



Nortek Air Solutions' AHU Customization and Sound Attenuation Help Kleinhans Music Hall Replace 83-Year-Old HVAC System

AT A GLANCE

- Two knockdown 41-foot-long AHUs and two 13-foot-long exhaust air units (EAU) were rigged into third-floor and basement mechanical rooms, respectively. All four units required quick assembly and start-up within a short summertime recess to meet the fall orchestra season's mission-critical opening night deadline.
- The design team's HVAC specification reduced ductwork air movement noise and equipment reverberation break-out sound by an average of 10 dBA throughout the seating and stage areas versus the original equipment.
- Nortek Air Solutions configured the Ventrol®-brand units' operating sequences to accommodate the mechanical room's obstructing support beams and to attenuate sound.



MAIN PLAYERS

Building Owner
City of Buffalo

Consulting Engineer
M/E Engineering, Buffalo, NY

Mechanical Contractor
John W. Danforth Co., Tonawanda, NY

HVAC Equipment Manufacturer
Nortek Air Solutions

Manufacturer's Rep
J.W. Swanson & Associates, LLC, Buffalo, NY

Original Equipment:

- **Manufacturer:** Buffalo Forge Co., Buffalo, NY, supplied the fans for two AHUs and two exhaust air units (EAU) that were custom-built in 1940 onsite with a variety of components inside Buffalo Forge cabinets
- **System:** two AHUs in a third-floor mechanical room that supply air to performance hall ceiling diffusers and two EAUs in a basement mechanical room that draw air into a basement exhaust plenum located under first-floor seating vents
- **Heating and Cooling:** steam and chilled water coils supplied by the two 10,900 MBH original steam boilers and two 150-ton chillers, respectively
- **Filtration:** MERV 8 filters
- **Fans:** conventional belt drive, 30hp motor plenum fans (one for each of the two AHUs and EAUs) with circa. 1980's manually operated VFDs
- **Controls:** manually controlled and not tied into a building management system



New Equipment:

- **Manufacturer:** Nortek Air Solutions
- **System:** two AHUs: (490 (l) x 122 (w) x 148 (h)-inches; two EAUs (156 (l) x 108 (w) x 95 (h)-inches
- **Heating and Cooling:** steam and chilled water from existing two boilers and chillers
- **Filtration:** MERV 8 prefilters; MERV 13 (12-in.-wide) final filters
- **Fans:** direct drive FANWALL TECHNOLOGY®. Both AHUs have nine 5hp fan arrays, each at 25,000-CFM. Both EAUs have four 3hp fan arrays, each at 24,500-CFM.
- **Control:** Tied into a BACnet-based building management system for damper openings, fan efficiencies, coil conditions, temperature, outdoor air, and other parameters that can be monitored and controlled via a front-end dashboard

PROBLEM/SOLUTION

Kleinhans Music Hall in downtown Buffalo, NY, is a world-class arts/culture destination and home to the Buffalo Philharmonic Orchestra. However, the historic landmark, designed by renowned architects Eliel and Eero Saarinen in 1940, needed a long-awaited renovation to prevent ongoing deterioration. Consequently, the facility was recently green-lighted for a \$21 million three-phase renovation.

Phase 1 included the renovation of the aging HVAC system. Maintaining Kleinhans' indoor air comfort is important, but HVAC sound attenuation throughout the acoustically perfect, 2,400-seat music hall is crucial for the world-class music performances held there. Increased noise and vibration from the aging HVAC air handling equipment in the third-floor mechanical room was problematic for some seating areas, especially during soft music passages. Basic VFDs were added to the two single-fan air handling units (AHU) and two single-fan exhaust air units (EAU) in the 1980s for manually attenuating the system's operational sound via airflow reduction. "We rarely had complaints, but I could hear some air movement noise at times," said Daniel Hart, executive director at the Buffalo Philharmonic Orchestra and director of Kleinhans Music Hall Inc.

