Monitoring of Volatile Organic Compounds in Alaska Health Houses

A Study

Prepared by:
Robert A Maxwell
ALASKA ENERGY ASSOCIATES
126 Boaters Lane
Fairbanks, AK 99709
(907) 479-5290
AlaskaEnergy@aol.com

September 2004
Revised 2/12/2007

Submitted to

COLD CLIMATE HOUSING RESEARCH CENTER

POB 82489, Fairbanks, AK 99708-2489
1000 Fairbanks Street, Fairbanks, Alaska
www.cchrc.org

TABLE OF CONTENTS

FIGURES AND TABLES 3

EXECUTIVE SUMMARY 4

INTRODUCTION 5

METHODOLOGY 5

RESULTS 6

DISCUSSION/CONCLUSION 15

APPENDIX A: TABLES OF VOC RESULTS 16

- **Table 1: Tentatively Identified Compounds (TICs) in 5 Alaska Homes……………..13**
- **Table 2. VOC Results For 5 Tested Homes in Alaska………………………………….15**
- **Table 3: VOC Results, Showing Exceeded EPA RCAC Vapor Intrusion Levels…..16**

Figures and Tables

Figures

Figures 1-2. Precccupancy VOCs for Each Study House, (PPBV). 8

Figures 3-4. Postoccupancy VOCs for Each Study House, (PPBV). 9

Figures 5 -10. Pre and Post Occupancy VOC concentrations by dwelling 10

Figures 11-12. Pre and Post Occupancy Levels of Tentatively Identified Compounds (TICs), measured in parts per billion by volume (PPBV). 13

Figure 13. Formaldehyde Concentrations in 5 Tested Alaska Homes……………………….11

Tables

Table 1. Comparison of VOC Concentrations in 5 Alaska Homes. 6

Table 2: Tentatively Identified Compounds (TICs) in 5 Alaska Homes. 16

Table 3. VOC Results For 5 Tested Homes in Alaska 19

Table 4: Exceeded EPA RCAC vapor intrusion levels.in 5 Tested Homes in Alaska 20

EXECUTIVE SUMMARY

Little information is available regarding the quantities and concentrations of volatile organic compounds (VOCs) that exist in average new homes, nor on how those levels might change after occupancy. Alaska Energy Associates tested the indoor air VOC levels in five Alaskan homes before occupancy (pre) and after a year of occupancy (post). The homes that were chosen for the study included two homes built to the American Lung Association "Health House" standards; one each in Fairbanks and Juneau. For comparison, we chose three non-Health House dwellings that represent standard new construction practices in these two communities.

The purpose of the study was to provide a start towards answering the following question:

> "Are measurable benefits in VOC-reduction achieved by taking extra steps during construction, and do those benefits still remain once people occupy the home?"

The results reveal a wide variety of VOCs inside these homes, yet both homes in Juneau were on the lower end of the scale in quantity and in concentration, when compared with Fairbanks homes. We are unable to determine if this is from different levels of ventilation between the dwellings.

Several dwellings exceeded minimum recommended exposure levels for benzene at all sampling stages.

Acetone was the most prevalent VOC detected in all the homes and was also found in the highest concentrations. Toluene was the second most prevalent, with much lower concentrations. With the exception of acetone, the majority of measurable VOCs decreased in concentration between pre and post samples, but in a few houses measurable levels of VOCs were detected post-occupancy that were not found in the pre-occupancy tests.

In general, when the same VOC was present in both pre and post samples, dwellings with a balanced mechanical ventilation system showed decreased concentrations. In homes with exhaust-only ventilation systems, a greater quantity of the VOCs appeared only in post occupancy samples.

For whatever reason, the houses that began with less VOCs in pre-occupancy samples had less VOCs in the long term post occupancy samples as well.

Both Health Houses had lower quantities and concentrations of VOCs than the non-Health House comparisons in their given communities post testing. The Health Houses also had lower VOC concentrations post-occupancy than they did pre-occupancy.

The study was quite limited in scope and size. However, it does provide a starting point for future studies and seems to indicate that efforts to reduce initial VOCs during construction result in reduced VOCs within the dwelling pre and post occupancy. In order to provide more meaningful conclusions, additional studies in different locations should be undertaken, involving a greater number of sample homes.

Homebuilders may find a competitive market advantage when selling a home if they practice low/no VOC material selection, especially in cabinetry, caulks, and finish materials such as floor coverings and paints.

This study was funded by the Cold Climate Housing Research Center in Fairbanks with funds from the Alaska Housing Finance Corporation.

Health House Volatile Organic Compound Monitoring

INTRODUCTION

With the advent of the American Lung Association (ALA) of Minnesota's Health House program and its subsequent recognition in Alaska, homebuilders have raised some economic concerns. They wonder if there is improved indoor air quality in the home that justifies the costs required to meet Health House standards. This study was conceived as a start towards answering the most pressing of those questions regarding volatile organic compounds (VOCs): Are measured benefits in VOC-reduction achieved by taking extra steps during construction and do those benefits still remain once people occupy the home?

The extra steps that are required for a dwelling to become a Health House in Alaska relate primarily to waterproofing; selection of low VOC materials such as adhesives, paint and caulk; and using little or no carpeting. The home must also meet the State of Alaska's AKWARM energy rating of five star plus criteria for its climate zone. The five star plus energy rating criteria is based on achieving thermal and air tightness standards that are greater than or equal to the thermal and air tightness standards required under the ALA of Minnesota Health House program. ALA of Alaska adopted its own standards for a Health House and then dropped the entire program in the fall of 2003.

Alaska Energy Associates proposed a small study to test the indoor air VOC levels in the first two homes built in Alaska that met ALA Minnesota Health House standards. For comparison, the study also included three non-Health House dwellings that represented standard construction practices in these two communities; these three homes included one high end five star plus and two standard five star homes. This study was funded by the Cold Climate Housing Research Center in Fairbanks with funding from the Alaska Housing Finance Corporation.

METHODOLOGY

The five homes chosen for the study included the Health House homes in Fairbanks and Juneau and, for comparison, three non-Health House dwellings that represented standard construction practices in these two communities.

Ventilation strategies in the homes included two with exhaust-only ventilation (Juneau and Fairbanks five star); the others had balanced mechanical ventilation in the form of heat recovery ventilators. One home (Juneau HH) was heated with a ground source heat pump and all others had oil-fired boilers providing hydronic heat via baseboard distribution systems. All homes except for the two Health House homes had attached garages. Occupancy rates for the homes were not comparable. The volume of the homes also varied dramatically. The Fairbanks five star plus home has a volume of over 35,000 cubic feet and the Fairbanks Health House about 13,000 cubic feet.

All homes were tested during winter or inclement weather months when the homes were without natural ventilation from open doors or windows. Each home was tested immediately after construction before occupancy, and after long-term occupancy. Four of the five homes were also tested immediately after occupancy (within 7-10 days). For the purposes of this report, the pre-occupancy testing is termed 'Pre' and the long-term post occupancy is 'Post'. Long term occupancy samples were taken one year or more after occupancy.

The testing method used whole air sampling in minicans from Galson Laboratories. Samples were sent to Galson for analysis using the EPA TO15 analytical method. In addition to testing for the 63 known VOCs the samples were compared to a list of 75,000 tentatively identified compounds (TICs).

