

CLOSELEIGH MANOR
101 – 100 LAMBERT STREET
WHITEHORSE, YUKON

VENTILATION SYSTEM REPORT

BY:
NORTHERN CLIMATE ENGINEERING LTD
March, 2014

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1.0 INTRODUCTION

1.1 Purpose of Report

The purpose of this report is to:

- provide an overview of the ventilation systems in the building,
- report on system deficiencies and issues,
- provide recommendations to improve performance and efficiency.

1.2 Codes, Standards, and Relevant Documents

The following codes and standards are primarily applicable to the design of the mechanical systems:

- *National Building Code of Canada*
- *CAN/CSA-F326-M-91 Residential Mechanical Ventilation Systems*
- *ASHRAE 62, Ventilation for Acceptable Indoor Air Quality*
- *NFPA 90A, Standard for the Installation of Air-Conditioning and Ventilation Systems*, and
- *Applicable SMACNA Design and Construction Guidelines.*

The following documents are relevant to the mechanical systems currently in the building:

- Aztech H.V.A.C. Balancing & Technical Services Ltd., *Operation and Maintenance Manual for Whitehorse Senior Citizen's Housing – Whitehorse, Yukon*
- Western Mechanical Services Ltd., *Whitehorse Senior Citizen's Complex – Operating & Maintenance Manual for Mechanical Systems (1994)*
- Howell-Mayhew Engineering, Inc., *Monitoring and Investigation of a Multi-Suite Residential Complex in Whitehorse, Yukon from 1988 to 1992 – Final Report (March 15, 1993)*

2.0 BACKGROUND

A full, detailed description of the mechanical systems and system data is given in the relevant documents described in section 1.2. The following descriptions provide a concise description of the mechanical systems relevant to this report. Up to date information for mechanical systems under investigation is provided in the attached Test, Adjust, and Balance Reports found in Appendix A.

2.1 Building Construction

Built in 1988 for Senior's Housing, Closeleigh Manor was the first apartment building of its kind to be built to R2000 standards. The three storey building houses thirty suites and common areas, plus 340 sq.m. of office space. From an energy perspective, the wood frame structure was built with good insulation levels for the period, as well as including a tight vapour barrier to reduce air leakage. The insulation levels include R28 walls, a R40 attic, and double-glazed low E windows.

2.2 Heating System

Heating is provided by an oil-fired boiler plant. The boiler plant distributes heat via hydronic baseboard radiation, cabinet heaters, and unit heaters with most spaces having individual control. Through the control system, the hydronic system is capable of resetting the heating fluid temperature during the heating season based on the outdoor temperature. With this approach, the heating system will tend to run 'smoother', plus will reduce the potential for overheating from the hot water circulating through the distribution piping. In addition, hydronic systems do provide an easily controllable means to temper the outdoor air introduced by the ventilation systems required for occupant comfort.

In 1992, modifications were made to improve the effectiveness of the heat reclaim system at the primary air-handling system. The changes included the provision of a dedicated run-around-loop between the exhaust and supply air paths, a heating coil, plus variable speed drives for the blower motors. Performance monitoring after the renovation indicated that the effectiveness of the heat reclaim was around 40% vs. the less than 20% achieved with the original design.

2.3 Ventilation System

The building is mechanically ventilated using one primary air-handling system and three secondary systems.

2.3.1 Primary Air System

Operating 24/7, the primary system provides ventilation air to the entire building by introducing 100% of outdoor air and exhausting the same amount to the exterior. The supply fan is matched by an exhaust fan, both located in the Mechanical Room. Heat recovery is provided by a run-around-loop between coils in each airstream using glycol as a medium. Supply air is distributed through main and branch ducts to the bedrooms and living room in the suites, to the common areas, the corridors, the crawlspace, and to the return inlets at the secondary system air-handling units. The ventilation exhaust system is comprised of two individual ducted loops, one serving the suite bathrooms, and the other serving the suite kitchens. One other exhaust system serves the garbage room.

The original design airflow was based on 1.0 Ac/hr. This was subsequently revised to 0.5 Ac/hr due to excessive drafts and energy costs.

2.3.2 Secondary Air Systems

The three secondary ventilation systems are located on the north end of the main floor in what was initially considered 'commercial space'. One unit serves the Film Commission offices, and the other two serve the Commissioner's office and board room. These systems circulate conditioned air (filtered and tempered) to the spaces. The outdoor air introduced by the primary air system amounts to approximately 20% of the total air at each system.

3.0 CURRENT SITUATION

Upon review of the physical condition of the mechanical equipment, the lack of preventative maintenance is apparent. At the air-handling units, the filters, belts, and sheaves are, or were, in poor condition. A more detailed description of the primary and secondary ventilation systems is given in the following subsections, along with air particulate measurements.

