308 - - - Q200002080003
Scientific Notebook # 223 (Thermal Effects on Flow KTI)

308 - - - Q200002080003
Scientific Notebook # 223 (Thermal Effects on Flow KTI)

Ventilation Lab Test

21
150

R

Sonny Leppala C.N.W.R.A. 522-5077

Gary Neely · Div 03 522-3546

* 20-5708-661

The Boorum & Pease® Quality Guarantee

The materials and craftsmanship that went into this product are of the finest quality. The pages are thread sewn, meaning they're bound to stay bound. The inks are moisture resistant and will not smear. And the uniform quality of the paper assures consistent rulings, excellent writing surface and erasability. If, at any time during normal use, this product does not perform to your expectations, we will replace it free of charge. Simply write to us:

Boorum & Pease Company
71 Clinton Road, Garden City, NY 11530
Attn: Marketing Services

Any correspondence should include the code number printed at the bottom of this page as well as the book title stamped at the bottom of the spine.

CNWRA
CONTROLLED
COPY 223

One Good Book Deserves Many Others.

Look for the complete line of Boorum & Pease® Columnar, Journal, and Record books. Custom-designed books also available by special order. For more information about our Customized Book Program, contact your office products dealer. See back cover for other books in this series.

Made in U.S.A.

5/19/97 Thermal Effects KTI
Initial entry by Sonny Leppala S.L

Title: Vaporization and removal of groundwater due to heating and Venting.

Individuals involved: Ron Green (Project Manager)
Randy Manteufel (University Mentor / Consultant)
Sonny Leppala (Graduate Student Engineer)
Gary Neely (Assisstant)

Experiment Objectives: To quantify moisture removal due to ventilation. Preliminary experiments are being conducted to determine whether alumina would be a sufficient media that can be used in this experiment. These experiments will determine whether the drift wall (Fine and rigid coarse screen mesh) will withstand the weight of the semi-saturated alumina. This has shown to be successful. The next preliminary task is to place a rope heater inside the drift and heat up the media until the region approximately 3cm away from the wall is dried out. This is necessary to determine whether the media will dry and then fall through the drift, thus causing unwanted results. If the screen mesh is not successful in keeping out the alumina, then the drift will be fabricated ~~using~~ as a porous ceramic tube. (S.L. 5/19/97)

Once the drift material and the system media is observed to meet their intended purpose, then the size of the system, drift, and drift spacing must be decided. This will be done by dimensionless scaling analysis using Fourier's number. The size of the system also depends on the manner in which the moisture will be measured. This involves the use of an I-beam used as a cantelever along with a scale to measure small quantities of mass. The preliminary evaluation will include loading approximately 1700 lbs on both sides of the beam while attempting to balance the beam. The end of one side of the beam will rest on a scale, thus providing an initial load to the scale. Then 1kg of mass will be removed from the opposite end. The purpose is to show that small quantities of mass can be removed relative to larger quantites of mass

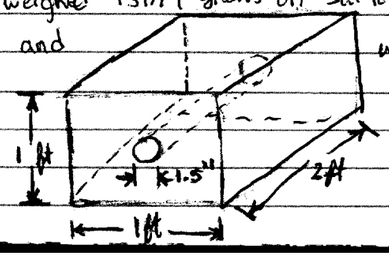
and can be kept accountable for laboratory measurements. This will show that if mositure were to be removed from a system by ventilation, it would be observed in the lab without difficulty.

Equipment : Box filled with saturated alumina
drift wall made of screen mesh or ceramic porous tubes.
Fluke multimeter
thermocouples
variac
humicaps
power supply
rope heater
pneumatic air pump
metal C-shape tubes
tensiometer
pressure gage
I-beam
Scale
insulation

5/19/97 Jay Seppala

Measurements :		Accuracy
	Suction pressure near heater	
	Temperature "	± 2°C
	Relative Humidity @ inlet + outlet	±2% R.H.
	mass differential	± 1 gram

The Following is a schematic of the preliminary setup to evaluate the alumina and the screen mesh as the possible media and drift wall respectively. Media sample of 40 mL weighed 131.74 grams on Sartorius scale. (SN 3903006) Sample was dried and weighed. New weight is 119.63 grams
Δmass = 12.11 grams.



5/20/97 Jay Seppala

Approx. 1700 lbs are tetering on both sides of the I-beam. objective is to remove 1Kg of mass from one side of the beam. On the opposite side of the beam a scale is used to take on an initial load of 1173.6 g. 1 Kg is removed from the side opposite the scale and the new reading is 2032.0 g. (Scale used Sartorius SN 3903006)

2032.0 g
− 1173.6 g
858.4 g ← Ammount of mass monitored

The 1Kg sample was placed back on the opposite side of the scale. The scale now reads 1028.8.

2032.0
− 1028.8
1003.2 g ← Ammount of mass monitored

Note: As the mass is placed closer to the end of the beam the true mass is more accurately monitored.

Take the 1Kg sample off the beam again. The scale reads 2033.8

2033.8
− 1028.8
1005.0 g ← Ammount of mass monitored ✓✓

Next Reading 2035.0 2035.0
− 1062.2
1062.2 972.8 ←

0.5 Kg will be used as the quantity of mass placed on the scale.

Initially scale reads 2037.4 g.
New Reading 1546.3 g
491.1 g ← ammount monitored

Now the mass is taken off the scale. New Reading 2037.8
Initial − 1546.3
491.5

Next mass to be placed on scale is 35.09 g

Initial 2037.8
Final 2005.2
32.6 g

Take off 35.09 Initial 2005.2 g
Final 2039.9 g
34.7 g

5/21/97 Applied heat to preliminary experiment to observe the effects of heat on the media, drift, box, mass loss. Placed the box on the I-beam and applied counter weights on the opposite end of the beam to balace the box. There was an initial load on the scale of 2384.8 g. (Scale Sartorius S.N. 3903006) Objective is to quantify mass loss from the box due to heating. Started at 10:45. It appears that 1 gram a minute is being lost by the system. The scale appears to be ~~[illegible]~~ reaching equilibrium after 10 gram loss.

(S.L. 5/21/97)

Temperature at drift is 100.5°C. (used Type T miniture thermocouple SN 2331447)

@ 11:30 Scale reads 2396.4 g (11.6 g lost)
T = 101.6°C

@ 12:50 Scale reads 2419.9 g (35.1 g lost)
(S.L. 5/21/97) T = ~~91.6°C~~ = 113.3 °C

@ 2:40 Scale reads 2462.2 g (71.4 g lost)
T = 115.2°C (@ center of drift)

@ 3:40 Scale reads 2493.9 g (109.1 g lost)
T = 115.5°C

@ 4:55 Scale reads 2538.1 g (153.3 g lost)
T = 117.4°C

@ 5:20 Scale reads 2553.0 g (168.4 g lost)
T = 118.2°C

@ 5:45 Scale reads 2572.0 g (187.2 g lost)
T = 118.7°C

@ 6:45 Scale reads 2613.5 g (228.7 g lost)
T = 120.2°C

5/22/97 On 5/19/97 measurements were taken of the sample of alumina. The sample was heated and 12.11 grams of water was removed. Density ($\rho = \frac{m}{V}$) of the dried sample is:

$$\rho_{al} = \frac{119.6\ g}{40 cm^3} \qquad 40 ml = 40 cm^3$$

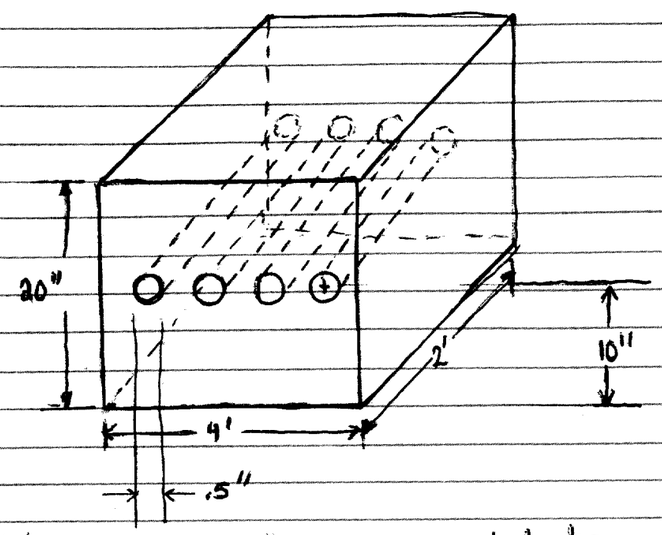
$$\rho_{al} = 2.991\ g/cm^3$$ ← measured value

Information taken from Whittaker, Clark + Daniels Inc. Order # 252022 shows S.G. = 3.2 − 3.9.

$$\rho_{water} = 1000\ kg/m^3 \left(\frac{1000 g}{1 kg}\right)\left(\frac{1 m^3}{100^3 cm^3}\right)$$
$$\rho_{water} = 1\ g/cm^3$$

$$\rho_{al} = 3.2 - 3.9\ g/cm^3$$ ← given value

A New Box is being built to evaluate mass loss, temperatures, suction pressure, relative humidity, and stability of drifts with smaller diameters. The following is a schematic of the new box.



Scaled Analysis:	Repository	Laboratory
Drift Spacing	25m	10.4 cm
Drift Dia.	4.0m	2.1cm
Drift length	30m	1.2 m
W.P. dia	1.8m	.5 cm
W.P. length	5.6m	
Q(heat)	8000W	
time	100yrs	8hrs

5/27/97 Discussion with Randy Manteufel

for Peppels

Propagation length $L = \sqrt{(\alpha)(t)}$

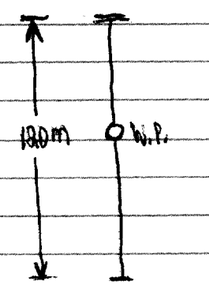
$L = \sqrt{(1\times10^{-6})\,m^2/s\,(3.153\times10^{9}\,s)}$

$\boxed{L = 56.2\,m}$

$\alpha = \frac{K}{\rho C} = \frac{2.10}{(2580)(840)}$

$\left(\frac{W}{m\,K}\right)\left(\frac{K\,s}{J}\right)\left(\frac{m^3}{kg}\right) = \frac{m^2}{s}$

$\alpha = 1\times10^{-6}\,m^2/s$



$L_{lab} = \sqrt{(1.2\times10^{-6})(28800)}$

$= .1859\,m = 18.59\,cm$ (7.436 in)

$(48\,in)\left(\frac{2.5\,cm}{1\,in}\right) = 120\,cm = 1.2\,m$

$(20\,in)\left(\frac{2.5\,cm}{1\,in}\right) = 50\,cm \cong .5\,m$ S.F. = Scale factor

$120 \times S.F. = .5\,m$

S.F. is 1 to 240
lab to repository

Drift Diameter $= 5m\left(\frac{1}{240}\,m\right) = 2.1\,cm$

Drift Spacing $= 25m\left(\frac{1}{240}\,m\right) = 10.4\,cm$

~~$Q_{lab} = Q_{repos}(S.F.)$~~
~~$= (8000\,W)(240) = 33.3\,W$~~

for Peppels 5/27/97

$\frac{P_{repos}}{\text{Drift length}} = \frac{8000\,W}{30\,m} = 400\,W/m$

(Rope heater) $\frac{P_{lab}}{\text{Drift length}} = \frac{500\,W}{3\,m} = 167\,W/m$

5/28/97 for Peppels

Consider a 2 ft wide box $(24\,in)\left(\frac{2.5\,cm}{1\,in}\right) = 60\,cm$

Consider 6 drifts:

$6\times2.1\,cm = 12.6\,cm$

(5 Drift Spacing) $5\times10.4\,cm = 52\,cm$

(Length to Boundary) $2\times60\,cm = 120\,cm$

$(184.6\,cm)\left(\frac{1\,in}{2.5\,cm}\right) = 73.8\,in$ (6.15 ft)

Consider 4 drifts: $4\times2.1\,cm = 8.4\,cm$

(3 Drift Spacing) $3\times10.4\,cm = 31.2\,cm$

(Length to Boundary) $2\times60\,cm = 120\,cm$

$(159.6\,cm)\left(\frac{1\,in}{2.5\,cm}\right) = 63.84\,in$ (5.32 ft)

Consider 3 drifts: $3\times2.1 = 6.3\,cm$

(2 DS) $2\times10.4\,cm$ 20.8 cm

(LOB) $2\times60\,cm = 120\,cm$ (4.9 ft)

5/28/97 JP Jim Pickryl

Thermocouple Calibration

Obj: calibrate thermocouples to be used in vaporizer + removal of granulate due to heavy + very expensive.

Method: calibrate thermocouples against calibrated thermometer.

Equipment + Supplies
- Calibrated thermometer (S/N C 96-784)
- Corning hot plate
- Fluke Datalogger
- Beakers
- Ice
- Omega type T thermocouple probes

Procedure:

① 20 Type T thermocouple probes were labeled T1 thru T20.

② Approximately 750 ml of demineralized water was placed in a 2L glass beaker and heated using a hot plate.

③ The calibrated thermometer was placed in the heated water along with the thermocouples to be calibrated.

④ The temperature reading of the thermocouples read from the Fluke Datalogger were compared to that of the calibrated thermometer. Readings are listed below.

Thermometer Temp °C	Thermocouple	Temp °C
92	T1	91.5
90.5	T2	91.1
91.0	T3	90.8
91.0	T4	90.8
90.9	T5	91.0
90.5	T6	91.1
91.0	T7	91.3
90.9	T8	91.0
90.5	T9	91.1
91.0	T10	91.5
91.0	T11	90.8
91.0	T12	90.2
91.0	T13	91.1
91.0	T14	90.7

(Cont.)

Thermometer Temp °C	Thermocouple	Temp °C
91.0	T15	91.4
91.0	T16	90.9
91.0	T17	91.1
91.0	T18	90.9
91.0	T19	91.2
91.0	T20	91.2
Cold Bath		
0.0	T1	0.7
0.0	T2	0.6
0.0	T3	0.5
0.0	T4	0.4
0.0	T5	0.6
0.0	T6	0.4
0.0	T7	0.2
0.0	T8	0.3
0.0	T9	0.3
0.0	T10	0.5
0.0	T11	0.3
0.0	T12	0.3
0.0	T13	0.5
0.0	T14	0.3
0.0	T15	0.3
0.0	T16	0.3
0.0	T17	0.3
0.0	T18	0.4
0.0	T19	0.3
0.0	T20	0.4

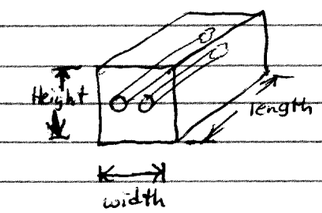
5/29/97 [illegible]

5/29/97 [illegible]

6/2/97 [illegible]

Based on earlier calculations (P.6, P.7) the following is concluded:

Scale Factor 240 to 1
Drift Diameter 2.1 cm
Drift Spacing 10.4 cm
Box:
Height = .5 m
Length = .6 m
Width = 1.5 m



Spoke with Randy Mantenfel: He said that the spacing length from the ~~last~~ end drifts to the boundry is half the drift spacing. Also he said that the drift diameters should not be included in the calculation involving the width. Also, ~~add~~ have 5 to 6 drifts in the Box.

5 drifts
Drift Diameter 2.1 cm
Drift Spacing from center to center drift 10.4 cm

Box: Height = .5 m
Length = 1.2 m
Width = .6 m

$$(5\text{ drifts})(1.2\text{ m/drift}) = (6\text{ m})\left(\frac{1.7\text{ kg}}{\text{m}}\right) = 10.2\text{ Kg}$$

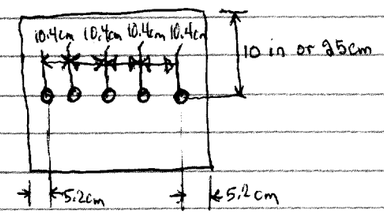
Media (Alumina) was wetted with dye and water and then heated to evaluate whether the water would wick to the top surface of the alumina in a beaker. This was done to show that the media had a low enough permeability. The results showed that wicking did occur in the alumina. This means that the mass transport of the water is not representative of the nature in which it occurs at the repository.

