PROBLEMS OF REAL TIME RADON MEASUREMENT

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ABSTRACT

The author, during a series of six radon equipment comparison tests in the basement of his own residence, encountered a number of difficulties with the handling and accuracy of the test equipment. Between the comparison tests, the author accidentally discovered that the outdoor levels at his residence were significantly higher than what is typically believed to be outdoor radon concentrations. A number of tests were performed to document this and to determine variations in radon levels due to height of the sampling above grade. This paper reveals the results of those tests and includes a discussion of some plausible reasons for the difficulties of certain instruments to properly measure radon and some suggestions as to possible remedies.

INTERCOMPARISON

Most of the measurements made in this report were done at the author's personal residence located in Bucks County, Pennsylvania, which is in the Eastern part of the state. The house is wood frame, approximately 100 years old. The foundation is constructed of rubble stone, the basement floor is concrete with a vapor barrier under it, but no sub-floor gravel. The heating system is oil fired hot water. A radon sub-slab system was installed a few years ago. There are three suction points into the sub-slab with the exhaust pipe work run outside and then below grade to a fan installed about thirty feet from the house in some shrubbery. The radon levels in the basement, with the fan system turned off, vary from 5 to 60 pCi/Lit. The levels on the first and second floor are considerably less because the ceiling of the basement is insulated with sprayed-in-place urethane, creating a very tight air seal and the basement door is weather-stripped. With the radon system running, the basement levels vary from about 1 to 5 pCi/Lit. All radon comparison tests were done with the sub-slab system turned off. The basement temperature varied from 58 to 61 degrees. The humidity varied from 70% to 85%. There are no windows in the basement and no measurable air flow. The radon comparison measurements in the basement were repeated six times.

FIRST TEST

The first test was run for three days, 2/3/89 to 2/6/89, to compare the performance of my AB5 Pylon with a passive radon detector (PRD) to a Femto-Tech continuous radon monitor that was on loan from the EPA. Four charcoal test kits were also included. The Femto-Tech measured only slightly lower than the Pylon by 3%. *Graph one* shows that while the two continuous monitors averaged close to each other overall, the hourly data shows much larger swings for the Femto-Tech. This would be due to the lower sensitivity of the Femto-Tech. Four charcoal samples from four different charcoal companies exposed at the same time however ranged from 28% to 64% higher compared to the Pylon. The overall average of the charcoal kits was 51% higher. Two At Ease monitors measured 24.7% and 55.7% higher and were returned to the manufacturer for re-calibration.

SECOND TEST

A second test was run for two days, 4/4/89 to 4/6/89, to repeat the comparison test of the Femto-Tech and the Pylon and to include some recently purchased E-Perm test kits and to repeat the charcoal canister measurements. This time the Femto-Tech measured slightly high compared to the Pylon by 6.7%. I had just purchased E-Perms and included them in this test. Two E-Perms measured about 7% lower than the Pylon while one was 5.6% higher and another was 19.5% higher. Only two charcoal canisters, were exposed this time. *OFCC3* measured 25.1% lower and *OFEC1* measured 36.9% higher than the Pylon.

THIRD TEST

A third test was done to better compare the performance of charcoal canisters and E-Perms. The test exposure period was three days, 4/28/89 to 5/1/89. This time, duplicate canisters were run for each method. Two of the charcoal companies, OFCC2 and OFEC3, measured less than one percent different from the Pylon. The three E-Perms averaged within 3% of the Pylon, with the largest variation only 7% different. Two OFCC4 test kits were 9% and 16% higher than the Pylon. Four test kits from OFEC1 averaged 52.3% higher than the Pylon, while OFEC2 averaged 71% higher. I questioned these two companies about the high bias of their results and whether it was due to the temperature of my basement, the humidity, their equipment or the software curves. Both companies, which used similar EPA specified 4" canisters and Nucleus analytical equipment, could give no reasonable explanation why their measurements were so far off. Another follow-up test was determined necessary to confirm whether there was indeed a problem with charcoal measurements tested under the conditions of my basement.