In addition to the air samples, the homes were tested for formaldehyde, using the SKC Indoors Air Sampler 526-100, a badge collection media. The analytical method utilized was Modified OSHA ID205-color. The level of quantification was 0.40 micrograms (ug), and the minimum concentration level was 0.054 parts per million (ppm). The level of concentration acceptable for people based on 8 hours per day/40 hour week for the duration of his/her working career according to OSHA is .75ppm.

RESULTS

Volatile Organic Compounds (VOCs)

Several organizations have determined VOC exposure risk levels for humans. The Occupational Safety and Health Administration (OSHA), the Agency for Toxic Substances and Disease Registry (ATSDR), Environmental Protection Agency (EPA), and a program under EPA known as the Resource Conservation and Recovery Act (RCRA) each provide their own exposure risk recommendations.

ATSDR uses the no-observed-adverse-effect-level/uncertainty factor (NOAEL/UF) approach to derive minimum risk levels (MRLs) for hazardous substances. They are set below levels that, based on current information, might cause adverse health effects in the people most sensitive to such substance-induced effects. MRLs are derived for acute (1-14 days), intermediate (>14-364 days), and chronic (365 days and longer) exposure durations, and for the oral and inhalation routes of exposure.

The charts in this report display, from the list of 63 known VOCs, those where the PPBV (parts per billion by volume) in any of the dwellings tested in this study exceeded the minimum measurable level. Most of the 63 known VOCs are measurable at levels above 3 PPBV although a few require a PPBV greater than 13 PPBV.

The results reveal a wide variety of VOCs inside these homes, yet both homes in Juneau were on the lower end of the scale in quantity and in concentration.

The EPA RCRA guidance levels were exceeded for the following VOCs in this study for the Fairbanks five star home after occupancy:

Table 1. Comparison of VOC Concentrations

Compound	Concentration Detected (PPBV)	RCRA screening level (PPBV)
Benzene	28	0.098
Toulene	128	110
Ethylbenzene	18	0.51
1,3,5-trimethylbenzene	6	1.2
1,2,4-trimethylbenzene	17	1.2

It should be noted that three of the four RCRA screening level concentrations above are well below the detectable concentration in the laboratory analysis. This indicates that there could have been other VOCs present in the samples that exceeded the RCRA guidelines yet did not show up in the air sample reports.

Acetone was the most prevalent VOC present in all the homes and was also the one found in the highest concentrations. Acetone is produced from a wide variety of sources, including human breath. Acetone was found at increased levels in the majority of post-occupancy samples when compared to the pre-occupancy samples. MRLs assigned by ATSDR for acetone range from 13 to 26 PPMV

(13,000 to 26,000 PPBV) from Chronic to Acute by inhalation. The largest concentration found in the samples was 1.11 PPMV.

Toluene was the second most prevalent VOC detected; yet the level of concentration was reduced by an order of magnitude. Only the Juneau five star home exhibited increased toluene concentrations in the post-occupancy test.

Several dwellings exceeded benzene MRLs at all sampling stages. A benzene reading above 4 PPBV exceeds the intermediate level and is considered acute when above 50 PPBV.

Methyl Ethyl Ketone was detected in two post-occupancy samples where the pre-occupancy sample showed none.

Heptane was found only in an immediate post occupancy test and is the only VOC to be found then that was not also found in the pre-occupancy or long-term post-occupancy results.

With the exception of acetone, the majority of the other measurable VOCs decreased in concentration between pre-occupancy and post-occupancy samples. A few houses saw measurable levels of VOCs in the post-occupancy tests that were not found in the pre-occupancy tests.

When the same VOC was present in both pre- and post-occupancy samples, given the exceptions mentioned above, dwellings with a balanced mechanical ventilations system showed decreased concentrations. Homes with exhaust-only ventilations systems saw a greater number of the VOCs that only appeared in post occupancy samples.

It appears that the houses that began with less VOCs in pre-occupancy samples had less VOCs in the long-term post-occupancy samples as well.

The following charts show the overall Pre- and Post-occupancy concentrations. Due to the wide spectrum in PPBV found in the samples, the pre-occupancy results chart below (fig 1a and 1b) are shown with two different ranges on the Y-axis. This is because one compound being found in large numbers of PPBV causes the majority of the other measured VOCs to become barely visible on a bar chart. Notes to the Charts are in the text above them.

Figure 1a. Pre-Occupancy VOCs for each study house, measured in parts per billion by volume (PPBV).

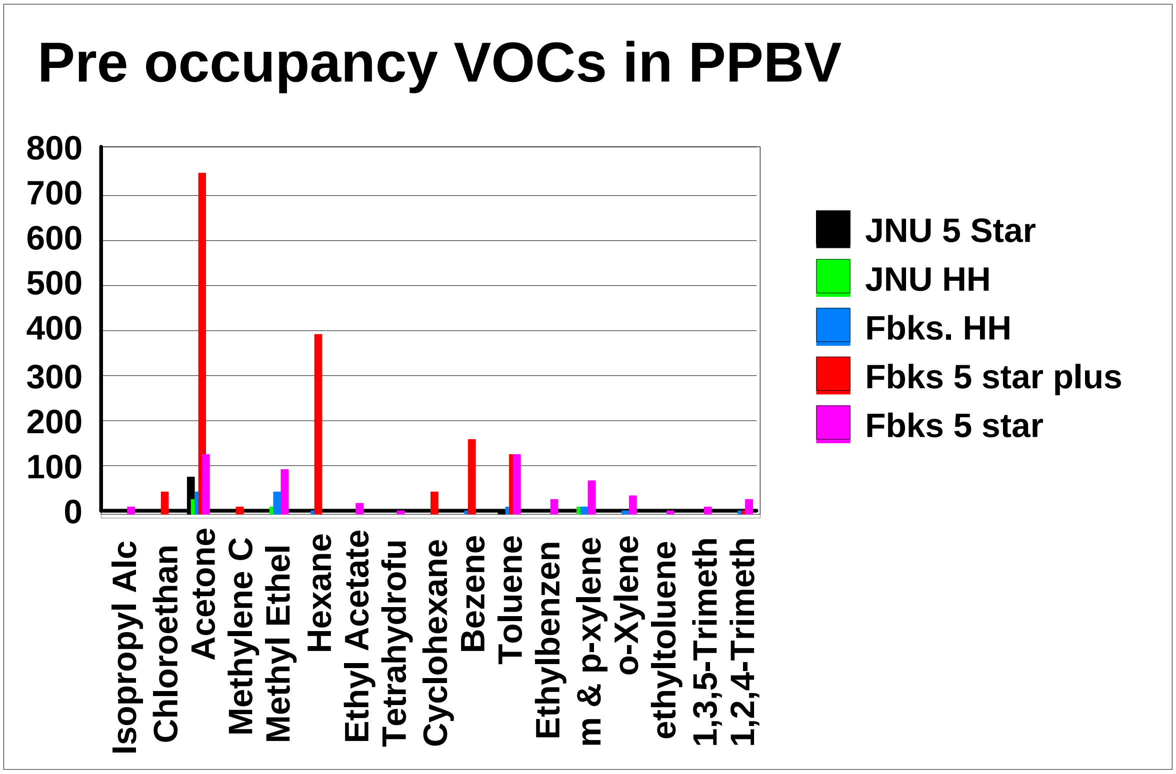


Figure 1b. Pre-Occupancy VOCs for each study house, measured in parts per billion by volume (PPBV). The scale has been reduced to 0-150 PPBV to give a better indication of concentration levels.