6/16/97 [signature]

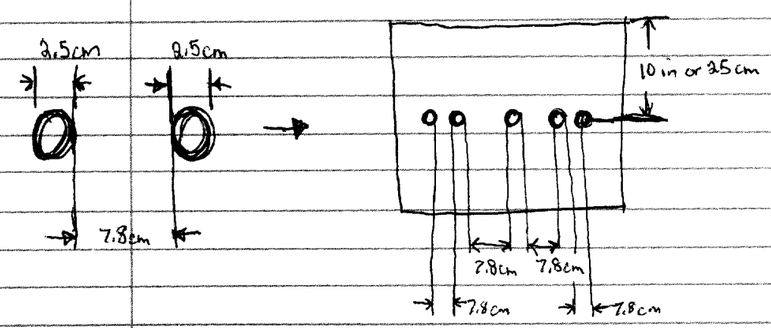
Completed Constructing the drifts. The drifts consist of spiral springs taken from a five subject notebook and fine mesh screen sewed around the springs.

Next Step is to locate the holes ~~that~~ where S.L. 6/16/97 the drifts will be located.

Front + Back Face of Box.



Above sketch has been changed.

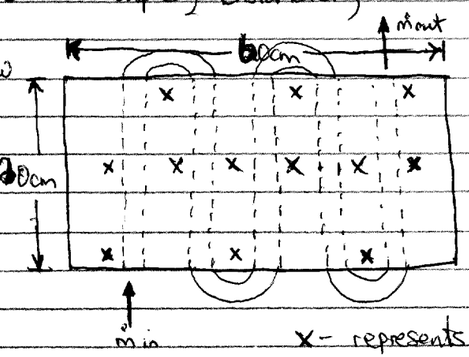


Front + Back Face of Box.

Locate thermocouple, tensiometer, humicap.

6/17/97

Top View



Note: Drawing is not scaled properly. The drifts will extend along the long end of the box.

x - represents thermocouple

All the thermocouples shown below are locate at the same height as the centerline of the drifts. (i.e. 25cm)
In addition, locate thermocouple at 2 locations above each centerline location.

Bentonite + Alumina Mixture (Measured using Mettler PM480 Delta Range SN 45601)

S.L. 6/17/97

①	1%	+ 99%	(118.8g alumina, 1.2 g Bentonite)
②	5%	+ 95%	(114g alumina, 6g Bentonite)
~~③~~	~~10%~~	~~+ 90%~~	
③	3%	+ 97%	(116.4g alumina, 3.6g Bentonite)

Sample Mixtures ①-③ were mixed and then saturated. The objective here was to heat the 3 samples and observe whether wicking occurs. This was achieved by viewing the heated media (S.L. 6/17/97) and locating the dye tracer.

The Results showed that 1% of Bentonite was not enough to prevent wicking. The 3% mixture of Bentonite showed a very small trace of wicking at the surface. The 5% mixture of Bentonite was successfull to prevent wicking.

Conclusion: Use No less then 5% Bentonite with 95% alumina as the media to be use for experimental purposes. this mixture most closely represents the repository site where wicking at the drift wall would not occur.

[signature] 6/19/97

Discussion with Randy Manteufel concerning air Flowrate at the repository. Flowrate is $12.5\ m^3/s$. Convert to cm^3/s or $\frac{mL}{s}$ and then L/s.

$$\left(12.5\ m^3/s\right)\left(\frac{100^3\ cm^3}{1\ m^3}\right) = 1.25\times10^8\ cm^3/s$$

$$= \left(1.25\times10^8\ mL/s\right)\left(\frac{1\ L}{1000\ mL}\right)$$

Volumetric Flow Rate: $\dot{Q} = 1.25\times10^5\ L/s$

Repository Drift Diameter 5m

Crosectional Drift Area $\pi R^2 = \frac{\pi D^2}{4} = \frac{\pi (5m)^2}{4} = 19.63\ m^2$

$\dot{Q} = 125\ m^3/s$

$V = \frac{\dot{Q}}{A} = \frac{125\ m^3/s}{19.63\ m^2} = 6.37\ m/s$

ν_{air} (350K) $20.3 \times 10^{-6}\ m^2/s$

$Re = \frac{VL}{\nu}$

ν - Kinematic Viscosity

V - Velocity

L - Drift ~~Length~~ Diameter

S.L. 6/19/97

$Re_{lab} = Re_{repos}$

$\left(\frac{VL}{\nu}\right)_{lab} = \left(\frac{VL}{\nu}\right)_{repos}$

assume: $\nu_{lab} = \nu_{repos}$

$(VL)_{lab} = (VL)_{repos}$

This is incorrect. → $V_{lab} = \frac{(VL)_{repos}}{L_{lab}} = \frac{(6.37\ m/s)(19m)}{6\ m}$

L_{lab} should be the diameter of the drift

$V_{lab} = \frac{(VL)_{repos}}{L_{lab}}$

$V_{lab} = \frac{(6.37\ m/s)(5\ m)}{.02\ m} = 1592.5\ m/s$

$\dot{Q}_{lab} = V_{lab} A_{lab} = (1592.5\ m/s)(\pi)\frac{(.02)^2}{4} = .5\ m^3/s$

convert $(.5\ m^3/s)\left(\frac{100^3 cm^3}{1 m^3}\right)\left(\frac{1L}{1000 mL}\right) = 500.3\ L/s$

↑ Value is too high

6/20/97

for Reports

Calculations of Flowrate

$\dot{Q} = 2.8\ m^3/s$

Repository

Assume this For Laboratory

min $(6\ SLPM)\left(\frac{1\ min}{60 s}\right)\left(\frac{1000 mL}{1 L}\right)$

$(100\ cm^3/s)\left(\frac{1 m^3}{100^3 cm}\right)$

$V = \frac{(1 \times 10^{-4}\ m^3/s)}{\frac{\pi (.02)^2}{4}} = .318$

S.L. 6/20/97

$Re = \frac{VL}{\nu} = \cancel{N.B.} = 314$ (too low)

$(2.8\ m^3/s)\left(\frac{60 s}{1 min}\right)\left(\frac{100^3 cm^3}{1 m^3}\right)\frac{1L}{(1000 mL)}$

shoot for this Volumetric Flow Rate: $\boxed{(40\ SLPM)}\left(\frac{1}{60}\right)\left(\frac{1000}{1}\right)$

1atm = 101.32 Pa = 14.7 psi → pressure conversions

$(90\ ft^3/hr)\left(\frac{1 hr}{60 min}\right)\left(\frac{12^3 in^3}{1 ft^3}\right)\left(\frac{2.5^3 cm^3}{1 in^3}\right)\left(\frac{1 L}{1000 mL}\right) = 40.5\ L/min$

Volumetric Flow Rate $(40.5\ L/min)\left(\frac{1 min}{60 s}\right)\left(\frac{1000 mL}{L}\right)\left(\frac{1 m^3}{100^3 cm^3}\right) = 6.75 \times 10^{-4}\ m^3/s$

Velocity $V = \frac{6.75 \times 10^{-4}\ m^3/s}{\frac{\pi (.02)^2}{4}} = 2.15\ m/s$ (5 mile/hr)

Reynolds # $Re = \frac{(2.15)(.02)}{20.3 \times 10^{-6}} = 2117$

6/25/97 [illegible]

How much Alumina ~~+~~ Bentonite will be need for the box? 5% Bentonite + 95% Alumina fills a volume of approximately 55 mℓ or 55 cm³. Box is 46.5 in x 22.5 in x 20 in or 116.35 cm x 56.25 cm x 50 cm

Box Volume = (326953.13 cm³) or .326953 m³

Alumina/Bentonite Density:

$V = 55 cm^3$

$m = 120 g$ (measured and recorded on p.13)

$$\rho = \frac{m}{V} = 2.1818 \ g/cm^3$$

mass of Mixture for box:

$$\dot{m} = \rho V_{BOX} = (2.1818 \ g/cm^3)(326953.13 \ cm^3)$$

$$= 713352.28 \ g$$

1 Kg = 2.2 lb

$$= 713.52 \ Kg \text{ or } 1569 \ lb$$

$\boxed{\text{78 lb Bentonite / 1490 lb Alumina}}$

7/15/97

7/6/97 [illegible]

We donot have enough Bentonite for the experiment. I Spoke with Ron and he suggest that I use another media to fill some ~~spa~~ S.L. 7/14/97 space in the box near the boundaries. He suggested Bricks or Bags of Sand.

7/7/97 [illegible]

I Spoke with Steve Snedeman and he will provide me with fine grade clean bags of sand to use ~~fo~~ S.L. 7/9/97 in place of the alumina closer to the upper and lower boundaries.

Fittings were obtained to maintain continuity between the adjacent drifts. The fittings consisted of 2 steel elbows with a nipple in between. The C-shaped fitting will connect the a ~~Wall~~ Flange that is located on the box where the drift is located.

7/14/97 [illegible]

Fluke Cartridge Module 1 Thermocouple T1-T10

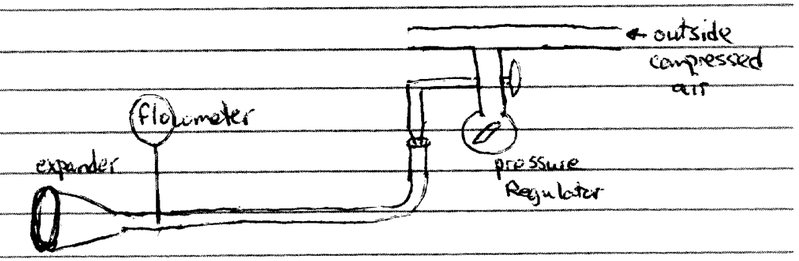
Module 2 Thermocouple T11-T20

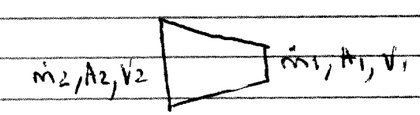
Ventilation 3 Flow rates:

low	24 L/min	@ Re_D = 1256	$Re_D = \frac{VD}{\nu}$ (Reynolds #)
med	30 L/min	@ Re_D = 1568	note: 2300 is the approximate transition from laminar to turbulent.
high	40 L/min	@ Re_D = 2189	

A bilmant Flowmeter ~~that~~ with S.L. 7/14/97 max. at 44 L/min will be purchased to monitor flowrates.

Schematic of ventilation scheme:





$$\dot{m}_1 = \dot{m}_2$$

$$(\rho V A)_1 = (\rho V A)_2$$

$$V_1 A_1 = V_2 A_2$$

$$A_1 = \frac{\pi D_1^2}{4} = \frac{\pi (.8cm)^2}{4} = .5027\ cm^2 \quad \text{or}$$

$$A_2 = \frac{\pi D_2^2}{4} = \frac{\pi (2)^2}{4} = 3.1416\ cm^2$$

Velocity: $V_1 = \frac{Q_1}{A_1} = \frac{24\ L/min}{.5027cm^2}\left(\frac{1000mL}{1L}\right)\left(\frac{1cm^3}{1mL}\right)$

$$= (47742.192\ cm/min)\left(\frac{1m}{100cm}\right)\left(\frac{1min}{60s}\right)$$

$\boxed{V_1 = 7.96\ m/s}$ low

$$V_1 A_1 = V_2 A_2$$

$$V_2 = \frac{V_1 A_1}{A_2} = \frac{(7.96\ m/s)(.5027cm^2)}{(3.1416cm^2)}$$

$\boxed{V_2 = 1.27\ m/s}$ low

7/16/97 by Kepple

$V_1 = \frac{Q_1}{A_1} = \frac{30\ L/min}{.5027cm^2}\left(\frac{1000mL}{1L}\right)\left(\frac{1cm^3}{1mL}\right)$

$$= (59677.74\ cm/min)\left(\frac{1m}{100cm}\right)\left(\frac{1min}{60s}\right)$$

$\boxed{V_1 = 9.95\ m/s}$ med

$$V_2 = \frac{V_1 A_1}{A_2} = \frac{(9.95m/s)(.5027cm^2)}{(3.1416cm^2)}$$

$\boxed{V_2 = 1.59\ m/s}$ med

$$V_1 = \frac{Q_1}{A_1} = \frac{40\ L/min}{.5027cm^2}\left(\frac{1000mL}{1L}\right)\left(\frac{1cm^3}{1mL}\right)$$

$$= (79570.32\ cm/min)\left(\frac{1m}{100cm}\right)\left(\frac{1min}{60s}\right)$$

$\boxed{V_1 = 13.26\ m/s}$ high

$$V_2 = \frac{V_1 A_1}{A_2} = \frac{(13.26\ m/s)(.5027cm^2)}{(3.1416cm^2)}$$

$\boxed{V_2 = 2.12\ m/s}$ high

7/17/97 by Kepple

Three 10 ft Rope heater are connected in series to a variable transformer. (120/140 V 15 A)

Ohms law $P = IR^2 = (15A)(120\ V) = 1800W$

$(15A)(140V) = 2100W$

1st Set Variable Transformer to 120V at 75% and Monitor temperature of rope heater. This should be 1350W At 75% the Temperature Rose very slowly..

2nd Set Variable Transformer to 120V at 100%. (3 rope heaters) Temperature Rose to only 46°C.

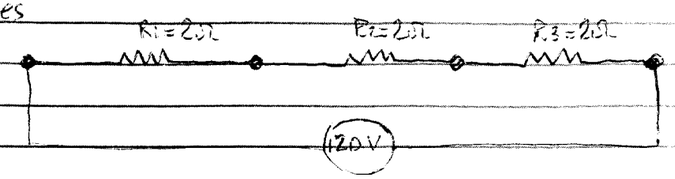
3rd Only use 1 Rope heater 120V at 80% Temperatures Reached 115°C very easily.

4th Set 2 Rope heaters in series at 120V at 100%. Temperatures Reached 51°C very slowly.

5th Try 3 Rope heaters in Parallel.

Example of parallel + Series.
3 Rope heaters each with 2Ω resistance.

Series



$V = I R_T$ $\qquad$ $R_T = R_1 + R_2 + R_3$

$\frac{V}{R_T} = I$ $\qquad$ $R_T = 6\Omega$

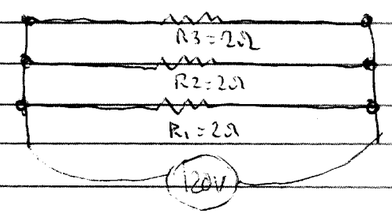
$\frac{120V}{6\Omega} = 20A = I$

$P = VI$

$P = (120V)(20A)$

$P = 2400W$

Parallel



$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

$\frac{1}{R_T} = \frac{1}{2} + \frac{1}{2} + \frac{1}{2}$

$R_T = .67\Omega$

$\frac{V}{R_T} = I$

$\frac{120V}{.67} = 179A = I$

$P = VI$

$P = (120V)(179A)$

$P = 21492.5W$

Conclusion: Parallel will provide 8.9 times the heat output that the series heater-setup will.

7/23/97 for Peggy

Test Procedure for constructing a tensiometer. The following materials were used:

1) B-400-3-4TMT Male tee Run
2) 1/4" copper tubing
3) 1/4" I.D. clear rubber tubing
4) porous cup

1st a 1/4" hole was drilled through the bore of the male tee run such that the copper tubing would fit all the way through. (A 1/8" hole was drilled through the copper at the center of the male tee Run such that the perpendicular extension open to the extended copper tubing. A ceramic porous cup was then adhieved to the copper using JB weld.)

7/24/97 for Peggy

The above procedure listed in parentheses has changed. A 1/8 inch hole was not necessary. The porous cup would not adhieve with JB weld. A rubber tube was clamped to connect the copper tubing and the ceramic porous cup. In addition to the above materials another fitting with a septum was connected such that water could be injected down into the porous cup without escaping. Also included was a power supply ~~and~~ a voltmeter and a pressure transducer to read suction pressure. S.L. 7/24/97

Pressure Transducer Reading	1V	→	Ø psig
	?V		? psig
linear interpolation:	6V		-15 psig

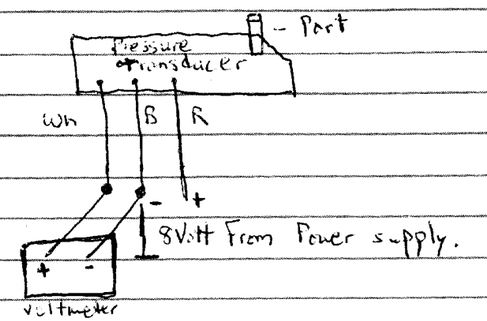
$$\frac{V-1}{6-1} = \frac{P-\emptyset}{-15-\emptyset}$$

$$P = \left(\frac{V-1}{5}\right)(-15) \Rightarrow \boxed{P = (V-1) * -3}$$

7/23/97 [illegible]

Calibration Procedure For the 141PC15GL Pressure transducers:

(1) Attach power supply and volt meter as shown below.