FOURTH TEST

Before the fourth test was run, the author's Pylon, PYLN1, and an EPA Pylon, PYLN2, were run through two separate radon chambers so that they could both be re-calibrated. The fourth test included these two Pylons. The two At Ease monitors that had just been re-calibrated by the factory were also included in the test. The test was again run for 3 days from 5/26/89 to 5/29/89. This time a larger sampling of each company was done. The two Pylons were within 3% of each other. One At Ease monitor, ATES2, was within 2% of the Pylon average. The other At Ease monitor, ATES1, was 69.8% low. This unit was returned to the manufacturer again and they returned it, reporting that it was operating satisfactorily. The E-Perms in this test averaged within 2.2% of the Pylons with the lowest reading 6% lower and the highest being 2% higher than the Pylons. Four charcoal companies, OFCC2, OFEC3, OFCC3, OFCC4 had measurements within 3% of the Pylon average. One of these companies OFCC4 had a spread in its measurements with one 18% lower and another 20% higher. PA.DER 4" EPA style canisters, OFEC4, averaged 15.6% but had a spread from 10% to 28% higher. Two of the companies repeated their tendency from previous tests to read substantially higher than the Pylons. Company OFEC1 averaged 40.8% high. Company OFEC2 averaged 43.5% high. A single liquid scintillation test kit, DBCC2 was 18.3% higher.

FIFTH TEST

After numerous discussions with the charcoal labs about temperature and humidity conditions of the previous test, it was suggested that the exposure length may be the critical reason for the consistently high readings from two of the charcoal companies. The actual instructions include with the test kit from company OFEC1 state that the test is to be run for two days, however the company would analysis from one to six day exposures. The other company OFEC2 had instructions with their canisters that allowed exposures from two to four days. The fifth test was set up so that varying exposure times could be investigated for all companies. The test was run for four days from 6/12 to 6/16, with all canisters beginning their exposure at the same time. Two canisters were exposed from each company for two days, three days and four days. In all, forty-two charcoal test kits were exposed. Although the radon levels fluctuated a lot in the basement, the average radon concentration for the four day period was within one pCi/lit. The one At Ease, ATES2, that had done well in the previous test again did well in this test. The liquid scintillation test kits, DBCC2, used for the two and three day exposures were 20.5% higher for two day exposures and 44.2% higher for three days exposures as compared to the Pylon. The liquid scintillation test kits, DBCC3, used for four day exposures were 2% lower and 12% higher compared to the Pylon. The liquid scintillation kits, DBCC3, exposed for six days were 3% and 32% lower compared to the Pylon. One charcoal company, OFCC2, was within 7% for all measurements if you don't include a canister damaged by the mail. OFCC3 varied from a low of 3% to a high of 25% for its canisters over the four-day period. Interestingly, the OFEC3 canisters which had done very well in previous three-day exposures also did very well with a three-day exposure, being only 3% higher than the Pylon. The same canisters exposed for two days were 39.2% lower and for four-day exposures were 46.5% higher compared to the Pylon. This plots a very definite straight line at a sharp angle to the Pylon average. The PA.DER canisters OFEC4 also showed the same upward climb. They were only 3.1% higher than the Pylon for a two-day exposure but 17% higher for three days. Four day readings were 31.1% and 43% higher than the Pylons. The two charcoal companies, OFEC1 and OFEC2 that were high in previous three-day tests were within a few percent of the Pylons for two-day exposures but climbed to 35.2% and 37.0% higher for three-day exposures. Company OFEC1 had a four day-exposure reading that averaged 58.4% higher and company OFEC2 had an average that was 39.1% higher as compared to the Pylons.

SIXTH TEST

The sixth comparison test was carried out for seven days from 9/14/89 to 9/21/89. I included three Pylons in the sixth test. One was from PA.DER, the other was on loan to Camroden from the EPA and the third was my own unit. All three pylons were exposed in the Radon QC chamber in Easton, Pa. a week before the test was begun. I also included three E-Perms in the chamber to check their performance. Two of the Pylons were within 1% of the radon chamber reported level. The other Pylon was 5% lower. The three E-Perms averaged 3.6% higher compared to the chamber levels.

