Title
Assessing the longevity of residential duct sealants

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Assessing the Longevity of Residential Duct Sealants

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Abstract

Duct leakage has been identified as a major source of energy loss in residential buildings. Most duct leakage occurs at the connections to registers, plenums or branches in the duct system. At each of these connections a method of sealing the duct system is required. Typical sealing methods include tapes or mastics applied around the joints in the system. Field examinations (both physical measurements and visual observations) of duct systems have shown that these seals tend to fail over extended periods of time. In this study, three test methods were used to test the longevity of duct sealants: simple heating, heat cycling and combined pressure and heat cycling (aging). The most advanced method was the "aging" test, developed to evaluate the longevity of duct sealants by alternatively blowing hot (75°C) and cold (-5°C) air through test sections, with the apparatus cycling between hot and cold air quickly. The temperatures and cycle length were chosen to accelerate the aging process of the duct seals. The aging apparatus was able to test eight samples at a time, with the test samples constructed from standard duct fittings. The results of these tests were used to evaluate different sealants relative to each other, so that recommendations regarding duct sealants may be developed. Typical duct tape (i.e. fabric backed tapes with rubber adhesive) was found to fail more rapidly than all other duct sealants. The accelerated test method is being developed into an ASTM Standard under sub-committee E6.41.

1. Introduction

In the U.S. forced air systems are the dominant method of heating and cooling residential buildings [1]. The air distribution systems require some sort of seal between duct sections, at branches and at plenum and register connections. Without these seals, duct systems would be extremely leaky and inefficient. Field studies [2,3,4,5] have shown that existing residential systems typically have 30-40% of the total air flow leaking in and out of the duct system. Because these ducts are often outside conditioned space this leakage corresponds to a similar amount of energy (30-40%) being lost from the duct system instead of going to heating or cooling the conditioned space. In addition, there are comfort, humidity and indoor air quality problems associated with return leaks drawing air from outside or unconditioned spaces within the structure (e.g., damp crawlspaces). Note that field studies [6] have shown that ducts located within the thermal envelope (e.g., in joist spaces between floors or interior partitions) can still have significant leakage to outside because these spaces are not air sealed.

Residential duct systems in the U.S. are normally field designed and assembled. There are many joints, often of dissimilar materials (e.g., plastic flex duct to sheet metal collar). The mechanical fastening together of the duct system components does not usually provide an air seal. High pressure drops in the vicinity of the air handler and associated plenum, make even small holes have potentially large leakage flows. Therefore, standard practice [7] calls for all joints in the duct system to be air sealed in addition to being mechanically fastened. However, field studies [6] have shown that many systems are poorly sealed.

Each sealant choice has different advantages or disadvantages, but a reasonably careful job of application, can produce a good initial seal for any of them. While any sealant method can produce a good initial seal, it is not clear that all last equally well. The length of time a duct seal can last is important given that houses are said to be designed to last 30 years and flex duct systems are often rated at 15 year life. Ideally, duct seals should last at least as long as the rest of the duct system, but are often observed to fail in a few years [8]. Poor installation of sealants (e.g., on dusty or oily surfaces prevalent during construction) can be a contributing factor (that will not be addressed here), but it appears that physical properties of some of the sealants themselves may result in poor seal longevity.

This study was undertaken by the State of California because it wanted to be able to make recommendations on acceptable practices for duct sealing for use in energy conservation programs and in building energy codes. These recommendations needed to include the effect on future energy consumption and therefore the longevity of duct system performance.

While some duct sealant technologies are rated (e.g. by Underwriters Laboratory [9,10,11]) on their manufactured properties, none of these ratings addresses the in-service lifetime. Selection of sealants that do not fail within the lifetime of the duct system requires the existence of relative ratings for sealant longevity. The purpose of this study was to develop such a rating method.

