Alfa Laval
Pure Air case study

Impact of liquid desiccant dehumidification technology on environmental microbial contamination within outside air being supplied to OR suites

Albany Medical Center — OR Suite liquid desiccant dehumidification system

Introduction

Alfa Laval was contracted by FPI Mechanical Inc. to design and manufacture a liquid dehumidification system to treat the outside air provided to (20) ORs (operating rooms) in the 'B' Building at the Albany Medical Center in Albany, NY in June of 2015. The two year old facility was unable to meet the specified OR area environmental design criteria. The Albany Medical Center employed the services of FPI Mechanical Inc. to procure and install the appropriate equipment and technology to meet the required OR environmental performance levels of 63°F and 40% RH.

During the development of the project a study was proposed to the Albany Medical Center that would look at the performance of the liquid desiccant dehumidification technology.

Additionally FPI Mechanical Inc. undertook a separate, concurrent energy performance study of the liquid desiccant dehumidification technology with the Albany Medical Center.

Purpose

The study was undertaken in May of 2015 to help understand the impact of the Pure Air liquid desiccant dehumidification technology on environmental microbial contamination present on surfaces of the dedicated heating, ventilating and air conditioning (HVAC) systems providing outside air serving the Building 'B' ORs. The study continued through November of 2016

Design

The study design focused on quantitative (colony forming units, CFUs) and qualitative (microorganism identity and species) aspects of the microbial contamination laden within the outside air. Sampling was conducted via sterile surface swab utilizing a BBL Culturette system. Pre-selected locations (see Sample Locations) were determined and the sampling repeated on a monthly basis. Sterile gloves were donned prior to sampling.

The executed samples were sealed and express couriered to an independent third party certified environmental laboratory for culturing and analysis.

Scope

The OR area air handling units (AHUs) in 'B' Building at the Albany Medical Center are designated AHU-3A serving ORs 1 through 10 and AHU-3B serving ORs 11 through 20. Each AHU provides 40,000 CFM of air to the OR areas.

The Alfa Laval Pure Air liquid desiccant dehumidification system was installed to provide a total of 30,000 CFM of dehumidified air to AHU-3A and AHU-3B. The sample locations for the study were located at:

- OA Plenum at the Pure Air intake
- Pure Air sump tank
- Pure Air supply air duct to AHU-3A and AHU-3B
- AHU-3A and AHU-3B air mixing compartments
- AHU-3A and AHU-3B final filter upstream compartments
- AHU-3A and AHU-3B final filter downstream compartments
- Cardio OR-17 supply air HEPA
- Cardio OR-17 return air grille

The sampling was scheduled monthly at 05:15 to minimize impact on the OR area. The OR AHU-3A and AHU-3B were shut down for access to conduct sampling at the designated sample locations. Upon completion of sampling in the mechanical space, the Cardio OR-17 was sampled. Baseline Pre-KATHABAR installation sampling was conducted at the OR AHUs and OR on May 12, 2015, May 28, 2015 and June 18, 2015. Post-Pure Air installation sampling began on July 9, 2015 and continued through August 2016.

All samples were coded and forwarded with chain of custody to Aerobiology Laboratory for culturing and analysis.

Analysis procedure

Each surface swab was immersed in a sterile test tube containing 10 ml of sterile distilled water upon arrival at the laboratory. The test tube sample was kept at room temperature for 10 minutes and then placed in a rotary shaker (3.81 throw, 220 rpm) for one (1) minute. The resulting suspension or dilution was then inoculated (0.1 ml aliquots) on a 2% malt extract agar (MEA- for saprotrophic fungal growth) and a trypticase soy agar (TSA- for environmental bacteria growth), presenting estimates of the total number of viable propagules per milliliter of suspension. Inoculated laboratory controls were then incubated. The samples were immediately incubated at 25° +/-1° C.

Macroscopic, microscopic and quantitative morphology results were documented every 24 hours following incubation. Organisms were identified to a species level. Incubation was then terminated after seven (7) days of observation depending on what species were present in the samples. The surface swab sample results were presented in total colony forming units per square inch (CFU/inch2).

A “No Growth Promoted” sample designation denoted no viable microbiological growth identified using the above listed sample preparation and analysis protocols. An “Over Loaded” sample designation denoted an over growth of viable microbiological matter and numerical identification was not possible.