For the sixth test I obtained 141 charcoal test kits, three At Ease test monitors, six short term E-Perms and five long term E-Perms. I decided this time to opened the test kits in groups each day and then closed up all kits on the last day. This would allow me to ship all kits back to the lab at one time, saving a lot of UPS charges. To handle that many test kits we had to spread them over three sheets of plywood. To avoid obtaining differences with each group of test kits, I placed a Pylon in the middle of each sheet of plywood. I also tried to keep the canisters evenly spaced with about four inches between test kits. The results are listed in the following table.

The results again seem to indicate that open faced EPA style canisters, (OFEC1, OFEC2, OFEC4, OFEC6, OFEC7) under humid conditions that use EPA developed moisture curves in their calculations are biased high for exposures longer than two days. In one case two canisters from OFEC1 were exposed six days and the levels were reported as 91.5 and 96.7 pCi/lit when the Pylon average concentration was 31.00 pCi/lit. Two of the companies that have developed their own moisture curves (OFEC5, OFCC1 & OFCC2) did quite well in getting close to the mark. Company OFCC3 did well for two and three day exposures but were 25% higher than the Pylon average for four days. Company OFCC3 which had done reasonably well in test three and four was from 20.9 to 43.8% higher throughout the test. This company reported that some of their test kits had picked up an excessive amount of moisture and they noted which kits had questionable results because of the moisture gain.

I exposed three E-Perms for one day and fourteen E-Perms for two-day exposures spread throughout the test period. The group of one day exposures at the end of the exposure period did very well. The two day exposures were all consistently higher than the Pylons. The highest bias averaged 16.8% higher than the Pylon. I am not sure why the E-Perms were consistently higher during this sixth test, although this much bias is well within the 25% variation allowed in RMP program. The calibration factor for the E-Perms included a carefully measured Background gamma level. The long term E-Perms did quite well with a measurement that was 5% lower than the Pylons.

The diffusion canisters that were exposed were the new F&J style that had a number of holes placed in the poly diffusion barrier. The results from all the different companies (DBEC1, DBEC2, DBEC3, DBEC4) that used this style canister were quite good, especially considering that the canisters are brand new and the companies have not had much time to thoroughly test them.

The three At Ease monitors gave very different readings. Unit #2 once again was the closest to the mark. Unit #1 which had been very low in the fourth test was still 40.1% low even after being re-calibrated at the factory for the sixth test. A professional At Ease model was 30.4% higher compared to the Pylons.

OBSERVATIONS

The interesting correlation observed in both test five and test six is that the companies that use EPA open faced 4" canisters and the EPA calculation curves for those canisters all showed an increasing bias with extended exposure times under the test conditions. If, however, you follow the recommended exposure times of two days, they appear to be very accurate. It is interesting that company OFEC3 recommends three day exposures which when followed gave consistently accurate results.

The EPA did a study that concluded that the four inch open face canisters should be exposed for two days. Unfortunately it appears that some of the companies that use EPA style open face canisters and EPA developed curves have not put enough emphasis on this recommendation for their clients. Many customers who use open face four inch canisters may be unknowingly exposing their canisters for longer periods than the optimum and getting results that are biased more than the 25% variation allowed in the RMP program.

Another interesting phenomena is that the summer readings averaged higher than the winter readings and the summer readings had much larger diurnal variations. Measurements I have taken this winter have confirmed this effect as they have been averaging half the summer readings. I speculate that this is due to the increased infiltration of outdoor air into my basement in the winter due to the increased negative pressure. There is not an increase in radon entry with this increased negative condition because my soil is very tight. The diurnal variation is less during the winter because there is less change in negative pressure from day to night. During the summer I would guess that the basement pressure can reverse between the warm days and cool nights causing big swings in the radon concentrations.