3.1 Primary (Residential) Ventilation

At the primary air-handling unit, the twinned belts were worn out to the extent that the resulting slipping had reduced air flow by at least 50%. The air-handler was found to have eight 24"x16"x1" filter media, rather than four 24"x16"x2" pleated filter media. The filters were subsequently replaced with 24"x16"x2" pleated filter media; Test data for both the original and the replacement filters can be found in the Air Handling Unit Test Report for AHU-1. The building operation and maintenance manuals call for four 25"x16"x2" pleated filter media. The current filter media are MERV 8. Upon replacing the belts, the frequency on the VFD had to be reduced from 60Hz to 50Hz to bring the fan back into its range of operation. The decrease in power required indicates that the supply fan has enough power to allow the MERV value of the filters to be increased, thereby increasing the air filtration of the supply air to the building. Air particulate measurements across the filters of the primary air handler showed an air particulate drop of 4000pt/cc with the 24"x16"x1" filters, and a drop of 4500pt/cc with the 24"x16"x2" filters. Further information on air particulate measurements are given in section 3.3.

The primary exhaust fan showed minor wear on the fan/motor sheaves; however, the belt was noted as recently replaced by building maintenance and was found to be in good condition. The filter media appeared to be clean, and exhibited low pressure drops which indicate they do not need replacement.

The initial measurements of the primary ventilation when compared with the last balancing report for the building indicate that the building is no longer in balance. The percent differences between the balanced measurements and the current measurements typically range from -100% to 150%. After replacing the belts on the primary air-handling unit, the measurements taken had differences of approximately -70% to 175% (compared to -100% to 130%). The measurements before and after replacing the belts showed, on average, a 112% increase. The fan speed increased from 490RPM to 1460RPM from replacing the belts, which leaves the primary air-handling unit at 93% of the maximum fan speed. The current fan speed, at 93%, is an 11% increase over the previously balanced fan speed of 1310RPM, which is 73% of the maximum fan speed. The primary exhaust fan had a fan speed of 1225RPM which is a 19% increase over the previously balanced fan speed of 1030RPM. The two fan speeds are at 95% and 84% of the maximum fan speed, respectively. By proportionately increasing the initial measurements according to the percent difference between the initial and final measurements, an air flow of approximately 3600CFM was found. This value is mid-way between the 0.5 and 1.0 air changes per hour and should provide an adequate supply of air flow.

3.2 Secondary (Office Space) Ventilation

The secondary air handling units showed a definitive lack of general maintenance. The belts all showed cracking, some with separation from the reinforcing bands in the belts. Fan and motor sheaves showed minor to medium wear, and all filter media were found to require replacement. The building operations & maintenance manuals for the building specify two 25"x16"x2" filters for the three secondary air-handling units.

Air handling units two and three, which are located above the board room and the film commission storage area respectively, were both manually set in the off position. Additionally, the two units are connected to a time clock such that the units can be set to turn on/off at designated times. The time clock was found to have no on/off dogs attached to the clock, thereby leaving the units permanently on or off according to both the manual setting of the units and the time clock setting. The on/off indicator light on the electrical box for air handling unit two was found to be burnt out. The breaker for air handling unit three was found to be in the "off" position, and was subsequently turned on. Both units could be run in the manual position. Air handling unit three produced excessive vibration and noise, which was observed to be coming from the supply fan drive train, and is likely caused by the extensive damage to the drive belt.

Air handling unit four, located above the reception area of the film commission office, was found to be running. As with the other two units, air handling unit four showed the same lack of general maintenance.

As can be seen by the measured values found on the air outlet test reports for air-handling units two through four, the systems are generally off of the original balance of the building. The lack of maintenance on these units is however a more pressing concern, as air-handling units two and three are currently not in operation.

3.3 Secondary Exhaust Fan

The secondary exhaust fan, located in the garbage room adjacent to the mechanical room, was found to be inoperable, despite being switched on. This could be the result of any number of electrical problems with the fan. Further investigation by a licensed electrical contractor is warranted.

3.4 Particulate Tracking

Air particulate measurements were taken throughout the building to assess the air quality throughout the building. It is important to note that the MERV 8 filter media currently used in the primary air-handling unit filters particles above 3-10 microns in size, whereas the P-Trak measures particles in the size of 0.02-1.0 microns. The P-Trak measurements can be found in the Air Particulate Test Report and the Outdoor Air Particulate Test Report provided in Appendix A. The air particulate measurements were on average between 5000pt/cc and 25000pt/cc with the exclusion of several exceptional units. The average units were found to have similar or slightly higher air particulate than the measured values of the outdoor air; however, air particulate measurements both before and after the air filter media in the supply air fan showed a reduction in air particulate. Units 102, 209, 210, 302, and 303 showed average particulate measurements of 42500pt/cc, 235000pt/cc, 116000pt/cc, 51000pt/cc, and 61500pt/cc, respectively.

