THERMOHYDROLOGY

21

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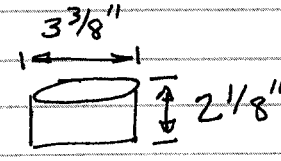
MIKE LEWIS

3/20/90 Establish Capillary Curve for # 2740 beads
Michael [illegible]

Volume of Tempe Cell w/ Beads



Vol. #2740 Beads $= \frac{\pi (3.375)^2}{4} (2.125) = 19.01 \text{ in}^3 = 311.52 \text{ cc}$

~~porosity $n = \frac{311.52 \text{ ml}}{108.5 \text{ ml}} = 34.83\%$~~ [illegible]

SATURATE BEADS VIA TITRATION OF DEIONIZED H_2O

water Balance

add + 50 ml
+ 50 ml
+ 8.5 ml
108.5 ml

Let Drain 3/20 12:45p 0 ml
3/20 6:15p .2 ml
−.2

$\boxed{\text{Total Volume Water} = 108.3 \text{ ml}}$

Porosity $= n = \frac{V_V}{V_T} = \frac{108.3 \text{ ml}}{311.5 \text{ ml}} = 34.76\%$

WEIGHT OF SATURATED BEADS + TEMPE CELL

1480.4 gm

Check pressure applied to tempe cell by integral use of both digital pressure transducer

Brainard Kilman model SN
with Digital Readout SN
and U-Tube manometer w/ 1.75 Gs Blue (Merriam Corp.)

PRESSURE	DATE	TIME	ELAPSED TIME (min)	EFFLUENT (ml)	Δ (ml)
1.0 psi 15.6" Manometer @ .06323 psi/in = .986 psi	3/20 3/21	6:30p 6:35p 7:10a	0 5 760	3.4 ml 5 ml 6 ml	2.6
2.0 31.4" Manometer @ .06323 psi/in 1.98 psi	3/21	7:10a 1:00p 7:40p	0 350 750	6 22 24	18
2.5 (19.7)2 = 39.4 @ .06323 psi/in = 2.49 Manometer	3/21 3/22	7:40p 7:30p	0 1430	24 47 ml	23
3.0 47" Manometer @ .06323 = 2.97 psi	3/22 3/23	7:30p 8:20a	0 770	47 84	37 * Pressure leak discovered 3/23
3.5 above Manometer range	3/23	8:30a 11:30a 1:50p	0 180 320	84 88 89	10
	3/26	8:45a	1455	94	
4.0	3/26 3/26 3/27	8:45a 4:45p 11:15a	0 480 1590	94 94.5 95	1 ml
6.0	3/27 3/28	11:15a 12:30p	0 1515	95 98	3
8.0	3/28 3/29	12:30p 11:15a	0 1395	98 98	0

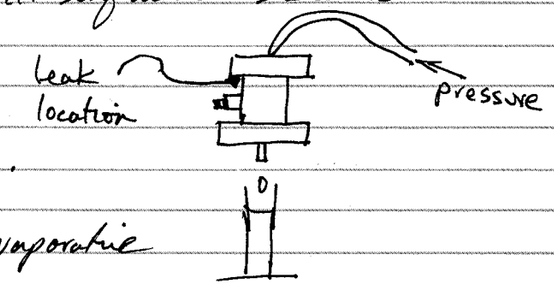
2/29/90 Analysis of Test Results

Michael [illegible]

Final wt. of Beads + Tempe Cell 1373.3 gm

Note: A pressure leak was discovered 3/23 and is believed that it will influence results

The leak was located on the upper O-ring seal at the brass ring interface.



It is believed that some evaporative losses were possible.

Mass balance 1480.4 gm SATURATED
− 1373.3 gm ~~Dry~~ (at test conclusion)
107.1 gm @ 1 g/cc (H_2O) = 107.1 cc

Water balance 108.3 ml START
− 98 ml EFFLUENT
10.3 ml
+ (108.3 − 107.1)
9.1 ml unaccounted for
* probably due to evap loss through system leak

Assuming the evap. loss is uniform throughtime we might distribute this loss and still arrive at a generally correct estimation of capillary-saturation relationship

