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April 9, 2021

Mr. Dan Milan
New Amsterdam Theatre
214 West 42nd Street
New York, NY 10036

RE: Grignard Pure Proof of Concept - Part I: Ventilation Studies (J2017616-V1)

Dear Mr. Milan:

Ambient Group, Inc. participated in a multidisciplinary collaboration of scientists and health professionals, mechanical engineers, and theatrical performance engineers to establish that a new anti-microbial air treatment, Grignard Pure, could be safely dispersed, and its concentration controlled, within the New Amsterdam Theatre. The studies were performed between October 14th and October 26th, 2020. The ventilation portion of this study (Part I) is the subject of this report.

The purpose of this assessment was to benchmark the ventilation rates and filtration efficacy within the theater. These variables are the cornerstone of any indoor air risk management plan for infectious disease control. They are also a key component of "*Best Practice*" reopening operational guidelines published by government agencies such as the CDC, and professional associations such as ASHRAE. Achievement of such measures demonstrate that a facility meets the concept of "*Enhanced Ventilation*", as currently defined.

The study achieved its ventilation objectives utilizing zonal tracer gas dilution techniques. Filtration efficacy was assessed by confirmation of filter installation and the change in particle concentration at the start-up of the fan systems.

The primary findings of this investigation include the following:

1. The results of the ventilation studies indicate that the building code ventilation rate is reached when the system is operated at the "*winter mode*" setpoint as defined by managment (Figures 1-3). At the 100% OA setpoint, the ventilation rate is double the building code and approaches three times the code within the orchestra pit (Figure 4).
2. The ventilation system was designed to operate with MERV 15 filters. The data suggests that the filters are providing a very high level of effieciency at the nanoparticle size range associated with viral particles (Figure 6.1). However, quantitation of the true efficiency requires further field verification
3. Visual inspection, combined with the testing results, identified numerous opportunities to optimize ventilation performance of the system that is already in place. Further efforts should focus on the return air system with synchronized testing of air flows made conjunction with real-time adjustments to the system by the engineering staff.

Based on these findings, the New Amsterdam Theatre's current ventilation system meets the definition of "*Enhanced Ventilation*" as defined herein and it can be futher optimized to meet future guidance requiring higher ventilation rates within limits.

Below please find a summary report that illustrates and supports the findings above. Please feel free to contact me with any questions or comments you may have regarding the contents of this letter.

Sincerely,

Signed for Ambient Group, Inc. by:

Dr. William A. Esposito, ***Dr.PH, CIH***
President

New Amsterdam Theatre-
Grignard Pure Proof of Concept
Part I
Ventilation Studies

The New Amsterdam Theatre
214 W 42nd St
New York, NY

Prepared For:

New Amsterdam Theatre
214 W 42nd St
New York, NY 10036

Prepared by:
Ambient Group, Inc.
470 Seventh Ave
New York New York 10018

Project Number J2017616

April 9, 2021

Signed for Ambient Group, Inc. By

Dr. William A. Esposito, Dr.PH, CIH
President

TABLE OF CONTENTS

New Amsterdam Theatre Study Participants

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The New Amsterdam Theatre
Dan Milan Steve Longo

INTRODUCTION

Ambient Group, Inc. participated in a multidisciplinary collaboration of public health professionals, mechanical engineers, and theatrical effects engineers to show that a new anti-microbial air treatment, Grignard Pure, could be dispersed, and its concentration controlled, within the New Amsterdam Theatre Auditorium. The studies were performed between October 14th and October 26th, 2020.

The subject of this report is focused on the ventilation studies that were performed during this event to investigate the air exchange rates and air flow dynamics within the theater under normal and experimental operating conditions. Ventilation has been identified as a key component of any indoor infectious disease control program and documentation of the proper ventilation rate will undoubtedly be a requisite of any reopening of Broadway protocol and public health and safety due diligence.

Figure 1. The perspective of this photograph, taken from the balcony of the theater, highlights the low visibility of Grignard Pure at an effective concentration of 0.5 mg/m^3. Here the haze level is contrasted between the black backdrop of the stage curtain and the intense stage lights. It is only under these high intensity contrast conditions that the haze becomes visible to the human eye. The photo also shows some of the analytical equipment used to determine the concentration of the Grignard Pure in the air and the airflow dynamics within the theater. Photo Taken October 19, 2020. 10:33 am.

GRIGNARD PURE

Grignard Pure is a revolutionary application of well-established technologies and can reduce the spread of viruses in the indoor air. The active ingredient in Grignard Pure is commonly used in fog machines for concerts and theatre productions and it is also a common ingredient in many household products. The antimicrobial properties of the active ingredient were originally described in 1947 as part of a series of studies conducted at the University of Chicago. The studies showed that the active ingredient has amphiphilic properties. This mechanism renders the virus inactive when microdroplets condense on the membrane surface of the airborne virus . More recently, it has been shown that Grignard Pure, at a level that is invisible to the human eye, inactivates airborne viruses in controlled environmental studies.

EPA ANNOUNCES EMERGENCY EXEMPTION APPROVAL FOR THE USE OF GRIGNARD PURE

On January 15, 2021, the EPA announced approval of an emergency exemption request for the first-ever "*airborne antiviral"* product, Grignard Pure. The EPA approved these emergency exemption requests from Georgia and Tennessee under Section 18 of the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA).

After carefully reviewing this product's effectiveness and safety data, the EPA concluded Grignard Pure is safe to use and that it is capable of inactivating 98 percent of airborne SARS-CoV-2 within 30 Seconds. The approval allows the product to be applied in Georgia and Tennessee in certain indoor spaces where adherence to current public health guidelines is impractical or difficult to maintain.

Application levels are monitored through visual assessment, or sensors which automatically regulate the amount of product suspended in the air. Additionally, the EPA-approved label requires that signs be posted at every entrance to the spaces notifying the public that the space has been treated.[1]

VENTILATION

THE EVOLUTION OF VENTILATION DESIGN AND VENTILATION RATES

Ventilation is the process of supplying air to or removing air from a space for the purpose of controlling air contaminant levels, humidity, or temperature within the space.[2] The ventilation rate dictates the speed at which the air is replaced with outside air within a space.

