.1
Phosphate-P	17.1	0.1
Sulfate	51.1	0.1

9/10/99 gf

Alkalinity was measured on the following samples using a Hach Model AL-36DT Test Kit.

Results

ALT-1R 82.4 mg/L as $CaCO_3$

ALT-2R 84.0 mg/L as $CaCO_3$

Results can be reported as "total alkalinity" which accounts for all $CO_3^=$, HCO_3^- and OH^-.

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6/12/01 JP

Copies of certificates of calibration for Vaisala HMP235 Relative Humidity / Temperature probes and TSI Model 8330-M Thermoanemometers are listed in the following pages. These instruments will be used in a proposed coldtrap experiment to determine the effects of condensation and dripping in a simulated heated adit.

VAISALA Certificate of Calibration

Report # 052401 W1840037 S.O.# 74327
Instrument Model: HMP235
Instrument Range: 0 to 100%RH
Accuracy: Relative Humidity: ±1%RH (0 to 90%RH), ± 2%RH (90 to 100%RH).
Accuracy: Temperature; ± 0.2 ºC @ 20 ºC

Calibration Date: 24 May 01
SeriaL Number : W1840037
Calibration Procedure: 11603019 Rev. F
Recommended calibration due date 24 May 02

Customer: SOUTHWEST RESEARCH INST.
City, State: SAN ANTONIO, TX

This unit was calibrated by adjusting its reading at 0% against dry nitrogen and at 75% against reference humidity and temperature instrument, Vaisala model HMP233. Additional instrument verification checkpoints were made against HMP233 reference at 11%RH and 97%RH. Calibration and instrument verification sequences utilize dry nitrogen and a set of controlled aqueous salt solutions Vaisala model HMK13B. Laboratory ambient conditions are maintained at a temperature of 22 ºC ± 1 ºC with relative humidity level of 50%RH ± 5%RH. The calibration uncertainty is presented at 95% confidence level, k=2. The calibration uncertainty is ±0.6%RH.

Calibration Data

Temperature Calibration (ºC)

Reference	Unit Under Test	Error	Tolerance
+ 22.17	+ 22.30	+ 0.13	± 0.20 ºC

Humidity Calibration (%RH)

Reference	Unit Under Test	Error	Tolerance
+ 0.10	+ 0.10	0.00	± 1.00
+ 11.30	+ 11.50	+ 0.20	± 1.00
+ 75.25	+ 75.20	- 0.05	± 1.00
+ 97.60	+ 96.00	- 1.60	± 2.00

The results of this calibration is traceable to the National Institute of Standards and Technology through NIST Test Report Number TN 264532 dated 02-Nov-00. Vaisala's calibration system has been established to meet the requirements of ANSI/NCS Z540-1-1994. This certificate can not be reproduced except in full, without the expressed written consent of Vaisala.

Calibration Equipment Used: Workstation 8

Model	Serial Number	Calibrate Date	Due Date
Power Supply	9800300	27-Nov-00	27-Nov-02
Fluke 45	6859005	25-Aug-00	25-Aug-01
HMK13B	S365000	12-Feb-01	12-Aug-01
HMP233	V4310011	30-Apr-01	30-Jul-01

Ambient Conditions
Humidity: 50.5%RH
Temperature: 22.2 ºC

Technical Operator
Linda Hall

Laboratory Manager
Mike Johnson

Mailing address:
Vaisala Inc.
100 Commerce Way
Woburn, MA 01801-1068
Tel. (781) 933-4500
Fax (781) 933-8029
http://www.vaisala.com

11604100

VAISALA Certificate of Calibration

Report # 051501 W1840062 S.O.# 74327
Instrument Model: HMP235
Instrument Range: 0 to 100%RH
Accuracy: Relative Humidity: ±1%RH (0 to 90%RH), ± 2%RH (90 to 100%RH).
Accuracy: Temperature; ± 0.2 ºC @ 20 ºC

Calibration Date: 15 May 01
Serial Number: W1840062
Calibration Procedure: 11603019 Rev. F
Recommended calibration due date 15 May 02

Customer: SOUTHWEST RESEARCH INST.
City, State: SAN ANTONIO, TX

This unit was calibrated by adjusting its reading at 0% against dry nitrogen and at 75% against reference humidity and temperature instrument, Vaisala model HMP233. Additional instrument verification checkpoints were made against HMP233 reference at 11%RH and 97%RH. Calibration and instrument verification sequences utilize dry nitrogen and a set of controlled aqueous salt solutions Vaisala model HMK13B. Laboratory ambient conditions are maintained at a temperature of 22 ºC ± 1 ºC with relative humidity level of 50%RH ± 5%RH. The calibration uncertainty is presented at 95% confidence level, k=2. The calibration uncertainty is ±0.6%RH.

Calibration Data

Temperature Calibration (ºC)

Reference	Unit Under Test	Error	Tolerance
+ 22.22	+ 22.40	+ 0.18	± 0.20 ºC

Humidity Calibration (%RH)

Reference	Unit Under Test	Error	Tolerance
+ 0.10	+ 0.10	0.00	± 1.00
+ 11.30	+ 11.50	+ 0.20	± 1.00
+ 75.44	+ 75.40	- 0.04	± 1.00
+ 97.60	+ 96.30	- 1.30	± 2.00

The results of this calibration is traceable to the National Institute of Standards and Technology through NIST Test Report Number TN 264532 dated 02-Nov-00. Vaisala's calibration system has been established to meet the requirements of ANSI/NCS Z540-1-1994. This certificate can not be reproduced except in full, without the expressed written consent of Vaisala.

Calibration Equipment Used: Workstation 9

Model	Serial Number	Calibrate Date	Due Date
Power Supply	134169	27-Nov-00	27-Nov-02
Fluke 45	6565002	01-Sep-00	01-Sep-01
HMK13B	P3940000	04-May-01	04-Nov-01
HMP233	V4310012	30-Apr-01	30-Jul-01

Ambient Conditions
Humidity: 50.5%RH
Temperature: 22.2' C

Technical Operator
Linda Hall

Deputy
Linda Hall

Mailing address:
Vaisala Inc.
100 Commerce Way
Woburn, MA 01801-1068
Tel. (781) 933-4500
Fax (781) 933-8029
http://www.vaisala.com

11604100

TSI CERTIFICATE OF CALIBRATION AND TESTING

TSI Model 8330-M TSI Serial No. 01030430

Description VELOCICHECK PORTABLE AIR VELOCITY METER

Calibration Standard WIND TUNNEL CALIBRATION SYSTEM, SERIAL NO. 109

CALIBRATION VERIFICATION RESULTS

Calibration Standard	Instrument Output	Percent Difference	Error Compared to Tolerance: Tolerance Limit-	0	Tolerance Limit+
0.000 m/s	0.000 m/s			*	
0.152 m/s	0.144 m/s	-5.0		*	
0.305 m/s	0.305 m/s	0.0		*	
0.506 m/s	0.505 m/s	-0.2		*	
1.014 m/s	0.987 m/s	-2.7	*		
2.022 m/s	1.972 m/s	-2.5	*		
3.546 m/s	3.526 m/s	-0.6		*	
6.069 m/s	6.036 m/s	-0.5		*	
9.590 m/s	9.576 m/s	-0.1		*	
13.696 m/s	13.668 m/s	-0.2		*	
19.389 m/s	19.375 m/s	-0.1		*	
0 °C	0 °C				
60 °C	60 °C				

Tolerance Limits:
± 5% of reading
or .025 m/s
whichever is greater
Velocity Corrected to Std Conditions of:
Ambient Temperature: 21.1°C
Barometric Pressure: 760.0 mmHg

TSI Incorporated does hereby certify that all materials, components, and workmanship used in the manufacture of this equipment are in strict accordance with the applicable specifications agreed upon by TSI and the customer and with all published specifications. All performance and acceptance tests required under this contract were successfully conducted according to required specifications. Furthermore, all test and calibration data supplied by TSI has been obtained using standards whose accuracies are traceable to the National Institute of Standards and Technology (NIST) or has been verified with respect to instrumentation whose accuracy is traceable to NIST, or is derived from accepted values of physical constants. Calibration procedures for this instrument comply with MIL-STD-45662A. The accuracy of the calibration facilities is greater than a ratio of 1:1 with respect to the accuracy specifications of the instrument being calibrated.

Applicable Test Report	Report Number	Date Last Verified
DC voltage	517979	09-18-00
Barometric Pressure	P-8264	05-15-00
Temperature (0°C)	254798	08-11-00
Temperature (19-35°C)	203537	08-11-00
Temperature (60°C)	216642	08-11-00
Pressure	822/260205-98	05-08-00
Pressure	822/258703-97	05-08-00
Velocity	836/259598-98	02-23-98
Dewpoint	257589	02-09-00

W. Swanson
Calibrated by

☒ Final Function Check

Mar 20, 2001
Calibration Date

TSI Incorporated
Environmental Measurements and Controls Division

Mailing Address: P.O. Box 64394 St. Paul, MN 55164 USA
Shipping Address: 500 Cardigan Road Shoreview, MN 55126 USA
Phone: (800) 777-8356 or (651) 490-2711 **Fax:** (651) 490-2874

TSI CERTIFICATE OF CALIBRATION AND TESTING

TSI Model 8330-M TSI Serial No. 01030433

Description VELOCICHECK PORTABLE AIR VELOCITY METER

Calibration Standard WIND TUNNEL CALIBRATION SYSTEM, SERIAL NO. 114

CALIBRATION VERIFICATION RESULTS

Calibration Standard	Instrument Output	Percent Difference	Error Compared to Tolerance: Tolerance Limit-	0	Tolerance Limit+
0.000 m/s	0.000 m/s			*	
0.149 m/s	0.147 m/s	-1.0		*	
0.305 m/s	0.305 m/s	0.0		*	
0.509 m/s	0.508 m/s	-0.2		*	
1.019 m/s	0.991 m/s	-2.8	*		
2.031 m/s	1.997 m/s	-1.7	*		
3.562 m/s	3.538 m/s	-0.7		*	
6.144 m/s	6.106 m/s	-0.6		*	
9.709 m/s	9.644 m/s	-0.7		*	
13.812 m/s	13.749 m/s	-0.5		*	
19.335 m/s	19.334 m/s	-0.0		*	
0 °C	0 °C				
60 °C	60 °C				

Tolerance Limits:
± 5% of reading
or .025 m/s
whichever is greater
Velocity Corrected to Std Conditions of:
Ambient Temperature: 21.1°C
Barometric Pressure: 760.0 mmHg

TSI Incorporated does hereby certify that all materials, components, and workmanship used in the manufacture of this equipment are in strict accordance with the applicable specifications agreed upon by TSI and the customer and with all published specifications. All performance and acceptance tests required under this contract were successfully conducted according to required specifications. Furthermore, all test and calibration data supplied by TSI has been obtained using standards whose accuracies are traceable to the National Institute of Standards and Technology (NIST) or has been verified with respect to instrumentation whose accuracy is traceable to NIST, or is derived from accepted values of physical constants. Calibration procedures for this instrument comply with MIL-STD-45662A. The accuracy of the calibration facilities is greater than a ratio of 1:1 with respect to the accuracy specifications of the instrument being calibrated.

Applicable Test Report	Report Number	Date Last Verified
DC voltage	517979	09-18-00
Barometric Pressure	P-8264	05-15-00
Temperature (0°C)	254798	08-11-00
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Temperature (60°C)	216642	08-11-00
Pressure	822/260205-98	05-08-00
Pressure	822/258703-97	05-08-00
Velocity	836/259598-98	02-23-98
Dewpoint	257589	02-09-00

W. Swanson
Calibrated by

☒ Final Function Check

Mar 20, 2001
Calibration Date

TSI Incorporated
Environmental Measurements and Controls Division

Mailing Address: P.O. Box 64394 St. Paul, MN 55164 USA
Shipping Address: 500 Cardigan Road Shoreview, MN 55126 USA
Phone: (800) 777-8356 or (651) 490-2711 **Fax:** (651) 490-2874

6/14/01 JP

Determination of liquid saturation of OK #1 dry silica sand

Obj - measure liquid saturation or moisture retention of OK #1 silica sand

Method and Procedure

① 5 cm of water was placed in a 25 cm tall, round sample container.

② Silica sand was added to container to make a 20 cm tall column of sand

③ Samples were taken at 2 cm intervals and placed in plastic sample containers.

④ Wts of containers and sample materials before and after heating at 90°C overnight were recorded and liquid saturation determined.

Data and Results are shown on the following pages.

Liquid saturation determination of OK # 1 dry silica sand

Experimental
5 cm of water was placed in a 25 cm tall, round sample container. Silica sand was then added to the container to make a 20 cm tall column of sand and water. Samples were taken at 2 cm intervals and placed in plastic sample containers. Wts of containers and sample materials were recorded and are shown below. Liquid was removed from samples by heating at 90C.

Properties of OK #1 dry silica sand

Bulk density

Compacted	108 lbs/ft3	1.73 g/cm3
Uncompacted	100 lbs/ft3	1.602 g/cm3

Porosity
0.27 Measure by Troy Maxwell
0.35 Calculated

Sample Data

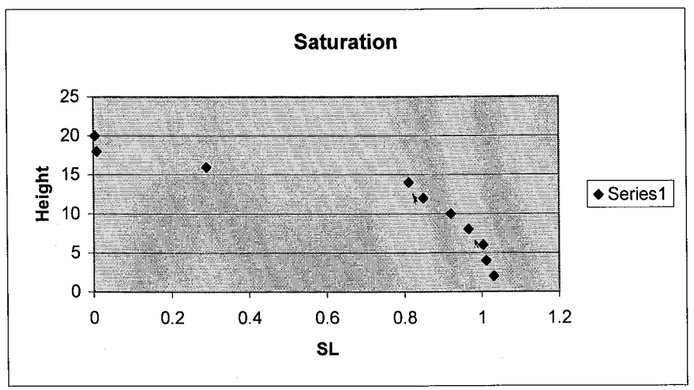
Sample ID	Container wt (g)	Container wt plus sample before heating (g)	Sample wt (g)	Container wt plus sample after heating (g)	Liquid wt (g)	Solid wt (g)	S_L using measured porosity	S_L using calculated porosity	
Controls									
C1	4.402	16.634	12.232	16.612	0.022	12.21	0.011544878	0.008314336	
C2	4.355	15.37	11.015	15.358	0.012	11.003	0.006987993	0.00503258	
C3	4.359	17.81	13.451	17.791	0.019	13.432	0.009063486	0.006527299	
MR20	4.385	14.244	9.859	14.236	0.008	9.851	0.005203457	0.003747401	20
MR18	4.387	17.135	12.748	17.112	0.023	12.725	0.011581169	0.008340472	18
MR16	4.377	14.139	9.762	13.563	0.576	9.186	0.401770811	0.289345412	16
MR14	4.403	19.645	15.242	17.367	2.278	12.964	1.125892786	0.810840169	14
MR12	4.381	17.742	13.361	15.666	2.076	11.285	1.178713139	0.848880083	12
MR10	4.426	19.652	15.226	17.122	2.53	12.696	1.276838433	0.919547495	10
MR8	4.404	18.828	14.424	16.332	2.496	11.928	1.340785453	0.96560056	8
MR6	4.347	21.288	16.941	18.262	3.026	13.915	1.393375121	1.00347434	6
MR4	4.421	21.574	17.153	18.492	3.082	14.071	1.403427591	1.01071388	4
MR2	4.383	20.462	16.079	17.528	2.934	13.145	1.430150881	1.029959333	2

liquid saturation was calculated using the following formula

$$S_L = (\text{Liquid wt(g)} / \text{solid wt(g)}) * (\text{bulk density} / \text{porosity})$$

JP 6/14/01

A plot of liquid saturation vs height is shown below.



6/22/01 JP Copies of calibration certificates issued by the SwRI cal lab for the Vaisala temp/humidity transmitters are entered below.

Southwest Research Institute
6220 Culebra Road
San Antonio, TX 78238
(210) 522-5215
Department of Quality Assurance
Calibration Laboratory

Certificate #
0972-01

Certificate of Calibration

19 June 2001

Issued to: JIM PRIKRYL DIV20 B57
Manufacturer/Model: VAISALA HMP235
Description: TEMPERATURE/HUMIDITY TRANSMITTER
Serial Number: W1840037
Asset Number: 008768
Work Order Number: 444044065

This certifies the above item was calibrated in compliance with MIL-STD-45662A and ANSI/NCSL Z540-1-1994. The results of this calibration relate only to the individual item as described above. Standards used in this calibration, described in the referenced calibration procedure with associated uncertainties or tolerances, are traceable to the National Institute of Standards and Technology (NIST). Supporting documentation relative to traceability is on file and available for examination upon request. This certificate is not to be reproduced, except in full, without the written approval of the Southwest Research Institute Department of Quality Assurance Calibration Laboratory.

This laboratory is accredited by the American Association for Laboratory Accreditation (A2LA) and the results of this calibration certificate were determined in accordance with the terms of accreditation unless stated otherwise below.

The uncertainty of the calibration was sufficient to determine that the item met the manufacturer's published specifications unless stated otherwise below.

Ambient Conditions: Temperature: 78.0 Degrees Fahrenheit Humidity: 52 % RH

Calibration Date: 18 Jun 01 **Calibration Procedure:** CL-61, 6/99

Condition as Received: SEE REMARKS

Condition as Released: SEE REMARKS

Remarks: SEE ATTACHED DATA SHEET FOR UNCERTAINTY

Approved by:
Walt Hill, Supervisor
Institute Calibration Laboratory

Measurements performed by:
Roger Dykstra, Technician

m\a2la.rpt Rev date 8 Jan 01

Page 1 of 1

Southwest Research Institute
Calibration Laboratory
Calibration Data Sheet

Work Order 444044065	**Mfr.** Vaisala		**Technician** R Dykstra
Asset No. 008768	**Model** HMP235		**Procedure** CL-61, 6/99
Serial No. W1840037	**Type** Tempereature/Humidity Transmitter		**Cal Date** 6/18/01
Remarks: The following readings are provided with an expanded uncertainty K=2 with an approximate confidence level of 95%.			

Parameter	Applied Value	Found/Left	Instrument Error	Uncertainty
Temperature	20.262 Degree C	20.325 Degree C	0.063 Degree C	0.30 Degree C
% Relative Humidity	25% RH	24.2 % RH	0.8 % RH	0.52 % RH
	50 % RH	49.5 % RH	0.5 %RH	0.53 % RH
	75 % RH	74.0 % RH	1.0 % RH	0.55 % RH

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6220 Culebra Road
San Antonio, TX 78238
(210) 522-5215
Department of Quality Assurance
Calibration Laboratory

Certificate # 0972-01

Certificate of Calibration

19 June 2001

Issued to: JIM PRIKRYL DIV20 B57
Manufacturer/Model: VAISALA HMP235
Description: HUMIDITY/TEMP TRANSMITTER
Serial Number: W1840062
Asset Number: 008769
Work Order Number: 444044064

This certifies the above item was calibrated in compliance with MIL-STD-45662A and ANSI/NCSL Z540-1-1994. The results of this calibration relate only to the individual item as described above. Standards used in this calibration, described in the referenced calibration procedure with associated uncertainties or tolerances, are traceable to the National Institute of Standards and Technology (NIST). Supporting documentation relative to traceability is on file and available for examination upon request. This certificate is not to be reproduced, except in full, without the written approval of the Southwest Research Institute Department of Quality Assurance Calibration Laboratory.

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The uncertainty of the calibration was sufficient to determine that the item met the manufacturer's published specifications unless stated otherwise below.

Ambient Conditions: Temperature: 79.0 Degrees Fahrenheit Humidity: 42 % RH

Calibration Date: 19 Jun 01 **Calibration Procedure:** CL-61, 6/99

Condition as Received: SEE REMARKS

Condition as Released: SEE REMARKS

Remarks: SEE ATTACHED DATA SHEET FOR UNCERTAINTY

Approved by:

Walt Hill, Supervisor
Institute Calibration Laboratory
m3a2la.rpt Rev date 8 Jan 01

Measurements performed by:

Roger Dykstra, Technician

Page 1 of 1

Southwest Research Institute
Calibration Laboratory
Calibration Data Sheet

Work Order 444044064	**Mfr.** Vaisala			**Technician** R Dykstra
Asset No. 008766	**Model** HMP235			**Procedure** CL-61, 6/99
Serial No. W1840062	**Type** Temperature/Humidity Transmitter			**Cal Date** 6/18/01
Remarks: The following readings are provided with an expanded uncertainty K=2 with an approximate confidence level of 95%.				
Parameter	**Applied Value**	**Found/Left**	**Instrument Error**	**Uncertainty**
Temperature	20.249 Degree C	20.400 Degree C	0.151 Degree C	0.30 Degree C
% Relative Humidity	25% RH	24.2 % RH	0.8 % RH	0.52 % RH
	50 % RH	48.8 % RH	1.2 %RH	0.53 % RH
	75 % RH	73.0 % RH	2.0 % RH	0.55 % RH

9/3/01 JP
Copies of calibration certificates for TSI Model 8345 thermoanemometer are listed on following pages.

TSI® CERTIFICATE OF CALIBRATION AND TESTING

TSI Model 8345 TSI Serial No. 01060216

Description VELOCICALC PORTABLE AIR VELOCITY METER

Calibration Standard WIND TUNNEL CALIBRATION SYSTEM, SERIAL NO. 106

CALIBRATION VERIFICATION RESULTS

Calibration Standard	Instrument Output	Percent Difference	Error Compared to Tolerance (Tolerance Limit- … 0 … Tolerance Limit+)
0.0 ft/min	0.0 ft/min		*
34.6 ft/min	34.2 ft/min	-1.2	*·
65.2 ft/min	64.8 ft/min	-0.6	*·
101.0 ft/min	101.2 ft/min	0.2	·*
158.5 ft/min	157.6 ft/min	-0.6	*·
330.2 ft/min	329.4 ft/min	-0.2	*·
657.4 ft/min	652.4 ft/min	-0.8	*·
1002.7 ft/min	999.8 ft/min	-0.3	*·
1470.3 ft/min	1473.6 ft/min	0.2	·*
2501.8 ft/min	2488.8 ft/min	-0.5	*·
4496.7 ft/min	4476.1 ft/min	-0.5	*·
5858.2 ft/min	5858.1 ft/min	-0.0	*
32.0 °F	32.0 °F		
140.0 °F	140.0 °F		

Tolerance Limits:
± 3% of reading
or 3 ft/min
whichever is greater
Velocity Corrected to Std Conditions of:
Ambient Temperature: 21.1°C
Barometric Pressure: 760.0 mmHg

TSI Incorporated does hereby certify that all materials, components, and workmanship used in the manufacture of this equipment are in strict accordance with the applicable specifications agreed upon by TSI and the customer and with all published specifications. All performance and acceptance tests required under this contract were successfully conducted according to required specifications. Furthermore, all test and calibration data supplied by TSI has been obtained using standards whose accuracies are traceable to the National Institute of Standards and Technology (NIST) or has been verified with respect to instrumentation whose accuracy is traceable to NIST, or is derived from accepted values of physical constants. Calibration procedures for this instrument comply with MIL-STD-45662A. The accuracy of the calibration facilities is greater than a ratio of 1:1 with respect to the accuracy specifications of the instrument being calibrated.

Applicable Test Report	Report Number	Date Last Verified
DC voltage	517979	09-18-00
Barometric Pressure	P-8264	05-15-00
Temperature (0°C)	254798	08-11-00
Temperature (19-35°C)	203537	08-11-00
Temperature (60°C)	216642	08-11-00
Pressure	822/260205-98	05-08-00
Pressure	822/258703-97	05-08-00
Velocity	836/264927	03-16-01
Dewpoint	257589	02-09-00

J. Swanson — Calibrated by
☒ Final Function Check
Jun 18, 2001 — Calibration Date

TSI Incorporated
Environmental Measurements and Controls Division
Mailing Address: P.O. Box 64394 St. Paul, MN 55164 USA
Shipping Address: 500 Cardigan Road Shoreview, MN 55126 USA
Phone: (800) 777-8356 or (651) 490-2711 **Fax:** (651) 490-2874

TSI® CERTIFICATE OF CALIBRATION AND TESTING

TSI Model 8345 TSI Serial No. 01060220

Description VELOCICALC PORTABLE AIR VELOCITY METER

Calibration Standard WIND TUNNEL CALIBRATION SYSTEM, SERIAL NO. 115

CALIBRATION VERIFICATION RESULTS

Calibration Standard	Instrument Output	Percent Difference	Error Compared to Tolerance (Tolerance Limit- … 0 … Tolerance Limit+)
0.0 ft/min	0.0 ft/min		*
35.6 ft/min	36.0 ft/min	1.1	·*
66.0 ft/min	65.7 ft/min	-0.5	*·
100.4 ft/min	100.5 ft/min	0.1	*
160.7 ft/min	160.3 ft/min	-0.2	*·
328.0 ft/min	328.9 ft/min	0.3	·*
650.3 ft/min	650.3 ft/min	0.0	*
1000.0 ft/min	996.3 ft/min	-0.4	*·
1475.3 ft/min	1480.3 ft/min	0.3	·*
2494.4 ft/min	2489.8 ft/min	-0.2	*·
4493.0 ft/min	4512.9 ft/min	0.4	·*
5914.4 ft/min	5889.4 ft/min	-0.4	*·
32.0 °F	32.1 °F		
140.0 °F	140.1 °F		

Tolerance Limits:
± 3% of reading
or 3 ft/min
whichever is greater
Velocity Corrected to Std Conditions of:
Ambient Temperature: 21.1°C
Barometric Pressure: 760.0 mmHg

TSI Incorporated does hereby certify that all materials, components, and workmanship used in the manufacture of this equipment are in strict accordance with the applicable specifications agreed upon by TSI and the customer and with all published specifications. All performance and acceptance tests required under this contract were successfully conducted according to required specifications. Furthermore, all test and calibration data supplied by TSI has been obtained using standards whose accuracies are traceable to the National Institute of Standards and Technology (NIST) or has been verified with respect to instrumentation whose accuracy is traceable to NIST, or is derived from accepted values of physical constants. Calibration procedures for this instrument comply with MIL-STD-45662A. The accuracy of the calibration facilities is greater than a ratio of 1:1 with respect to the accuracy specifications of the instrument being calibrated.

Applicable Test Report	Report Number	Date Last Verified
DC voltage	517979	09-18-00
Barometric Pressure	P-8264	05-15-00
Temperature (0°C)	254798	08-11-00
Temperature (19-35°C)	203537	08-11-00
Temperature (60°C)	216642	08-11-00
Pressure	822/260205-98	05-08-00
Pressure	822/258703-97	05-08-00
Velocity	836/264927	03-16-01
Dewpoint	257589	02-09-00

J. Swanson — Calibrated by
☒ Final Function Check
Jun 18, 2001 — Calibration Date

TSI Incorporated
Environmental Measurements and Controls Division
Mailing Address: P.O. Box 64394 St. Paul, MN 55164 USA
Shipping Address: 500 Cardigan Road Shoreview, MN 55126 USA
Phone: (800) 777-8356 or (651) 490-2711 **Fax:** (651) 490-2874

9/19/01 JP
Calibration certificates for OMEGA PX302-015GV pressure transducers are shown on following pages.

Southwest Research Institute
6220 Culebra Road
San Antonio, TX 78238
(210) 522-5215
Department of Quality Assurance
Calibration Laboratory

Certificate #
0972-01

Certificate of Calibration

15 June 2001

Issued to: RON GREEN DIV20 B57
Manufacturer/Model: OMEGA PX302-015GV
Description: PRESSURE TRANSDUCER
Serial Number: 971112
Asset Number: 006322
Work Order Number: 444044001

This certifies the above item was calibrated in compliance with MIL-STD-45662A and ANSI/NCSL Z540-1-1994. The results of this calibration relate only to the individual item as described above. Standards used in this calibration, described in the referenced calibration procedure with associated uncertainties or tolerances, are traceable to the National Institute of Standards and Technology (NIST). Supporting documentation relative to traceability is on file and available for examination upon request. This certificate is not to be reproduced, except in full, without the written approval of the Southwest Research Institute Department of Quality Assurance Calibration Laboratory.

This laboratory is accredited by the American Association for Laboratory Accreditation (A2LA) and the results of this calibration certificate were determined in accordance with the terms of accreditation unless stated otherwise below.

The uncertainty of the calibration was sufficient to determine that the item met the manufacturer's published specifications unless stated otherwise below.