Complete microbial analysis report documenting quantitative and qualitative results was forwarded within 10 days of receipt of samples to the Albany Medical Center.

Results

See Appendix “A” for environmental microbial contamination data summary.

Conclusion

The goal of this study was to examine the efficacy of the Alfa Laval liquid dehumidification technology with naturally occurring microorganisms present in outside air being supplied to AHUs that support environmental conditions within ORs at the Albany Medical Center.

The sampling conducted over a period of twelve (12) months demonstrated up to a six (6) 99.9999% log reduction in environmental microbial contamination found on surfaces of the HVAC system providing outside air to OR AHU-3A and AHU-3B. This is significant as many of the microorganisms identified through the sampling are representative of pathogens that are prevalent within healthcare facilities and associated with HAIs (Healthcare Associated Infections).

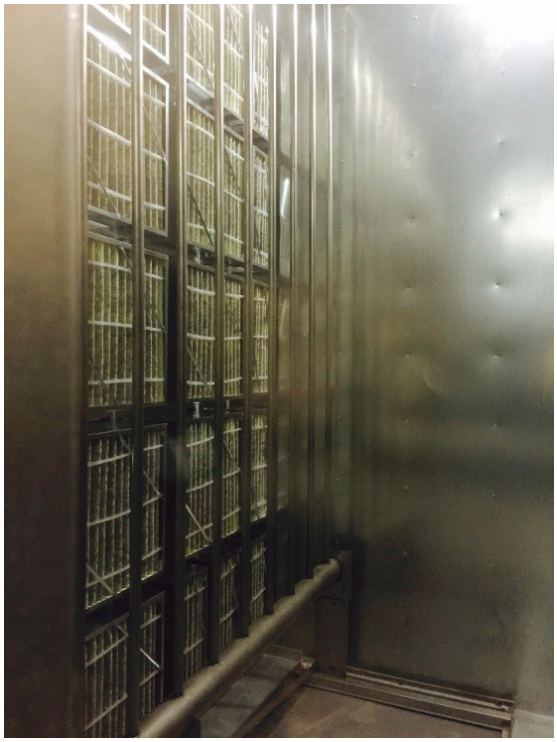
It is also noted that the sampling demonstrated a great deal of microbial contamination within the return air to the OR AHU-3A and AHU-3B units which is not treated by the Pure Air system.