E-PERM HANDLING

During the fourth round of testing it was discovered that E-Perm electrets gave voltage readings that varied with the temperature of the electret surface. The exposure of the E-Perm in different temperatures did not seem to make a difference on the accuracy of the readings; however, if the before and after readings were done at different temperatures, this needs to be taken into consideration. We calculate the difference for short term electrets as 0.26 volts per degree temperature difference times the midpoint of the voltage over 700. Long term electrets had a difference of 0.17 volts per degree temperature difference. Since our office temperature can be as high as 80 degrees and the test location cellar is only 60 degrees, if we read the final voltage in the cellar it can make a 5 volt difference on the reading. I also measured the response time it took an E-Perm to stabilize in a new temperature at around an hour if the E-Perm is exposed to the air. Between measurement tests a number of the E-Perm electrets showed excessive voltage loss while they were in storage. It was suggested from another user that any dust trapped during periods when the electret is exposed for reading may be the cause. We began to dust off the reader, the electret and the shell before re-assembling the parts after reading the electret voltage. We first tried using a hair dryer but became concerned about dust in the air being blown against the electret surface. We switched to a camera lens dust-off cleaner thinking that would be cleaner air but noticed that it would sometimes spit moisture. Eventually, we set up a nitrogen cylinder outside the office and ran a vinyl hose to the inside and connected it to a hand held air sprayer. This seems to work fine and is now included as part of our standard operating procedures.

OUTDOOR MEASUREMENTS

At the conclusion of the fourth test, I placed the two Pylons outdoors on an open porch, in order to get a good background reading on the passive radon detector head, the PRD. I left the pylons turned on in order to observe how long it took for the background counts to dissipate. Instead, I observed that the radon levels would climb every night to a concentration above one pCi/Lit. Thinking that the pylons were reading some radon coming from the house, I moved them to the picnic table in the back yard and had a similar night-time reading. This wasn't giving me the background reading I needed so I tried placing the Pylons up in my son's tree house, fifteen feet above grade. The two Pylons ran for two days and *graph fourteen* included shows the radon levels averaged .45 pCi/lit with the night-time highs being over 1 pCi/lit.

To get a true background for the PRD heads of the Pylons I ran vinyl tubing from a nitrogen tank into the head of the PRDs and taped off the other openings except a small opening. I set the nitrogen tank regulator to just enough flow to slightly pressurize the PRD heads and measured the background counts over twenty-four hours. This gave me enough confidence in the Pylons to see very low concentrations. The outdoor test was repeated from 7/22 to 7/26 in the same area of my yard but three feet off the ground. This time I was amazed to observe again the strong diurnal cycles with a peak reading over 3 pCi/lit in the early hours of the morning. The average was .82 pCi/lit over the four days. I observed that the levels rose the highest only at night when the air was very still. Rain or any wind would generally produce low concentrations. Cloudy, still nights seemed to produce the highest concentrations. I then left a Pylon outdoors at a house near Allentown, Pa. where we had previously done numerous indoor measurements. The initial basement reading at this house was around 80 pCi/lit. Once again you could clearly see in graph *sixteen* the diurnal cycles with a peak reading of 1.85 pCi/lit in the early hours and an overall average of .37 pCi/lit for the ten days.

I next ran a series of three first floor indoor, basement, and outdoor radon measurements. In Comparison 1 and 3, the house was occupied normally with the air conditioner running and the windows shut. During Comparison 1 the indoor level was 30% lower than the outdoor level which shows that it is possible to not only meet but surpass the national goal of indoor levels the same as outdoor levels. In Comparison 3 the indoor levels were the same as the outdoor levels. In Comparison 2 the house was not occupied and the indoor levels went twice as high as the outdoor levels. During this period the air conditioner was shut down. When the air conditioner is used the fan is set to run continuously. The cooling effect tends to limit the amount of radon that can rise up out of the basement. In Comparison 1 and 2 with the air conditioner on, the first floor radon level averaged 32% of the basement level. In Comparison 2 with the air conditioner off and the house unoccupied, the first floor radon level was 58% of the basement level. There may also be a compounding effect because the air handler for the air conditioner is in the attic and it contains a high efficiency HEPA filter.

