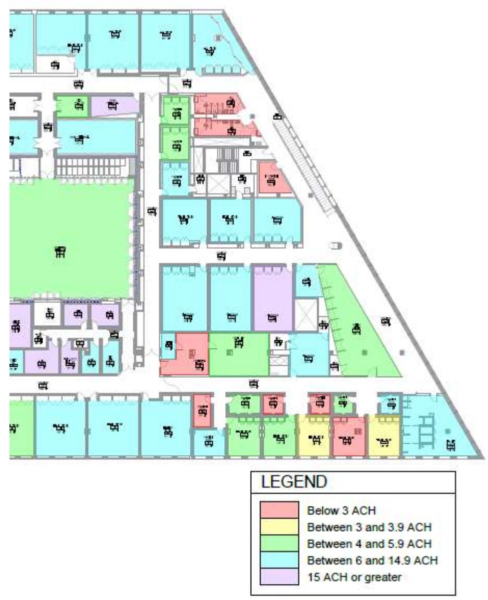
Juilliard

## Statement of Program and Results

The ventilation study and improvements project along with the ongoing monitoring program is an effort to ensure that the Juilliard community not only has a comfortable environment for them to do their work but also maintain the safety recommendations published to protect against the spread of COVID-19. This was achieved by a study conducted by in-house engineers that identified key improvement needs of the systems.

In all, 182 rooms over 42,799 square feet received improvements. The average ACH of those requiring attention rooms improved from 1.60 to 10.45. Most of the rooms were improved by the completion of basic maintenance activities. Through implementation of the associated monitoring program, the system improvements implemented will be effectively maintained as well as new needs identified.




As a result, the community can breathe easier knowing ventilation systems meet the requirements to protect against COVID-19 while also providing a more comfortable and energy efficient environment. The data revealed in this program was also instrumental in our successful request for additional resources in the engineering shop to support our efforts to stay on top of these needs and avoid allowing them to slip back into disrepair.

# Juilliard

## Institutional Benefits

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The institutional benefits of this program are vast and meaningful. While not everyone is aware of the details or scope of this project, everyone has benefitted.

First and foremost, the program helped prevent the spread of COVID-19. Along with other protocols in place, Juilliard has experienced less than 1% positive test rate throughout the pandemic since testing was implemented in October, 2020. In addition, there have been no confirmed cases of community spread such as a student infecting another student or faculty member while inside the school building. All positive cases of COVID-19 were brought in from outside the community and were stopped there. We believe that ventilation, together with strict mask-wearing, social distancing, testing, hand hygiene, and contact tracing, played a key role in that achievement.

In addition to the health and safety benefits, there were a number of climate control benefits. Not only have we received numerous comments on how much better the building feels, Juilliard is home to more Steinway pianos than any other single facility in the world. More than 260 pianos are found throughout the school along with other precious and delicate instruments with critical humidity and temperature control requirements. By improving the HVAC systems of the facility, these pianos are better protected from the deterioration caused by wide temperature and humidity swings.

As is typical with any study to improve the efficiency and effectiveness of HVAC systems, there was also an energy efficiency impact that is expected. Many systems and units required calibration and maintenance and these repairs and maintenance activities will undoubtedly have an impact on energy consumption. Because of the de-densification of the building, it is difficult to quantify the impact of the energy conservation measure aspect of this work but, in time, we will be able to compare the cost of operation to pre-pandemic levels and that will be more prevalent.

Perhaps one of the more prominent institutional impacts of this work is the awareness, additional resources, and monitoring that grew out of the program. This is not a one-time project that will eventually fade. The principles and intelligence attained during this program will provide necessary tools and foundational support to maintain the ventilation systems at a higher level than years past.

# Juilliard

## Document of Results, Analysis, and Benchmarks

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When COVID-19 began, there were a lot of mixed emotions and ideas that were spread throughout the world. Beliefs ranging from "a great plague" to "just another flu" were rampant. Even among professionals within the built environment, we didn't quite know what to make of it and the steps that we should take to protect those we serve.