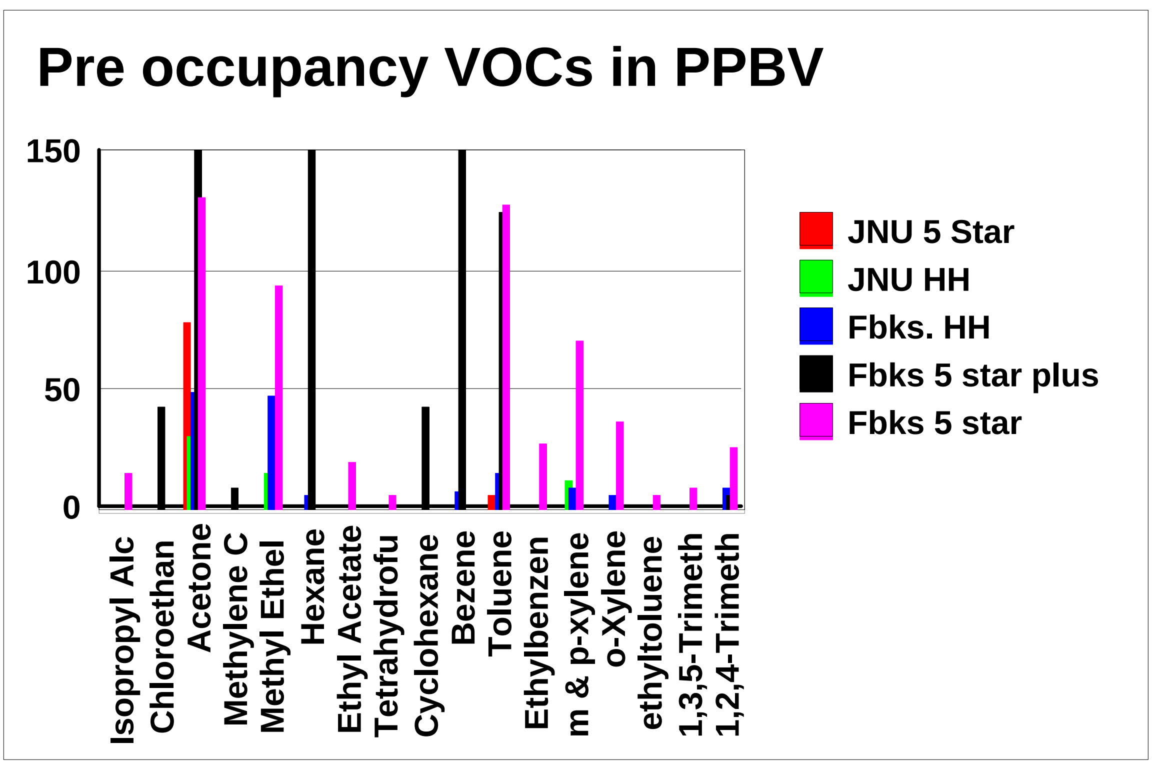
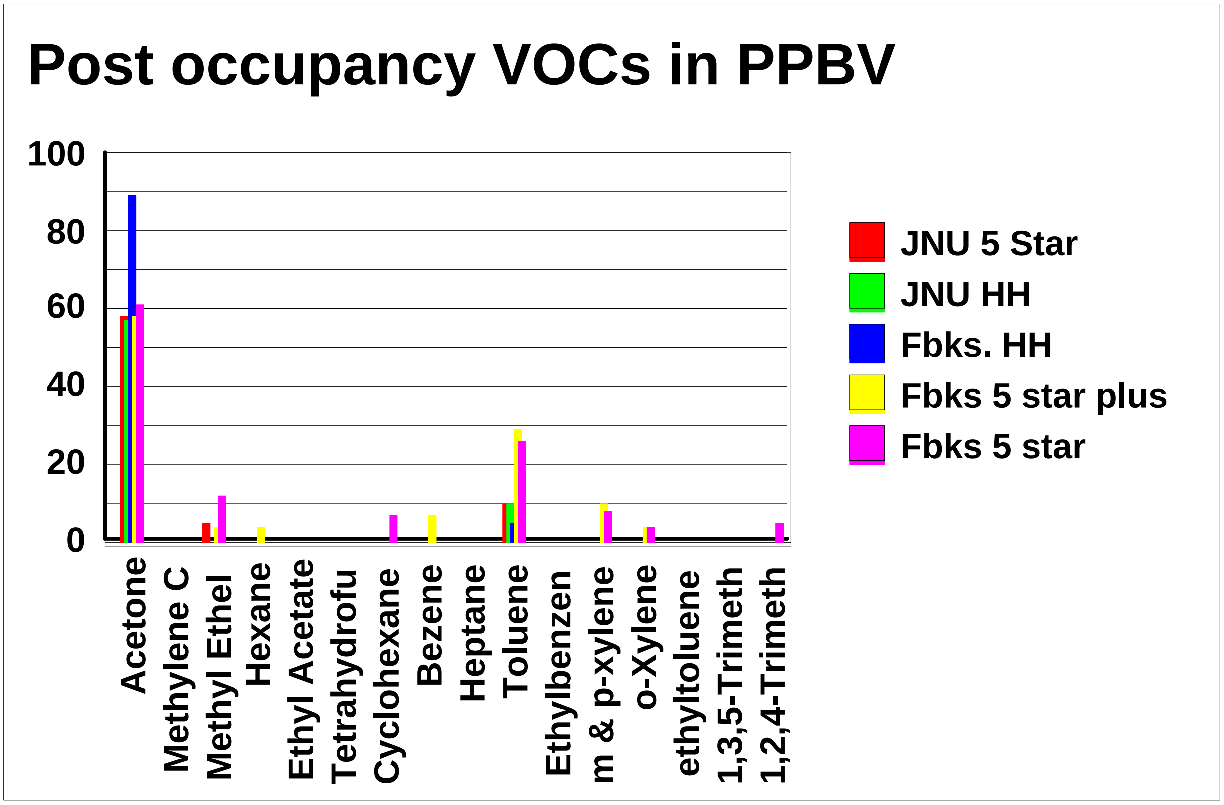
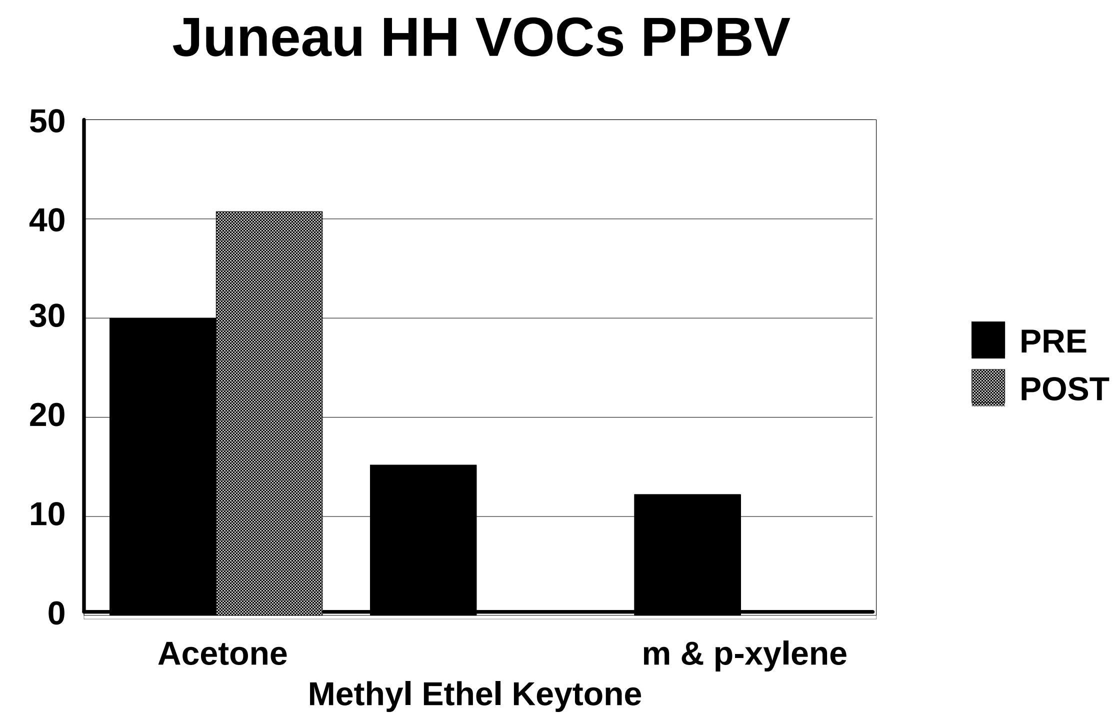
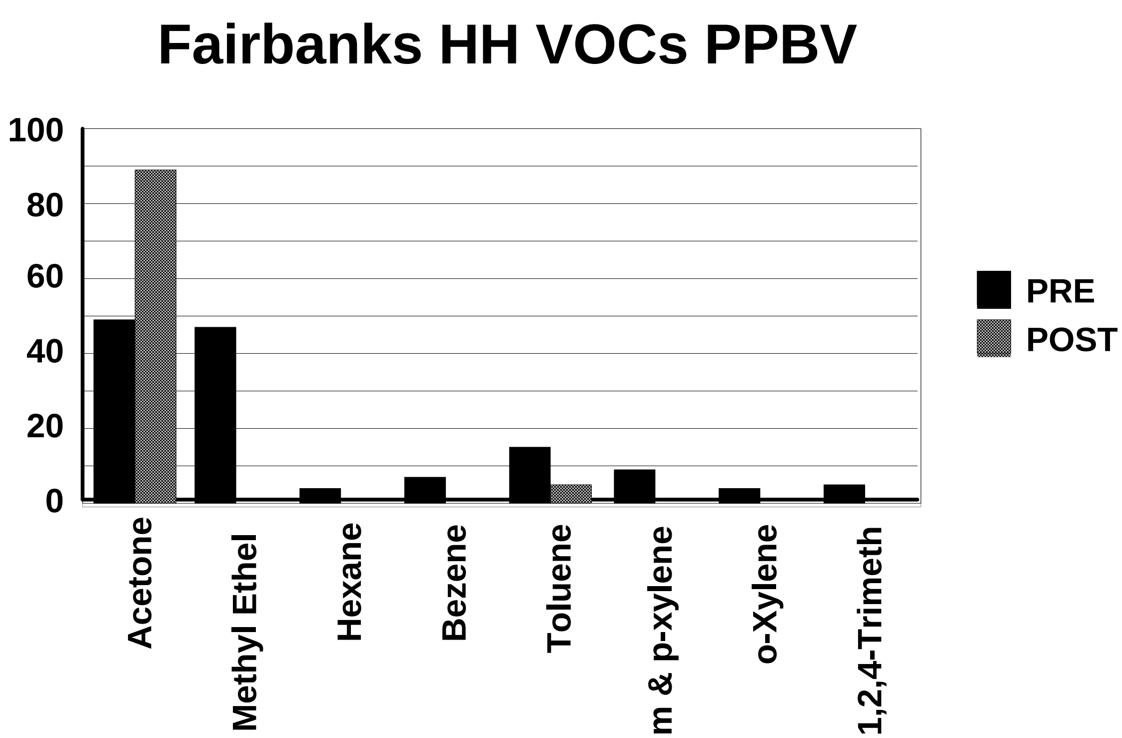