Historically, the role of ventilation, and the rate at which a space is ventilated, has been the subject of much study and vigorous debate. Accordingly, varied ventilation rates have been proposed over time by industry associations based on the current state of knowledge, health and safety concerns and special interests dictated by socioeconomic impacts and priorities (Table 1).[3,4] Over time, these opinions and consensus standards have been modified and incorporated into the building code either locally, regionally, or internationally.[5]

With the outbreak of the SARS-CoV-2 pandemic in early 2020, the role of ventilation, and the proper ventilation rate within an indoor space, has again become the subject of scrutiny and debate.[6] Recommendations for future ventilation rates will likely be increased and building codes will eventually be updated to reflect ventilation's evolving role in the control of airborne infectious disease in addition to other health concerns and comfort factors.

Table 1. Paradigm Shifts in the Philosophy of Ventilation Since 1800

Time	*Paradigm*	*Pollution Source*	*Comments*
2020	**Infectious Disease + Others**	**People + Buildings + Outdoor Air**	**Ventilation to control airborne infectious disease, building source pollutants and comfort and promote productivity**
2000	**Comfort + Health + Sources**	**People + Buildings**	**Ventilation to control comfort and building source pollutants**
1975			
1935	**Comfort**	**People**	**Ventilation to control odor and comfort *(Yaglou Studies)***
1900	**Contagion**		**Disease transferred by intimate contact and independent of ventilation**
1850	**Poison**		**CO_2 is not poisonous; CO_2 Indicator of IAQ. *(Pettenkofer Studies)***
1800-			**"*Anthropotoxin*"- CO_2 considered to be poisonous**

Modified from "*The philosophy behind ventilation: past, present, and future*" Fanger, 1996 and "*Indoor Air Quality Factors in Designing a Healthy Building*", Spengler and Chen, 2000.

ENHANCED VENTILATION

Enhanced ventilation is a loosely defined concept that is gaining recognition due its potential role in the control of infectious disease within the indoor environment. As early as May of 2020, industry groups such as ASHRAE acknowledged the role of increased ventilation and filtration in their Journal article addressing the COVID 19 pandemic.[7] Other groups, such as The United States Green Building Counsel and The WELL Institute have long recognized concept of enhanced ventilation in their voluntary performance standards, although the purpose of these performance standards is not necessarily infectious disease control.[8,9] Federal Agencies such as the U.S. Centers for Disease Control and Prevention (CDC) and Occupational Safety and Health Administration (OSHA), have recommended a range of precautionary actions, including enhanced ventilation measures, to help reduce indoor airborne levels of the COVID-19 virus and thus the chance of transmission.[10,11]

ENHANCED VENTILATION- NEW YORK STATE

In New York State, Governor Cuomo has made many references to enhanced ventilation throughout the pandemic. On July 8, 2020, he stated, "*The more we learn about COVID, the clearer it is that safe ventilation is crucial*". On July 10, 2020, the state announced that shopping malls could reopen if they had an Enhanced Heating, Ventilation and Air Conditioning or HVAC -filtration system and proper ventilation protocols.

ENHANCED VENTILATION- REOPENING OF PUBLIC STRUCTURES

Unfortunately, the term "*Enhanced Ventilation*" remains vague and not clearly defined. However, some level of increased ventilation, filtration or air purification will likely be required in buildings before they can reopen to the public. Some examples that are common to most guidelines and opinions include the following:

1. An increase ventilation rate over the current codes and to operate the ventilation system extended periods of time.
2. Upgrading or maintaining filtration systems at minimum value MERV-13 or higher and proper installation and maintenance.
3. Utilization of natural ventilation when applicable.
4. Assurance that existing exhaust fans are operating as designed and the utilization of localized ventilation and filtration to manage air flows in occupied spaces.

Until such a time that Enhance Ventilation is defined, documentation of measures taken since the outbreak occurred should be maintained and available at short notice. Proactive due diligence should include validation and documentation that proper filtration and ventilation parameters have been met and will be maintained during periods of occupancy.

Ventilation in Theaters

Historically, the need for air conditioning and ventilation within theaters has helped advance the innovation of heating, ventilation, and air conditioning systems in large structures. Early systems were used to condition venues such as Nickelodeon's, early picture houses and eventually Broadway theaters. [12] This trend grew out of necessity to offer theatergoers a haven from the elements and to extend the performance season into the summer months and year-round. The building ventilation codes for theaters or auditoriums have also change over time, and current international codes are now set at about 5 cfm per person and 0.06 cfm per square foot (Table 2).

Table 2. Applicable Mechanical Codes- Minimum Ventilation Rates for Auditoriums and Theaters

Occupancy	Airflow Rate		Default Occupant Density	Ventilation Efficiency
	CFM/ Per Person	CFM/FT^2	# /1,000 FT^2	E_V
New York City Mechanical Code 2014-Section 403.3[13]	5	0.06	150	1
New York State Mechanical Code[14]	5	0.06	150	1
International Mechanical Code[15]	5	0.06	150	1
ASHRAE 62.1-2016 addendum s 2019[16]	5	0.06	150	1

Enhanced Ventilation- Reopening of Live Entertainment Venues

In the absence of specific state or federal reopening guidance for live entertainment venues, we have monitored the literature to anticipate the main caveats of any reopening plan that may be formalized.

In New York state, there have been two sets of guidelines issued for movie theaters. The economics of a live Broadway production compared to showing movies are vastly different, but the existing guidance can provide insight as to what may be required in order to reopen a Broadway production with a full occupancy.

Initial Guidance for reopening Movie Theaters in New York State

Initial Guidance for reopening certain movie theaters in New York State was provided on October 23, 2021, with the following provisions:

1. Social distancing between parties, assigned seats and masks will be always required,
2. Additional staffing will be needed to control occupancy, traffic, and seating to ensure compliance.
3. Theaters must meet enhanced air filtration, ventilation, and purifications standards. [17]

Detailed Interim Guidance For The Reopening Of Movie Theaters In New York State

Detailed interim guidance for the reopening of movie theaters in New York State was published on February 23rd, 2021 to provide owners/operators with precautions to help protect against the spread of COVID-19.[18]

This guidance document is sixteen pages and builds on the initial guidance issued in October of 2020. The document is organized around three distinct categories: people, places and processes. It adds specific language that assigns responsibilities to certain "*Responsible Parties*" or team participants. It also provides interim guidance, which indicates that it can and will be updated as new information becomes available. The key components of this document as it relates to ventilation are shown in Table 4.