Make this assumption and carry forward the data reduction

START TIME 3/20 6:30p
STOP 3/29 11:15a
> 12525 minutes

$$\frac{9.1\ \text{ml}}{12525\ \text{min}} = 7.265\times10^{-4}\ \text{ml/min}$$

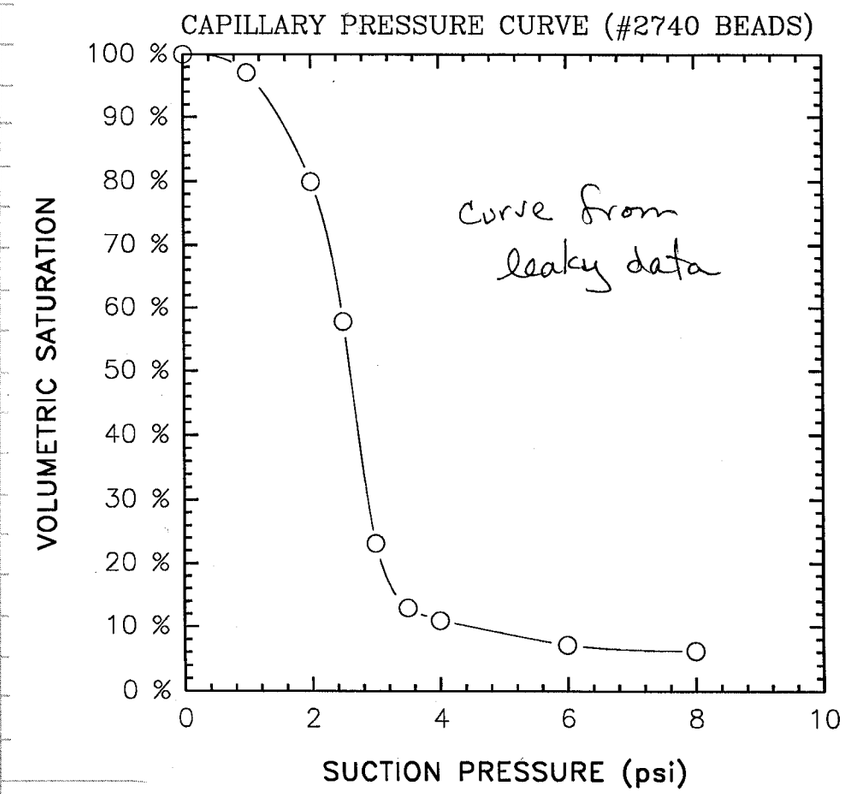
corrected Δ = (Duration)*(7.265×10⁻⁴ ml/min) + Δ

CAPILLARY PRESSURE	DURATION	Δ	corrected Δ	SATURATION
1.0	760	2.6	3.15	97.1
2.0	750	18	18.54	79.9
2.5	1430	23	24.04	57.8
3.0	770	37	37.56	23.1
3.5	1455	10	11.06	12.9
4.0	1590	1	2.15	10.9
6.0	1515	3	4.10	7.1
8.0	1395	0	1.01	6.2

SATURATION

$$\frac{V_v - \Sigma\Delta}{V_v} = \frac{V_w}{V_v}$$

This curve needs to be verified with another test in which the leak is not present.



5/17/90 Capillary Pressure Curve

Glass Beads #2740 and #812 mixture

Use 50/50 mix by volume

Add 400ml #812 beads to 1000ml beaker

Add 400ml #2740 beads to same beaker

Stir mix then, pour into another beaker back + forth until completely mixed ~ 2 to 3 minutes mixing time