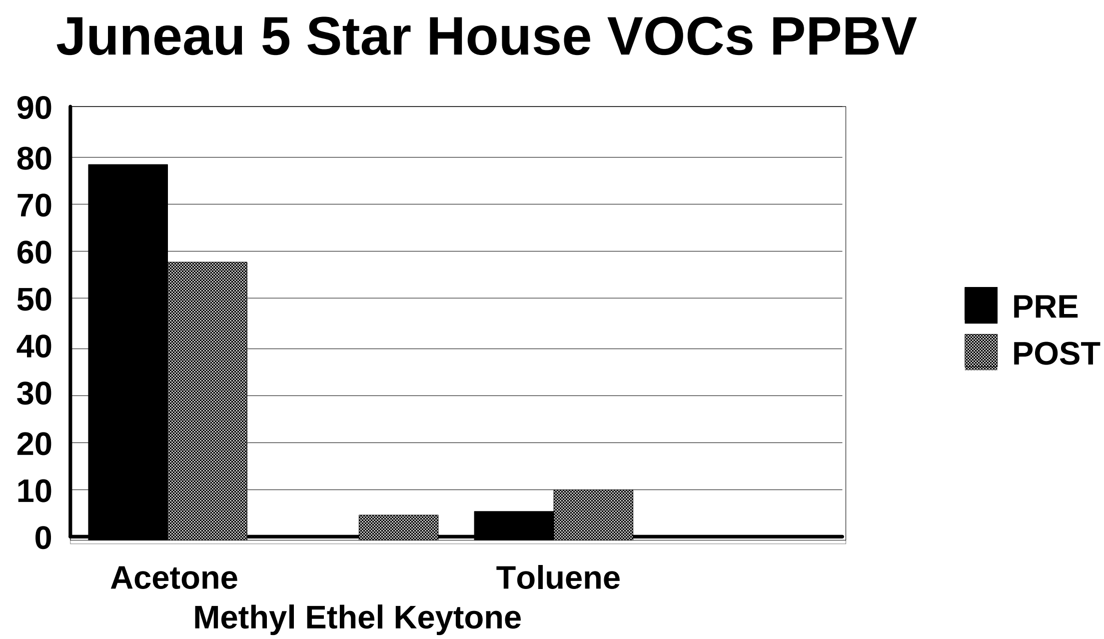
Figure 2. Post-Occupancy VOCs for each study house, measured in parts per billion by volume (PPBV).