The duct sealing methods examined in this study can be split into the following classes:

- **"Duct Tape"** has a vinyl or polyethylene backing with fiber reinforcement and has a rubber-based adhesive. It comes in wide variety of grades with different tensile strengths. The composition and material of the backing has some variation, with some tapes having a distinctive backing that has the appearance of cloth rather than vinyl or polyethylene. The classic duct tape is silver/gray, but is available in many colors.
- **"Clear UL181B Tape"** has a thin typically clear polyester backing and an acrylic adhesive. Clear UL 181B tape is often used on factory-assembled duct systems.
- **"Foil Tape"** has metal foil backing and can have either acrylic or rubber adhesive (we tested only acrylic adhesive tapes). Foil tapes are often used on rigid duct systems (e.g. duct board).
- **"Butyl Tape"** typically has foil backing as well, but uses a thick (0.38 to 1.3 mm) butyl adhesive to allow it to conform to more irregular shapes.
- **"Mastic"** is wet application, gooey adhesive that fills gaps and dries to a semi-rigid solid. Mastics may also be used together with reinforcing fibers or mesh tape.
- **"Aerosol Sealant"** is a sticky vinyl polymer that is applied to the leaks internally, by blowing aerosolized sealant through the duct system. This sealant system was developed by LBNL, and is discussed in more detail in [12].

Three separate experiments were used to examine the longevity of these duct sealants:

1. **Cycling tests.** This experiment alternately blew heated and room temperature air through sample duct connections. The pressure difference across the duct leaks was also cycled.
2. **Baking tests.** Samples were placed in an oven and held at a steady temperature with no air flow through the test sections.
3. **Aging tests.** This was the most sophisticated experiment that alternately blew heated and cooled air through the test sections and also cycled the pressure difference across the leaks.

This paper will present a summary of these test procedures and their results. Additional information about thermal distribution systems and duct sealing can be found at the following web page: **http://ducts.lbl.gov**.

2. Evaluating sealant longevity performance

The longevity measurements in this study focussed on the properties of the sealants themselves. Therefore considerable effort was made to ensure good initial seals by following good practice and manufacturers instructions carefully. For example, the sample connections were thoroughly cleaned and dried before the tapes were applied. This is particularly important for sheet metal that has an oily residue left over from the manufacturing process that impairs a good initial seal and would presumably impair longevity performance also. The ducts were not cleaned before the application of the mastic and aerosol sealants. For the tests in this report, the application of the sealant was meticulous and all the sample connections were measured to ensure a good seal before beginning any of the tests.

In a field application, it is not practical to take this level of care during the installation of the duct system. Access to the ducts may be limited; also, ducts may be or become dirty before the sealant is applied. Because tapes are particularly sensitive to these issues, some taped seals may not perform well because of their installation rather than any intrinsic fault of the tape itself. Non-tape sealants can often be more tolerant of dirt and/or able to reach all the leaks. The longevity tests discussed in this paper did not address these installation issues.

Existing UL 181 standards [9,10,11] concentrate on evaluating safety, tensile strength and initial adhesion. They have not been developed to measure the ability of sealants to maintain the seal when subjected to the environmental conditions normally experienced by ductwork. The three longevity test methods developed for this study specifically focus on evaluating the longevity of the sealant. The longevity tests stress a standardized joint configuration with different environmental conditions. The testing includes visual observation of seal degradation and measurement of sample leakage. It should also be noted that this paper does not attempt to correlate how long the sealants last in the tests to how long they would last in a real house. This is because the range of operating conditions varies enormously between installations in individual houses.

The longevity tests were designed to use conditions of temperature, pressure and airflow that would be experienced by typical duct system installations. The testing is accelerated compared to real installations by having the ducts at a continuously high temperature in the **baking test**; continually cycling (there are no long "off" periods during which the seals are not stressed) in the **cycling test**; and rapidly changing from hot to cold conditions in the **aging test**. For the aging test the high and low temperature and pressure limits are individually typical of real duct systems, but it is unlikely that a duct system would experience these rapid hot to cold and cold to hot transitions.

For the leakage measurements of individual sealants, a standard pressure of 25 Pa was chosen because this is a typical pressure that would exist in the branches of a residential duct system. It is between the high pressures at a plenum (on the order of 100 Pa) and the low pressures at registers (on the order of 5 Pa). In addition, existing leakage measurements for duct systems installed in houses also use this reference pressure [13,14]. In all the longevity tests, temperatures are kept below 93°C (200°F) because some of the tested tapes had this as an upper limit temperature rating. The cycling apparatus puts about 200 Pa of pressure across the sample joints, which is higher than the pressures measured in most residential duct systems, but it acts to accelerate any failure by putting a larger mechanical stress on the seal than it would experience in a real installation.