Ambient Conditions: Temperature: 68.0 Degrees Fahrenheit Humidity: 40 % RH

Calibration Date: 15 Jun 01 **Calibration Procedure:** CLCP-PI-001, 6/99

Condition as Received: SEE ATTACHED DATA

Condition as Released: SEE ATTACHED DATA

Remarks: CALIBRATION DATA ATTACHED

Approved by:
Walt Hill, Supervisor
Institute Calibration Laboratory

Measurements performed by:
Mack Wood, Technician

Southwest Research Institute
Calibration Laboratory
Calibration Data Sheet

Work Order 444044001	**Mfr.** Omega	**Technician** C.M.Wood	
Asset No. 6322	**Model** PX302	**Procedure** CLCP-PI-001	
Serial No. 971112	**Type**	**Cal Date** Jun. 15, 01	
Remarks:			

Parameter	Applied Value	Found/Left	Instrument Error	Test Uncertainty	Result
Pressure	PSI	mV	N/A	+/-mV	
	0	-0.448		0.026	
	3.75	24.755		0.026	
	7.50	49.909		0.027	
	11.25	74.969		0.028	
	15.00	99.899		0.029	
	11.25	74.967		0.028	
	7.50	49.906		0.027	
	3.75	24.753		0.026	
	0	-0.446		0.026	

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Department of Quality Assurance
Calibration Laboratory

Certificate #
0972-01

Certificate of Calibration

15 June 2001

Issued to: RON GREEN DIV20 B57
Manufacturer/Model: OMEGA PX302-015GV
Description: PRESSURE TRANSDUCER
Serial Number: 980121
Asset Number: 007622
Work Order Number: 444044000

This certifies the above item was calibrated in compliance with MIL-STD-45662A and ANSI/NCSL Z540-1-1994. The results of this calibration relate only to the individual item as described above. Standards used in this calibration, described in the referenced calibration procedure with associated uncertainties or tolerances, are traceable to the National Institute of Standards and Technology (NIST). Supporting documentation relative to traceability is on file and available for examination upon request. This certificate is not to be reproduced, except in full, without the written approval of the Southwest Research Institute Department of Quality Assurance Calibration Laboratory.

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Ambient Conditions: Temperature: 68.0 Degrees Fahrenheit Humidity: 40 % RH

Calibration Date: 15 Jun 01 **Calibration Procedure:** CLCP-PI-001, 6/99

Condition as Received: SEE ATTACHED DATA

Condition as Released: SEE ATTACHED DATA

Remarks: CALIBRATION DATA ATTACHED

Approved by:
Walt Hill, Supervisor
Institute Calibration Laboratory

Measurements performed by:
Mack Wood, Technician

Southwest Research Institute
Calibration Laboratory
Calibration Data Sheet

Work Order 444044000	**Mfr.** Omega	**Technician** C.M.Wood	
Asset No. 7622	**Model** PX302	**Procedure** CLCP-PI-001	
Serial No. 971112	**Type**	**Cal Date** Jun. 15, 01	
Remarks:			

Parameter	Applied Value	Found/Left	Instrument Error	Test Uncertainty	Result
Pressure	PSI	mV	N/A	+/-mV	
	0	1.016		0.026	
	3.75	26.106		0.026	
	7.50	51.229		0.027	
	11.25	76.283		0.028	
	15.00	101.162		0.029	
	11.25	76.283		0.028	
	7.50	51.229		0.027	
	3.75	26.107		0.026	
	0	1.020		0.026	

10/22/01 JP

Coldtrap Experiment

Objective - to determine if condensation will form on a target sample in a differentially heated simulated drift surrounded by a ≥ 90% saturated porous media.

Method - construct a small scale simulated drift that is heated on one end. The drift is constructed of a porous ceramic tube which will be surrounded by ≥ 90% saturated sand. A target sample on the opposite end of the drift will be cooled to induce condensation and the condensation will be collected.

Material and Equipment
- ½" & 1" lexan plastic
- silicin sealant
- 1" and 1½" stainless steel bolts
- Porous ceramic tube - 61 cm long, 5 cm I.D., 6.35 cm O.D. (Kellundite ½ tubes, FAO-30, Filtros Ceramic Products).
- stainless steel screws - various lengths.
- O-ring, rubber 7.5 cm diameter
- Vaisala HMP235 Humidity and Temperature probes and transmitter (Serial nos. W1840062 and W1840037)

- Epsco Model D612-T power supply (2)
- Fluke 87 multimeter (S/N 61830517)
- CoolFlow CFT-33 refrigerated recirculator by NESLAB
- 3/8" NPT plastic pipe fittings
- TSI Model 8345 Velocicalc thermoanemometer (2)
  S/N 01060220 and 01060216
- Chromalux C-205 cartridge heater (3" long; 3/8" diameter)
  120V. 100W.
- Staticc variable transformer
- 1/4" OD Copper tubing
- 1/4" NPT plastic pipe fittings
- 1/32" copper wire
- aluminum tape
- 1/2" pipe insulation
- Neslab Exacal water bath circulator with a Neslab FTC-350 cooler.
- Omega thin wire type K thermocouples.
- Hydra dataloggers: Fluke; 20 channels
- Hydra station software.
- Silica Gel (OK #1 Dry)
- DI water

A. Construction of coldtrap apparatus

10/23/01 (1) Hexaw plastic was used to construct a box with the following dimensions:

Height - 25 cm
length - 60.5 cm
Width - 30.5 cm

A schematic showing the dimension of the box is shown in Fig 1 on following page.
The box was put together by drilling and bolting the sides together using 1" or 1½" stainless steel bolts. Silkon sealant was applied along the contacts of the plastic to provide a water and air tight seal.

(2) A porous ceramic tube was mounted lengthwise in the box as shown in Fig 1 (p50) The tubes had dimensions of 61cm long, 5cm ID, of 6.35 cm OD. The tube was approximately centered in the box; the center of the tube was measured 10/23/01 to be 12.25 cm from the bottom of the box.
The tube was mounted by drilling a 6.35 cm hole in one end of the box. On the opposite end of the box a 22cm x 14cm piece of plastic with a 6.35 cm hole drilled in it was mounted on the inside of the box with stainless steel screws. (see Fig 2) on p 51).

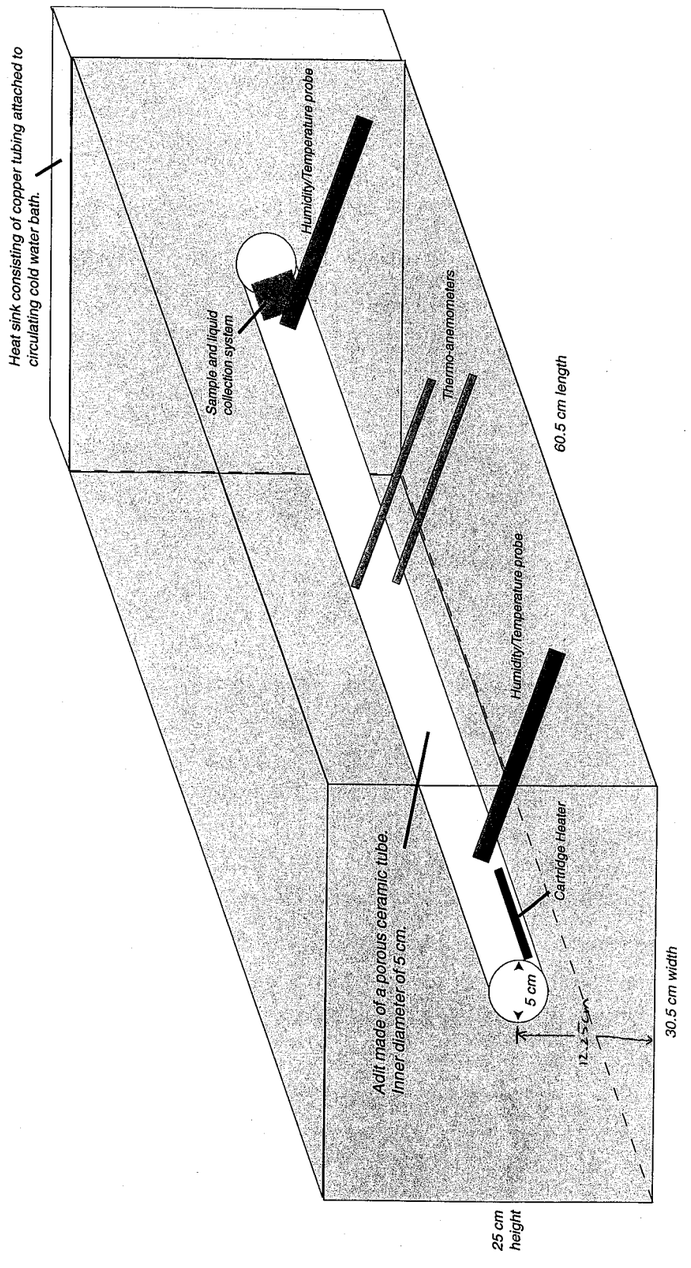
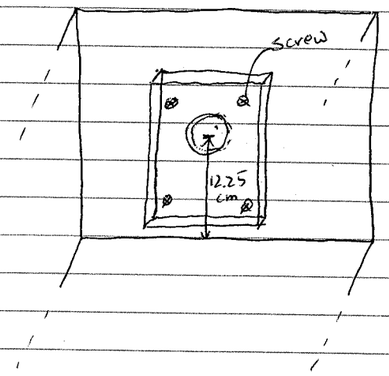


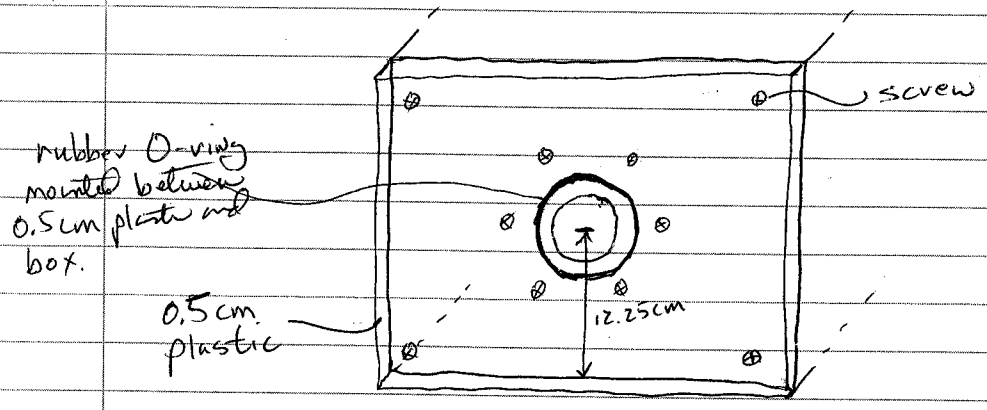
Fig 1 Schematic of cold trap apparatus

Fig 2. Schematic of piece of plastic with 6.35 cm hole drilled in it mounted on inside at one end of box to accomodate mounting of ceramic tube.



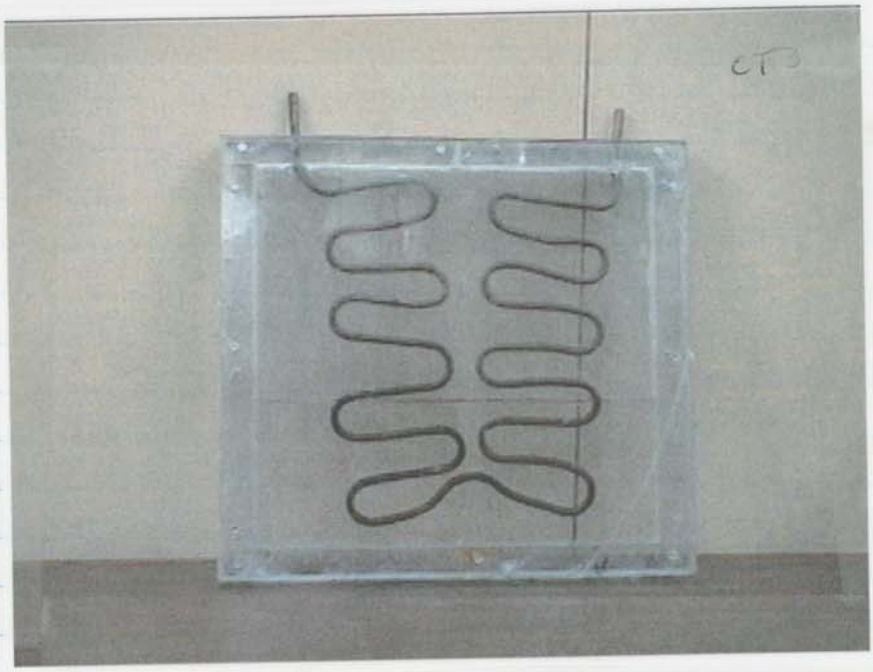
(3) To accomodate access to the adit, a 0.5 cm piece of plastic was mounted over the end of the box which had the 6.35 cm hole drilled for mounting of the ceramic tube. This plastic was secured with stainless steel screws. To achieve an air tight seal between the 0.5 cm piece of plastic and the box an O-ring was mounted between the 0.5 cm plastic and the box along the periphery of the 6.35 cm hole (see Fig 3 on p 52).

Fig 3. Schematic of 0.5 cm piece of plastic mounted on one end of coldtrap apparatus to accomodate access to the drift.



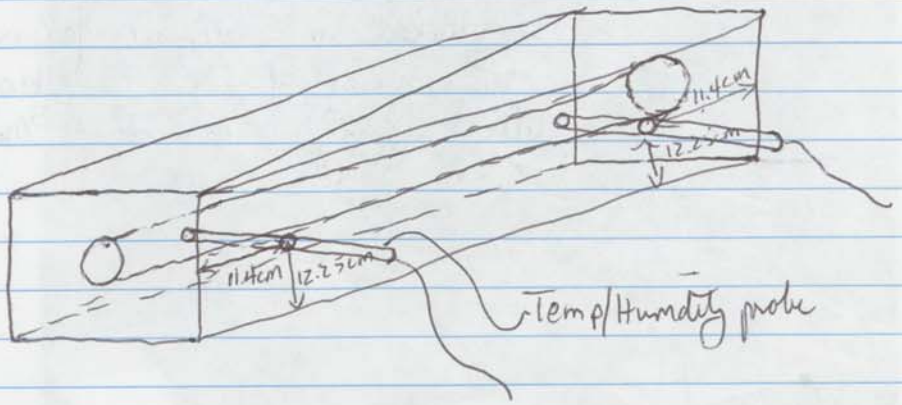
(4). A 35cm x 33cm plexiglass enclosure sealed with silicone to hold water was constructed to act as a heat sink. The enclosure is made of 1/2" and 3/16" plexiglass. held together with stainless steel screws. The enclosure contains coiled copper Tubing attached to a circulating water bath. The enclosure was designed so that it can be placed at one end of the coldtrap apparatus. A photo of the heat sink enclosure is shown on the following page. The heat sink apparatus was attached with plastic tubing to a circulating water bath.

Photo of heat sink assembly



B. Mounty of Vaisala HMP235 temperature/humidity probes

(1) Along 1 side of the apparatus 2 9/16" holes were drilled to accomodate placement of temp/humidity probes. The holes were drilled ~ 11.4 cm (4.5") from each end and ~ 12.25 cm (4.8") from the bottom of the box (see digram below).



(2) Holes were also drilled one the sides of the pavcon ceramic tube to accomdate diameter of the probes. These holes were also about 9/16" in diameter and were drilled about 4.5" from each end of the tube (see diagram on pervious page).

(3) The probes were passed through mounty flanges mounted over the holes on the outside of the box to create an airtight seal.

(4) The probe sensors were placed at the approximate center of the drift.

(5) Epsco D612-T units provided power to the probe transmitters and mA readings of humidity and temperature were collected using a Fluke multimeter.

C. Mounty of thermoanemometer

(1) Along 1 side of the box 2 9/16" holes were drilled to accomdate thermoanemometer. The holes were offset 1/2" on either side of the midpoint of the box and were drilled about 5 5/16" and 4 5/16" from the bottom of the box.

(2) Holes were also drilled in the porous ceramic tube to accomodate placement of the probes. These holes were about 1/4" in diameter and as in step 1 were offset 1/2 inch on either side of the midpoint of the tube and drilled about 5 5/16" and 4 5/16" from the bottom of the box.

(3) The 9/16 holes in the side of the box accomodate 3/8 NPT plastic pipe fittings with 3/8" openings

(4) A good seal was created when passing the ~~thermoanemometer~~ probes thru these fittings.

(5) The anemometer probes were placed so that airflow along the top and bottom of the duct could be measured.

(6) A photo showing location of probes is shown in the photo below.

Photo showing location of anemometer & T/H probes.

11/14/01 D. Mounty of cartridge heater

(1) At one end of the adit a 3" long 3/8" diameter cartridge heater was placed (see Fig 1).

(2) Two 1/8" holes were drilled through the plaster at one end of the box to accomodate the leads of the cartridge heater. The leads to the heater were pased through the plaster and connected to a variable transformer.

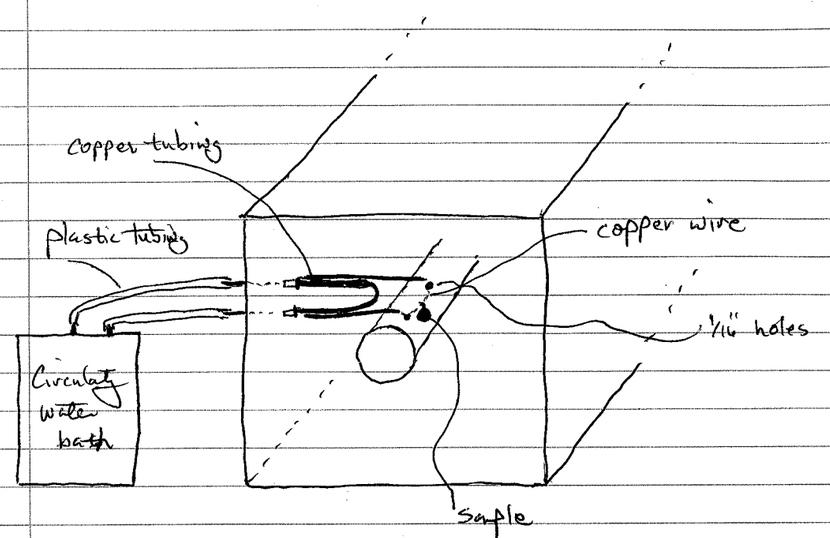
(3) The heater was placed near the bottom of the adit.

E. Construction and mounty of assembly to cool sample.

(1) A piece of 1/4" OD copper tubing was mounted at one end of the box at which the sample will be placed in the adit.

(2) Two holes were drilled in the side of the box at the propsed cold end of the box to accomodate 1/4" NPT plastic fittings. The copper tubing was passed thru these holes as shown in Fig 4. The copper Tubing was attached to a circulaty water bath.

Fig 4. Schematic of assembly to cool sample



(3) Two 1/16" holes were drilled into the top of the ceramic tube at ~ 1" and 4" from the end (see Fig 4).

(4) Two ~ 6" pieces of copper tubing were attached to the tubing connected to the water bath with aluminum tape. The ends of these Tubes were placed above the holes drilled in #3.

(5) A piece of 1/32" copper wire ran from the inside of the tubes in #4 thru the holes in the ceramic tube. The wire was positioned so that it ran along the inside top of the ceramic tube.

(6) The copper tube assembly with the box was covered with 1/2" pipe insulation. Aluminum tape was used to secure the insulation.

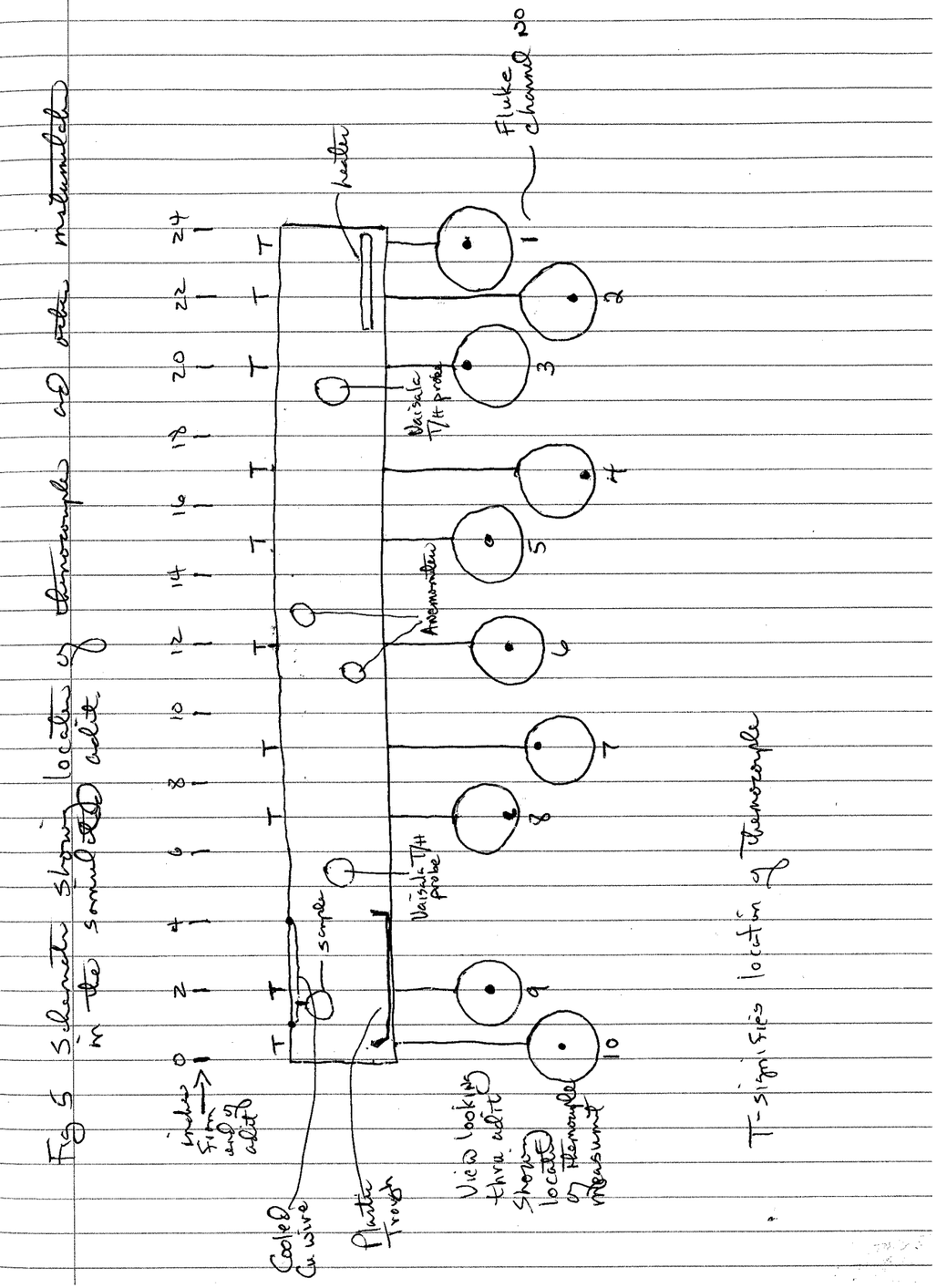
11/14/01 F. Preliminary test

The purpose of this test is to determine if the cold trap apparatus as designed will result in the formation of condensate + dripping from the sample. Before additional insulation and sample collection devices are installed.

(1) Ten thin wire thermocouples were placed in the simulated adit at the locations shown in Fig 5. The thermocouples were attached to a Fluke hydradatalogger. The hydradatalogger was attached via RS232 connection to IBM PC running Hydra Starter Software to monitor temperatures.

(2) A plastic trough container made from cutting a 250 ml PP bottle was placed under the copper wire assembly on the cold side of the adit to collect water dripping from the sample.

(3) The metal sample is a 3/4" diameter stainless steel disk. The disk was attached to the copper wire and can be moved along the copper wire to determine an optimum location for condensate on the sample.



11/15/01 (4) Following are photos showing placement and location of instruments for the preliminary test.

Photo showing placement & location of thin wire thermocouples along ceramic tube.

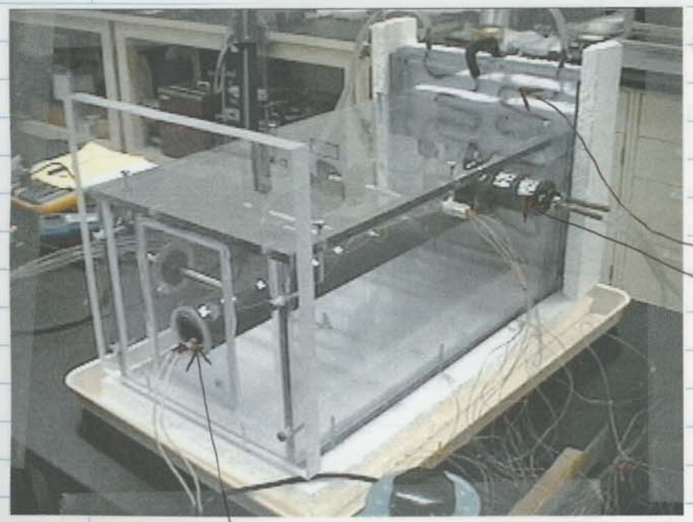


Photo showing cartridge heater, heat sink assembly, and assembly to cool sample.

heat sink assembly attached to end of box.

assembly to cool sample - insulated copper tubing

cartridge heater

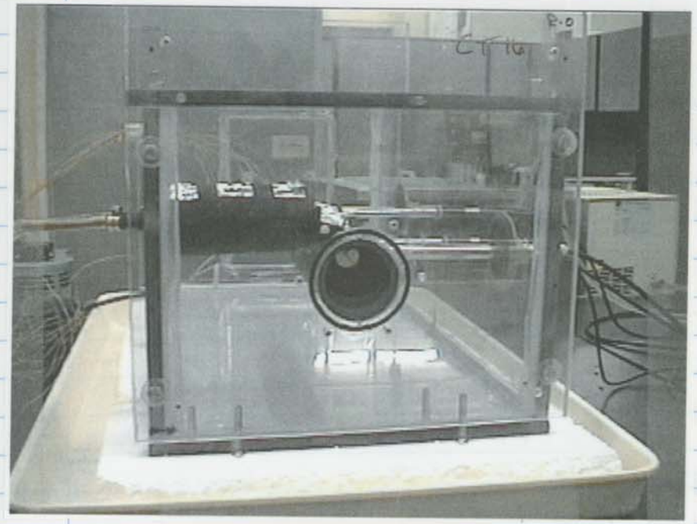


Photo showing assembly to cool sample

cooled copper wire.

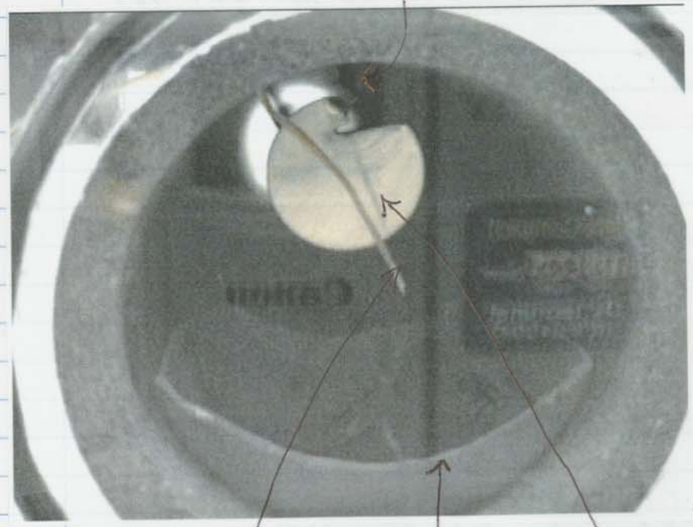


Photo of stainless steel disk sample mounted in adit and plastic trough for collecting water dripping from sample.

thin wire thermocouple.

plastic trough

stainless steel disk

11/26/01 JP

④ The box was filled with DI water and sand. A total of 15L of water (~7cm column) was added. Sand was added to make a column about 24cm high.

⑤ After adding water + sand the top of the enclosure was secured and the apparatus was insulated using 1" thick fiberglass insulation. The system was then allowed to set overnight.

