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APPLICATION AND CASE HISTORIES OF ACTIVE SILENCERS IN HVAC SYSTEMS

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INTRODUCTION[1]

Visual, thermal, and acoustical comfort for the employees inside were prime concerns for a new 50,000/sqm office building planned as a regional office for a U.S. based insurance company. The Tampa, Florida location called for a large capacity HVAC system. With an ASHRAE-recommended NC-40 as the design goal, air handler noise was a prime concern.

Active silencers are increasingly being used to attenuate the low-frequency (up to 400 Hz) noise generated by HVAC fans. When combined with minimal acoustical lining in the duct for high frequency attenuation, good overall attenuation can be achieved, without the pressure loss normally associated with passive silencers. Large passive silencers can also be difficult to accommodate in space constrained layouts. Due the expected high fan sound power levels in the low frequencies, 85 active silencers were installed to operate on 33 of the 40 air handlers in the building.

The design for the seven-story building was poured concrete with two mechanical equipment rooms on each floor. These were located in a core with rest rooms, stairs, electrical room and service corridor to serve as buffers, isolating them from the open-plan occupied areas.

The use of a variable air volume (VAV) air distribution system meant that additional noise would be created in the office space by the VAV boxes. The criteria for the duct silencers was to attenuate the fan noise to be 10 dB below the VAV box sound power level.

HVAC NOISE DESIGN EVALUATION AND RESULTS

The design evaluation of a typical air handling unit indicated a requirement for a 3m silencer, an acoustically lined elbow with exterior acoustical lagging, and a 1.5m silencer in service in the supply path. Two 1m silencers with an elbow would be required on the return air path.

The size of the passive silencers was a concern. To achieve the required attenuation of the low frequency energy, without imposing an excessive pressure drop, required a silencer with a large cross sectional area.

The space available in the duct layout for silencers of this size were very restrictive. They would not physically fit into the available space. Nor would they fit under and around the concrete beams that had been designed. The design of the building core was complete and could not be altered to fit the silencer requirements.

DECISION TO USE ACTIVE SILENCERS

The acoustical consultant, on behalf of the design team, began investigating the use of active silencers for this building. Active noise control is based on the principle of destructive interference, using sound which is equal in amplitude and frequency but of opposite phase to cancel the incident noise.

A manufacturer of active silencing systems with several years experience in applying this technology to control noise in HVAC ducts was evaluated along with their references. The consultant interviewed customer references supplied by the manufacturer to determine the manufacturer's capabilities for product performance, installation services, and follow-through after the sale. Based on the consultant's recommendations, the design team met with the manufacturer to learn more about the active silencers. It was determined that active silencers could be used to attenuate the low frequency sound propagating in the duct.

In order to demonstrate the technology the manufacturer developed a full size mock-up in the laboratory. The fan which had been specified was supplied by the mechanical contractor. A fan discharge elbow and approximately 10m of the supply duct was configured according to the contract documents for the mock-up,

MOCK-UP TESTS

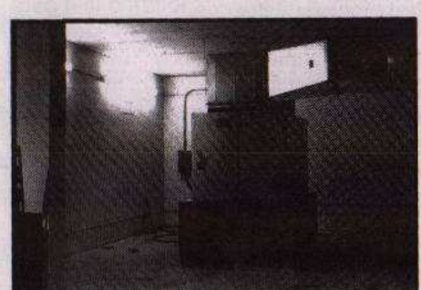

Fig. 1

Preliminary mock up test data was supplied to the consultant to evaluate and report to the design team. Based on these results, the design team visited the manufacturer's laboratory to witness the tests, and hear the noise reduction provided by the active silencing system. Figure 1 shows the fan, set up within a concrete block wall room, with the discharge duct penetrating the wall. The active system actually starts very near the fan discharge. The input microphones are located just after the elbow, on the transition piece. Mock up tests of a transition designed for the system was tested and compared with an ASHRAE-recommended 15 degree included angle. This showed a 3 dB improvement in attenuation in the lower frequencies. The transition was changed in the final design.