(2) Attach a hose from the port shown above to one side of a water manometer.

(3) Attach another hose on the other side of the manometer leading to a fitting with a septum.

S.L. 7/23/97 (4) ~~Pull~~ Create a suction using a syringe and record the displacement of water in the manometer and the voltage reading on the voltmeter.

(5) Compare manometer pressure ($-P = \rho g h$) to pressure transducer reading ($P = (V-1)*-3$)

	Manometer h(in)	Voltmeter (V)	
P1 S.L. 7/23/97 ~~[illegible]~~	2.0	1.116	-.348 psig
P2	2.0	1.346	-1.038 psig
P3	2.0	1.364	-1.092 psig
P4	2.0	1.325	-.975 psig
P5	2.0	1.348	-1.044 psig
P6	2.0	1.326	-.978 psig
P7	2.0	1.346	-1.038 psig
P8	2.0	1.338	-1.014 psig
P9	2.0	1.117	-.351 psig
P10	[illegible]	1.246	-.738 psig

Note: 14.7 psi = 101325 Pa
$\rho_w = 1000\ kg/m^3$
$g = 9.81\ m/s^2$
2.5cm = 1 inch

Manometer: $-P = \rho g h$
$-P = (1000\ kg/m^3)(9.81\ m/s^2)(h\ in)\left(\frac{2.5cm}{1in}\right)\left(\frac{1m}{100cm}\right)$
$-P = 245.25 * h\ (in)$ Pa

$P_{abs} = P_{gage} + P_{atm}$

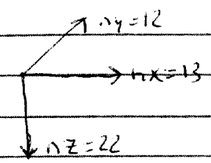
* Note: Gage pressure will be the pressure used such that the varying atmospheric pressure does not become a variable. Also, because Each displacement was the same, no pressure values were used for comparison.

7/31/97 [illegible]

Started Metra Run using 33 Watt heat sources to represent the Rope heaters. Start Time was 11:35 am. Locations were monitored at the heater (middle heater in ~~Box~~ midst) and at 2 locations right above the drift wall. This Metra Run involves a 3-D heat conduction problem on a laboratory scale. I changed the Limit for dtmn to 0.1s and dtmx to 1000s. Begin Next Run at 12:25. Input data File Features are as Follows:

S.L. 7/31/97

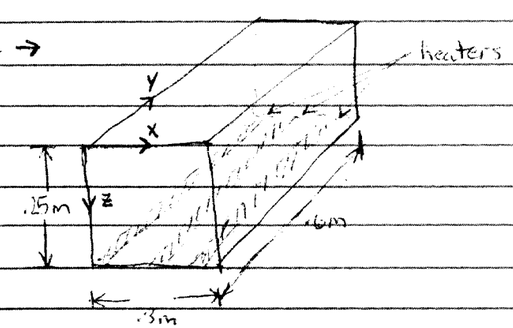
GRID



PCKR	i	type	swir	rpm	alpha	swext	sge	reom
	1	Van-Gen	.08	.0296	13.1×10^{-5}	0	0.0	0

Thermal-Prop	no	e	c	ckdry	ckwet
	1	2.29×10^{3}	940	2.6	4

Schematic →



Run ended at 2:20. Note: Temperature of heater reached 31.3° (Too Low).

7/31/97 [illegible]

Next Run heater will be set at ~~930~~ 720 Watts

See p.7 (167 W/m). 167/18m = 93W. Run Started at 3:10.

8/1/97 [illegible]

(9.00am.)

Last Run has been stopped. Apparently the Heat Flux was too high. Note. Temperature of heater reached 281.5°C (Too High) Simulation time was 2922 seconds (48.7 minutes CPU)

8/4/97 S.L.

Next Run heater will be set at 140 Watts. The time is 9:20am. Runtime was 10065 seconds. Temperature at heater reached 67.7°C after 8 hr simulation. (2.8 hrs CPU time)

8/4/97 S.L.

8/4/97 [illegible]

Next Run heater will be set at 200 Watts. Run start time is 1:50. Runtime was 13280 seconds. Temperature at heater reached 88.2°C after 8 hr Simulation. (3.7 hr CPU time)

8/4/97 S.L.

Next Run heater will be set at 250 Watts. Run start time is 11:05. Runtime was 20339 seconds. Temperature at heater reached 105.2°C after 8 hr Simulation. (5.6 hr CPU time)

8/5/97 [illegible]

Next Run heater will be set at 300 Watts. Run Start time is 12:00. Runtime was 22463 seconds. Temperature at heater reached 122.2°C after 8 hr Simulation. (6.2 hr CPU time)

8/6/97 [illegible]

Following on the Next Pages is a copy of the input data Files for the above Runs.

```
     Simulation of laboratory-scale venting experiment - Bldg 51 CNWRA
           July 29, 1997
 : drip27.dat
 : heater set at 33 3W  140 W  8/1/97 S.V.
 : heat loss at boundaries included
 : boundary elements at 1e-2
 : heat capacity of boundary elements at 840
 : ipvtab set to 1
 : changed cp of drift from 10 to 840
 : changed density of drift from 2600 to 1600
 : changed drift to linear capillary function
 : removed heater from drift properties
 : set sgc in ecm to 0.0
 : set heater porosity to 0.0
 : set residual saturation and drift to 0.0
RSTART  0
:
:       XYZ                        = 1 table look-up,; pref = ref. press.
:       RADIAL                     = 0 correlations;   tref = ref temp.
:       OTHER                        ^
:                                    |
:grid  geometry  nx ny  nz ivplwr ipvtab  iout    pref tref  href
Grid   XYZ       13 12  22  1       1      3       0    0
:
Monitor  2100 2256 2724
:        data taken from sandia report:Green et al. 1995, NUREG/CR-6348
Pckr                                :relative perm and pc 0eyword
:   i  type-curv swir   rpm(lamda)  alpham  swext  sgc  iecm
    1  Van-Gen   0.08   .6296      13.10e-5    0     0.0  0   : alumina
    2  linear    0.00    0.0        0.0     0.005   0.0  0   ! emplacement drift
0            :blank line
:
: Debug  1
: 0
Thermal-prop
: no rho        cpr    ckdry  cksat    crp  crt   tau  cdiff   cexp  enbd
  1  2.290e+03 940.0   2.60    4.0      0    0    .5  2.13e-5  1.8  0. 0 !alum
  2  2.290e+03 940.     7.      7.      0    0    .5  2.13e-5  1.8  0. 0 !drift
  3  2.290e+03 940.0   0.50    0.50     0    0    .5  2.13e-5  1.8  0. 0 !boundaries
0
:      igrid   rw      re
DXYZ   0
: (dx(i),i=1,nx)
.005 .0055 .0531 .0531 .0055 .01 .0055 .0531 .0531 .0055
.01 .0055 .0351
: (dy(j),j=1,ny)
.05 .05 .05 .05 .05 .05 .05 .05 .05
.05 .05
: (dz(k),k=1,nz)
.025 .025 .025 .025 .0125 .0125 .0125 .0125 .0125 .0125
.0125 .0125 .0125 .0125 .003125 .003125 .003125 .003125 .003125 .003125
.003125 .003125
PhiK
: i1 i2 j1 j2 k1 k2 iist ithrm vb  por permx  permy  permz  pormm permm
  1  13  1 12  1  22 1   1     0. 0.45
  1  13  1 1    1 22 1   3 1.0e-2 0.45                                        !front
 13  13  1 12   1 22 1   3 1.0e-2 0.45                                        !side
  1  13  1 12   1  1 1   3 1.0e-2 0.45                                        !top
  1  13  1 12  22 22 1   3 1.0e-2 0.45                                        !bottom
  3   3  1 12  15 22 2   2     0. 0.99 1.e-12 1.e-12 1.e-12 0.99  1.e-12 !drift
  6   6  1 12  15 22 2   2     0. 0.99 1.e-12 1.e-12 1.e-12 0.99  1.e-12 !drift
  8   8  1 12  15 22 2   2     0. 0.99 1.e-12 1.e-12 1.e-12 0.99  1.e-12 !drift
 11  11  1 12  15 22 2   2     0. 0.99 1.e-12 1.e-12 1.e-12 0.99  1.e-12 !drift
 13  13  1 12  15 22 2   2     0. 0.99 1.e-12 1.e-12 1.e-12 0.99  1.e-12 !drift
  1   1  1 12  17 20 1   1     0. 0.00 1.e-18 1.e-18 1.e-18 0.00  1.e-18 !heater
  7   7  1 12  17 20 1   1     0. 0.00 1.e-18 1.e-18 1.e-18 0.00  1.e-18 !heater
```

(cont. on p.27)


```
 12  12  1 12  17 20 1   1     0. 0.00 1.e-18 1.e-18 1.e-18 0.00  1.e-18 !heater
   0
:
Init
:  i1  i2  j1  j2  k1  k2   p          t    sg   x2  sgm
   1  13  1   12   1  22  1.0315e5 20.0  0.52 0.  .50
0
:
:
Recurrent
:        ns      fach        facm  (fach and facm are multipliers to
:                                      read-in values of qht and qmt)
Source   3       1.          1.
:  is1 is2 js1 js2 ks1 ks2  istyp
   1   1   1 12   17  20   33
 0     1.40e+2
1.e+10 1.40e+2
0
:  is1 is2 js1 js2 ks1 ks2  istyp
   7   7   1  12   17  20   33
 0     1.40e+2
1.e+10 1.40e+2
0
:  is1 is2 js1 js2 ks1 ks2  istyp
   12  12  1  12  17  20   33
 0     1.40e+2
1.e+10 1.40e+2
0
Output   C=-10 Q=-10   T=1   G=1   P=1
:
:  isolv  newtnmn  newtnmx
Solve 4     2        7        2
:
:AUTO-step  DPMXE    DSMXE  DTMPMXE   DP2MXe
AUTO-step   5.0E+4   0.04    5.0       5.e4
:
:TOLR TOLP  TOLS  TOLT  TOLP2  TOLM  TOLA  TOLE
Tolr   10. 1.e-4  1.e-3  10.   1.e-3 1.e-2 1.e-3  1.e-12  1.e-12   1.e-12
:
:Limit dpmx    dsmx dtmpmx dp2mx dtmn dtmx icutmx
LIMIT  1.e5    .08    10.   1.e5 1.e-1 1000
:
:       target  dt    dpmx    dsmx    dp2mx   dtmpmx
:
:        print all at every target time
PLOTS 1
Time[s] 3600
Time[s] 7200
Time[s] 10800
Time[s] 14400
Time[s] 18000
Time[s] 21600
Time[s] 25200
Time[s] 28800
Ends
```

Adjustments were made to the DXYZ card that corrected the nonsymetrical conditions due to gravity in the z-direction. This also meant fixing the PhiK card to accomodate the above changes. The new data file is shown on the next 2 pages. The changes are highlighted. Note, also changes were made to the Source card for KS1 + KS2.

```
    Simulation of laboratory-scale venting experiment - Bldg 51 CNWRA
          Aug. 6 , 1997
 : drip27.dat
 : heater set at 300.0W
 : heat loss at boundaries included
 : boundary elements at 1e-2
 : heat capacity of boundary elements at 840
 : ipvtab set to 1
 : changed cp of drift from 10 to 840
 : changed density of drift from 2600 to 1600
 : changed drift to linear capillary function
 : removed heater from drift properties
 : set sgc in ecm to 0.0
 : set heater porosity to 0.0
 : set residual saturation and drift to 0.0
RSTART  0
:
:       XYZ                          = 1 table look-up,; pref = ref. press.
:       RADIAL                       = 0 correlations;   tref = ref temp.
:       OTHER                          ^
:                                      |
:grid  geometry  nx ny  nz ivplwr ipvtab  iout    pref tref  href
Grid   XYZ       13 12  22  1       1      3       0    0
:
Monitor  2100 2256 2724
:        data taken from sandia report:Green et al. 1995, NUREG/CR-6348
Pckr                                :relative perm and pc 0eyword
:   i  type-curv swir   rpm(lamda)  alpham  swext  sgc  iecm
    1  Van-Gen   0.08   .6296      13.10e-5    0     0.0  0   ! alumina
    2  linear    0.00    0.0        0.0     0.005    0.0  0   ! emplacement drift
0            :blank line
:
: Debug  1
: 0
Thermal-prop
: no rho        cpr     ckdry  cksat    crp  crt   tau  cdiff   cexp  enbd
  1  2.290e+03 940.0    2.60    4.0      0    0    .5  2.13e-5  1.8  0. 0 !alum
  2  2.290e+03 940.      7.      7.      0    0    .5  2.13e-5  1.8  0. 0 !drift
  3  2.290e+03 940.0    0.50   0.50     0    0    .5  2.13e-5  1.8  0. 0 !boundaries
0
:     igrid   rw      re
DXYZ   0
: (dx(i),i=1,nx)
.005 .0055 .0531 .0531 .0055 .01 .0055 .0531 .0531 .0055
.01 .0055 .0351
: (dy(j),j=1,ny)
.05 .05 .05 .05 .05 .05 .05 .05 .05
.05 .05
: (dz(k),k=1,nz)
.0625 .0625 .025 .025 .025 .025 .025 .003125 .003125 .003125
.003125 .003125 .003125 .003125 .003125 .025 .025 .025 .025 .025
.05 .05
PhiK
: i1 i2 j1 j2 k1 k2 iist ithrm vb  por permx  permy  permz  pormm permm
  1  13  1  12   1  22 1    1     0. 0.45
  1  13  12 12   1  22 1    3 1.0e-2 0.45                                    !front
 13  13  1 12     1  22 1    3 1.0e-2 0.45                                    !side
  1  13  1 12     1   1 1    3 1.0e-2 0.45                                    !top
  1  13  1 12    22  22 1    3 1.0e-2 0.45                                    !bottom
  3   3  1 12     8  15 2    2     0. 0.99 1.e-12 1.e-12 1.e-12 0.99  1.e-12 !drift
  6   6  1 12     8  15 2    2     0. 0.99 1.e-12 1.e-12 1.e-12 0.99  1.e-12 !drift
  8   8  1 12     8  15 2    2     0. 0.99 1.e-12 1.e-12 1.e-12 0.99  1.e-12 !drift
 11  11  1 12     8  15 2    2     0. 0.99 1.e-12 1.e-12 1.e-12 0.99  1.e-12 !drift
 13  13  1 12     8  15 2    2     0. 0.99 1.e-12 1.e-12 1.e-12 0.99  1.e-12 !drift
  1   1  1 12    10  13 1    1     0. 0.00 1.e-18 1.e-18 1.e-18 0.00  1.e-18 !heater
  7   7  1 12    10  13 1    1     0. 0.00 1.e-18 1.e-18 1.e-18 0.00  1.e-18 !heater
```

(Cont on p.29)


```
 12  12  1 12    10 13 1   1     0. 0.00 1.e-18 1.e-18 1.e-18 0.00  1.e-18 !heater
   0
:
Init
:  i1  i2  j1  j2  k1  k2   p         t    sg   x2  sgm
    1  13  1   12   1  22  1.0315e5 20.0  0.52 0.  .50
0
:
:
Recurrent
:       ns     fach       facm  (fach and facm are multipliers to
:                                read-in values of qht and qmt)
Source   3     1.          1.
:  is1 is2 js1 js2 ks1 ks2  istyp
    1   1   1 12   10  13   33
 0     3.00e+2
1.e+10 3.00e+2
0
:  is1 is2 js1 js2 ks1 ks2  istyp
    7   7   1  12   10  13  33
 0     3.00e+2
1.e+10 3.00e+2
0
:  is1 is2 js1 js2 ks1 ks2  istyp
    12  12  1  12  10  13   33
 0     3.00e+2
1.e+10 3.00e+2
0
Output   C=-10 Q=-10   T=1   G=1   P=1
:
:  isolv  newtnmn  newtnmx
Solve 4     2        7        2
:
:AUTO-step  DPMXE    DSMXE  DTMPMXE   DP2MXe
AUTO-step   5.0E+4   0.04    5.0       5.e4
:
:TOLR TOLP  TOLS  TOLT  TOLP2  TOLM  TOLA  TOLE
Tolr   10. 1.e-4  1.e-3  10.   1.e-3 1.e-2 1.e-3  1.e-12  1.e-12   1.e-12
:
:Limit dpmx    dsmx dtmpmx dp2mx dtmn dtmx icutmx
LIMIT  1.e5    .08    10.   1.e5 1.e-1 1000
:
:      target  dt    dpmx   dsmx   dp2mx   dtmpmx
:
:       print all at every target time
PLOTS 1
Time[s] 3600
Time[s] 7200
Time[s] 10800
Time[s] 14400
Time[s] 18000
Time[s] 21600
Time[s] 25200
Time[s] 28800
Ends
```

8/7/97 by Lepp

Calculation of mass and volume of Beam.