11/27/01 JP

0800 hr. ⑥ Heat was applied to the cartridge heater via the variable transformer. The heat will be ramped up slowly to determine optimum settings for the coldtrap.
Dataloggers will be monitored to determine temperature + rel humidity in the adit.

Test comments

11/27/01
1430hr JP Temperature of the cartridge heater was ramped up slowly through the day. Condensate was observed forming on the stainless steel sample + copper wire cooling assembly. The test was allowed to run overnight.

11/28/01
JP 0945hr
The following observations of the coldtrap test are noted below after running overnight.

1) Condensate formed on the plastic at the cool end of the assembly.
2) The temperature around the sample was higher than the temperature at the end of the adit.
3) Air movement was registered on the anemometer placed at the top of the adit and had a reading of 0.2 cm/sec.

Apparently the sample cooling assembly was not set low enough to keep the sample area cooler than the end of the adit resulting in condensation on the plastic.

1015hr JP The sample cooling assembly was lowered to a cooler temperature and the heat sink assembly was raised to a higher temperature to see if the condensate on the plastic could be removed and induced to form on the sample.

1330 hr JP The temperature around the sample area is cooler than the end of the adit. The condensate on the adit was removed and condensate could be seen forming on the sample dish and copper wire. A few drops of water have collected in the sample trough below the sample + copper wire.

11/28/01 JP
1605hrs Inspection of instruments in the adit indicated that condensate was forming & dripping from the anemometer placed along the top middle of the adit.

12/3/01 JP
1100hrs AC/DC power adapters were connected to anemometers. This allowed anemometer to record continuously. Continous power to the anemometer followed then to remain warm which resulted in removal of condensate from the to p anemometer.

12/4/01 JP Condensate was noticed forming on the trough used to collect dripping from the sample rod copper wire holding the sample. The trough was removed to determine if more condensate would then form on the sample.

12/5/01 JP Inspection revealed that removal of the trough caused more condensate to form on the sample disk.

11/28/01 JP

Request and reciept of samples of in-drift materials to investigate chemistry of condensate water dripping into drifts.

A letter requesting in drift materials for use in the calditrap experiment was draped by Dr. Lauren Browning and sent to Dr. Stephan Brocoum of the DOE/OCRWM. A copy of the letter in shown below.

September 28, 2001

Dr. Stephan Brocoum, Assistant Manager
Office of Licensing and Regulatory Compliance
U.S. Department of Energy
Office of Civilian Radioactive Waste Management
Yucca Mountain Site Characterization Office
P.O. Box 30307
North Las Vegas, NV 89036-0307

SUBJECT: REQUEST FOR IN-DRIFT MATERIAL SAMPLES

Dear Dr. Brocoum:

In accordance with the agreement between the U.S. Department of Energy (DOE) and the U.S. Nuclear Regulatory Commission (NRC) regarding pre-licensing interactions dated November 16, 1998, the NRC formally requests samples of in-drift materials to investigate the chemistry of condensate water dripping into drifts. Specifically, the NRC requests the following items:

1) steel sets - two 1 inch squares and two 2 inch squares of steel support material
2) grout - 1 kg of powdered grout mix
3) rock bolt - one whole rock bolt
4) wire mesh - 5 square feet of wire mesh

In addition, the NRC plans to perform trace element analyses on the condensate water that has reacted with the requested materials, therefore, the NRC requests DOE provide the compositional analyses of the requested materials. Please send the materials to:

Dr. Lauren Browning
Southwest Research Institute/Div. 20
Center for Nuclear Waste Regulatory Analysis
6220 Culebra Road, Building 189
San Antonio, TX 78238-5166

Thank you in advance for your assistance with this matter. If you have any questions regarding this letter, please contact the technical lead for the Thermal Effects on Flow Key Technical

S. Brocoum -2-

Issue, Mr. Jeffrey Pohle or the Senior Project Manager for issue resolution, Mr. James Andersen. Mr. Pohle can be reached at (301) 415-6703 and Mr. Andersen at (301) 415-5717.

Sincerely,

/RA/ nks for cwr

C. William Reamer, Chief
High-Level Waste Branch
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards

cc: See attached distribution list

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DOCUMENT NAME: S\DWM\HLWB\JWA\REQUEST FOR SAMPLES.WPD

OFC	HLWB	HLWB	HLWB	HLWB	
NAME	JAndersen jwa	JPohle jap	DBrooks djb	CWReamer	nks for cwr
DATE	09/27/01	09/27/01	09/27/01	09/28/01	

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ACNW: YES X NO ___ Delete file after distribution: Yes ___ No ___
1) This document should be made available to the PUBLIC - 09/27/01 JWA
2) This document is related to the HLW program. It should be placed in the LSS - 09/27/01 JWA

A letter explaining transmittal of the requested in drift material samples drafted by Stephan Brocoum to C. William Reamer of the NRC is shown on the following page.

This letter described the materials & documents that were shipped.

Department of Energy
Office of Civilian Radioactive Waste Management
Yucca Mountain Site Characterization Office
P.O. Box 364629
North Las Vegas, NV 89036-8629

QA: N/A

NOV 09 2001

OVERNIGHT MAIL

C. William Reamer, Chief
High-Level Waste Branch
Division of Waste Management
Office of Nuclear Materials Safety
and Safeguards
U. S. Nuclear Regulatory Commission
Two White Flint North
Rockville, MD 20852

TRANSMITTAL OF IN-DRIFT MATERIAL SAMPLES

Reference: Ltr, Reamer to Brocoum, dtd 9/28/01

In the referenced letter, the U.S. Nuclear Regulatory Commission (NRC) and the Center for Nuclear Waste Regulatory Analysis (CNWRA) requested samples of various materials. The materials requested and the materials we are providing are as follows:

Requested	Shipping
1. Steel sets – two 1" squares and two 2" squares of steel support material	One 12" section of steel set
2. Grout – one kg of powdered grout mix	One kg of powdered grout mix
3. Rock bolt – one whole rock bolt	One Split Set rock bolt and one Super Swellex rock bolt
4. Wire mesh – five square feet of wire mesh	Five square feet of wire mesh

Compositional analyses for the materials were also requested. With the materials, we included an analysis of the grout as well as American Society for Testing Materials (ASTM) standards A 36 and F 432, which include chemical composition requirements for steel sets and rock bolts respectively. The specification for wire mesh, ASTM A 185, does not include any requirements for chemical composition, nor does the specification for the steel wire used to fabricate the wire mesh, ASTM A 82.

Differences between the samples requested and those being provided have been discussed with NRC and CNWRA staff and these differences were agreed to be acceptable.

As per your request the above listed materials will be sent to:

Dr. Lauren Browning
Southwest Research Institute/Div. 20
Center for Nuclear Waste Regulatory Analysis
6220 Culebra Road, Building 189
San Antonio, TX 78238-5166

The materials were shipped on November 7, 2001.

If you require any additional information, please contact Timothy C. Gunter at (702) 794-1343.

Stephan Brocoum
Assistant Manager, Office of
Licensing and Regulatory Compliance

OL&RC:TCG-0180

11/28/01 JP

The subject sample materials were received at the CNWRA (Bldg 189) on 11/20/01 and placed in Rm 137.

The samples were opened and inspected in Rm 137 on 11/28/01. A sperm custody receipt log sheet with the samples is stored in the Sorting Page. All samples listed on this receipt log were present.

A sample custody form was filled out for each of the samples. The sperm ID listed on the DOE receipt log was retained. The sample custody forms were placed in a binder entitled "Thermal Effects in Flow Simple Custody Log".

SMF Specimen Custody Receipt

CSITS v.1

Requestor:		Ship To:		
Lauren Browning **SRI** **6220 Culebra Rd.**		**Lauren Browning** **SRI** **6220 Culebra Rd.**		Date Received: _____ Shipment ID: 01000522 Shipping Date: 06-nov-2001
San Antonio, TX	**78238-5166**	**San Antonio, TX**	**78238-5166**	SMF Geotechnician _____ Date 11-5-01

Container ID: 01004854 Specimens in this container: 7

Specimen ID	Specimen Type	Site Type	Collected For	Date Collected	Collector's Sample ID
01014633	N/A	Other	Browning	29-oct-2001	Grout
01014634	N/A	Other	Browning	29-oct-2001	Steel Set Section
01014635	N/A	Other	Browning	29-oct-2001	10' Swellex Rock Bolt
01014636	N/A	Other	Browning	29-oct-2001	2' Swellex Rock Bolt
01014637	N/A	Other	Browning	29-oct-2001	10' Split Set Rock Bolt
01014638	N/A	Other	Browning	29-oct-2001	3"x2.5" Wire Mesh
01014639	N/A	Other	Browning	29-oct-2001	3"x2.5" Wire Mesh

Please Sign this form and return to:
Sample Management Facility
Yucca Mountain Site Characterization Project
P.O. Box 617
Mercury, NV 89023-0617

I hereby acknowledge the receipt of the Specimens listed above. I will return this form to the SMF within 10 business days of receipt.

Recipient Lauren Browning Date 11-28-01

Page 1 of 1: 1 Containers shipped.

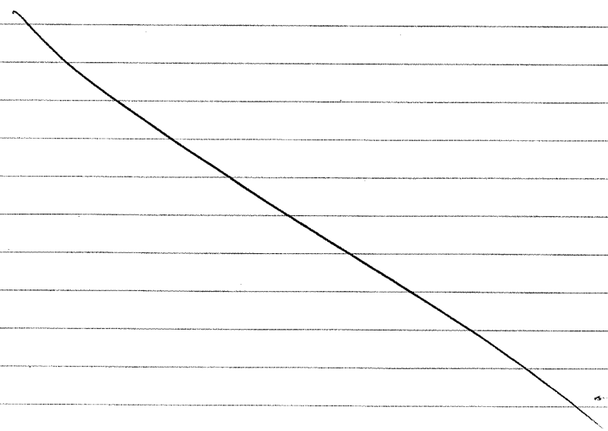
12/5/01 gp Instrument readings - Following is a list of the instrument readings taken during the test.

Date	Time	Cold end %RH	Cold end T°C	Hot end RH%	Hot end T°C	Anemometer Velocity Top	Anemometer Velocity Bottom	Transformer Setting
11/27/01	0825	~~98.6~~ ~~#1278~~	~~22.4~~ ~~7.3~~	96.2	22.5	0.00	0.00	10
	0850	98.6	22.4	96.1	22.6	0.00	0.00	10
	0910	98.6	22.4	96.2	22.6	0.00	0.00	10
	1015	98.6	~~22.4 23.2~~ gp 11/27/01	96.3	23.2	0.00	0.00	15
	1105	98.6	~~22.4 24.0~~ gp 11/27/01	96.2	24.0	0.00	0.00	20
	1150	98.7	~~22.4 25.0~~ gp 11/27/01	94.7	25.0	0.00	0.00	25
	1305	98.7	22.4	92.1	26.6	0.00	0.00	30
	1335	98.7	22.4	90.6	28.0	0.00	0.00	35
	1430	98.7	22.4	89.4	29.4	0.00	0.00	40
11/28/01	0935	98.6	25.3	87.9	38.9	0.00	0.00	40
	1100	98.6	25.5	87.7	35.4	0.00	0.00	40
	1330	98.7	26.5	88.1	35.7	0.00	0.00	40
11/29/01	0840	98.6	31.1	85.7	43.9	0.00	0.00	40
	1115	98.7	31.6	87.1	44.4	6.00	0.00	40
11/30/01	0935	99.2	32.9	88.8	45.7	0.00	0.00	40
12/3/01	0930	100.0	33.6	91.4	47.1	0.00	0.00	40
	1350	100.0	33.6	91.5	47.0	0.00	0.00	40
12/4/01	0730	100.0	33.9	92.2	47.5	0.00	0.00	40
	1330	100.0	34.0	92.1	47.5	0.00	0.00	40
12/5/01	0830	100.0	34.9	92.5	47.7	0.00	0.00	40
12/6/01	0730	100.0	34.2	92.2	47.2	0.00	0.00	40
12/7/01	1000	100.0	34.2			0.00	0.00	40
12/7/01	1300	Transformer set to 36						
12/10/01	0930	100.0	33.5	92.6	45.0	6.00	0.00	36
12/10/01	0940	Transformer set to 32						
12/11/01	0925	99.9	32.7	93.6	42.2	0.00	0.00	32
12/11/01	1325	100.0	32.6	93.5	42.2	0.00	0.00	32
12/11/01	Transformer set to 28 at 1325							
12/12/01	0800	100.0	32.0	94.5	39.7	0.00	0.00	28
12/13/01	0930	100.0	30.6			0.00	0.00	28
12/13/01	0940 transformer set to 24							

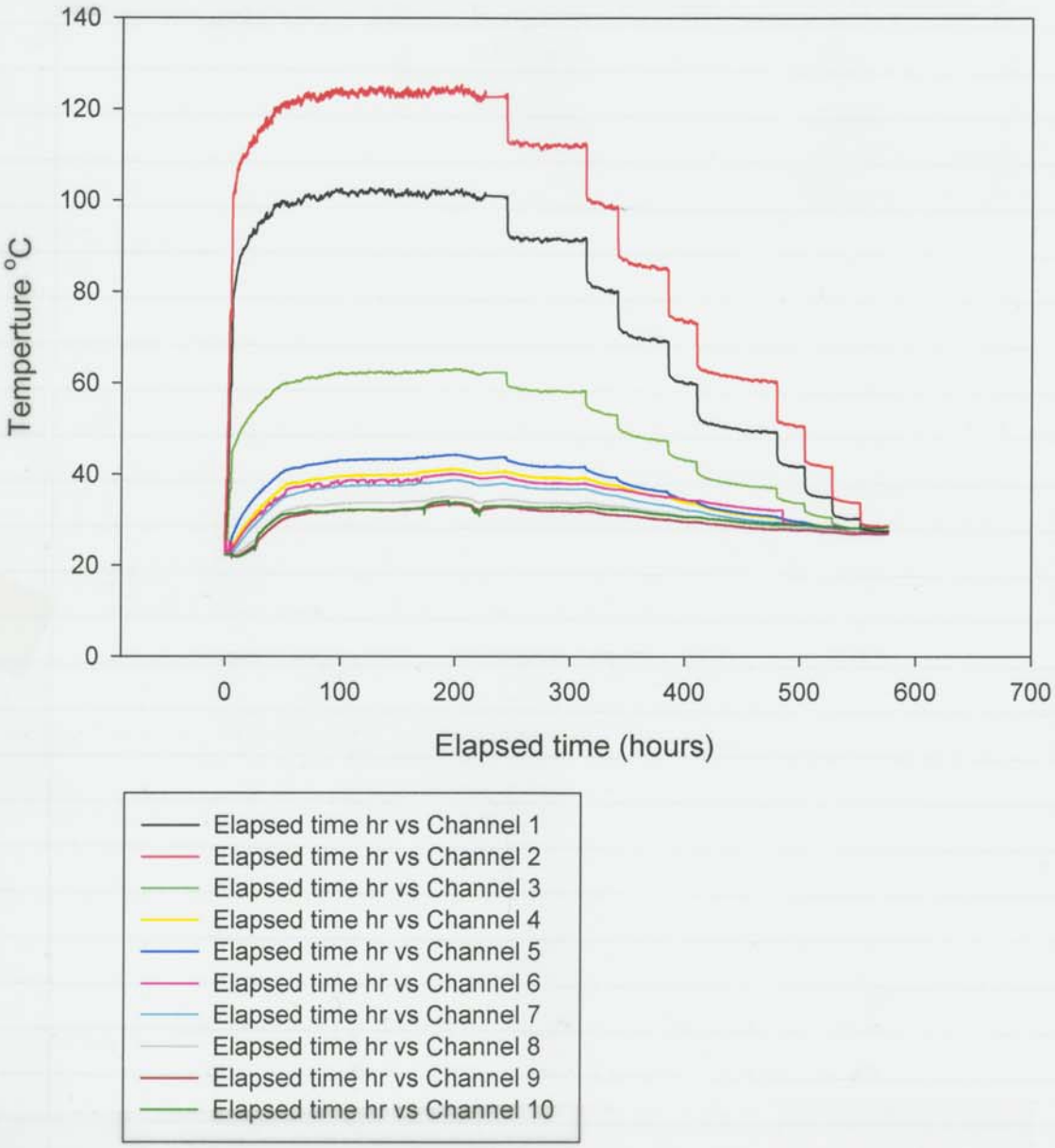
cont on next page

Date	Time	Cold end %RH	Cold end T°C	Hot end %RH	Hot end T°C	Anemometer Velocity Top	Anemometer Velocity Bottom	Transformer Setting
12/14/01	0930	99.7	30.4	95.4	36.2	0.00	0.00	24
12/14/01	1040	transformer set to 20						
12/17/01	0815	99.8	28.4	96.3	32.4	0.00	0.00	20
12/17/01	0815	transformer set to 16						
12/18/01	0750	99.7	28.1	97.3	30.7	0.00	0.00	16
12/18/01	0815	Transformer set to 12						
12/19/01	0800	99.9	27.5	98.0	28.9	0.00	0.00	12
12/19/01	0815	Transformer set to 8						
12/20/01	0815	99.9	27.1	98.4	27.5	0.00	0.00	8
12/20/01	0830	Transformer set to 4						
12/21/01	0815	99.9	27.0	98.4	26.9	0.00	0.00	4
12/21/01	0815	Transformer set to 0 - end of experiment.						

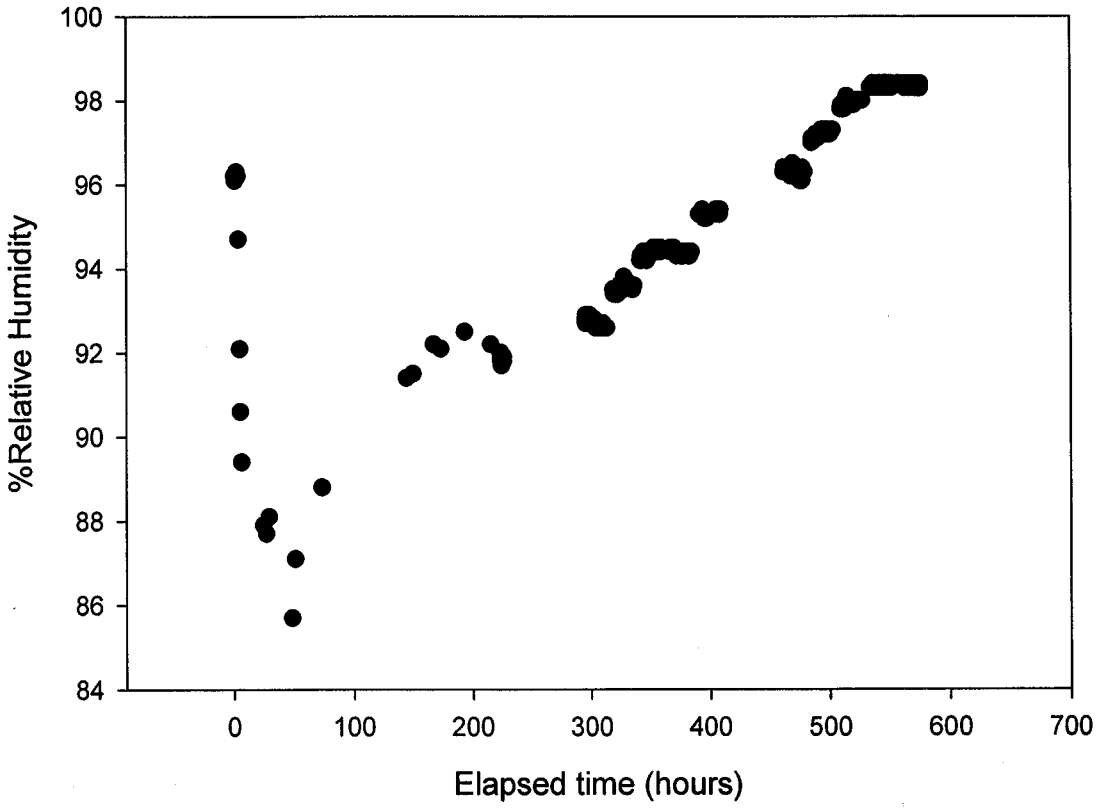
* Note - Ramp down of heat or power applied to the variable transformer commenced on 12/7/01. During the ramp down combustion continued to form on sample disk and copper wire. No air movement was detected by the anemometer during the ramp down.



12/21/01 gp A plot showing temperature of thermocouples during the test are shown below. See Fig 5 on p 59 for thermocouple location.



12/21/01 gp A plot showing % relative humidity detected by the Vaisala Temperature/humidity probe placed at the hot end of the adit is shown below.



12/21/01 gp Relative Humidity at the cool end of the adit varied from 98.6 to 100% and remained at near 100% RH after the first week of the test.

12/27/01 gp

Because no air movement was picked up and registered on the anemometer during the test, a second test was performed. Before this test commenced two strips of paper (strips of kimwipes) were hung from the top of the adit near the middle. One strip was about 1" long and the other was about 1.8" long. The purpose of these strips was to determine if air movement is occurring by visually inspecting the strips for movement during the test.

All other conditions and instruments remained the same as in the first test.

Test #2 was started at 1318 hrs by setting the variable transformer to 10. The heat sink was set to 25°C and the sample apparatus to cool the sample was set to 5°C. Heat was raised by changing the variable transformer setting as follows.

Transformer set to 20 at 1358 hr
" " " 30 at 1448 hr
" " " 40 at 1527 hr

Temperature and RH data will be collected and recorded and the paper strips will be visually inspected periodically.

1/3/02 gp

Preparation of samples of in drift materials for chemical analyses.

Subsamples of the in drift materials sent to the CWNRA from the YM Site Characterization Project Sample Management Facility were removed from the original samples, labeled, and sent to Cowam Inspection Inc for chemical analyses.

Subsamples were removed from the original samples using either a hacksaw with carbon steel blade or a dremel tool with heavy duty cutoff wheels or diamond cutty wheels.

Subsamples were labeled as shown below; a description of the sample is also given.

Label	Sample ID Original	Description	Subsample Size
634 A	01014634	Steel set section	1"x1" square
634 B	01014634	Steel set section	1"x1" square
635 A	01014635	10' Swellex Rock Bolt	1"x1" round
635 B	01014635	10' Swellex Rock Bolt	1"x1.25" round
636 A	01014636	2' Swellex Rock Bolt	1"x1.25" round
636 B	01014636	2' Swellex Rock Bolt	1"x1.25" round
637 A	01014637	10' Split Set Rock Bolt	1"x1.25" round
637 B	01014637	10' Split Set Rock Bolt	1"x1.25" round
638 A	01014638	Wire Mesh	26.1 g
639 A	01014639	Wire Mesh	27.1 g

A sample custody log sheet was filled out for each subsample and placed in the 3 ring binder entitled "Thermal Effects on Flow Sample Custody Log".

The following samples were selected and sent to Conam Kawin Inspection for chemical analysis.

634A
634B
635A
636A
637A
637B
638A
639A

A letter describing the analyses and analysis requirements to be performed by Conam Kawin is showed on the following page.

CNWRA *A center of excellence in earth sciences and engineering*

A Division of Southwest Research Institute™
6220 Culebra Road • San Antonio, Texas, U.S.A. 78228-5166
(210) 522-5160 • Fax (210) 522-5155

January 4, 2002

Frank Donmez
Conam Kawin Inspection
194 Internationale Blvd.
Glendale Heights, IL 60139

Dear Mr. Donmez,

Enclosed please find 8 samples of steel materials submitted for chemical analyses. Per our conversation I need a full chemical analysis of each sample. Also, as per our conversation the rust on the surface of the samples should be removed before performing the analyses. Sample numbers and a brief description of each sample are given below:

Sample No.	Description
634A	Portion of steel set
634B	Portion of steel set
635A	Portion of rock bolt
636A	Portion of rock bolt
637A	Portion of rock bolt
637B	Portion of rock bolt
638A	Portion of wire mesh
639A	Portion of wire mesh

According to the supplier, all the samples are carbon steel. The steel set samples (634A and 634B) should be within the chemical composition ranges for carbon, phosphorous, sulfur, and silicon specified in ASTM A36. The rock bolt samples (635A, 636A, 637A, and 637B) should be within the chemical composition ranges for carbon, phosphorous, and sulfur specified in ASTM F432. The specification of wire mesh (ASTM A185) does not include any requirements for chemical composition. The chemical requirements specified in ASTM A36 and ASTM F432 are listed below and are included for quality assurance purposes.

	ASTM A36 (steel sets)	ASTM F432 (rock bolts)
Carbon, max %	0.26	0.79
Phosphorous, max %	0.04	0.058
Sulfur, max %	0.05	0.15
Silicon, max %	0.4	

The chemical analyses performed by Conam Kawin should provide the method of analysis for each element and the measurement uncertainty must be identified. If multiple analyses or multiple analysis methods are performed, the results of all measurements should be presented along with the measurement uncertainty. Finally, the remaining material should be returned to me at Southwest Research Institute so these samples are available to our QA department.

Washington Office • Twinbrook Metro Plaza #210
12300 Twinbrook Parkway • Rockville, Maryland 20852-1606

My phone and fax number are listed below along with my email address. Please contact me if you have any questions. Thank you for your assistance.

Sincerely,

James D. Prikryl

James D. Prikryl
Southwest Research Institute
6220 Culebra Rd
San Antonio, TX 78228-5166
Phone: 210-522-5667
Fax: 210-522-5184
Email: jprikryl@swri.edu

1/7/02 JP

(Continued from p 74)

Stated rampdown of Test #2

Variable Transformer was set to 32 at 1005 on 1/7/02.

No air movement has been detected through visual inspection of the kimwipe strips placed in the adit.

1/8/02 JP

Variable transformer was set to 24 at 0850.

1/9/02 JP

Variable transformer was set to 16 at 1030 hrs.

1/10/02 JP

Heat sink cut off at 1000 hrs.

1/11/02 JP

Variable transformer set to 12 at 1055 hrs.

01/14/02 JP

Variable transformer set to 16 at 1000 hrs.

01/16/02 JP

Variable transformer set to 12 at 0930 hrs.

01/16/02 JP

Variable transformer set to 48 at 1100 hrs

01/17/02 JP

Variable transformer set to 54 at 0940 hrs.

01/23/02 JP

Variable transformer set to 56 at 1500 hrs.

01/30/02 JP

Test 2 was terminated at 1145 hrs.

Plots of temperatures within adit and Relative humidity are shown on p 83.

1/16/02 JP

Results of chemical analyses of steel samples sent to Conam-Kawin are shown below.