Sample location

OR AHU-3A Inlet Sample

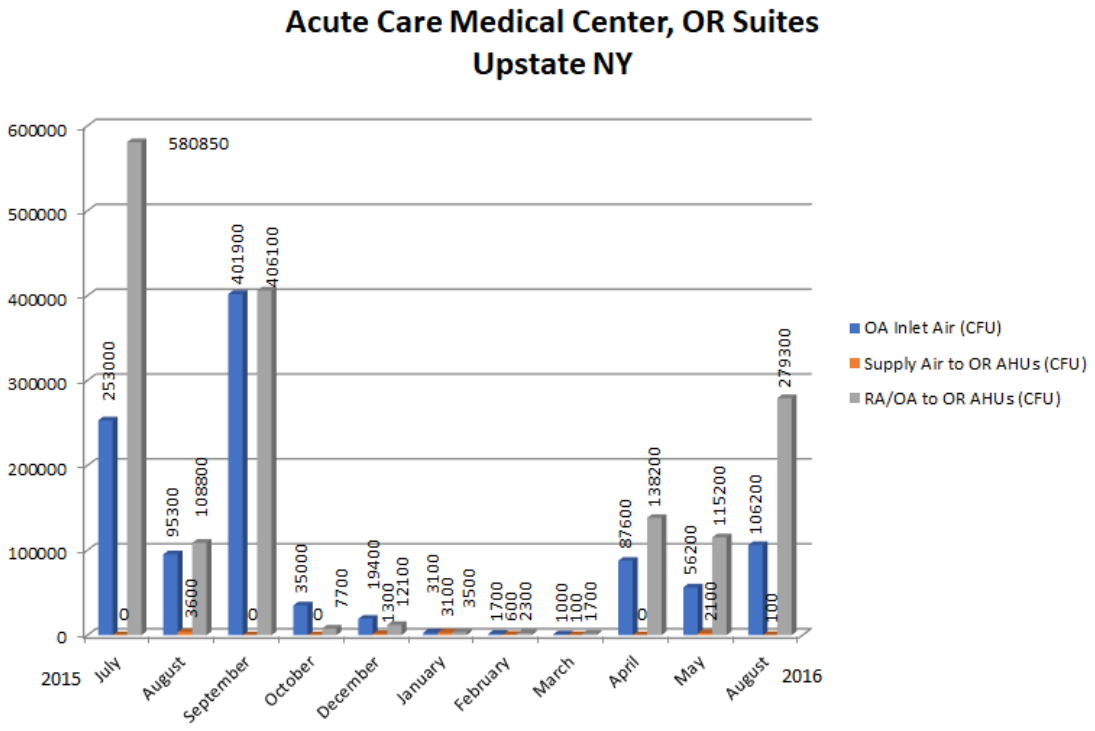
OR AHU-3B Inlet Sample

Final Filter Upstream Sample



Final Filter Downstream Sample

Appendix ‘A’


Acute Care Medical Center, OR Suites
Upstate NY
600000
500000
400000
300000
200000
100000
0
2015
July
August
September
October
December
January
February
March
April
May
August
2016
253000
0
580850
95300
3600
108800
401900
0
406100
35000
0
7700
19400
1300
12100
3100
3100
3500
1700
600
2300
1000
100
1700
87600
0
138200
56200
2100
115200
106200
100
279300
OA Inlet Air (CFU)
Supply Air to OR AHUs (CFU)
RA/OA to OR AHUs (CFU)

Appendix ‘B’

Baseline

Date	Sample Location	Characterization	# Colony Forming Units	Total CFU/ Sq In.
5/12/2015	OR AHU-3A Air Inlet Sample	Bacillus sp.	22	22,000
		Eurotium sp.	2	200
		Penicillium sp.	1	100
		Alternaria sp.	2	200
		Cladisporium sp.	3	300
		Non-sporulating fungi	3	300
		Micrococcus sp.	1	1,000
	OR AHU-3B Air Inlet Sample	Bacillus sp.	25	25,000
		Eurotium sp.	1	100
		Cladisporium sp.	4	400
		Non-sporulating fungi	2	200
		Verticillium sp.	1	100
		Yeast sp.	1	100
5/28/2015	OR AHU-3A Air Inlet Sample	Bacillus sp.	48	48,000
		Cladisporium sp.	2	200
		Non-sporulating fungi	4	400
		Yeast sp.	2	200
		Alternaria sp.	3	300
		Aureobasidium sp.	6	600
		Cladisporium sp.	2	200
	OR AHU-3B Air Inlet Sample	Bacillus sp.	88	88,000
		Cladisporium sp.	2	200
		Non-sporulating fungi	1	10
		Yeast sp.	3	300
		Alternaria sp.	2	200
		Aureobasidium sp.	1	100
		Penicillium sp.	1	100
		Staphylococcus sp.	6	6,000
		Ustilago sp.	1	100
		Acremonium sp.	1	100
6/18/2015	KATHABAR Supply Air Sample	Bacillus sp.	3	3,000
		Aureobasidium sp.	7	700
	OA Inlet to KATHABAR Sample	Bacillus sp.	22	22,000
		Aureobasidium sp.	2	200
		Cladisporium sp.	1	100
		Non-sporulating fungi	3	300

Baseline continued

Date	Sample Location	Characterization	# Colony Forming Units	Total CFU/ Sq In.
	OR AHU-3A Air Inlet Sample	Bacillus sp.	26	260,000
		Aspergillus flavus	1	100
		Aspergillus niger	1	100
		Cladisporium sp.	4	400
		Epicoccum sp.	2	200
		Non-sporulating fungi	2	200
		Penicillium sp.	1	100
	OR AHU-3B Air Inlet Sample	Bacillus sp.	62	620,000
		Alternaria sp.	2	200
		Aureobasidium sp.	2	200
		Epicoccum sp.	1	100
		Eurotium sp.	1	100
	KATHABAR Sump Sample	ND	ND	ND