$\rho = 7840\ Kg/m^3$ for Carbon steel

$V = .13331\ m^3$

$\rho = \frac{m}{V} \Rightarrow m = \rho V$

$m = (7840\ Kg/m^3)(.13331\ m^3)$

$\boxed{m = 1045.2\ Kg}$

Convert to lbs $1Kg = 2.2\ lb$

$m = (1,045.2Kg)\frac{2.2\ lb}{1Kg}$

$\boxed{m = 2299.4\ lb}$

From p.16 Box of Alumina/Bentonite will weigh Approximately 1569 lb + approx 100 lb for Box for a total of 1669 lb.

8/8/97 for Lepp

Last Run shown on page 25 was terminated with an error. The error reads: "bad vp press in pvtvp.f-see lfn_errs file. Note: the following IEEE floating-point arithmetic exceptions occured and were never cleared; see ieee_flags(3M): Inexact; UnderFlow;"

8/14/97 by Lepp

Next Run heater will be set back to 250 Watts. Run start time is 9:40 a.m. Run time was 71388 seconds. Temperatures at the heater reached 147.3 °C after 8hr Simulation (19.8 cpu time)

8/15/97 by Lepp

Next Run heater will be set at 225 Watts. Run start time is 10:55 a.m. Note: the Locations being monitored are m = 2100, m = 2256, and m = 2724. These locations correspond to i = 7, j = 6, and K = 13, 14, and 17 respectively. These are locations at the heater and below the heater. The following equation is used in METRA to determine the location (m)

that is being monitored:

$m = i + (j-1)(nx) + (K-1)(nx)(ny)$

8/18/97 At 225 Watts, Run time was 53365 seconds. Temperature at the heater was 134.6 °C after 8hr Simulation. (14.8 CPU time)

8/19/97 Next Run heater will be set at 215 Watts. Run Start time is 10:25 a.m. Runtime was 44290 seconds. Temperature at the heater was 139.6 °C after 8hr Simulation. (12.3 cpu time)

The Following are copies of Certificate of Calibration for the Humidity sensor and the air flow meter:

Southwest Research Institute
6220 Culebra Road
San Antonio, TX 78238
Department of Quality Assurance
Calibration Laboratory

Certificate of Calibration

14 July 1997

Issued to: RON GREEN DIV20 B57
Manufacturer/Model: VAISALA HMP235
Description: HUMIDITY SENSOR
Serial Number: S1240028
Asset Number: 005603

Environmental Conditions

Temperature: 78.0 Deg. F **Humidity:** 44%

Calibration Information

Calibration was in accordance with requirements of MIL-STD-45662A and ANSI/NCSL Z540-1-1994. Measurements are traceable to the National Institute of Standards and Technology (NIST). This report may not be reproduced except in full without written approval of the originator. Inspection and test data are on file and available for inspection.

Calibration Date: 11 Jul 97 **Calibration Procedure:** MFGR #5603

Interval: 12 months **Accuracy:** MFGR

Next Calibration Due: 11 Jul 98 **Received:** In Tolerance

Remarks: TUR: 1 TO 1. TYPE A EVALUATION OF UNCERTAINTY ACCOMPLISHED.

Standards Used

Asset	MFR	Model	Description	Serial No.	Due Cal
004296	PROTIMETER	DP989M	DEWPOINT METER	MF-410501	2 Jul 98

Certificate # 25989

Signed:

LAST PAGE OF REPORT
Total Pages Printed: 1

N044-07ST FLOWMETER CALIBRATION DATA 005 / 588

CUSTOMER	CUST. P.O.No	REF.CURVE NUMBER
COLE-PARMER INSTRUMENTS	58076	0897-OS-10

Max.Flow	Min.Flow	Units	Metered Fluid	Date
94	10	scfh	air	08/12/97

Model Number	P14/1	Metering Temperature	70.0 °F
Tube Number	N044-07ST	Metering Pressure	14.70 psia
Serial Number	137793	Metering Density	0.001200 g/ml
Float Material	316 Stainless Steel	Density at STD.Cond	0.001200 g/ml
Float Density	8.04 g/ml	Metering Viscosity	0.01812 cp
STD. Conditions	STP: 1 atm @ 70 °F	Accuracy	±5%
Room Temperature	72.5 °F	Barometric pressure	762.0 mm of Hg

SCALE READINGS AT CENTER OF FLOAT

Scale Readings [scfh]	Flow [flow units]
90	94
80	84
70	73
60	62
50	51
40	41
30	31
20	20
10	10

TEST EQUIPMENT

		Calibration Due
CS96100014	Calibrator	12/09/97

This instrument is certified against standards which are traceable to N.I.S.T. test #18030C.
The calibration is performed by passing a calibrated flow through a calibrated instrument and then is collected in a calibrator. Here timing, collected volume, pressure and flow temperature measurements are performed. All instruments used in the calibration procedure are certified against standards traceable to N.I.S.T.

Certified by: T. Barbakov Date: 08.12.97

COLE-PARMER INSTRUMENT COMPANY
625 East Bunker Court, Vernon Hills, IL 60061 USA
Phone: 1-847-549-7600 or Toll-free 1-800-323-4340

8/20/97
Dry Pappas

Conversions for 24 L/min, 30 L/min, 40 L/min to (ft^3/hr).

$$\left(\frac{L}{min}\right)\left(\frac{1000\,mL}{1\,L}\right)\left(\frac{1\,cm^3}{1\,mL}\right)\left(\frac{1\,in^3}{2.5^3\,cm^3}\right)\left(\frac{1\,ft^3}{12^3\,in^3}\right)\left(\frac{60\,min}{1\,hr}\right)$$

$$\left(\frac{L}{min}\right) * 2.22 = \frac{ft^3}{hr}$$

low 24 L/min → 53.3 ft^3/hr

med 30 L/min → 66.6 ft^3/hr

high 40 L/min → 88.8 ft^3/hr

The following are the pressures that will provide the above flowrates:

low approx 6 psi

med approx 8 psi

high approx 10 psi

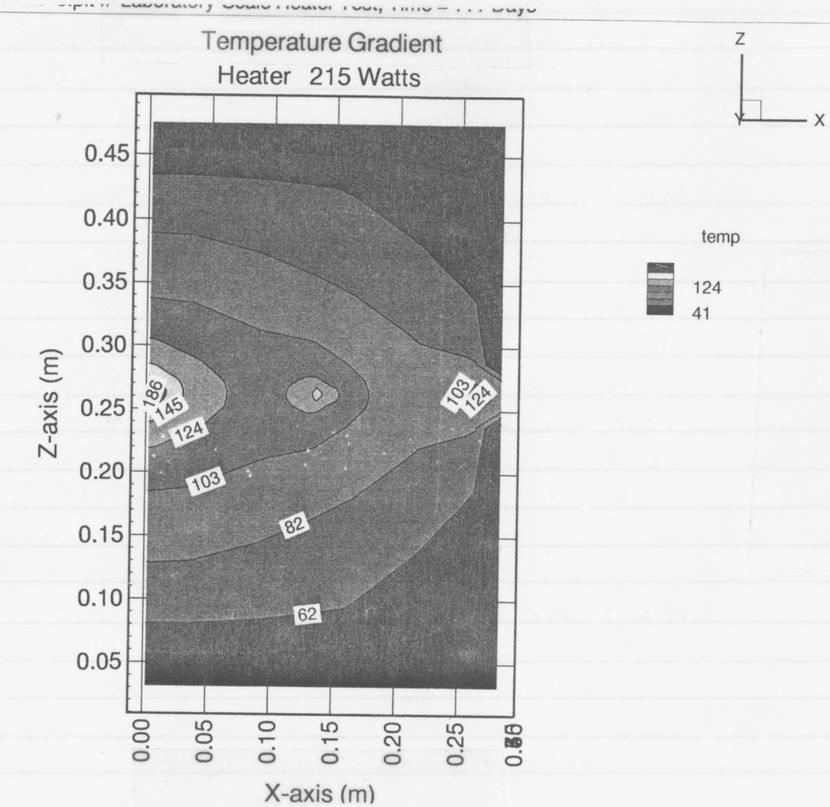
The following shows results obtained with the heater set at 215 watts for 8 hrs.

V = 120V
I = 1.8A

P = VI = 1800 W

Heater (1.8 W/in)(120 in)

Heater (216 W)



9/5/97 I am Evaluating the heat that will be supplied by the rope heaters in the lab-scale experiment. 215 watts was shown the be the appropiate Heat rate using METRA. The heat source will be incrementally reduced to represent similar characteristics as the exponentially decaying heat source (Waste Package) at the repository.

Time (yrs)	Repository (w)	Time (min)	Lab ~~Repository~~ (w)
0	8016	0	215
1	7874	4.8	211
2	7738	9.6	208
5	7347	24	197
10	6735	48	181
20	5748	96	154
50	3841	240	103
100	2414	480	65

S.L. 9/5/97

Procedure for measuring the media saturation:
Fill beaker with 70 ml of Media. Use another beaker of water to be poured and mixed with the media until saturated. Record the amount of water in terms of Volume necessary to saturate 70 ml of Media. Apply this ratio to the laboratory experiment.

Weighed Bag of Alumina = 109 grams
Bag 4.95 grams
Alumina = 104.05 grams
Bentonite + 5.2 grams
Total = 109.25 grams

Note: Procedure was changed. The media was mixed 5% Bentonite + 95% Alumina in a ziplock bag. 50 ml of water exist in a beaker. This water will be poured into the bag slowly until the media is saturated.

20 ml remains in the beaker therefor 30 ml of water was necessary to saturate 109.25 grams of media. The Amount of Alumina/Bentonite mixture is estimated to fill a Container that is 1 ft in diameter and 1 ft in height. The Volume is:

$$V = \left(\frac{\pi D^2}{4}\right)(L) = \frac{\pi (1ft^2)(1ft)}{4}$$

$$V = .7854\ ft^3$$

ρ_{al} is approximately $3\ g/cm^3$ (value taken from page 5)

~~Convert 3 g/cm³ →~~ S.L. 9/5/97

Convert $.7854\ ft^3 \rightarrow cm^3$

$$V = (.7854\ ft^3)\left(\frac{12^3\ cm^3}{1\ ft^3}\right)\left(\frac{2.5^3\ cm^3}{1\ in^3}\right)$$

$$V = 21205.75\ cm^3$$

$$m_{al} = \rho_{al} V$$

$$m_{al} = (3\ g/cm^3)(21205.75\ cm^3)$$

$$m_{al} = 63617.25\ g \quad \text{or}$$

$$m_{al} = 63.62\ Kg$$

Determine How much water per 63.62 Kg of media for full Saturation.

$$\frac{30\ ml}{109.25\ g} = \frac{X\ ml}{63617.25\ g}$$

$$X\ ml = \frac{30\ ml}{109.25\ g}(63617.25\ g)$$

$$X\ ml = 17469.27\ ml$$

For 80% Saturation + 63.62 Kg of Media 13975.416 ml of

water will be needed. ((13.975 L of water))

9/8/97 [illegible]

The time history of heat on a laboratory scale has been revised to the following:

Time (min.)	Lab (W)
0	215
2.4	213
7.2	210
16.8	203
36	189
72	168
168	129
360	84
480	65

Media Total Weight 63.62 Kg without water

3.18 Kg of Bentonite
60.44 Kg of Alumina
~ 14.0 L of Water

Procedure for mixing:

1) Set aside each quantity of media + water shown above.
2) Start with approximated 1/3 of the quantity of alumina and add 1/3 of the quantity of the Bentonite and water slowly.
3) Mix and then repeat the Process until the Full quantity described above is met.
4) Repeat procedure with a new set of Alumina/Bentonite/Water.

The Packing Process will be conducted and controlled to meet a uniform packing spatially within the box. The methods to meet ~~this~~ ~~st~~ this standard will be recorded.

S.L. 9/8/97

The Instrumentation will be placed throughout the packing process such that it will set on top of the already packed medium.

Heat Source: $V = IR$

$P = VI$

$P = V^2/R$

For Rope heater 10 ft $V = 120$ Volts

$P \approx 500$ Watts

$\therefore R = V^2/P = \frac{120^2}{500} = 28.8\,\Omega$

For repository W.P.: $P = 8000$ Watts / 20 m W.P. spacing (400 W/m)

For lab-scale Drift tunnel: $400\,W/m\,(1.2\,m) = 480\,W$

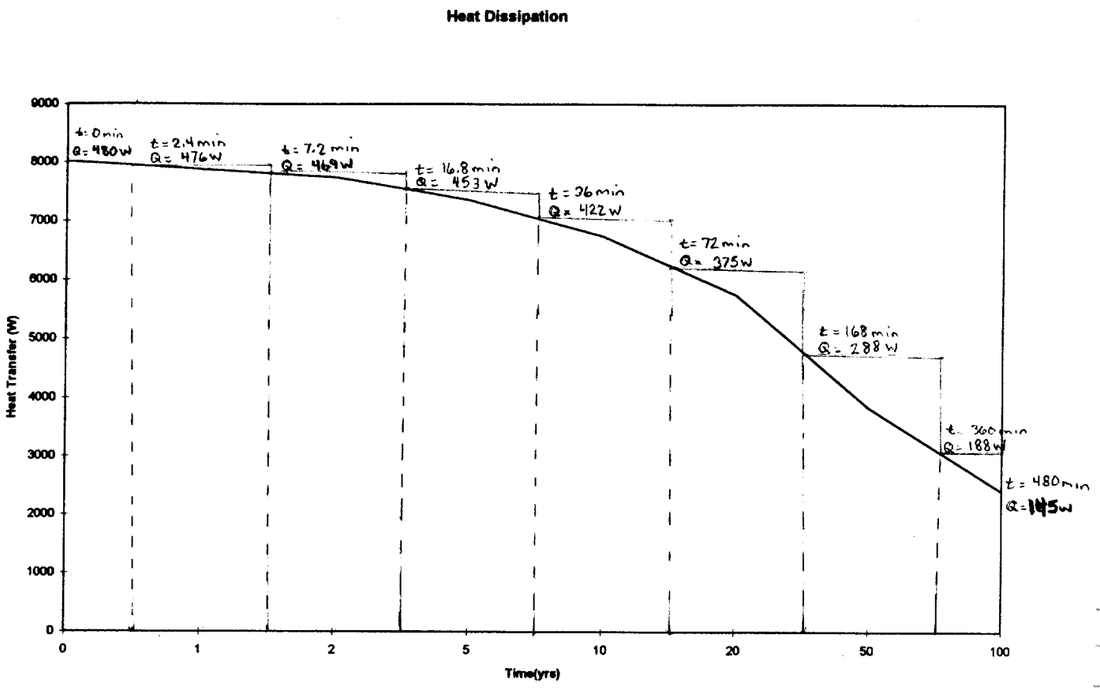
$\sqrt{(480\,W)(28.8\,\Omega)} = V$

$V = 118$ Volts

9/11/97

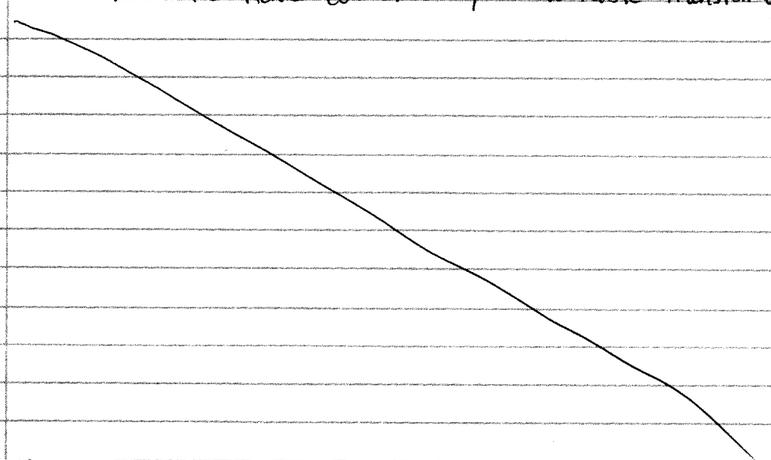
The time history of heat on a laboratory scale has been revised to the following:

Time (min.)	Heat (W) For Lab	Voltage (V)
0	480	118
2.4	476	117
7.2	469	116
16.8	453	114
36	422	110
72	375	104
168	288	91
360	188	74
480	145	65



9/1/97 S.L.

