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Ensuring ductwork doesn't leak requires special preparations

Vaughn Industries Mike Swirloin seals duct on a project in Columbus, Ohio.

   

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There is an increasing demand from building owners, architects and mechanical HVAC construction engineers for energy efficiency in buildings.

The U.S. Department of Energy has recognized that sealing ductwork is one of the best ways to reduce HVAC construction energy consumption. Unsealed ducts can result in leakage of 30 percent of the system's airflow. Duct leakage of 15 percent increases the amount of fan power by 40 percent. Current American Society of Heating, Refrigeration and Air-Conditioning Engineers' standard No. 90.1 recognizes the impact of duct leakage on energy consumption and indoor air quality. ASHRAE standards require duct to be sealed to the Sheet Metal and Air-Conditioning Contractors' National Association's Seal Class A regardless of pressure. This means that all seams — except spiral lock seams — joints and penetration in medium- and low-pressure, return and exhaust ductwork must be sealed.

The demand for low duct leakage, zero energy building, energy-efficient HVAC construction and green HVAC buildings will only continue to grow, many expert say. A commercial building with the U.S. Green Building Council's Leadership in Energy and Environmental Design certification increases its sale price 10 percent to 13 percent and increases office building rental rates 2 percent to 17 percent, according to the Institute for Building Efficiency.

Green rules

LEED's green HVAC requirements call for duct to be sealed in accordance to ASHRAE standard 90.1. According to Spiral Duct Manufacturers Association technical director Bob Reid, the chairman of an ASHRAE duct design and construction committee, the estimated average cost of a cubic feet per minute of air is $1.75 annually.

Financial consideration will continue to drive duct sealing.

In the not too distant past, visual inspection of duct seams and joints or listening for air leaks was the common method to determine duct leakage. Duct system air leakage testing a maximum 5 percent of the total system CFM eventually became commonplace.

The new standard is quickly becoming 1 percent total CFM leakage.

Sheet metal works contractors are finding it more difficult to meet these rigorous leakage standards. Failure to meet leakage requirements on the first try will result in increased labor costs and possible project delays. Low duct-leakage requirements are here to stay and the number of projects will only increase. Through proper strategies and materials, duct can be sealed to meet low-leakage requirements. Here are some tips to meet 1 percent leakage requirements.

Use a quality sealant

The first key to meeting low-leakage requirements is to simply use a quality duct sealant. A quality sealant is one that is flexible during application and stays flexible over time. Flexibility allows the sealant to move with mechanical vibrations and expand or contract due to pressure and temperature cycling without cracking. It should also have good metal adhesion to prevent air loss at the point of sealing.

A quality duct sealant should spread, caulk or spray easily, allowing the installer to apply the correct amount of sealant. A "fluffy" duct sealant can lead to thin areas of duct sealant where the brush bristles have pushed down to the metal. A sealant that is difficult to apply typically leads to thick areas of sealant at the beginning of the brush stroke and thin areas at the end of the brush stroke.

Unfortunately, the quality of duct sealants cannot be determined by reviewing submittal sheets. A common misconception is that the higher the solid content — what remains after the water or solvent evaporates — the better the sealant. This is untrue. Fillers such as clay can be used to increase the solid content of sealer; use of clay will negatively affect flexibility and adhesion. A 68 percent solid-content sealant that is primarily polymer will far outperform an 80 percent solid-content sealant that is primarily filler.

The same holds true for viscosity. Ease of application cannot be determined by viscosity (thickness) rating on a submittal sheet. A high-viscosity sealant may be much easier to spread than a low viscosity sealant.

The best determination of a quality duct sealant is through shop and field testing.

Use the proper sealant

Use the correct tool for the job. This holds true for duct sealants. There are a number of duct sealant manufacturers in the HVAC market and most of these manufacturers have different grades of sealants. Sealant manufactures generally have premium-grade duct sealants with high-polymer (rubber for flexibility and glue for adhesion) content and general-purpose duct sealants. The additional polymer in premium-grade sealants not only provides more flexibility and better adhesion, these properties also provide more forgiveness if the installer applies sealant too thin. Additionally, premium sealants withstand handling and movement due to installation better than general-purpose duct sealants.

The job-cost difference between premium and general-purpose sealants is almost always much less than the cost of one callback. Premium grade sealants should be used for 1 percent leakage projects.

For unconditioned buildings in northern climates, sealing with a solvent-based duct sealant may be required during the winter. The water in water-based sealants will freeze when exposed to very cold temperatures. This can happen anytime during the curing process. For example, a water-based duct sealant applied at 45°F during the day can freeze if the temperatures drop below 32°F that night. The frozen water within the water-based sealant is inflexible. Any movement of the duct — wind, work performed on the ductwork, other trades, etc. — will lead to the ice within the sealant to crack. Solvent-based duct sealants will eliminate failures due to freezing. There are low-volatile organic compound solvent-based sealants available for LEED projects.

Plan ahead

The vast majority of duct sealant used is water-based. Water-based sealants need time to cure before pressure testing, generally 24 to 72 hours depending on humidity and temperature. Pressure testing and handling the duct before the sealant is fully cured will lead to failures. There are ways to decrease cure time and reduce the chance of failures:

- Forced air movement from fans greatly increases the evaporation rate of duct sealants, decreasing dry time significantly. Air should not be blown directly at the sealant at high velocity, this may cause the outside film to cure quickly and trap wet sealant underneath which can extend cure time.