ACCREDITED

CONAM KAWIN

194 Internationale Blvd., • Glendale Heights, IL 60139 • Telephone + 1 630-681-0008 • Facsimile + 1 630-871-5520

TEST REPORT

SOUTHWEST RESEARCH INST. 7010
6220 CULEBRA RD
P. O. DRAWER 28510
SAN ANTONIO TX 78284
JAMES D. PRIKRYL

P. O. # 50138

DESCR 01/04/02
CARBON STEEL

REPORT DATE: 01/08/2002

LAB NO: 0107-043 / 01 JOB NO: 01/08 #V21

ASTM A36 #634A - PORTION OF STEEL SET

CHEMICAL ANALYSIS

Si	.23	Mn	.91	C	.10
P	.012	S	.027	Ni	.10
Cr	.06	Mo	.01	Cu	.34
Al	<.01	Pb	.001	V	<.01
B	<.0005	Cb	<.01		

THE ABOVE CHEMICAL TEST RESULT CONFORMS TO ASTM A36

TEST METHODS: ASTM E 1019 ; ASTM E 415 ;

LAB NO: 0107-043 / 02 JOB NO: 01/08 #V22

ASTM A36 #634B - PORTION OF STEEL SET

CHEMICAL ANALYSIS

Si	.24	Mn	.91	C	.09
P	.013	S	.027	Ni	.09
Cr	.06	Mo	.01	Cu	.35
Al	<.01	Pb	.001	V	<.01
B	<.0005	Cb	<.01		

THE ABOVE CHEMICAL TEST RESULT CONFORMS TO ASTM A36

TEST METHODS: ASTM E 1019 ; ASTM E 415 ;

LAB NO: 0107-043 / 03 JOB NO: 01/08 #V23

ASTM F432 #635A - PORTION OF ROCK BOLT

CHEMICAL ANALYSIS

Si	.01	Mn	.54	C	.08
P	.010	S	.006	Ni	.04
Cr	.01	Mo	<.01	Cu	.01
Al	.04	Pb	.001	V	<.01
B	<.0005	Cb	<.01		

THE ABOVE CHEMICAL TEST RESULT CONFORMS TO ASTM F432

TEST METHODS: ASTM E 1019 ; ASTM E 415 ;

LAB NO: 0107-043 / 04 JOB NO: 01/08 #V24

ASTM F432 #636A - PORTION OF ROCK BOLT

CHEMICAL ANALYSIS

Si	.01	Mn	.34	C	.09
P	.007	S	.007	Ni	.01
Cr	.01	Mo	<.01	Cu	.01
Al	.04	Pb	.001	V	<.01
B	<.0005	Cb	<.01		

THE ABOVE CHEMICAL TEST RESULT CONFORMS TO ASTM F432

TEST METHODS: ASTM E 1019 ; ASTM E 415 ;

LAB NO: 0107-043 / 05 JOB NO: 01/08 #V25

ASTM F432 #637A - PORTION OF ROCK BOLT

CHEMICAL ANALYSIS

Si	.03	Mn	.97	C	.06
P	.012	S	.011	Ni	.04
Cr	.01	Mo	.01	Cu	.09
Al	.03	Pb	.001	V	<.01
B	<.0005	Cb	<.01		

THE ABOVE CHEMICAL TEST RESULT CONFORMS TO ASTM F432

TEST METHODS: ASTM E 1019 ; ASTM E 415 ;

LAB NO: 0107-043 / 06 JOB NO: 01/08 #V26

ASTM F432 #637B - PORTION OF ROCK BOLT

CHEMICAL ANALYSIS

Si	.01	Mn	.78	C	.07
P	.011	S	.011	Ni	.03
Cr	<.01	Mo	.01	Cu	.07
Al	.03	Pb	.001	V	.04
B	<.0005	Cb	<.01		

THE ABOVE CHEMICAL TEST RESULT CONFORMS TO ASTM F432

TEST METHODS: ASTM E 1019 ; ASTM E 415 ;

LAB NO: 0107-043 / 07 JOB NO: 01/08 #18

ASTM A185 #638A - PORTION OF WIRE MESH

CHEMICAL ANALYSIS

Si	.14	Mn	.34	C	.05
P	.026	S	.011	Ni	.02
Cr	.03	Mo	<.01	Cu	<.01
Al	<.01	Pb	.001	V	<.01
B	<.0005	Cb	<.01		

THE ABOVE CHEMICAL TEST RESULT CONFORMS TO AISI 1006

TEST METHODS: ASTM E1024 ; ASTM E 1019 ; ASTM E 354 ; ICP ;

LAB NO: 0107-043 / 08 JOB NO: 01/08 #19

ASTM A185 #639A - PORTION OF WIRE MESH

CHEMICAL ANALYSIS

Si	.13	Mn	.34	C	.16
P	.023	S	.033	Ni	.02
Cr	.03	Mo	<.01	Cu	<.01
Al	<.01	Pb	.001	V	<.01
B	<.0005	Cb	<.01		

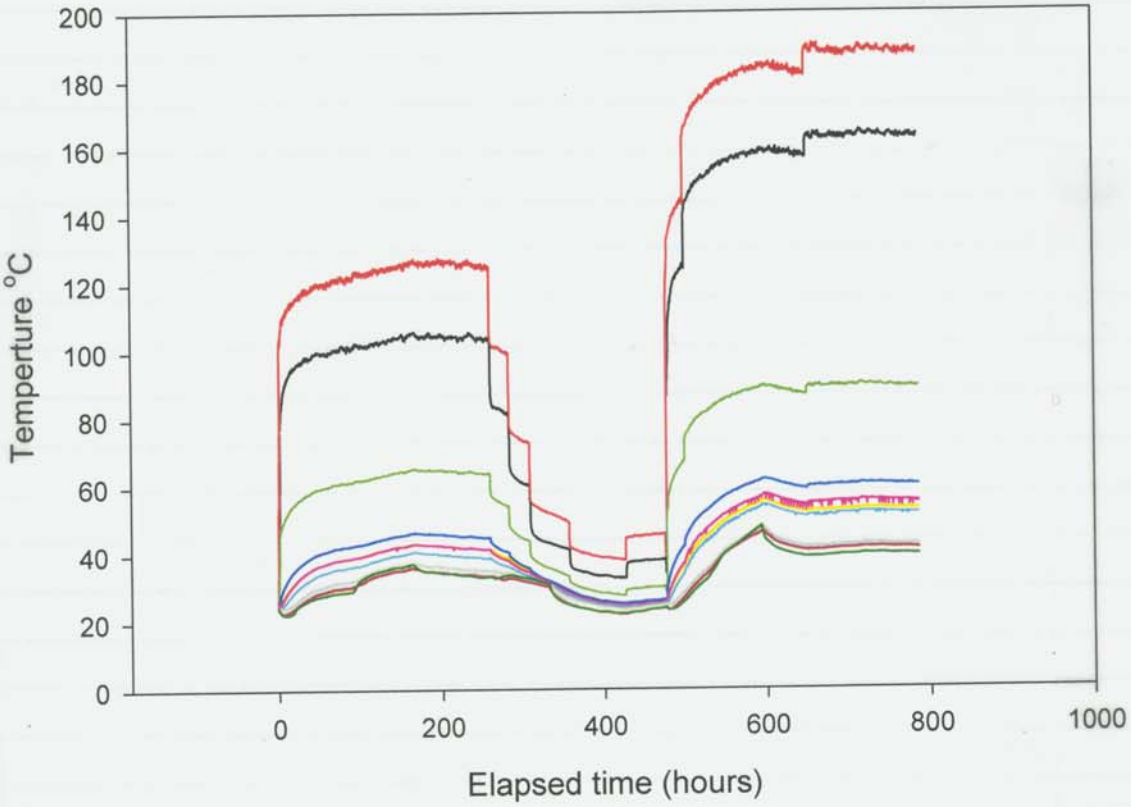
THE ABOVE CHEMICAL TEST RESULT CONFORMS TO AISI 1015

TEST METHODS: ASTM E1024 ; ASTM E 1019 ; ASTM E 354 ; ICP ;

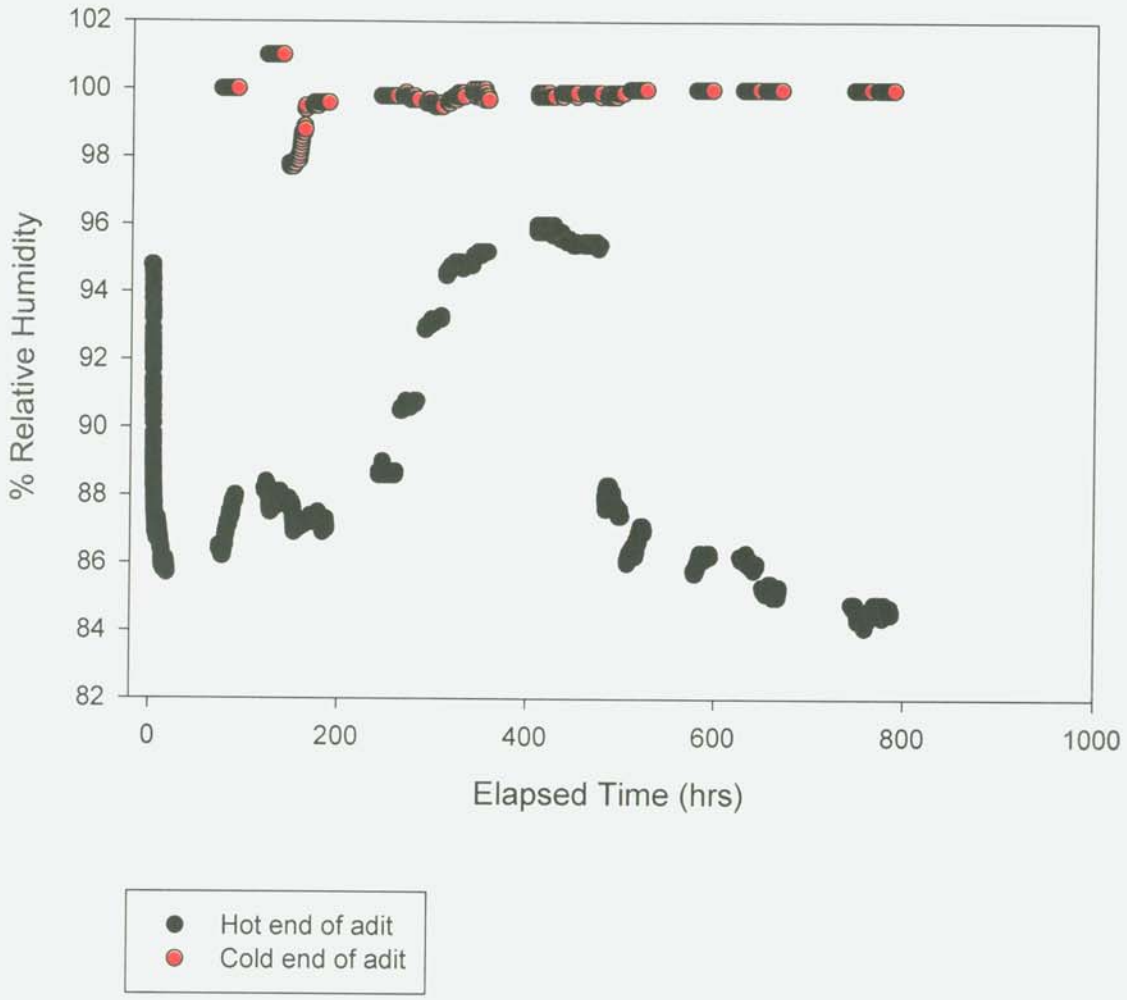
QA INSPECTOR

ALL CHEMICAL TEST RESULTS ARE REPORTED IN WEIGHT PERCENT UNLESS OTHERWISE NOTED.

01/30/02 JP A plot showing ~~temperatures of thermocouples~~ during ~~the~~ test ~~are~~ shown below. See Fig 5 and p 59 for thermocouple location.



01/30/02 JP A plot showing % Relative Humidity in the adit detected by the Vaisala RH probes are shown below



01/30/02 gp

Test 2 observations

The purpose of test 2 was to try to detect air movement in the adit. Air movement was detected on the anemometer mounted at the low end of the adit but only when the temperature of the heater cartridge was increased significantly at about 500 hrs into the test. No air movement was detected by the tissue strips mounted in the adit.

02/01/02 JP

Test 3

In this test the anemometers were removed from their initial position and remounted vertically in the box. The new mounting allowed the sensor tips of the anemometers to be moved up and down in the adit. The purpose of this test was again to determine air movement. It is hoped that by moving the anemometer sensors up and down an optimal position for moving air movement can be determined.

All of the conditions and instruments remained the same as in the first test.

Test 3 was started at 1321 hrs by setting the variable transformer to 40. Initially the heat sink was placed on the cool end of the box at ambient air conditions to allow moisture to form on the back or cool wall of the adit. Also no cooling of the sample was initially done.

Temperature and RH data will be collected and reported graphically.

2/1/02 JP

Variable transformer set to 46 at 1500 hrs.

2/6/02 JP

Observations

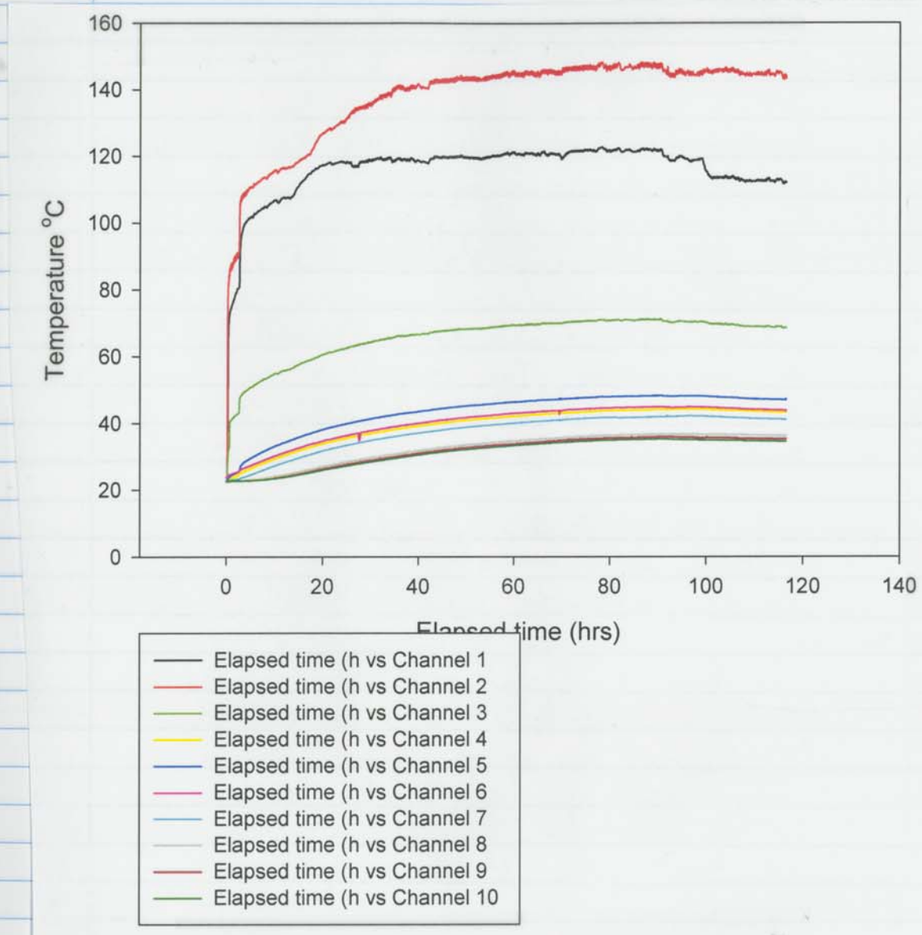
Air movement was detected on the anemometer placed in the lower portion of the adit. The maximum reading was 0.03 m/s when the anemometer sensor was about 3/8" from the bottom of the adit. This was the lowest position that could be achieved for the anemometer. The length of the sensor on the anemometer is about 1/4". Thus air movement was being measured from about 3/8" above the bottom of the adit to about 5/8" above the adit.

No air movement was detected in the upper portion of the adit. This may be due to drying out of the ceramic tube and sand above the cartridge heater which achieved a temperature above boiling during this test.

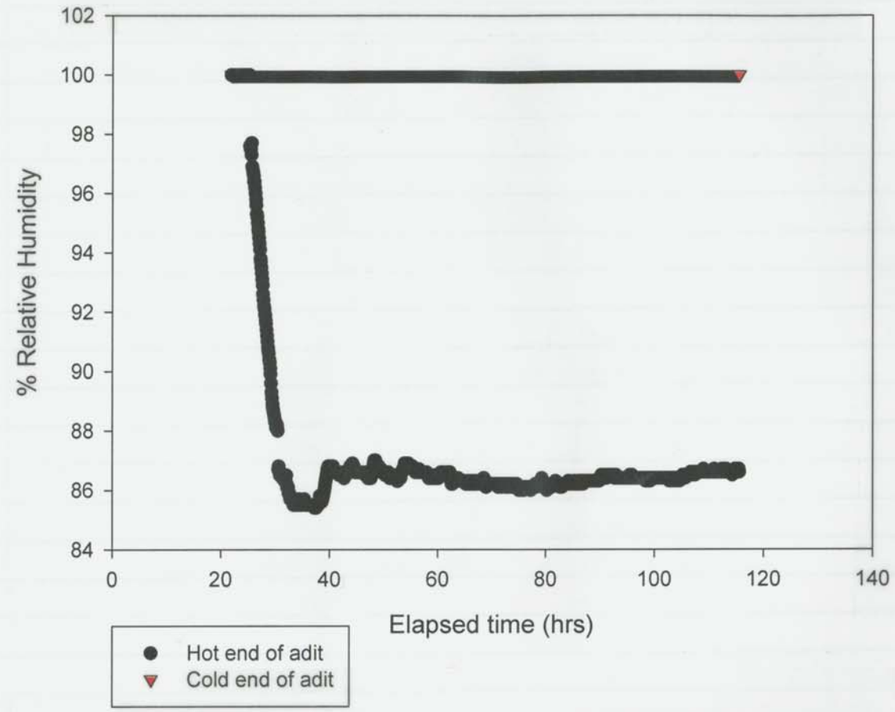
2/6/02 JP

The test 3 was terminated at 1300 hrs. Plot of temperature with the adit and RH are shown on the next page.

2/7/02 gp A plot showing temperature of thermocouples during test 3.



2/7/02 gp A plot of % relative humidity in the adit detected by the RHF probes.



2/13/02 gf

Gravimetric water content vs hydrosense reading of OK #1 sand

Obj - determine the relationship of water content to reading supplied by the hydrosense TDR for the OK #1 sand.

Method - compare calculated gravimetric water contents to hydrosense readings.

Materials + Equipment
1) OK #1 Sand
2) Plastic ware as need
3) Sartorius balance s/n 39030006
4) DI water
5) Blue M drying oven
6) Hydrosense TDR with 12 cm probes

Procedure
1) Oven dry about 20kg of OK #1 sand
2) Weigh out about 2000g of OK #1 sand + place in plastic container. Record wt of sand.
3) Add a weighed amount of DI water to the sand + plastic container. Record wt of water
4) Mix sand + water thoroughly until a homogenous medium is produced.

5) Pack medium in a plastic container (7.5"x6"x2.5" plastic container).
6) Insert hydrosense probes horizontally into the packed media and record the VWC reading.
7) Determine gravimetric water content of the media using the following formula:

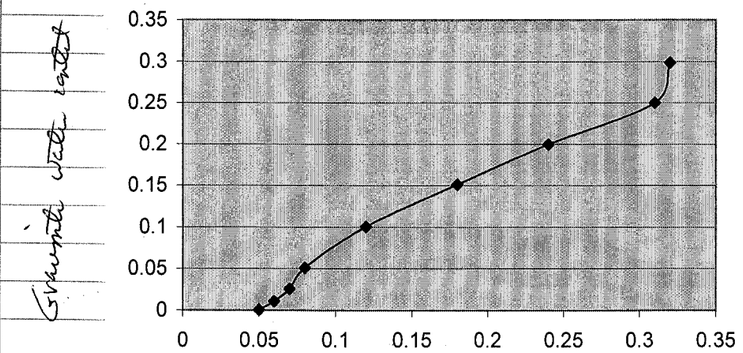
$$GWC = \frac{\text{wt of wet sample} - \text{wt of oven dry sample}}{\text{wt of oven dry sample}}$$

Data + results

Wt of oven dry sample(g)	Wt of wet sample(g)	wt of water added(g)	GWC %	Hydrosense reading %
2001.6	2103.3	101.7	0.0508	8
2000.9	2201.7	200.8	0.1003	12
2001.4	2303.5	302.1	0.1509	18
2007.6	2407.6	400.0	0.1992	24
2011.0	2513.1	502.1	0.2497	31
2003.5	2024.8	21.3	0.0106	6
2006.6	2605.0	598.4	0.2982	32
1998.5	2049.8	51.3	0.0257	7
2057.5	2057.9	0.4	0.0002	5

2/13/02 gp

A plot of hydrosense readings vs gravimetric water content of the OK#1 sand is shown below.



02/13/02 gp

Test 4

In this test the hydrosense TDR probe was mounted horizontally in the coldtrap apparatus above the ceramic tube in the sand directly above the cartridge heater. The initial reading of the probe when the apparatus was completely assembled was 27% VWC. Hydrosense readings during the test will indicate the the sand is drying out about the heat source.

Test 4 was started at 11:43 hrs by setting variable transformer to 10.

Temperature and RH data will be collected & monitored & reported graphically.

Heat sink was set to 25°C.

2/13/02 gp Variable Transformer set to 16 at 1305 hrs.

2/14/02 gp 0930 hrs
Readings
Hydrosense TDR - 26%
Anemometer - upper orbit - 0.00 m/s
lower orbit - 0.00 m/s

2/14/02 gp 0932 hrs
Variable Transformer set to 20 at 0932 hrs.

2/15/02 JP 1000 hr
Ready
Hydrosense TDR - 26%
Anemometer - upper adit 0.00 m/s
lower adit 0.00 m/s

2/15/02 JP 1000 hr.
Variable transformer set To 24 at 1000 hr.

2/18/02 JP 0800 hr
Ready
Hydrosense TDR - 25%
Anemometer - upper adit 0.00 m/s
lower adit 0.00 m/s

2/18/02 JP 0100 hr.
Variable transformer set to 20 at 1000 hr.

2/19/02 JP 0805 hr
Ready
Hydrosense TDR - 25%
Anemometer - upper adit 0.00
lower adit 0.00

2/19/02 JP 1445 hr.
Variable transformer set to 25 at 1448 hr.

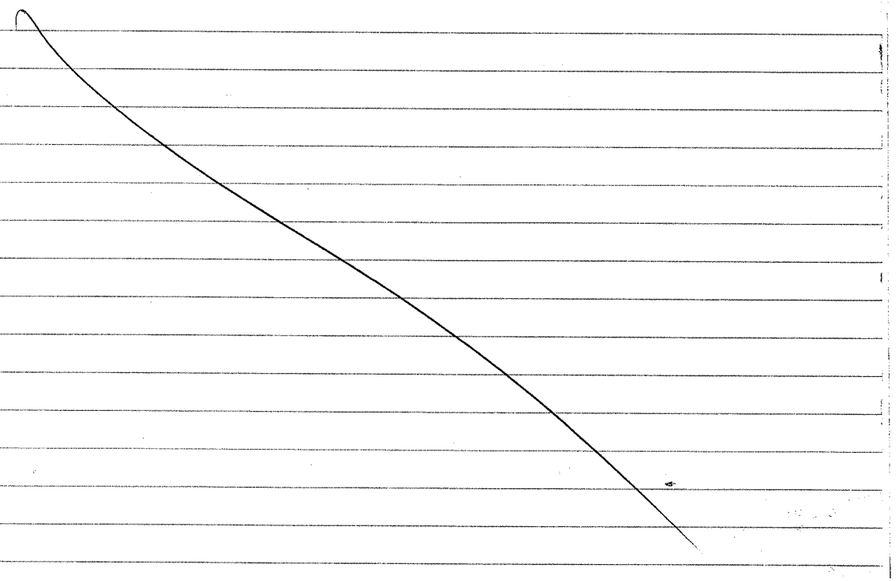
2/20/02 JP 0940 hr
Ready
Hydrosense TDR - 25%
Anemometer - upper adit 0.00 m/s
lower adit 0.01 m/s

2/20/02 JP 1115 hr

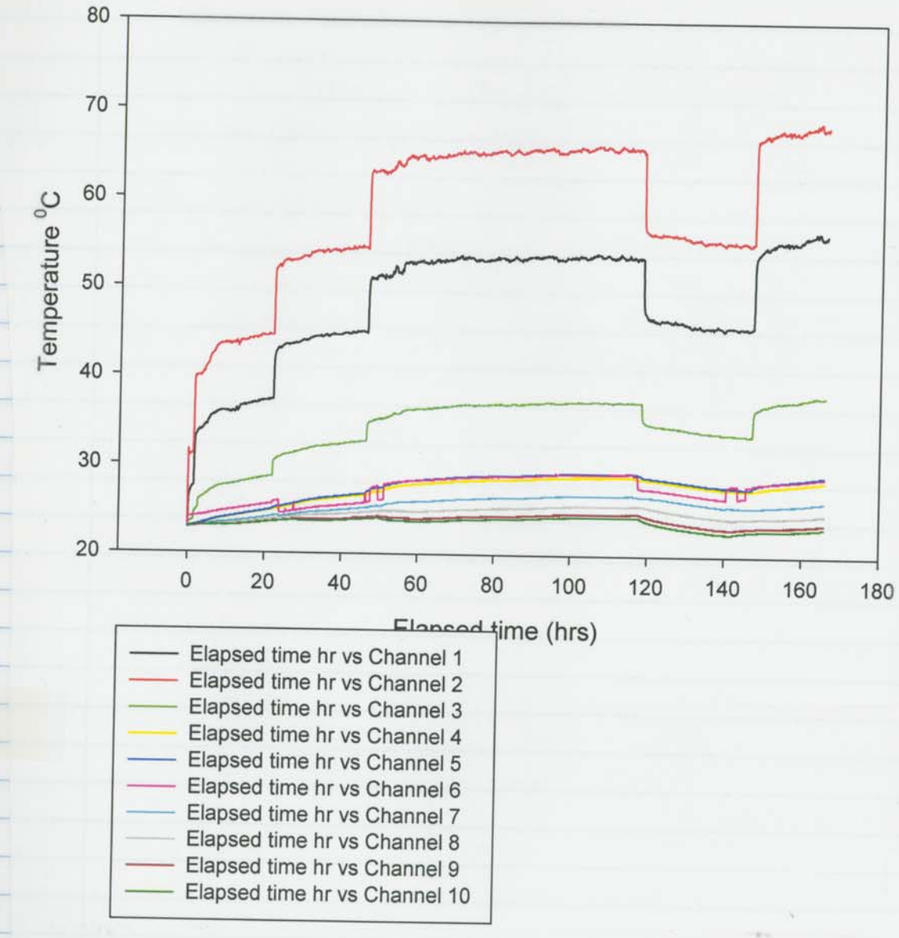
Test 4 was terminated

Observations -
Air movement was again detected in the lower adit but not the upper adit. Testing of the anemometer velocity sensors by moving the sensors up and down in the adit suggest that the velocity sensor may not be heating up enough to detect low movement. This may be due to moving the sensors thru the wet sand which may dampen the heating effect.

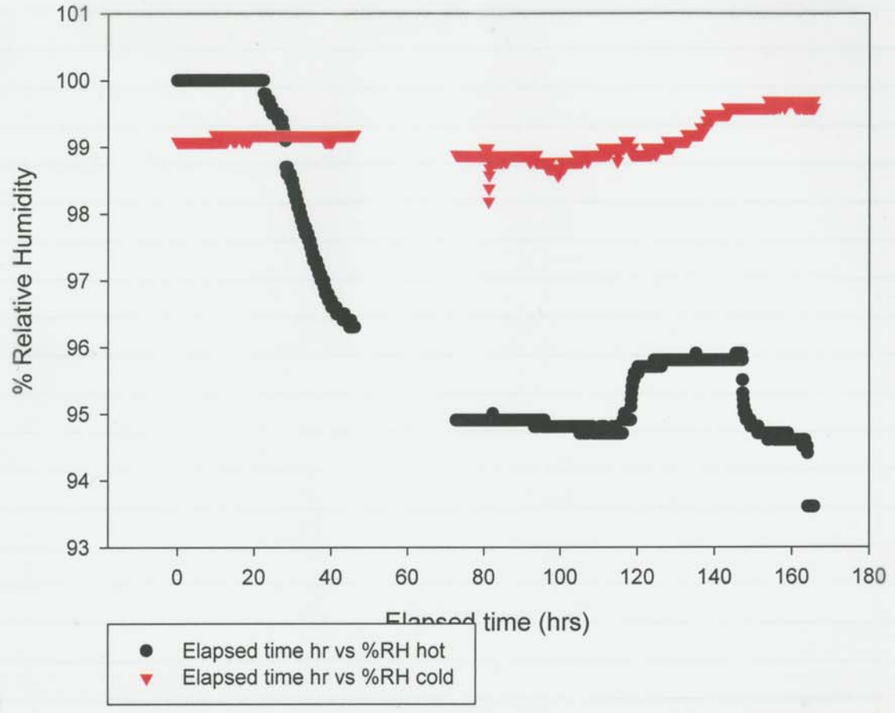
Plots of temperature and relative humidity with the adit are shown on the next page for Test 4



2/20/02 GP A plot showing temperature of thermographs during test 4



2/20/02 GP A plot of % relative humidity in the adit during Test 4.



2/20/02 gp

Test 5

In this test the anemometer probes were insulated with ½" neoprene insulation. The purpose of the insulation is to keep the surfaces of the probes away from the heat sink so that they can be heated enough to detect air movement in the edit. Aluminum tape was used to secure the insulation around the probes.

All other equipment and condition were kept the same.

Temperature & RH data will be collected & reported graphically.

Test 4 was stated at 1505 by setting Variable transformer to 15.

The initial reading of the Hydrosense TDR was 25%

Heat Sink was set to 10°C

2/21/02 gp 0830 hr
Readings
Hydrosense TDR - 25%
Anemometer upper edit 0.00 m/s
lower edit 0.00 m/s

2/21/02 gp 0835 hr.
Variable transformer set to 20 at 0835 hr.