Shown above is a comparison of a heat dissipating waste package to a lab scale heater controlled by a variable transformer.



9/15/97 From page 16 it is shown that 1569 lbs of medium will be used in this experiment. Bags of sand will be used to fill the void boundaries at top and bottom. We have approximately 1150 lb of media that will fill a volume as follows:

$m = 1150$ lb or 522.73 Kg 1 Kg = 2.2 lb

$\rho \sim 2.2$ g/cm^3

$\rho = \frac{m}{V}$ $V = \frac{m}{\rho} = \frac{522.73 \times 10^3 g}{2.2 g/cm^3}$

$V = 237.6$ ~~cm^3~~ $\times 10^3$ cm^3 S.L. 9/15/97

From page 16 Volume to be filled is 326953.13 cm^3

$V_{void} = V_{filled} - V_{available} = 326.953 \times 10^3 cm^3 - 237.6 \times 10^3 cm^3$

$V_{void} = 89353$ cm^3

Note: Box length = 116.25 cm
width = 56.25 cm

What height will fill that volume:

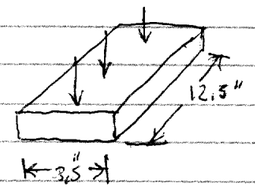
$V_{void} = 89353 cm^3 = \text{length} \times \text{width} \times \text{height}$

$89353 cm^3 = (116.25 cm)(56.25 cm)(\text{height})$

height = 13.66 cm of Sand

height/2 = 6.83 cm on top and bottom. Assume that 7.5 cm will be needed at the top and bottom boundaries. Plan to place 3 inches of sand of top and bottom.

9/19/97 9:00 A.M. Began to fill box. Bottom layer will consist of saturated quality ground Silica. Sprinkle cup filled scoops of the wetted sand at the bottom of the box. After approximately 1 inch deep, I began packing with a hammer and a ~~piece~~ block of wood (12.5 x 3.5 inches) S.L. 9/19/97 The wood was tapped 4 times at both ends of the block and 4 times in the center as shown below.



9/19/97 2:20 pm Calculation of volumes for ratio of mixture.

$$V_{Alumina} = \frac{m}{\rho_{Al}} = \frac{(60.44\ kg)}{(3\ g/cm^3)} \times (1000\ g/kg) = 20146.67\ cm^3$$

note: m obtained from page 38.

Betanite density obtained experimentally.

$$\rho_{Bet.} = \frac{127.6\ g}{150\ cm^3} = 0.851\ g/cm^3$$

$$V_{Bet.} = \frac{m}{\rho_{Bet.}} = \frac{(3.13\ kg)(1000\ g/kg)}{0.851\ g/cm^3} = 3738.24\ cm^3$$

$$\frac{V_{Bet}}{V_{Bet}+V_{Al}} = \frac{3738.24}{3738.24 + 20146.67} = 0.1565\ \frac{cm^3\ Bet}{cm^3\ mixture}$$

For 1 bucket full of Alumina → $V_{Al} = 21205.75\ cm^3$

$$V_{Bet} = V_{Al} \times \left(\frac{V_{Bet}}{V_{Al}}\right) = (21205.75\ cm^3)\left(\frac{3738.24}{20146.67}\right) = 3934.75\ cm^3$$

Assuming bucket diameter is a constant value of 1 ft

$$\text{height of Betanite} = \frac{V_{Bet}}{A_{Bucket}} = \frac{3934.75\ cm^3}{\pi\left[(0.5\ ft \cdot \frac{12\ in}{1\ ft}) \cdot (\frac{2.54\ cm}{1\ in})\right]^2} = 5.39\ cm = \underline{2.12\ in}$$

now need to compute volume of water for mixture.

JM 9/19

$$\frac{V_{H_2O}}{V_{Bet}\ V_{Al}} = \frac{14.0\ L}{3738.24 + 20146.67}$$

JM 9/19

$$V_{H_2O} = \frac{14.0\ L}{3738.24 + 20146.67} \times (3934.75 + 21205.75) = \underline{14.74\ L}$$

big water jug volume $= \pi\frac{(11.5)^2}{4}(16.5\ in) = 1713.8\ in^3$

amount of dye added = ~~160 ml~~ JM 9/19 240 ml

small water jug holds 4 L

J. Kepple 9/19/97

6 Liters of water will be used for for the total mixture of Bentonite + alumina. Not 14.74 Liters, this would have been entirely too much water.

Note: During the course of packing, the large egg beater started to fail. Therefor, we switched to the other mixer extension. Soon After this replacement, a bolt poped out of a location that holds the ~~pot~~ S.L. 9/19/97 mixer pot in place. At this point we stopped packing and covered the box with plastic to maintain the moisture. Today I mixed for 9 hrs.

J. Kepple 9/22/97

The bolt on the mixer pot was secured. The more heavy duty mixer extension will be used for future mixing. Continued mixing for 7 hrs.

J. Kepple 9/23/97

Continued Mixing for 8 hrs. It appears that there may be a shortage of the proper grain size of alumina. Objective today is to place the rest of the instrumentation and pack the medium up to 3 inches below the top of the box.

J. Kepple 9/24/97

The top layer of sand will be placed in the box. Upon completion, the rope heaters will be placed in the drifts and the cast Iron fitting will be connected to the ends of the box

9/25/97

Fittings were connected to the ends of the box and silicon rubber was used to seal the fittings. Thermocouples were tested. Below is the equation for the Relative Humidity Sensor: (Input is 20 Volts)

$$R.H. = \frac{\text{Reading} - 4}{16} * 100$$

$$T = \left[\frac{\text{Reading} - 4}{16} * 200\right] - 20$$

CH. 1 Relative humidity reading (%)
CH. 2 Temperature (C°)

Test: CH. 1 = 11.20 45%
CH. 2 = 7.71 → 26.4°C

S.L. 9/26/97

9/26/97

Tensiometers were ~~moved~~ rotated such that they were parallel to the ground. This was done to avoid an induced suction due to gravity. Nails were used to provide stability to holdup the tensiometers. Small sticks will be used to hold up the pressure transducers.

Calibration for the Sartorius SN 3903006 using various weights that will be removed from the end of the beam holding the box. The scale will be tetered at approximately 1463 grams. 25.5 grams was placed on the box and the scale reads as follows:

S.L. 9/26/97

Weight	Measurement	Weight gained
25.5g	1446	17g

Now weight was removed:

Measurement	Weight Loss
1460	14 ~~26~~g

S.L. 9/26/97

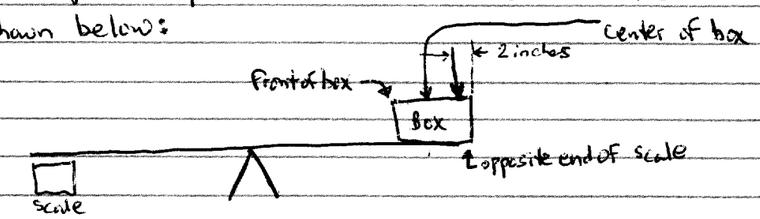
25.5 grams was again replaced:

Measurement	Weight gained
1448	14g

Weight was removed:

Measurement	Weight loss
1463	15g

Note: this weight was placed 2 inches from the end of the Box as shown below:



Renewed Procedure for Calibrating the Sartorius Scale:

1) place 13 wts that sum to approximately 5Kg on the Box and Remove the weights incrementally taking Scale reading each time. (Weights will be placed at Center of box)

2) Compare to actual weight and plot the differences.

S.L. 9/26/97

Wt #	(actual) grams	Scale (reading) grams @ center
1	~~4288~~ 5387.33	2215.5
2	~~11~~ 5377.61	2224.9
3	~~4132.1~~ 5356.08	2241.6
4	5319.69	2273.1
5	5187.2	2384.9
6	5054.01	2498.4
7	4921.0	2611.1
8	4789.55	2722.1
9	4656.16	2835.6
10	~~3524.96~~ 4523.3	2950.2
11	~~2392.86~~ 3392.1	3925.6
12	~~1261.16~~ 2260	4888.4
13	~~132.86~~ 1128.3	5864.2

S.L. 9/26/97

Next, Place weights at the Far end of the box away from the scale and remove incrementally. Use actual wts from p.45.

wt (actual) grams		wt (Scale Reading) grams	@ end opposite scale
5387.33		1712.9	
5377.61		1722.4	
5356.08		1743.5	
5319.69		1776.7	
5187.2		1900.8	
4921.0		2157.2	s.h. 9/26/97
~~3524.96~~	4523.3	2533.1	
~~2392.86~~	3392.1	3596.2	s.h. 9/26/97
~~1261.16~~	2260.0	4673.8	
~~132.86~~	1128.3	5755.6	

@ center

Actual Diff (grams)	Scale Reading Diff (grams)
9.72	9.4
21.53	16.7
36.39	31.5
132.49	111.8
133.19	113.5
133.01	112.7
131.45	111.0
133.39	113.5
132.86	114.6
1131.2	975.4
1132.1	962.8
1131.7	975.8

9/29/97 ~~M~~ Leppek

	wt (actual)	wt (Scale Reading) grams	@ Front of box
	5387.33	1344.8	
	5377.61	1354.3	
	5356.08	1372.2	
	5319.69	1400.7	
	5187.2	1513.1	
	4921.0	1712.6	
4523.3	~~3524.96~~	2018.0	
3392.1	~~2392.86~~	2878.9	s.h. 9/29/97
2260.0	~~1261.16~~	3763.1	
1128.3	~~132.86~~	4647.4	

@ end opposite scale

Actual Diff (grams)	Scale Reading Diff (grams)
9.72	10.1
21.53	21.1
36.39	33.2
132.49	124.1
266.2	256.4
397.7	375.9
1131.2	1063.1
1132.1	1077.8
1131.7	1081.8

@ Front of Box

Actual Diff (grams)	Scale Reading Diff (grams)
9.72	9.5
21.53	17.9
36.39	28.5
132.49	112.4
266.2	199.5
397.7	305.4
1131.2	830.9
1132.1	884.2
1131.7	884.3

Procedure for Filling Tensiometers:

1) Use 6½ inch syringe and Fill tensiometer from inside out to avoid any trapped air inside.

2) Keep filling until water comes out the end where the pressure transducer will be located.

3) Place the transducer on the end of the tensiometer.

Test start time: 11:00

S.L. 9/29/97

~~R.H. @ 11:04 R.H. - 18.68 mA @ Exit~~
~~T @ 11:04 T - 7.54 mA @ Exit~~

→ Test start : 11:27 * R.H. initially jumped to 18.68 mA (91.75%)

T @ exit 11.08 mA (68.5°C)
R.H. @ exit R.H. - 5.99 mA ~~(6.19%)~~ (12.44%)

S.L. 10/1/97

11:31 T @ exit - 15.14 mA (119.25°C)
R.H @ exit - 4.85 mA (5.3%)

* Note a piece of glass blanketing Removed.

~~11:37 Scale Reads 2794.5~~ S.L. 9/29/97

11:40 T @ exit - 17.03 mA (142.87°C)
R.H. @ exit - 4.58 mA (3.63%)

T_1 30°C
T_2 26.6°C
T_3 25.1°C
T_4 26.1°C
T_5 26.9°C
T_6 27.6°C
T_7 25°C
T_8 27.2°C

T_9 24.2°C
T_{10} 27.1°C
T_{11} 21.5°C
T_{12} 24.7°C
T_{13} 26.1°C
T_{14} 32.3°C
T_{15} 33.1°C
T_{16} 26.7°C
T_{17} 25.6°C
T_{18} 24.4°C
T_{19} 23.4°C
T_{20} 23.2°C

@ 11:42 Scale Reads 2710.2 grams
@ 11:51 T @ exit 14.51 mA (111.38°C)
R.H @ exit 4.56 mA (3.5%)

* Note @ 11:48 Wattage was reduced to 454 watts from 480 watts.

@ 11:54 T @ exit 13.6 mA (100°C)
R.H. @ exit 4.72 mA (4.5%)

@ 11:55 Scale Reads 2712.8 grams

@ 11:56 T @ exit 12.49 mA (86.13°C)
RH @ exit 5.06 mA (6.63%)

@ 12:01 Scale Read 2737.0 grams

@ 12:11 T @ exit ~~7~~ 10.09 (56.13°C) 9/29/97
R.H @ exit ~~10.09~~ 7.56 (22.25%)

@ 12:11 Adjust wattage to 422

@ 12:19 T @ exit 9.5 (48.15°C)
RH @ exit 9.0 (31.25%)

@ 12:40 2753.6 g (scale Reading)

@ 1:11 T@ exit ~ 7.97 mA (29.63°C)
R.H@ exit ~ 17.05 mA (81.56%)
Scale Reading 2765.2 g

@ 1:46 Adjust temperature to 118 W (98%)

@ 1:47 T@ exit 7.77 mA (27.13°C)
RH@ exit 18.67 mA (91.69%)

more water was added to the tensiometers approx. 14 grams

@ 3:06 adjusted temperature to 118 W (98%). Heater is actually working this time @ 480 W.

@ 3:06 T@ outlet 11.84 mA (78°C)
RH @ outlet 6.54 mA (15.87%)
Scale Reading 2896.0 grams +14g

@ 3:19 T@ outlet 15.64 mA (125.5°C)
R.H. outlet 4.77 mA (4.81%)

@ 3:29 T@ outlet 17.94 mA (154.25°C)
RH@ outlet 4.53 mA (3.31%)

Account for Adding 2.8 g x6 pieces of tape 16.8 g
Each Reading on the Scale will include an additional 30.8 g of mass.

@ 3:45 Scale reading 2822.5 g + 30.8 g

9/29/97

@ 3:48 T @ outlet 17.5 mA (173.88°C)
R.H @ outlet 4.45 mA (2.88%)

@ 3:56 T@ outlet 19.83 mA (177.87°C)
R.H @ outlet 4.45 mA (2.8%)

T1 39.8°C
T2 38.4°C
T3 32.8°C
T4 34.8°C
T5 33.5°C
T6 37.6°C
T7 38.8°C
T8 37.6°C
T9 29.5°C
T10 37.6°C
T11 22.1°C
T12 30°C
T13 36.4°C
T14 54.0°C
T15 53.4°C
T16 38°C
T17 33.4°C
T18 29.7°C
T19 25°C
T20 24.1°C

S.L. 9/29/97

Scale Reading 30.8 g + ~~2936.8~~ g
2969.6 g

@ 4:00 Adjust Variac to 94% or 442 W
@ 5:00 Adjust Variac to 90% or 432 W
@ 5:17 T@ outlet 19.34 mA (171.75°C)
R.H @ outlet 4.57 mA (3.56%)

S.L.
@ 7:17 I Stopp skipped measuring suction pressure because it was changing too slowly.