After replacing the supply fan drive belts and filters, units 203, 301, and 312 were re-tested. While units 301 and 312 showed a small reduction in the measured air particulate, unit 203 showed an increase in air particulate. This result is likely caused by the increase in outdoor air particulate relative to the prior test of unit 203, and the similar outdoor air particulate relative to the prior tests of unit 301 and 312.

Air particulate measurements in the Commissioner's Office and the Film Commission Office were an average of 6100pt/cc and 13000pt/cc respectively. The air particulate measurements of the two office spaces were taken with the secondary air-handling units as they were found.

Further measurements taken by Juergen Korn and Mark Lutkehaus confirmed the variability of the P-Trak readings; however, the readings were on average, lower than the readings provided in the Air Particulate Test Report. The lower readings may be as a result of, in general, lower outdoor air particulate compared to the readings provided, or it may be as a result of the increased supply air flow to the building. Readings taken both pre and post-filter were highly variable, and could not confirm the effectiveness of the filter media. This is likely due to the particle size range (0.02-1.0 microns) measured by the P-Trak, and the particle size filtered (3-10 microns) by the MERV 8 filter media. The carbon monoxide (CO) readings provided were below the accuracy of the Q-Trak Plus used. The low CO readings are not a cause for health concern. The carbon dioxide readings provided were generally below levels that provide a cause for concern; however, the readings for the elevator pump room, film commission office, and the commissioner's office are at, or nearly at, CO₂ levels where additional ventilation is required. The higher CO₂ levels in the commissioner's office would likely be resolved by restoring operation of air handling units two and three. The higher CO₂ levels in the film commission office could likely be resolved by increasing the fraction of outdoor air to air handling unit four.

4.0 RECOMMENDATIONS

Based on the current situation, the following recommendations can be made:

- Complete a thorough overhaul of all air-handling units; clean fans, clean heating/cooling coils, replace filters, replace damaged belts and replace worn sheaves.
- Perform electrical tests on the secondary exhaust fan and fix as required, or replace the secondary exhaust fan.
- Replace current MERV 8 filter media in the primary air-handling unit with MERV 11 or MERV 14 filter media and adjust the supply fan frequency on the variable frequency drive accordingly. For this air-handling unit, AAF AmAir 1100 16x25x2, which have a MERV 11 rating, can be used in place of the current MERV 8 filters without requiring any alteration of the system. A higher MERV filter media would require renovation of the air handling unit and/or its associated ductwork to allow installation of the desired filter media. It is important to note that MERV 13 to MERV 16 filter media are required to remove the 0.3-1.0 micron particles that the P-Trak measures; however, MERV 11 filter media will remove a portion of automotive emissions. Once filter media has been replaced with higher MERV rating filters, and several air changes have been allowed for, the building should be re-tested with the P-Trak to assess the effect of the change.
- If there are further complaints, the residential ventilation should be re-balanced, including a re-tuning of the primary air-handling unit and exhaust fan to provide the proper air flows.
- After overhauling the secondary air-handling units, the commercial ventilation should be rebalanced, including a re-tuning of the secondary air-handling units to provide proper air flows, if there are complaints.
- Increase the outdoor air fraction, if possible, to address the relatively high carbon dioxide levels in the film commission office.
- Set up the time clock for air-handling units two and three to provide ventilation according to scheduled office hours, and manually set the units on after overhaul of air-handling units. Setting both air-handling units on prior to an overhaul of air-handling units will likely result in complaints due to excessive noise produced by the two units. Operation of air-handling units two and three should address the relatively high carbon dioxide levels in the commissioner's office.
- Determine which residents have pets in their units, and which units have had the original carpeting replaced. This information should be cross-correlated with the air particulate measurements, and may provide some insight to additional causes for high air particulate.

- Although the outdoor air intake has been raised substantially above the original main floor level in an effort to introduce a better quality of air, the alley tends to have a higher particulate count than other building exposures. Reducing the particulates through improved filtration should be the initial course of action. If this does not improve the situation, consideration should be given to further reworking of the air intake location.

APPENDIX - Test, Adjust, and Balancing Report

TEST, ADJUST AND BALANCE REPORT

Closleigh Manor
Forensic TAB
Whitehorse, Yukon

March 10th, 2014

TAB Firm:



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Whitehorse, Yukon Y1A 2Z6
nce@northernclimate.com
T. 867-667-6900
F. 867-668-4252

Air Handling Unit Test Report

Unit Tag:		AHU-1
Unit Data		
Location		Mechanical Room
Manufacturer		Engineered Air
Model No.		LM-4-WR
Serial No.		13142-AHU-1
Type/Size		Sized Horizontal
Motor	Make / Model No.	Baldor / M3710T
	HP / RPM	7.5 / 1725
	Volts / Ph. / Freq.	208 / 3 / 60
	F.L. Amps / S.F.	21.5 / 1.15
Sheaves Bore / Diam.	Motor	1-3/8" Bore / 5-3/4" DP / 6-5/16" OD / fixed
	Fan	1" Bore / 5-3/4" DP / 6-5/16" OD / fixed
No. Belts/Size		2 / B55 [1]
No. Filters/Size		4 / 24x16x2 MERV8 [2,3]