Every institution throughout the country had their own unique challenges in dealing with the pandemic; Juilliard was no different. Being a performing arts conservatory, our work predominantly consists of acting, dancing, singing, and playing instruments. Our mission at Juilliard is to provide an educational environment for young artists to receive the highest level of training and performing experience so they can realize their true potential as professional musicians, dancers, actors, composers, playwrights, and choreographers in a myriad of career opportunities.

Now came the great challenge… What do we do to keep Juilliard going?

We began to review what the experts were telling us. In the beginning, it seemed like opinions and recommendations were changing almost daily. It was very difficult to keep up. We knew that our unique challenges and geography warranted our very best and we were determined to deliver.

One key topic that was emerging as a critical item in protecting against COVID-19 was ventilation. Even more than surface disinfecting, proper ventilation helped to prevent community spread of the disease.

This posed another great challenge…

Juilliard's Irene Diamond Building opened in 1969. Most of the air handling units are over 50 years old. There have been great efforts to maintain the systems throughout the years but we were faced with issues related to balance, outside air intake, fan control, and supply volume.

**Study Design & Initial Survey**

We knew that we had to do something to improve the ventilation of the building. To do that, we needed to know what we were dealing with.

The Juilliard Office of Facilities Management set out to undertake a study of the ventilation systems with our in-house engineers. This was a first-ever comprehensive assessment of the ventilation systems. Smaller by-zone studies have been done in connection with capital projects and retro-commissioning studies in the past but this was the first attempt to survey and assess the building as a whole since construction 50 years earlier.

Following a considerable review of recommendations, it was determined that, in addition to adequate filtration, optimal ventilation would need to be maintained. Nearly all the air handling units already had MERV 13 or better filtration and those that didn't were adaptable to it. For the ventilation, the metric to be used would be Air Changes per Hour (ACH). The minimum target ACH was set at 3 ACH with 4 – 6 being optimal. This was calculated by measuring the volume of air being supplied to a space and dividing that by the total volume of air in the room. Understanding that there are other factors to calculating the real value of air exchange, we determined that this was an acceptable metric and means of calculation for our circumstances.

For a number of reasons, this study was conducted internally using only Juilliard staff. Equipment was purchased to measure the ventilation being supplied throughout the building. This equipment has also been and will continue to be useful in ongoing testing as adjustments.

The Juilliard engineers were trained on using the equipment, how to measure the volume and velocity of the ventilation, and how to record that in the provided online Excel workbook linked to their mobile devices. The engineers then went out and captured the following data:

- Room ceiling heights as that was not presently known in the space inventory database.
- Volume of supplied air by either using a capture hood to measure cubic feet per minute (CFM) or an anemometer to measure feet per second (FPS).

The engineers then entered the data and the ACH was calculated using formulas built into the provided spreadsheet.

As an example, if the volume of air being supplied to the space through the HVAC systems totaled 68 cubic feet per minute (CFM) and the total interior volume of the room was 96 square feet with a 9 foot ceiling, the ACH was calculated as follows:

(68 CFM x 60 minutes) / (96 SF x 9 feet) = 4.72 ACH

The findings were then classified into the following categories:

- Less than 3 – Too low, Unacceptable
- Between 3 and 3.99 – Acceptable
- Between 4 and 5.99 – Optimal
- Between 6 and 14.99 – High but acceptable
- 15 or greater – Atypically high