@ 8:45 Drops of water were spotted dripping off the box

where the grooves for the heater wires are located. Pictures were taken of the leak.

S.L. 10/1/97

Experiment was stopped after 10.5 hrs.

10/1/97 The 1st experiment was conducted using an air flow rate of 888 ft³/hr (or 40 ft³/min) ~~[illegible]~~ S.L. The velocity going through the drift was calculate on p.19 to be 2.12 m/s.

$\dot{m}_{air} = \rho_{air} V A$ Assume: ρ_{air} @ 77°C = 1.009 kg/m³

$A = \pi D^2/4 = \pi (.021)^2/4 = 3.46\times10^{-4}\ m^2$

$\dot{m}_{air} = (1.009\ kg/m^3)(2.12\ m/s)(3.46\times10^{-4}\ m^2)$

$\dot{m}_{air} = 7.41\times10^{-4}\ kg/s$ or $4.446\times10^{-2}\ kg/min$

Mass removal of water:

$M_{water} = \dot{m}_{air}(t)(\omega)$

$\omega = 621.98 * R.H. * \left(\frac{P_{ws}}{100P - R.H.\,P_{ws}}\right)$

$p_{ws} = A.10^{\wedge}\left(\frac{mt}{t+T_n}\right) = \cancel{6.2301\cdot10^{\frac{(7.3033)(77)}{(77)(230.0)}}}$ S.L. 10/1/97

$p_{ws} = (5.9987)\ 10^{\wedge}\left(\frac{(7.3313)(77)}{77+229.1}\right) = 419.04$ mbar

$\omega = 621.98 * R.H. * \left(\frac{419.04}{(100)(1000) - (R.H.)(419.04)}\right)$

$\omega = \frac{260636.44 * R.H.}{1\times10^5 - (R.H.)(419.04)}$

Exit Relative Humidity vs Time

						Δt (min)
R.H.	91.75%	t = 11:27				0
R.H.	~~6.19%~~ 12.44%	t = 11:27:30			S.L. 10/1/97	.5
R.H.	5.3%	t = 11:31	~~R.H. 6.24~~			4
R.H.	3.63%	t = 11:40				13
R.H.	3.5%	t = 11:42	* (heater failed)			15
R.H.	4.5%	t = 11:54			S.L. 10/1/97	27
	~~6.63%~~	~~t = 11:55~~				
R.H.	6.63%	t = 11.56				29
R.H.	14%	t = 11:57				30
R.H.	22.25%	t = 12:11				44
R.H.	31.25%	t = 12.19	→ R.H.	45.56%	t = 12:27 (60)	52
R.H.	81.56%	t = 1:11	→ R.H.	75.25%	t = 12.57 (90)	104
			→ R.H.	87.75%	t = 1:27 (120)	
R.H.	91.69%	t = 1:47				140
R.H.	93.5%	t = 1:57	* (heater fixed)			150
R.H.	15.87%	t = 3:06				219
R.H.	4.81%	t = 3:19				232
R.H.	3.31%	t = 3:29				242
R.H.	3.06%	t = 3:36				249
R.H.	2.88%	t = 3:48				261
R.H.	2.8%	t = 3:56				268
R.H.	3.06%	t = 4:06				278
R.H.	3.31%	t = 4:36				308
R.H.	4%	t = 5:06				338
R.H.	4.06%	t = 5:36				368
R.H.	4.38%	t = 6:06				398
R.H.	4.56%	t = 6:36				428
R.H.	4.81%	t = 7:06				458
R.H.	5.06%	t = 7:36				488
R.H.	5.38%	t = 8:06				518
R.H.	5.75%	t = 8:36				548
R.H.	5.81%	t = 9:06				578
R.H.	5.81%	t = 9:36				608

Mass lost (grams)	vs time	
0	t = 11:27	
191.2	t = 11:42	* ~~heater Failed~~
193.8	t = 11:55	
218.0	t = 12:01	
234.6	t = 12:40	
246.2	t = 1:11	
254.5	t = ~~1:46~~ 1:41	S.L. 10/1/97
295.6	t = 2:11	S.L. 10/1/97
	~~t = 2:41~~ * skipped because heater was being fixed.	
391.0	t = 3.06	
436.3	t = 3.46	
481.4	t = 3.56	
507.3	t = 4:16	
582.3	t = 4:46	
662.3	t = 5:16	S.L. 10/1/97
703.9	t = 5:46	
754.3	t = 6:16	
946.7	t = 6:46	
1098.2	t = 7:16	
1140.8	t = 7:46	
1290.3	t = 8:16	
1438.3	t = 8:46	
1651.8	t = 9:16	
1946.3	t = 9.46	
2290.8	t = 10.16	

Δm (grams)		Δt (min)	
0		0	
191.2		15	* ~~heater Failed~~
2.6		28	
24.2		34	
16.6		73	
11.6		104	
8.3		134	
41.1		164	* heater Fixed
95.4		219	* ~~heater Fixed~~ S.L. 10/1/97
45.3		259	
45.1		269	
25.9		289	
75		319	
80		349	
41.6		~~379~~ → 50.4	409
192.4		~~409~~ 439	
151.5		~~439~~ 469	* These errors were the result of a skipped difference on p. 54 S.L. 10/1/97
	~~42.6~~ 42.6	~~469~~ 499	
149.5	~~149.5~~ ~~42.6~~	~~499~~ 529	
148	~~148~~ ~~149.5~~	~~529~~ 559	
213.5	~~213.5~~ ~~148~~	~~559~~ 589	
294.5	~~294.5~~ 213.5	~~589~~ 619	
344.5	~~344.5~~ ~~294.5~~	~~619~~ 649	
	~~344.5~~	~~649~~	

Exit Temperatures (°c)	Time (min)	Δt (min)	temp	time	Δt
24.1	11:27	0			
68.5	11:27:30	.5			
119.25	11:31	4			
142.87	11:40	13			
111.38	11:51	24			
100	11:54	27			
86.13	11:56	29			
56.13	12:11	44			
48.75	12:19	52			
40.75	12:27	60			
31.25	12:57	90	39.63	1:11	104
28.13	1:27	120			
27.13	1:47	140			
26.75	1:57	150			
78°	3:06	219			
125.5	3:19	232			
154.25	3:29	242			
166.63	3:36	249			
173.88	3:48	261			
177.87	3:56	268			
176.75	4:06	278			
176.25	4:36	308			
176.13	5:06	338			
170.25	5:36	368			
171.13	6:06	398			
172.38	6:36	428			
173.5	7:06	458			
175.13	7:36	488			
175.38	8:06	518			
175.38	8:36	548			
177.75	9:06	578			
178.13	9:36	608			

SL 10/1/97

10/2/97

The Following displays the results From the First experiment:

Sheet1

Heating and Venting Experiment — *by Sonny Leppala*

Test # : #1
Date : 9/29/97
Start Time : ~~7:56~~ 11:00 (11:37)
Finish Time : 7:37
Flow Rate: 88 ft³/hr

* Before test R.H. = 15.84 mA
* Temp @ exit = 7.51 mA

Time (hrs)	CH 1 R.H. (%) @ Exit	CH.2 T(C) @ Exit	P1(-psi)	P2(-psi)	P3(-psi)	P4(-psi)	P5(-psi)
0	17.92	7.53 mA	.960	.991	1.135 V	.978	.941
0.5	6.24	10.86	.963	.989	1.203	.974	.952
1	~~+10.5~~ 11.29	3.86	.958	.993	1.165	.978	.982
1.5	16.04	8.10	.957	.994	.979	.990	1.125
2	18.04	7.85	.957	.986	.976	.974	1.185
2.5	18.96	7.74	.986	.992	.877	.978	1.222
3							
3.5	6.54	11.84	.921	.952	.833	.936	1.006
4	4.49	18.93	.923	.949	.840	.933	.912
4.5	4.46	19.74	1.018 ~~.924~~	1.04	~~.847~~ .956	1.031	.999
5	4.49	19.78	1.011	1.039	.87	1.029	.986
5.5	4.53	19.69	1.022	1.047	1.014	1.035	1.013
6	4.64	19.72	1.029	1.056	.943	1.042	1.020
6.5	4.65	19.29	1.033	1.060	.933	1.048	1.029
7	4.70	19.39	1.030	1.060	.953	1.045	1.027
7.5	4.73	19.48					
8	4.77	19.52	1.030	1.057	.955	.988	1.026

Time (hrs)	P6(-psi)	P7(-psi)	P8(-psi)	P9(-psi)	P10(-psi)	T1(C)	T2(C)
0	.967	.918	.968 V	.991	.928	23.3	23.3
0.5	.967	.919	.967	.900	.936	28.7	27.8
1	.961	.923	1.026	.983	.939	26.7	26.5
1.5	.972	.932	1.059	1.004	.932	26.2	26.1
2	.963	.930	1.136	1.023	.936	25.8	25.8
2.5	.963	.933	1.138	1.044	.939	25.6	25.6
3							
3.5	.924	.893	1.119	.985	.900	28.6	27.5
4	.922	.891	.922	.885	.898	36.3	32.3
4.5	1.019 ~~.937~~	.937	~~.899~~ .913	~~.907~~ .899	~~.902~~ .891	42.2	38.0
5	1.015	.988	.993	.992	.996	45.6	40.7
5.5	1.026	1.003	1.006	1.016	1.000	47.7	43.5
6	1.035	1.008	1.008	1.023	1.009	50.9	47.0
6.5	1.038	1.015	1.018	1.028	1.017	52.4	48.4
7	1.037	1.010	1.015	1.027	1.014	55.2	51.3
7.5						57.4	~~55.~~ 53.2
8	1.037	1.016	1.011	1.026	1.013	58.5	54.4

Time (hrs)	T3(C)	T4(C)	T5(C)	T6(C)	T7(C)	T8(C)	T9(C)
0	23.3	23.3	23.3	23.3	23.3	23.3	23.3
0.5	26.7	27.9	26.0	29.3	25.7	29.1	25.3

Page 1

Continued from p. 57

Sheet1

1	26.2	25.8	24.7	27.0	24.8	27.3	24.8
1.5	24.5 26.0	25.1 26.6	24.2	26.2	24.4	26.6	24.5
2	25.7	24.7	23.9	25.7	23.1	26.1	24.2
2.5	25.6	24.4	23.7	25.3	23.9	25.7	24.0
3							
3.5	25.7	24.6	25.9	25.9	24.4	26.3	24.0
4	30.1	31.4	30.9	33.8	28.5	33.6	27.2
4.5	35.3	37.2	35.3	40.6	32.8	40.8	31.4
5	37.5	39.5	37.2	43.5	34.8	43.8	33.3
5.5	40.6	42.0	39.2	46.2	36.8	46.9	35.3
6	44.3	44.5	41.6	49.3	39.4	50.5	38.1
6.5	45.7	45.5	42.6	50.4	40.4	51.7	39.0
7	48.5	47.6	44.7	52.8	42.5	54.0	41.2
7.5	50.4	49.0	45.9	54.3	43.8	56.3	42.5
8	51.7	50.0	46.9	55.4	44.8	57.5	43.6

Time (hrs)	T10(C)	T11(C)	T12(C)	T13(C)	T14(C)	T15(C)	T16(C)
0	23.3	23.2	23.2	23.3	23.3	23.3	23.3
0.5	29.2	21.6	25.3	28.0	34.7	35.9	28.7
1	27.1	21.5	24.4	26.5	31.7	30.4	27.9
1.5	26.5	21.4	24.0	25.9	29.3	28.2	27.4
2	26.0	21.2	23.7	25.4	27.7	26.9	26.9
2.5	25.8	21.1	23.5	25.1	27.0	26.2	26.6
3							
3.5	26.2	20.7	23.9	25.4	28.4	28.6	27.1
4	33.7	21.4	27.8	33.2	45.4	45.5	33.7
4.5	40.5	23.0	31.9	39.6	59.8	58.5	41.3
5	43.5	23.8	33.6	42.7	64.1	62.7	44.5
5.5	46.5	25.0	35.7	45.8/68.5	Initial	66.6	47.9
6	50.2	26.4	38.2/49.8	/72.6/72.4	Scale Reading	259.0	/52.0
6.5	51.5	27.0	39.2	50.7	1.00/214	71.7	53.4
7	54.5	28.01	41.2	53.3	76.6	75.1	56.5
7.5	56.3	28.9	42.6	55.3	79.2	77.9	58.6
8	57.7	29.3	43.4	56.5	86.4	79.3	59.8

Time (hrs)	T17(C)	T18(C)	T19(C)	T20(C)	Inlet T(C)	Mass Lost (g)
0	23.3	23.3	23.3	23.2	23.6	0
0.5	26.9	25.5	23.9	23.2	↓	218.0
1	24.2	25.6	23.6	23.3		234.6
1.5	25.9	25.5	23.8	23.5		247.8
2	25.7	25.3	24.1	23.7		254.5
2.5	25.6	25.2	24.4	23.9		295.6
3						
3.5	25.9	25.2	24.8	24.1		377.0 +14 = 391
4	30.4	27.6	25.0	24.2		430.3
4.5	36.0	31.8	25.2	24.3		507.3
5	38.6	32.2	25.6	24.5		582.3
5.5	41.5	36.7	26.4	25.1		662.3
6	45.3	40.4	28.0	26.6		703.9
6.5	46.5	41.4	28.7	27.3		754.3
7	49.5	44.2	30.7	28.8		946.7
7.5	51.6	46.3	32.3	30.0		1098.2
8	52.9	47.3	33.2	30.7		1146.8

Page 2

Continued from p. 58

Sheet1

Heating and Venting Experiment *by Sonny Leppala*

Test #:	#1 (Continued)
Date:	9/29/97
Start Time:	8:07
Finish Time:	
Flow Rate:	88 ft³/hr

* This is a continuation after 8 hrs.
* Suction pressure is reducing while moisture is still being removed and temperatures are increasing.
* Focus here will be on temperature increase and moisture removal.

Time (hrs)	R.H. (%) @ Exit	T(C) @ Exit	P1(-psi)	P2(-psi)	P3(-psi)	P4(-psi)	P5(-psi)
0 8.5	4.81 mA	19.61 mA	1.032	1.059V	.954V	.865V	1.033
0.8 9	4.86 mA	19.63 mA					
1 9.5	4.92 mA	19.63 mA	.980	1.007	.918	.931	.978
1.8 10	4.93 mA	19.82 mA	.985	1.016	.930	.877	.977
2 10.5	4.99 mA	19.85 mA	.989	1.017	.945	.883	.976
2.5							
3							
3.5							
4							
4.5							
5							
5.5							
6							
6.5							
7							
7.5							
8							

Time (hrs)	P6(-psi)	P7(-psi)	P8(-psi)	P9(-psi)	P10(-psi)	T1(C)	T2(C)
0 8.5	1.035	1.014	1.012	1.024V	1.012 V	60.8	56.9
0.8 9						62.6	58.7
1 9.5	.988	.957	.958	.977	.964	64.4	60.4
1.8 10	.989	.958	.963	.988	.965	66.1	62.1
2 10.5	.992	.958	.970	.991	.964	68.3	64.3
2.5							
3							
3.5							
4							
4.5							
5							
5.5							
6							
6.5							
7							
7.5							
8							

Time (hrs)	T3(C)	T4(C)	T5(C)	T6(C)	T7(C)	T8(C)	T9(C)
0 8.5	54.1	51.7	48.5	57.2	46.5	54.4	45.2
0.8 9	55.8	52.9	49.3	58.5	47.8	61.1	46.6

Page 1

More thermocouples will be used to capture temperature readings at more locations. These locations are intended to be located near the drift wall to evaluate gradients of temperature. Type E- thermocouples are going to be used.