Unit Characteristics	Design	Actual - Initial	Actual - Final
Fan Speed (RPM)	1566 [7]	490	1460 [1,4]
Motor Speed (RPM)	1725[7]	1790	1460 [1,4]
Motor Frequency (Hz)	60 [7]	60	50 [1,4]
Motor Volts (V)	208		
Motor Amps (A)	21.5		

Air Flows	L/s (CFM)	L/s (CFM)	L/s (CFM)
Total	5000 [7]	1353	3614 [5]
Outside	5000 [7]	1353	3614 [5]
Return	0 [7]	0	0

Static Pressures		Pa (in. w.c.)	Pa (in. w.c.)	Pa (in. w.c.)
Heating / Cooling Coils	Inlet		-0.0812	-0.329
	Outlet		-0.225	-1.41
	ΔP		0.1438	1.081
Filter	Inlet		0.02	-0.135
	Outlet		-0.0812	-0.329
	ΔP		0.1012	0.194 [2]
Inlet			-0.225	-1.41
Outlet			0.05	0.124
External		1.5 [7]	0.03	0.259
Total		3.57 [7]	0.275	1.534

Air Handling Unit Test Report

Unit Tag:		EF-1	AHU-2
Unit Data			
Location		Mechanical Room	Commissioner's Office
Manufacturer		Engineered Air	Engineered Air
Model No.		LM-4-W	LM-1
Serial No.		13142-EF-1	13142 AHU-2
Type/Size		Sized Horizontal	Sized Horizontal
Motor	Make / Model No.	Leroy Somer / 51HT48	Leroy Samson / 613W48
	HP / RPM	3 / 1725	1 / 1740 / 143T
	Volts / Ph. / Freq.	208 / 3 / 60	230 / 3 / 60
	F.L. Amps / S.F.	9.5 / 1.15	3.6 / 1.15
Sheaves Bore/Diam.	Motor	1-1/8" Bore / 3-3/4" DP / 4-1/4" OD / fixed [1]	7/8" Bore / 2-1/2" DP / 3-7/8" OD [1]
	Fan	1" Bore / 4-1/2" DP / 5-1/4" OD / fixed [1]	3/4" Bore / 9-3/8" DP / 10" OD [1]
No. Belts/Size		B48 (5L510) [2]	1 / A43 (4L450) [2]
No. Filters/Size		4 / 24x16x1 MERV	2 / 25x16x2 MERV 8 [3]

Unit Characteristics	Design	Actual - Initial	Design	Actual
Fan Speed (RPM)	1285 [3]	1225	1100 [7]	510
Motor Speed (RPM)	1725 [3]	1650	1740 [7]	1815
Motor Frequency (Hz)	60 [3]	60		
Motor Volts (V)	208			
Motor Amps (A)	9.5			

Air Flows	L/s (CFM)	L/s (CFM)	L/s (CFM)	L/s (CFM)
Total	4023 [3]	2094	1484 [7]	600
Outside	0 [3]	0	276 [7]	60
Return	4023 [3]	2094	1208 [7]	540

Static Pressures		Pa (in. w.c.)	Pa (in. w.c.)	Pa (in. w.c.)	Pa (in. w.c.)
Heating / Cooling Coils	Inlet		-0.876		n/a
	Outlet		-1.92		n/a
	ΔP		1.044		n/a
Filter	Inlet		-0.655		-0.0187
	Outlet		-0.876		-0.0651
	ΔP		0.221		0.0464
Inlet			-1.92		-0.0651
Outlet			0.0192		0.00442
External		1.5 [3]	0.6742	0.5 [7]	0.02312
Total		2.4 [3]	1.9392	0.92 [7]	0.06952

Air Handling Unit Test Report

Unit Tag:	EF-1	AHU-2 [4,5,6]
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<u>Unit Characteristics</u>		<u>Design</u>	<u>Actual</u>	<u>Design</u>	<u>Actual</u>
<u>Air Particulate</u>		<u>pt/cm³</u>	<u>pt/cm³</u>	<u>pt/cm³</u>	<u>pt/cm³</u>
Filters	Inlet				
	Outlet				
	Δ pt/cm ³				