The twenty minute cycle time of the cycling test was limited by the need to warm up and cool down the test sample. Also the cycling apparatus could not subject the test sample to the cold temperatures that might be expected either in the winter or in air conditioning supply ducts. The aging test was designed to be able to overcome these limitations and provide accelerated longevity testing.

2.1 Sample connections sealed in this study

There are several types of connection commonly seen in duct systems. For sheet metal and duct board systems there are linear joints between the individual sections making up the duct system. For round sheet metal systems there are the round joints between pieces of duct. For plastic flex duct systems there are the round joints between individual pieces of flex duct required for long runs. However, there is one joint common to all systems: that is the perpendicular joint created when a duct connects to a plenum (for duct board and sheet metal systems) and where a collar (connected to the end of a piece of flex duct) connects to a plenum or junction box in flex duct systems. In addition, in field observations of duct systems, it is often this type of connection that has sealant failure. This may be because it is difficult to apply tapes to this interior right-angled joint, particularly for ducts of round cross section. It was also expected that this joint may accelerate failure because the holes to be sealed can be relatively large (about 6 mm x 6 mm) compared to other system joints (e.g., the longitudinal seam in sheet metal ducts).

Figure 1 illustrates the sample connections constructed for the baking and aging tests. The sample connection section used in the baking and aging tests was built from standard duct fittings. It consisted of a flange and a collar with fingers to fold in and out of the hole in the flange. The gap between the flange and the collar was 6 mm all around the perimeter. The collar was centered in the flange. Sheet metal screws were used to mechanically connect the collar to the flange.

2.2 Leakage measurement method

All three test methods were designed so that individual sections could be removed from the test apparatus and tested using a pressurization test procedure, as shown in Figure 2. For the leakage measurement, the sample connection was blocked at one end and a fan was connected to the other end to pressurize the test section to 25 Pa. The flow was then measured using a calibrated orifice. Because a large range of leakage flows were expected, from about 15 m^3/hour (25 cfm) @ 25 Pa with no sealant in place to close to zero leakage when the sealants are initially applied, several orifices (from 6mm to 30mm in diameter) were used depending on the measured flow.

The sample connections were all tested for leakage before any seal was applied because the failure criteria was based on the fraction of unsealed leakage. The test sections that were used in this study had pre-sealed leakage within a few percent of 17 m^3/hour (10 cfm) @ 25 Pa. After sealing all the joints had close to the same small amount of leakage, typically less than 0.9 m^3/hour (0.5 cfm) @ 25Pa.

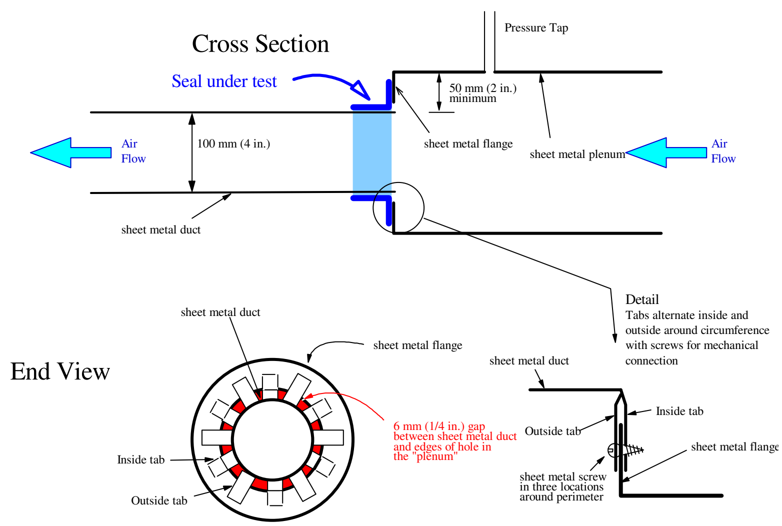

Figure 1. Sample Connection for Duct Seal Longevity Testing

2.3 Baking test

Sample sections, sealed according to manufacturers' instructions, were placed in an oven set to a temperature typical of a hot attic or a hot supply plenum on a heating system. The oven was set to operate in the range of 60°C to 80°C. The leakage of each sample was measured every few days to get a quantitative estimate of the failure rate with time. The sample sections were also visually inspected to note any changes in the sealant.