Although the original HVAC system was still operational, nearly every component had been replaced or updated except for the cabinets. Building a new system inside the original single wall, uninsulated cabinets was not an option because today's new double wall, insulated, sound-absorbing cabinet technology would significantly improve sound attenuation efforts. Furthermore, the original components were housed in a cabinet with three metal sides, and the fourth side was the building's concave exterior wall, which isn't ideal for sound absorption.



Before



After

Two newly installed white NEMA1 VFD panels. ABB multi-drive ACS320 VFD model provided. Each VFD panel has one VFD per motor.

For engineering company M/E Engineering, Buffalo, NY, and mechanical contractor John W. Danforth Co., Tonawanda, NY, the replacement project had a myriad of hurdles:

- More than 700 knockdown pieces of the two AHUs had to be rigged up a narrow three-story stairwell and through the mechanical room's 36-inch-wide doorway
- Nortek Air Solutions also designed a 12'-0" x 10'-2" x 6'-6" acoustical expansion chamber (AEC) positioned above each AHU's discharge air point
- The two knockdown 41-foot-long AHUs and two 13-foot-long EAUs required specification, design, manufacturing, factory testing, and delivery in less than six months; then rigging, assembly, and startup were required within 10 weeks of the BPO's summer recess



“Ventrol’s® customization capabilities were critical to the success, because the AHUs fit the original footprint within one inch, while also circumventing the mechanical room’s low hanging support beams and other customizations. The FANWALL TECHNOLOGY® was also crucial because it can maintain tight temperature tolerances while applying the minimal speed needed for sound attenuation.”

– Peter C. Murrer, P.E., P.M.P., C.E.M., CCP, LEED AP BD+C, a partner at M/E Engineering

- Both new AHU units required a “notched out” design of their cabinet tops to fit under 3 square foot low hanging steel beams that pass through the mechanical room
- The units required a stringent dBA and noise criteria (NC) rating mandated by facility management
- The building’s interior envelope could not be altered for supply/return air path improvements or for mechanical room enlargement because of Kleinhans’ National Historic Landmark status

Nortek Air Solutions’ in-house manufacturing of coils and FANWALL TECHNOLOGY® was instrumental in accomplishing the mission-critical lead time. What’s more, Nortek Air Solutions’ in-house manufacturing of major components enabled M/E Engineering to tweak the coils, fans, and cabinets to their specifications. In-house manufacturing also boosts quality control and expedites any warranty issues.

Ventrol access door located beside Blender Products air blender component.



CUSTOMIZING EQUIPMENT TO THE SITE

The new AHUs are positioned in their predecessors' footprints for convenient existing piping, ductwork connections, and mechanical room space considerations. Since the new units are butted against the concave brick exterior wall with little access, Nortek Air Solutions innovated unique bolt/lug connection points that enabled contractor John W. Danforth Co., Tonawanda, NY to adjoin the sections unconventionally from within the cabinet.

Another customization was the notching out of a three-foot-long section of each 16-foot-high, 41-foot-long AHU. The notched-out sections are 35% shorter in height than the flanking sections in order to circumvent low-hanging steel support beams. The notched-out section doesn't disrupt the air tempering sequence or compromise the size of any components, such as fans and coils. Instead, it was designated as a mixing box that blends makeup air and outdoor air. "Nortek Air Solutions used every trick in the book to customize accommodations for obstructions, accessibility and other jobsite challenges," said Dan Arnold, P.E., Sales Engineer, J.W. Swanson. "The expertise and attention to detail by Glenn Gatineau (Nortek Air Solutions' Senior Applications Technologist) and the SAE team being fully integrated into the design process also contributed to the project's success."

Nortek Air Solutions' knockdown parts strategy helped the team meet the critical mission completion deadline. Unlike some manufacturers that may send similar-sized systems in a thousand or more pieces, Nortek Air Solutions' 356 knockdown parts/AHU were designed/manufactured as large as possible to minimize assembly time but small enough for Danforth's crew to safely transport up three flights of stairs and through the mechanical room's 36-inch-wide doorway. Danforth's crew created a sheet metal slide system to winch the parts easily and safely up the stairs on dollies without damaging the 80-year-old concrete.