- Do not use plastic wrap on interior sealed duct until it is cured, or nearly cured. Sealants cure by evaporation. If the interior air becomes saturated, the curing process with stop. Depending on the amount of sealant, installers can find uncured sealant when they unwrap duct weeks later.
- Duct should not be installed, loaded, shipped or handled when duct sealant is in a semi-cured state. Semi-cured sealant has not developed film strength and will tear (wet sealer usually re-seals). Tearing of semi-cured sealant is a very common failure and almost always misidentified as cracking. Contractors often wonder why a sealant that appears very flexible has cracked.
- In cold climates, keep water-based shop applied duct sealant as warm as possible as long as possible to speed curing. As a rule: seal early, load late. Wet sealer will freeze in storage trailers and in transit.

Keep an edge

By far the most common area of duct leakage in HVAC construction is at sheet metal edges. This is the point that where the brush applies least amount of sealant, often leading to paper-thin sealant. Duct sealant often is so thin that it can be transparent. Quality sealants can often overcome this mistake, but there are limitations.

The edges of slips and drives, whether hemmed or straight, are a major source of ductwork fabrication leakage. Installers should brush sealant into the void between the slip/drive and the duct to effectively air seal. Brushing over the joint creates a “bridge” between the duct and the slip/drive with the weakest point being the thin duct sealant film at the edge of the slip/drive. This also holds true for applied round and oval flange connections.

Brushing over the drive cleat will almost certainly lead to air leakage. The edge of the drive cleat is relatively sharp and the gap relatively large. Sealant should be brushed into the drive cleat with enough sealant to fill the void.

New technology of spray applied duct sealant can eliminate the “bridge” effect of brush applied duct sealants. Duct sealant is atomized and applies to the duct with a velocity that allows the sealant to fill the gaps. It effectively fills the gaps found between duct and slips/drive and applied flanges. Spray duct sealant also does a particularly good job penetrating into Pittsburgh seams, gore locks of round elbows and under drive cleats. Labor savings for spray duct sealant can be up to 75 percent versus brush on duct sealant.

TDC/TDF and applied flange corners should be carefully duct sealed. Again making sure ample amounts of sealant is used and that there are no thin spots at the edges. Corners are one of the most likely areas to leak. Using a quality gasket tape between transverse duct connections and transverse duct flanges and applied flange connections will greatly reduce the chance of air leakage.

Seal everything

One percent leakage projects do not allow room for error. Small areas of leakage can add up and result in test failure, which in turn lead to call backs and lost profit. Some key areas for small duct leakage that should be addressed:

- Seal the ends of Pittsburgh seams. Air can travel down the Pittsburgh seam and find the small areas to escape.
- Even non-curing butyl seam sealant injected into Pittsburgh seams may need to be sealed after assembly with a duct sealer. Often injection seam sealants are started a few inches from the beginning of the duct and ended a few inches from the end to avoid mess.
- Air pocket from pump systems can also leave gaps in the Pittsburgh seams. Applied flanges with seam sealant may also be sealed around the connection to the duct.
- Seal connections between flexible duct (inner core for insulated flexible duct) and the sheet metal takeoffs. The band of sealant should cover the connection between the flexible duct and the take-off and the connection between the takeoff and the truck duct.
- All penetrations including screw heads, tie rod penetrations and pin holes at welds should be sealed.
- Caulked sealant should be back brushed. Sheet metal has a layer of oil on the surface. Back brushing caulked sealant breaks this film and allows for adhesion to the metal. Lightly caulked sealants can “float” on the metal surface and allow air leakage.
- Seal variable-air-volume boxes thoroughly. VAV boxes should be treated as ductwork, with all joints, seams and gaps sealed.
- Seal fire/smoke dampers as allowed by the manufacturer. Use duct sealant approved by the fire/smoke damper manufacturer.

Know your testing equipment

Many contractors are performing their own leakage testing instead of using a testing-and-balancing company. Test kits are used to determine the amount of air leaking from a duct system. Duct is pressurized by means of a fan that blows air through an orifice tube. Once pressure in the duct system section is equalized, typically in the 2-inch to 6-inch water gauge pressure range, the amount of air passing through the orifice tube equals the amount of air leaking from the duct system. The air flowing across the orifice plate in the tube creates a pressure drop. This pressure drop corresponds to leakage CFM on a chart provided by the orifice tube manufacturer.

Properly sealed duct systems can fail pressure tests due to operator error. Duct leakage test kit operators must be aware of how to properly operate the equipment and read the leakage chart. Each orifice tube is independently tested with a serial number that corresponds to a specific chart with the same serial number. Using the wrong chart for the wrong tube will result in incorrect leakage calculations.

Be aware of the dangers of soap-bubble testing. Inspectors, engineers or project managers can use bubble testing to fail duct sealing before it is even tested. Know the math: The volume of a 1/16-inch diameter air bubble requires over 7,800 bubbles to make a cubic inch of air leakage. This translates into 13.5 million 1/16-inch diameter bubbles for just one cubic foot of air leakage.

Demands for energy-efficient building with low air duct leakage rates will only increase. With a quality duct sealant, there a way to meet 1 percent leakage requirements.

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