Weatherization Test Drives Spray Sealant

by Mark P. Ternes

Until recently, duct-sealing methods have not gotten enough attention from building scientists. Aerosol spray sealant offers a relatively new way to seal ducts—one that is becoming commercialized in some parts of the United States (see "Aerosol Spray Technology"). One advantage of this technology is that it reduces diagnostic and repair times, because the location of small leaks does not need to be visually identified, and wall, ceiling, and floor cavities do not need to be opened to gain access to the leaks. Aerosol spray can seal small or unreachable leaks that cannot be sealed in other ways.

Oak Ridge National Laboratory conducted a field test during the winter of 1999–2000 to determine the efficacy of advanced duct-sealing technology in housing weatherized by DOE's Weatherization Assistance Program (WAP). We had three main goals. First, we wanted to know whether we could improve duct leakage reduction by using aerosol-based sealant. Second, we wanted to know how much time and labor might be saved by using this technology. Third, we wanted to know how the technology might be integrated with other work that weatherization crews perform.

Field Test Design

For our test, ducts in 40 houses eligible for the WAP work were sealed by the aerosol spray approach and ducts in another 40 houses were sealed using the conventional approach. Most weatherization agencies use pressure pan measurements and, less frequently, the measured change in indoor air pressure when the air handler fan is turned on to determine if duct sealing is needed and to locate duct leakage sites. They seal duct leaks manually based on these measurements as well as on visual inspections that identify obvious or potential leakage sites based on what they've learned from past experiences. We enhanced this approach by measuring the total duct leakage and duct leakage to the outside using a duct blower. Weatherization crews can use these measurements to help determine when duct sealing is warranted. Postrepair measurements allow crews to decide if the system has been sufficiently tightened.

New aerosol spray technology can allow weatherization crews to seal even tiny duct leaks in places that are difficult to reach using conventional methods.

The duct repairs were performed by five weatherization agencies experienced in duct sealing:

- Community Action of South Eastern West Virginia, Bluefield, West Virginia;
- Virginia Mountain Housing, Incorporated, Christiansburg, Virginia;
- Iowa East Central Teaching, Rehabilitating, Aiding Iowa's Needy (TRAIN), Davenport, Iowa;
- Wyoming Energy Council, Incorporated, Laramie, Wyoming; and
- The Opportunity Council, Bellingham, Washington.

All the houses were single-family homes heated by a central, forced-air gas or oil furnace. We did not include mobile homes because the aerosol spray duct-sealing technology had not been previously tested on this type of home.

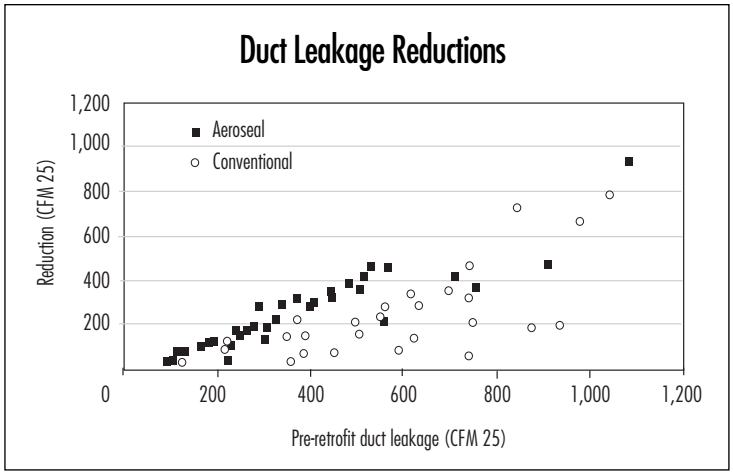
Duct sealing was performed in January 2000, allowing pre-retrofit space-heating energy use to be measured for the first half of the winter starting in November 1999, and allowing postretrofit space-heating energy use to be measured the second half of the winter ending in March 2000. Duct leakage and other one-time measurements were made immediately before and after the ducts were sealed. Duct sealing was the only weatherization measure performed on the houses during the field test. Starting in April 2000, the agencies returned to the houses to perform other weatherization measures as dictated by their respective weatherization programs.

