Aerosol Duct Sealing in Central Exhaust Systems

PIER Buildings Program | Research Powers the Future | www.energy.ca.gov/research

The Problem

Leaky ducts cannot maintain adequate grille pressures and designed flow rates without increasing leakage and fan flow dramatically, thereby wasting energy. Leaks increase heating and cooling loads by improperly distributing conditioned air and by increasing infiltration through the building envelope.

The Solution

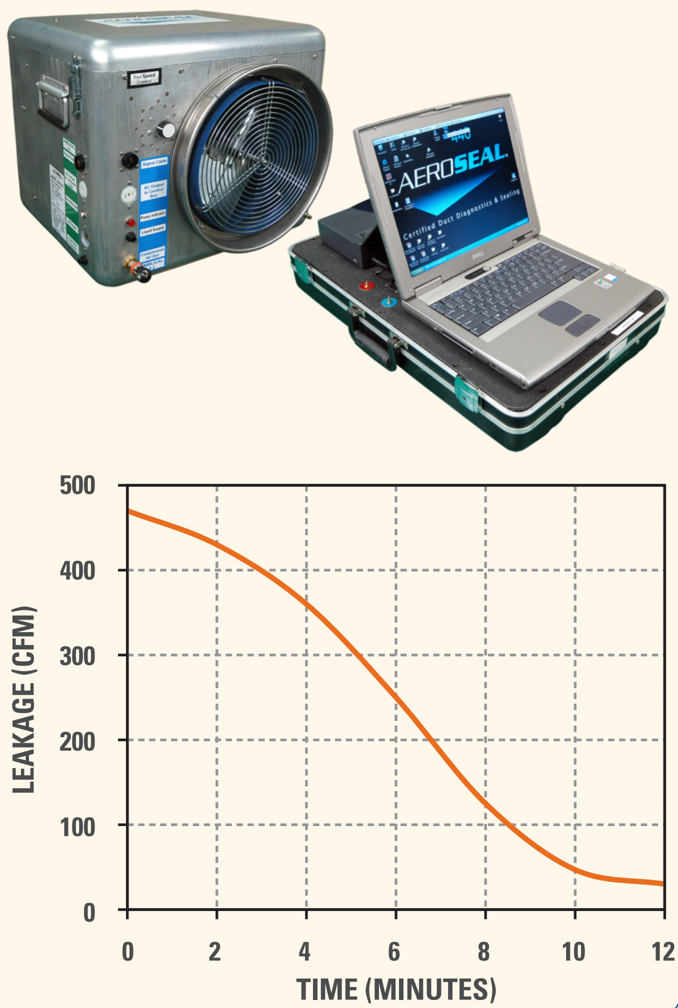
Aeroseal is a cost effective method to seal leaks in ducts; it uses a vinyl polymer adhesive sprayed into the duct as an aerosol. Developed at Lawrence Berkeley National Laboratory, Aeroseal is designed to quickly repair leaks that are otherwise inaccessible without significant building renovation.

The technology is installed by shutting off the fan, blocking all inlets and outlets, pressurizing the system with a calibrated-flow fan, and injecting the aerosol adhesive from an accessible location. The aerosol is suspended in the low-velocity pressurized flow and does not coat interior faces of the ductwork. Rather, sealant is only deposited at leaks, where the momentum of particles accelerated through cracks causes adhesive to nucleate on edges and build a seal to block flow.

Features and Benefits

- Allows reduction of fan flow proportional to the leakage sealed. In exhaust systems fan power scales roughly with the cube of flow, so sealing 25% leakage in a central exhaust system will save more than 50% in fan energy. In supply systems fan power scales roughly with the square of flow.
- In exhaust systems, lower fan flow translates to reduced infiltration and decreased heating and cooling loads. The relationship between reduced fan flow and reduced infiltration is non-linear and varies by climate and building design. Sealing 25% leakage can reduce heating and cooling by 20%.

FIGURE 1: AEROSEAL EQUIPMENT, AND EXAMPLE SEALING PROFILE



Demonstration Results

University of California, Davis

Aeroseal was installed to seal leaks in the central exhaust systems of three residence halls at the University of California, Davis. The three are exactly similar, three-story, negatively pressurized, exhaust ventilated buildings. Heating and cooling is provided by fan coils in each bedroom and by electric resistance heaters in each bathroom. One central rooftop fan in each building runs continuously and draws from registers and ventilated lockers in each shared bathroom, from storage closets and janitorial closets on each floor.

Initially, flow through each rooftop fan was between 2,700 and 3,500 cfm and leakage in each system accounted for approximately 25% of the flow. Aeroseal was applied to seal leaks in the ductwork, and some construction was required to remedy flaws in the initial ductwork design. The work resulted in near complete elimination of leaks, and the rooftop fans were replaced with lower flow, high-efficiency, direct-drive fans with VFDs. The work resulted in measured fan energy savings of almost 70%, and an estimated 20% energy savings for heating and cooling.