On 11/6/89 to 11/8/89 I ran a comparison test to try to determine the difference height made on outdoor measurements. I ran vinyl tubing outside to three different elevations. The tubing ran back into my office and each tube was connected to a separate Pylon. I set up the PRD heads of each Pylon to be an active cell with just a trickle of flow through each cell. Graph *twenty* shows there was just the slightest difference in the three different height measurements. Notice that the radon levels stayed above one pCi/lit till noon on 11/7/89 and that the six meter elevation dropped in concentration first, which is probably due to a breeze blowing in during the day.

If we are to pursue the national goal of reducing indoor radon levels to ambient levels it would appear we need to have more measurements of outdoor levels. We left an alpha track exposed outdoors from 8/17/89 to 10/3/89 and it can back with a reading of 1.1 pCi/lit. This kind of background reading might also be a factor in epidemiological studies. For our own company the outdoor levels are a complicating factor in determining our employee exposures because the employees leave their personal alpha track detectors hanging in the trucks at night. We are trying to determine if we should sub-tract a portion of their readings from the lab report to get a true reading of their exposure during their working hours. Measuring radon is indeed more complicated than exposing a test kit and mailing it back to the lab.

RADON DETECTOR COMPANY CODE CHART

OPEN FACE CHARCOAL CANISTERS, 4" DIAMETER 200 GRAMS CHARCOAL
EPA DEVELOPED MOISTURE CURVES

OFEC1 N/A
OFEC2 N/A
OFEC3 N/A

OFEC4 PENNSYLVANIA DER
OFEC5 RADON ANALYTICAL LABS, INC., INDIANAPOLIS, IN.
OFEC6 RPI
OFEC7 US EPA

OPEN FACE CHARCOAL CANISTERS, VARYING CANISTER SIZE
COMPANY DEVELOPED MOISTURE CURVES

OFCC1 TCS INDUSTRIES, HARRISBURG, PA., STANDARD CANISTER
OFCC2 TCS INDUSTRIES, HARRISBURG, PA., OVERSIZE CANISTER
OFCC3 KEY TECHNOLOGY, JOHNSTOWN, PA.
OFCC4 N/A

DIFFUSION BARRIER CANISTERS
EPA DEVELOPED MOISTURE CURVES

DBEC1 PA. DER
DBEC2 RADON ANALYTIC LABS, INC., INDIANAPOLIS, IN.
DBEC3 RPI
DBEC4 US EPA

DIFFUSION BARRIER CANISTERS
COMPANY DEVELOPED MOISTURE CURVES

DBCC1 RADON MITIGATORS
DBCC2 EKS-RADTECH, INC., TRAINER, PA., 2-3 DAY KITS
DBCC3 EKS RADTECH, INC., TRAINER, PA., 4-6 DAY KITS

CONTINUOUS MONITORS

PYLN1 WPB PYLON AB5
PLYN2 CAMRODEN PYLON AB5
PYLN3 DER PYLON AB5
ATES1 AT EASE UNIT 1
ATES2 AT EASE UNIT 2
ATES3 AT EASE UNIT 3
FEMT1 FEMTO-TECH

OTHER TEST KITS

EPST1 E-PERM SHORT TERM
EPLT1 E-PERM LONG TERM

COMPARISON TEST DATA

TEST #1 2/3/89 TO 2/6/89

INSTRUMENT	AVG PCI	% off PYLON	INDIVIDUAL RESULTS
PYLN1	17.40	<-REFERENCE	
FEMT1	16.80	-3.4%	
OFCC4	22.20	27.6%	
OFEC1	26.10	50.0%	
OFEC3	28.10	61.5%	
OFEC*2*	28.50	63.8%	
ATES1	27.10	55.7%	RETURNED AT EASE UNITS TO
ATES2	21.70	24.7%	MANUF. FOR CALIBRATION

TEST #2 4/4/89 to 4/6/89

INSTRUMENT	AVG PCI	% off PYLON	INDIVIDUAL RESULTS
PYLN1	19.50	<-REFERENCE	
FEMT1	20.80	6.7%	
OFCC4	14.60	-25.1%	<-EXPOSURE TOO SHORT
EPMST	20.10	3.1%	18.1, 18.2, 20.6, 23.3
		-7.2%, -6.7%, 5.6%, 19.5%	
OFEC1	26.70	36.9%	