<u>Notes:</u>	<u>Notes:</u>
[1] Slight wear on fan sheave, wear on motor sheave	[1] Wear on both fan and motor sheave
[2] Belt was replaced by building maintenance January 3rd, 2014; still in good shape	[2] Belt is cracked and requires replacement
[3] Original design values provided; Unit output was reduced from 1.0 Ac/hr to 0.5 Ac/hr, and thus original design values can be adjusted accordingly	[3] Filters are dirty, and require cleaning or replacement
	[4] on/off indicator light on AHU-2 electrical box was found to be burnt out
	[5] AHU-2 was found to be set in the off position
	[6] AHU-2 was found to be connected to a time clock; however, there were no tabs connected to the time clock to energize and de-energize the unit at specified times
	[7] Original design values provided; Unit output was reduced from 1.0 Ac/hr to 0.5 Ac/hr, and thus original design values can be adjusted accordingly

Air Handling Unit Test Report

Unit Tag:		AHU-3	AHU-4
Unit Data			
Location		Commissioner's Office	Film Commission
Manufacturer		Engineered Air	Engineered Air
Model No.		LM-1	LM-1
Serial No.		13142-4	13142-AHU-3
Type/Size		Sized Horizontal	Sized Horizontal
Motor	Make / Model No.	Leroy Samson / 851EW480	Leroy Samson / 61EW48
	HP / RPM / Frame	1 / 1740 / 143T	1 / 1740 / 143T
	Volts / Ph. / Freq.	230 / 3 / 60	208 / 3 / 60
	F.L. Amps / S.F.	3.6 / 1.15	3.6 / 1.15
Sheaves Bore/Diam.	Motor	7/8" Bore / 2-3/4" DP / 3-3/4" OD [1]	7/8" Bore / 3-1/4" DP / 3-3/4" OD [1]
	Fan	3/4" Bore / 7-3/4" DP / 8" OD [1]	3/4" Bore / 9" DP / 10" OD [1]
No. Belts/Size		1 / A39 (4L410) [2]	1 / A48 [2]
No. Filters/Size		2 / 25x16x2 MERV 8 [3]	2 / 24x16x2 MERV8 [3]

Unit Characteristics	Design	Actual	Design	Actual
Fan Speed (RPM)	1100 [8]	659	1100 [7]	646
Motor Speed (RPM)	1740 [8]	1790	1740 [7]	1789
Motor Frequency (Hz)				
Motor Volts (V)				
Motor Amps (A)				

Air Flows	L/s (CFM)	L/s (CFM)	L/s (CFM)	L/s (CFM)
Total	1484 [8]	889	1484 [4]	744
Outside	276 [8]	89	373 [4]	74
Return	1208 [8]	800	1111 [4]	670

Static Pressures		Pa (in. w.c.)	Pa (in. w.c.)	Pa (in. w.c.)	Pa (in. w.c.)
Heating / Cooling Coils	Inlet		n/a		n/a
	Outlet		n/a		n/a
	ΔP		n/a		n/a
Filter	Inlet		-0.0292		-0.0249
	Outlet		-0.12		-0.0731
	ΔP		0.0908		0.0482
Inlet			-0.12		-0.0731
Outlet			0.0602		0.0985
External		0.5 [8]	0.0894	0.5 [4]	0.1234
Total		0.92 [8]	0.1802	0.92 [4]	0.1716

Air Handling Unit Test Report

Unit Tag:	AHU-3 [4,5,6]	AHU-4
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<u>Unit Characteristics</u>		<u>Design</u>	<u>Actual</u>	<u>Design</u>	<u>Actual</u>
<u>Air Particulate</u>		<u>pt/cm³</u>	<u>pt/cm³</u>	<u>pt/cm³</u>	<u>pt/cm³</u>
Filters	Inlet				
	Outlet				
	Δpt/cm³				

<u>Notes:</u>	<u>Notes:</u>
[1] minor wear on both the fan sheave and the motor sheave	[1] Slight wear on motor sheave, wear on fan sheave
[2] Belt is cracked and separating from reinforcing cables; belt requires replacement	[2] Belt is cracked and separating from reinforcing cables; belt requires replacement
[3] Filters are dirty, and require cleaning or replacement	[3] Filters are dirty, and require cleaning or replacement; O&M manual calls for 2 / 25x16x2 filters
[4] The breaker for AHU-3 had been tripped; the unit ran once the breaker was flipped back on	[4] Original design values provided; Unit output was reduced from 1.0 Ac/hr to 0.5 Ac/hr, and thus original design values can be adjusted accordingly
[5] AHU-3 produced excessive noise and vibration, which was likely caused by severely damaged belt	
[6] AHU-3 was found to be set in the off position	
[7] AHU-3 was found to be connected to a time clock; however, there were no tabs connected to the time clock to energize and de-energize the unit at specified times	
[8] Original design values provided; Unit output was reduced from 1.0 Ac/hr to 0.5 Ac/hr, and thus original design values can be adjusted accordingly	