Wt. dry w/ Bead mixture 1435.9g

Saturate using de Ionized H_2O using Titration pipet

+50ml
+50ml +.2ml
+.1ml
~~100ml~~ MJL 5/17/90

Total 100.2ml but .1ml overflow

Specimen full w/ 100.1ml

Allow to free gravity drain + measure effluent

11:28pm Michael J. Lewis Jr. 5/17/90

5/17/90

1.8ml free drained @ 3:15pm

Total saturated water volume = 100.1ml
− 1.8ml
98.3ml

Saturated total weight of beads + container 1532.9g

1532.8g
−1435.9g
~~97.9g~~ MJL 5/17/90
97.9 grams

Triple Regulate Pressure
initial { Reg 1 − 10psi
Reg 2 − 2psi
Reg 3 − .2psi

PRESSURE LEVEL	Date	TIME	ELAPSED TIME (MIN)	EFFLUENT (ml)	Δ (ml)	SATURATION %	Evaporation Control Check
.2 psi	5/17/90	4:35p MJL	0	0			
3.1" 1.75 Blue	5/18	8:10a	935	1.5	1.8	98.16	3ml
	5/19	12:00p	2605	MJL 5/19/90 ~~2.0~~ 1.8			3ml
.4 psi	5/19	12:00p	0	1.8			3ml
6.3" 1.75 Blue	5/21	8:05a	2640	2.3	1.4	96.73	3ml
.6 psi	5/21	8:05a	0	2.3			3ml
9.5" 1.75 Blue	5/22	3:20p	1875	4.0	1.7	95.00	3ml
.8 psi	5/22	3:25p	0	4.0			3ml
12.6"	5/24	9:45a	2540	4.8ml	0.8	94.18	2.9ml
1.2 psi	5/24	9:45a	0	4.8ml	~~0.6~~ MJL	6/15/90	2.9
18.9" 1.75 Blue	5/25	1:05p	1640	5.4ml			2.9

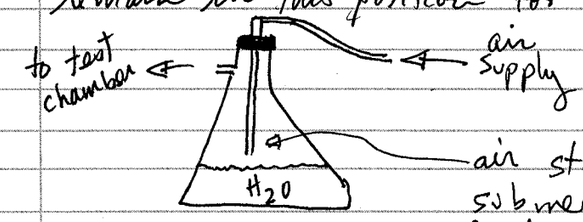
Pressure Level	Date	Time	Elapsed Time (min)	Effluent (ml)	Δ (ml)		Evap. Control
1.2 psi	5/25/90	6:00p	1935	5.5ml	0.7	93.47	2.9
1.6 psi	5/25	6:00p	0	5.5ml	12.2	81.02	2.9
25.2" 1.75 Blue	5/28	8:00a	3720	17.7 ml			2.82
2.0 psi	5/28	8:00a	0	17.7ml			2.82
31.6" 1.75 Blue	5/28	4:16p	490	42.0 ml			2.80
	5/29	10:00a	1560	55.5 ml	38.3	41.19	2.80
	5/29	2:00p	1800	56.0 ml			2.80
2.4 psi	5/29	2:00p	0	56.0 ml			2.80
38" 1.75 Blue	5/29	2:50p	50	61.0 ml			2.80
	5/30	10:40a	1240	73.0 ml	17.0	24.59	2.80
	5/31	2:30p	2910	73.0 ml			2.78
2.6 psi	5/31	2:30p	0	73.0 ml			2.78
41.1" 1.75 Blue	6/4	8:30a	5400	77.0 ml	4.0	20.51	2.65
2.8 psi	6/4	8:30a	0	77.0 ml			2.65 ml
44.3" 1.75 Blue	6/5	8:45a	1455	81.0 ml	4.0	16.43	2.63 ml
	6/5	4:15p	1905	81.0 ml			2.63 ml
3.0 psi	6/5	4:15p	0	81.0 ml			2.63 ml
47.4" 1.75 Blue	6/6	3:10p	1375	84.5 ml	3.5	12.86	2.60 ml
3.4 psi	6/6	3:15p	0	84.5 ml			2.60 ml
	6/7	11:00a	1185	87.8 ml	3.5	9.28	2.60 ml
	6/7	5:20p	1565	88.0 ml			2.60 ml

5/18/90 Michael Johnson Jr

Use an evaporation control to check the effect upon the effluent collected in the graduated cylinder. Start w/ an open 10cc graduated cylinder surface area approx 1cm² with 3 ml water (deionized) standing open to air. Check @ regular intervals with effluent measurements.

At the same time the pressure lines were inspected for leaks and the test chamber was also inspected for leaks, none were found.

The air line is run into a container having a free water surface to allow humidification of the air supply. As a check, the stem of the supply line was submerged and no bubbling was detected which indicates that the air pressure is static and that no appreciable air leaks are present. The pipe (supply) was then withdrawn from the water to eliminate any additional H_2O head. It will remain in this position for the remainder of the test.



air stem which was temporarily submerged to check for system leaks. None were detected.