Table 4. Interim Movie Theater Guidance Requirements – Operations – Central Air Handling System.

Requirement	Responsible Party	
Professional Certification Signoff	Ambient Group, Inc. Ventilation Services	
Testing, Balancing and Ventilation Optimization	Ambient Group, Inc. Ventilation Services	
Increasing Ventilation Rates	Ambient Group, Inc. Ventilation Services	Disney Engineering
Extended System Operation		Disney Engineering
Maintaining Humidity (40-60%)		Disney Engineering
Opening outdoor air dampers to reduce or eliminate recirculation to the extent possible	Ambient Group, Inc. Ventilation Services	Disney Engineering
Sealing edges of the filter to limit bypass		Disney Engineering
Regularly inspecting systems and filters to ensure proper installation, operation, maintenance, and service life		Disney Engineering
Opening windows to the extent allowable for occupant safety and comfort	Ambient Group, Inc. Ventilation Services	Disney Engineering
Airborne Viral Particle Inactivation	Grignard Pure	Disney Engineering
Portable Cleaners/ Purifiers	Grignard Pure	Disney Engineering

Disney Engineering, Ambient Group, Inc. **Ventilation Services** Grignard Pure

Towards Reopening Broadway

The last section of this report focused on the operations or "*Place*" portion of the new guidelines for movie theaters. However, the *"People"* and "*Process"* portion of the guidance remains the same in that masking, social distancing and reduced occupancy or capacity are still required.

Any plan to reopen Broadway will have to overcome the distancing and capacity restrictions to be financially viable.

We believe that the new guidance offers a pathway towards this goal and our work at the New Amsterdam Theater shows that a solution that achieves both goals is in reach. Such plan must be carefully crafted, scientifically sound and diligently monitored, enforced, and documented.

The program could include maintaining ventilation rates in excess of current code but achievable under optimized conditions, the use of an airborne viral inactivation agent to control the viral load (Table 4), and the concept of Time Weighted Averages (TWA) and purge procedures during the performance cycle to limit exposure potential to other patrons. These factors can be combined with administrative protocols such as COVID-free or immunity policies and masking to maximize the safety of theatergoers while operating the theater at near capacity occupancy.

THE NEW AMSTERDAM THEATRE

HISTORY

The New Amsterdam Theatre was built in 1903. At the time, it was the largest theatre in New York with a seating capacity of 1,702. In 1993 the theatre underwent a massive restoration project and it reopened in 1997.

MECHANICAL SYSTEMS

Figure 1. Architectural drawing A-407 depicts the of the layout of the 7th floor of the theatre building. It was issued by HLW International (New York) on December 27, 2006 and modified by Jaros Baum & Boles (New York) in 2020 for the purposes of showing the approximate locations of ventilation system components serving the auditorium from the roof the facility. Here Fans AC: 1-3 are identified. These fans supply outside air and conditioned air to the ceiling diffusers of the auditorium. We also used the column measurements noted on this drawing as the basis of our volumetric measurements for our ventilation calculations.

Specific Aims

The purpose of this assessment was to benchmark the New Amsterdam Theater's auditorium ventilation rates to published pandemic "*Best Practice*" guidelines developed by government agencies such as the CDC and OSHA, and professional industry associations such as ASHRAE (Table 2).

The study achieved these objectives utilizing single zone tracer gas dilution techniques to determine the amount of outside air supplied to the space, its distribution, and the exchange rates within the auditorium under normal and controlled operating conditions.

Ventilation has been cited as a critical mechanical factor to control the spread of airborne infectious disease within the indoor environment. It is also a key component in any successful public health pandemic response in addition other measures such as social distancing, vaccination, mask wearing and handwashing.

The ventilation data will also be used as the foundation of further investigations designed to characterize the aerodynamic properties of Grignard Pure microdroplets in the indoor environment while the product is aerosolized in the auditorium by commercial fogging or hazing machines and if those concentrations could be maintained at nonvisible haze levels or within established EPA set points.

In addition to the ventilation parameters, filtration efficacy was also evaluated by visual confirmation of filter type and installation in fan systems and cursory examination of actual particle arrestance (the ability of a filter to remove particles from the airstream) in the theater during fan system start up on October 19, 2020

Table 5. Recommended COVID 19 Workplace Engineering Controls and Practices

Workplace Engineering Control	CDC	WHO	OSHA	NY State	ASHRAE	LEED
General IAQ Standards	☑	☑	☑		☑	☑
Ventilation Rate and Effectiveness	☑	☑	☑	☑	☑	☑
Filtration Efficacy Evaluation	☑	☑	☑	☑	☑	☑
Risk and Mechanical System Upgrade Assessment	☑	☑	☑	☑	☑	

METHODS

DERIVATION OF VENTILATION RATES

We relied on professional reports and design specifications, official documents, published codes, standards and guidelines and interviews with staff to derive the ventilation requirements and system performance parameters reported here. Table 4, presents the minimum ventilation rates that will be required as a baseline in any reopening guidance document or program that will be developed going forward.

THEATRE DIMENSIONS AND ZONAL BOUNDARIES

We defined our zonal boundaries as the demised New Amsterdam Theatre auditorium including the orchestra, mezzanine, and balcony, the stage and stage crossovers, and orchestra pit (Figure 2). We relied on architectural drawing A-407 delineate the length and width of the auditorium portion of the theater (Figure 1). The height of the auditorium was estimated using a laser measuring device.