TEST #3 4/28/89 to 5/1/89

INSTRUMENT	AVG PCI	% off PYLON	INDIVIDUAL RESULTS
PYLN1	31.06	<-REFERENCE	
OFCC2	31.20	0.5%	32.1, 30.3
OFEC3	30.90	-0.5%	31.9, 29.8
EPMST	31.70	2.1%	31.6, 33.4, 30.0
OFCC4	35.00	12.7%	34.0, 36.0
OFEC1	47.30	52.3%	51.4, 47.1, 44.6, 45.9

OFEC2	53.10	71.0%	52.9, 53.2

TEST #4 5/26/89 to 5/29/89

INSTRUMENT	AVG PCI	% off PYLON	INDIVIDUAL RESULTS
	25.86	<-REFERENCE AVG OF 2 PYLONS	
PYLN1	25.55	-1.2%	
PYLN2	26.16	1.2%	
ATES2	25.50	-1.4%	
OFCC2	25.50	-1.4%	25.3, 25.6, 25.6
OFCC4	25.50	-1.4%	21.2, 24.1, 25.8, 31.0
EPMST	25.30	-2.2%	24.2, 25.1, 25.8, 26.2
OFEC3	25.20	-2.6%	24.7, 25.7
OFCC3	25.40	-1.8%	
OFEC4	29.90	15.6%	28.5, 28.6, 29.3, 33.1
DBCC2	30.60	18.3%	
OFEC1	36.40	40.8%	35.5, 36.1, 36.8, 37.2
OFEC2	37.10	43.5%	35.9, 38.2
ATES1	7.80	-69.8%	

TEST #5-2 6/12/89 to 6/14/89

INSTRUMENT	AVG PCI	% off PYLON	INDIVIDUAL RESULTS
	36.46 <-REFERENCE		
PYLN1	36.46	0.0%	
OFEC2	36.35	-0.3%	36.4, 36.3
OFEC1	36.05	-1.1%	35.3, 36.8
ATES2	35.50	-2.6%	
OFCC*1*	33.35	-8.5%	34.1, 32.6 <-Can.Damaged
OFEC4	37.60	3.1%	38.4, 36.8
DBCC3	43.95	20.5%	43.54, 44.35
OFCC3	44.30	21.5%	45.7, 42.9
OFEC3	22.18	-39.2%	23.16, 21.21

TEST #5-3 6/12/89 to 6/15/89

INSTRUMENT	AVG PCI	% off PYLON	INDIVIDUAL RESULTS
	35.69	<-REFERENCE	
PYLN1	35.69	0.0%	
OFCC2	35.90	0.6%	34.2, 37.6
ATES2	35.40	-0.8%	
OFEC3	36.75	3.0%	36.55, 36.95
OFCC3	38.45	7.7%	42.1, 34.8
OFEC4	41.75	17.0%	41.7, 41.8
OFEC2	48.25	35.2%	48.5, 48.0
OFEC1	48.90	37.0%	46.3, 51.5
DBCC2	51.45	44.2%	50.22, 52.69

TEST #5-4 6/12/89 to 6/16/89

INSTRUMENT	AVG PCI	% off PYLON	INDIVIDUAL RESULTS
	36.52	<-REFERENCE	
PYLN1	36.52	0.0%	
ATES2	36.90	1.0%	
DBCC2	38.17	4.5%	40.72, 35.62
OFCC2	34.10	-6.6%	34.0, 34.2
OFCC3	41.65	14.0%	41.5, 41.8
OFEC4	50.10	37.2%	47.9, 52.3
OFEC1	50.80	39.1%	50.3, 51.3
OFEC3	53.52	46.5%	52.92, 54.12
OFEC1	57.85	58.4%	56.0, 59.7