Fan Test Report

FAN DATA				
Number	EF-2			
Location	Garbage Room / Garage			
Service	Garbage Room			
Manufacturer	Zephyr Electric Fans			
Model Number	Z-8			
Type/Class				
Motor Make/Model No.	n/a [1]			
Motor HP/RPM/Frame	n/a [1]			
Volts/Phase/Hertz	115 / 1 / 60			
F.L. Amps/S.F.	1.95			
Motor Sheave	n/a [2]			
Diam./Bore				
Fan Sheave Make	n/a [2]			
Diam./Bore				
No. Belts/Make/Size	n/a [2]			
TEST DATA				
	Design	Actual	Design	Actual
Airflow - L/s (CFM)		n/a [3]		
Fan RPM		n/a [3]		
Motor RPM		n/a [3]		
Frequency		n/a [3]		
Voltage		n/a [3]		
Amperage		n/a [3]		
External Static Press. Pa (in. w.c.)		n/a [3]		
	NOTES		NOTES	
	[1] Name plate data not accessible			
	[2] Direct drive fan			
	[3] Fan switched on, but not running			

Air Outlet Test Report

Air Flow													
CFM													
Unit No.	101	102	103	104	105	107	Room		Pioneer's	1st Floor	2nd Floor	3rd Floor	
Room	K	20	15	19	0	37	0	Outlet No. [2]	1 (S/A)	15	26	110	143
	LR	0	10	6	7	5	0		2 (S/A)	25	137	x	x
	WC	32	26	22	0	38	7		3 (S/A)	x	x	x	x
	MBR	0	26	7	7	0	0		4 (E/A)	165	68	31	38
	BR	x	x	x	x	x	x		5 (E/A)	38	x	50	55
Unit No.	201	202	203	204	205	206	207	208	209	210	211	212	
Room	K	23	40	20	0	0	19	0	0	58	6	50	0
	LR	12	7	7	12	5	9	4	0	11	9	18	22
	WC	29	10	29	10	19	0	29	0	37	111	11	79
	MBR	10	4	9	11	5	12	4	19	12	9	9	26
	BR	0	8	x	x	x	x	x	5	x	7	22	x
Unit No.	301	302	303	304	305	306	307	308	309	310	311	312	
Room	K	14	47	14	0	0	37	60	20	71	0	84	134
	LR	14	22	12	9	11	22	20	12	16	18	29	49
	WC	51	18	31	0	27	37	37	4	16	79	71	69
	MBR	14	17	19	18	9	0	17	26	15	14	27	54
	BR	20	19	x	x	x	x	x	7	x	14	24	x

Notes:
[1] K = kitchen (E/A), LR = living room (S/A), WC = water closet/bathroom (E/A), MBR = master bedroom (S/A), BR = bedroom (S/A)
[2] 1st Floor Outlets: No. 1 is the lobby supply, No. 2 is a combination of the two mechanical room supplies, No. 4 is the electrical room exhaust; 2nd Floor outlets: No. 1 is the hallway supply, No. 4 is the garbage chute closet exhaust, No. 5 is the common room exhaust; 3rd Floor outlets: No. 1 is the hallway supply, No. 4 is the garbage chute closet exhaust, No. 5 is the common room exhaust
[3] x's indicate measurements that do not apply

Air Outlet Re-Test Report

		Air Flow											
		CFM											
Unit No.		101	102	103	104	105	107	Room	Pioneer's	1st Hall	2nd Hall	3rd Hall	
Room	K	21	11					Outlet No.	1 (S/A)	46	56	310	330
	LR	9	15						2 (S/A)	75	290 [4]	x	x
	WC	27	9						3 (S/A)	x	x	x	x
	MBR	15	20						4 (E/A)		62		
	BR	x	x	x	x	x	x		5 (E/A)		x	x	x
Unit No.		201	202	203	204	205	206	207	208	209	210	211	212
Room	K			18									
	LR			20									
	WC			26									
	MBR			22									
	BR			x	x	x	x	x		x			x
Unit No.		301	302	303	304	305	306	307	308	309	310	311	312
Room	K	13											127
	LR	20											64
	WC	53											69
	MBR	20											60
	BR	26		x	x	x	x	x		x			x

	Total	Partial		Percent
	Initial CFM	Initial CFM	Final CFM	
Supply Air	1353	496	1052	1.12
Exhaust Air	2094	410	374	-0.09

Notes:
See notes [1] to [3] from initial air outlet test report
[4] Boiler room supply is a combination of two supply grills which were measured at 155 CFM and 135 CFM

Air Outlet Test Report

Area Served	Tag	Outlet		Design	Preliminary		Final [1]		Percent of Design
		No.	Size	L/s (CFM)	CFM	pt/cc	CFM	pt/cc	
AHU-2									
Lunch Room	1			200 (420) [2]	n/a		210		
Meeting Room	2			200 (420) [2]	n/a	5800	175		
Meeting Room	3			200 (420) [2]	n/a	5800	165		
Office	4			200 (420) [2]	n/a	6100	50		
				700 (1470) [2]			600		
AHU-3									
Reception	5			175 (370) [2]	n/a	6100	207		
Reception	6			175 (370) [2]	n/a	6100	224		
Commissioner's Office	7			175 (370) [2]	n/a	6100	232		
Commissioner's Office	8			175 (370) [2]	n/a	6100	226		
				700 (1470) [2]			889		

Notes:

[1] Measurements taken prior to replacement of belts on AHU-1.