The only samples that have shown degradation from baking are those with rubber based adhesives (i.e. duct tapes). The visual inspections indicated that at the elevated temperatures of the oven, rubber backed duct tapes have a tendency to delaminate. The tape is a sandwich of several layers: the rubber adhesive, a mesh of reinforcing fibers and vinyl, polyethylene or cloth backing and a low adhesion outer surface. Delamination occurred as the vinyl or polyethylene backing tended to shrink. This left only the reinforcing mesh and the adhesive behind around the edges of the pieces of duct tape. Because the reinforcing mesh was a fairly open weave, air could then leak out through this "unbacked" mesh. This shrinkage also made the pieces of tape wrinkle up and pull away completely from the sample connections. Visual inspection of the samples in the aging apparatus showed the same behavior. However, the addition of pressure across the leaks made the effects of wrinkling and shrinkage worse because it forced the tape off the sample.

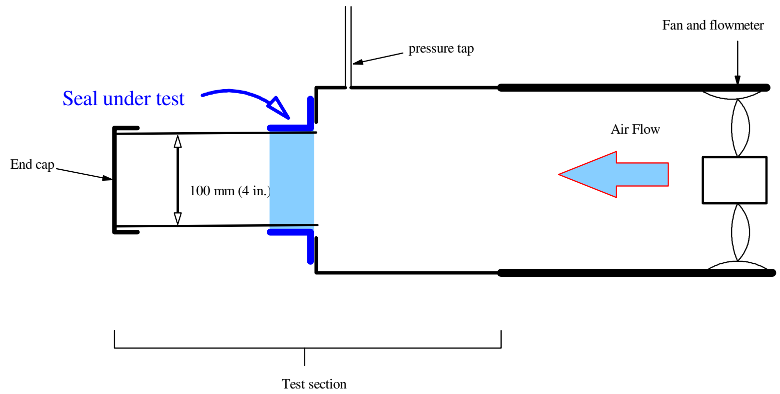

Figure 2. Apparatus for measuring leakage of sample sections

2.4 Cycling test

The baking test subjected the sample joints to heat only, without air flow through the samples or a pressure difference across the seal. In the cycling test, the sample joints were subjected to cyclic temperature and/or pressure stresses by blowing heated or room temperature air through the sample at various pressures. The air is heated to about 93°C (199°F) and the resulting duct surface temperatures are about 65°C (149°F). Development of this cycling apparatus was funded three years ago by the US Environmental Protection Agency to determine the longevity of the aerosol sealant technique (developed at Lawrence Berkeley National Laboratory) under accelerated conditions. This apparatus alternately blows heated or room temperature air through half of the sample joints with about a 20 minute cycle time. The other half of the samples experience pressure cycling only using room temperature air. The system has an open cycle (i.e. the heated or room air exiting the test sections is not recovered by the apparatus and simply enters the laboratory where the testing takes place. Eight sample joints are tested at the same time so that different sample joints can be evaluated simultaneously. The apparatus puts about 200 Pa of pressure across the sample connections, which is higher than the pressures measured in most residential duct systems, but it acts to accelerate any failure by putting a larger mechanical stress on the seal than it would experience in a real installation. Note that this is the total leakage for all the sample connections. Before applying the sealant, the total leakage was approximately 170 m^3/hour (100 cfm) at 25 Pa. After sealing this was reduced to approximately 12 m^3/hour (7 cfm) at 25 Pa.

The measured leakage has very little change over the 18 month measurement period. Not only has there been no failure, slight reduction has been measured. This trend would indicate that the seal was getting tighter with time. It is possible to speculate that this might be caused by dust build-up improving the seal. The trend is sufficiently small, however, that it is more likely statistical or experimental bias.