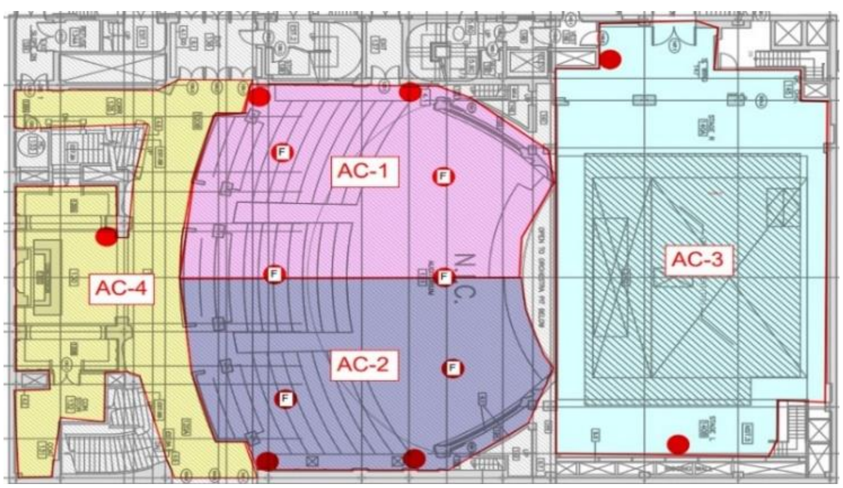


Figure 2. Architectural drawing issued by HLW International (New York) on December 27, 2006 which illustrates the main auditorium and stage of the New Amsterdam Theatre. The original drawing was modified by Jaros Baum & Boles (New York) in 2020 for the purposes of showing the approximate locations served by the main ventilation fans of the theatre identified as AC-1-4.

PEAK OCCUPANCY

The management reported that the theatre now has a capacity of 1727 seats within the auditorium. For the purposes of this study, we used a total of 1,800 occupants to estimate peak occupancy during a performance which includes ticket holders, actors, musicians, and staff that may be in the auditorium during peak occupancy.

Table 4: Theater Dimensions and Minimum Ventilation Rates Required by Local and International Code.

Location	Auditorium Dimensions				Peak Occupancy				Ventilation Rate Code		
	Area ft^2	Height ft	Volume ft^3	Volume m^3	Seats	Staff	Performers	Total	CFM/Person	CFM/ft^2	CFM
Auditorium	11,760	65	764,400	21,645	1,727	30	43	1,800	9,000	706	9,706

VENTILATION EFFICACY STUDIES

Ventilation rates were determined utilizing a single zone tracer gas dilution technique based on published standard test methods such as ASTM E741 "Standard Test Method for Determining Air Change in a Single Zone by Means of a Tracer Gas Dilution" 2006 and "Air Exchange Rate and Airtightness Measurements Techniques- An Applications Guide", Air Infiltration and Ventilation Centre, August 1988.

Briefly, this test method uses the measurement of tracer gas dilution to determine air change within a building that is characterized as a single zone. The measurement of the concentration allows calculation of the volume rate of outgoing and incoming air from the zone can be determined.[19]

Ventilation studies including air exchange measurements were accomplished using Sulfur Hexafluoride (SF_6) as a tracer gas to dose and track build up and decay. Continuous monitoring was accomplished utilizing a multipoint sampling device, which collects samples sequentially from up to 6 or 12 locations around the building and processes them for analysis by a photo-acoustic gas analyzer (Advanced Energy Systems Denver, CO).

CONCENTRATION DECAY METHOD

The "single zone" demised auditorium as defined above is served by four separate mechanical ventilation systems (i.e., AC-1, AC-2, AC-3 and AC-4 (Figure 1)). Therefore, it was determined that the concentration decay method would be the best representative measurement to calculate and report the air exchange rate for the theater under the various operational parameters test.

FILTRATION EFFICIENCY

filtration efficacy was also evaluated by visual confirmation of filter type and installation in fan systems and cursory examination of actual particle arrestance in the theater during fan system start up on October 19, 2020.

PRIMARY FINDINGS

VENTILATION STUDIES

The results of the ventilation studies indicate that the mininum building code ventilation rate is reached when the system is operated at the "winter mode" setpoint as defined by managment (Figures 1-3). At the 100% OA setpoint, the ventilation rate is double the building code and approaches three times the code within the orchestra pit (Figure 4).

The data indicates that approximately 1300 CFM of outdoor air infiltrates into the building across the building envelope while the fans are not in operation. This equates to a difference in ventilation rates between the two modes of operation from approximately two air changes per hour at 100% OA to one air change in 10 hours with the fans off.

The results aslo show that the average air exchange rate within the Orchestra Pit was approximately 2.15 air changes per hour while the at 100% OA setpoints. Under these operating conditions the system is approaching three times the building code requirement for ventilation.

The data also indicates that some of the outside air supplied to the auditorium is "short cycling" directly into the orchestra pit and bypassing the breathing zones in audience seating areas.

FILTRATION EFFICIENCY

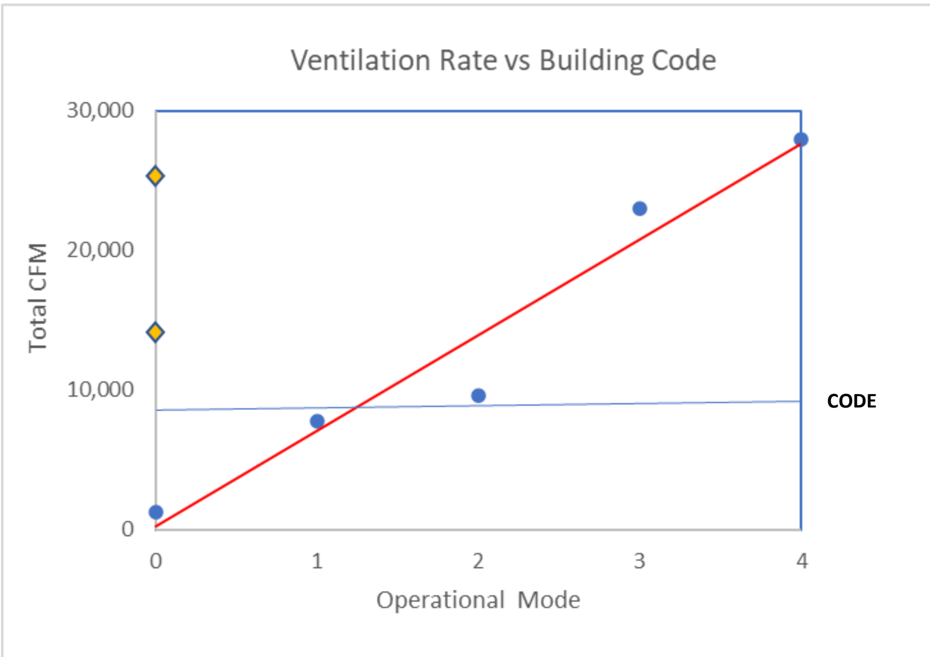
The ventilation system was designed to operate with MERV 15 filters. The data suggests that the filters are providing a very high level of effieciency at the nanoparticle size range associated with viral particles (Figure 6.1). However, quantitation of the true efficiency requires further field verification

RECOMMENDATIONS

Visual inspection, combined with the testing results, identified numerous opportunities to optimize ventilation performance of the system that is already in place. Further efforts should focus on the return air system with synchronized testing of air flows made conjunction with real-time adjustments to the system by the engineering staff.