Post installation

Date	Sample Location	Characterization	# Colony Forming Units	Total CFU/ Sq In.
7/9/2015	OR AHU-3B Air Inlet Sample	Bacillus sp.	600	600,000
		Acremonium sp.	5	500
		Alternaria sp.	4	400
		Chaetomium sp.	1	100
		Cladophialophora sp.	7	700
		Aureobasidium sp.	2	200
		Rhodotorula sp.	4	400
		Yeast sp.	75	7,500
	KATHABAR Sump Sample	ND	ND	ND
	OR AHU-3A Air Inlet Sample	Bacillus sp.	550	550,000
		Cladisporium sp.	3	300
		Chaetomium sp.	1	100
		Non-sporulating fungi	3	300
		Penicillium sp.	2	200
		Yeast sp.	6	600
	KATHABAR Supply air to OR AHU-3A & 3B	ND	ND	ND
	OA Inlet to KATHABAR Sample	Bacillus sp.	200	200,000
		Psuedomonas sp.	14	14,000
		Alternaria sp.	1	1,000
		Aureobasidium sp.	22	22,000
		Rhodotorula sp.	14	14,000
		Yeast sp.	2	2,000
	Cardio Surgery OR-17 RA	Bacillus sp.	123	123,000
		Psuedomonas sp.	25	25,000
		Aureobasidium sp.	1	100
		Rhodotorula sp.	13	1,300
		Yeast sp.	25	2,500
	Cardio Surgery OR-17 HEPA SA	ND	ND	ND
8/6/2015	OR AHU-3A UVGI Compartment	Yeast sp.	8	800
	OR AHU-3A Final Filter Up	ND	ND	ND
	OR AHU-3A Final Filter Dn	ND	ND	ND
	OR AHU-3B UVGI Compartment	ND	ND	ND
	OR AHU-3B Final Filter Up	Bacillus sp.	100	100,000
		Fusarium sp.	1	100
	OR AHU-3B Final Filter Dn	ND	ND	ND
	OR AHU-3B Air Inlet Sample	Bacillus sp.	58	58,000

Post installation continued

Date	Sample Location	Characterization	# Colony Forming Units	Total CFU/ Sq In.
		Alternaria sp.	1	100
		Cladisporium sp.	1	100
		Fusarium sp.	3	300
	OR AHU-3A Air Inlet Sample	Bacillus sp.	18	18,000
		Psuedomonas sp.	32	32,000
		Alternaria sp.	1	100
		Aureobasidium sp.	1	100
		Cladisporium sp.	1	100
	KATHABAR Sump Sample	ND	ND	ND
	KATHABAR Supply air to OR AHU-3A & 3B	Bacillus sp.	36	3,600
	OA Inlet to KATHABAR Sample	Bacillus sp.	42	42,000
		Psuedomonas sp.	40	40,000
		Acremonium sp.	10	1,000
		Alternaria sp.	3	300
		Aureobasidium sp.	60	6,000
		Curvularia sp.	1	100
		Epicoccum sp.	6	600
		Rhodotorula sp.	38	3,800
		Yeast sp.	15	1,500
	Cardio Surgery OR-17 HEPA SA	ND	ND	ND
	Cardio Surgery OR-17 RA	ND	ND	ND
9/3/2015	OR AHU-3B Air Inlet Sample	Acinetobacter sp.	300	300,000
		Cladisporium sp.	1	100
	KATHABAR Sump Sample	ND	ND	ND
	OR AHU-3A Air Inlet Sample	Bacillus sp.	100	100,000
		Micrococcus sp.	6	6,000
	KATHABAR Supply air to OR AHU-3A & 3B	ND	ND	ND
	OA Inlet to KATHABAR Sample	Acinetobacter sp.	378	378,000
		Bacillus sp.	12	12,000
		Psuedomonas sp.	10	10,000
		Alternaria sp.	6	600
		Aureobasidium sp.	4	400
		Bipolaris sp.	1	100
		Curvularia sp.	1	100
		Epicoccum sp.	2	200