2.5 Aging test

The design of the aging apparatus was intended to overcome many of the limitations imposed by the cycling and ultimately to perhaps become a standardized way of testing the longevity of duct sealant systems using accelerated methods. The specific design objectives included the following:

- Combined thermal and pressure cycling in a pressure range typical of residential duct systems.
- Rapid cycle times: 6 minute target to speed up the aging process.
- Maximum duct surface temperature should be as hot as the hottest attic, but under 93°C (200°F).
- Minimum duct surface temperature should be cold enough to form condensation and perhaps frost.
- A standardized joint and assembly method should be used so that only the sealant is being tested.
- Multiple sealant materials evaluated simultaneously.
- Automated data taking and leak monitoring.

The aging apparatus has a source of hot air (the hot deck) and a source of cold air (the cold deck) as shown in Figure 3. A selector valve, directs air from either the hot deck or the cold deck to flow through each test section. Air exiting the test section is recirculated to reduce the heating and cooling energy requirements. Further energy requirement reductions were made by heavily insulating the apparatus (except for the sample joints). A typical insulation level for most of the system is about RSI 3 (R19).

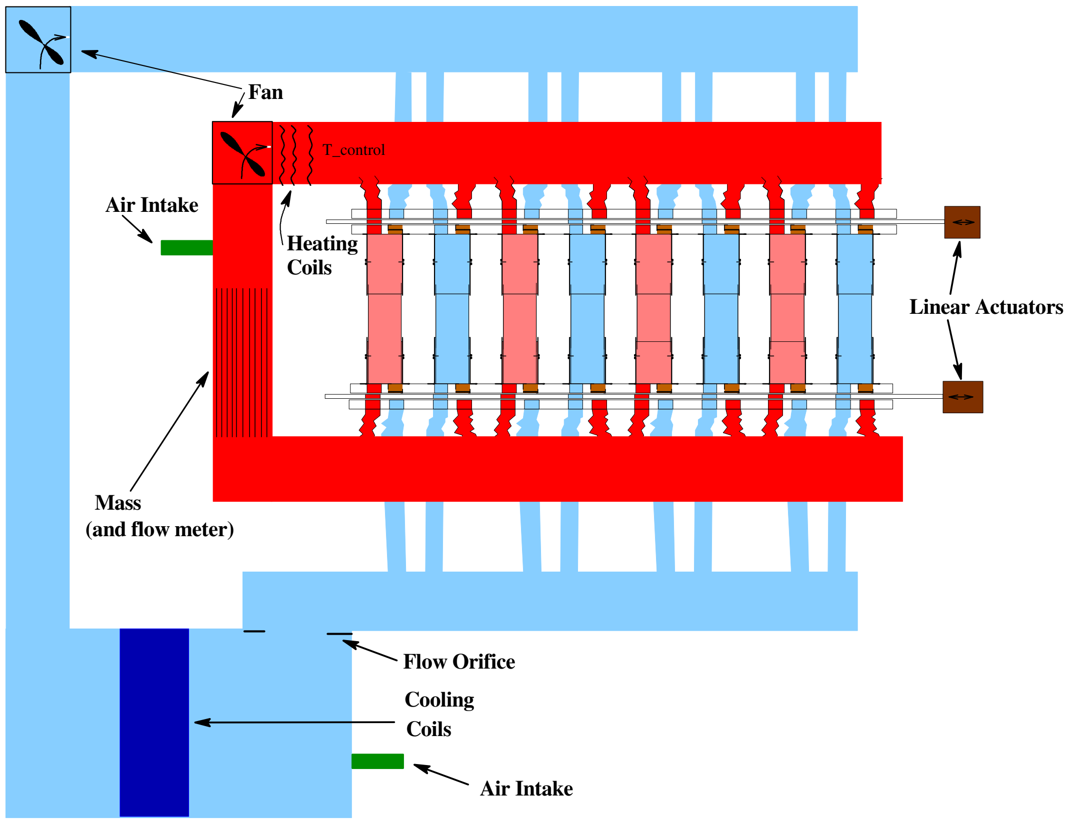

Figure 3 Aging Test Apparatus

The apparatus was designed so that half of the sample sections have hot air while the other half have cold air flowing through them. When the selector valve changes position, the sections that had hot air blown through them now have cold air and the previously cold air sections get hot air. This alternating of hot and cold air provides the thermal cycling. In addition, the pressures changed in the system with each cycle: as the previously hot section cooled, the pressure decreased from about 200 Pa to 100 Pa (these pressure differences are all relative to the room - i.e. across the seals). Similarly, the previously cold section pressure increased by a similar magnitude. An orifice downstream of the fan was used to control the pressure at the leak site and was also used to monitor the system air flow. The hot and cold decks were designed to have high (thermal) mass to stabilize the system load.

The mass in the hot air deck consists of multiple plates of sheet metal and weighs about 70 kg (150 lb.). The flow resistance of this mass was calibrated so that it could be used as a flow meter. A location for air to flow into the system was provided to allow outflow at the leaks, this make-up air was brought into the system at the low pressure side of the fan. The makeup air to the hot deck was fitted with a calibrated anemometer, which measured the total leakage flow of the hot deck and the four sections that were currently

