Aerosol-Based Sealant for Air Ducts Technology

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National Renewable Energy Laboratory

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Cover Photos by Dennis Schroeder: (clockwise, left to right) NREL 51934, NREL 45897, NREL 42160, NREL 45891, NREL 48097, NREL 46526.

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1 Detailed Description of the Technology

Aerosol-based sealant can be used to seal air duct leaks. This is done by pressurizing the ducts and injecting the spray sealant. This technology can be used to seal small (up to ½-inch diameter) and inaccessible duct leaks hidden in wall, ceiling, and floor cavities (Ternes and Hwang2001). The aerosol sealant itself is a nontoxic vinyl polymer (Kallett et al. 2000). The technology is a proprietary duct-sealing method developed jointly by the U.S. government and Aeroseal, the company that holds an exclusive license to use the technology (Ternes and Hwang 2001). Specifically, Lawrence Berkeley National Laboratory developed the aerosol-spray technology with funding from the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency, and others while Aeroseal developed the current version of the equipment and software to apply the technology in practice (Ternes and Hwang 2001).

The process for using this technology starts with determining the portion of the ductwork to be sealed, usually the entire duct system, both supply and return sides. Importantly, ducts that are very dirty, which are especially prevalent in older homes, should be cleaned first.[1] Calculating duct leakage (including checking for leaks greater than ½-inch in diameter) is done by connecting equipment to the duct system to directly measure leakage using proprietary software. All supply registers and supply grilles are blocked off with foam plugs and adhesive tape, making a tight temporary seal. The heat exchangers in the air handler unit must be blocked off with foam plugs to prevent the sealant from accumulating on these surfaces. Blocking off the heat exchangers effectively isolates the duct system into two halves where only one half can be sealed at a time. Most case studies generally conclude this is the most time-consuming portion of the work; a case study in Minnesota estimates about 75% of labor for the technology is devoted to blocking and unblocking the registers and grilles (Quinnell et al. 2016).

Next, the proprietary Aeroseal equipment is set up and connected to the permanent, hard ductwork with a large flexible duct. Then, the equipment is set up and is pressurized to calculate duct leakage in cubic feet per minute (cfm). This pre-sealant leakage reading serves as a point of reference for the duct sealing process. Next, the sealant material is aerosolized into the air directed into the duct system, sealing leaks wherever the aerosol is allowed to escape the walls of the ducts (shown on the right of Figure 1). Leaks of greater than ½-inch diameter must be sealed manually either before or during the aerosol process (shown on the left of Figure 1). The duct leakage (cfm) and the duct pressure is monitored in real time, with leakage becoming smaller and pressure increasing as the duct sealing proceeds. The equipment can also monitor for leaks larger than ½-inch throughout the sealing process. If such a leak is discovered, the sealing process can be paused so the service provider can inspect the leak and determine appropriate solutions on a case-by-case basis. The sealing process can then resume.[2] The aerosol sealant works by accumulating at the leaks to plug them progressively and effectively. The equipment-usage portion of the process may only take 98 minutes for a single person (Ternes and Hwang 2001). The final step is to generate leakage reports showing differences between pre- and post-procedure leakages for the customer. Aeroseal provides a 10-year warranty on the sealing, but they have reported that the sealant can last up to 40 years (Aeroseal 2021).

[1] "Frequently Asked Questions," Aeroseal, accessed 2021, https://aeroseal.com/residential/faqs-2/.
[2] "Frequently Asked Questions," Aeroseal, accessed 2021, https://aeroseal.com/residential/faqs-2/.