Post installation continued

Date	Sample Location	Characterization	# Colony Forming Units	Total CFU/ Sq In.
		Rhodotorula sp.	5	500
	Cardio Surgery OR-17 RA	ND	ND	ND
	Cardio Surgery OR-17 HEPA SA	ND	ND	ND
10/15/2015	OR AHU-3B Air Inlet Sample	Psuedomonas sp.	5	5,000
		Acremonium sp.	1	100
		Aureobasidium sp.	5	500
		Cladisporium sp.	4	400
	OR AHU-3A Air Inlet Sample	Bacillus sp.	6	600
		Coag-negative Staphylococcus sp.	1	100
		Aureobasidium sp.	4	400
		Cladisporium sp.	1	100
		Non-sporulating fungi	2	200
		Yeast sp.	3	300
	OR AHU-3B Final Filter Up	Aureobasidium sp.	3	300
		Non-sporulating fungi	1	100
	OR AHU-3B Final Filter Dn	ND	ND	ND
	OR AHU-3A Final Filter Up	Psuedomonas sp.	16	16,000
		Acremonium sp.	3	300
		Non-sporulating fungi	1	100
	OR AHU-3A Final Filter Dn	ND	ND	ND
	KATHABAR Sump Sample	ND	ND	ND
	KATHABAR Supply air to OR AHU-3A & 3B	ND	ND	ND
	OA Inlet to KATHABAR Sample	Bacillus sp.	26	26,000
		Aureobasidium sp.	4	4,000
		Cladisporium sp.	1	1,000
		Epicoccum sp.	1	1,000
		Phoma sp.	1	1,000
		Rhodotorula sp.	4	4,000
		Yeast sp.	2	2,000
	Cardio Surgery OR-17 RA	ND	ND	ND
	Cardio Surgery OR-17 HEPA SA	ND	ND	ND
12/10/2015	OR AHU-3B Air Inlet Sample	Bacillus sp.	12	1,200
		Aspergillus candidus	1	100
		Aspergillus fumigatus	2	200
		Aureobasidium sp.	1	100

Post installation continued

Date	Sample Location	Characterization	# Colony Forming Units	Total CFU/ Sq In.
		Penicillium sp.	2	200
		Yeast sp.	4	400
	OR AHU-3B Final Filter Up	Bacillus sp.	15	1,500
		Alternaria sp.	3	300
		Aspergillus fumigatus	1	100
		Aureobasidium sp.	5	5,000
		Cladisporium sp.	3	300
		Epicoccum sp.	2	200
		Penicillium sp.	3	300
		Trichoderma sp.	2	200
		Yeast sp.	2	2,000
	OR AHU-3B Final Filter Dn	Bacillus sp.	1	100
	Pure Air Sump Sample	Bacillus sp.	6	600
		Micrococcus sp.	4	400
	OR AHU-3A Air Inlet Sample	Bacillus sp.	6	600
		Aspergillus fumigatus	1	100
		Aureobasidium sp.	3	300
		Cladisporium sp.	2	200
		Non-sporulating fungi	2	200
		Rhodotorula sp.	1	100
		Yeast sp.	1	100
	OR AHU-3A Final Filter Up	Psuedomonas sp.	8	800
		Aureobasidium sp.	7	700
		Rhodotorula sp.	1	100
		Yeast sp.	1	100
	OR AHU-3A Final Filter Dn	ND	ND	ND
	Pure Air Supply air to OR AHU-3A & 3B	Aureobasidium sp.	3	300
		Yeast sp.	10	1,000
	OA Inlet to Pure Air Sample	Bacillus sp.	21	2,100
		Psuedomonas sp.	32	3,200
		Alternaria sp.	3	300
		Aureobasidium sp.	7	7,000
		Epicoccum sp.	5	500
		Trichoderma sp.	3	300
		Yeast sp.	6	6,000
	Cardio Surgery OR-17 RA	Bacillus sp.	16	1,600