2/22/02 gp 0950 hr
Readings
Hydrosense TDR - 24%
Anemometer readings upper edit 0.00 m/s
lower edit 0.01 m/s

2/22/02 gp 1305 hr.
Variable transformer set to 26 at 1305 hr.

2/22/02 gp 1525 hr
Variable transformer set to 20 at 1525 hr.

2/25/02 gp 0725 hr
Reading Hydrosense TDR - 23%
Anemometer readings upper edit 0.00
lower edit 0.01

Test terminated at 0725 hrs on 2/25/02.

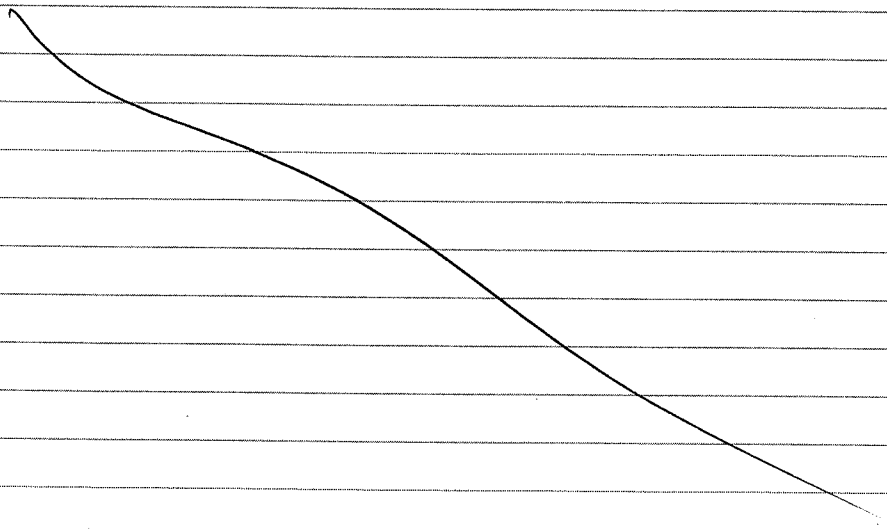
2/25/02 gp

Observations - Test 5

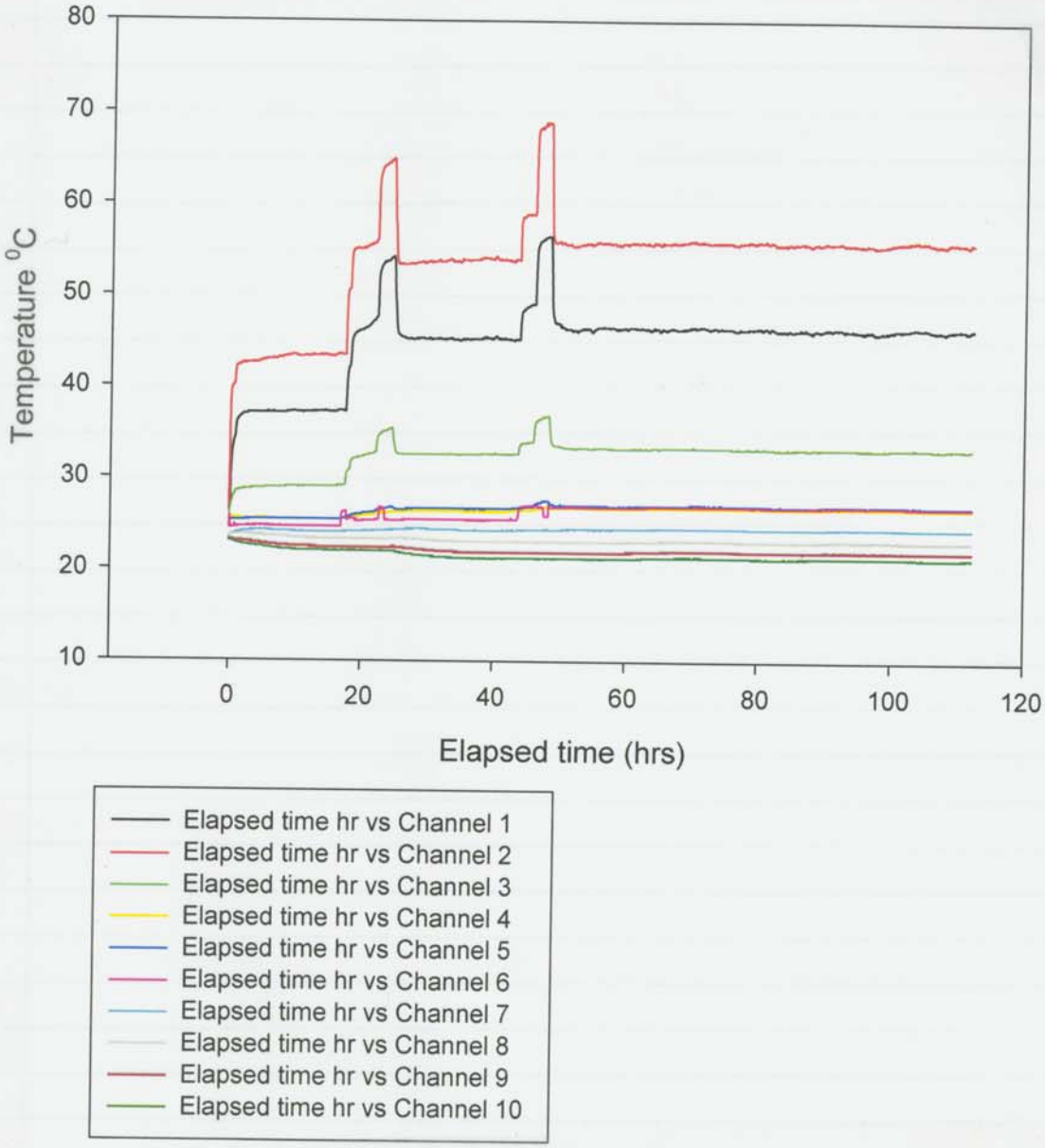
In this Test we were able to detect air movement along the bottom of the adit without raising temperature above boiling - (100°C) However air movement at the top of the adit was not detected.

It may be that the Temperature of the air moving across the velocity sensor at the top of the adit is not cool enough to reduce the temperature of the sensor so that air movement is detected.

Plot of temperature and relative humidity with the adit are shown on the next page for Test 5



2/25/02 gp Plot of temperature of thermocouples during test 5.



2/25/02 JP

Test 6

In this test the anemometer probe closest to the heater was moved about 7 inches toward the cold end of the adit. This was done to determine if air moving along top of adit could be detected in the top of the adit as it cools on its way to the cool end of the adit.

All other equipment and constants were kept the same.

Test 6 was started at 1230hrs by setting Variable transformer to 16.

Initial reading of Hydrosense TDR was 23%

Heat sink was set to 5°C.

2/26/02 JP 0850hrs
Readings
Hydrosense TDR - 22%
Anemometer - 0.00 Upper adit
0.00 Lower adit.

2/26/02 JP 0845hrs
Variable transformer set to 20.

2/26/02 JP 1500hr
Variable Transmn set To 26

2/27/02 JP 0940 hr
Readings
Hydrmnr TDR - 22%
Anemometer upper adjt 0.00 m/s
lower adjt 0.00 m/s

2/27/02 JP 1400hr
Variable transmn set to 20

2/28/02 JP 0930hr
Readings
Hydrmnr TDR - 22%
Anemometer upper adjt 0.00 m/s
lower adjt 0.00 m/s

2/28/02 JP 1000 hr
Test 6 terminated at 1005 hr.

2/28/02 JP 1030hr.
Observation - no air movement detected.

2/28/02 JP 1450hr

Test 7

In this test anemometers were mounted horizontally thru the side of the box as in Test 1. However, the holes in the ceramic tubes were enlarged so that the sensors could be moved up or down.

All other equipment & conditions were kept the same.

Test 7 was started at 14:55 by setting the variable transmn to 16

Initial reading of Hydrmnr TDR - 23%

Heat sink set at 20°C

3/1/02 JP 0940hr
Readings
Hydrmnr TDR - 23%
Anemometer - upper adjt 0.00 m/s
lower adjt 0.00 m/s

3/1/02 JP 1025hr.
Variable transmn set to 20.

3/1/02 JP 1530hr
Variable transmn set to 30

3/4/02 JP 0800hr
Readings
Hydrus TDR - 20%
Anemometer upper adit 0.00
lower adit 0.00

3/5/02 JP 0815hr.
Readings
Hydrus TDR - 20%
Anemometer upper adit
lower adit

3/5/02 JP 1200hr.
Variable trimmer set to 44

3/6/02 JP 0930 hr
Readings
Hydrus TDR - 19%
Anemometer readings upper adit 0.00 m/s
lower adit 0.00 m/s

3/6/02 JP 1025hr
Test 7 terminated at 1025hr.

3/6/02 JP 1100hr.
Observations
No air movement was detected in the adit.

3/7/02 JP 1500 hr.

Test 8

In this test anemometer were mounted vertically as in test 3. However the Vaisala Humidity / Temperature probes were removed along with the Hydrus TDR probe.

Test 8 was started at 1525 hrs by setting variable trimmer to 20.

Heat sink was set at 10°C.

3/8/02 JP 1100hr.

Air movement at 0.01 m/s was detected in lower adit with variable Trimmer set to ~24.

3/8/02 JP 1345 hr.
Test 8 terminated

3/13/02 JP
1400 hrs

Thermocouple calibration

Obj - calibrate Type K thin wire thermocouples for use in coldtrap experiment.

Method - compare temperature measured by thermocouples to those measured using a calibrated thermometer.

Equipment -
- Omegaa type K thin wire thermocouples with 6 ft leads
- Calibrated thermometer S/N C96-816
- Corning hot plate
- Ice
- 2L glass beaker
- HP

Procedure
(1) Attach thermocouples to the HP data acquisition unit and set unit to read temperature in °C.

(2) Place thermocouples and calibrated thermometer in an ice bath. Read + record temperature of thermocouples + thermometer. Results are shown on next page

Thermometer reading 2°C

Thermocouple readings -

Channel #	Read °C	Channel #	Read °C	Channel #	Read °C
1	3.1	31	1.7	61	1.0
2	1.0	32	1.7	62	2.3
3	2.9	33	1.6	63	2.7
4	1.4	34	2.2	64	1.2
5	1.0	35	1.9	65	2.1
6	2.2	36	1.8	66	3.3
7	2.6	37	1.2	67	2.4
8	2.8	38	2.2	68	3.5
9	3.2	39	2.3	69	2.1
10	3.0	40	2.3	70	2.3
11	2.2	41	0.5	71	2.7
12	2.1	42	0.6	72	2.5
13	2.1	43	0.8	73	1.0
14	2.1	44	1.5	74	1.5
15	1.8	45	1.2	75	2.4
16	1.9	46	1.7	76	1.6
17	1.8	47	1.6	77	2.3
18	0.6	48	1.8	78	1.1
19	2.6	49	2.0	79	2.2
20	3.0	50	1.1	80	2.0
21	1.1	51	0.8		
22	1.4	52	1.4		
23	1.3	53	0.5		
24	0.8	54	1.4		
25	1.2	55	0.5		
26	1.7	56	0.1		
27	2.7	57	0.6		
28	1.2	58	1.3		
29	1.3	59	0.7		
30	1.2	60	0.2		

(3) Place thermocouples + thermometer in a heated water bath at 80°C. Read + record temperatures.

Results Thermometer read 80°C

Chan#	Read °C	Chan#	Read °C	Chan#	Read °C
1	80.7	31	80.7	61	80.2
2	82.0	32	83.9	62	80.4
3	80.5	33	80.5	63	79.9
4	80.7	34	78.8	64	79.4
5	80.3	35	78.5	65	80.3
6	80.7	36	78.8	66	80.1
7	81.6	37	78.5	67	80.4
8	80.7	38	82.2	68	80.6
9	80.5	39	82.0	69	79.9
10	81.4	40	81.4	70	78.9
11	81.0	41	76.0	71	80.4
12	80.6	42	77.5	72	80.5
13	80.5	43	78.2	73	80.3
14	80.3	44	78.3	74	80.8
15	80.3	45	78.2	75	80.2
16	80.1	46	79.2	76	79.6
17	80.3	47	79.7	77	80.3
18	79.6	48	79.6	78	80.5
19	79.4	49	79.8	79	80.4
20	79.7	50	79.0	80	80.1
21	79.6	51	80.0		
22	79.6	52	88.1		
23	80.2	53	81.2		
24	79.2	54	84.1		
25	78.8	55	80.1		
26	79.1	56	79.7		
27	80.9	57	79.8		
28	79.4	58	81.7		
29	79.0	59	83.0		

3/18/02 JP

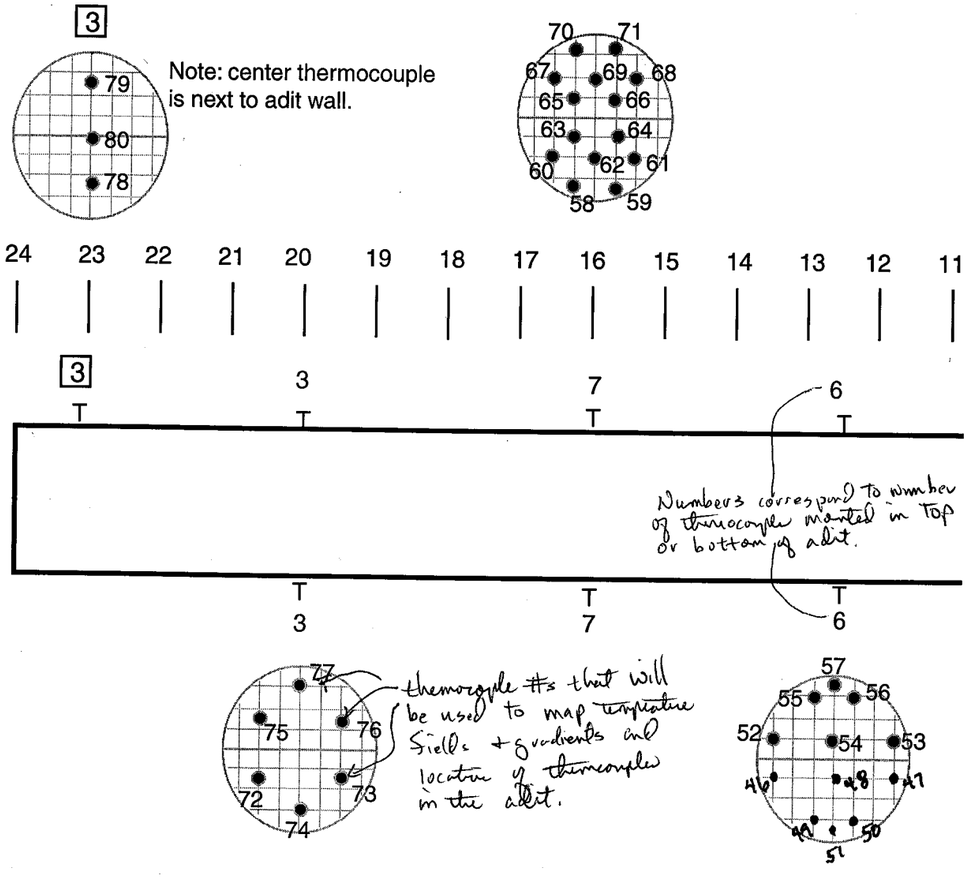
The coldtrap apparatus was dismantled and a new ceramic tube was mounted in the box.

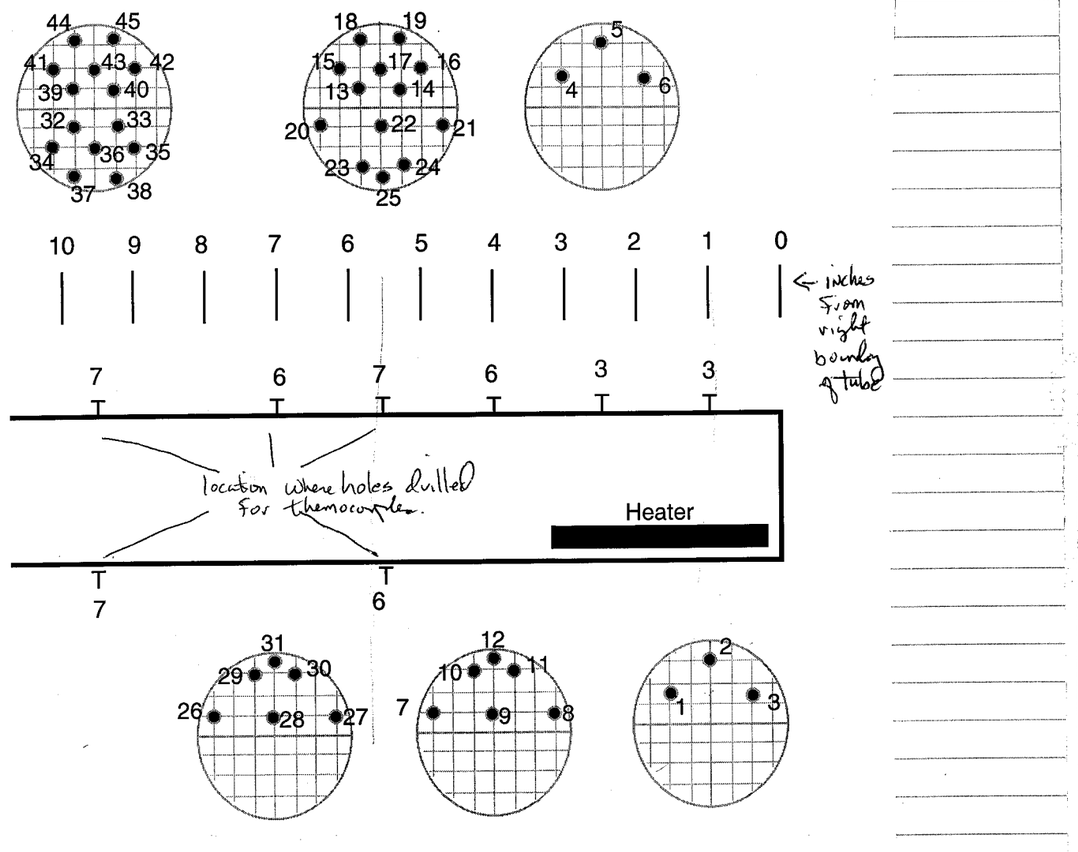
1/8" holes were drilled along the top and bottom of the tube to accomodate the placement of thermocouples inside the tube. The schematic on the following page shows the location of the holes. The purpose of placing the thermocouples in the adit is to define temperature gradients with in adit, so that optimum location of air movement can be determined. Once these locations are defined, equipment (e.g., anemometer) can be placed to measure air flow.

Schematic diagrams on the following pages show the location of thermocouples with the adit.

3/19/02 JP

Schematic Diagram show location of thermocouples with adit.





3/26/02 gp

As power is supplied to the cartridge heater the temperature of the thermocouples will be monitored. Temperature data will be captured using an HP3497A data acquisition unit and HP Benchlink Datalogger Software.

3/26/02 gp

Test 9

Test 9 was started at 0815 by setting variable transformer to 12.

Temperature data will be collected every 10 minutes.

Heat sink was set to 20°C.

3/26/02 gp

11:05 hr Variable transformer set to 16

13:10 hr Variable transformer set to 20.

3/28/02 gp
0930 hr Temp data was downloaded + saved to file cttest9a (Excel compatible)

3/29/02 gp
0900 hr Temp data was downloaded + saved to file cttest9b.

4/1/02 gp
0730 hr. Test data saved to file cttest9c.

4/2/02 gp
0735 hr Test data saved To cttest9d.

4/3/02 gp
0930 hr Test data saved To cttest9e.

4/4/02 gp
0915 hr Test data saved to cttest9f.

4/5/02 gp
0935 hr Test data saved to cttest9g.

4/8/02 gp
0800 hr Test data saved to cttest9h.

4/9/02 gp
0745 hr. Test data saved to cttest9i.

4/10/02 gp
0905 hr Test data saved To cttest9j.

4/12/02 gp
0925 hr Test data saved to cttest9k.

4/15/02 gp
0745 hr Test data saved to cttest9l.

4/19/02 gp
0920 hr Test data saved to cttest9m.

4/19/02 gp
0925 hr CT test 9 was terminated.

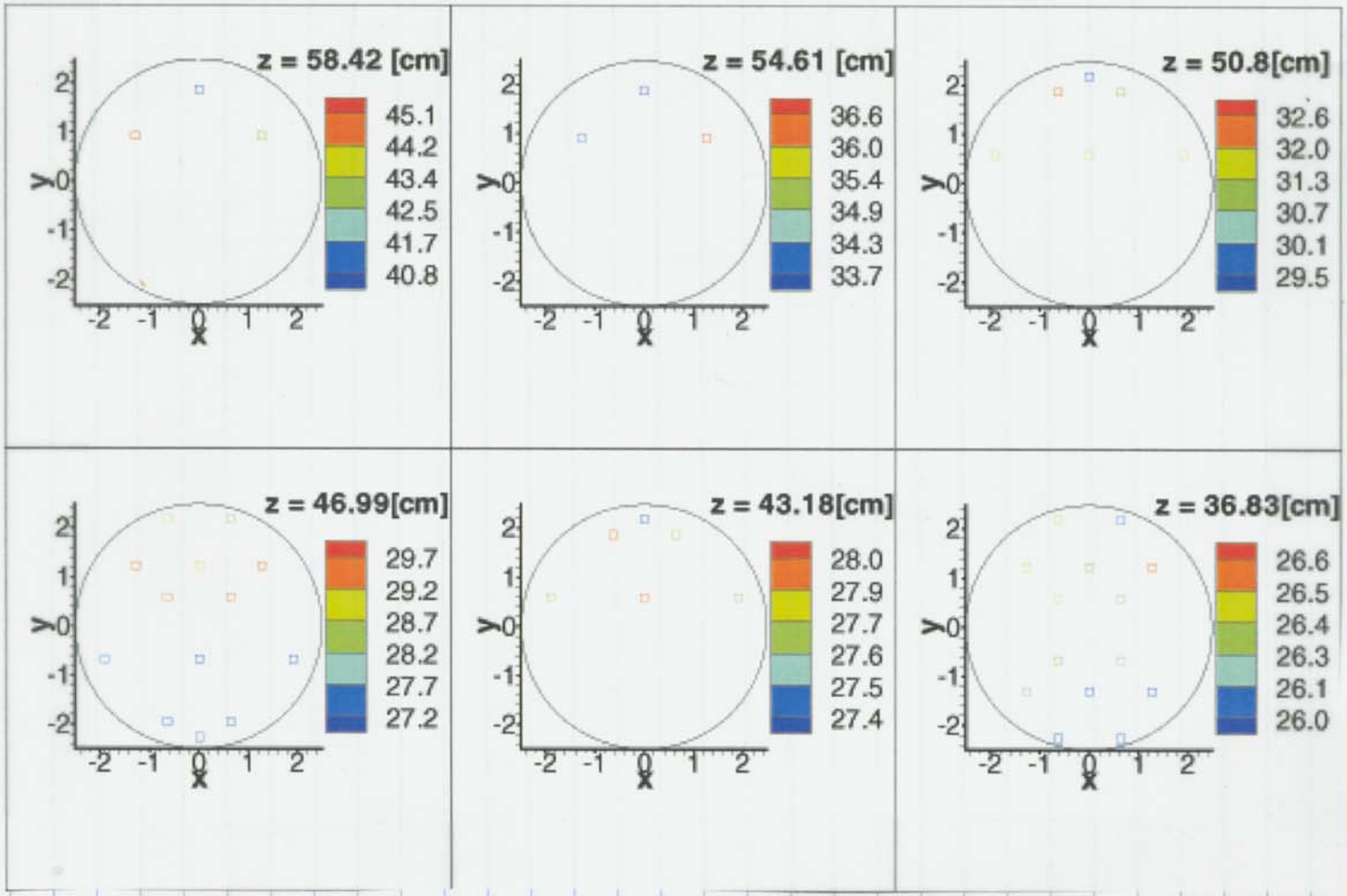
4/22/02 JP

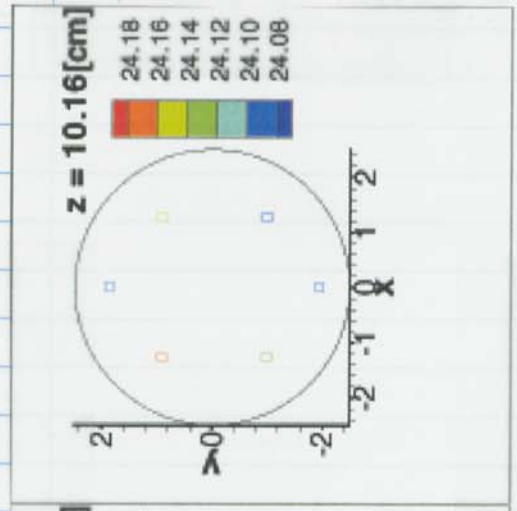
Test 9 observations.

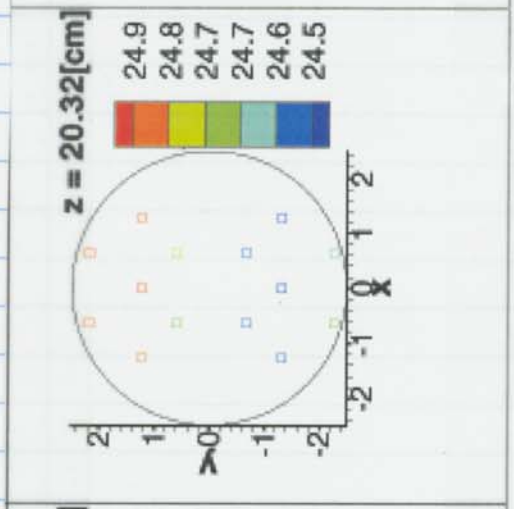
Test data did not conform to modeling results which indicate that hottest temperatures would be present at the top of the adit.

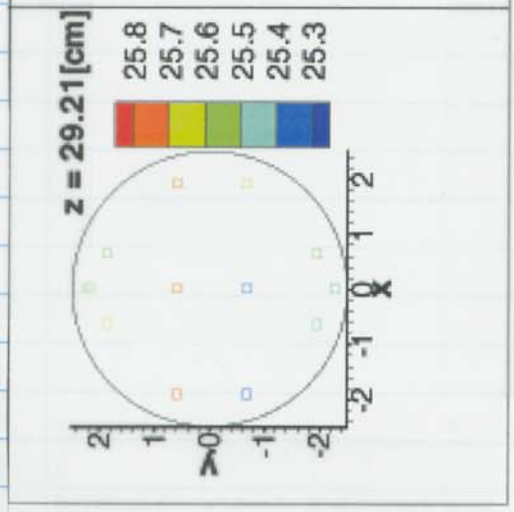
Plots of temperature distributions at 72 hrs after start of the heat cycle are shown in the following pages. Z is the distance from the cold end of the adit. In general hottest temperatures occur in top half of adit at the approximate midpoint and are off center from the middle.