selected to it. This total leakage was continuously monitored in order to detect catastrophic seal failure and record the failure time. Every few days the test sections had their leakage measured individually, using an orifice flowmeter, using the procedure discussed above. This measurement was in addition to the four sample total measured by the orifice mounted in the system.
A data acquisition system was used to continuously monitor the following parameters for the aging tests: total leakage, surface temperature of each sample, pressure difference across the samples, air temperatures in the hot and cold plenums, ambient air temperature, ambient air humidity. This continuous monitoring ensured that the temperature, pressure and humidity stresses for each test section were well known – essential for a test that is used to compare one sample to another. The surface temperatures and ambient air humidity allow estimates of surface condensation for the cold samples.

Figure 4 shows the temperature cycling for one of the sample connections. The hot plenum was operating at 75°C (170°F) and the cold plenum operated at -5°C (23°F). The test sample surface temperatures had a maximum of about 60°C (140°F) and a minimum of 0°C (32°F). These surface temperatures were not as extreme as the plenum temperatures, but still provide a considerable stress for the sealants. The cold plenum temperatures greater than 0°C (32°F) were measured during the defrost cycle for the cooling coil.

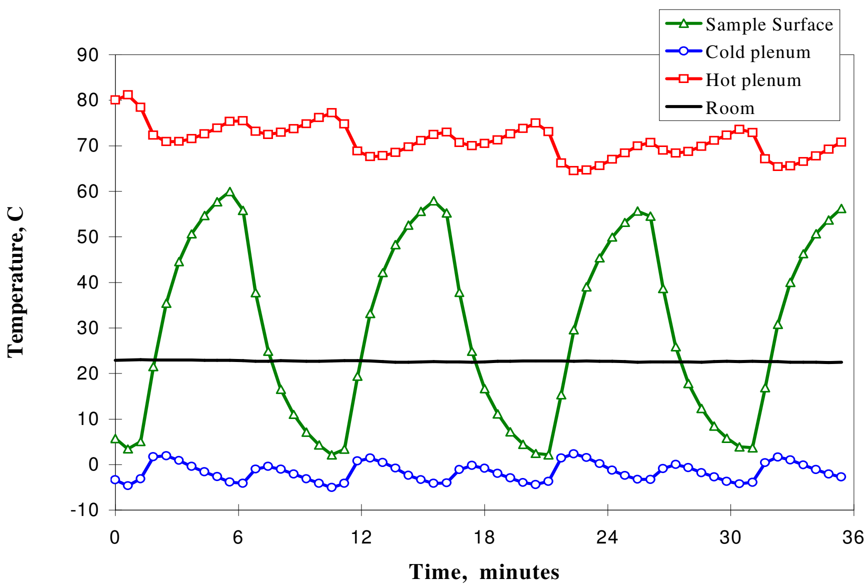

Figure 4. Temperature cycling in aging apparatus

3. Selection of sealants to be tested

The sealants tested in our apparatus were those tapes and sealants which are either commonly used or are being considered for use in various duct sealing programs (e.g., within utility sponsored energy efficient homes). One exception to this criterion was that any tape that had a maximum temperature rating below 60°C (140 °F) was excluded. Not only would it be expected to fail quickly in the longevity tests because of their higher temperatures, but any duct tape with such a poor temperature rating should not be used, because either hot attics or normal heating systems would expose ducts to such temperatures. In preparation for testing, major tape and sealant manufacturers were contacted to ensure that a wide range of available products were tested and to determine which ones have been certified by UL. Duct tapes are discussed separately from the other sealants because duct tape is the most popular method of sealing ducts in the U.S. and comes in the most grades and types. In addition, the test results showed that duct tapes performed differently from all the other sealants.