Figure 1. Photos of manual sealing (left) and aerosol-based sealing (right)

Source: "The Secret Sauce For Contractors: Duct Sealant By Aeroseal," Aeroseal, accessed 2017, https://aeroseal.com/air-duct-sealing-blog/secret-sauce-contractors-duct-sealant/

2 Advantages of the Technology

The primary benefit of this technology is its ability to seal small (up to 1/2-inch diameter) and inaccessible duct leaks hidden in wall, ceiling, and floor cavities (Ternes and Hwang 2001). Case studies reveal that the aerosol-spray seals 70%–90% of duct leaks when combined with manual pre-sealing for large leaks, compared to 40%–50% when only using manual sealing methods (Ternes and Hwang 2001). If a high percentage of ducts are in an unconditioned attic and crawl space, the savings from duct sealing are likely to be high, as less conditioned air is lost. Sealing ducts usually results in greater generalized thermal comfort, creating an incentive to set the thermostat to an energy-saving level to save heating or cooling energy. Sealing also keeps conditioned air in the ducts, allowing more of this distribution air to move through the air-handler filter, leading to improved indoor air quality (Carrie et al. 2000).

Aeroseal's method generally requires less equipment operation time than manual sealing methods from start-to-finish. Ternes and Hwang (2001) demonstrated manual duct sealing required 147 minutes and Aeroseal's method required 98 minutes to complete the procedure.

3 Disadvantages of the Technology

The equipment needed to seal the ducts is expensive and is only available to franchisees, which can prevent the technology from meeting Weatherization Assistance Program (WAP) savings-investment ratio (SIR) requirements. The user must pay a franchise fee to Aeroseal of around $20,000 to gain access to the software and equipment needed to apply the technology (Quinnell et al. 2001). Subgrantees can spread the franchise costs to all the jobs for which it is used, but they still have to consider potential difficulties and work out the details of the franchise within the agency, including considering initial costs, cost sharing provisions, training, equipment maintenance and storage, as well as how to charge other WAP agencies that use the franchising agency.

Anecdotal evidence shows that the technology generally is only used for private (non-WAP) projects to meet duct tightness codes and it would otherwise not be cost-effective.[3] Furthermore, this method of duct-sealing cannot repair large duct leaks (larger than ½”), so it must be used in conjunction with manual methods of duct-sealing.

4 Best Suited Regions for the Technology

Given the importance of duct leaks as a source of wasted energy, this technology can be implemented in all climate zones. However, regions with more extreme weather (either hot or cold) can derive greater cost savings from duct sealing in general, but house layout and duct-run location significantly impact energy savings.

5 Dwelling Types that Benefit Most

Because the aerosol-based duct sealing market is controlled by Aeroseal, a set of industry standards does not exist. Homes with ducts that are difficult to access would benefit most from using the technology. However, other features come into play when determining which dwelling types benefit most from aerosol-based sealing. A series of building specifications developed from a case study in Minnesota provide some insights into these features, but given that the study focused on commercial buildings, these features are generalized here for relevance to WAP dwelling characteristics (Quinnell et al. 2016):

- The higher the air handler operating pressure within the duct system, the greater the potential for savings
- The higher the percentage of the ductwork in unconditioned spaces (outside the thermal/pressure boundary), such as attics and crawlspaces, the greater the potential for savings
- The greater the percentage of ductwork hidden in inaccessible wall, floor, and ceiling cavities, the greater the potential for savings
- Air handlers that operate a higher percentage of the time, such as in some multifamily buildings, have a greater potential for savings.
- Duct system complexity can lead to more time preparing the existing system to receive the aerosol sealant. This required preparation, which is normally the most time-consuming task of the entire process, reduces or eliminates the cost-effectiveness of the process.
- If the duct system is already tight, aerosol sealing is not cost-effective.

6 Savings and Cost Data from Past Case Studies

The savings and cost data vary considerably for this technology. Two of the case studies focus on differentiating manual duct-sealing as one option and aerosol sealing plus manual sealing for large leaks as the second option.

A case study of residential buildings in Raleigh, North Carolina, in 2014 revealed costs to be about $700 per dwelling unit for aerosol sealing plus manual sealing for large leaks, compared to $300–$500 for manual sealing alone (DOE BTO 2014). The aerosol sealing plus manual sealing

[3] Interview with a Boston ABCD subgrantee, 2021

resulted in projected energy savings of 17% and around $300–$600 in annual savings. However, it is worth noting that the dwellings evaluated in this study were low-rise multifamily housing units, which may not represent all dwelling types and costs in the WAP program.