Post installation continued

Date	Sample Location	Characterization	# Colony Forming Units	Total CFU/ Sq In.
		Psuedomonas sp.	10	1,000
		Pithomyces sp.	2	200
		Rhodotorula sp.	1	100
		Yeast sp.	3	300
	Cardio Surgery OR-17 HEPA SA	ND	ND	ND
1/7/2016	OR AHU-3B Air Inlet Sample	Bacillus sp.	6	600
		Aspergillus candidus	1	100
		Aspergillus versicolor	1	100
		Cladisporium sp.	6	600
		Non-sporulating fungi	2	200
		Penicillium sp.	1	100
		Ustilago sp.	1	100
	OR AHU-3B Final Filter Up	Coag-negative Staphylococcus sp.	5	500
		Alternaria sp.	2	200
		Aureobasidium sp.	1	100
		Cladisporium sp.	5	500
		Epicoccum sp.	1	100
		Non-sporulating fungi	1	100
	OR AHU-3B Final Filter Dn	Coag-negative Staphylococcus sp.	6	600
	Pure Air Sump Sample	ND	ND	ND
	OR AHU-3A Air Inlet Sample	Bacillus sp.	1	100
		Alternaria sp.	2	200
		Aspergillus niveus	1	100
		Cladisporium sp.	10	1,000
		Penicillium sp.	2	200
		Rhodotorula sp.	1	100
	OR AHU-3A Final Filter Up	Alternaria sp.	2	200
		Aureobasidium sp.	1	100
		Cladisporium sp.	4	400
		Penicillium sp.	1	100
		Rhodotorula sp.	2	200
		Yeast sp.	1	100
	OR AHU-3A Final Filter Dn	ND	ND	ND
	KATHABAR Supply air to OR AHU-3A & 3B	Coag-negative Staphylococcus sp.	23	2,300

Post installation continued

Date	Sample Location	Characterization	# Colony Forming Units	Total CFU/ Sq In.
		Micrococcus sp.	7	700
		Cladisporium sp.	1	100
	OA Inlet to Pure Air Sample	Bacillus sp.	5	500
		Alternaria sp.	6	600
		Aureobasidium sp.	4	400
		Cladisporium sp.	5	500
		Non-sporulating fungi	6	600
		Rhodotorula sp.	1	100
		Trichoderma sp.	2	200
		Yeast sp.	2	200
	Cardio Surgery OR-17 RA	ND	ND	ND
	Cardio Surgery OR-17 HEPA SA	ND	ND	ND
2/25/2016	OR AHU-3B Air Inlet Sample	Bacillus sp.	2	200
		Cladisporium sp.	1	100
		Non-sporulating fungi	4	400
		Penicillium sp.	1	100
		Yeast sp.	1	100
	OR AHU-3B Final Filter Up	Bacillus sp.	2	200
		Aspergillus versicolor	1	100
		Aureobasidium sp.	2	200
		Non-sporulating fungi	4	400
		Penicillium sp.	1	100
		Rhodotorula sp.	2	200
	OR AHU-3B Final Filter Dn	Coag-negative Staphylococcus sp.	1	100
	Pure Air Sump Sample	ND	ND	ND
	OR AHU-3A Air Inlet Sample	Bacillus sp.	2	200
		Cladisporium sp.	1	100
		Eurotium sp.	1	100
		Non-sporulating fungi	2	200
		Penicillium sp.	1	100
		Rhodotorula sp.	1	100
	OR AHU-3A Final Filter Up	Bacillus sp.	1	100
		Alternaria sp.	1	100
		Penicillium sp.	6	600
		Yeast sp.	1	100

Post installation continued

Date	Sample Location	Characterization	# Colony Forming Units	Total CFU/ Sq In.
	OR AHU-3A Final Filter Dn	ND	ND	ND
	KATHABAR Supply air to OR AHU-3A & 3B	Aureobasidium sp.	1	100
	OA Inlet to KATHABAR Sample	Bacillus sp.	5	500
		Aureobasidium sp.	1	100
		Cladisporium sp.	1	100
		Non-sporulating fungi	1	100
		Penicillium sp.	1	100
		Rhodotorula sp.	1	100
	Cardio Surgery OR-17 RA	Coag-negative Staphylococcus sp.	1	100
		Micrococcus sp.	3	300
	Cardio Surgery OR-17 HEPA SA	ND	ND	ND
3/17/2016	OR AHU-3B Air Inlet Sample	Bacillus sp.	7	700
		Cladisporium sp.	4	400
		Eurotium sp.	1	100
		Non-sporulating fungi	4	400
		Penicillium sp.	1	100
	OR AHU-3B Final Filter Up	Bacillus sp.	1	100
		Cladisporium sp.	1	100
		Curvularia sp.	1	100
	OR AHU-3B Final Filter Dn	Coag-negative Staphylococcus sp.	1	100
	KATHABAR Sump Sample	ND	ND	ND
	OR AHU-3A Air Inlet Sample	Bacillus sp.	1	100
		Non-sporulating fungi	4	400
		Yeast sp.	1	100
	OR AHU-3A Final Filter Up	Bacillus sp.	1	100
		Penicillium sp.	1	100
	OR AHU-3A Final Filter Dn	Coag-negative Staphylococcus sp.	2	200
		Verticillium sp.	1	100
	Pure Air Supply air to OR AHU-3A & 3B	Coag-negative Staphylococcus sp.	1	100
		Aureobasidium sp.	1	100
		Non-sporulating fungi	2	200
		Penicillium sp.	1	100
		Yeast sp.	1	100