Duct Leakage Test Results

We measured an average duct leakage of 500–600 CFM at 25 Pa in the field test homes. This is larger than the average leakage of 100–300 CFM at 25 Pa found in many other studies of non-low-income homes.

Although both the conventional and the aerosol-spray technologies were successful at sealing duct leaks, we found that the aerosol spray technology combined with manual sealing of large leaks was more effective

than the conventional technology used alone. Our weatherization crews were able to seal 60%–70% of the duct leakage, on average, when they used the aerosol spray technology to seal small leaks and sealed the large leaks manually. They were able to seal only about 40%–50% of the leakage using manual methods alone. A reduction of 50% is consistent with results obtained by others using manual methods (see "Duct Detailing in the Northwest," *HE* May/June '00, p. 9).



MARK TERNES

Figure 1. Duct leakage reductions were more consistent and predictable in the Aeroseal-treated houses than they were in the conventional houses.

We also found that duct leakage reductions were more consistent and more predictable in the houses receiving the aerosol spray treatment than in those receiving conventional treatment alone (see Figure 1). The manual methods produced more varied results.

Pressure pan readings further support these findings. We calculated a total pressure pan reading for each house by summing the measurements made at each register. The distribution of these readings was about the same for the two groups of houses before their ducts were sealed (see Figure 2). Following duct sealing, 70% of the aerosol houses had totals that

Aerosol Spray Technology

The aerosol-spray technology was developed by Lawrence Berkeley National Laboratory and is commercially available as a product from Aeroseal, Incorporated (see "Fix-a-Flat for Ducts," *HE* July/Aug '95, p. 5). It consists of a solid sealant (a vinyl acetate polymer sometimes used as a base in chewing gum) that is suspended in an aerosol spray. This is sprayed into the ducts, where the sealant accumulates at the leakage sites. The technology is especially effective at sealing leaks that are ½-inch or less, although larger leaks can be sealed in some cases if given enough time. An injector (see Figure A), using large diameter flexible plastic tubing, sprays a mixture of water, sealant, and solvent (2-ethyl 1-hexanol) into the ductwork. Foam plugs temporarily seal registers and protect the heat exchanger surfaces in the indoor air handler unit, so that the solid sealant particles are deposited at the leakage sites as air exits only through the leaks. Only about 10–20 oz of sealant is used on a typical home.

MARK TERNES

Figure A. Aeroseal's injector consists of a blower, heater, and sprayer that are designed to create an air stream containing a mixture of water, sealant, and solvent. Plastic tubing connects the injector to the duct system.

The Aeroseal equipment measures the total duct leakage of the entire system (both supply and return) before and after sealing using the same approach described for the conventional duct sealing technology, but with the Aeroseal injector taking the place of the blower fan. The duct leakage is also continuously monitored as the sealing occurs, so that duct sealing operators can gauge progress and determine when sealing should be stopped.

The aerosol spray technology shares some common elements with the conventional approach. Manual duct sealing of major leakage sites is still required because the aerosol spray approach cannot reconnect ducts or seal large openings such as end plates missing from panned floor joists. To improve effectiveness and to ensure timely sealing of ½ to 1-inch leaks or bigger, it is recommended that 15 to 30 minutes be spent sealing these larger leaks by hand while the aerosol spray equipment is automatically sealing other leaks. In duct systems that have a short return or a portion of the duct system that is hard to connect to the equipment, it can be more effective to seal a portion of the system by hand while the aerosol spray equipment seals the rest of the system automatically. Finally, junctions between register boots and walls or floors need to be sealed by hand while the aerosol spray equipment is operating. Because the foam seals used to block off the registers during the sealing process are placed inside the ducts, the registers are not sealed automatically.