Another study, done in 2000 and focused on WAP-eligible buildings, concluded that excluding equipment costs, the aerosol-sealing methods plus manual sealing had a potential economic cost of $189 compared to $260 for the manual sealing only method, showing the operational efficiency of the technology (Ternes and Hwang 2001). This study concluded the resulting metrics were an SIR of 2.9 and a payback period of 4.0 years, compared to an SIR of 2.1 and a payback period of 5.5 years. However, this case study excluded equipment and overhead costs by calculating labor costs from market rates. Including overhead costs would increase the cost of the procedure because of the licensing fee of $20,000 for the aerosol sealing method (to pay for the equipment and franchising fee) compared to only around $2,000 for the manual method.

7 Specifications Needed for Procurement

Materials and training can only be obtained by paying a franchising fee to the company, Aeroseal, which currently has an exclusive license over this technology. Subgrantees could spread the cost of the franchise across jobs for which it was being used; however, they might face challenges working out the franchise within the agency, including paying the initial cost, designing appropriate cost sharing considerations, instilling necessary training, maintaining and storing the equipment, and determining how to charge other WAP agencies for jobs if the franchising agency decides to provide the service to other subgrantees. So, acquiring the license is a significant barrier to increased adoption of the technology for crew-based subgrantees within the WAP. Furthermore, the software for the equipment and the accompanying training, which is designed for experienced contractors, is insufficient for inexperienced heating, ventilation, and air conditioning (HVAC) contractors. Thus, simplifying the software and increasing the comprehensiveness of training are key factors identified by the WAP case study to accelerate adoption (Ternes and Hwang 2001).

For *distribution and installer networks*, due to the franchising structure, only about 400 contractors are licensed to use the technology across the United States (Aeroseal). Subgrantees with a contractor-based structure can reach out to these licensed contractors to use the Aeroseal technology within their projects. However, this approach may have higher costs due to both the expensive nature of the Aeroseal technology and contractor fees.

8 Lessons Learned and Challenges

First, the aerosol sealant has limited effects if leaks total less than 40–60 cfm because the airflow speed becomes too low and the equipment may not function properly.[4] Furthermore, high ambient relative humidity complicates use of the technology because the sealant may become too wet. Also, the actual sealant injection system and equipment require enough space (both vertically and horizontally) to be set up, which can present an issue if a home is space restricted. Finally, the Aeroseal process increases the weight of the ducts, which could lead to performance

[4] "Injected Spray Sealant for Existing HVAC Ducts," U.S. Department of Energy Building Technologies Office, accessed [date], https://basc.pnnl.gov/resource-guides/injected-spray-sealant-existing-hvac-ducts#edit-group-description. Accessed March 2022.

issues if the ducts are in poor condition.[5] Therefore, this technology should not be seen as a remedy for substandard ducts in need of replacement.

[5] Interview WAP Manager, Housing Authority of Skagit County, Washington, 2021.

9 Past Evaluations and Case Studies

This section includes Table 1, which compares five case studies that are relevant to the technology. For each case study, presented information includes the number of units, costs, savings, and the source where the case study was found.