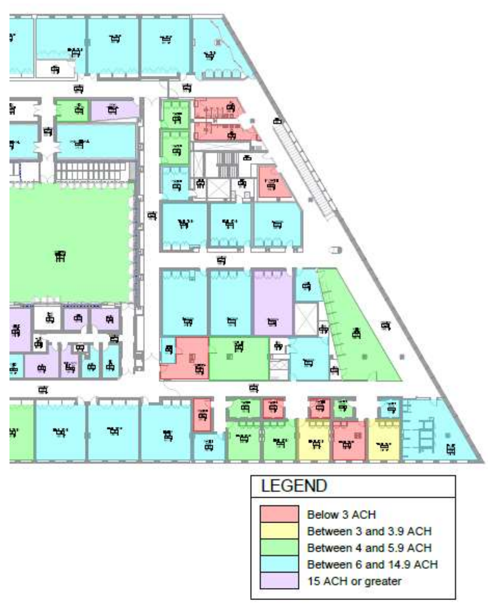


*Figure 1: Sample Floorplan*

Following categorization of the ranges, the findings were plotted on a floorplan of the building (see Figure 1). This assisted with identifying opportunities through juxtaposition and comparison with mechanical drawings of the facility. For example, for many rooms that we identified as low volume, the rooms around it on the same circuit had sufficient or even excess volume. That was an indication we had a stuck damper, clogged coil, or other obstruction that would be easily cleared. If we saw the entire circuit was low, we knew we needed to look more broadly at that system or air handling unit for a potential remedy.

Using those tools, recommendations were made regarding individual rooms and fan systems.

***Initial Survey Results***
An evaluation of the data revealed some areas had high velocity and required dampening while others were starved for adequate ventilation and HVAC control. Some areas had stuck dampers or matted coils obstructing flow. The data in this study provided clear illustrations of where the most critical needs were located.

In total, 568 spaces were evaluated throughout the building totaling 215,728 square feet. The summary of their ACH readings is in Table 1.

| ACH Reading | Count | % of Total | Total SF | % of Total |
|---|---|---|---|---|
| Less than 3 | 132 | 23% | 41,491 | 19% |
| Between 3 and 3.9 | 65 | 11% | 19,537 | 9% |
| Between 4 and 5.9 | 115 | 20% | 71,188 | 33% |
| Between 6 and 14.9 | 198 | 35% | 74,673 | 35% |
| 15 or greater | 58 | 10% | 8,839 | 4% |
| **Total** | **568** | | **215,728** | |

*Table 1*

We found that, approximately 19% of the square footage surveyed did not meet the acceptable standard for ACH.

**Improvement Efforts**
Following the survey, many recommended actions were identified and pursued including:

- Check and clear stuck dampers and obstructions in ductwork.
- Balance manually operated dampers to provide more capacity downline.
- Evaluate air handling units for opportunities to increase capacity and volume.

Each area found deficient was prioritized into either 1st, 2nd, or 3rd priority. Work was completed starting with the 1st priority in August and all feasible remaining recommendations of all priorities completed before the start of the spring semester in January. A sample of the report of findings is shown in Figure 2.

**Ventilation Survey**

***Detail of Recommended Actions by Priority***

| Room | Floor | Room Description | Room Area (SF) | Room Volume (CF) | Total Supply (CFM) | ACH | Recommended Actions | Priority |
|---|---|---|---|---|---|---|---|---|
| 315 | 3rd Floor | Office | 456 | 4,104 | 94 | 1.37 | Check for stuck damper or stopped CAV coil. | 2nd Priority |
| 315A | 3rd Floor | Instrument Storage | 147 | 1,323 | 0 | 0.00 | Duct came apart. Connect diffuser and retest | 3rd Priority |
| 317 | 3rd Floor | Orchestra Library Storage | 139 | 1,251 | 0 | 0.00 | Duct came apart. Connect diffuser and retest | 3rd Priority |
| 329D | 3rd Floor | Office | 146 | 1,314 | 59 | 2.69 | Check for stuck damper or stopped CAV coil. | 2nd Priority |
| 338 | 3rd Floor | Dance Offices | 239 | 1,912 | 0 | 0.00 | Duct came apart. Connect diffuser and retest. | 1st Priority |
| 338B | 3rd Floor | Conference Room | 360 | 2,880 | 87 | 1.81 | Check for stuck damper or stopped CAV coil. | 1st Priority |
| 338F | 3rd Floor | Office | 88 | 704 | 25 | 2.13 | Check for stuck damper or stopped CAV coil. | 2nd Priority |
| 338H | 3rd Floor | Office | 174 | 1,392 | 27 | 1.16 | Check for stuck damper or stopped CAV coil. | 2nd Priority |
| 340 | 3rd Floor | Jazz Rehearsal | 987 | 20,727 | 470 | 1.36 | Check for stuck damper or stopped CAV coil. | 1st Priority |