TRACER GAS -VENTILATION STUDIES

VENTILATION SUMMARY

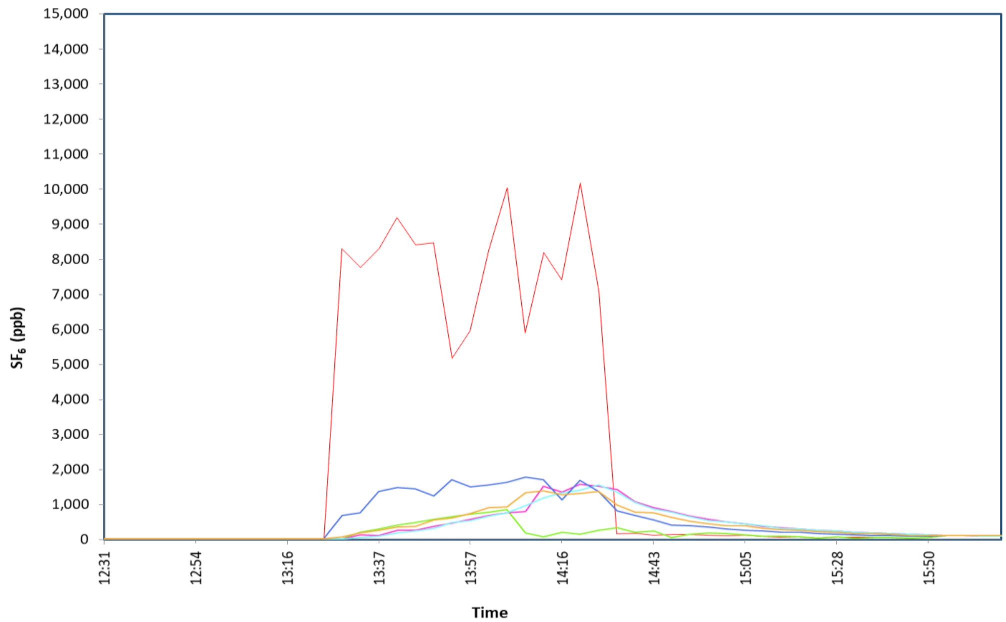


Ventilation Study Summary Data: Mary Bridge - Theater Center and Orchestra Pit

#	Mode	Air Exchange	Age of Air		Ventilation Rates	
		(h^{-1})	Hour	Min	CFM	CFM/Person
0	Fans Off	0.11	9.30	560	1,366	0.8
1	Summer Mode	0.67	1.56	93	8,154	4.7
2	Winter Mode	0.75	1.33	80	9,555	5.5
3	100% Outside Air-Auditorium	1.76	0.54	32	22,422	13.0
4	100% Outside Air – Orchestra Pit	2.21	0.45	27	28,000	16.0

Figure 1.1. This graph illustrates summary of the ventilation rate data collected at different system operational modes during the study period. The results indicate that the average air exchange rate within the auditorium and stage was approximately 1.75 air changes per hour while the at 100% OA setpoints. Under these operating conditions the system is more than double the building code requirement for ventilation. Approximately 1,300 CFM of displacement air is a result of infiltration or leakage across the building envelope through openings or penetrations or the operation of fans elsewhere in the building over evening hours. If the theater is operated in winter mode or with more ventilation air, it will meet the current building code (blue line). We note that this study was performed as part of a larger study and the results and system operation can likely be greatly optimized if attention is focused specifically to the boundaries of the ventilation systems under the continuum of operational settings.

Ventilation Study - 100% OA – Auditorium and Stage



Ventilation Study 1: Dosing Point AC-1- Summary Data

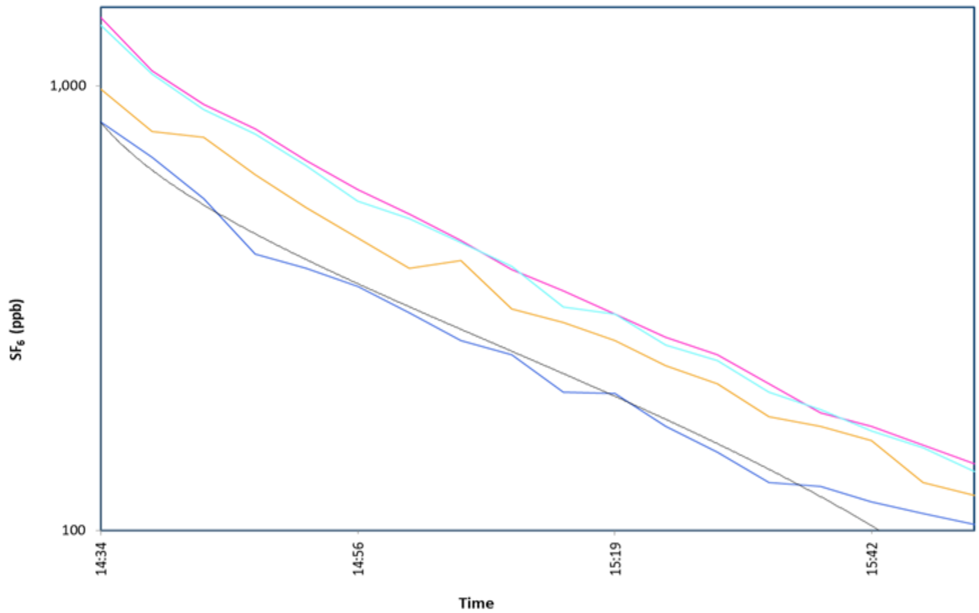
Location	Air Exchange	Age of Air		Ventilation Rates	
	(h^{-1})	Hour	Min	CFM	CFM/Person
AC-1 Sensor Dome (red)	-	-	-	-	-
AC-2 Sensor Dome (green)	-	-	-	-	-
4th Electric Stage Center (magenta)	1.91	0.52	31.4	24,333	14.1
Crossover Stage Right (cyan)	1.78	0.55	32.1	22,677	13.1
Mary Bridge – Theatre Center (dark blue)	1.76	0.54	32.4	22,422	13.0
Crossover Stage Left (yellow)	1.76	0.54	32.4	22,422	13.0

