# 2. DUCT-SEALING TECHNOLOGIES USED IN THE FIELD TESTS

In this field test, two approaches to sealing ducts in houses were studied: a conventional, best-practice approach using simple diagnostics and manual sealing augmented by advanced diagnostics, and an approach using an aerosol-spray technology.

## 2.1 CONVENTIONAL, BEST-PRACTICE DUCT-SEALING TECHNOLOGY

Currently, most Weatherization Assistance Program agencies that include duct sealing as a conservation measure use pressure pan and, less frequently, dominant duct leakage measurements to determine if duct sealing is needed and to help locate duct leakage sites. The leaks identified through these measurements as well as leaks identified from visual inspection of obvious or potential leakage sites are sealed manually.

Pressure pan measurements are usually made by using a blower door to depressurize the house to 50 Pa relative to the outside. To make the measurements, supply and return registers are temporarily blocked off one at a time (typically by a shallow pan), and the pressure difference across each register is measured. Pressure pan measurements help identify and prioritize leakage sites. If the pressure difference is <1.0 Pa, any duct leaks are thought to be distant from the measured register. A larger pressure difference (2–5 Pa or more) indicates a duct leak near the register. Thus, pressure pan measurements help find leaks hidden in walls and floors and can be used to provide feedback on progress. Some agencies also use the number of pressure pan measurements greater than a selected value (say 1.0 Pa) as an indicator of how tight the entire duct system is and whether any duct sealing is warranted.

The dominant duct leakage measurement is made by turning on the air handler fan and measuring the pressure difference in the main part of the house relative to the outside. If the pressure in the main part of the house becomes less than outside pressure, the measurement indicates that leaks in the supply ducts are larger than leaks in the return ducts. A positive pressure in the house indicates the reverse — that return leaks are dominant. If the pressure in the house does not change, then the amount of duct leakage in the house may be small, or supply leaks may be the same magnitude as return leaks.

Weatherization crews usually first repair and seal major leakage sites such as disconnected ducts, panned floor joists (missing end plates and poor joints), junctions between register boots and wall and floor surfaces, filter slots, and equipment panels. They then manually apply sealants to all remaining visible and accessible leaks and joints until measurements and/or experience dictate that no other leaks can be sealed cost-effectively. Materials used to fix or seal these leaks include mechanical fasteners (screws, clamps, etc.) for reconnecting ducts, duct materials (sheet metal, duct board, drywall, plywood, rigid board insulation, etc.) to repair major leakage sites, and sealants (mastic, spray foams, caulk, etc.), which are used for all applications.

In this field test, this basic approach was enhanced to form a best-practice approach by measuring the total duct leakage and duct leakage to the outside using a duct blower. A duct blower (essentially a smaller version of a blower door) is connected to the duct system and used to measure the flow through duct leaks. All registers are sealed, and the duct is typically pressurized to 25 Pa with respect to the house and outside so that the total duct leakage is measured (reported in units of cfm25). Total duct leakage includes both leaks to the outside of the house as well as to the inside conditioned space.

The duct leakage to the outside can also be measured by pressurizing the house to 25 Pa with respect to the outside using the blower door and pressurizing the ducts to 25 Pa with respect to the outside using the duct blower. Because there is no pressure difference between the house and the ducts, all the flow through the duct blower is through leaks to the outside.

Including the total duct leakage of the duct system in the best-practice approach, especially the amount that leaks just to the outside, is a powerful tool when combined with the other diagnostics and the weatherization crew’s experience. Crews can use the initial direct measurements to help determine when duct sealing is warranted, rather than relying on indirect or anecdotal information from pressure pan and dominant duct leakage test. The magnitude of the duct leakage can also forewarn crews that big leaks in the system may be expected. Measuring the duct leakages at the end of the sealing work allows crews to decide if the system has been sufficiently tightened and whether any big leaks might have been missed.

## 2.2 AEROSOL-SPRAY TECHNOLOGY

The aerosol-spray technology involves a solid sealant that is suspended in an aerosol spray. This is sprayed into the ducts, where it seeks out and seals cracks that are ½ in. or less, although larger leaks can be sealed in some cases if given enough time. The technology consists of an injector, large-diameter flexible plastic tubing to connect the injector to the duct system, foam plugs to temporarily seal registers and protect heat exchanger surfaces in the indoor air handler unit, and computer software to operate the equipment. The equipment used in the field test was manufactured by Aeroseal, Inc., which holds the exclusive patent rights to the technology.

The injector (Fig. 2.1) consists of a blower, heater, and sprayer. The sprayer injects a mixture of water, sealant, and solvent into an airstream created by the blower. The heater is used to control the temperature of the air so that the water and solvent are evaporated from the mixture, leaving just the

**Fig. 2.1. The Aeroseal injector.**

sealant suspended in the air stream in solid form. This sealant-laden air is delivered into the duct system by the plastic tubing (Fig. 2.2), and the solid sealant particles are deposited at the leakage sites as air exits through the leaks. The blower is calibrated so that it can measure duct leakage as described in Sect. 2.1 for a more traditional duct blower. Three electrical circuits are needed to operate the equipment: a 110-V circuit to operate the blower, a 110-V circuit to operate the sprayer and its compressor, and preferably a 220-V circuit to operate the heater (a 110-V circuit can be used in many but not all applications).