The aerosol sealant was developed by Lawrence Berkeley National Laboratory as an alternative duct sealing method. Several samples were prepared: one each for the baking and aging tests and another eight for the cycling tests.

Mastic is available in several varieties (but an order of magnitude less variety than tapes) some of which include added fibers for increased mechanical strength. The mastic product tested here did not include these reinforcing fibers and was one with a UL rating (only a few mastic products carry the UL rating).

Clear UL 181B tape is produced by a single manufacturer and is only available in the single type that was tested. Three samples were tested: one for baking and two for aging. The second aging sample was tested because part way through the test program this product obtained a UL rating and it was important to observe if the tape had been changed in any way that affected longevity. Visual inspection and the aging test results indicate that the tape was not changed.

Butyl tapes are available with different thickness adhesive and in several tape widths. As with the other tape products, 50 mm (2 inches) wide tape was used because this is the most common width used in field installations. A single type of butyl tape was used in these tests that had a 0.38 mm (15 mil) thick adhesive layer with a metal foil backing. Three different foil tapes were tested. The tapes were from different manufacturers and had different foil thickness and formulations and all had acrylic adhesive. Figure 5 shows pictures of four of the first set of samples that were tested on the aging apparatus.

3.1 Duct Tape

Samples were obtained from several companies, only some of which were tested in this study. There is a wide range of duct tape products available that claim to suitable for duct sealing, but there is often little in their specifications or product literature to differentiate them. While there is general agreement that there are several grades of duct tape it is not clear what that means. For example one major manufacturer lists 16 different duct tapes (not including color variation) and 8 foil tapes. Some of these tapes have their product codes printed on the tape, some on the cores, and some do not have any product number on them. Some are listed as “Code Approved” (e.g., by codes from Building Officials and Code Administrators International or U.S. Department of Housing and Urban Development). There was nothing exceptional in the product specifications to separate the approved from non-approved tapes.

Catalogues call the different tape grades Economy, Utility, General Purpose, Contractor, Industrial, Professional, Premium and even Nuclear! They are all listed as being used on HVAC ducts. Several companies have recently produced UL 181B-FX [9] tapes that were not listed in product catalogs when this study was performed. While we have not investigated mastics as much, there seems to be fewer grades. There are fewer grades of mastics for use as duct sealants, and a few mastics are currently UL 181B-M [9] approved although many are UL 181A [10].

4. Longevity Test Results

When the aging experiments were started it was expected that it would take weeks to begin to see degradation in performance. Surprisingly, some of the sealants failed in a matter of days. Most of the failure modes to date have been what might be termed catastrophic rather than gradual. In other words, the seal does not gradually become poorer with time, rather the seal is maintained and then fails rapidly. This is in some ways fortunate because determining an exact numerical failure criterion is somewhat arbitrary. Nevertheless, the following failure criterion was selected based on the results of preliminary testing such that a good seal is adequately differentiated from a failed seal. The criterion was that a seal has failed when it lets more than 10% of unsealed flow pass through. Analysis of the test results showed that the passing or failing of a sample is not strongly dependent on this failure criterion. i.e., sealants did not fail a little bit (e.g. at 20% of unsealed leakage) and then stop. Most samples were tested past this 10% failure criterion and showed continual degradation.