Figure 2.1. This graph illustrates the continuous monitoring data of our initial ventilation study conducted within the New Amsterdam Theatre on October 16, 2020. The study focused on the ventilation rates and spatial distribution of the air flows within the auditorium and the stage areas. Our dosing and sampling points were strategically located to isolate key ventilation points. The ventilation system was operated at 100% outside air setpoints during the study period.

The dosing point was located just downstream of the AC 1 supply duct as it opened into the ceiling supply air plenum above the auditorium. SF_6 was dosed at a constant concentration of 7 ml/sec during the dosing period. Analysis of the ventilation rate was performed on the decay portion of the curve after the dosing was stopped.

The results indicate that the average air exchange rate within the auditorium and stage was approximately 1.75 air changes per hour while the at 100% OA setpoints. Under these operating conditions the system is more than double the building code requirement for ventilation.

VENTILATION STUDY - 100% OA – AUDITORIUM AND STAGE



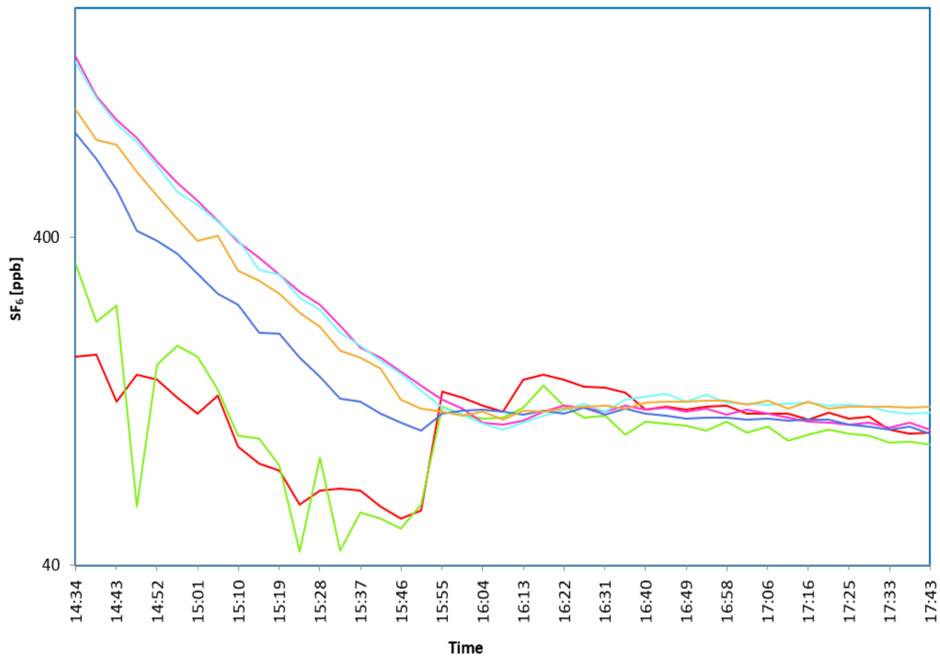
Ventilation Study 1: Dosing Point AC-1- 100% OA – Concentration Decay Method

	Location	Air Exchange	Age of Air		Ventilation Rates	
		(h^{-1})	Hour	Min	CFM	CFM/Person
■ (red)	AC-1 Sensor Dome	-	-	-		
■ (green)	AC-2 Sensor Dome	-	-	-		
■ (magenta)	4th Electric Stage Center	1.91	0.52	31.4	24,333	14.1
■ (cyan)	Crossover Stage Right	1.78	0.55	32.1	22,677	13.1
■ (dark blue)	Mary Bridge – Theatre Center	1.76	0.54	32.4	22,422	13.0
■ (orange)	Crossover Stage Left	1.76	0.54	32.4	22,422	13.0

Figure 2.2. This graph focuses on the continuous monitoring data of the points within the auditorium after the dosing was stopped but while the system was operated at 100% outside air setpoints.

The results indicate that the average air exchange rate within the auditorium and stage was approximately 1.75 air changes per hour while the at 100% OA setpoints. Under these operating conditions the system is more than double the building code requirement for ventilation.