*Figure 2: Sample Results Data*

In addition, the previous year, the Office of Facilities Management had implemented a new Capital Needs Analysis program that assessed asset life-cycles and condition. From that study, we identified capital improvements that were already funded and shovel-ready before the pandemic hit. Projects to add and upgrade variable speed drives and rehab outside air dampers proved particularly providential for our efforts.

***Repairs & Remedies***

In all, 182 rooms received improvements. The average ACH of those requiring attention rooms improved from 1.60 to 10.45. Most of the rooms were improved by the completion of basic maintenance activities. The most common remedies are listed below.

- Opened a closed or stuck damper (39%)
- Tested and serviced exhaust systems (34%)
- Cleared obstructions in ductwork (17%)
- Adjusted variable speed drive at the air handling unit (4%)
- Other remedy (6%)

When inquired, the engineers indicated that many of these issues were known but they were unable to attend to them because of other demands on their time. At the start of the pandemic, the engineers moved from a 16-hour shop to a 24-hour shop in order to keep the ventilation systems running longer. The additional time in the building and lower occupancy allowed them greater time to attend to the identified needs and make the remedies required to improve the ventilation.

**Final Results**

At the outset, it was fully expected that the engineers would be able to have an impact on the ventilation throughout the building. However, the scale of that impact was underestimated. The engineering team did an exceptional service improving the effectiveness of the existing aging equipment.

Following the improvement work, few rooms remained below the target. Air purifiers were added to supplement the rooms still below target. Ongoing retro-commissioning and other assessments are being pursued to try to address the few remaining needs. Tables 1 and 2 juxtapose the summary findings both before and after the improvements completed by the engineers.

**Initial Survey**

| ACH Reading | Count | % of Total | Total SF | % of Total SF |
|---|---|---|---|---|
| Less than 3 | 132 | 23% | 41,491 | 19% |
| Between 3 and 3.9 | 65 | 11% | 19,537 | 9% |
| Between 4 and 5.9 | 115 | 20% | 71,188 | 33% |
| Between 6 and 14.9 | 198 | 35% | 74,673 | 35% |
| 15 or greater | 58 | 10% | 8,839 | 4% |
| **Total** | **568** | | **215,728** | |

*Table 1*

## After Improvements

| ACH Reading | Count | % of Total | Total SF | % of Total SF |
|---|---|---|---|---|
| Less than 3 | 25 | 4% | 12,125 | 6% |
| Between 3 and 3.9 | 70 | 12% | 20,054 | 9% |
| Between 4 and 5.9 | 144 | 25% | 82,878 | 38% |
| Between 6 and 14.9 | 254 | 45% | 90,188 | 42% |
| 15 or greater | 75 | 13% | 10,483 | 5% |
| **Total** | **568** | | **215,728** | |

*Table 2*

**Monitoring**
The nature of HVAC systems is that they are dynamic equipment. Just because a survey was completed in August does not mean that data holds true in January. Therefore, a system of monitoring was needed to ensure that the systems were proactively tracked. This system developed consists of three methods.