Post installation continued

Date	Sample Location	Characterization	# Colony Forming Units	Total CFU/ Sq In.
	OA Inlet to Pure Air Sample	Bacillus sp.	7	700
		Coag-negative Staphylococcus sp.	1	100
		Aureobasidium sp.	1	100
		Chaetomium sp.	1	100
		Cladisporium sp.	2	200
		Non-sporulating fungi	3	300
		Rhodotorula sp.	2	200
	Cardio Surgery OR-17 RA	ND	ND	ND
	Cardio Surgery OR-17 HEPA SA	ND	ND	ND
4/21/2016	OR AHU-3B Air Inlet Sample	Bacillus sp.	32	32,000
		Micrococcus sp.	2	2,000
		Aureobasidium sp.	2	200
		Cladisporium sp.	2	200
		Eurotium sp.	1	100
		Penicillium sp.	2	200
		Yeast sp.	7	700
	OR AHU-3B Final Filter Up	Bacillus sp.	50	50,000
		Psuedomonas sp.	10	10,000
		Alternaria sp.	1	100
		Aureobasidium sp.	4	4,000
		Cladisporium sp.	2	200
		Penicillium sp.	1	100
		Yeast sp.	4	4,000
	OR AHU-3B Final Filter Dn	ND	ND	ND
	Pure Air Sump Sample	ND	ND	ND
	OR AHU-3A Air Inlet Sample	Bacillus sp.	101	101,000
		Alternaria sp.	2	200
		Aureobasidium sp.	5	500
		Chaetomium sp.	1	100
		Cladisporium sp.	5	500
		Rhodotorula sp.	1	100
		Yeast sp.	4	400
	OR AHU-3A Final Filter Up	Bacillus sp.	85	85,000
		Aureobasidium sp.	1	100
		Cladisporium sp.	2	200
		Rhodotorula sp.	32	3,200

Post installation continued

Date	Sample Location	Characterization	# Colony Forming Units	Total CFU/ Sq In.
	OR AHU-3A Final Filter Dn	ND	ND	ND
	Pure Air Supply air to OR AHU-3A & 3B	ND	ND	ND
	OA Inlet to Pure Air Sample	Bacillus sp.	86	86,000
		Aureobasidium sp.	14	1,400
		Epicoccum sp.	1	100
		Non-sporulating fungi	1	100
	Cardio Surgery OR-17 RA	ND	ND	ND
	Cardio Surgery OR-17 HEPA SA	ND	ND	ND
5/19/2016	OR AHU-3B Air Inlet Sample	Bacillus sp.	42	42,000
		Alternaria sp.	2	200
		Cladisporium sp.	5	5,000
		Fusarium sp.	1	100
		Penicillium sp.	3	300
		Yeast sp.	14	14,000
	OR AHU-3B Final Filter Up	Bacillus sp.	56	56,000
		Acremonium sp.	4	400
		Aureobasidium sp.	8	800
		Cladisporium sp.	7	700
		Rhodotorula sp.	3	300
		Yeast sp.	2	200
	Pure Air Sump Sample	ND	ND	ND
		ND	ND	ND
	OR AHU-3A Final Filter Up	Bacillus sp.	23	23,000
		Psuedomonas sp.	21	21,000
		Aureobasidium sp.	5	5,000
		Cladisporium sp.	7	700
		Phoma sp.	1	100
		Rhodotorula sp.	3	3,000
		Yeast sp.	8	800
	OR AHU-3A Final Filter Up	Bacillus sp.	22	22,000
		Cladisporium sp.	8	800
		Fusarium sp.	4	400
		Rhodotorula sp.	8	8,000
	OR AHU-3A Final Filter Dn	ND	ND	ND
		ND	ND	ND
	Pure Air Supply air to OR AHU-3A & 3B	Bacillus sp.	21	2,100