Michael Johnson Jr

5/25/90 Check for air leaks – none found

Michael Johnson Jr

5/29/90 Check for air leaks – none found

Michael Johnson Jr

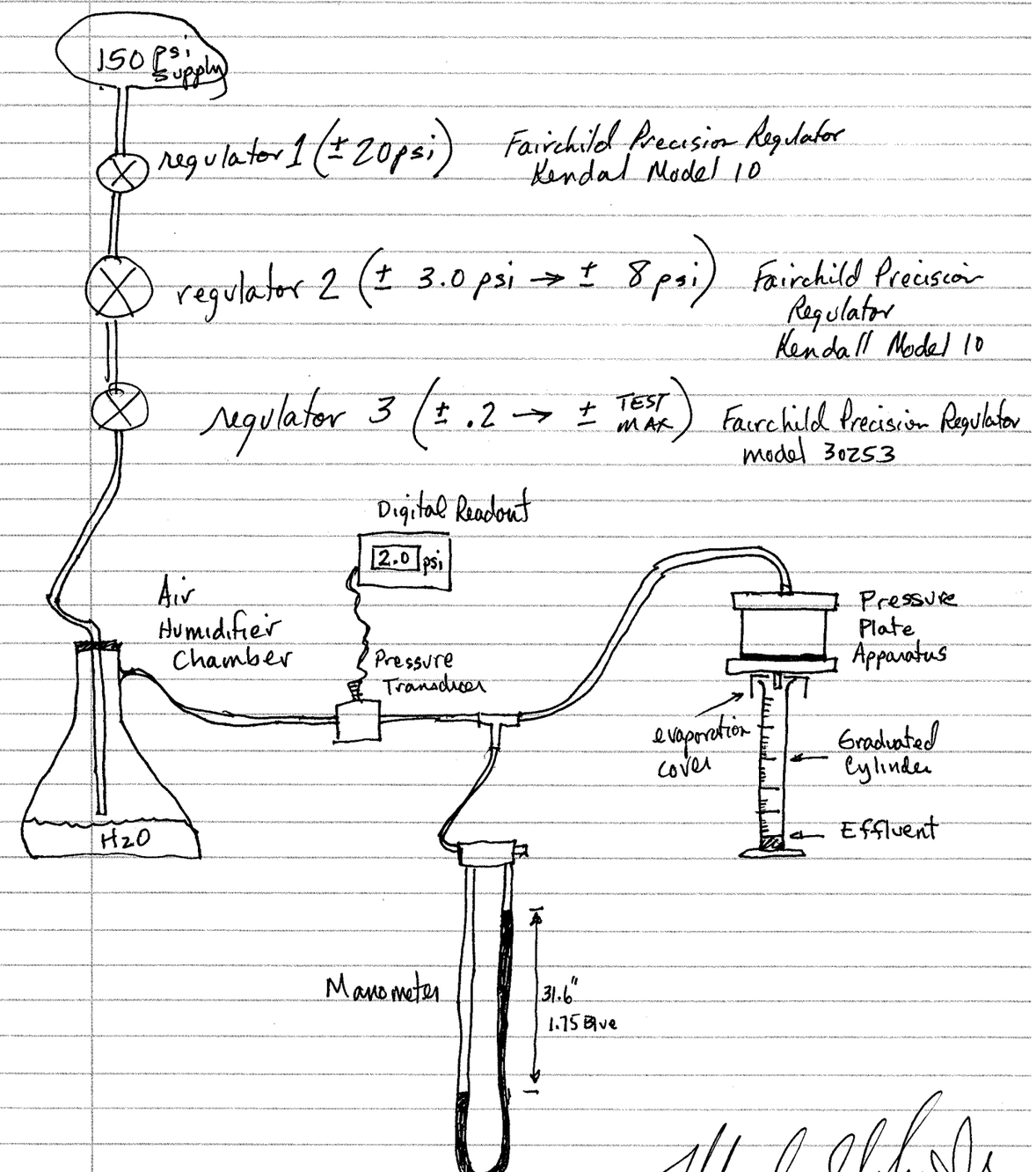
5/29/90 A U-tube manometer is used to verify all input air pressures. A blue oil having specific gravity of 1.75 in a manometer with a 50" range allows a limit of 3.16 psi to be registered. A digital readout is also used in conjunction with a diaphram type transducer in series with the manometer. The digital readout and transducer are Brainard Kilman E124 0-150 psi transducer SN 206
E400 readout SN-341

The combination was factory calibrated and is concurrently calibrated during the test using the manometer. In the pressure range > 3.0 psi, the transducer is accurate to better than 0.1 psi and therefore is considered adequate for pressure determination above the range of the manometer.