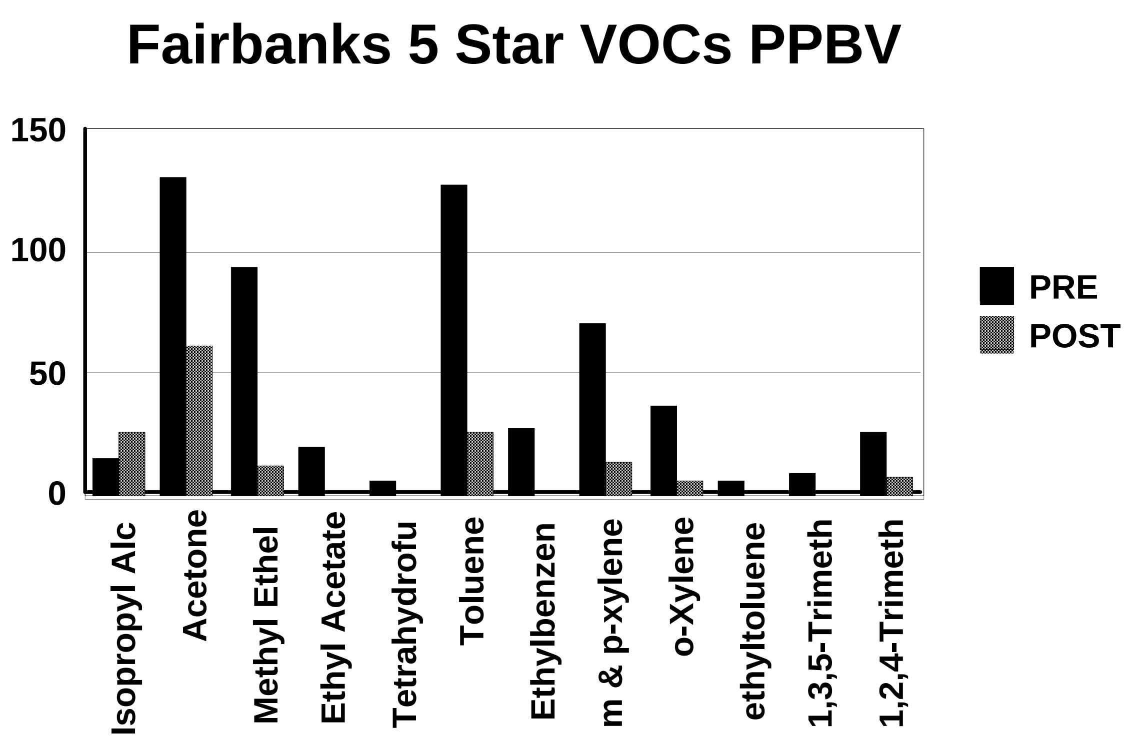


Figures 3-8. Pre and post-occupancy VOC concentrations by dwelling, with an extra, reduced scale chart created for the Fairbanks 5 star plus dwelling.

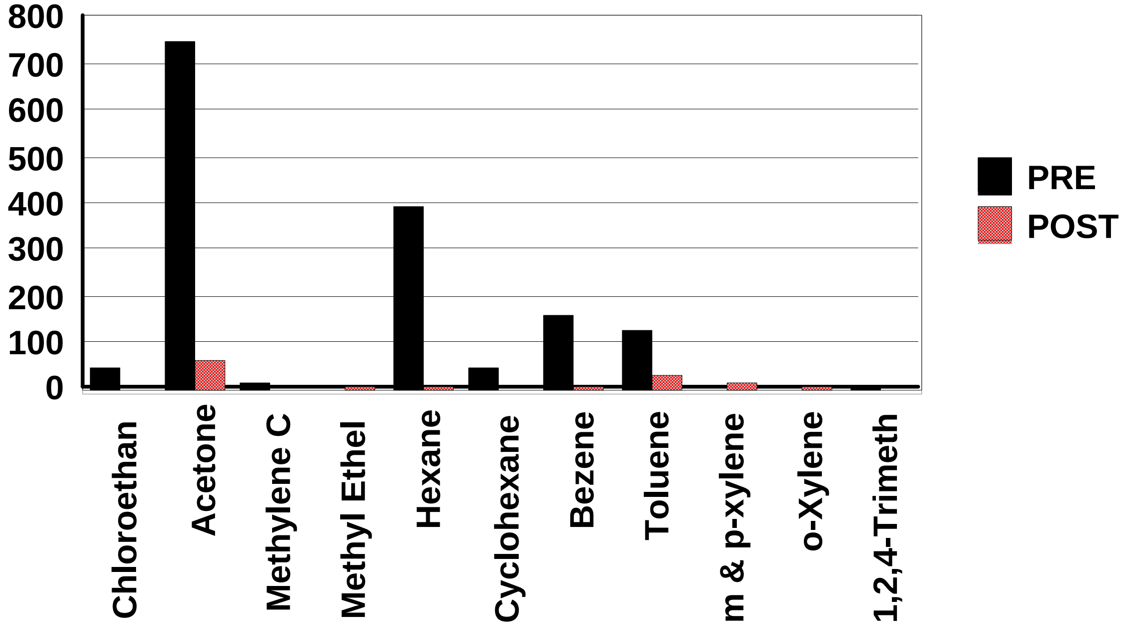




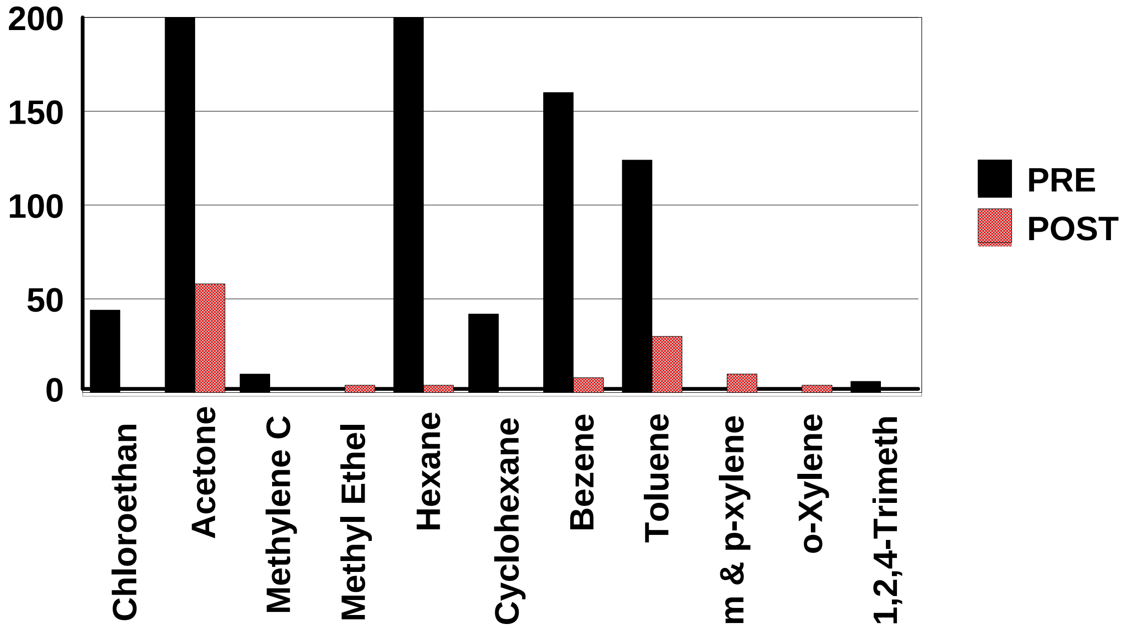

Juneau 5 Star House VOCs PPBV
90
80
70
60
50
40
30
20
10
0
Acetone
Toluene
Methyl Ethel Keytone
PRE
POST