"Without our field staff's slide/dolly/winch innovation, we would have been at a huge disadvantage to meet the project's deadline. Once we got the parts in the mechanical room, Nortek Air Solutions' on-site tech was great and worked closely with our field foreman during unit assembly."

**– Matt Peters,
Danforth's project executive**



Inlet view of the Passive Noise Control system with Ventrol backdraft dampers.

ATTENUATING OPERATIONAL NOISE

Decreasing noise levels was a major goal of the HVAC replacement project. The many strategies the design team employed reduced sound levels in the performance hall and stage by an average of 10 dBA versus the original system.

Murrer, whose firm also designed HVAC systems for Buffalo's Broadway-style theater, Sheas Performance Arts, said previous unwanted performance space noise originated from several HVAC-related sources:

- Mechanical equipment reverberation through supply/exhaust ducts
- Equipment vibration felt in several rows on the balcony that shares a common brick wall with the third-floor mechanical room
- Duct/diffusers air movement breakout noise

The Ventrol®-brand units feature double walls with four-inch-thick fiberglass rolled insulation and a perforated inner liner to offset the inherent operational sound characteristics of HVAC equipment.

Nortek Air Solutions also designed a 12'-0" x 10'-2" x 6'-6" acoustical expansion chamber (AEC) positioned above each AHU's discharge air point. The AEC is essentially an insulated box with a perforated inner liner to capture reverberation breakout sound.

Kim Osborn, Nortek Air Solutions' acoustical engineering manager, performed acoustic CAD modeling and tests that determined Kleinhans' ideal cabinet component sequencing, inlet/outlet locations, baffles, and other design parameters targeting equipment sound attenuation. "It was incredible how accurate the modeling was to the post-startup onsite sound performance tests," said Arnold.

Although they fit the original units' footprint, the Ventrol®-brand AHUs' compact FANWALL TECHNOLOGY® consumes 20% less space than the preceding equipment's huge conventional single-motor fans. This extra space allowed upgrades to MERV 13 filtration and a pre-filter. More importantly, the extra internal cabinet space enabled additional attenuation with 27-inch long Coplanar Silencers and Passive Noise Control inlet attenuation on customized 37-inch-deep FANWALL TECHNOLOGY® cubes, which typically range from 24 to 30 inches deep.

The FANWALL TECHNOLOGY® also uses a high-performance aluminum airfoil fan wheel. The premium, efficient, quiet fan has an improved aerodynamic blade shape, shroud, and cone. Additionally, its material provides damping to reduce sound tones from the impeller and motor, resulting in typical sound reduction of 5 dB of fan blade passage frequencies on inlet and discharge.

12" Deep MERV13 AAF
VariCel VXL SH filters.

FANWALL TECHNOLOGY® is designed to eliminate vibration at the source—within each FANWALL cube—through stringent balance requirements and the use of sturdy components. This results in a more efficient and quieter operation that eliminates the need to isolate a FANWALL array within the air handler.

Attenuating mechanical reverberation is also critical for the EAUs, which are located under the ground-floor seating areas.

All the equipment's sound attenuation is a credit to the Ventrol®-brand units' design and M/E Engineering's specification, but also the assembly and installation by project contractor John W. Danforth Co.: due to their superb onsite construction and sealing, the units don't leak air or sound.