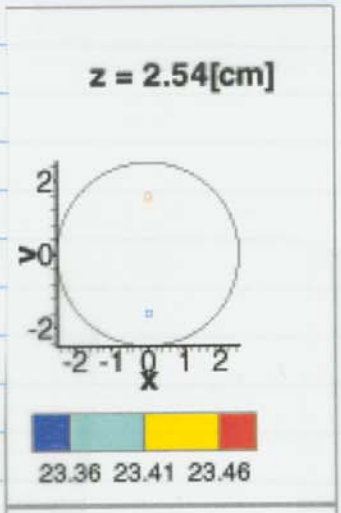
Temperature distributions in cold trap experiment - 72 hrs after start of heating cycle

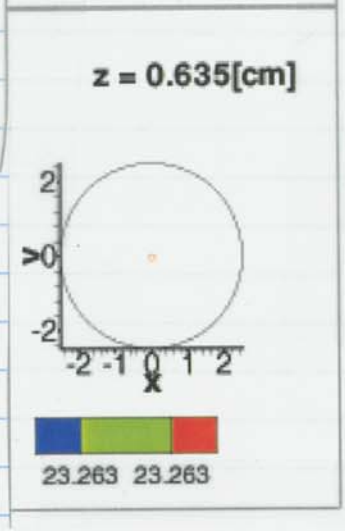



z = 10.16[cm]
24.18
24.16
24.14
24.12
24.10
24.08


z = 20.32[cm]
24.9
24.8
24.7
24.7
24.6
24.5


z = 29.21[cm]
25.8
25.7
25.6
25.5
25.4
25.3


z = 2.54[cm]
23.36 23.41 23.46


z = 0.635[cm]
23.263 23.263

4/23/02 JP

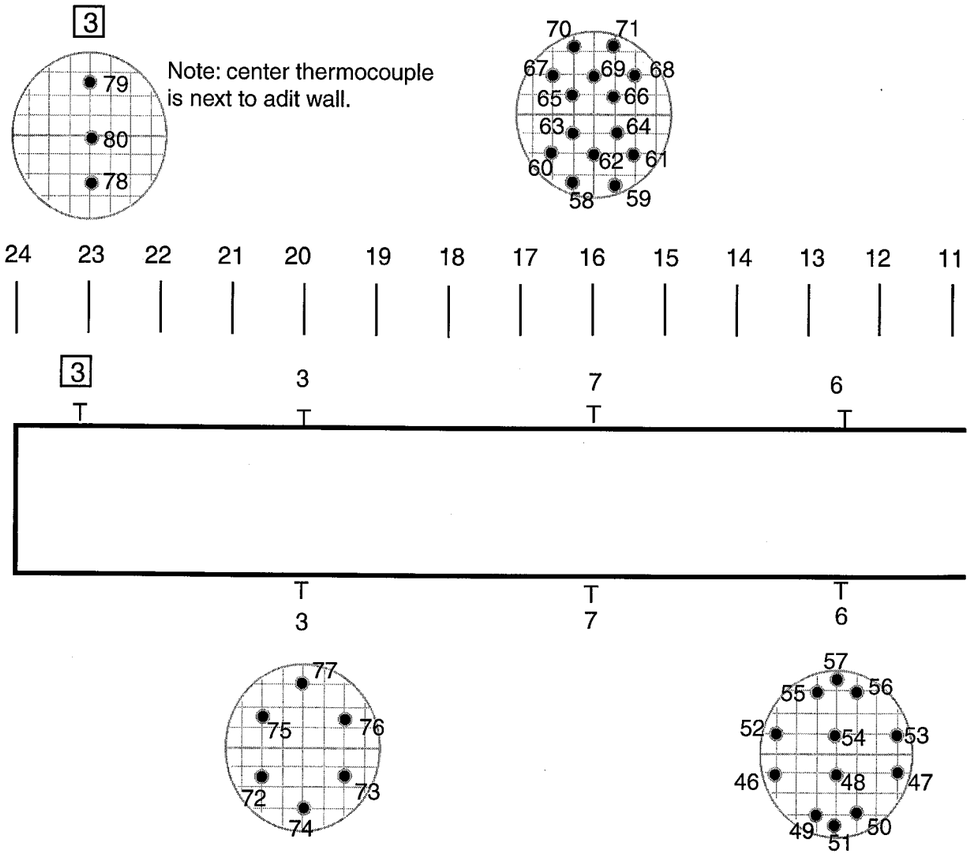
The coldtrap experiment was dismantled and additional thermocouples were placed above the heater cartridge and in the media above and below the ceramic tube at 1" from the hot end of the adit and at 5 1/2" from the hot end of the adit. This was done to better define temperature fields in the adit at the heater element and to determine effects of temperature in the media near the heater cartridge.

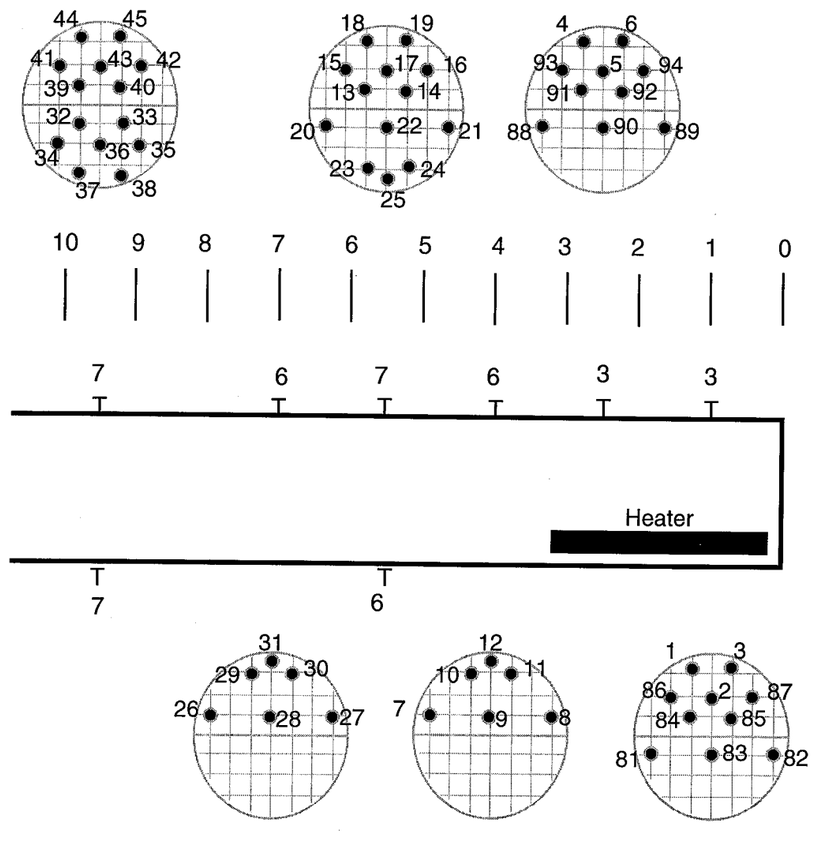
In addition aluminum tape which was used to secure the thermocouples in the ceramic tube was removed and silicone sealant was used to secure the thermocouples.

The schematic diagram on the following page shows the location of the additional thermocouples with the adit

4/23/02 JP

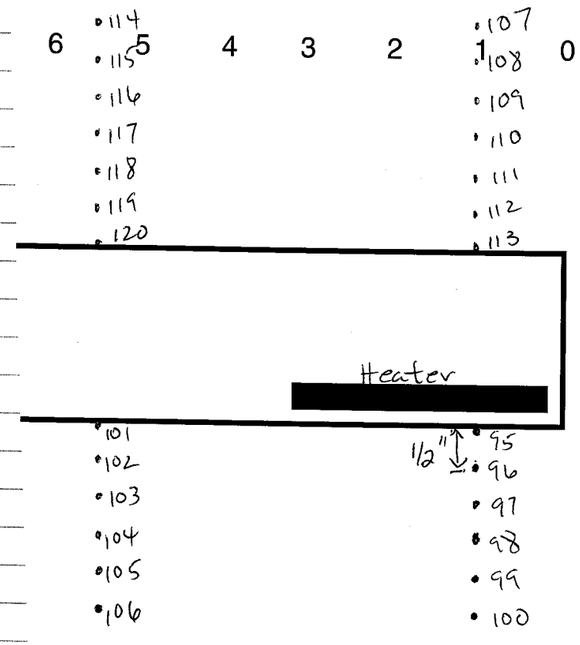
Schematic diagram showing location of thermocouples with adit.





4/26/02 JP

Schematic diagram showing location of thermocouples in sand media outside of adit



4/30/02 JP

Test 10.

After placement of additional thermocouples the coldtrap was reassembled. Sand was added and the DI water was added to saturate the sand. Insulate was then placed around the box.

Test 10 was begun at 13:17 hours Heat will not be applied to the heater cartridge until the air inside the adit has reached a steady state.

Temperature data will be collected every 10 minutes & monitored to determine steady state temperature distribution before cutting on heater.

4/30/02 JP
1530hrs Temp data saved to ct-test10a

5/1/02 JP
0925hrs Temp data saved to ct-test10b.

5/2/02 JP
0927hrs Temp data saved to ct-test10c.

5/2/02 JP

1330hr. Four type T thermocouples were placed at locations outside the coldtrap apparatus to monitor temperature fluctuations due to variation in room temperature or escape of heat from the apparatus.

The thermocouple were attached to a Fluke Hydradatalogger. Temperatures will be scanned every 15 minutes.

Thermocouples were labeled T1, T2, T3, & T4.

T1 is located over the adit opening at the cold end of the equipment
T2 is located on the top center of the box about 8 inches from cold end
T3 is located on top center of box 2 inches from hot end.
T4 is located over adit opening at hot end of box.

5/3/02 JP
0930hr Temp data saved to c:ttest10d. & test10d.

5/3/02 JP
1400hr Temp data saved to c:ttest10e & test10e.

5/6/02 JP
0930hr Temp data saved to c:ttest10f & test10f.

5/7/02 JP
0745hr. Test data saved To c:ttest10g & test10g

5/9/02 JP
0930hr Test data saved to c:ttest10h & test10h

5/10/02 JP
0930hr Test data saved to c:ttest10i & test10i

5/13/02 JP
0740hr Test data saved To c:ttest10j & test10j

5/15/02 JP
0740hr Test data saved to c:ttest10k & test10k

5/20/02 JP
0920hr Test data saved to c:ttest10L & test10L

5/28/02 JP
0815hr Test data saved to c:ttest10m & test10m

5/29/02 JP
0805 Test data saved to c:ttest10N & test10N

Test Terminated at 0805 on 5/29/02.

5/29/02 JP

Comparison of Temperature readings of Thermocouple #0 (with edit) indicated that this Thermocouple was reading lower than expected when compared to a calibrated thermometer, in a waterbath (23.0°C vs 24.3°C of calibrated thermometer). Therefore, it appears that a correction will have to be applied to each thermocouple to get an accurate reading.

Coldtrap was dismantled in order to check thermocouple readings.

5/30/02 JP

Calibration Check of thermocouples.

Obj - check calibration and accuracy of temperature readings of thermocouples being used in the coldtrap experiment.

Method - compare thermocouple temperature readings at different temperatures to a calibrated thermometer.

Equipment -
- thin wire thermocouples (OMEGA type K-Cut #0 5TC-TT-K-30-72)
- calibrated thermometer AN:007617 SN: 1709
- Fisher water bath
- HP Data Logger software
- HP 34970A Data acquisition unit
- Excel software to perform regression of temperature data & generate regression coefficients

Procedure:
1. Thermocouples + calibrated thermometer were placed in a water bath at different temperatures (20°C to 50°C).
2. When water bath reached a stable temperature the reading on the calibrated thermometer was read & recorded. Then the HP 34970A Data acquisition unit & data logger software was used to take a temperature reading of the thermocouples.

③. Results of the temperature comparisons are shown below.

Thermocouple calibration check

Thermometer reading °C	20.4	22.8	29.6	35.4	42.6	49.7
Thermocouple no.	Thermocouple readings °C					
1	18.80	21.18	28.05	33.77	40.99	47.96
2	18.96	21.46	28.25	33.94	41.14	48.12
3	18.73	21.26	28.08	33.83	41.01	48.02
4	19.06	21.52	28.31	34.05	41.27	48.24
5	18.96	21.50	28.32	34.02	41.21	48.19
6	18.95	21.39	28.21	33.93	41.10	48.03
7	19.27	21.84	28.64	34.37	41.61	48.61
8	19.23	21.80	28.59	34.38	41.50	48.49
9	19.22	21.81	28.62	34.38	41.60	48.60
10	19.38	21.93	28.69	34.45	41.63	48.60
11	19.24	21.75	28.56	34.29	41.46	48.44
12	19.40	21.93	28.72	34.47	41.65	48.65
13	19.49	21.92	28.71	34.44	41.61	48.55
14	19.44	21.90	28.69	34.42	41.63	48.57
15	19.47	21.89	28.68	34.42	41.60	48.55
16	19.29	21.83	28.50	34.22	41.41	48.35
17	19.26	21.84	28.51	34.24	41.46	48.41
18	19.26	21.81	28.47	34.30	41.46	48.45
19	19.25	21.84	28.47	34.18	41.38	48.32
20	19.20	21.77	28.40	34.15	41.36	48.33
21	18.76	21.21	28.08	33.84	41.09	48.09
22	18.84	21.33	28.18	33.88	41.08	48.09
23	18.78	21.35	28.20	33.94	41.15	48.19
24	18.95	21.46	28.27	34.11	41.26	48.28
25	19.12	21.65	28.42	34.12	41.30	48.30
26	19.05	21.62	28.44	34.15	41.31	48.33
27	19.21	21.83	28.59	34.35	41.52	48.50
28	19.28	21.79	28.58	34.40	41.53	48.55
29	19.24	21.87	28.65	34.41	41.59	48.59
30	19.19	21.84	28.64	34.45	41.62	48.64
31	19.42	21.88	28.66	34.48	41.59	48.57
32	19.27	21.85	28.68	34.41	41.61	48.60
33	19.29	21.86	28.68	34.46	41.64	48.63
34	19.38	21.86	28.67	34.46	41.63	48.56
35	19.26	21.83	28.64	34.37	41.54	48.47
36	19.19	21.82	28.49	34.26	41.45	48.44
37	19.27	21.87	28.50	34.27	41.40	48.31
38	19.18	21.85	28.50	34.27	41.41	48.42
39	19.09	21.81	28.42	34.16	41.32	48.26
40	19.02	21.76	28.36	34.12	41.28	48.22
41	19.19	21.33	28.29	34.11	41.31	48.36
42	19.31	21.53	28.44	34.31	41.52	48.53
43	19.13	21.34	28.26	34.10	41.28	48.27
44	19.25	21.59	28.42	34.18	41.39	48.37
45	19.22	21.54	28.38	34.18	41.29	48.36
46	19.16	21.45	28.35	34.04	41.18	48.22
47	19.51	21.96	28.73	34.38	41.49	48.50
48	19.36	21.83	28.64	34.33	41.48	48.48
49	19.51	21.90	28.72	34.40	41.47	48.53
50	19.53	21.98	28.77	34.41	41.55	48.52

Difference between calibrated thermometer and thermocouple reading in °C

1.60	1.62	1.55	1.63	1.61	1.74
1.44	1.34	1.35	1.46	1.46	1.58
1.67	1.54	1.52	1.57	1.59	1.68
1.34	1.28	1.29	1.35	1.33	1.46
1.44	1.30	1.28	1.38	1.39	1.51
1.45	1.41	1.39	1.47	1.50	1.67
1.13	0.96	0.96	1.03	0.99	1.09
1.18	1.00	1.01	1.02	1.10	1.21
1.18	0.99	0.98	1.02	1.00	1.10
1.02	0.87	0.91	0.95	0.97	1.10
1.16	1.05	1.04	1.11	1.14	1.26
1.00	0.87	0.88	0.93	0.95	1.05
0.91	0.88	0.89	0.96	0.99	1.15
0.96	0.90	0.91	0.98	0.97	1.13
0.93	0.91	0.92	0.98	1.00	1.15
1.12	0.97	1.10	1.18	1.19	1.35
1.14	0.96	1.09	1.17	1.14	1.29
1.14	0.99	1.13	1.10	1.14	1.25
1.16	0.96	1.13	1.22	1.22	1.38
1.20	1.03	1.20	1.26	1.25	1.37
1.64	1.59	1.52	1.56	1.51	1.61
1.56	1.47	1.42	1.52	1.52	1.61
1.62	1.45	1.40	1.46	1.45	1.51
1.45	1.34	1.33	1.29	1.34	1.42
1.28	1.15	1.18	1.28	1.30	1.40
1.36	1.18	1.16	1.25	1.29	1.37
1.19	0.97	1.01	1.05	1.08	1.20
1.12	1.01	1.02	1.00	1.07	1.15
1.16	0.93	0.95	0.99	1.01	1.11
1.21	0.96	0.96	0.95	0.98	1.06
0.98	0.92	0.94	0.92	1.01	1.13
1.13	0.95	0.92	0.99	0.99	1.10
1.11	0.94	0.92	0.94	0.96	1.07
1.02	0.94	0.93	0.94	0.97	1.14
1.14	0.97	0.96	1.03	1.06	1.23
1.21	0.98	1.11	1.14	1.15	1.26
1.13	0.93	1.10	1.13	1.20	1.39
1.22	0.95	1.10	1.13	1.19	1.28
1.31	0.99	1.18	1.24	1.28	1.44
1.38	1.04	1.24	1.28	1.32	1.48
1.21	1.47	1.31	1.29	1.29	1.34
1.09	1.27	1.16	1.09	1.08	1.17
1.27	1.46	1.34	1.30	1.32	1.43
1.15	1.21	1.18	1.22	1.21	1.33
1.18	1.26	1.22	1.22	1.31	1.34
1.24	1.36	1.25	1.36	1.42	1.48
0.89	0.84	0.87	1.02	1.11	1.20
1.04	0.97	0.96	1.07	1.12	1.23
0.89	0.90	0.88	1.00	1.13	1.17
0.87	0.82	0.83	0.99	1.05	1.18

51	19.44	21.75	28.70	34.36	41.54	48.52
52	19.60	21.98	28.83	34.45	41.54	48.45
53	19.58	21.92	28.81	34.40	41.55	48.53
54	19.50	21.87	28.79	34.42	41.51	48.49
55	19.46	21.84	28.78	34.42	41.54	48.52
56	19.36	21.76	28.64	34.26	41.35	48.32
57	19.41	21.81	28.64	34.31	41.39	48.35
58	19.45	21.84	28.67	34.35	41.45	48.41
59	19.40	21.75	28.61	34.24	41.40	48.37
60	19.36	21.73	28.58	34.20	41.33	48.32
61	19.10	21.37	28.31	34.16	41.33	48.38
62	19.06	21.38	28.29	34.10	41.29	48.34
63	19.06	21.41	28.29	34.09	41.23	48.25
64	19.10	21.49	28.35	34.16	41.32	48.36
65	19.25	21.62	28.43	34.18	41.37	48.39
66	19.33	21.63	28.51	34.23	41.32	48.33
67	19.48	21.85	28.66	34.32	41.46	48.43
68	19.34	21.85	28.67	34.32	41.48	48.43
69	19.47	21.92	28.74	34.37	41.50	48.50
70	19.51	21.89	28.72	34.40	41.53	48.53
71	19.49	21.87	28.76	34.36	41.49	48.44
72	19.39	21.91	28.82	34.48	41.58	48.58
73	19.57	21.83	28.74	34.41	41.50	48.49
74	19.51	21.83	28.77	34.42	41.49	48.54
75	19.40	21.80	28.72	34.32	41.44	48.44
76	19.45	21.75	28.61	34.22	41.31	48.28
77	19.35	21.79	28.67	34.29	41.43	48.41
78	19.32	21.72	28.61	34.25	41.44	48.43
79	19.32	21.68	28.56	34.22	41.36	48.37
80	19.34	21.68	28.53	34.19	41.33	48.30
81	20.83	23.15	30.15	35.82	43.08	50.04
82	20.74	23.20	30.07	35.83	43.04	50.05
83	20.65	23.02	29.91	35.65	42.87	49.84
84	20.64	23.06	29.86	35.67	42.81	49.81
85	20.46	22.97	29.78	35.54	42.72	49.74
86	20.33	22.80	29.66	35.41	42.61	49.60
87	20.24	22.96	29.69	35.46	42.67	49.69
88	20.50	23.01	29.77	35.51	42.69	49.71
89	20.27	22.95	29.68	35.43	42.64	49.63
90	20.27	22.87	29.60	35.37	42.58	49.57
91	20.36	22.87	29.77	35.51	42.70	49.73
92	20.40	22.88	29.72	35.44	42.64	49.60
93	20.39	22.79	29.69	35.47	42.64	49.62
94	20.17	22.69	29.61	35.37	42.55	49.61
95	20.02	22.49	29.40	35.20	42.38	49.39
96	20.29	22.55	29.55	35.36	42.51	49.50
97	20.22	22.62	29.53	35.38	42.53	49.44
98	20.41	22.68	29.66	35.45	42.63	49.56
99	20.23	22.61	29.61	35.36	42.53	49.61
100	20.40	22.63	29.61	35.40	42.56	49.53
101	20.74	23.13	30.08	35.83	43.02	50.02
102	20.59	23.06	29.96	35.74	42.91	49.92
103	20.54	23.02	29.89	35.59	42.80	49.82
104	20.50	22.99	29.79	35.53	42.71	49.69
105	20.47	22.89	29.68	35.47	42.69	49.62
106	20.29	22.85	29.69	35.41	42.59	49.73
107	20.47	22.95	29.71	35.48	42.63	49.62
108	20.35	22.98	29.71	35.47	42.67	49.66
109	20.40	22.89	29.67	35.46	42.63	49.60
110	20.11	22.76	29.50	35.27	42.47	49.43
111	20.31	22.82	29.71	35.43	42.61	49.62
112	20.39	22.79	29.68	35.47	42.63	49.63
113	20.21	22.70	29.62	35.35	42.55	49.53
114	20.05	22.57	29.49	35.23	42.41	49.43
115	19.93	22.43	29.37	35.15	42.35	49.39
116	20.31	22.58	29.56	35.30	42.47	49.50
117	20.30	22.65	29.64	35.36	42.54	49.59
118	20.29	22.61	29.60	35.33	42.52	49.53
119	20.28	22.60	29.58	35.32	42.53	49.53
120	20.12	22.59	29.58	35.35	42.56	49.58

0.96	1.05	0.90	1.05	1.06	1.18
0.80	0.82	0.77	0.95	1.06	1.25
0.82	0.88	0.79	1.00	1.05	1.17
0.90	0.93	0.81	0.98	1.09	1.21
0.94	0.96	0.82	0.98	1.07	1.18
1.04	1.04	0.96	1.14	1.25	1.38
0.99	0.99	0.96	1.09	1.21	1.35
0.95	0.96	0.93	1.05	1.15	1.29
1.00	1.05	0.99	1.16	1.20	1.33
1.04	1.07	1.02	1.20	1.27	1.38
1.30	1.43	1.29	1.24	1.27	1.32
1.34	1.42	1.31	1.30	1.31	1.36
1.34	1.39	1.31	1.31	1.37	1.45
1.30	1.31	1.25	1.24	1.29	1.34
1.15	1.18	1.17	1.22	1.23	1.31
1.07	1.17	1.09	1.17	1.28	1.37
0.92	0.95	0.94	1.08	1.14	1.27
1.06	0.95	0.93	1.08	1.12	1.27
0.93	0.88	0.86	1.03	1.10	1.20
0.89	0.91	0.88	1.00	1.07	1.17
0.91	0.93	0.84	1.04	1.11	1.26
1.01	0.89	0.78	0.92	1.02	1.12
0.83	0.97	0.86	0.99	1.10	1.21
0.89	0.97	0.83	0.98	1.11	1.16
1.00	1.00	0.88	1.08	1.16	1.26
0.95	1.05	0.99	1.18	1.29	1.42
1.05	1.01	0.93	1.11	1.17	1.29
1.08	1.08	0.99	1.15	1.16	1.27
1.08	1.12	1.04	1.18	1.24	1.33
1.06	1.12	1.07	1.21	1.27	1.40
-0.43	-0.35	-0.55	-0.42	-0.48	-0.34
-0.34	-0.40	-0.47	-0.43	-0.44	-0.35
-0.25	-0.22	-0.31	-0.25	-0.27	-0.14
-0.24	-0.26	-0.26	-0.27	-0.21	-0.11
-0.06	-0.17	-0.17	-0.14	-0.12	-0.04
0.07	0.00	-0.06	-0.01	-0.01	0.10
0.16	-0.16	-0.09	-0.06	-0.07	0.01
-0.10	-0.21	-0.17	-0.11	-0.09	-0.01
0.13	-0.15	-0.08	-0.03	-0.04	0.07
0.13	-0.06	0.00	0.03	0.02	0.13
0.04	-0.07	-0.17	-0.11	-0.10	-0.03
0.00	-0.08	-0.12	-0.04	-0.04	0.10
0.01	0.01	-0.09	-0.07	-0.04	0.08
0.23	0.11	-0.01	0.03	0.05	0.09
0.38	0.31	0.20	0.20	0.22	0.31
0.11	0.25	0.05	0.04	0.09	0.20
0.18	0.18	0.07	0.02	0.07	0.26
-0.01	0.12	-0.06	-0.05	-0.03	0.14
0.17	0.19	-0.01	0.04	0.07	0.09
0.00	0.17	-0.01	0.00	0.04	0.17
-0.34	-0.33	-0.48	-0.43	-0.42	-0.32
-0.19	-0.26	-0.36	-0.34	-0.31	-0.22
-0.14	-0.22	-0.29	-0.19	-0.20	-0.12
-0.10	-0.19	-0.19	-0.13	-0.11	0.01
-0.07	-0.09	-0.08	-0.07	-0.09	0.08
0.11	-0.05	-0.09	-0.01	0.01	-0.03
-0.07	-0.15	-0.11	-0.08	-0.03	0.08
0.05	-0.18	-0.11	-0.07	-0.07	0.04
0.00	-0.09	-0.07	-0.06	-0.03	0.10
0.29	0.04	0.10	0.13	0.13	0.27
0.09	-0.02	-0.11	-0.03	-0.01	0.08
0.01	0.01	-0.08	-0.07	-0.03	0.07
0.19	0.10	-0.02	0.05	0.05	0.17
0.35	0.23	0.11	0.17	0.19	0.27
0.47	0.37	0.23	0.25	0.25	0.31
0.09	0.22	0.04	0.10	0.13	0.20
0.10	0.15	-0.04	0.04	0.06	0.11
0.11	0.19	0.00	0.07	0.08	0.17
0.12	0.20	0.02	0.08	0.07	0.17
0.28	0.21	0.02	0.05	0.04	0.12

(4) The OMEGA type K thin wire thermocouples have a standard limit of error of 2.2°C or 0.75 % (whichever is greater). Temperature measurements recorded on the previous pages indicate the thermocouples are within tolerances.

6/3/02 JJF

(5) Based on thermocouple readings and readings of the calculated thermometer at different temperatures a regression of the data for each thermocouple was performed to generate coefficients that can be used to translate the thermocouple readings to the calculated thermometer readings. The translation is based on the following formula

$$y = ax + b$$

Where x is the thermocouple reading, a is the slope of the regression + b is the intercept. The a and b values created by the regression for each thermocouple are listed on the following page. The Datalogger software allows these coefficients to be entered into the software setup so that temperatures can be translated.

Regression coefficients

Thermocouple no.	b	a			
1	1.5078	1.0036			
2	1.2455	1.0060	63	1.2802	1.0026
3	1.5344	1.0019	64	1.2661	1.0007
4	1.2027	1.0043	65	1.0571	1.0048
5	1.2537	1.0040	66	0.8980	1.0091
6	1.2400	1.0075	67	0.6624	1.0119
7	1.0106	1.0004	68	0.7903	1.0086
8	0.9852	1.0031	69	0.6513	1.0108
9	1.0690	0.9992	70	0.6732	1.0097
10	0.8423	1.0039	71	0.6179	1.0122
11	0.9758	1.0046	72	0.7636	1.0060
12	0.8523	1.0029	73	0.6170	1.0116
13	0.7036	1.0080	74	0.6942	1.0091
14	0.7891	1.0057	75	0.7538	1.0096
15	0.7472	1.0072	76	0.6449	1.0156
16	0.8402	1.0096	77	0.7930	1.0092
17	0.9024	1.0070	78	0.9118	1.0065
18	0.9565	1.0051	79	0.8925	1.0084
19	0.8507	1.0102	80	0.8312	1.0112
20	0.9635	1.0079	81	-0.4576	1.0009
21	1.6186	0.9985	82	-0.4011	0.9999
22	1.4267	1.0028	83	-0.3188	1.0024
23	1.5269	0.9986	84	-0.3537	1.0038
24	1.3695	0.9997	85	-0.1722	1.0017
25	1.0703	1.0060	86	-0.0282	1.0013
26	1.1637	1.0032	87	0.0003	0.9989
27	0.9878	1.0029	88	-0.2719	1.0047
28	0.9916	1.0022	89	-0.0650	1.0014
29	0.9982	1.0008	90	-0.0270	1.0020
30	1.0925	0.9977	91	-0.0387	0.9989
31	0.8155	1.0052	92	-0.1554	1.0038
32	0.9825	1.0009	93	-0.0646	1.0014
33	0.9812	1.0003	94	0.1936	0.9967
34	0.8681	1.0038	95	0.3470	0.9977
35	0.9172	1.0046	96	0.1345	0.9997
36	0.9967	1.0045	97	0.1099	1.0006
37	0.7946	1.0109	98	-0.0307	1.0015
38	0.9565	1.0058	99	0.1964	0.9969
39	0.9594	1.0087	100	-0.0134	1.0023
40	1.0459	1.0076	101	-0.3828	0.9999
41	1.3286	0.9997	102	-0.2496	0.9991
42	1.1901	0.9986	103	-0.2511	1.0017
43	1.3159	1.0012	104	-0.2647	1.0043
44	1.0723	1.0045	105	-0.1843	1.0040
45	1.1120	1.0045	106	0.0430	0.9984
46	1.1281	1.0069	107	-0.2549	1.0058
47	0.5832	1.0125	108	-0.1316	1.0023
48	0.8168	1.0076	109	-0.1527	1.0038
49	0.6486	1.0107	110	0.1011	1.0017
50	0.5749	1.0117	111	-0.0291	1.0009
51	0.8411	1.0059	112	-0.0533	1.0012
52	0.4435	1.0153	113	0.1002	0.9997
53	0.5699	1.0117	114	0.2628	0.9987
54	0.6335	1.0108	115	0.4692	0.9953
55	0.7198	1.0084	116	0.0806	1.0014
56	0.7408	1.0122	117	0.0820	0.9996
57	0.6882	1.0128	118	0.1006	1.0001
58	0.6712	1.0118	119	0.1186	0.9997
59	0.7618	1.0111	120	0.3024	0.9945
60	0.7758	1.0120			
61	1.3806	0.9977			
62	1.3784	0.9988			

6/4/02 JP

⑥ A test using the regression coefficients to determine how well temperatures are translated to the calculated thermometer readings is shown below.