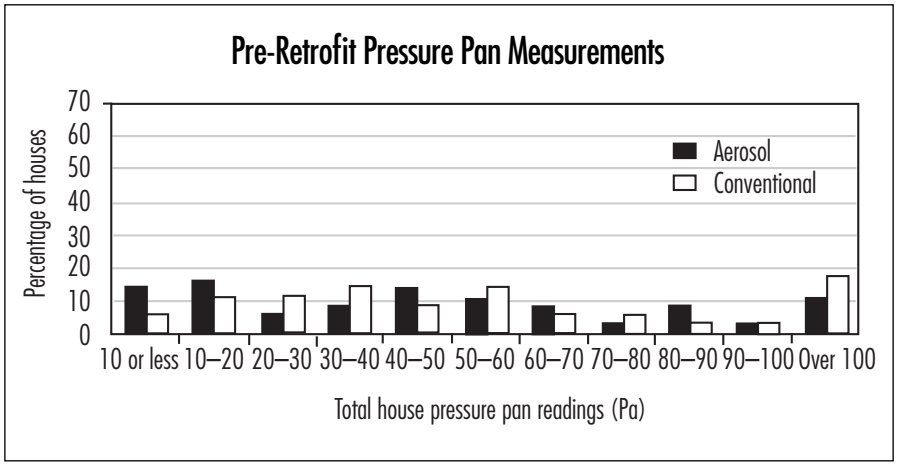


Figure 2. Total pressure pan readings were the same in the aerosol and conventional houses before duct sealing, indicating that the two groups of homes had similar duct leakage characteristics.

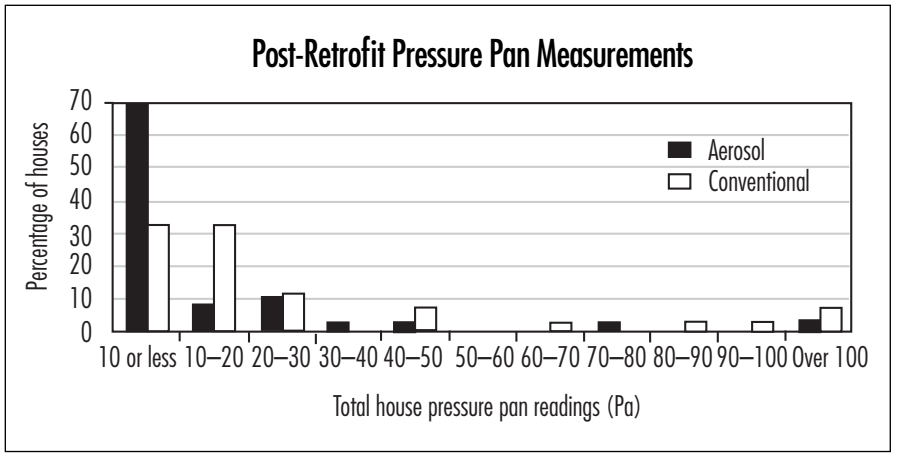


Figure 3. Total pressure pan readings were lower in the aerosol houses than they were in the conventional houses after duct sealing, indicating that the aerosol spray technology is better able to seal duct leaks than is the conventional approach.

were less than 10 Pa, compared to only about 30% of the conventional houses (see Figure 3).

The percentage of houses with no more than one register with a pressure pan reading greater than 1 Pa increased dramatically in the aerosol group following retrofit—from 14% to 54%. We observed only limited improvement in the conventional homes with less than two registers—from 6% to 17%. In addition, the percentage of homes with three or more registers with a pressure pan reading greater than 1 Pa dropped markedly in the aerosol group—from 84% to 38%. We observed a much smaller drop in the conventional group—from 94% to 69%.

Energy Savings

We found an average savings of 5% in space-heating energy use from the duct sealing performed in this field test. However, in homes where the ducts were clearly located outside the conditioned space of the home—such as in insulated attics or carports rather than in basements and uninsulated crawlspaces—the space-heating energy savings was nearly twice the average value, or about 9%.

We were not able to measure the difference in energy savings between the two duct-sealing methods because the scatter in the energy usage data was too great. However, the larger air leakage reductions measured in the homes using the aerosol spray technology would be expected to translate into higher energy savings compared to the homes using just the conventional approach.