Achieving optimal performance from the active system requires that the HVAC system designer provide for good aerodynamics. This generated localized turbulence. Locally generated turbulence due to poor transitions, improper fittings, and very high velocities are not coherent with the fan noise at the input microphone. This limits performance of active system.

Figure 2 shows the test room on the other side of the concrete block wall. In the test set up the cancellation loudspeakers are located right at the wall, mounted on top of the duct. Error microphones are approximately 30cm downstream of the loudspeakers. The supply air duct is 183cm x 60cm with 25cm of acoustical lining. Since cancellation takes place at the loudspeakers, external duct lagging may be required if the duct between the microphone and speaker is over a sensitive area.

Fig. 2

Figure 3 shows the octave band results in the duct. The in-duct results were measured with an independent microphone near the fan and at the end of the duct. The rise in the sound level in the higher frequencies is due to regenerated noise from the turning vanes in the discharge elbows. This was an audible hiss in the test room. The discharge duct length of the mock up was not of sufficient length to attenuate this noise. Later it was shown that this was not a problem in the field as the regenerated noise in attenuated by downstream duct elements and duct lining.

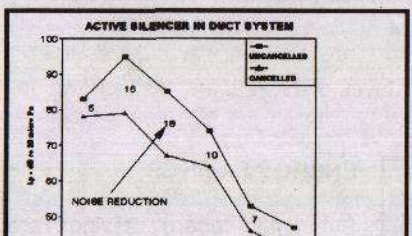

Fig. 3

FIELD TESTS

The consultant determined which of the air handling units required active silencing. The manufacturer selected the active silencer components, including the locations of microphones, loudspeakers and controllers.

In order to prove the design in the field, an air unit was selected for testing at the site. Figure 4 shows the microphone placement and controllers for the active silencers. The in-duct measurements showed good correlation to the laboratory measurements. Based on the field test data, acceptance of the active silencing systems was recommended.

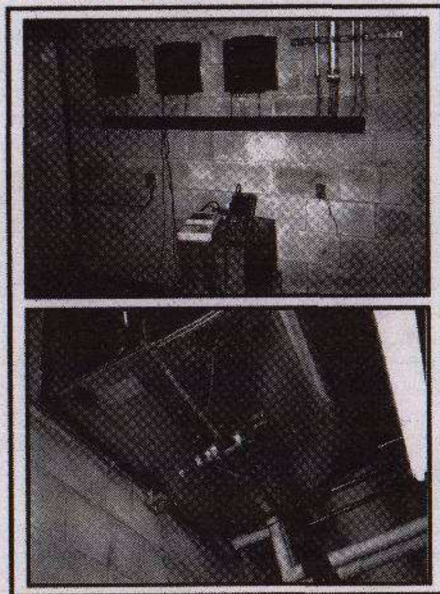

Fig. 4

FINAL ACCEPTANCE TESTS AND RESULTS

A final set of measurements was made in the space after the ceiling and furniture for the open-plan office were installed. Figure 5 shows the NC-36 that was achieved with the active silencers in place. The design criteria of NC-40 and the ambient level of NC-22 are also shown for comparison.

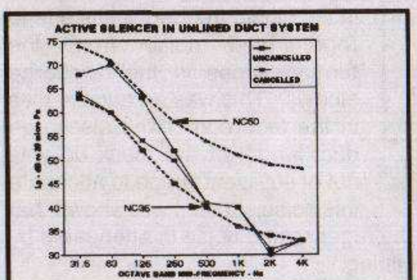

Fig. 5

ENERGY SAVINGS

Substantial energy savings are realized, since active silencing does not impose a pressure penalty on the system. Using a pressure drop of 1.38 inches of water for the passive silencers replaces, the energy savings can be calculated from:

$$\Delta\$ = (1.03 \times \textit{pressure drop} \times \textit{cfm} \times UC)/E$$

where: ΔS = annual energy savings in dollars
ΔP = pressure drop, i.w.g.
cfm = airflow in cu. ft./min.
U = utilization as percent of hrs/yr (50 = 50%)
C = cost in $/kWhr
E = system fan and motor operating efficiency (75 = 75%)

The savings would be $38,000 per year for 33 air handlers with active silencers.