Thermocouple temperture translation check

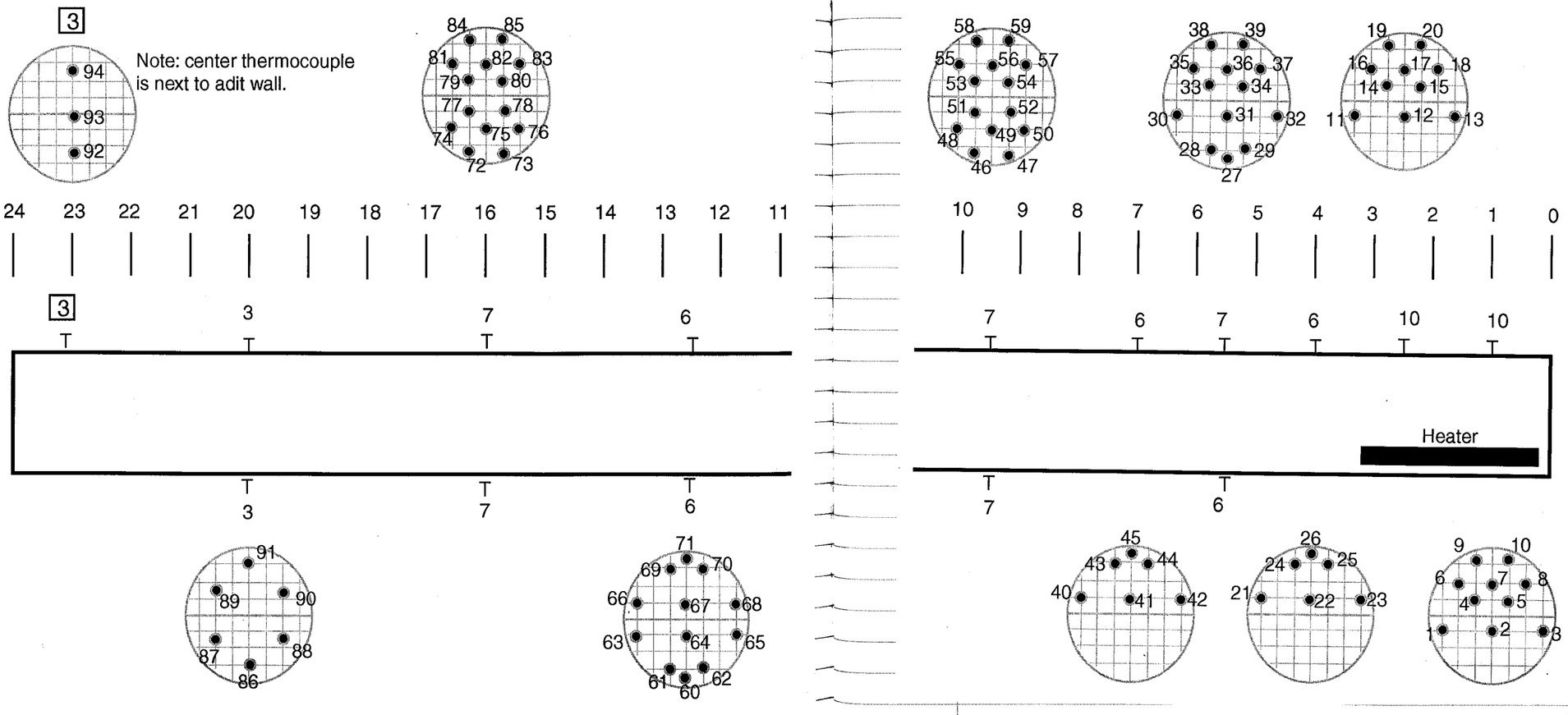
Thermometer reading °C 22.4

Thermocouple no.	Translated thermocouple reading °C	Difference between readings °C
1	22.38	0.02
2	22.39	0.01
3	22.42	-0.02
4	22.36	0.04
5	22.36	0.04
6	22.35	0.05
7	22.32	0.08
8	22.31	0.09
9	22.30	0.10
10	22.29	0.11
11	22.30	0.10
12	22.28	0.12
13	22.24	0.16
14	22.27	0.13
15	22.27	0.13
16	22.35	0.05
17	22.38	0.02
18	22.34	0.06
19	22.40	0.00
20	22.39	0.01
21	22.38	0.02
22	22.41	-0.01
23	22.40	0.00
24	22.38	0.02
25	22.37	0.03
26	22.37	0.03
27	22.33	0.07
28	22.30	0.10
29	22.32	0.08
30	22.32	0.08
31	22.28	0.12
32	22.31	0.09
33	22.29	0.11
34	22.27	0.13
35	22.32	0.08
36	22.40	0.00
37	22.37	0.03
38	22.42	-0.02
39	22.47	-0.07
40	22.46	-0.06
41	22.35	0.05
42	22.32	0.08
43	22.35	0.05
44	22.35	0.05
45	22.35	0.05
46	22.30	0.10
47	22.30	0.10
48	22.28	0.12
49	22.30	0.10
50	22.26	0.14
51	22.23	0.17
52	22.23	0.17
53	22.26	0.14
54	22.25	0.15
55	22.26	0.14
56	22.32	0.08
57	22.30	0.10
58	22.31	0.09
59	22.32	0.08
60	22.33	0.07
61	22.39	0.01
62	22.36	0.04
63	22.35	0.05
64	22.38	0.02
65	22.33	0.07
66	22.26	0.14
67	22.26	0.14
68	22.32	0.08
69	22.27	0.13
70	22.26	0.14
71	22.28	0.12
72	22.29	0.11
73	22.24	0.16
74	22.23	0.17
75	22.28	0.12
76	22.29	0.11
77	22.34	0.06
78	22.31	0.09
79	22.31	0.09
80	22.32	0.08
81	22.40	0.00
82	22.44	-0.04
83	22.41	-0.01
84	22.35	0.05
85	22.40	0.00
86	22.37	0.03
87	22.41	-0.01
88	22.33	0.07
89	22.41	-0.01
90	22.37	0.03
91	22.38	0.02
92	22.36	0.04
93	22.34	0.06
94	22.38	0.02
95	22.36	0.04
96	22.36	0.04
97	22.40	0.00
98	22.35	0.05
99	22.40	0.00
100	22.33	0.07
101	22.41	-0.01
102	22.40	0.00
103	22.42	-0.02
104	22.39	0.01
105	22.36	0.04
106	22.39	0.01
107	22.34	0.06
108	22.41	-0.01
109	22.33	0.07
110	22.38	0.02
111	22.38	0.02
112	22.34	0.06
113	22.39	0.01
114	22.39	0.01
115	22.40	0.00
116	22.38	0.02
117	22.39	0.01
118	22.38	0.02
119	22.36	0.04
120	22.45	-0.05

Results of the test indicate that translated thermocouple readings compare well to calculated thermometer readings.

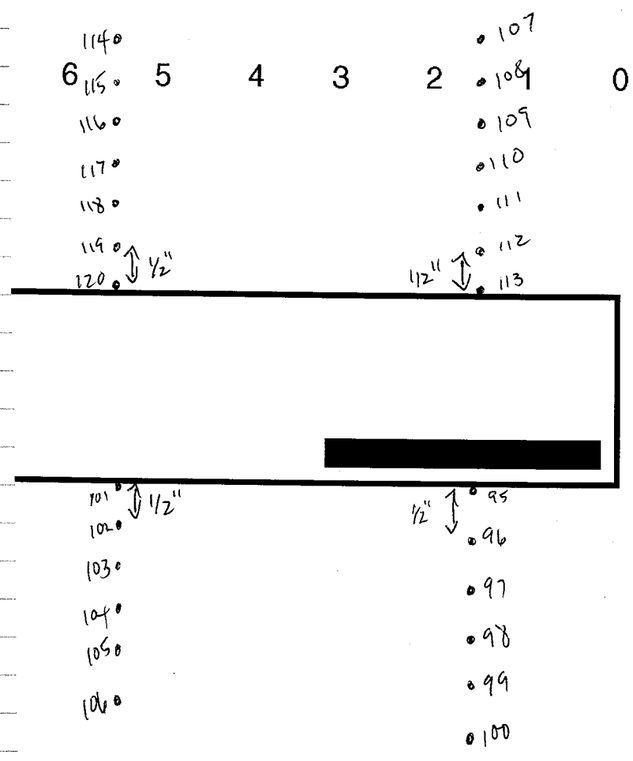
6/10/02 JP

The coldtrap was reassembled. Thermocouples were placed and mounted as in the previous test (Test 10). 94 thermocouples were placed in the adit + 26 thermocouples in the sand media outside the adit. The schematic diagram below shows the location of each thermocouple with the adit.



6/10/02 JP

The schematic diagram on p122 shows the location of thermocouples in the sand media outside the adit.
* Note - thermocouples 95, 100, 101, 113 are actually mounted 1½" from the boundary of the adit. The diagram on p122 shows them mounted 1" from the boundary. The diagram below shows the actual location of the thermocouples in the sand.



6/17/02 JP

After thermocouples were placed, sand was added and then DI water to saturate the sand. The box was then sealed and insulated with Fiberglass & styrofoam.

Test 11

Test 11 was begun at 16:04

Four type T thermocouples were placed at the following location outside the box.

T1 located over adit opening on cold end
T2 located at top center of the box
T3 located at top center of box below the insulation & beneath T2.
T4 located over adit opening on hot end.

These thermocouples were attached to a Fluke Hydrodatalogger. Temperature will be scanned every 20 minutes

Heat sink circulation system was turned on & set to 20°C.

6/18/02 JP

0800 hrs Test data saved as C:\test11a & test11a

6/19/02 JP

0710 hrs Test data saved as C:\test11b & test11b.

6/20/02 JP

0735 hrs Test data saved to C:\test11c & test11c.

6/21/02 JP
0740hr Test data saved to cttest11o + test11o.

6/24/02 JP
0730hr Test data saved to cttest11e + test11e.

6/26/02 JP
0730hr Test data saved to cttest11f + test11f

6/27/02 JP
0720hr Test data saved to cttest11g + test11g

6/27/02 JP
10:39hr Heating in the adit was initiated.
Variable transformer was set to 14.
The transformer will be adjusted
subsequently to achieve at temperature
of about 50°C at the heater
Electrolyte.

6/27/02 JP
1610 hr Variable transformer was set to 18.

6/28/02 JP
0745 hr Test data saved to cttest11h + test11h.

6/28/02 JP
08:00 hrs. Variable transformer was set to 20.

7/1/02 JP Test data saved to cttest11i + test11i.

7/2/02 JP Test data saved to cttest11j + test11j.

7/3/02 JP Test data saved to cttest11k + test11k

7/5/02 JP Test data saved to cttest11L + test11L

7/8/02 JP Test data saved to cttest11m + test11m
7/9/02 JP Test data saved to cttest11n + test11n
7/10/02 JP Test data saved to cttest11o + test11o
7/11/02 JP
0941hr Test data saved to cttest11p + test11p

7/11/02 JP
0950hr An additional thermocouple (type T)
was placed inside the heat
sink apparatus at a location near
the center to determine variation
in the heat sink temperature.
This thermocouple was labeled TS.

7/11/02 JP
1000hr. Variable transformer was set to 23

7/11/02 JP
1605hr Variable transformer was set to 24

7/12/02 JP
0745hr Variable transformer was set to 25.

7/12/02 JP
0745hr Test data saved to cttest11q + test11q

7/15/02 JP
0820hr Test data saved to cttest11r + test11r.

7/16/02 JP
0730hr Test data saved to cttest11s + test11s.

7/17/02 JP
0800hr Test data saved to cttest11t + test11t

7/18/02 JP
0740h Variable transformer set to 16.

7/18/02 JP
1415h Variable transformer set to 15.

7/19/02 JP
0800h Test data saved to c:\test11\u + tot11u

7/19/02 JP
0810hr Variable transformer set to 12.

7/22/02 JP
0815h Test data saved to c:\test11\v + tot11v.

7/24/02 JP
0740h Test data saved to c:\test11\w + tot11w.

7/26/02 JP
0755h Test data saved To c:\test11\x + test11x

7/26/02 JP
0800hr Heat to experiment was shut off.

7/29/02 JP
0745hr Test data saved to c:\test11\y + tot11y

7/29/02 JP
0745hr Test 11 terminated

7/29/02 JP
0900hr Coldtrap was disassembled.

7/29/02 JP

Check of thermocouple.

Obj - check accuracy of thermocouple readings beijng used in coldtrap experiment.

Method - compare thermocouple readings with calibrated thermometer.

Equipment
- thirty wire thermocouples (120) Nos. 1-120
- type T thermocouples (5) Nos T1-T5
- calibrated thermometer AN-007617 SN:1709
- HP Data logger software
- HP 34970A Data acquisition unit (thirty wire thermocouples)
- Fluke Hydra Data Logger (type T thermocouples)
- Fisher Waterbath (Model 10 Liter Water bath) (921561)

Procedure - 1
(1) Thermocouples + calibrated thermometer were placed in a water bath at different temperatures (room temperature - 50°c)

(2) When water bath reached a stable temperature a reading on the calibrated thermometer was recorded. The the HP Data logger acquisition unit ad Fluke data logger were used to take a temperature reading of the thermocouples.

(3) Results of temperature checks are shown below.

Thermocouple check after test 11

Thermometer reading °C	23.80		30.85		38.00		44.90		51.00		57.90	
Thermocouple no.		Difference		Difference		Differcence		Difference		Difference		Difference
1	23.81	0.01	30.88	0.03	37.97	-0.03	44.85	-0.05	51.03	0.03	57.84	-0.06
2	23.81	0.01	30.90	0.05	37.96	-0.04	44.83	-0.07	51.12	0.12	57.85	-0.05
3	23.84	0.04	30.96	0.11	37.97	-0.03	44.88	-0.02	50.88	-0.12	57.88	-0.02
4	23.76	-0.04	30.84	-0.01	37.95	-0.05	44.85	-0.05	50.89	-0.11	57.96	0.06
5	23.81	0.01	30.85	0.00	37.95	-0.05	44.82	-0.08	50.87	-0.13	57.71	-0.19
6	23.82	0.02	30.93	0.08	38.01	0.01	44.92	0.02	50.90	-0.10	58.09	0.19
7	23.77	-0.03	30.81	-0.04	38.01	0.01	44.87	-0.03	51.08	0.08	57.91	0.01
8	23.78	-0.02	30.85	0.00	37.97	-0.03	44.91	0.01	50.90	-0.10	57.94	0.04
9	23.77	-0.03	30.87	0.02	37.98	-0.02	44.81	-0.09	51.06	0.06	57.88	-0.02
10	23.77	-0.03	30.81	-0.04	37.96	-0.04	44.83	-0.07	51.15	0.15	57.83	-0.07
11	23.80	0.00	30.93	0.08	38.02	0.02	44.87	-0.03	50.85	-0.15	58.08	0.18
12	23.78	-0.02	30.92	0.07	37.95	-0.05	44.83	-0.07	51.01	0.01	57.84	-0.06
13	23.76	-0.04	30.94	0.09	37.93	-0.07	44.97	0.07	50.92	-0.08	57.98	0.08
14	23.78	-0.02	30.90	0.05	38.02	0.02	45.01	0.11	50.89	-0.11	58.01	0.11
15	23.77	-0.03	30.80	-0.05	38.00	0.00	44.94	0.04	50.93	-0.07	58.03	0.13
16	23.75	-0.05	30.84	-0.01	38.00	0.00	44.99	0.09	50.93	-0.07	58.14	0.23
17	23.76	-0.04	30.87	0.02	38.01	0.01	45.01	0.11	50.93	-0.07	58.10	0.20
18	23.72	-0.08	30.87	0.02	37.99	-0.01	44.98	0.08	50.95	-0.05	58.13	0.23
19	23.75	-0.05	30.83	-0.02	37.98	-0.02	44.86	-0.04	51.11	0.11	57.95	0.05
20	23.72	-0.08	30.85	0.00	37.95	-0.05	44.85	-0.05	51.05	0.05	57.96	0.06
21	23.80	0.00	30.82	-0.03	37.94	-0.06	44.81	-0.09	51.20	0.20	57.77	-0.13
22	23.82	0.02	30.85	0.00	37.95	-0.05	44.87	-0.03	51.03	0.03	57.86	-0.04
23	23.83	0.03	30.87	0.02	37.92	-0.08	44.86	-0.04	51.06	0.06	57.84	-0.06
24	23.78	-0.02	30.78	-0.07	37.88	-0.12	44.75	-0.15	51.22	0.22	57.67	-0.23
25	23.81	0.01	30.81	-0.04	37.91	-0.09	44.81	-0.09	51.20	0.20	57.72	-0.18
26	23.82	0.02	30.83	-0.02	37.93	-0.07	44.76	-0.14	50.99	-0.01	57.67	-0.23
27	23.79	-0.01	30.82	-0.03	37.92	-0.08	44.79	-0.11	50.99	-0.01	57.72	-0.18
28	23.73	-0.07	30.77	-0.08	37.94	-0.06	44.75	-0.15	51.07	0.07	57.75	-0.15
29	23.79	-0.01	30.83	-0.02	37.96	-0.04	44.78	-0.12	50.93	-0.07	57.75	-0.15
30	23.81	0.01	30.82	-0.03	37.90	-0.10	44.74	-0.16	50.86	-0.14	57.58	-0.32
31	23.76	-0.04	30.81	-0.04	37.91	-0.09	44.76	-0.14	51.03	0.03	57.75	-0.15
32	23.81	0.01	30.86	0.01	38.00	0.00	44.86	-0.04	51.01	0.01	57.84	-0.06
33	23.82	0.02	30.84	-0.01	37.97	-0.03	44.83	-0.07	50.95	-0.05	57.75	-0.15
34	23.78	-0.02	30.81	-0.04	37.97	-0.03	44.81	-0.09	51.20	0.20	57.76	-0.14
35	23.83	0.03	30.88	0.03	37.96	-0.04	44.82	-0.08	50.94	-0.06	57.88	-0.02
36	23.77	-0.03	30.79	-0.06	37.95	-0.05	44.88	-0.02	51.13	0.13	57.90	0.00
37	23.76	-0.04	30.85	0.00	37.94	-0.06	44.81	-0.09	51.03	0.03	57.84	-0.06
38	23.77	-0.03	30.82	-0.03	37.94	-0.06	44.84	-0.06	51.07	0.07	57.87	-0.03
39	23.78	-0.02	30.84	-0.01	37.96	-0.04	44.81	-0.09	51.11	0.11	57.80	-0.10
40	23.77	-0.03	30.78	-0.07	37.95	-0.05	44.80	-0.10	51.11	0.11	57.76	-0.14
41	23.96	0.16	31.09	0.24	38.08	0.08	44.84	-0.06	50.83	-0.17	57.96	0.06
42	23.85	0.05	30.96	0.11	38.02	0.02	44.80	-0.10	50.87	-0.13	57.91	0.01
43	23.87	0.07	30.94	0.09	38.03	0.03	44.85	-0.05	50.89	-0.11	57.90	0.00
44	23.82	0.02	30.94	0.09	37.96	-0.04	44.86	-0.04	50.96	-0.04	57.87	-0.03
45	23.82	0.02	30.85	0.00	37.96	-0.04	44.81	-0.09	51.26	0.26	57.80	-0.10
46	23.73	-0.07	30.93	0.08	37.94	-0.06	44.78	-0.12	50.83	-0.17	57.96	0.06
47	23.65	-0.15	30.75	-0.10	37.93	-0.07	44.89	-0.01	50.91	-0.09	58.02	0.12
48	23.66	-0.14	30.78	-0.07	37.92	-0.08	44.83	-0.07	50.88	-0.12	58.05	0.15
49	23.62	-0.18	30.74	-0.11	37.87	-0.13	44.78	-0.12	50.88	-0.12	58.00	0.10
50	23.61	-0.19	30.75	-0.10	37.90	-0.10	44.83	-0.07	50.90	-0.10	58.06	0.16
51	23.60	-0.20	30.70	-0.15	37.89	-0.11	44.85	-0.05	50.92	-0.08	58.03	0.13
52	23.59	-0.21	30.70	-0.15	37.86	-0.14	44.82	-0.08	50.96	-0.04	57.90	0.00
53	23.60	-0.20	30.72	-0.13	37.85	-0.15	44.79	-0.11	50.89	-0.11	57.93	0.03

	23.80		30.85		38.00		44.90		51.00		57.90	
54	23.61	-0.19	30.72	-0.13	37.81	-0.19	44.79	-0.11	50.88	-0.12	57.82	-0.08
55	23.59	-0.21	30.69	-0.16	37.80	-0.20	44.76	-0.14	50.94	-0.06	57.80	-0.10
56	23.61	-0.19	30.68	-0.17	37.80	-0.20	44.73	-0.17	50.87	-0.13	57.83	-0.07
57	23.59	-0.21	30.70	-0.15	37.82	-0.18	44.76	-0.14	50.88	-0.12	57.99	0.09
58	23.57	-0.23	30.67	-0.18	37.86	-0.14	44.82	-0.08	51.01	0.01	57.95	0.05
59	23.56	-0.24	30.65	-0.20	37.81	-0.19	44.77	-0.13	50.94	-0.06	57.92	0.02
60	23.59	-0.21	30.66	-0.19	37.82	-0.18	44.76	-0.14	50.94	-0.06	57.88	-0.02
61	23.94	0.14	31.02	0.17	38.12	0.12	44.99	0.09	50.87	-0.13	58.01	0.11
62	23.91	0.11	30.98	0.13	38.11	0.11	44.93	0.03	50.95	-0.05	57.97	0.07
63	23.89	0.09	30.94	0.09	38.13	0.13	45.02	0.12	50.93	-0.07	58.02	0.12
64	23.84	0.04	30.89	0.04	38.03	0.03	44.91	0.01	50.83	-0.17	58.03	0.13
65	23.76	-0.04	30.91	0.06	38.01	0.01	45.01	0.11	50.88	-0.12	58.01	0.11
66	23.67	-0.13	30.81	-0.04	37.92	-0.08	44.86	-0.04	50.92	-0.08	58.02	0.12
67	23.62	-0.18	30.76	-0.09	37.95	-0.05	44.84	-0.06	50.95	-0.05	58.06	0.16
68	23.68	-0.12	30.76	-0.09	37.92	-0.08	44.86	-0.04	51.03	0.03	57.92	0.02
69	23.64	-0.16	30.79	-0.06	37.94	-0.06	44.96	0.06	51.06	0.06	58.10	0.20
70	23.61	-0.19	30.72	-0.13	37.93	-0.07	44.99	0.09	51.00	0.00	58.11	0.21
71	23.66	-0.14	30.71	-0.14	37.97	-0.03	44.91	0.01	51.01	0.01	58.06	0.16
72	23.64	-0.16	30.72	-0.13	37.78	-0.22	44.72	-0.18	50.82	-0.18	57.66	-0.24
73	23.60	-0.20	30.71	-0.14	37.91	-0.09	44.88	-0.02	51.12	0.12	57.94	0.04
74	23.59	-0.21	30.78	-0.07	37.89	-0.11	44.87	-0.03	50.86	-0.14	58.04	0.14
75	23.63	-0.17	30.68	-0.17	37.84	-0.16	44.83	-0.07	50.93	-0.07	57.92	0.02
76	23.58	-0.22	30.76	-0.09	37.88	-0.12	44.92	0.02	51.03	0.03	57.98	0.08
77	23.63	-0.17	30.70	-0.15	37.81	-0.19	44.79	-0.11	51.05	0.05	57.84	-0.06
78	23.57	-0.23	30.66	-0.19	37.83	-0.17	44.74	-0.16	51.12	0.12	57.81	-0.09
79	23.56	-0.24	30.68	-0.17	37.90	-0.10	44.86	-0.04	51.05	0.05	58.01	0.11
80	23.57	-0.23	30.68	-0.17	37.89	-0.11	44.85	-0.05	51.02	0.02	58.01	0.11
81	23.71	-0.09	30.85	0.00	37.93	-0.07	44.85	-0.05	51.05	0.05	57.86	-0.04
82	23.69	-0.11	30.85	0.00	37.92	-0.08	44.81	-0.09	51.03	0.03	57.87	-0.03
83	23.65	-0.15	30.77	-0.08	37.86	-0.14	44.82	-0.08	51.02	0.02	57.82	-0.08
84	23.63	-0.17	30.76	-0.09	37.89	-0.11	44.82	-0.08	51.04	0.04	57.82	-0.08
85	23.65	-0.15	30.78	-0.07	37.91	-0.09	44.76	-0.14	51.04	0.04	57.78	-0.12
86	23.65	-0.15	30.75	-0.10	37.91	-0.09	44.82	-0.08	51.01	0.01	57.87	-0.03
87	23.68	-0.12	30.75	-0.10	37.92	-0.08	44.78	-0.12	51.00	0.00	57.82	-0.08
88	23.63	-0.17	30.74	-0.11	37.94	-0.06	44.85	-0.05	51.04	0.04	57.93	0.03
89	23.69	-0.11	30.76	-0.09	37.94	-0.06	44.85	-0.05	51.01	0.01	57.94	0.04
90	23.66	-0.14	30.75	-0.10	37.95	-0.05	44.84	-0.06	50.94	-0.06	57.92	0.02
91	23.72	-0.08	30.79	-0.06	37.94	-0.06	44.82	-0.08	50.93	-0.07	57.80	-0.10
92	23.70	-0.10	30.77	-0.08	37.96	-0.04	44.87	-0.03	51.13	0.13	57.86	-0.04
93	23.67	-0.13	30.72	-0.13	37.89	-0.11	44.76	-0.14	50.97	-0.03	57.78	-0.12
94	23.74	-0.06	30.77	-0.08	37.93	-0.07	44.78	-0.12	50.94	-0.06	57.73	-0.17
95	23.71	-0.09	30.75	-0.10	37.90	-0.10	44.80	-0.10	50.99	-0.01	57.73	-0.17
96	23.69	-0.11	30.74	-0.11	37.89	-0.11	44.77	-0.13	50.99	-0.01	57.71	-0.19
97	23.75	-0.05	30.79	-0.06	37.95	-0.05	44.85	-0.05	50.96	-0.04	57.94	0.04
98	23.71	-0.09	30.72	-0.13	37.88	-0.12	44.75	-0.15	51.03	0.03	57.77	-0.13
99	23.74	-0.06	30.74	-0.11	37.84	-0.16	44.77	-0.13	50.98	-0.02	57.76	-0.14
100	23.69	-0.11	30.75	-0.10	37.86	-0.14	44.72	-0.18	50.99	-0.01	57.68	-0.22
101	23.71	-0.09	30.82	-0.03	37.98	-0.02	44.87	-0.03	50.95	-0.05	57.86	-0.04
102	23.70	-0.10	30.82	-0.03	37.89	-0.11	44.77	-0.13	50.93	-0.07	57.87	-0.03
103	23.68	-0.12	30.80	-0.05	37.89	-0.11	44.84	-0.06	50.92	-0.08	57.87	-0.03
104	23.66	-0.14	30.77	-0.08	37.94	-0.06	44.86	-0.04	51.13	0.13	57.88	-0.02
105	23.62	-0.18	30.74	-0.11	37.91	-0.09	44.83	-0.07	50.98	-0.02	57.93	0.03
106	23.67	-0.13	30.76	-0.09	37.87	-0.13	44.75	-0.15	50.92	-0.08	57.76	-0.14
107	23.60	-0.20	30.71	-0.14	37.90	-0.10	44.81	-0.09	51.05	0.05	57.90	0.00
108	23.69	-0.11	30.76	-0.09	37.96	-0.04	44.82	-0.08	51.00	0.00	57.88	-0.02
109	23.62	-0.18	30.70	-0.15	37.90	-0.10	44.81	-0.09	51.10	0.10	57.94	0.04
110	23.69	-0.11	30.76	-0.09	37.91	-0.09	44.88	-0.02	51.00	0.00	57.93	0.03
111	23.74	-0.06	30.80	-0.05	37.94	-0.06	44.81	-0.09	50.97	-0.03	57.82	-0.08
112	23.66	-0.14	30.74	-0.11	37.89	-0.11	44.85	-0.05	50.94	-0.06	57.90	0.00
113	23.73	-0.07	30.78	-0.07	37.95	-0.05	44.85	-0.05	50.99	-0.01	57.99	0.09
114	23.74	-0.06	30.80	-0.05	37.95	-0.05	44.86	-0.04	50.93	-0.07	57.88	-0.02
115	23.74	-0.06	30.75	-0.10	37.88	-0.12	44.75	-0.15	50.89	-0.11	57.71	-0.19
116	23.73	-0.07	30.76	-0.09	37.90	-0.10	44.80	-0.10	50.98	-0.02	57.83	-0.07
117	23.74	-0.06	30.78	-0.07	37.93	-0.07	44.82	-0.08	50.84	-0.16	57.83	-0.07
118	23.72	-0.08	30.78	-0.07	37.93	-0.07	44.82	-0.08	50.90	-0.10	57.89	-0.01
119	23.71	-0.09	30.77	-0.08	37.90	-0.10	44.76	-0.14	50.96	-0.04	57.75	-0.15
120	23.78	-0.02	30.81	-0.04	37.93	-0.07	44.76	-0.14	50.87	-0.13	57.69	-0.21
T1	23.86	0.06	30.94	0.09	38.1	0.10	44.98	0.08	51	0.00	58.02	0.12
T2	23.9	0.10	30.96	0.11	38.16	0.16	45.06	0.16	51.1	0.10	58	0.10
T3	23.9	0.10	30.94	0.09	38.14	0.14	45.04	0.14	51.04	0.04	58	0.10
T4	23.9	0.10	30.94	0.09	38.16	0.16	45.04	0.14	51.08	0.08	58	0.10
T5	23.9	0.10	30.92	0.07	38.08	0.08	44.92	0.02	51.02	0.02	57.82	-0.08

8/1/02 JP

The power output of the cartridge heater used in the coldtrap experiments was determined at different transformer settings. This was done by the measuring the voltage and current of the heater at different transformer settings & then calculating the wattage output. The measurements were taken by Don Bannon.