Labor Savings

We found that the aerosol spray technology can potentially reduce labor time and labor costs associated with just sealing the ducts by 70%, or almost four person hours. The average time to seal ducts using the aerosol spray technology was 98 minutes, and one person could potentially operate the equipment and perform the necessary manual sealing during this time period. The conventional approach took an average of 147 minutes and required 330 person minutes. The material costs associated with both methods are about the same.

Setup, teardown, and diagnostic times must also be considered in determining the overall or total costs associated with a particular duct sealing technology. These times could not be determined from the field test. The person hours required to perform setup, teardown, and diagnostics are probably greater for the aerosol technology than the conventional technology (especially if the diagnostics are limited to pressure pan readings and not duct leakage measurements). However, based on our field test experience, the additional time is much less than the four additional person hours needed to seal the ducts under the conventional technology.

Agency Feedback

Four of the five agencies felt that the aerosol spray technology was superior to the conventional approach, although these four recognized that it was not the correct tool for all applications, such as for simple, small, and accessible duct systems that could easily be sealed by hand. Implementation issues raised by the agencies included equipment costs, equipment size,

and the existing software used to operate the equipment. The software was designed by Aeroseal, Incorporated, for use by private-sector HVAC contractors to market, diagnose, and perform duct sealing. Much of the household, safety, preliminary diagnostics, and other information required by this software is not needed by weatherization agencies or duplicates data that the agencies already collect. The need to transfer collected data to Aeroseal was also viewed as problematic and unnecessary.

Streamlined software designed specifically for use by weatherization agencies could easily be developed that would address this concern. The agencies also generally saw some value in making duct leakage measurements in addition to just pressure pan readings as part of the conventional approach, although a strong consensus was not reached.

Recommendations

We concluded that duct sealing using the best available method should continue to be a recommended weatherization measure. We believe that continued training on conventional approaches is needed to achieve better duct leakage reductions and lower postretrofit duct-leakage rates than those observed in this field test. Training should also promote more consistent results among agencies and perhaps faster installation times.

We also recommend further study to encourage and promote the use of the aerosol spray technology within the WAP. A pilot test is needed to develop approaches for integrating this technology with other energy conservation measures and minimizing impacts on weatherization agency logistics. In addition, three issues identified during the field test and raised by the participating weatherization agencies must be addressed. These issues are:

- the franchise structure and equipment/franchise costs established by Aeroseal;
- the software used to control the equipment; and
- the safety of this product.

The aerosol spray technology was developed by Lawrence Berkeley National Laboratory, but Aeroseal now holds an exclusive license to use this technology on residential and small commercial buildings. Users interested in using this technology must purchase a franchise from Aeroseal, which includes the equipment, software, and training on how to implement the technology. Under the franchise agreement, the franchise must meet minimum production quotas, provide Aeroseal with collected data for quality control purposes, and pay Aeroseal a royalty fee for each house sealed using the technology. This franchise arrangement would overly restrict the work performed by weatherization agencies, possibly breech confidentiality requirements that weatherization agencies must adhere to, and make it quite expensive to set up each weatherization agency throughout the United States as a franchise.

Aeroseal states that aerosol sealing "has been tested by Underwriters' Laboratories, Incorporated, (UL) and the Indoor Environmental program at Lawrence Berkeley National Laboratory." However, the safety of this product and its components should be further investigated and documented before full-scale implementation within the WAP. When the ducts in the basement of a house are especially leaky, for example, a fog of aerosol spray can collect in the basement at the commencement of duct sealing. Although Aeroseal recommends the use of a scrubber fan and a dust mask to mitigate the danger of workers and occupants breathing in the sealant or solvent suspended in this fog, the need for such mitigation and the effectiveness of the recommendations should be determined. In addition, the effect of the aerosol spray on animals (especially exotic pets) and occupants with poor health should be investigated.

Finally, we recommend application testing of the aerosol spray technology in mobile homes. The WAP is serving more and more mobile homes each year, and mobile homes are the predominant house type served by many weatherization agencies. The aerosol spray technology has been tested in mobile homes only on a very limited basis, and this field test addressed application of this technology only in single-family type homes.

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For more information:

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