CASE HISTORY SUMMARY

The building was completed and occupied by the owner in October 1993, who finds the following advantages:

1. The systems are performing as expected;
2. The energy savings are guaranteed by the design and selection of the equipment;
3. There is potential for using this equipment to establish trend information on fan and drive-system maintenance requirements by evaluating the acoustical signature of the equipment as detected by the microphones.

EFFECT OF ACTIVE SILENCERS WITHOUT DUCT LINING[2]

In today's environment the use of fiberglass duct lining is being questioned as it relates indoor air quality (IAQ). The EPA has classified fiberglass as a suspect carcinogen. ASHRAE on the other hand has taken the position, based on significant research, that a more serious concern is the conditions of the dirt, dampness and darkness that provides good conditions for the growth of molds and bacteria. The elimination of fiberglass duct liner has required some creative noise control engineering to reduce fan and system noise. Coated duct liners with fungicide impregnated in the fibers, packless silencer, standard passive silencers with imperious material behind the perforated metal and active silencers are at least methods that can be used.

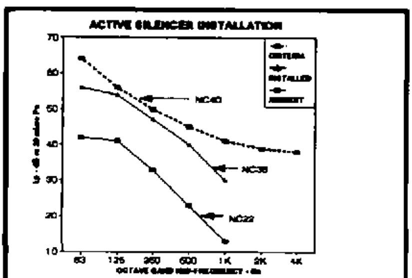

Fig. 6

This requires that fiberglass ductliner be eliminated from the active silencer. This does reduce performance to some degree. The standard active silencer with at least 3.1m of duct liner is comparable to a 3.1m standard passive silencer. Without duct lining in the active silencer duct the performance is reduced as shown in Figure 6. This is compatible to a 1.6m standard passive silencer. These silencers have been installed in a building in the State of Florida, USA. Active silencers are a reasonable alternative. Without fiberglass duct lining there will be more inherent ductborne noise in the building. The ductliner tends to take care of many air flow noise problems.

MULTI-ZONE AIR HANDLING UNIT

This unit serves a portion of the back of the house in a new theatre in Florida. Most of the duct runs served none noise sensitive spaces like the projection booth, except one, while served the theatre directors office and the Green Room. No duct lining was allowed and additional noise reduction was required for these two spaces. A passive silencer would add pressure drop making this system difficult to balance. Therefore, an active silencer was selected to provide noise reduction without imposing pressure drop.

SPORTS ARENA AIR HANDLERS

The arena was designed for ice hockey and types of traveling shows. The large cfm units were specified with intake plenums. The supply air noise control was evaluated against an RC-40 in the arena. A computer model was used to evaluate the noise level at several locations with sound power levels of the supply grills. This evaluation showed that active the silencers provided a more balanced spectrum and follows the RC profile. The passive silencer reduced too much noise in the mid and high frequencies resulting in a rumbly spectrum.

SUMMARY

The case histories include active silencers for a 500,000 sf new office building, active silencers without duct lining, and applications an multi-zone unit and air handlers for a sports arena.

The new active silencers require more up front work for the Acoustical consultant to convince the design team that this new technology can and should be considered in every HVAC noise control evaluation. Active silencers are not always feasible or the correct application, but they should be given equal considered as acoustical plenums, passive silencers or heavy duct lining.

REFERENCES

[1] Pelton, Wise, Sims; "Active HVAC Noise Control Systems Provide Acoustical Comfort," Sound & Vibration Magazine, July 1994.

[2] Private communication from Digisonix.