Michael J Lewis

5/29/90

A rough diagram of the test set-up:



Michael J Lewis

6/4/90 Check for leaks in air flow system — none found

Michael [illegible]

Pressure Level	Date	Time	Elapsed Time (min)	Effluent (ml)	Δ (ml)		Evap. Control
4.0 psi	6/7	5:20p	0	88.0 ml			2.60 ml
	6/8	9:10a	950	89.0 ml	1.5	7.76	2.6 ml
	6/11	9:00a	3820	89.5 ml			2.5 ml
6.0 psi	6/11	9:00a	0	89.5 ml			2.5 ml
	6/12	1:30p	1710	89.9 ml	0.4	7.35	2.45 ml
12.0 psi	6/12	1:30p	0	89.9 ml			2.45
	6/14	5:30p					

terminate test due to blown seal on the humidifier arrangement

6/11/90 Increased pressure to 6.0 psi and checked for leaks by inserting humidifier rod below the water level. Pressure was found to be static with no air leak in the system.

Michael [illegible]

6/15/90 Data Reduction

① Calculate Elapsed Time for each increment
② Calculate effluent difference each increment
③ Calculate Saturation

$$\%S = \frac{V_{water}}{V_{void}} = \frac{V_{void} - \Sigma\Delta}{V_{void}}$$

By weight - the total saturated void volume = 97.9 ml
By volume - " " " = 98.3 ml

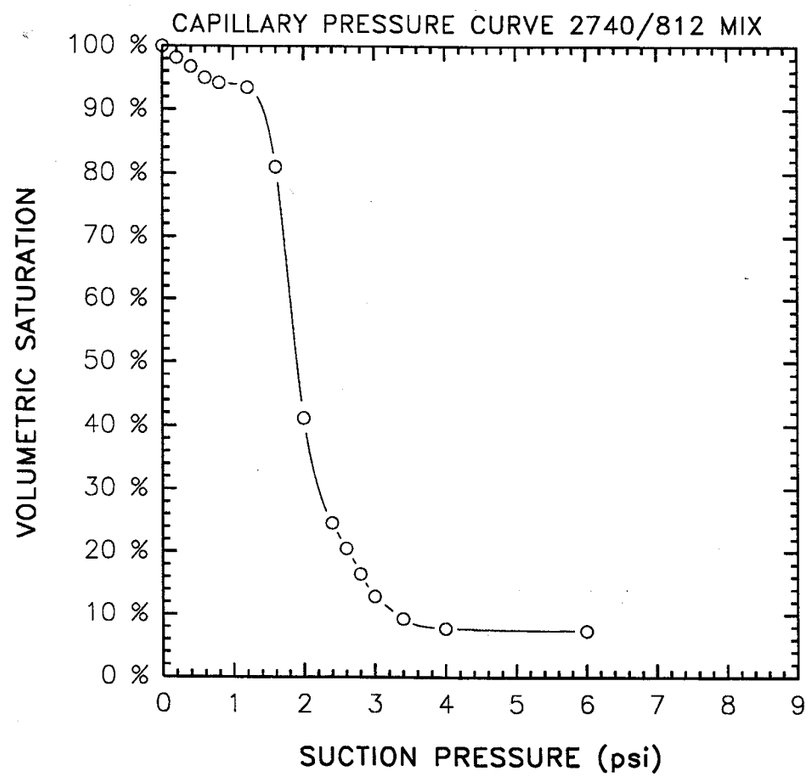
∴ Assume V_{void} = 98 ml

Note: The test could not be completed @ the 12 psi pressure due to a blown seal on the humidifier arrangement which allowed the test to be corrupted.

Total evaporation = 3.0 ml − 2.45 ml = 0.55 ml
This is not perceived to be significant

and is an upper limit bound on the evaporation in the effluent. The surface area exposed to the atmosphere was less in the covered effluent cylinder.

Michael J Lewis Jr. 6/15/90



Notebook closed out 11/13/92 [illegible]