The sealant is a vinyl acetate polymer (an ingredient sometimes used as a base in chewing gum) and was originally used to remove the smoky smell from ducts after a fire by coating the inside of the ducts. Only about 10–20 oz of sealant is used in a typical home. For air-sealing applications, the aerosol-spray equipment is specially configured and designed so that the sealant fills the holes rather than lining the duct. The solvent used in the mixture is 2-ethyl 1-hexanol. Aeroseal reports that this solvent is not designated as hazardous by the Occupational Safety and Health Administration.

**Fig. 2.2. The Aeroseal tubing connection.**

The aerosol-spray equipment can be connected to the duct system in one of several ways:

- The typical approach is to cut a large hole (20- to 24-in.-diameter) in the supply or return duct near the air handler equipment and use a commercially available flange or collar to fasten the large-diameter plastic tubing from the injector to the duct system. (See the hole cut in the supply duct at the top of Fig. 2.2.)
- The plastic tubing can be connected to the air handler unit itself, as shown in Fig. 2.2. In this case, the air handler fan and cover are removed, a 20- to 24-in. hole is cut in a piece of cardboard or other similar material the same size as the fan cover, and the flange or collar is again used to fasten the plastic tubing to this cardboard blank, which is then temporarily taped to the air handler unit.
- The entire air handler unit can be removed, allowing the plastic tubing to be connected directly to the ends of the supply and return ducts.
- If needed, the plastic tubing can be connected to supply and return registers, although this is the least preferred method because supply registers are not very large.

Once the aerosol-spray equipment is connected to the duct system and all registers are sealed with the foam plugs or by other means, the duct leakage of the entire system (both supply and return) is measured using the aerosol equipment following the same approach as discussed in Sect. 2.1. (The aerosol-spray equipment performs the same function as the duct blower.) Before the sealant is sprayed in, the heat exchangers in the air handler unit must be blocked off with the foam plugs, cardboard, or other materials so that sealant does not gum up these surfaces. This effectively isolates the supply ducts from the return ducts: only one-half of the duct system can be sealed before the equipment must be removed and connected to the other half of the duct system so that this other half can be sealed. The duct leakage is continuously monitored as the sealing occurs so that operators can gauge progress and determine when sealing should be stopped. When both the supply and return ducts are sealed, the heat exchanger is unblocked, and a final duct leakage measurement of the entire system is made. The aerosol-spray equipment is then removed. The final steps are to remove the foam plugs from the registers and air handler unit, cover and seal any holes cut in the ducts with sheet metal and mastic, reinstall fans and covers, and reinstall any air handler units that were removed.

The aerosol-spray technology shares some common elements with the conventional, best-practice approach described in Sect. 2.1.

- The aerosol-spray technology still requires manual sealing of major duct leakage sites. The aerosol-spray approach cannot reconnect ducts or seal large openings such as end plates missing from panned floor joists. When the aerosol-spray sealing process begins, the equipment will shut down and/or notify the equipment operator if a large leak is present.
- Although the aerosol-spray technology might be able to seal leaks ½ in. or larger if given enough time, it is most effective in sealing cracks less than ¼ in. To improve effectiveness and to ensure timely sealing of these large leaks, it is recommended that 15–30 min. be spent sealing these larger leaks by hand while the aerosol-spray equipment seals the rest of the duct system to help the aerosol-sealing process along.
- In some duct systems, 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. A duct system with a short return or one in which it is difficult to connect a portion of the system to the equipment is a good candidate for this approach.
- The foam seals used to block off the registers during the sealing process are placed inside the ducts such that the junction between register boots and wall and floors are not sealed automatically. While the aerosol-spray equipment is operating, these leakage sites need to be sealed by hand.
- The aerosol-spray technology measures duct leakage before and after sealing, providing the same information and feedback as explained in Sect. 2.1 from using the duct blower.

Thus, perhaps a better way of viewing the aerosol-spray technology is as another tool to be used in a comprehensive approach to duct sealing rather than as a separate approach to the conventional technology. Once major duct leaks are sealed, a determination can be made as to whether further duct sealing should be done manually using conventional methods, automatically using the aerosol-spray technology, or not at all.

The operation of the aerosol-spray equipment is controlled by a Window-based software program operating on a portable personal computer. The software was developed by Aeroseal for private-sector heating, ventilating, and air-conditioning (HVAC) contractors to market, diagnose, and perform duct sealing using the aerosol-spray technology. The software is designed to be used in two phases. In the first phase, a salesman uses the software and simple diagnostic equipment (not the injector itself) to determine the need for air sealing and to sell a client on a job. In addition to performing a simple duct leakage analysis using methods other than those described in this report, the software performs other tests and diagnostics to check on room air flow and air distribution throughout the house, register temperatures and the need for duct insulation, total air flow and the need for a larger return system, and health and safety. The software also collects household and house information needed to sell, cost, and plan an air-sealing job.

If a job is sold, an air-sealing crew returns at a later date to implement the second phase. In this second phase, the Aeroseal equipment is installed to seal the ducts. The software is used to operate the equipment and collect data throughout the sealing process. As part of Aeroseal's licensing arrangements with its HVAC contractors, data collected by the contractors on air-sealing jobs must be transferred to Aeroseal on a periodic basis for quality control reasons or the software will fail to function.

Only portions of Aeroseal's software were needed for this field test. In addition, the data collection needed for this field test required a nonstandard use of the software. Nevertheless, this software package had to be used in the field test because there was insufficient funds or time to develop a customized version.