The results and equipment used are shown on the following page.

Heater element: 100W OMEGALUX, 3/8 inch sheath

Equipment used:
Wavetek 27XT
S/N 971004157
Calibrated: 17 JUL 02

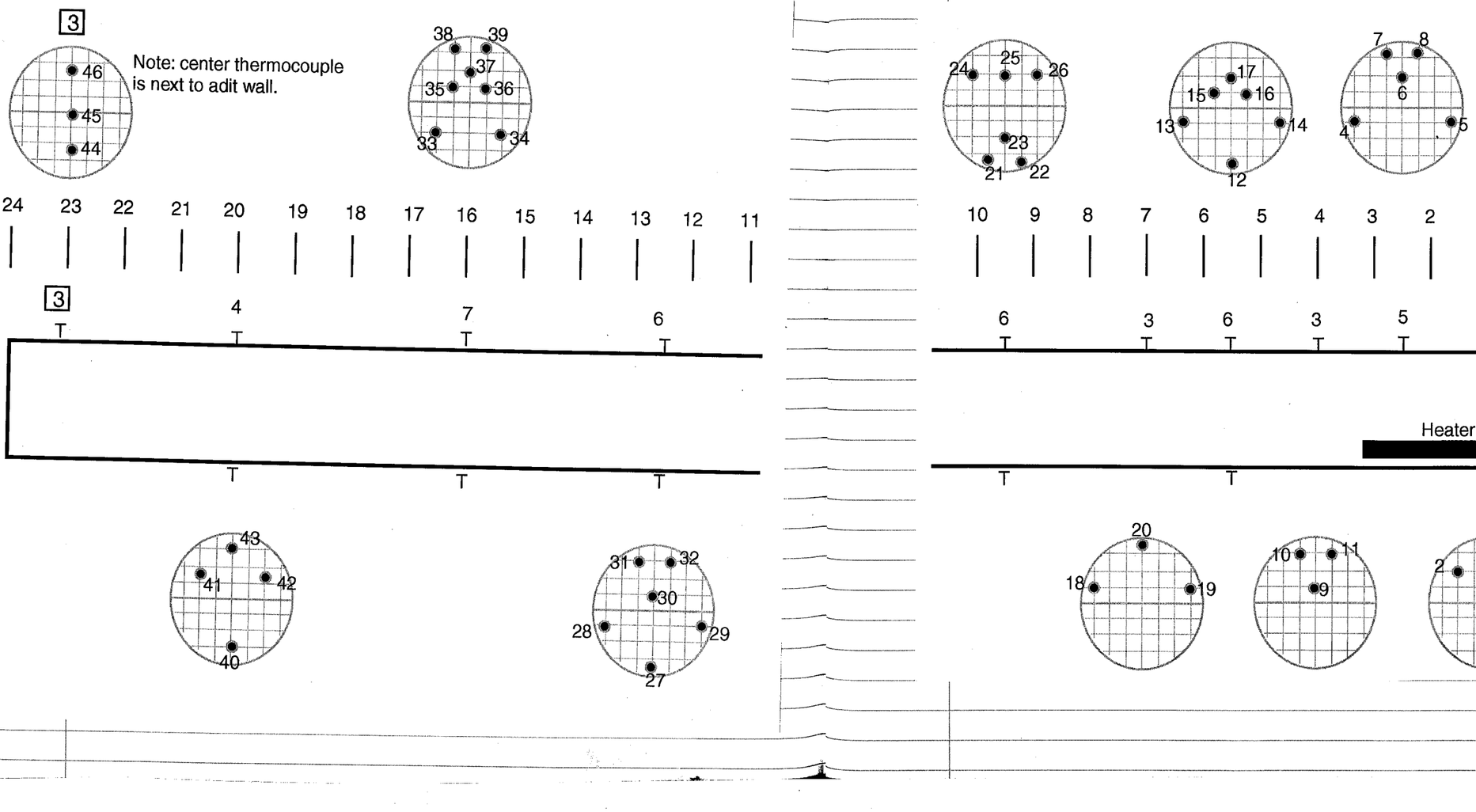
Fluke 87
S/N 61880517
Calibrated: 11 MAR 02

Staco Energy Products Co.
Type 3PN1010
Variable Autotransformer

% of Max. Output	A.C. (Volts)	Current (Amps)	Calculated Power (Watts)
0	0.51	0.003	0.0017
1	1.44	0.010	0.0138
2	2.53	0.017	0.0435
3	3.53	0.025	0.0893
4	4.56	0.032	0.1477
5	5.56	0.040	0.2207
6	6.57	0.047	0.3081
7	8.02	0.057	0.4595
8	9.11	0.065	0.5922
9	10.13	0.072	0.7324
10	11.15	0.080	0.8875
12	13.70	0.098	1.3385
14	15.63	0.111	1.7412
16	17.74	0.127	2.2441
18	20.10	0.145	2.9065
20	22.10	0.159	3.5161
22	24.60	0.177	4.3468
24	26.60	0.191	5.0806
26	28.50	0.209	5.9565
28	31.00	0.224	6.9440
30	33.60	0.242	8.1312
32	35.70	0.256	9.1392
34	37.70	0.271	10.2167
36	40.30	0.289	11.6467
38	42.40	0.304	12.8896
40	45.00	0.322	14.4900
42	47.50	0.339	16.1025
44	48.90	0.348	17.0172
46	51.40	0.367	18.8638
48	53.40	0.379	20.2386
50	55.90	0.398	22.2482
52	58.50	0.424	24.8040
54	60.60	0.438	26.5428
56	62.60	0.451	28.2326
58	65.40	0.471	30.8034
60	67.80	0.486	32.9508
65	73.20	0.525	38.4300
70	79.30	0.569	45.1217
75	85.30	0.611	52.1183
80	91.50	0.654	59.8410
85 ~~75~~ 8/4/02 JP	97.10	0.694	67.3874
90	103.30	0.738	76.2354
95	109.50	0.787	86.1765
100	115.30	0.839	96.7367
FULL Clockwise	116.80	0.853	99.6304

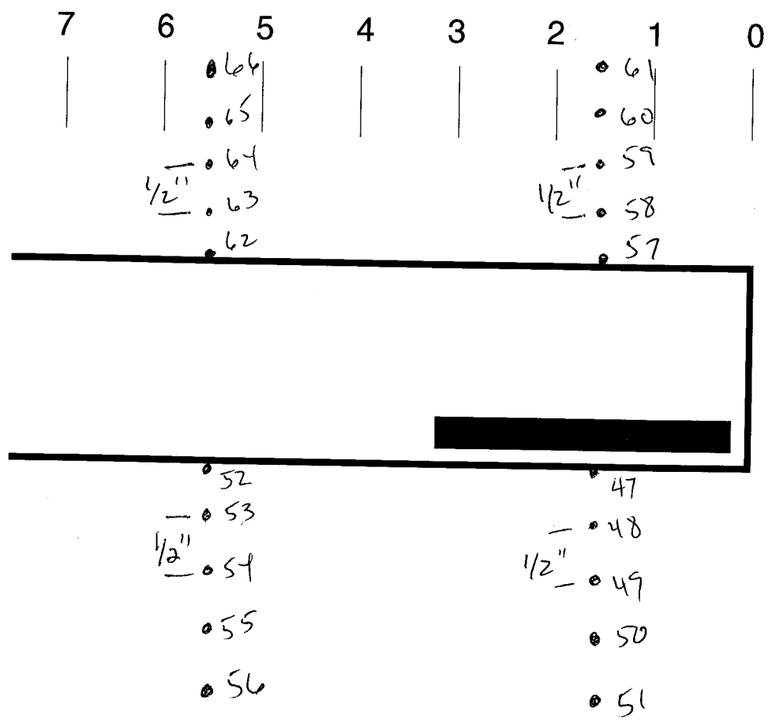
8/5/02 JP

The coldtrap was reassembled. 46 thermocouples were placed in the adit and 20 thermocouples were placed in the sand media outside the adit. The schematic diagram below shows the location of each thermocouple within the adit.



8/5/02 JP

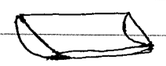
The design below shows the locations of the 20 thermocouples in the sump.



8/5/02 JP

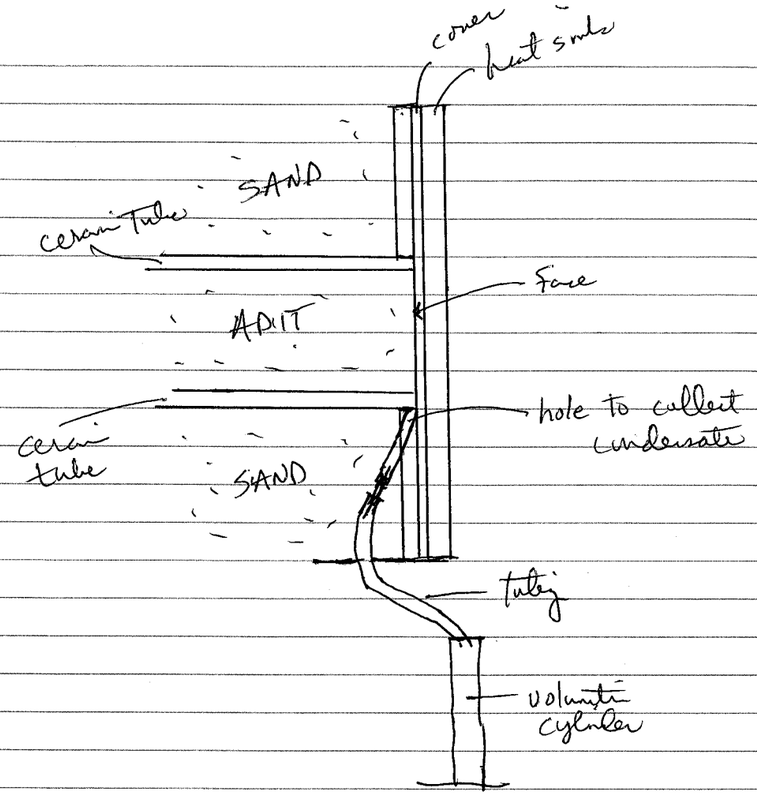
After thermocouples were placed, water collection systems to collect condensate were constructed in the adit. Two systems were installed.

(1) The first system consisted of a simple plastic container on through. A 60 ml PP bottle was cut in half to form the collection through. A drawing is shown below



Condensate forming inside the container will be collected and its volume measured at the end of the test.

(2) For the second system condensate will be collected that forms and runs off the cold face of the end of the adit. A well (2.0 cm in diameter was drilled in the plaster below the face of the adit. Plastic tubing was run from the drilled hole out of the bottom of the coldtrap and into a volumetric cylinder. The plastic tubing contain a wick (cotton string) to draw water out of the well. A schematic of this system is shown on the following page.



After water collection systems installed sand was added & the DI water to saturate the sand. The box was sealed & insulated.

8/5/02. 5
Five thermocouples (type T) were placed at the location outside the box described below.

T1 - over adit opening on cold end
T2 - top center of box
T3 - top center of box under insulation
T4 - over adit opening at hot end
T5 - inside heat sink at location near center of adit opening.

These thermocouples were attached to a Fluke Hydraulotalogger. Temperatures will be scanned every 20 minutes

Heat sinks was set to 20°C.

Test 12

8/5/02 Test 12 was initiated at 1325 hrs
gp

8/5/02
1507 hrs Variable transformer set to 20.

8/7/02 gp
0850 hrs Test data saved to c:\testi2a & testi2a.

8/7/02 gp
0852hr Test 12 was terminated.

Test 12 was stopped because it appeared that the collection system set up to collect condensate off the cold face of the adsit was not draining properly.

8/7/02 gp
1000hr The coldtrap was partly disassembled to provide access to the condensate collection system. The collection system was taken apart and then reassembled. Silica cement was used to create a well for water to collect and drain out of the coldtrap.

8/7/02 gp
1400hr The coldtrap was reassembled

8/12/02 gp Type T thermocouples T1 thru T5 were
1000hr. remounted as on p 151.

Heat sink was set to 20°C.

8/12/02 gp

11:30hr
Test 13 was started at 1130hrs.

8/12/02 gp
1312hrs. Variable transformer was set to 20.

8/13/02 gp
0745hr Test data saved to ct test 13a + test 13a.

8/14/02 gp
0850hr Test data saved to ct test 13b + test 13b.

8/14/02 gp
0850hr Test 13 was terminated.
Condensation again was not draining from the collection system.

8/14/02 gp
1330hr The tubing for the drain system was replaced.

8/15/02 gp
1300hr The coldtrap was reassembled

8/15/02 gp
1410 hr.
Test 14 was started at 1410 hrs

Heat sink set to 20°C

Variable transformer set to 20 at 1412 hrs.

8/16/02 gp
0805h Test data saved to c:\test14a + tst14a.

8/19/02 gp
0800h Test data saved to c:\test14b + tst14b

8/21/02 gp
0807hr Test data saved to c:\test14c + tst14c.

8/23/02 gp
0810hr Test data saved to c:\test14d + tst14d

8/26/02 gp
0725hr Test data saved to c:\test14e + tst14e

8/28/02 gp
0815hr Test data saved to c:\test14f + tst14f.

8/28/02 gp
0925hr Variable transformer set to 12.

8/29/02 gp
1350 hr Test data saved to c:\test14g + tst14g

9/5/02 gp
0945hr Test data saved to c:\test14h + tst14h

9/9/02 gp
0825h Test data saved to c:\test14i + tst14i

The table below records the mass of water collected in the volumetric cylinder attached to the water collection system. This system collects water forming and dripping from the cold face of the drift. (see page 158). The mass was determined by weighing the volumetric cylinder before water collection and then weighing after water was collected. A Mettler PM480 balance was used to weight the cylinder. The difference of the cylinder wts. is the amount of water collected.

Start collection time + date	End collection time + date	Cylinder wt before collection	Cylinder wt after collection	Wt of water collected
		gp 8/15/02	gp 8/15/02	
8/15/02 1410	8/16/02 0800	26.976 ~~27.707~~ g	27.707 ~~26.976~~ g	0.731 g
8/16/02 0800	8/19/02 0800	26.728 g	29.480 g	2.752 g
8/19/02 0800	8/21/02 0812	26.978 g	28.830 g	1.852 g
8/21/02 0812	8/23/02 0812	26.728 g	28.527 g	1.799 g
8/23/02 0812	8/26/02 0730	26.973 g	29.720 g	2.747 g
8/26/02 0730	8/28/02 0820	26.728 g	28.578 g	1.850 g
8/28/02 0820	8/29/02 1355	26.979 g	27.912 g	0.933 g
8/29/02 1355	9/5/02 0950	26.728 g	30.402 g	3.674 g
9/5/02 0950	9/9/02 0830	26.976 g	29.024 g	2.048 g
9/9/02 0830	9/10/02 1307	26.728 g	27.474 g	0.746 g
9/10/02 1307	9/12/02 0907	26.976 g	27.860 g	0.884 g
9/12/02 0907	9/16/02 0744	26.729 g	28.544 g	1.815 g
9/16/02 0744	9/18/02 0910	26.976 g	28.018 g	1.042 g

gp 9/9/02 0830h

9/9/02 JP 1257hr
Variable transformer set to 8

9/10/02 JP 0910hr
Variable transformer set to 7

9/11/02 JP 0910hr
Test data saved to cttest14j + tst14j.

9/11/02 JP 1305hr
Variable transformer set to 6.

9/13/02 JP 0925hr
Test data saved to cttest14k + tst14k.

9/14/02 JP 0740hr
Test data saved to cttest141 + tst141.

9/18/02 JP 0907hr
Test data saved to cttest14m + tst14m.

9/19/02 JP 0930hr
Variable transformer set to 3.

9/19/02 JP 1310hr
Variable transformer set to 2

9/20/02 JP 0912hr
Test data saved to cttest14n + tst14n.

9/23/02 JP 0730hr
Test data saved to cttest140 + tst140.

9/25/02 JP 0915hr
Test data saved to cttst14p + tst14p.

9/27/02 JP 0925hr.
Test data saved to cttest14q + tst14q

(cont'd from 155)

Start collection time + date	End collection time + date	Cylinder wt before	Cylinder wt after	Wt of water collected
9/18/02 0910	9/19/02 0930	26.728g	27.197g	0.469g
9/19/02 0930	9/20/02 0915	26.975g	27.463g	0.488g
9/20/02 0915	9/23/02 0730	26.728g	27.908g	1.180g
9/23/02 0730	9/25/02 0920	26.976g	27.816g	0.840g
9/25/02 0920	9/27/02 0930	26.728g	27.584g	0.851g
9/27/02 0930	9/30/02 0725	26.976g	28.164g	1.188g
9/30/02 0725	10/1/02 0915	26.728g	27.239g	0.511g

9/30/02 JP 0725hr
Test data saved to cttest14r + tst14r.

10/1/02 JP 0910hr
Test data saved to cttest14s + tst14s.

10/1/02 JP 0910hr
CTTest14 Terminated at 0910hr.

10/10/02

Data files for coldtrap tests 1 thru 14 were copied to a CD ROM disk. The disk is labeled 021010_0951 and includes 14 folders: CT test 1 thru CT test 14. Under each folder are data files containing temperature and relative humidity data taken in each of the coldtrap tests. The data file in each folder are listed below. The CD ROM disk has been placed in a folder & attached to the last page of this notebook.

CT test 1

- comreads
- comused
- CTTEST1
- cttest1
- cttest1
- CTTEST1A
- cttest1a
- CTTEST1B
- cttest1b
- CTTEST1C
- cttest1c
- cttest1d
- CTTEST1E
- CTTEST1F
- CTTEST1G
- cttest1g
- CTTEST1H
- cttest1h
- CTTEST1I
- cttest1i
- CTTEST1J
- cttest1j
- CTTEST1K
- cttest1k
- CTTEST1L
- cttest1l
- CTTEST1M
- cttest1m
- CTTEST1N
- cttest1n
- valcold
- vaicoldf
- viacolde
- viacoldg
- viacoldh
- viacoldi
- viacoldj
- viacoldk
- viacoldl
- viacoldm
- viacoldn

CT test 2

- cttest2
- cttest2
- CTTEST2A
- cttest2a
- CTTEST2B
- CTTEST2C
- cttest2c
- CTTEST2D
- cttest2d
- CTTEST2E
- cttest2e
- CTTEST2F
- cttest2f
- CTTEST2G
- cttest2g
- CTTEST2H
- cttest2h
- CTTEST2I
- cttest2i
- CTTEST2J
- cttest2j
- CTTEST2K
- cttest2k
- CTTEST2L
- cttest2l
- CTTEST2M
- cttest2m
- CTTEST2N
- cttest2n
- CTTEST2O
- cttest2o
- CTTEST2P
- cttest2p
- CTTEST2Q
- cttest2q
- CTTEST2R
- cttest2r
- CTTEST2S
- cttest2s
- CTTEST2T
- cttest2t
- viacold2b
- viacold2c
- viacold2d
- viacold2e
- viacold2f
- viacold2g
- viacold2h
- viacold2i
- viacold2j
- viacold2k
- viacold2l
- viacold2m
- viacold2n
- viacold2o
- viacold2p
- viacold2q
- viacold2r
- viacold2s
- viacold2t
- viahot2a
- viahot2b
- viahot2c
- viahot2d
- viahot2e
- viahot2f
- viahot2g
- viahot2h
- viahot2i
- viahot2j
- viahot2k
- viahot2l
- viahot2m
- viahot2n
- viahot2o
- viahot2p
- viahot2q
- viahot2r
- viahot2s
- viahot2t

CT test 3

- cttest3
- cttest3
- CTTEST3A
- cttest3a
- CTTEST3B
- cttest3b
- CTTEST3C
- cttest3c
- viacold3a
- viacold3b
- viacold3c
- viahot3a
- viahot3b
- viahot3c

CT test 4

- cttest4
- cttest4
- CTTEST4A
- cttest4a
- CTTEST4B
- cttest4b
- CTTEST4C
- cttest4c
- CTTEST4D
- cttest4d
- CTTEST4E
- cttest4e
- viacold4a
- viacold4b
- viacold4c
- viacold4d
- viacold4e
- viahot4a
- viahot4b
- viahot4c
- viahot4d
- viahot4e

CT test 5

- cttest5
- cttest5
- CTTEST5A
- cttest5a
- CTTEST5B
- cttest5b
- CTTEST5C
- cttest5c
- viacold5a
- viacold5b
- viacold5c
- viahot5a
- viahot5b
- viahot5c

CT test 6

- cttest6
- cttest6
- CTTEST6A
- cttest6a
- CTTEST6B
- cttest6b
- CTTEST6C
- cttest6c
- viacold6a
- viacold6b
- viacold6c
- viahot6a
- viahot6b
- viahot6c

CT test 7

- cttest7
- cttest7
- CTTEST7A
- cttest7a
- CTTEST7B
- cttest7b
- CTTEST7C
- cttest7c
- CTTEST7D
- cttest7d

CT test 8

- cttest8
- cttest8
- CTTEST8A
- cttest8a

CT test 9

- cttest9
- cttest9_plot
- cttest9a
- cttest9a_a
- cttest9b
- cttest9b_a
- cttest9c
- cttest9c_a
- cttest9d
- cttest9d_a
- cttest9e
- cttest9e_a
- cttest9f
- cttest9f_a
- cttest9g
- cttest9g_a
- cttest9h
- cttest9h_a
- cttest9i
- cttest9i_a
- cttest9j
- cttest9j_a
- cttest9k
- cttest9k_a
- cttest9l
- cttest9l_a
- cttest9m
- cttest9m_a

CT test 10

- cttest10
- cttest10_plot
- cttest10a
- cttest10a1
- cttest10b
- cttest10b1
- cttest10c
- cttest10c1
- cttest10d
- cttest10d1
- cttest10e
- cttest10e1
- cttest10f
- cttest10f1
- cttest10g
- cttest10ga
- cttest10h
- cttest10h1
- cttest10i
- cttest10i1
- cttest10j
- cttest10j1
- cttest10k
- cttest10k1
- cttest10l
- cttest10l1
- cttest10m
- cttest10m1
- cttest10n
- cttest10n1
- TEST10D
- TEST10E
- TEST10F
- TEST10G
- TEST10H
- TEST10I
- TEST10J
- TEST10K
- TEST10L
- TEST10M
- TEST10N

CT test 11

- cttest11
- cttest11a
- cttest11a_1
- cttest11b
- cttest11b_1
- cttest11c
- cttest11c_1
- cttest11d
- cttest11d_1
- cttest11e
- cttest11e_1
- cttest11f
- cttest11f_1
- cttest11g
- cttest11g_1
- cttest11h
- cttest11h_1
- cttest11i
- cttest11i_1
- cttest11j
- cttest11j_1
- cttest11k
- cttest11k_1
- cttest11l
- cttest11l_1
- cttest11m
- cttest11m_1
- cttest11n
- cttest11n_1
- cttest11o
- cttest11o_1
- cttest11p
- cttest11p_1
- cttest11q
- cttest11q_1
- cttest11r
- cttest11r_1
- cttest11s
- cttest11s_1
- cttest11t
- cttest11t_1
- cttest11u
- cttest11u_1
- cttest11v
- cttest11v_1
- cttest11w
- cttest11w_1
- cttest11x
- cttest11x_1
- cttest11y
- cttest11y_1
- TEST11A
- TEST11B
- TEST11C
- TEST11D
- TEST11E
- TEST11F
- TEST11G
- TEST11H
- TEST11I
- TEST11J
- TEST11K
- TEST11L
- TEST11M
- TEST11N
- TEST11O
- TEST11P
- TEST11Q
- TEST11R
- TEST11S
- TEST11T
- TEST11U
- TEST11V
- TEST11W
- TEST11X
- TEST11Y

CT test 12

- cttest12a
- cttest12a_1
- TEST12A

CT test 13

- cttest13
- cttest13a
- cttest13a_1
- cttest13b
- cttest13b_1
- TEST13A
- TEST13B

CT test 14

- cttest14
- cttest14_water_collection
- cttest14a
- cttest14a_1
- cttest14b
- cttest14b_1
- cttest14c
- cttest14c_1
- cttest14d
- cttest14d_1
- cttest14e
- cttest14e_1
- cttest14f
- cttest14f_1
- cttest14g
- cttest14g_1
- cttest14h
- cttest14h_1
- cttest14i
- cttest14i_1
- cttest14j
- cttest14j_1
- cttest14k
- cttest14k_1
- cttest14l
- cttest14l_1
- cttest14m
- cttest14m_1
- cttest14n
- cttest14n_1
- cttest14o
- cttest14o_1
- cttest14p
- cttest14p_1
- cttest14q
- cttest14q_1
- cttest14r
- cttest14r_1
- cttest14s
- cttest14s_1
- TEST14A
- TEST14B
- TEST14C
- TEST14D
- TEST14E
- TEST14F
- TEST14G
- TEST14H
- TEST14I
- TEST14J
- TEST14K
- TEST14L
- TEST14M
- TEST14N
- TEST14O
- TEST14P
- TEST14Q
- TEST14R
- TEST14S

10/10/02 JP

Entries for the coldtrap experiment continue in scientific notebook # 554.

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.

R. C. Perry
3/13/2003

ADDITIONAL INFORMATION FOR SCIENTIFIC NOTEBOOK #: 337

Document Date:	05/18/1999
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Remarks: (computer runs, etc.)	Media contains cold trap test data for tests 1 through 14