TEST #6-1 9/20/89 to 9/21/89 64*F 85% HUM

INSTRUMENT	AVG PCI	% off PYLON	INDIVIDUAL RESULTS
	38.64	<-REFERENCE	DAILY PYLON AVERAGES
PYLN1	38.92	0.7%	38.92
PYLN3	38.75	0.3%	38.75
PYLN2	38.24	-1.0%	38.64
		INDIVIDUAL RESULTS	
OFCC2	38.75	0.3%	38.1, 39.4
OFCC3	39.95	3.4%	38.9, 41.0
EPMST	39.03	1.0%	39.1, 38.3, 39.7

ATES2	30.43	-21.2%	32.2, 27.6, 36.0

TEST #6-2 9/19/89 to 9/21/89 64*F 85% HUM

INSTRUMENT	AVG PCI	% off PYLON	INDIVIDUAL RESULTS
	37.57	<-REFERENCE	DAILY PYLON AVERAGES
PYLN1	37.58	0.0%	36.19
PYLN3	38.08	1.4%	37.38
PYLN2	37.06	-1.4%	35.83
			INDIVIDUAL RESULTS
OFEC1	41.55	10.6%	41.6, 41.5
OFCC4	45.42	20.9%	44.1, 44.7, 48.4, 44.5
ATES2	35.73	-4.9%	32.2, 33.9, 41.1
DBEC1	40.25	7.1%	39.5, 41.0
OFEC1	43.15	14.9%	42.8, 43.5
DBEC4	38.38	2.2%	40.3, 40.4, 39.6, 36.9, 34.6
OFEC7	36.65	-2.4%	38.3, 36.4, 36, 38.5, 36, 34.2
OFCC3	32.65	-13.1%	32.2, 33.1
DBEC2	43.30	15.3%	43.1, 43.5
OFEC5	41.60	10.7%	42.3, 41.0
DBCC1	35.40	-5.8%	35.4
OFEC3	22.92	-39.0%	22.65, 23.19
DBEC3	40.90	8.9%	40.9
OFEC6	40.80	8.6%	41.51, 40.1
OFCC1	38.10	1.4%	38.3, 37.9

TEST #6-3 9/18/89 to 9/21/89 64*F 85% HUM

INSTRUMENT	AVG PCI	% off PYLON	INDIVIDUAL RESULTS
	31.69	<-REFERENCE	DAILY PYLON AVERAGES
PYLN1	31.66	-0.1%	19.56
PYLN3	32.08	1.2%	19.85
PYLN2	31.33	-1.1%	19.63
			INDIVIDUAL RESULTS
OFEC2	46.00	45.2%	46.5, 45.5
OFCC4	43.37	36.9%	46.8, 44.7, 37.6, 44.4
DBEC1	32.90	3.8%	31.5, 34.3
OFEC1	52.90	66.9%	53.9, 51.9

DBCC2	33.68	6.3%	34.0, 33.8, 35.2, 31.7	
OFEC7	37.90	19.6%	38.5, 39, 38, 36.9, 37.3, 37.7	
OFCC3	31.85	0.5%	31.5, 32.2	
DBEC2	31.50	-0.6%	32.3, 30.7	
OFEC5	34.55	9.0%	35.7, 33.4	
DBCC1	32.00	1.0%	32.0	
OFEC3	31.58	-0.3%	31.92, 31.24	
DBEC3	34.00	7.3%	34.0	
OFEC6	42.95	35.5%	42.3, 43.6	
OFCC2	30.45	-3.9%	29.9, 31.0	