VENTILATION STUDY- SYSTEM SHUT DOWN TRANSITION – AUDITORIUM AND STAGE

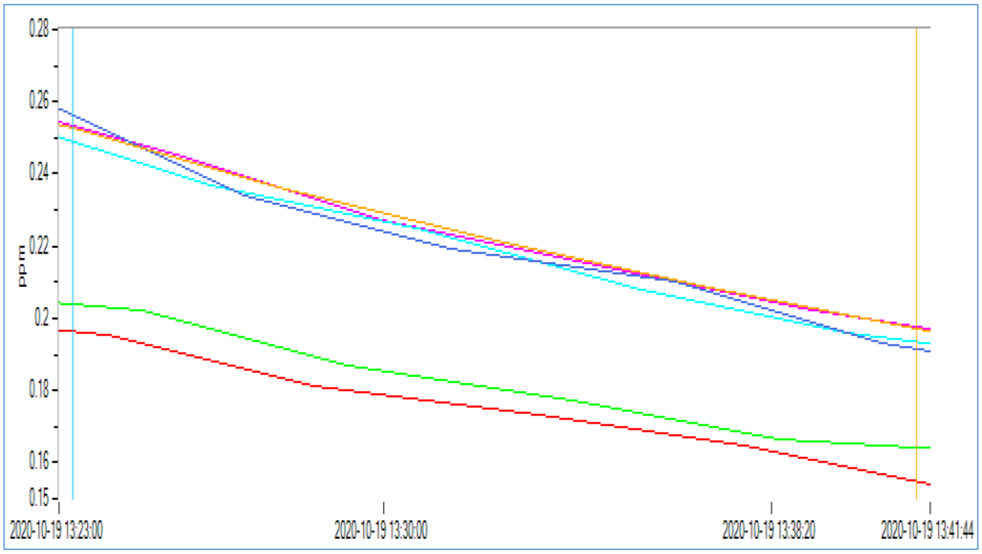


Ventilation Study 1: Dosing Point AC-1- Fans Off - Concentration Decay Method

Location	Air Exchange	Age of Air		Ventilation Rates	
	(h^{-1})	Hour	Min	CFM	CFM/Person
AC-1 Sensor Dome	0.08	11.8	708	1019	0.6
AC-2 Sensor Dome	0.12	8.4	504	1514	0.9
4th Electric Stage Center	0.14	7.3	437	1750	1.0
Crossover Stage Right	0.08	12.0	720	1064	0.6
Mary Bridge – Theatre Center	0.11	9.3	560	1366	0.8
Crossover Stage Left	0.08	11.4	716	1073	0.6

Figure 2.3. This graph highlights the dramatic change in the slope (and thus the volume of dilution air) while the fans are operating at 100% OA and as they are shut down for the day. The data indicates that approximately 1300 CFM of outdoor air infiltrates into the building across the building envelope while the fans are not in operation. This equates to the difference in ventilation rates between the two modes of operation from approximately two air changes at 100% OA per hour to one air change in 10 hours with the fans off.

VENTILATION STUDY - WINTER MODE – AUDITORIUM AND STAGE

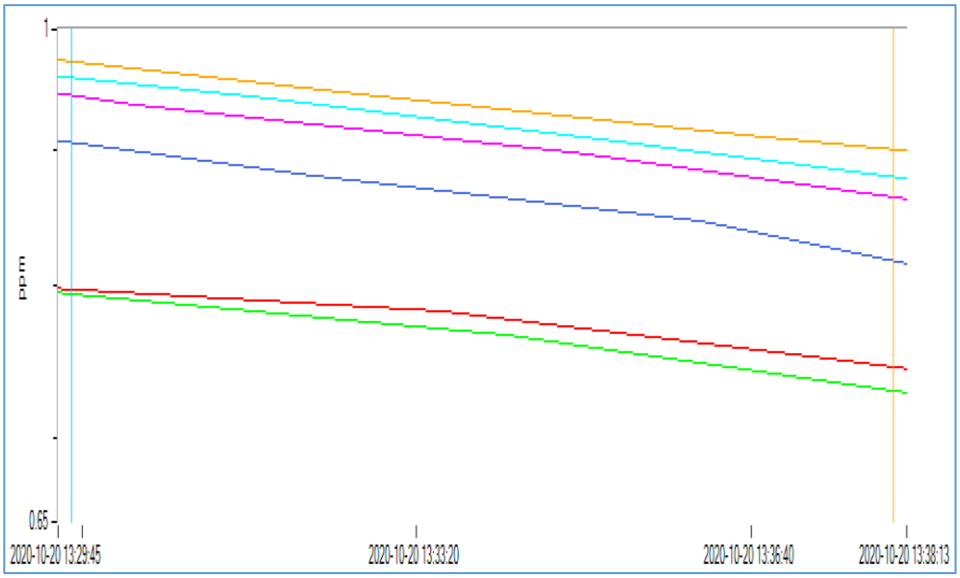


Ventilation Study 2: Dosing Point AC-1- Winter Mode Data- Concentration Decay Method

Location	Air Exchange	Age of Air		Ventilation Rates	
	(h^{-1})	Hour	Min	CFM	CFM/Person
AC-1 Sensor Dome	-	-	-		
AC-2 Sensor Dome	-	-	-		
4th Electric Stage Center	0.73	1.37	82	9300	5.4
Crossover Stage Right	0.77	1.30	78	9797	5.7
Mary Bridge – Theatre Center	0.75	1.33	80	9555	5.5
Crossover Stage Left	0.77	1.30	78	9810	5.7

Figure 3.1. This graph shows the continuous monitoring data of the points within the auditorium after the dosing was stopped but while the system was operated at the winter mode setpoints. The data indicates that the "Winter Mode" is the minimum operational set point that will meet the current building code. We are confident that the settings that constitute the different operating modes can be better defined and further optimized with additional investigation and coordination with the engineering and management staff.

VENTILATION STUDY - - SUMMER MODE – AUDITORIUM AND STAGE



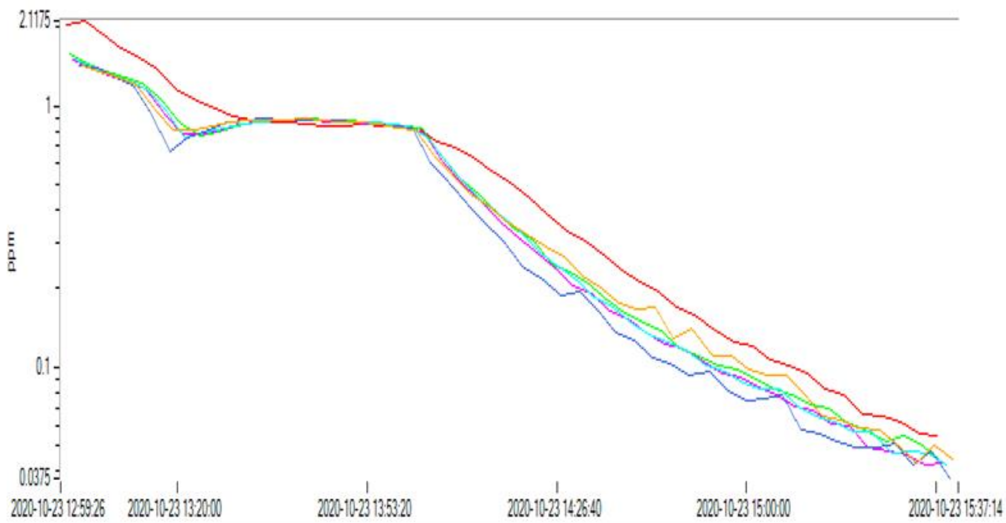
Ventilation Study 3: Dosing Point AC-1- Summer Mode - Concentration Decay Method

Location	Air Exchange	Age of Air		Ventilation Rates	
	(h^{-1})	Hour	Min	CFM	CFM/Person
AC-1 Sensor Dome	-	-	-		
AC-2 Sensor Dome	-	-	-		
4th Electric Stage Center	0.64	1.56	93.8	8154	4.7
Crossover Stage Right	0.67	1.49	89.6	8536	4.9
Mary Bridge – Theatre Center	0.67	1.56	93.0	8154	4.7
Crossover Stage Left	0.50	2.00	120.0	6370	3.7

Figure 4.1. This graph shows the continuous monitoring data of the points within the auditorium after the dosing was stopped but while the system was operated at summer mode setpoints.