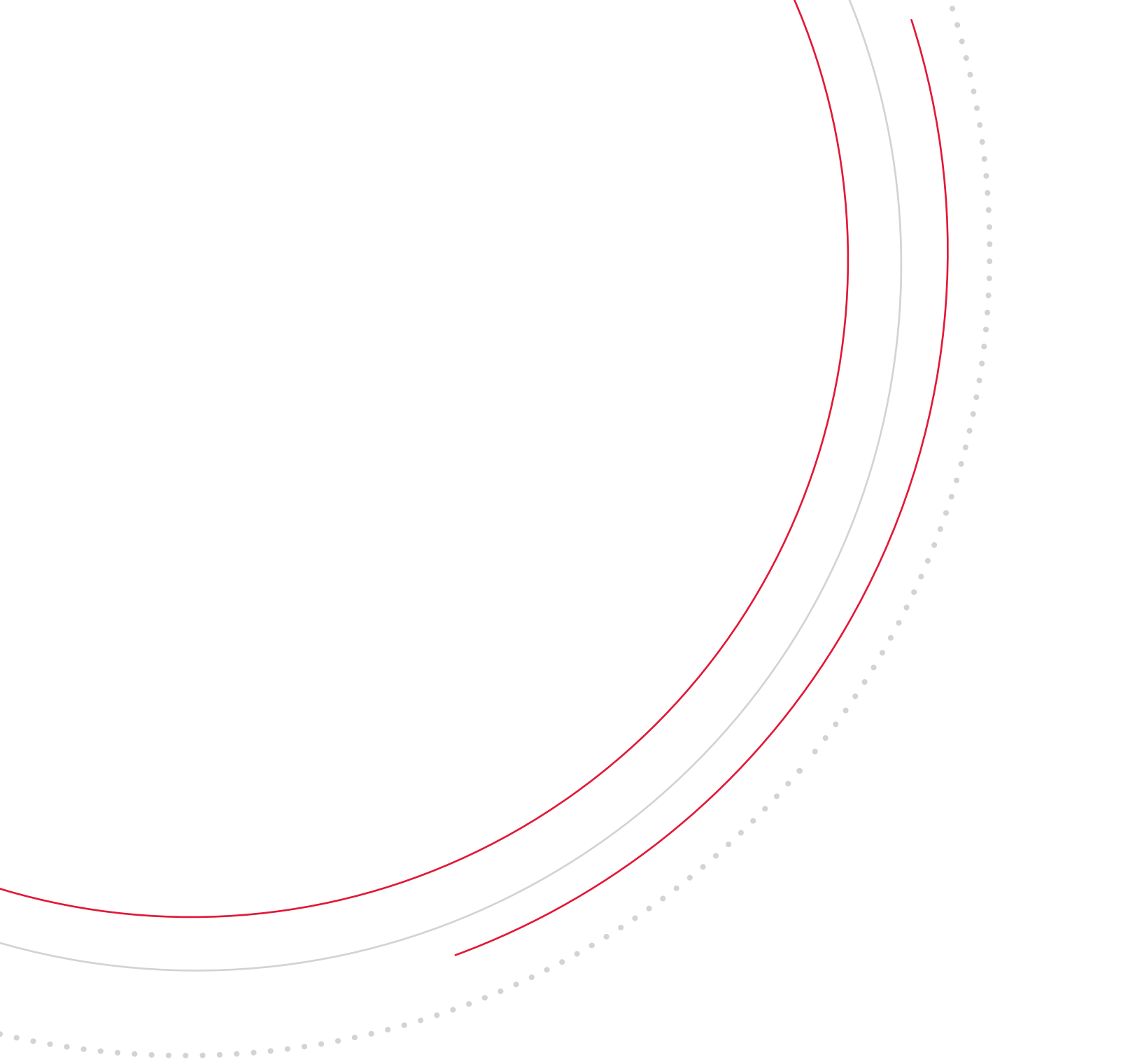


PLANNING FOR THE FUTURE

The use of FANWALL TECHNOLOGY® will considerably reduce Kleinhan's HVAC maintenance costs. It is virtually maintenance-free and more reliable, thanks to its direct drive versus the old system's belt drive methodology. Reliability was also increased over the original system's one-fan design because the system can still operate if one of the nine fans needs replacement.

The design team's compliance with the International Energy Code (IEC) by including an economizer on the AHUs will have a fringe benefit: if a pandemic strikes the U.S., the facility will be able to easily execute the American Society of Heating Refrigerating and Air Conditioning Engineers' (ASHRAE) recommendations of 100% outdoor air to help mitigate potential infectious airborne diseases and pathogens.

"This project had great communication among the manufacturer, engineer, contractor, and other design team members from the very beginning," said Hart. Long-term relationships between Nortek Air Solutions and J.W. Swanson, and between J.W. Swanson and M/E Engineering and John W. Danforth Co. helped the teams work together efficiently and effectively. "I could also see a sense of pride within the design team to do the best job possible in renovating a historic building like Kleinhan's that is so important to the community."



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