FIGURE 2: SHEAVE ADJUSTMENT TO EXISTING FANS
University of California, Davis

Key lessons were learned through the field demonstration

- Aeroseal easily repairs leaks in the seams and joints of ductwork, but be prepared to address initially undiscovered design flaws or major ductwork failures if they arise. In the UC Davis installation it was discovered that ventilated lockers in each bathroom were not properly ducted and that a significant fraction of exhaust flow was drawn from within the building wall cavities and duct chases. In other cases, contractors report finding disconnected ductwork, or open access panels. These issues often go unidentified until sealing is in progress.
- In an under-ventilated building, flow increases due to duct sealing should be used to improve indoor air quality, and may result in less significant energy savings. For this demonstration fan flow was reduced by the volume offset by leak sealing, thus maintaining initial ventilation rates and achieving maximum energy savings.
- Not all fans will adjust as far as needed to make up for the impact of sealing leaks. The Aeroseal installation at UC Davis resulted in 25% increase in ventilation flow, but the existing fans could only be slowed by approximately 15%.
- Aerodynamic fan efficiency may not remain constant across a range of fan speeds, thus electrical power may not scale with the cube of flow rate, even while aerodynamic power does. If this is true, as it was for the fans in the UC Davis demonstration, fans may need to be replaced.
- Aeroseal doesn't usually require ducts to be cleaned, but if ducts are particularly dirty it may be necessary. Exhaust ductwork in UC Davis residence halls was initially very dirty, and cleaning was required prior to installing Aeroseal.

Technology Costs and Incentives

The economics of aerosol leak sealing are highly dependent on application and availability of rebates. Cost of the aerosol sealant is dependent mostly on system size, and complexity of installation. If additional in situ construction work is required to repair damaged or improperly designed ductwork, or if cleaning of the ducts is necessary, additional costs will be incurred. If reduction of exhaust flow requires fan replacement, costs will be considerably higher. The energy savings and reduction in annual operating cost is dependent on the initial leakage rate, the magnitude of exhaust flow, and climate. In any case, the economic benefit for aerosol duct sealing in central exhaust systems is compelling.