Table 1. Comparison of Costs and Savings for Five Case Studies

Case Study	Number of units	Costs	Savings	Source
California (Sacramento Municipal Utility District), 1999	127 homes	$872–$1,119 contractor cost per job	Not included	Kallett et al. (2000)
Iowa, Virginia, Wyoming, West Virginia, and Washington, 2001 (DOE WAP field test)	127 homes	Not accounting for equipment costs: • Conventional approach: $260/job • Aerosol sealing approach and conventional approach for large leaks: $189/job	Deemed: • SIR = 2.1 for conventional approach • SIR = 2.9 for aerosol sealing approach plus conventional approach for large leaks (neither account for equipment costs)	Ternes and Hwang (2001)
Minnesota, 2016	30 large duct systems: • 27 commercial buildings • 3 residential multifamily units	• $5,489 for the average design flow of 12,068 cfm • $15,194 for the average design flow of 16,563 cfm The second cost calculation used a sample of duct systems specifically selected for criteria from the first cost calculation, which means the ducts were better suited for using this technology.	$3,995/year for the second set of duct systems	Quinnell et al. 2016
North Carolina (Raleigh), 2014	Not reported, mostly residential single-family and multifamily homes	$700/job	$300/year–$600/year	DOE BTO 2014
Washington (State WAP)	One completed unit,[a] out of a total of two units (one incomplete)	$2,858/job	SIR = <1	Interview[b]

[a] The one completed unit used funding from the Washington State "Weatherization + Health" program to cover costs given the SIR of the technology being less than 1. This program is specific to WA. Our resource indicated that although the technology is expensive right now, further competition and innovation could bring down capital costs to where contractors would adopt it. In fact, contractors may find the technology easier to use than manual duct sealing, which provides hope for long-term adoption of this technology in the market.
[b] Interview WAP Manager, Housing Authority of Skagit County, Washington, 2021.

10 Implementation Steps

This section describes the steps necessary to implement the aerosol-based sealant technology. Implementation of the technology involves four steps: gaining access to use the technology, estimating whether the home/unit/duct system is a good fit for the technology, executing the aerosol sealing process, and producing a leakage report for the customer to show differences between pre- and post-sealing leakages.

1. Gain access to use the technology. Either bring in a certified Aeroseal contractor or pay a franchise fee and receive the training, software, and equipment needed to execute the aerosol sealing process.
2. Estimate whether the home/unit/duct system is good fit for the technology.
    - Confirm there are no large leaks (1/2” or greater), and if there are, check that they can be accessed and sealed manually.
    - Confirm ducts have high enough design operating pressure (and thus substantial enough leakage) to justify sealing.
    - Confirm ducts have enough total airflow volume to justify sealing, and if not, confirm the potential leakage is high enough.
    - Confirm the duct system is not overly complex, which can make blocking off ducts for sealing difficult.
    - Note that a tight duct system can reduce the scope of possible leaks, decreasing potential savings from using the technology.
    - Confirm the duct system operates for enough time every day to have enough potential savings from sealing.
    - The higher the percentage of the ductwork in unconditioned spaces (outside the thermal/pressure boundary), such as attics and crawlspaces, the greater the potential for savings.
    - Confirm that the home or unit has enough room to set up the equipment needed.
3. Execute the aerosol sealing process.
    - Determine which part of duct system is to be sealed.
    - Clean ducts if they are extremely dirty.
    - Block off the section of duct system using foam plugs and tape. Also block off heat exchangers.
    - Set up equipment inside the home or unit and connect it to the ductwork.
    - Pressurize the ductwork to calculate pre-seal leakage. Aeroseal software will do this.
    - Manually seal large leaks (1/2” or greater) if needed and they are accessible; this can be done either before the aerosol sealing is done or while it is being done.
    - Set up the equipment to inject aerosol sealant.
    - Repressurize the ducts to calculate post-procedure leakages.

4. Produce leakage report for customer to show differences between pre- and post-sealing leakages.

11 Conclusion

Given the high capital costs of equipment used in the Aeroseal duct sealing method, franchise holders can charge high prices to seal ducts, which could cause the SIR to fall below 1. Furthermore, this technology is mostly used for private projects to meet local duct tightness codes and would otherwise not be cost-effective. However, given the possible health and safety benefits of the technology, some regions (such as Washington state) may have health and safety set-asides, which would enable usage despite the high costs. Although manual methods are much less costly right now, long-term trends may cause costs of Aerosol to decrease, especially if competition and usage are increased, which may lead contractors to prefer using the Aeroseal method in conjunction with manual methods to seal larger leaks (instead of manual methods alone) because it is less labor-intensive in aggregate.

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