Post installation continued

Date	Sample Location	Characterization	# Colony Forming Units	Total CFU/ Sq In.
	OA Inlet to Pure Air Sample	Bacillus sp.	42	42,000
		Alternaria sp.	8	800
		Aureobasidium sp.	3	3,000
		Cladisporium sp.	3	300
		Epicoccum sp.	1	100
		Yeast sp.	10	10,000
	Cardio Surgery OR-17 HEPA SA	ND	ND	ND
		ND	ND	ND
	Cardio Surgery OR-17 RA	Bacillus sp.	1	100
		Psuedomonas sp.	21	2,100
		Rhodotorula sp.	1	100
8/4/2016	OR AHU-3B Air Inlet Sample	Bacillus sp.	110	110,000
		Coag-negative Staphylococcus sp.	55	55,000
		Alternaria sp.	7	700
		Aureobasidium sp.	2	200
		Curvularia sp.	1	100
		Epicoccum sp.	1	100
	OR AHU-3A Air Inlet Sample	Bacillus sp.	101	101,000
		Alternaria sp.	13	1,300
		Aspergillus niger	1	100
		Cladisporium sp.	6	600
		Epicoccum sp.	1	100
		Penicillium sp.	2	200
	OA Inlet to Pure Air Sample	Bacillus sp.	102	102,000
		Alternaria sp.	11	1,100
		Aureobasidium sp.	1	1,000
		Cladisporium sp.	4	400
		Curvularia sp.	1	100
		Epicoccum sp.	16	1,600
	Pure Air Sump Sample	ND	ND	ND
	Pure Air Supply air to OR AHU-3A & 3B	Bacillus sp.	1	100

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Alfa Laval is active in the areas of Energy, Food, Water and Marine, offering its expertise, products and service to a wide range of industries in some 100 countries. The company is committed to optimizing processes and creating responsible growth. We drive progress, always going the extra mile to support customers in achieving their business goals and sustainability targets.

Alfa Laval's innovative technologies are dedicated to purifying, refining and recycling material. They contribute to enhanced energy efficiency, improved heat recovery, responsible use of natural resources, better water treatment, and reduced emissions. Thereby not only accelerating success for our customers, but also for people and our planet. Making the world better, every day. It's all about ***Advancing better***™.

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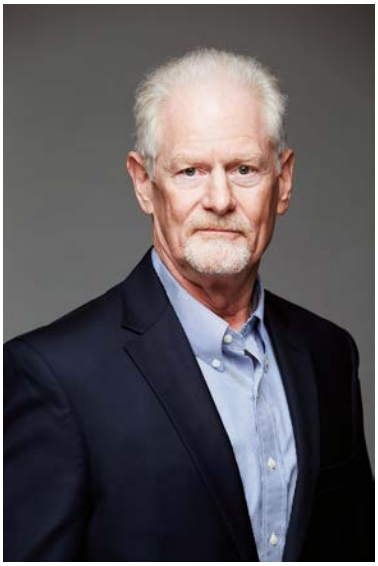
Patrick Leach
Alfa Laval — Pure Air



Patrick Leach is as an authority on the role of HVAC (heating, ventilation and air conditioning) in healthcare and bio-defense. He has been involved in the design and implementation of clinical studies demonstrating the reduction of Healthcare Acquired Infections (HAIs) through application of Ultra Violet Germicidal Irradiation in Hospital HVAC systems. These published studies include Women and Children's Hospital of Buffalo, NY and Georgetown University Hospital in Washington, DC.

Mr. Leach has functioned as an invited consultant with government agencies including The White House Office of Science and Technology, the GSA and Department of Homeland Security.

He has designed and overseen microbial exposure testing in collaboration with the State University of New York at Buffalo, Buffalo, NY, School of Medicine. The resulting study demonstrated the efficacy on pathogens associated with HAIs through exposure to desiccant solutions.

Additionally, he has undertaken design and implementation of a study demonstrating the near sterilization of a controlled airstream containing aerosolized surrogate pathogens via liquid desiccant and ultraviolet germicidal irradiation technologies.

He is a member of ASHE (the American Society for Healthcare Engineering) and APIC (the Association for Professionals in Infection Control and Epidemiology.)

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