

INDOOR AIR QUALITY MANAGEMENT DURING CONSTRUCTION RELOCATION OF A BONE MARROW TRANSPLANT UNIT

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INTRODUCTION

Bone marrow transplant (BMT) patients are among the most vulnerable to opportunistic fungal species while hospitalized. A BMT unit at the University of Minnesota needed renovation to upgrade the facility. The BMT patients were temporarily relocated to an intensive care unit which previously did not meet the required ventilation specifications of a BMT unit.

Criteria	Required Ventilation Specification in a BMT unit	Renovated Ventilation Retrofitting BMT	Into the room
Air Changes	> 12 air changes/hour	6 air changes/hour	
Pressure (ΔP)	> 2.5 Pa (unit); >0.57a (room)	< 0.0 Pa	
Filtration Efficiency	99.97%	90.00%	
Airflow direction	Out of the room	Into the room	

To provide quality ventilation, the following basic retrofit measures were implemented in the temporary BMT unit:

- Increase in air changes from 6 AC/hour to >12 AC/hour
- Increase in pressure in the temporary BMT unit and patient rooms
- Installation of point-of-use (POU) HEPA filters
- Installation of booster fan (1.5 hp) in the ventilation duct
- Installation of in-duct HEPA filters in corridors and portable filters in the BMT patient rooms

PURPOSE OF THE STUDY

To evaluate the effectiveness of the retrofit measures in protecting the BMT patients by monitoring the room pressure, air changes, airborne particles, and airborne fungi.

INSTRUMENTS

- A condensation particle counter was used for real-time airborne particles (0.01 to 1.0 μm).
- A digital pressure gauge was used for pressure (sensitivity >0.1 Pascal)
- A balance hood was used for air change rate determination.
- A high volume air sampler was used for airborne fungal sampling (700 L/min).

METHODS

Sampling Locations

- Measurements were taken in five (5) sampling locations:
- Outside
 - Old BMT unit (eBMT)
 - Retrofitted BMT unit (rBMT)
 - Medical office building (MOB)
 - Intensive care unit (ICU)

Sampling Time

Surveillance testing was done before and during patient occupancy in the rBMT unit. Sampling was made within a sampling period of four (4) months. The sampling time was categorized into two periods:

- Pre-Retrofit Period
- Post-Retrofit Period

The post-retrofit period, which is made up of 25 days, was further divided into three sub-periods:

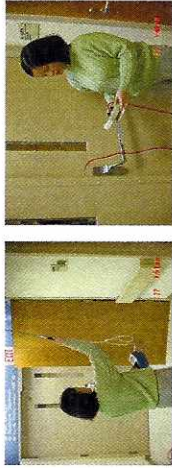
- Preparation period (2 days)
- Before occupancy (10 days)
- During occupancy (17 days)

Sampling Parameters

The following sampling parameters were measured in the sampling locations:

- 10-second average of airborne particles in particles per cubic centimeter (p/c)
- 10-second average of pressure in Pascal
- Air change rates in AC/hour
- Airborne fungal count in CFU/m³ at 25°C-inhalation

250 Pascal = 1 inch of water

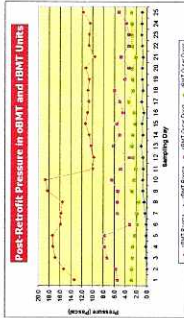
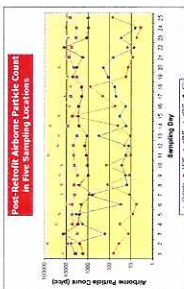


Measurement of Airborne Particles

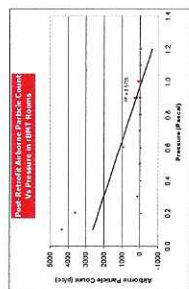
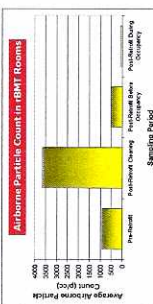
Measurement of Pressure

RESULTS

Location	Pre-Retrofit Airborne Particle Count (p/c)	Post-Retrofit Pressure (Pascal)
Outside	23,650 ± 20478	
MOB	5,008 ± 1,886	
eBMT	48 ± 175	15.9 ± 5.3
rBMT	242 ± 2,585	5.4 ± 2.1
ICU	2,952 ± 3,310	0.8 ± 0.7
		2.8 ± 0.4



Sampling Period	Average	Minimum	Maximum	Median	Standard Deviation
Pre-Retrofit	900	700	1200	900	0.4
Post-Retrofit Cleaning	3628	11	31700	687	6036
Post-Retrofit Before	503	1	12400	12	2427
Post-Retrofit Occupancy	64	1	3700	10	318



DISCUSSION

Airborne Particle Count

- The large particle count is <50 p/c
- The average air change rate in the rBMT is much lower than outside the hospital and in the adjacent medical office building (MOB) due to the effective ventilation system in these BMT units.
- High particles levels observed in the rBMT rooms occurred during the preparation period and during emergency procedures. However, these levels were dramatically reduced afterwards due to the effective ventilation system.
- The average airborne particle count in rBMT unit is highest during the preparation period and is lowest during the occupancy period, showing a decreasing trend.

Pressure

- The pressure in the rBMT rooms has an average of >0.5 Pa, while the pressure in the outer doors of the rBMT unit has an average of >2.5 Pa.
- The pressure measurement in the rooms and outer doors of the rBMT unit are lower than those in the rooms and outer doors of the eBMT unit.
- The pressure in the rBMT unit shows an increasing trend while the pressure in the eBMT unit shows a decreasing trend.
- The average pressure in the rBMT rooms is lowest during the preparation period and is highest during the occupancy period, showing an increasing trend.

Air Change Rate

- The average air change rate in the rBMT rooms is 20.15 ± 3.11 AC/hour, which is more than the required 12 AC/hour.

Airborne Fungal Count

- The airborne fungal count in the rBMT unit showed a lower average as compared to the average airborne fungal count outside the preparation period.
- The average fungal count in the rBMT unit is low during the post-retrofit period than during the pre-retrofit period.

CONCLUSION

- The ventilation system in the rBMT unit is effective in bringing the deviant airborne particle levels to normal levels, thus making the environment protective of the BMT patients in the unit.
- The pressure in the rBMT unit is not as high as those in the old BMT units, but the pressure in the outer doors of the rBMT unit shows that increase in the pressure (ΔP) within the BMT patient rooms is associated with the decrease in the airborne particle count in these rooms.
- No fungal disease was acquired by the BMT patients at risk during the sampling period, thus indicating acceptable levels of the monitored parameters.

Period	Average Airborne Fungal Count (CFU/m ³)
Pre-Retrofit	13.3 ± 11.0
Post-Retrofit	4.3 ± 3.2
	64.3 ± 6.1