[2] Original design values for the building. While AHU-1 was described as having its air flow reduced from supplying 1.0 ach to 0.5 Ac/hr, there is no mention of any change to the AHU-2 & AHU-3 Ac/hr. Both the current air flow and the fan RPM appear as though the units' output have been reduced by 50%.

Air Outlet Test Report

Area Served	Tag	Outlet		Design	Preliminary		Final [1]		Percent of Design
		No.	Size	CFM	CFM	pt/cc	CFM	pt/cc	
AHU-4									
Reception	1						343	10800	
Front Office	2						93	10000	
Back Office	3						222	18000	
Lunch Room	4						86		
				700 (1484) [2]			744		
Notes:									
[1] Measurements taken prior to replacement of belts on AHU-1.									
[2] Original design values for the building. While AHU-1 was described as having it's air flow reduced from supplying 1.0 ach to 0.5 Ac/hr, there is no mention of any change to the AHU-4 Ac/hr. Both the current air flow and the fan RPM appear as though the unit's output have been reduced by 50%.									

Air Outlet Test Comparison

		Air Flow											
		CFM											
Unit No.		101	102	103	104	105	107	Room	Pioneer's	1st Floor	2nd Floor	3rd Floor	
Room	K	-0.21667	-0.40833	-0.25	-1	0.458333	-1	Outlet No.	1 (S/A)	-0.90533	-0.86333	-0.66516	-0.56452
	LR	-1	-0.57273	-0.74545	-0.7	-0.78182	-1		2 (S/A)	-0.84267	n/a	x	x
	WC	-0.34348	-0.18	-0.30667	-1	0.193333	-0.78		3 (S/A)	x	x	x	x
	MBR	-1	0.118182	-0.7	-0.7	-1	-1		4 (E/A)		0.284	0.46	0.79
	BR	x	x	x	x	x	x		5 (E/A)	-0.22174	x	x	x
Unit No.		201	202	203	204	205	206	207	208	209	210	211	212
Room	K	-0.1	0.575	-0.21667	-1	-1	-0.25	-1	-1	1.283333	-0.76667	0.966667	-1
	LR	-0.48182	-0.7	-0.7	-0.48182	-0.78182	-0.61818	-0.82727	-1	-0.52727	-0.61818	-0.22727	-0.05455
	WC	-0.40435	-0.79565	-0.08667	-0.68667	-0.4	-1	-0.08667	-1	0.166667	1.278261	-0.77391	1.486667
	MBR	-0.57273	-0.82727	-0.61818	-0.52727	-0.78182	-0.48182	-0.82727	-0.18182	-0.48182	-0.61818	-0.61818	0.118182
	BR	-1	-0.525	x	x	x	x	x	-0.78182	x	-0.5875	0.3	x
Unit No.		301	302	303	304	305	306	307	308	309	310	311	312
Room	K	-0.45	0.85	-0.45	-1	-1	0.458333	1.358333	-0.21667	1.791667	-1	2.3	4.266667
	LR	-0.4	-0.05455	-0.48182	-0.61818	-0.52727	-0.05455	-0.14545	-0.48182	-0.31818	-0.22727	0.37	1.1
	WC	0.047826	-0.63043	-0.02667	-1	-0.15333	0.166667	0.166667	-0.91739	-0.5	0.621739	0.456522	1.166667
	MBR	-0.4	-0.27273	-0.18182	-0.22727	-0.61818	-1	-0.27273	0.118182	-0.35455	-0.4	0.27	1.318182
	BR	0.175	0.125	x	x	x	x	x	-0.7	x	-0.175	0.4125	x

Air Outlet Re-Test Comparison

		Air Flow											
		CFM											
Unit No.		101	102	103	104	105	107	Room	Pioneer's	1st Hall	2nd Hall	3rd Hall	
Room	K	-0.175	-0.56667					Outlet No.	1 (S/A)	-0.71067	-0.70667	-0.05677	0.004516
	LR	-0.61818	-0.35455						2 (S/A)	-0.528	x	x	x
	WC	-0.44783	-0.72						3 (S/A)	x	n/a	x	x
	MBR	-0.35455	-0.14545						4 (E/A)		0.168		
	BR	x	x	x	x	x	x		5 (E/A)		x	x	x
Unit No.		201	202	203	204	205	206	207	208	209	210	211	212
Room	K			-0.29167									
	LR			-0.14545									
	WC			-0.18									
	MBR			-0.05455									
	BR			x	x	x	x	x		x			x
Unit No.		301	302	303	304	305	306	307	308	309	310	311	312
Room	K	-0.49167											3.991667
	LR	-0.14545											1.745455
	WC	0.086957											1.166667
	MBR	-0.14545											1.572727
	BR	0.5375		x	x	x	x	x		x			x

