Ventilation Leaks Are Solved when Two Technologies Come Together

Written By Marc Zuluaga ◇ Energy

Ever since man first began living and working indoors, proper building ventilation has been directly linked to the relative health and safety of the buildings' occupants. Over time, various methods were employed to facilitate the "proper" indoor flow and exhaustion of air. By 1925, assisted with the development of the electric power industry and the use of mechanical ventilation systems, 22 states had laws governing the minimum standards for indoor building ventilation.

Sealant particles do not coat the entire inside of the shafts but form a tight seal around individual leaks. PHOTO: Aeroseal LLC and Steven Winter Associates Inc.

Since that time, the majority of buildings in the U.S. have been constructed with mechanical ventilation systems that use the same basic design principles as those built in the 1920s and '30s. Aside from the excessive noise often associated with these systems, commonly found leaks in the shafts result in uneven and inadequate ventilation. Like trying to draw water through a straw with holes in it, the leaks make it difficult for the roof fans to evenly draw air up through the shafts. To compensate, the fans are often turned up higher than should be necessary or replaced completely with bigger fans. As a result, upper-level spaces are typically overventilated while those near the bottom floors remain under-ventilated.

As bigger fans run at higher levels to compensate for leaks in the shafts, building owners face another significant issue: increased energy usage. According to a 2003 report published by Lawrence Berkeley National Laboratory (LBNL), Berkeley, Calif., "Thermal Distribution Systems in Commercial Buildings," even a low leakage rate can lead to a substantial increase in fan power consumption and energy use. As dictated by the fan affinity laws, an increase in fan power is proportional to the required increase in flow rate to overcome the shaft leakage. Therefore, just a 15 percent leakage rate leads to a 25 to 35 percent increase in fan power consumption—an amount that can easily equate to thousands of dollars per month in additional energy costs for a single apartment building or other multi-floor structure.

Ask most experts in the field and they'll say the reason poor ventilation is so prevalent in existing buildings is because of one simple fact: There is no viable solution. Adequately sealing ductwork requires direct access to the leaks. Because ventilation shafts are located behind walls and under ceilings, getting to those leaks requires tearing down the existing walls, fixing the shafts and then rebuilding. Building owners and regulation agencies opt instead to live with the problem—until now.

New York-based building consultants Steven Winter Associates (SWA) Inc. successfully completed the first comprehensive building ventilation retrofit in the Carlyle Towers, a 48-year-old multifamily apartment building in Caldwell, N.J., with 100 individual units. In doing so, the firm solved the unsolvable, proving that with the innovative use of new technologies, it was finally possible to adequately address the indoor air quality and energy-conservation issues that affect the vast majority of low- and high-rise buildings throughout the U.S.

New Technologies

The U.S. Department of Energy (DOE), Washington, D.C., estimates the excessive energy used to compensate for leaky air ducts is costing Americans $5 billion annually. In its 40-plus years of experience in performing building retrofits, SWA has found every central exhaust ventilation system it has ever evaluated in an existing building performs sub-optimally from an indoor air quality and/or energy-usage standpoint.

Carlyle Towers' ventilation system includes 25 main vertical shafts with 25 rooftop fans. The property owners observed energy usage for the apartment building was substantially higher than similar buildings in the neighborhood. Measurements taken by SWA prior to the retrofit indicated over-ventilation was occurring on the upper-floor apartments while lower-floor units were under-ventilated. This difference ranged from 135 CFM on the ninth floor to less than 10 CFM on the bottom floor. As a result, top-floor residents experienced loud, overly powerful exhaust while those living on the bottom floor found exhaust to be weak and inadequate.

SWA engineers recognized the complementary nature of two new technologies—constant airflow regulators (CARs) and aeroseal duct sealing. With funding from the New York State Energy Research and Development Authority, Albany, SWA was able to evaluate the effectiveness of using the technologies together to improve ventilation and energy efficiency at Carlyle Towers.

Constant airflow regulators are factory calibrated so they open and close as needed to maintain the preset balance, no matter the changing environmental conditions. PHOTO: American Aldes Ventilation Corp.

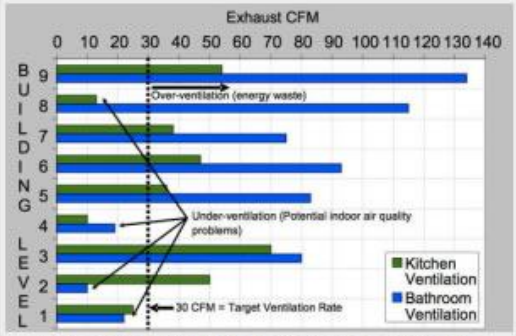
Traditional dampers consist of louvers that are manually adjusted and balanced at the time of construction. Then, each damper must be manually opened and closed on an ongoing basis to ensure an even flow of air is achieved on all floors of the building. Because the flow through any one grille interacts with the flow through all others, the process can be a long and arduous task; adjusting one grille requires re-measuring and readjusting all other grilles. Proper adjustments are difficult to attain and seldom accomplished. More importantly, because tall buildings are subject to ever-changing wind and stack-effect pressures, a system balanced in the summer may not be balanced in the winter.