TEST #6-4 9/17/89 to 9/21/89 64*F 85% HUM

INSTRUMENT	AVG PCI	% off PYLON	INDIVIDUAL RESULTS	
	31.18	<-REFERENCE	DAILY PYLON AVERAGES	
PYLN1	31.12	-0.2%	29.47	
PYLN3	31.64	1.5%	30.29	
PYLN2	30.78	-1.3%	29.13	
		INDIVIDUAL RESULTS		
OFEC2	53.00	70.0%	51.9, 54.1	
OFCC4	41.42	32.8%	43.8, 38.4, 40.8, 42.7	
DBEC1	32.95	5.7%	32.8, 33.1	
OFEC1	66.30	112.6%	66.1, 66.5	
OFEC7	42.05	34.9%	42.3, 41.8, 43.0, 42.1, 42.5,	
OFCC3	32.65	4.7%	32.4, 32.9	40.6
DBEC2	33.50	7.4%	32.4, 34.6	
DBCC1	32.60	4.6%	32.6	
OFEC3	46.16	48.0%	47.23, 45.09	
DBEC3	33.20	6.5%	33.2	
OFEC6	53.90	72.9%	51.4, 56.4	
OFCC2	29.50	-5.4%	30.1, 28.9	

TEST #6-5 9/16/89 to 9/21/89 64*F 85% HUM

INSTRUMENT	AVG PCI	% off PYLON	INDIVIDUAL RESULTS
	30.12	<-REFERENCE	DAILY PYLON AVERAGES
PYLN1	29.94	-0.6%	25.21
PYLN3	30.64	1.7%	26.58

PYLN2	29.77	-1.2%	25.66
		INDIVIDUAL RESULTS	
OFCC4	43.30	43.8%	46.3, 44.0, 44.4, 38.5
DBEC1	30.25	0.4%	28.7, 31.8
OFEC1	68.10	126.1%	68.1, 68.1
OFCC3	37.70	25.2%	37.7
DBEC2	33.10	9.9%	32.3, 33.9
DBCC1	30.50	1.3%	30.5
DBEC3	30.80	2.3%	30.8
OFCC2	32.00	6.2%	30.1, 33.9

TEST #6-6 9/15/89 to 9/21/89 64*F 85% HUM

INSTRUMENT	AVG PCI	% off PYLON	INDIVIDUAL RESULTS
	31.00	<-REFERENCE	DAILY PYLON AVERAGES
PYLN1	30.82	-0.6%	35.25
PYLN3	31.57	1.8%	36.29
PYLN2	30.61	-1.3%	34.86
		INDIVIDUAL RESULTS	
OFCC4	42.47	37.0%	43, 42.3, 45.W, 39.6
DBEC1	34.75	12.1%	35.8, 33.7 "W" INDICATES
OFEC1	94.10	203.5%	96.7, 91.5 WET SAMPLE
DBEC2	32.60	5.2%	33.2, 32.0
DBEC3	33.00	6.5%	33.0

TEST #6-7 9/14/89 to 9/21/89 64*F 85% HUM

INSTRUMENT	AVG PCI	% off PYLON	INDIVIDUAL RESULTS
	30.37	<-REFERENCE	DAILY PYLON AVERAGES
PYLN1	30.37	0.0%	27.62
PYLN3	30.80	1.4%	26.10
PYLN2	29.95	-1.4%	25.94
		INDIVIDUAL RESULTS	
OFCC4	40.75	34.2%	38.W, 41.W, 44.W, 40.W
ATES1	18.20	-40.1%	18.2
ATES2	33.20	9.3%	33.2
ATES3	39.60	30.4%	39.6
DBEC1	33.00	8.7%	33.1, 32.9

DBEC4	31.89	5.0%	30.7, 31.2, 31.5, 34.6, 31.4
EPMLT	28.76	-5.3%	34.0, 28.4, 26.5, 28.5, 26.4
DBEC2	34.80	14.6%	34.0, 35.6
DBCC1	28.05	-7.7%	29.56, 26.53
DBEC3	29.50	-2.9%	29.5

TEST #6-2A 9/14/89 TO 9/16/89

PYLNS AVG	31.02		
EPMST	34.20	10.3%	34.5, 33.9

TEST #6-2B 9/16/89 TO 9/18/89

PYLNS AVG	27.73		
EPMST	30.90	11.5%	31.0, 31.2, 30.6, 32.6, 30.1, 29.9

TEST #6-2C 9/18/89 TO 9/20/89

PYLNS AVG	28.08		
EPMST	32.80	16.8%	33.8, 31.8, 32.8, 32.7, 34.0, 31.7,