Fairbanks 5 Star VOCs PPBV
150
100
50
0
Isopropyl Alc
Acetone
Methyl Ethel
Ethyl Acetate
Tetrahydrofu
Toluene
Ethylbenzen
m & p-xylene
o-Xylene
ethyltoluene
1,3,5-Trimeth
1,2,4-Trimeth
PRE
POST

Fairbanks 5 Star Plus VOC's PPBV



Fairbanks 5 Star Plus VOC's PPBV



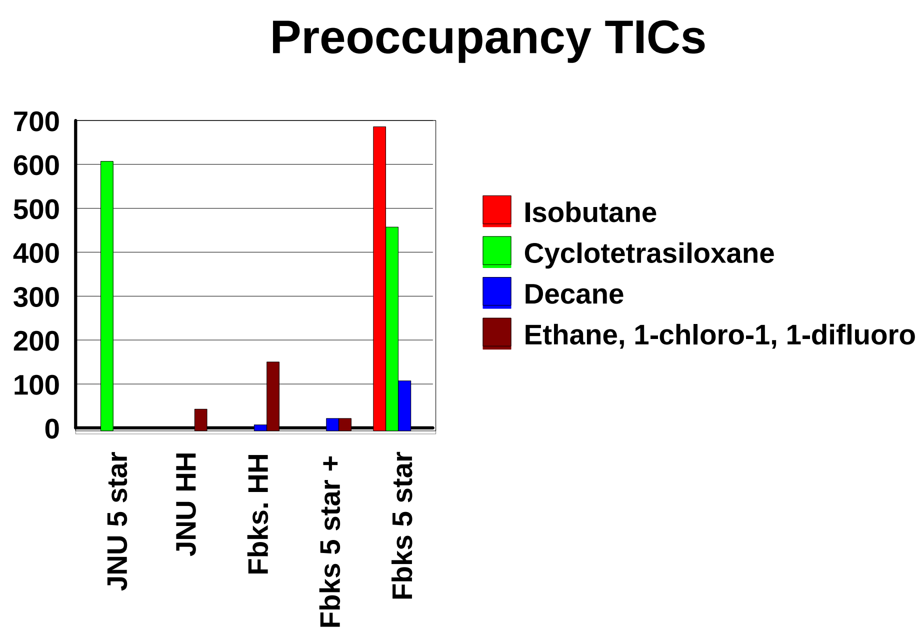
Tentatively Identified Compounds

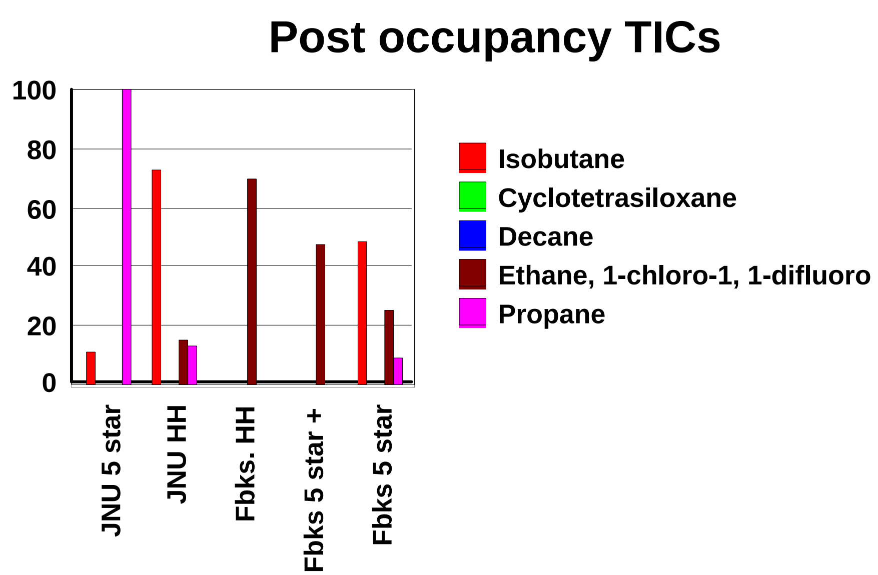
A tentatively identified compound (TIC) is a compound that the testing instrumentation can detect but the analysis is not targeting specifically. Its identity and concentration cannot be confirmed since the laboratory does not have the calibration gases for every compound available within the gas chromatography mass spectrometry library. In this study we simply noted the variations between pre and post occupancy in the different homes.

A short list of TICs found in at least two of the five dwellings is presented. Many more TICs were found and the entire list of TICs found by dwelling is attached in Appendix A, Table 2.

The TIC comparisons by home are shown in Figures 9 and 10. These are the VOCs found in the TICs list in more than one sample. We can conclude that the concentration levels of these TICs were significantly reduced in the Post samples as compared to the Pre samples.

Figures 9-10. Pre and Post Occupancy Levels of Tentatively Identified Compounds (TICs), measured in parts per billion by volume (PPBV).