The results indicate that the average air exchange rate within the auditorium is below the current code under this operational mode. Further investigation should be performed during the summer months to determine the optimal set points required to exceed current code ventilation rates while providing the proper dehumidification and conditioning of summer air to maintain the heat load of a full audience during a performance in this region of the United States.

VENTILATION STUDY - 10/23/20- ORCHESTRA PIT



Ventilation Study 4: Dosing Point AC-1- Transition (Fans off and Fans at 100% OA) - Concentration Decay Method

Location	Air Exchange	Age of Air		Ventilation Rates	
	(h^{-1})	Hour	Min	CFM	CFM/Person
Trap	2.2	0.45-	27.0	28,155	16.3
Drums	2.3	0.44	26.7	28,665	16.6
Percussion	2.1	0.48	28.7	26,627	15.4
Return AC-2	2.2	0.46	27.4	27.901	16.2
Mary Bridge – Theatre Center	2.2	0.46	27.5	27,773	16.1
Return Theater 4	2.1	0.48	28.7	26,627	15.4

Figure 5.1. This graph shows the continuous monitoring data of the points within the orchestra pit after the dosing was stopped but while the system was operated at 100% outside air setpoints.

The results indicate that the average air exchange rate within the Orchestra Pit was approximately 2.15 air changes per hour while the at 100% OA setpoints. Under these operating conditions the system is approaching three times the building code requirement for ventilation.

The data also indicates that the outside air supplied to the auditorium is short cycling directly into the orchestra pit and bypassing the audience seating breathing zones. This provides an opportunity to optimize ventilation rates within the seating area with minor adjustments of the existing system. Further efforts should focus on the return air system with synchronized testing of air flows made conjunction with real-time adjustments to the system by the engineering staff.

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PARTICLE OVERNIGHT STUDY – FILTRATION EFFICIENCY INDEX

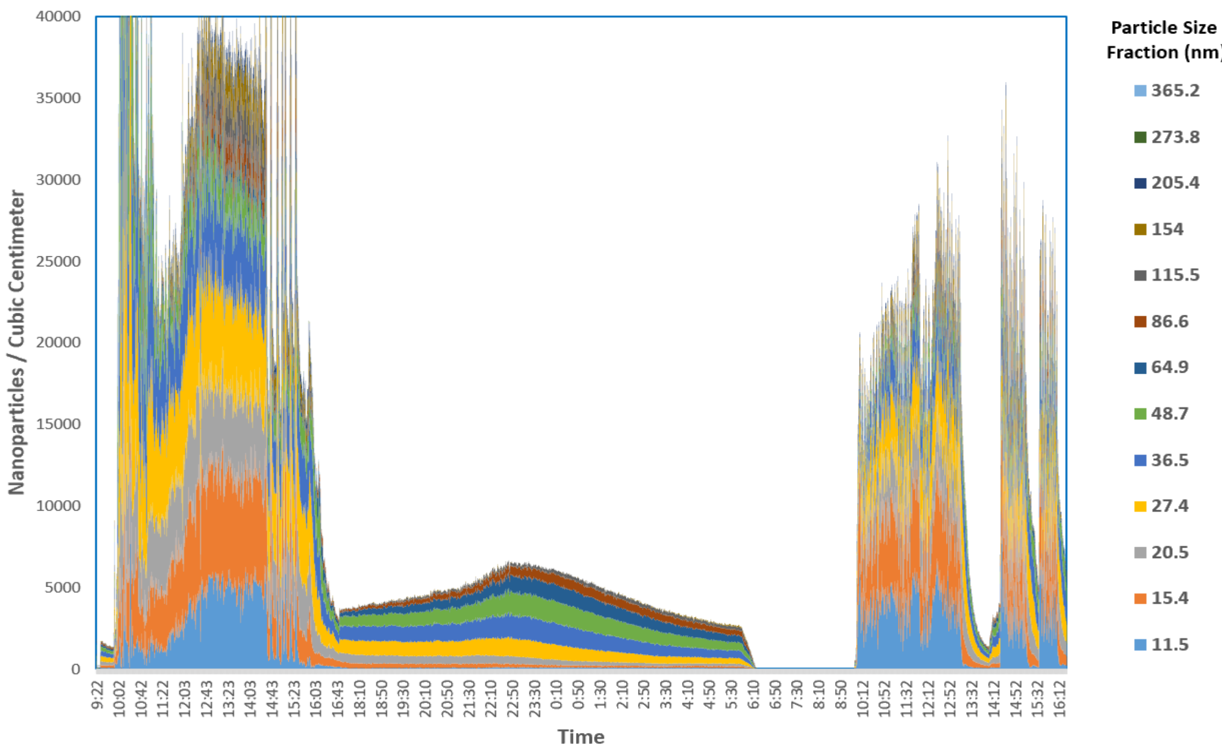

Figure 6.1. This graph shows the continuous monitoring data of the number of nanoparticles in the air per cubic centimeter over a two day and overnight period. The time of interest is between 5:30 am and 10 am when the fans switched on and no one was present within the theater to generate particles. The concentration dropped from 5,000 to approximately zero indicating a very high filtration efficiency for this particle size within a short period of time. This data offers compelling evidence exceptional filtration performance by the mechanical systems serving the auditorium. Further testing to specifically address the phenomenon may prove valuable in demonstrating the performance of this ventilation parameter.

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