CARs precisely regulate airflow across a wide range of pressures and automatically adjust to compensate for current conditions. Once installed, the CAR dampers open and close as needed to maintain a constant preset balance, no matter the changing environmental conditions.

Aeroseal is a duct-sealing technology that works from the inside of the shafts to locate and close any holes or gaps that may exist. Developed by LBNL with funding support from DOE, the Washington-based U.S. Environmental Protection Agency and others, the sealant consists of a nontoxic vinyl acetate polymer. Applied as an aerosol mist, the sealant is blown into the exhaust shafts where it remains suspended until it comes upon a leak. There, the sealant sticks to the edge of the hole and binds with other sealant particles until the hole is completely closed. Laboratory testing shows the sealant lasts at least 10 years, likely the lifetime of the duct system.

Installation

To mitigate the substantial ventilation leakage at Carlyle Towers, CARs were installed behind all the apartments' kitchen and main exhaust grilles. The CAR dampers were factory calibrated for 30 CFM. Because the air restriction mechanism of the dampers open and close with air pressure, they do not require an external power source to operate and need no manual adjustments to compensate for the variable conditions typically caused by seasonal changes.



Before treatment, the efficiency of Carlyle Towers' exhaust system varied widely from floor to floor; over-ventilation occurred on floors closest to the exhaust fans. GRAPH: Aeroseal LLC and Steven Winter Associates Inc.

Because aeroseal technology works from the inside of the shafts, there was no need to tear down walls or other internal structures. Instead, each ventilation shaft was accessed, one at a time, via its termination point where the roof fans are placed. Each roof fan was removed and a thin, flexible tube was connected to the outside entranceway of the exposed shaft. The delivery tube runs lengthwise back to the aeroseal equipment where a small, window-frame-sized external blower fan is used to push the sealant through the tube and down the shaft. The technician monitored the sealing operation via a laptop computer attached to the mechanical components of the equipment. The computerized delivery system allowed the technician to adjust the procedure and observe the real-time progress of the sealing process.

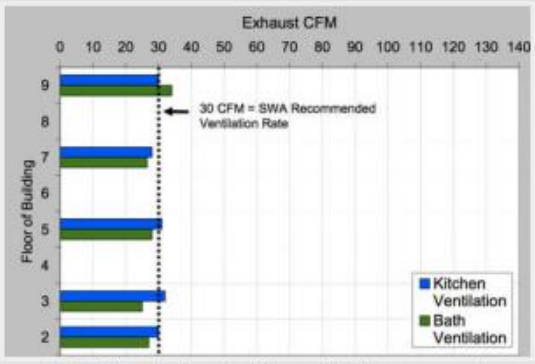
The technologies are quite complementary from an installation standpoint. The aeroseal process begins by accessing and temporarily blocking each grille, which provides an opportune time to install the CAR dampers, which are also located at each grille site.

Real Results

Through the combined use of these two technologies, the property owners noticed significant differences in the performance of the Carlyle Towers building. Ongoing testing since 2008 demonstrates the retrofit resulted in a 25 percent reduction in gas use for space heating. The duct sealing also allowed for a downsizing of fans from 300 watts to 140 W per fan, a savings of about $7,000 annually in energy costs.

Residents of the Carlyle Towers noticed the difference, as well. Appreciation was expressed by many of the occupants for the improvements made to the building's heating system—something that was never directly addressed. However, by improving the exhaust system, the retrofit project also helped improve overall heating. Previously, fans were working so hard to exhaust air from the bottom floors that it was drawing cold air from the outside and distributing it throughout the building. The heaters could never keep up. Now that the leaks in the ventilation shafts are sealed and the system is balanced from floor to floor, this problem no longer exists. A significant reduction in fan noise and ambient odors also was immediately apparent.

In addition, the entire project took only weeks to complete, and disruption to tenants was minimal.



After the duct retrofit, ventilation on each Carlyle Towers' floor was balanced. GRAPH: Aeroseal LLC and Steven Winter Associates Inc.

With the success of the Carlyle Towers project, this new approach to retrofitting older buildings' ventilation systems is becoming a game-changer for those who had given up looking for a solution. Lessons learned from this project have influenced the crafting of New York City's Green Codes Task Force recommendation, HT 6, "Ensure Ventilation Airflow in Residences."In addition, the National Center for Healthy Housing, Columbia, Md., has published a guide to provide homeowners with more information about these technologies and how they work to improve ventilation and energy efficiency. Lastly, a recent Washington-based U.S. Department of Housing and Urban Development funded study is examining the health benefits of this approach as a means of quantifying solutions to help control health-care costs.

More telling is the fact that since the Carlyle Towers project was completed, more than 5,000 additional apartments have already undergone similar performance upgrading by various contractors throughout the New York City metropolitan region alone. New technologies are providing simple and effective answers to age-old problems and having a real impact on what we can do to improve the safety and performance of today's buildings.