Continued From P. 60

Sheet1

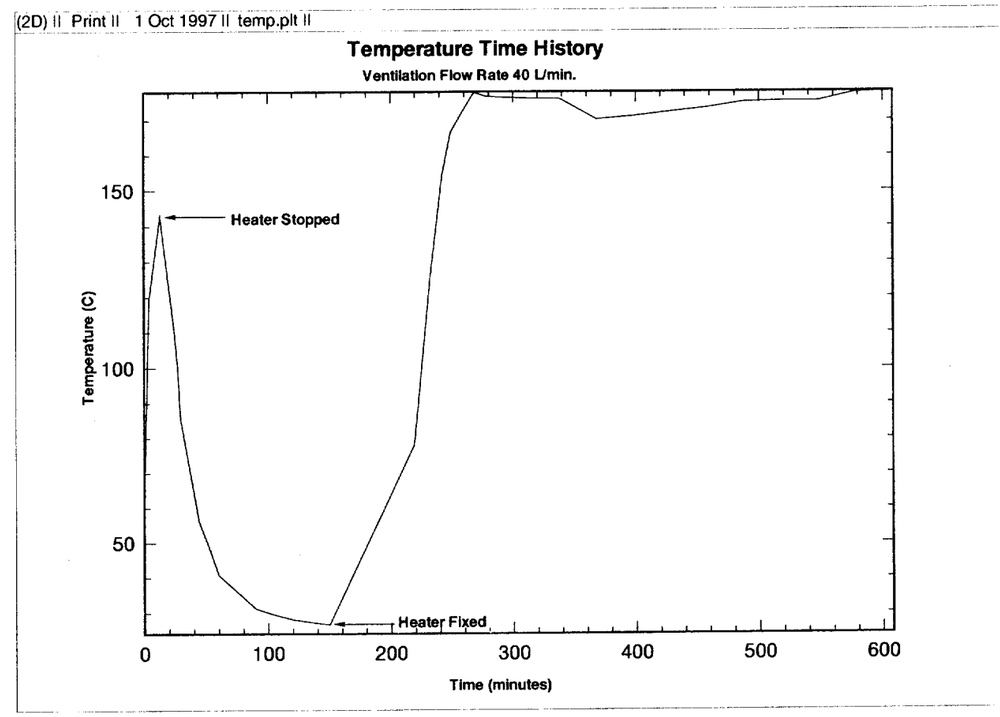
	3	4	5	6	7	8	9
1 9.5	~~54.1~~ 57.6	~~54.7~~ 54.1	~~55.~~ 55.0	~~57.2~~ 59.8	~~49.5~~ 49.6	~~54.4~~ 62.5	~~45.8~~ 47.9
1.5 10	59.7	55.4	52.4	61.1	50.4	64.7	49.3
2 10.5	63.0	56.1	53.0	61.8	51.0	65.8	51.2
2.5							
3							
3.5							
4							
4.5							
5							
5.5							
6							
6.5							
7							
7.5							
8							

me (hrs)	T10(C)	T11(C)	T12(C)	T13(C)	T14(C)	T15(C)	T16(C)
8.5	59.8	30.2	45.2	58.8	82.8	82.3	62.1
9	61.7	31.6	46.3	66.5	84.4	84.2	63.9
9.5	63.2	31.7	47.7	62.2	86.2	86.3	65.5
10	65.0	32.5	49.0	64.4	88.3	88.7	67.6
10.5	67.1	33.0	51.0	66.3	90.3	90.4	68.3
2.5							
3							
3.5							
4							
4.5							
5							
5.5							
6							
6.5							
7							
7.5							
8							

Time (hrs)	T17(C)	T18(C)	T19(C)	T20(C)	Inlet T(C)	Mass Lost (g)
8.5	55.1	49.7	35.2	32.3	23.6	1290.3
9	57.8	51.4	36.7	33.5	↓	1438.3
9.5	58.9	53.0	38.3	34.6		~~2064.2~~ 1651.8
10	60.6	54.9	40.2	36.0		1946.3
10.5	61.9	55.8	42.4	37.8		2290.8
2.5						
3						
3.5						
4						
4.5						
5						
5.5						
6						
6.5						
7						
7.5						
8						

Page 2

This displays the results in graphical form using tecplot.



Thermocouple calibration:

Type T#1 was shown to read 24.5 °C at Room temperature.

T1: 24.3

T2: 24.5 * Note T10 thermocouple gave no reading

T3: 24.5 at all. It was considered broken.

T4: 24.6

T5: 24.5

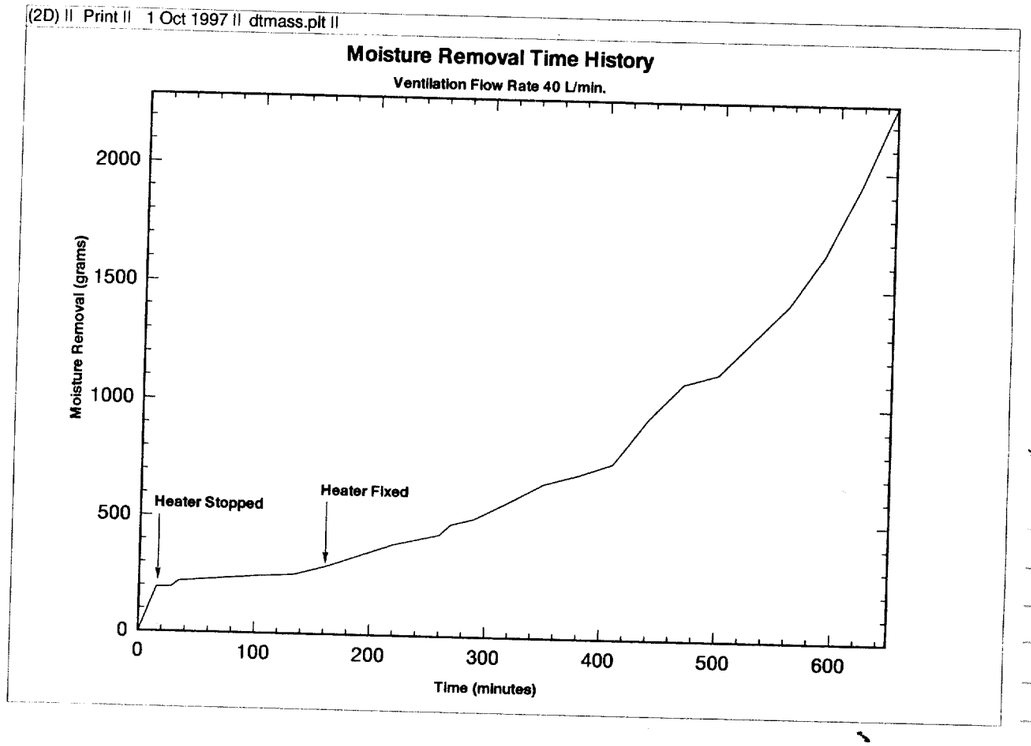
T6: 24.6

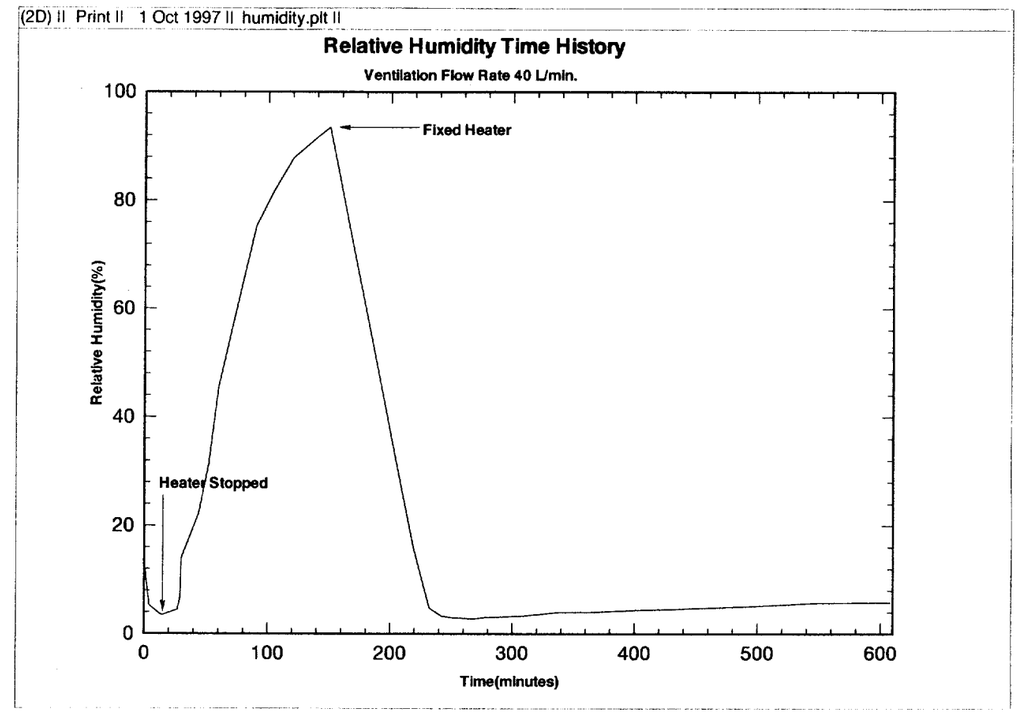
T7: 24.6

T8: 24.5

T9: 24.5

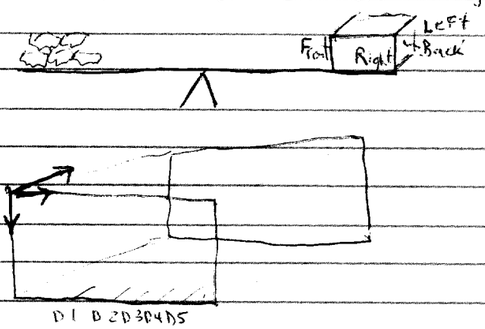
T10: [illegible]


(2D) II Print II 1 Oct 1997 II dtmass.plt II
Moisture Removal Time History
Ventilation Flow Rate 40 L/min.
Moisture Removal (grams)
2000
1500
1000
500
0
Heater Stopped
Heater Fixed
0
100
200
300
400
500
600
Time (minutes)


(2D) II Print II 1 Oct 1997 II humidity.plt II
Relative Humidity Time History
Ventilation Flow Rate 40 L/min.
Relative Humidity(%)
100
80
60
40
20
0
Fixed Heater
Heater Stopped
0
100
200
300
400
500
600
Time(minutes)

10/7/97

The media will be removed from the box and the exact locations of the instrumentation will be noted. Below shows a schematic of the Box configuration



Thermocouple locations:

	Length (in)	Width (in)	Height (in)
T1	23 1/2"	19 5/8"	9"
T2	23"	19 5/8"	8.5"
T3	22 1/2"	19 5/8"	7 15/16"
T4	23 1/4"	5 1/4"	9 1/16"
T5	23 1/4"	3 1/4"	9"
T6	23 1/4"	9 1/4"	9"
T7	22 3/4"	3 1/4"	8.5"
T8	23 1/4"	13 1/2"	8 7/8"
T9	22 3/16"	3 1/4"	8 1/8"
T10	23 5/8"	17 1/2"	8 13/16"
T11	3/16"	1"	10 1/16
T12	23 3/16"	1"	10 1/16
T13	46 1/8"	1"	10"
T14	46 7/16"	9 1/4"	10"
T15	46 7/16"	10 1/2"	10"
T16	46 1/8"	1"	9 15/16
T17	23 3/16	21 7/8"	10"
T18	3/16"	21 11/16"	10 1/8"
T19	23 1/16"	21 5/8"	1"
T20	23 1/16"	1"	19"

10/7/97

Tensiometer locations:

	Length	width	height
P1	7 1/4"	1 1/16"	10 3/16"
P2	35 1/4"	13/4"	10 1/2"
P3	39 1/8	4 1/4	11 3/8
P4	7 1/8"	9"	11 3/4"
P5	39 1/8	13 1/8	11 1/4"
P6	7"	17 1/4"	12 1/2"
P7	35 1/4"	20 15/16"	10 1/4"
P8	7 1/4	21 15/16"	11"
P9	7 1/4"	11 1/4"	9 1/8"
P10	7 1/4"	11 3/8	12 3/4"

Drift 1	middle	3"	9 3/4"
2	↓	7 1/2"	9 1/4"
3		11 1/2"	9"
4		15 1/2"	9 3/4"
5		19 3/4"	9 3/16"

10/9/97
Jay Peppel

The Following are calculations using Exel to find mass of moisture removal as a function of Flowrate.

$\Delta m = \dot{m}\,\omega\,\Delta t$

Δt - change in time
$\dot{m}$ - mass flow rate
ω - humidity ratio

Sheet1

Air Flow Rate		:	0.04446	kg/min.							
Avg. Air Temperature		:	77	C							
Partial Pressure of Water :			419.0431	mbar							
MOISTURE REMOVAL CALCULATIONS											
					Total Mass Loss:		Total Loss Using Balance Scale Readings:				
Time (min)	R.H.(%)	w (g/kg)	dm(grams)		1833.161	grams	2290.8	grams			
0	91.75	388.5022	0								
0.5	12.44	34.20631	0.760406		Difference:						
3.5	5.3	14.12749	2.198379		457.6392	grams					
9	3.63	9.607241	3.844241								
2	3.5	9.258059	0.823227								
12	4.5	11.95406	6.377728								
2	6.63	17.774	1.580464								
1	14	38.76318	1.723411								
14	22.25	63.95454	39.80787								
8	31.25	93.72185	33.33499								
8	45.56	146.7659	52.20171								
30	75.25	286.4576	382.0771								
14	81.56	322.9503	201.0172								
16	87.75	361.7147	257.3094								
20	91.69	388.0896	345.0892								
10	93.5	400.686	178.145								
69	15.87	44.30969	135.9306								
13	4.81	12.7945	7.394964								
10	3.31	8.748409	3.889543								
7	3.06	8.079071	2.514368								
12	2.88	7.598026	4.053699								
7	2.8	7.384464	2.298193								
10	3.06	8.079071	3.591955								
30	3.31	8.748409	11.66863								
30	4	10.60319	14.14253								
30	4.06	10.76499	14.35834								
30	4.38	11.62932	15.51119								
30	4.56	12.11655	16.16105								
30	4.81	12.7945	17.0653								
30	5.06	13.4739	17.97149								
30	5.38	14.34566	19.13424								
30	5.75	15.35661	20.48265								
30	5.81	15.52085	20.70172								

Note on p.57 the start time was originally 11:00, but the 1st Variac used never worked. 27 minutes elapsed with ventilation before the 2nd Variac was up and running.

Time elapsed = 27 minutes = Δt
$\dot{m}$ = .04446 kg/min
$\omega(t=0)$ = 388.5022 g/kg

$\Delta m = \dot{m}\,\omega\,\Delta t$
$= (.04446\ \text{kg/min})(388.5022\ \text{g/kg})(27\ \text{min})$
$\boxed{\Delta m = 466.36 \text{ grams}}$

New Total Mass Loss = 1833.161 + 466.36
$= \boxed{2299.521 \text{ grams}}$

New Difference = 2299.521 − 2290.8
$\boxed{= 8.721 \text{ grams}}$

10/13/97
Jay Peppel

Revisited Metra Runs by applying 480 watts of heat to each heat source. See p.26+27 for old Metra input file. This Run Failed after 6898 seconds. A New run will be can by maintaing the same heat, but adjusting the volume of the boundaries to zero.

Note: the First run stopped with the message "temperature beyond table look-up range in prtFunc and, so may have produced nonstandard Floating-point results.

S.L.
10/13/97

New Wattage will be used ~~for~~ to account for the reduction in drift tunnel length. This is due to the fact that the end Fittings to the drifts will be moved inside the box.

$\dot{Q}_{repas} = \dot{Q}_{lab}$

$\frac{8000\,W}{19m} = \frac{X}{1m}$ $\qquad \dot{Q}_{lab} = 421\ \frac{W}{m}\ (1\,m)$

$\underline{\underline{\dot{Q}_{lab} = 421\ W}}$

This require the Following voltage:

$P = V^2/R$ $\qquad R_{rope\ heater} = 28.8\Omega$

$V = \sqrt{(P)(R)}$

$V = \sqrt{(421\,W)(28.8\Omega)}$

$V = 110$ Volts

These calculations presume that each end of each drift tunnel will be pushed in 4 inches. This reduces each drift tunnel to 1 meter length. The total Drift length will be 5 meters, Compared to an assumed 1.2 Km repository drift tunnel which has been scale using a 240:1 ratio

The Metra Run Failed just as before. The volumes were set back to .01 and the heat was adjusted to 421 Watts. (Volumes @ the boundaries)

10/16/97 The Metra input file was adjusted on the 15th of October. The heater and drift conductivities were changed to 50 ± 20 w/mK respectively. The run lasted longer than before running to 1.02×10^4 seconds. The Next run will utilize the same input file but with reduced heat. The heat will be adjusted from 421 to 321 Watts.