Air Pressure Test Report

Static Pressure Difference*												
in. w.c.												
Unit No. / Room	101	102	103	104	105	107	Pioneer's					
	0.00293	-0.0465	0.00329	0.00025	0.00609	0.00034	0.0034					
Unit No. / Room	201	202	203	204	205	206	207	208	209	210	211	212
	-0.0073	-0.001	0.00328	-0.0029	-0.0001	-0.0007	0.00025	-0.0083	0.00542	-0.005	0.0024	0.00289
Unit No. / Room	301	302	303	304	305	306	307	308	309	310	311	312
		-0.0003	0.00039	-0.0015	-0.0004	0.00075	0.00336	-0.0039	0.0041	0.0032	0.00484	-0.022

Notes:
*S.P. as measured in hall, relative to unit / room

Air Particulate Test Report

Air Particulate													
pt/cm ³													
Unit No.	101	102	103	104	105	107	Room		Pioneer's	1st Hall	2nd Hall	3rd Hall	
Room	K	110000	43000	9000	7000	11000	16000	Outlet No.	1 (S/A)	24000	10000	15000	20100
	LR	112000	41000	5000	13000	6000	17000		2 (S/A)	20000	x	x	x
	WC	103000	45000	10000	7000	10000	16000		3 (S/A)	10000	x	x	x
	MBR	117000	40000	5000	13000	10000	18000		4 (E/A)	x	x	11000	14600
	BR	x	x	x	x	x	x		5 (E/A)	11000	x	x	x
Unit No.	201	202	203	204	205	206	207	208	209	210	211	212	
Room	K	15000	20000	11000	11000	6000	4500	8500	7000	410000	150000	13000	16000
	LR	16000	19000	8000	4500	6000	13000	4000	7000	190000	120000	8000	15000
	WC	16000	20000	11000	11000	6000	5000	8500	7000	260000	105000	10000	18000
	MBR	17000	10000	6000	7000	4500	9000	4000	10000	80000	101000	9000	12000
	BR	15000	10000	x	x	x	x	x	5000	x	102000	6000	x
Unit No.	301	302	303	304	305	306	307	308	309	310	311	312	
Room	K	11000	55000	62000	8500	7000	15000	12000	23000	9000	11000	15000	12000
	LR	10000	65000	59000	18000	16000	22000	12000	16000	10000	12000	16000	12000
	WC	12000	59000	72000	8000	6500	16000	12000	23000	8500	11000	14000	12000
	MBR	11000	26000	52000	11000	16000	17000	13000	14000	9000	11000	14000	13500
	BR	11000	50000	x	x	x	x	x	14000	x	11000	14000	x

Notes:

See notes [1] to [3] from initial air outlet report

Air Particulate Re-Test Report

		Air Flow											
		CFM											
Unit No.		101	102	103	104	105	107	Room	Pioneer's	1st Hall	2nd Hall	3rd Hall	
Room	K							Outlet No.	1 (S/A)				
	LR								2 (S/A)		x	x	x
	WC								3 (S/A)		x	x	x
	MBR								4 (E/A)	x	x		
	BR	x	x	x	x	x	x		5 (E/A)		x	x	x
Unit No.		201	202	203	204	205	206	207	208	209	210	211	212
Room	K			17000									
	LR			10000									
	WC			17000									
	MBR			10000									
	BR			x	x	x	x	x		x			x
Unit No.		301	302	303	304	305	306	307	308	309	310	311	312
Room	K	10000											11000
	LR	11000											10000
	WC	12000											11000
	MBR	9000											10000
	BR	10000			x	x	x	x	x	x			x

Notes:
See notes [1] to [3] from initial air outlet report

Outdoor Air Particulate Test Report

Rooms/Units Tested	Outdoor Air Particulate pt/cm ³	Weather Observations / Notes	Date dd-mmm-yy
301, 312, Comissioner's Office, Film Commission	16700, 18600-24400, 33000	none	19-Feb-14
302-311	30000-42000; 14000-20000	clear with slight haze, and initially with ice fog over river; cloudy with very light snow	20-Feb-14
201-212	2000, 5000	clear, light SSE wind	24-Feb-14
Pioneer's Room, 101-107	4000, 5000, 18000	clear, light SSE wind	25-Feb-14
301, 312, 203	23000-25000	clear / units re-tested after replacement of belts in AHU-1	27-Feb-14