FIGURE 3: IMPACT ON TOTAL VENTILATION FLOW AT REGISTERS

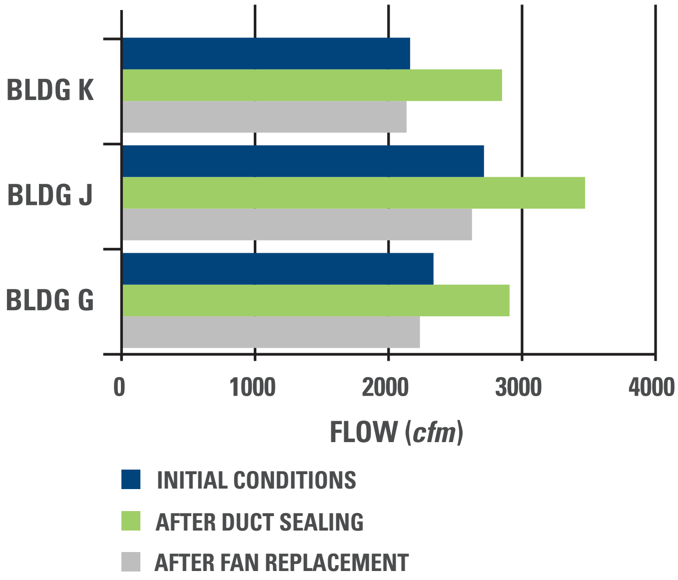


FIGURE 4: IMPACT ON FAN ELECTRICAL POWER

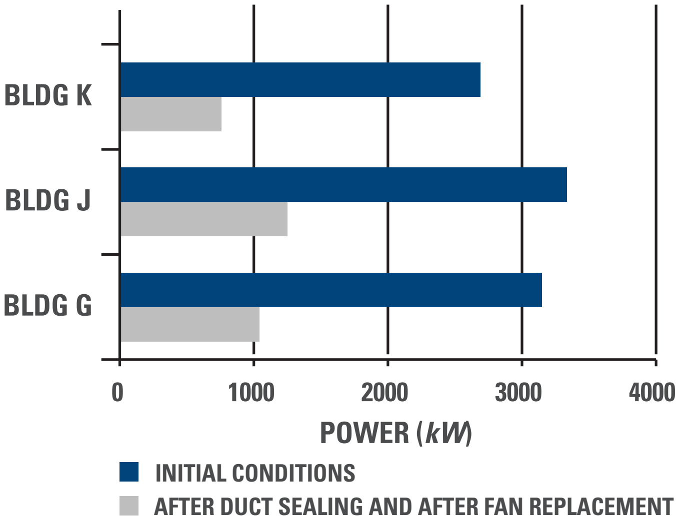
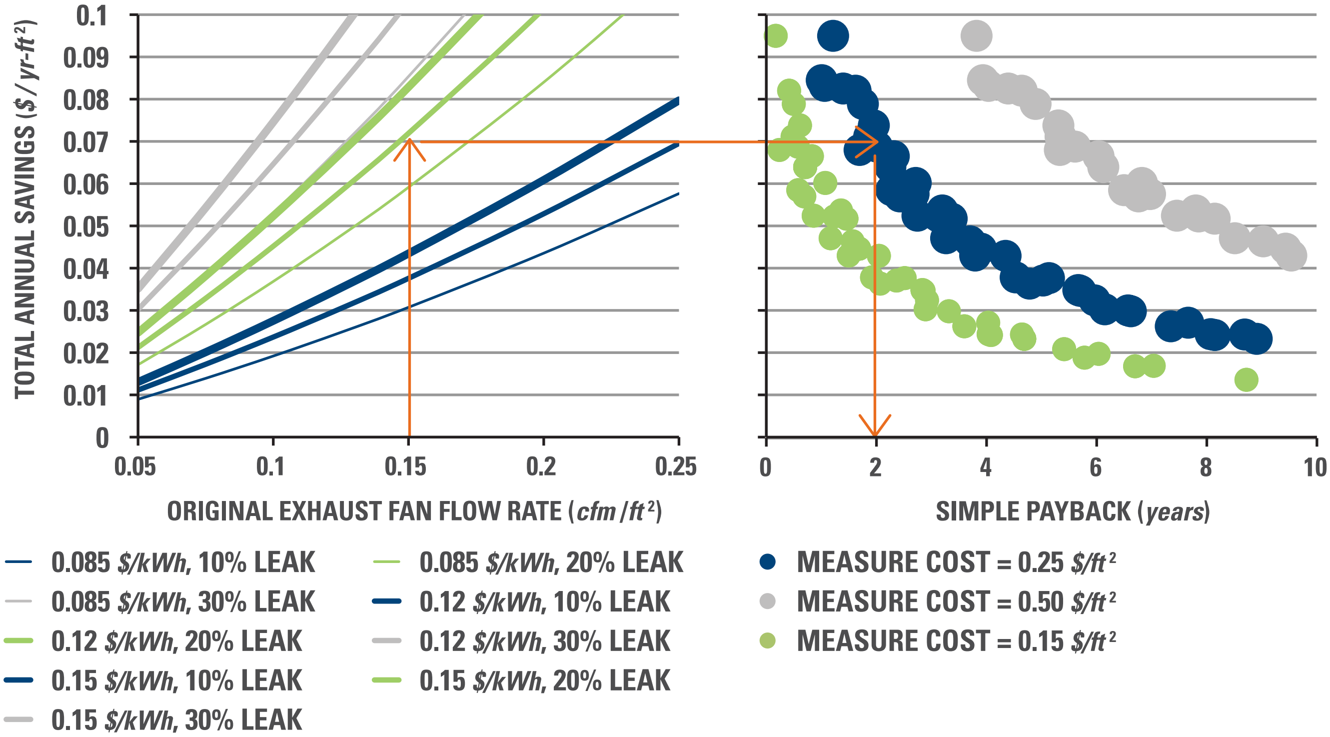


FIGURE 5: NOMOGRAPH TO ESTIMATE ENERGY COST SAVINGS AND SIMPLE PAYBACK OF AEROSOL SEALING FOR CENTRAL EXHAUST SYSTEMS



For the demonstration at UC Davis, estimated savings amount to more than $3,000 per year. This amounts to a simple payback of 4.3 years or a debt service ratio of 43%. If the existing fans could operate efficiently at a reduced flow rate and replacement fans were not required, simple payback would be 2.3 years and the debt service ratio would be 23%.

The nomograph in Figure 5 shows the approximate energy cost savings and simple payback of aerosol sealing for central exhaust systems as a function of initial leakage and exhaust fan flow rate, electricity cost, and measure cost. The chart assumes that fan efficiency remains constant, that fan power draw is 0.5 (W/cfm), that cooling is from electricity with a COP of 3.52, and heating is from gas with a delivered efficiency of 80%.Calculations include UC/CSU/IOU Partnership rebates of 0.24 $/kWh and 1.00 $/therm. Results are charted for two measure costs which were derived based on real costs for the demonstration. 0.50 $/ft^2 is the approximate cost including high efficiency replacement exhaust fans, 0.25 $/ft^2 is the approximate cost for all project costs excluding replacement fans. The measure cost could vary significantly based complexity, and size of the system; cost for a large, but simple exhaust system could be on the order of 0.15 $/ft^2

For More Information

Western Cooling Efficiency Center
Jonathan Woolley
jmwoolley@ucdavis.edu
(530) 752-1101
http://wcec.ucdavis.edu

About PIER

This project was conducted by the California Energy Commission's Public Interest Energy Research (PIER) Program. PIER supports public interest energy research and development that helps improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

Arnold Schwarzenegger, ***Governor***

For more information, see www.energy.ca.gov/research

California Energy Commission

Chair: Karen Douglas   Vice Chair: James D. Boyd

Commissioners: Jeffrey D. Byron, Anthony Eggert, Robert Weisenmiller