10/17/97 Metra Run Failed after 1.64×10^4 seconds. This run utilized 321 Watts for the heat Source. Once again, the temperatures were beyond table lookup range in the pit func.

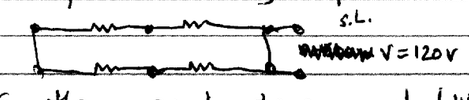
10/20/97 The new design for the drifts involves reducing the length of the drifts and placing the Fittings that connect the drifts inside the box. The Fittings will be changed to a non-corrosive material to avoid oxidation. Yet, the material must withstand high temperatures. One possible tubing to be use will be 1 in Soft Copper tubing.

10/20/97 Metra Run was adusted by reducing the heat to 250 Watts. This Heat Source has been applied successfully in the past.

11/3/97 Set up experiment with new tensiometer locations, extra thermocouples, different fittings located inside the Box and a new rope-heater setup. The tensiometers were improved using extra hose clamps and duct tape. The humidity Sensor at the outlet was setup such that it would not sit directly on the outlet Fittings.

The First attempt to turn on the rope heater with all the instrumentation hookedup caused a power failure of the multiple outlet power supply. An Ampmeter was used to evaluate amperage through the rope heaters and into the variac. No reading was recorded because of the immediate power failure. Technicians were called in to investigate the problem and found that one of the rope heaters may not be working or somewhere inside the box the wires from the rope heater are not connected properly.

11/5/97 Rope Heater were taken out of the box. One Rope heater was cut in half. Today the Following rope heater orientation was set-up:



The temperature of the rope heaters reached 145°C.

11/9/97

Started experiment 2 at 10:00. Note; the Power supply for the tensiometers was 1 Volt too high for the initial readings

After evaluating the 1st 2 hrs of results, it appears that T6 has been moved slightly upward. This is causing the temperatures at this spot to be read lower than what they should be.

Note: The Air to ventilate was turned on approximately 10 minutes before recording scale measurements. Moisture may have been removed in this time from, therefor future test will start off with 10 minutes of ventilation without heat.

Note: This experiment is being conducted with the variac set at 100% in an attempt to reach Boiling isotherm temperatures.

Note: After 3.5 hrs, Moisture removal has been recorded to be 100 grams less than the 1st experiment. Possible Reasons for difference:

(1) Drift length is 32 inches shorter
(2) Ventilation was turned on without heat 10 minutes prior to the start of the experiment.
(3) losses of water from tensiometers.

Note: The drift reduction is 32 inches. Therefor the drift was 240 inches and is now 208 inches. This is a 13% reduction where the majority is at the center 3 drifts. This is important because the temperatures are higher at the center of the drift.

Note; the air exit temperature is more representative of the air as opposed to the heated fittings the the humidity sensor based upon before.

11/9/97

Note: There is approximately a 5 minute lapse between measurements T(1-20) and J(21-28). This may be causing a problem in interpreting the nature of the thermal gradients. At 5.5 hours, the readings will be ~~meas~~ recorded such that only one minute will lapse between measurements.

Note: At 5.5 hrs, every tensiometer reading dropped and some made the largest drop since the start of the experiment.

Note: Relative Humidity at exit is up to 99.6%. The Fitting at the exit of the box may be trapping alot of the moisture. The tensiometer #7 at the exit of the box is showing the highest positive pressure.

11/13/97

The Following are results obtained in experiment #2:

Average Inlet temperature: 28.7 °C
Average Air temperature @ exit: 8.48 mA or 35.97 °C
Air flow rate: .04446 kg/min.
Partial Pressure of water: 59.28 mbar

% R.H. @ exit = $\frac{\text{reading (mA)} - 4}{16} * 100$

Time	% R.H. @ exit
0	99.75
.5	94.75
1	83.0
1.5	81.38
2	82.06
2.5	83.63
3	83.38
3.5	86.38
4	86.44
4.5	88.19
5	87.75
5.5	88.0
6	88.75
6.5	93.56
7	96.56
7.5	99.56

Time	R.H.
8.0	100%

→ Note Average air temp in drift

$T_{AVG} = \frac{28.7 + 35.97}{2} = 32.19$ °C

$$T = \left[\frac{\text{Reading (mA)} - 4}{16} * 200\right] - 20$$

Time (hr)	Temp (°C)
0	31
.5	29.75
1	33
1.5	34.5
2	35.38
2.5	35.88
3	36.5
3.5	36.5
4	37.88
4.5	~~38.38~~ 37.63
5	~~38.38~~ 38.38
5.5	39.25
6	39.5
6.5	39.25
7	39.38
7.5	39.5
8	39.38

for Peppla 11/14/97

Note to self involving ventilation:

It is expected that lower flow rates will remove more moisture. This is due to the fact that humidity ratio is highly dependent on temperature. Higher flow rates will modify (i.e. lower) temperatures whereas lower flowrates will not lower temperatures as much. Therefor the capacity for air to hold moisture is much greater at lower flow rates.

11/18/97 for Peppla

The Following are the results for the tensiometers converted from volts to pascals. $P = (V-1) * -3$ [psi]

101325 Pa = 14.696 psi

1 psi = 6894.7 pa

$$P = \left[(V-1) * -3\right] \frac{6894.7 \text{ Pa}}{1 \text{ psi}}$$

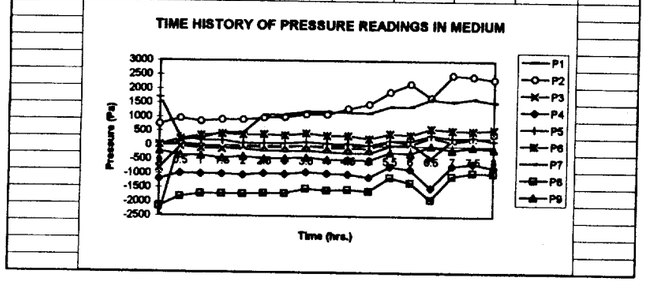
$$P = (V-1) * -20684.2 \quad [\text{Pa}]$$

Sheet1

TENSIOMETER READINGS FOR EXP#2									
TIME (hrs.)	P1(Volts)	P2(Volts)	P3(Volts)	P4(Volts)	P5(Volts)	P6(Volts)	P7(Volts)	P8(Volts)	P9(Volts)
0	0.998	0.964	1.039	1.058	0.918	0.999	1.12	1.105	1.01
0.5	0.997	0.954	1.002	1.048	0.986	0.989	0.991	1.068	1.017
1	1	0.959	1.005	1.049	0.991	0.983	0.988	1.063	1.018
1.5	1.005	0.956	1.006	1.049	0.992	0.98	0.978	1.063	1.022
2	1.007	0.956	1.002	1.051	0.996	0.982	0.978	1.063	1.019
2.5	1.009	0.953	1.003	1.048	0.996	0.981	0.948	1.062	1.023
3	1.01	0.952	1.003	1.049	0.996	0.983	0.947	1.062	1.022
3.5	1.009	0.947	1	1.046	0.994	0.979	0.942	1.074	1.021
4	1.011	0.947	1.004	1.048	0.996	0.983	0.942	1.077	1.024
4.5	1.013	0.937	1.004	1.049	0.997	0.983	0.943	1.075	1.024
5	1.013	0.929	1.005	1.054	0.999	0.988	0.944	1.078	1.025
5.5	1	0.908	0.991	1.036	0.991	0.979	0.933	1.054	1.011
6	0.998	0.894	0.995	1.04	0.991	0.981	0.933	1.063	1.013
6.5	0.985	0.917	1.021	1.072	0.982	0.97	0.92	1.092	1
7	0.993	0.879	0.989	1.034	0.986	0.973	0.924	1.052	1.007
7.5	0.988	0.881	0.986	1.03	0.985	0.974	0.919	1.046	1.002
8	0.988	0.886	0.987	1.037	0.991	0.972	0.925	1.047	1.005
TIME (hrs.)	P1(Pa)	P2(Pa)	P3(Pa)	P4(Pa)	P5(Pa)	P6(Pa)	P7(Pa)	P8(Pa)	P9(Pa)
0	41.3684	744.631	-806.684	-1199.68	1696.1	20.6842	-2482.1	-2171.84	-206.842
0.5	62.0526	951.473	-41.3684	-992.842	289.579	227.526	186.158	-1820.21	-351.631
1	0	848.052	-103.421	-1013.53	186.158	351.631	248.21	-1716.79	-372.316
1.5	-103.421	910.105	-124.105	-1013.53	165.474	413.684	455.052	-1716.79	-455.052
2	-144.789	910.105	-41.3684	-1054.89	82.7368	372.316	455.052	-1716.79	-393
2.5	-186.158	972.157	-62.0526	-992.842	82.7368	393	1075.58	-1696.1	-475.737
3	-206.842	992.842	-62.0526	-1013.53	82.7368	351.631	1096.26	-1696.1	-455.052
3.5	-186.158	1096.26	0	-951.473	124.105	434.368	1199.68	-1530.63	-434.368
4	-227.526	1096.26	-82.7368	-992.842	82.7368	351.631	1199.68	-1592.68	-496.421
4.5	-268.895	1303.1	-82.7368	-1013.53	62.0526	351.631	1179	-1551.32	-496.421
5	-268.895	1468.58	-103.421	-1116.95	20.6842	248.21	1158.32	-1613.37	-517.105
5.5	0	1902.95	186.158	-744.631	186.158	434.368	1385.84	-1116.95	-227.526
6	41.3684	2192.53	103.421	-827.368	186.158	393	1385.84	-1303.1	-268.895
6.5	310.263	1716.79	-434.368	-1489.26	372.316	620.526	1654.74	-1902.95	0

Sheet1

7	144.789	2502.79	227.526	-703.263	289.579	558.473	1572	-1075.58	-144.789
7.5	248.21	2461.42	289.579	-620.526	310.263	537.789	1675.42	-951.473	-41.3684
8	248.21	2358	268.895	-765.315	186.158	579.158	1551.32	-972.157	-103.421



11/21/97 by [illegible]

I spoke with Randy Mantenfel and he suggested the following:

(1) Better insulate inside of box using styrofoam
(2) move thermocouples to driftwall location and remove those that provide gradients above drift.
(3) use a male-T×Run fitting for outlet
(4) Check to see pressure as a function of tensiometer displacement because tensiometer reading have a great deal of variability. (induce suction due to gravity and see how small transducer displacenest affect suction pressure output.
(5) tensiometers are acting as heat pipes causing temperatures to be higher.
(6) monitor temperatures inside drift by pushing the thermocouple from the drift wall into the drift after the dowels are pulled out.

11/25/97 by [illegible]

I continued to build the background for thesis report. Several papers were provided to me by Randy Mantenfel. Some of those papers were highlighted to emphasize key points involved in theoretical development and repository design.

12/1/97

Tensiometer measurements are being evaluated. Note the following tensiometers have 2cm or 196.2 Pa additional pressure head: P1, P2, P7, P8. This 2cm displacement will be compared using a manometer and a syringe for suction to evaluate how this displacement effects the pressure transducer measurements. ~~2.5~~ 5cm of suction will be initially applied. S.L. 12/1/97

$P = \rho g h = (1000\ kg/m^3)(9.81\ m/s^2)(.05\ m) = \cancel{490.5\ Pa}$ 245.25 S.L. 12/1/97

The corresponding reading from the transducer was 1.156 V

$P = (V-1) * -20684.2 = -3226.7\ Pa$ (for ~~7~~ 5cm suction) S.L. 12/1/97

Now reduce by 2cm suction to ~~7cm~~ ~~0.05~~ 5cm = 5cm S.L. 12/1/97

$P = \rho g h = (1000\ kg/m^3)(9.81\ m/s^2)(.005\ m) = \cancel{294.3\ Pa}$ 49.05 Pa 12/1/97 S.L.

ΔP (static from manometer) = ~~196.2 Pa~~ $\boxed{196.2\ Pa}$ S.L. 12/1/97

The corresponding reading from the transducer was 1.045 V

$P = (V-1) * -20684.2 = -930.74\ Pa$

For a 2cm difference pressure head $\boxed{\Delta P\ (\text{transducer}) - 2245.91\ Pa}$

12/9/97

At 11:05 experiment # 3 was started. The following changes were made for this experiment:

(1) The Boundaries were insulated more tightly.
(2) The majority of the thermocouples were located at the drift wall.
(3) The tensiometers were relocated such that they were all on the same plane as the center of the drifts.
(4) A male Run Tee was used as the exit or outlet fitting that holds the humidity sensor.
(5) Low flow rate at 53.3 ft^3/hr.

Observations:

(1) Less moisture removed at lower flowrate.
(2) Higher temperatures exist at drift wall.
(3) Tensiometer readings are difficult to understand.

After 5.5 hrs the following are results from the high flowrate (88 ft^3/hr) and low flow rate (54 ft^3/hr) experiments:

	Low (°C)	high °(C)
T1	30.6	30.0
T8	34.5	34.0
T6	35.7	39.2
T5	33.8	34.3
mass loss	255.5 grams	447.3 grams
outlet R.H. (%)	67.5	88
outlet T(C)	42.1	39.25

12/10/97

Results from experiment #3:

Time	R.H.%	Temp (c) → @ outlet
0	99.69	18.88
0.5	65.63	32.25
1	59.81	35.38
1.5	58.81	37.25
2	59.06	38.00
2.5	59.31	39.13
3	62.56	38.88
3.5	63.94	39.50
4	65.38	40.25
4.5	64.06	41.75
5	67.06	41.38
5.5	67.5	42.13
6	67.44	43.25
6.5	70.0	43.25
7	67.75	45.00
7.5	69.31	45.13
8	68.94	46.00

10/5/97 [illegible]

The measured value of alumina was found to be 2991 kg/m^3 From p. 5. Today, bentonite was evaluated to determine its density. A beaker weighing 29.514 grams was used with 10 ml or 10 cm^3 of bentonite. The combination of beaker and bentonite weighed 38.092 grams.

$$m_{bentonite} = (38.092 - 29.514)\,g = 8.578\ g$$

5.4
12/5/97

$$\rho_{bentonite} = \frac{m}{V} = \cancel{8.78} \quad \frac{8.578\,g}{10\,cm^3}$$

$$\rho_{bentonite} = .8578\ g/cm^3 \text{ or } 857.8\ kg/m^3$$

$$\text{Total density} = \left[.95\,(2991) + .05\,(857.8)\right] kg/m^3$$

$$\text{Total density} = 2841.88\ kg/m^3$$

2/9/98
[illegible]

I am making preparations to rerun the high ventilation flow experiment. Alan, the electrician came in to take readings from the rope heater that has been placed in the box. The following was recorded:

Voltage from wall : $V = 117.8\,V$
Voltage from variac : $V = 117.5\,V$
Current through heater : $I = 4A$
Resistance through heater : $28\,\Omega$

$$P = V^2/R = (117.5\,V)^2/28\,\Omega = 493 \text{ Watts}$$

2/10/98
[illegible]

Rerunning high ventilation flow experiment. Experiment start time is 10:00 A.M. The first moisture removal reading was 112.9 grams. This is close to the last high ventilation flow rate experiment where moisture removal was 139.9 grams. The moisture removal for the low flowrate experiment was 56.3 grams. Initially, temperatures are pretty much the same for the high + low flowrate experiments. So moisture removal would be solely dependent on flowrate. All the gradients above the drifts are consistant such that temperatures are warmer at drift wall and slightly cooler away from the wall. One exception is J24 which is reading unusually low. It may be broken.

Moisture Removal observation: The largest percentage of moisture is removed in the 1st hour. This agrees with the prior experiments. After 2 hours moisture removal is greater for this experiment then it was for the last high ventilation flow rate experiment. This may be because the last high flowrate experiment had a moisture trap at the outlet.

Final Entry:

This Notebook appears to comply with QAP-001.

E. C. [illegible]
2/8/2000