- **Real-time monitoring through the BAS.** For those few spaces that have received modernized HVAC controls, those spaces provide the ability to monitor real-time CFM supply to the spaces. Using the integrated features of the BAS, alarms can be set to alert the engineers if one of these areas drops below the required CFM to maintain 4 ACH.
- **Real-time monitoring through VSDs.** For those spaces that do not have real-time BAS readings of the CFM in the space, real-time monitoring can be accomplished by using the VSD fan speed readout. Through trial and error, the acceptable minimum fan speed required to deliver at least 4 ACH to the worst case room can be determined. Using the BAS, automated alarms can be used to alert the engineers if the fan speed drops below that threshold.
- **Manual Testing.** Manual testing is, of course, the most labor intensive and least predictive form of monitoring. However, due to the age and condition of many of the spaces throughout the school, it is the only option. There are two systems of manual testing that are being employed.
  - *Weekly Testing of Key Rooms*. For rooms that require manual testing and are of a greater risk factor (i.e. rooms that have small ensemble work), weekly testing is administered using the IWMS.
  - *Sample Testing of Systems*. For those rooms that are of a lower risk factor, a periodic sampling of rooms within a circuit is being employed. Once per month, a small number of rooms as part of an AHU's circuit of rooms are tested. If those rooms fall below acceptable levels, the entire circuit for that AHU is retested and evaluated.

**Ongoing Efforts**
The completion of this project was an exceptional achievement. Not only has an assessment of this magnitude never been done before at Juilliard, it was completed with our own internal crew giving them the experience and saving on the cost. It is the result of great effort by the engineers as well as the tremendous support of the senior administration in reinvesting in the ventilation systems of the facility. This level of effort and reinvestment would be difficult to sustain for the long-term without other areas of the operation suffering. As a result, it is not to be assumed that this work is, or will ever be, complete. This work will take continuous commissioning and other ongoing efforts including staffing adjustments, IWMS adaptation and deployment, and BAS enhancements.

Having a full understanding and comfort level with the ventilation systems was a key component in Juilliard's return strategy. This work, coupled with other strategic initiatives taken by multiple departments and divisions throughout the school, led to the ability for students to return to limited in-person activity in August, 2020 and incrementally increasing throughout the school year to where they were able to do small-ensemble work and other collaborative in-person work. By the end of the school year, the students were fully ready to deliver nearly 50 public performances.

Many faculty and staff have already commented on the vast difference they feel throughout the building and expressed their great appreciation. This work, coupled with the ongoing efforts to maintain and continually improve, will help ensure that these systems will remain as effective assets in the overall building health for the Juilliard community not only during but long after we have left the pandemic behind.

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# Juilliard

## Innovative Characteristics

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Admittedly, the basic tenets of this program are not new. Facilities operations have been conducting similar retro-commissioning studies for a long time. What makes this program particularly innovative is the approach and implementation. Compelled by a pandemic prompting building de-densification, budget constraints, rapid response, and labor shortages, we needed to find a way to assess and prepare the building for safe re-occupancy.

For larger institutions with larger teams, these studies are more attainable with the constraints mentioned. For a small operation with three total management staff and four engineers, completing the study, making the repairs, and implementing the monitoring program was an immense challenge.

The successful implementation of this program helped to demonstrate and trailblaze a path for other small to medium size institutions on how this can also be done to support their work. They do not need to hire expensive consulting and mechanical firms to get this done. With the right tools and training, they can complete this study themselves and better support their campus communities.

The key characteristics that make this program innovative are…

- The simplicity of the equipment and software required. All that was required was…
  - Bolometer (capture hood) for diffusers 2' x 2' or smaller.
  - Anemometer for linear diffusers or any diffuser larger than 2'x 2'.
  - Microsoft Excel.
  - AutoCAD or other drafting software to plot the findings.
- The scarcity of staff available to implement the program.
  - Through a building of approximately 500,000 SF, only an AVP, Director, Ops Manager, Chief Engineer, and 3 engineers
- The budget constraints available to carry out the plan.
  - No new capital funds were required. Less than $10,000 in repairs and overtime labor.
- The competing impacts and demands of an ongoing pandemic.
  - In addition to ventilation improvements and all required ongoing preventive and corrective maintenance, some other demands included…
    - Isolation valve repairs and replacements
    - Ongoing capital renewal projects on mechanical systems already in motion
    - Ongoing, in-progress construction projects to manage
    - Entry sequence development
    - Disinfecting practice implementation
    - Social distance planning and de-densification modeling
    - Signage installation
    - Workspace planning and relocation management