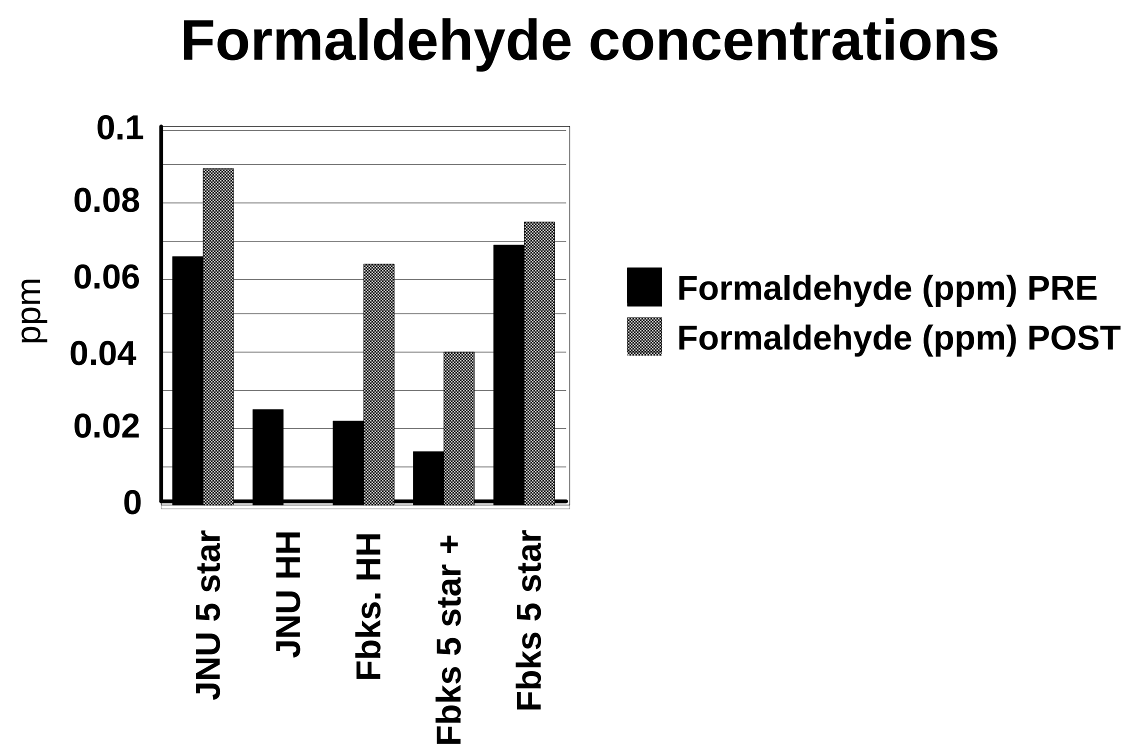
Formaldehyde

The Formaldehyde readings inside the five dwellings sampled are shown in Figure 13. Formaldehyde Concentrations. The Juneau Health House post-occupancy sample showed no formaldehyde within detectable levels

None of the formaldehyde samples exceeded the OSHA standards of .75 ppm, yet they do exceed the ATSDR MRLs of .04 ppm for acute inhalation exposure.

With the exception of the Juneau Health House, all other homes showed an increase in formaldehyde after long-term occupancy. It would be reasonable to conclude that the increase is related to occupant choices of materials introduced into the dwelling, such as furniture.

Figure 11. Formaldehyde Concentrations



DISCUSSION/CONCLUSION

It is difficult to draw many hard and fast conclusions from this study. The sample size is quite small and the results are widely varied. There are no other known similar studies we can use for comparison.

We do know that even before occupancy Fairbanks homes in this study exceeded the ATSDR MRLs for benzene and formaldehyde.

In this study, the Juneau Health House exhibited the best indoor air quality in regard to VOCs in all comparative air samples. The VOCs found in the Juneau samples were all lower in quantity and in concentration than the Fairbanks samples.

Both Health Houses had lower quantities and concentrations of VOCs than the non-Health House comparisons in their given communities in post occupancy testing. The Health Houses also had lower VOC concentrations before occupancy than after occupancy with the exception of acetone. These were the only homes where acetone was higher after occupancy.

The two five-star homes, which used exhaust-only ventilation systems, showed an increase in VOCs after occupancy. This seems to indicate that the ventilation rate is lower in these two dwellings than the others included in the study, which all used a balanced mechanical ventilation system with heat recovery.

For whatever reason, the houses that began with less VOCs in pre-occupancy samples had less VOCs in the long term post occupancy samples as well.

The study does provide a starting point for future studies and seems to indicate that efforts to reduce initial VOCs during construction result in reduced VOCs within the dwelling both before and after occupancy. In order to provide more meaningful conclusions, additional studies in different locations should be undertaken, involving a greater number of sample homes.

With increasing consumer interest in green building, and healthy indoor air quality homebuilders could find a competitive market advantage when selling a home if they practice low/no VOC material selection, especially in cabinetry, caulks, and finish materials such as floor coverings and paints.

Appendix A: Tables

Table 2: Tentatively Identified Compounds (TICs) in five Alaska Homes

Juneau 5 Star – Pre-occupancy

Tentatively Identified Compounds	CAS Number	Retention Time	Estimated Concentration ppbv
Cyclotetrasiloxane, octamethyl-	000556-67-2	17.47	410

Juneau 5 Star – Post occupancy

Tentatively Identified Compounds	CAS Number	Retention Time	Estimated Concentration ppbv
Propane	000074-98-6	4.62	68
Dimethyl ether	000115-10-6	4.81	9.1
Isobutane	000075-28-5	4.98	7.3
Ethanol	000064-17-5	5.83	53
Pentane, 2-methyl-	000107-83-5	9.14	4.3
Hexanal	000066-25-1	16.86	8.7
.alpha.-Pinene	000080-56-8	20.13	9.6
3-Carene	013466-78-9	21.18	8.8
Substituted Benzene		21.23	3.5
Limonene	000138-86-3	21.37	5.7
Unknown Hydrocarbon		21.39	9.2
Undecane	001120-21-4	22.07	5.4

Juneau Health House – Pre-occupancy

Tentatively Identified Compounds	CAS Number	Retention Time	Estimated Concentration ppbv
2-Butenal, (E)-	000123-73-9	6.22	9.6
Ethane, 1-chloro-1,1-difluoro-	000075-68-3	6.48	43
Ethanol	000064-17-5	7.62	9
Undecane	001120-21-4	29.13	4.4

Juneau Health House – Post occupancy

Tentatively Identified Compounds	CAS Number	Retention Time	Estimated Concentration ppbv
Propane	000074-98-6	4.62	8.8
Ethane, 1-chloro-1,1-difluoro-	000075-68-3	4.82	15
Isobutane	000075-28-5	4.98	49
Ethanol	000064-17-5	5.84	9.4
Cyclotrisiloxane, hexamethyl-	000541-05-9	17.79	69
Cyclotetrasiloxane, octamethyl-	000556-67-2	20.75	88
Nonanal	000124-19-6	21.96	6.1

Fairbanks Health House – Pre-occupancy

Tentatively Identified Compounds	CAS Number	Retention Time	Estimated Concentration ppbv
Propane	000074-98-6	4.92	3.9
Ethane, 1-chloro-1,1-difluoro-	000075-68-3	5.14	150
Butane	000106-97-8	5.50	5
Butane, 2-methyl-	000078-78-4	6.40	4.5
Pentane, 2-methyl-	000107-83-5	8.38	4.4
Nonane	000111-84-2	20.64	5
C3 substituted benzene + methyl nonane		23.47	3.8
Decane	000124-18-5	24.56	14
Decane, 4-methyl-	002847-72-5	25.39	4.1
Undecane	001120-21-4	28.11	10

Fairbanks Health House – Post-occupancy

Tentatively Identified Compounds	CAS Number	Retention Time	Estimated Concentration ppbv
Ethane, 1-chloro-1,1-difluoro-	000075-68-3	3.72	70
Unknown		14.57	14

Fairbanks 5 Star plus - Pre-occupancy

Tentatively Identified Compounds	CAS Number	Retention Time	Estimated Concentration ppbv
Ethane, 1-chloro-1,1-difluoro-	000075-68-3	5.95	28
Pentane, 2-methyl-	000107-83-5	9.43	74
Pentane, 3-methyl-	000096-14-0	9.87	110
Cyclopentane, methyl-	000096-37-7	11.39	140
Hexane, 2-methyl-	000591-76-4	12.45	33
Hexane, 3-methyl-	000589-34-4	12.78	40
Pentane, 2,2,4-trimethyl-	000540-84-1	14.43	22
Hexane, 2,5-dimethyl-	000592-13-2	14.78	44
Cyclohexane, methyl-	000108-87-2	14.93	290
Unknown Alkane		15.31	22
Hexane, 2,3-dimethyl-	000584-94-1	15.97	22
Heptane, 2-methyl-	000592-27-8	16.11	190
Heptane, 3-methyl-	000589-81-1	16.42	53
Cyclohexane, -dimethyl-,		17.05	26
Cyclohexane, -dimethyl-,		17.17	9.9
Octane	000111-65-9	17.41	83
Cyclohexane, -dimethyl-,		17.92	9.9
Acetaldehyde, 2-butenylhydrazone	075268-07-4	18.14	14
Cyclohexane, ethyl-	001678-91-7	19.26	11
Decane	000124-18-5	24.89	22
Undecane	001120-21-4	27.95	28

Fairbanks 5 Star plus - Post occupancy

Tentatively Identified Compounds	CAS Number	Retention Time	Estimated Concentration ppbv
Ethane, 1-chloro-1,1-difluoro-	000075-68-3	3.71	47
Butane	000106-97-8	3.99	7.1
Ethanol	000064-17-5	4.60	27
Butane, 2-methyl-	000078-78-4	4.80	8.1

Fairbanks 5 Star – Pre-occupancy

Tentatively Identified Compounds	CAS Number	Retention Time	Estimated Concentration ppbv
Isobutane	000075-28-5	3.72	690
Cyclohexane, -trimethyl-(isomer)		15.76	14
Nonane	000111-84-2	16.40	45
Octane, 2,6-dimethyl-	002051-30-1	16.98	22
Cyclotetrasiloxane, octamethyl-	000556-67-2	17.41	460
Benzene, 1-chloro--methyl-(isomer)		17.50	17
Benzene, 1-ethyl--methyl-(isomer)		17.55	27
Benzene, 1-ethyl--methyl-(isomer)		17.86	25
Decane	000124-18-5	17.95	110
Decane, 4-methyl-	002847-72-5	18.24	23
Benzene, 1,2,3-trimethyl-	000526-73-8	18.46	34
Cyclohexane, (2-methylpropyl)-	001678-98-4	18.57	33
Unknown Alkane		18.65	16
Unknown Alkane		18.70	19
Unknown Alkane w/ sub. benzene		18.75	33
Unknown Alkane w/ sub. benzene		18.83	36
Unknown		19.06	52
Undecane	001120-21-4	19.15	57
Naphthalene, decahydro-2-methyl-	002958-76-1	19.67	27

Fairbanks 5 Star – Post occupancy

Tentatively Identified Compounds	CAS Number	Retention Time	Estimated Concentration ppbv
Norflurane	000811-97-2	3.39	22
Ethane, 1,1-difluoro-	000075-37-6	3.45	150
Isobutane	000075-28-5	3.73	63
Butane	000106-97-8	3.93	12
Ethanol	000064-17-5	4.51	120
Butane, 2-methyl-	000078-78-4	4.72	29
Nonane	000111-84-2	16.41	9
Benzene, 1-ethyl--methyl-(isomer)		17.56	7.4
Benzene, 1-ethyl--methyl-(isomer)		17.86	6.1
Decane	000124-18-5	17.95	25
Benzene, 1,2,3-trimethyl-	000526-73-8	18.47	9.2
Cyclohexane, (2-methylpropyl)-	001678-98-4	18.58	7.5
Unknown Alkane		18.70	5.7
Unknown Alkane w/ sub. benzene		18.76	11
Unknown Alkane w/ sub. benzene		18.84	13
Unknown		19.06	16
Undecane	001120-21-4	19.15	24
Benzene, -tetramethyl-(isomer)		19.58	5.9
Naphthalene, decahydro-2-methyl-	002958-76-1	19.67	16

Table 3. VOC Results Five Tested Homes in Alaska

Volitile Organic Compounds found above			Pre- Occupancy PPBV					Post- Occupancy PPBV				
Measureable limits in PPBV	JNU 5 *	JNU HH	Fbks. HH	Fbks 5 *+	Fbks 5*		JNU HH	Fbks. HH	Fbks 5 *+	Fbks 5*		JNU 5*
						I		10			I	
Isopropyl Alcohol					21	I				39	I	
Chloroethane				43		I					I	
Acetone	78	44	74	1110	195	I	61	127	334	92	I	86
Methylene Chloride				14		I					I	
Methyl Ethel Keytone		23	70		140	I		15	10	17	I	8
Hexane			5	580		I			20		I	
Ethyl Acetate					30	I					I	
Tetrahydrofuran					9	I					I	
Cyclohexane				62		I		5	6		I	
Bezene*			10	241		I		12	19		I	
Heptane						I		6	14		I	
Toluene	6		22	187	191	I		24	111	39	I	15
Ethylbenzene					27	I		6	8		I	
m & p-xylene		9	7		104	I		16	28	13	I	
o-Xylene			6		37	I		7	10	5	I	
ethyltoluene					5	I					I	
1,3,5-Trimethylbenzene					9	I					I	
1,2,4-Trimethylbenzene			8	6	26	I		13	10	7	I	
						I					I	
	PRE Occupancy					I	Immediate Post Occupancy				I	Long Te
TENTATIVELY IDENTIFIED COMPOUNDS	JNU 5 *	JNU HH	Fbks. HH	Fbks 5 *+	Fbks 5*		JNU HH	Fbks. HH	Fbks 5 *+	Fbks 5*		JNU 5*
Isobutane					690	I				63	I	11
Cyclotetrasiloxane	610				460	I				7.5	I	
Decane			20	32	110	I		59	48	25	I	
Ethane, 1-chloro-1, 1-difluoro		64	220	41		I	78	740	170	150	I	
Propane						I					I	100
FORMALDEHYDE	JNU 5 *	JNU HH	Fbks. HH	Fbks 5 *+	Fbks 5*	I					I	
Formaldehyde (ppm) PRE	0.066	0.0245	0.022	0.014	0.069							
Formaldehyde (ppm) POST	0.066	<0.054	0.064	0.04	0.075							

Table 4: VOC results for five homes in Alaska, Showing Exceeded EPA RCAC vapor Intrusion Levels

Volitile Organic Compounds found	Pre- Occupancy PPB's					Long Term Occupancy PPB'					EPA RCRA Vapor Intrusion
above measurable limits in PPB'	JNU 5 *	JNU HH	Fbks. HH	Fbks	Fbks 5*	JNU 5*	JNU HH	Fbks. HH	Fbks 5 *+	Fbks 5*	Guidance Table 2C
Freon 11											120
Isopropyl Alcohol					21					35	NA
Chloroethane				43							3800
Acetone	78	44	74	**1110**	**195**	86	85	132	87	138	150
Methylene Chloride				**14**							1.5
Methyl Ethel Keytone		23	70		140	8			6		340
Hexane			5	**580**					6	15	57
Ethyl Acetate					30						870
Tetrahydrofuran					9						NA
Cyclohexane				62						7	NA
Benzene			**10**	**241**					**11**	**28**	0.098
Heptane											NA
Toluene	6		22	**187**	**191**	15		8	43	106	110
Ethylbenzene					**27**					**12**	0.51
m & p-xylene		9	7		104				16	50	1600 (for ea. compound
o-Xylene			6		37				5	21	1600
ethyltoluene					5						NA
1,3,5-Trimethylbenzene					**9**					**6**	1.2
1,2,4-Trimethylbenzene			**8**	**6**	**26**					**25**	1.2

Bold numbers indicate amount exceeds EPA RCAC vapor intrusion levels