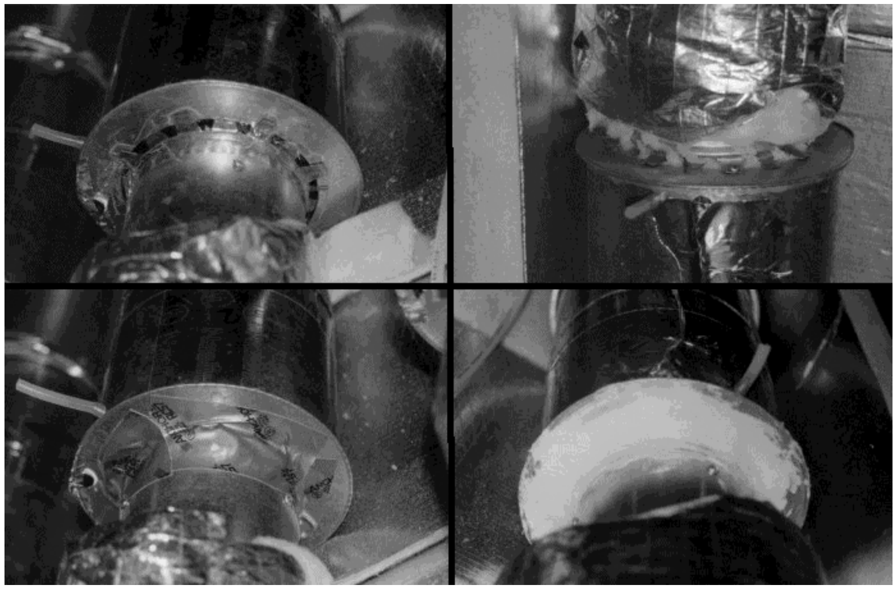

Figure 5. Four samples connections for the aging test. Clockwise from top left: clear UL 181B tape, aerosol sealant, mastic and 181B-FX duct tape.

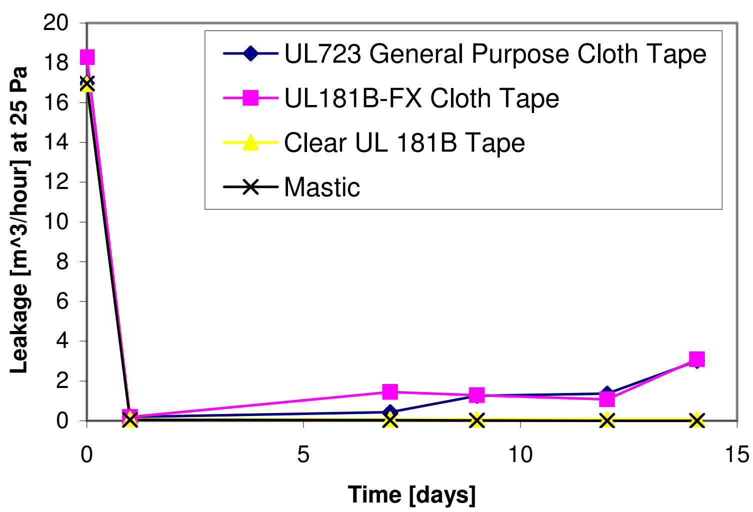

Figure 6a. Changing test sample leakage at 25 Pa, from the aging apparatus

Figures 6a and 6b show the change of leakage for some early samples with time in the aging apparatus. The initial high leakage number (about 17 m^3/hour (10 cfm) @ 25 Pa) is the leakage of the sample connection before the sealant was applied. All of the rubber backed tapes showed visible signs of failure within about 3 days of the start of the test. Visible signs include shrinkage of the vinyl or polyethylene backing and wrinkling and delamination of the vinyl or polyethylene backing and the reinforcing mesh from the adhesive. The measured leakage for the duct tapes shown in Figure 7 showed that samples had about 10% to 20% of the unsealed leakage after two weeks. The "Premium" tape failed completely (it fell off the test section), but the other tapes had just started to delaminate at this time. This complete failure was due to separation of the backing from the adhesive (some of the adhesive was left behind on the sheet metal). A second sample of the Premium Grade tape was tested to see if this was a repeatable failure; it lasted about 7 days before complete failure (note that this second sample is not shown in the figures). The foil backed rubber or vinyl adhesive tapes, the clear tape, the aerosol and the mastic show no visible or measurable signs of degradation after these two weeks of testing.

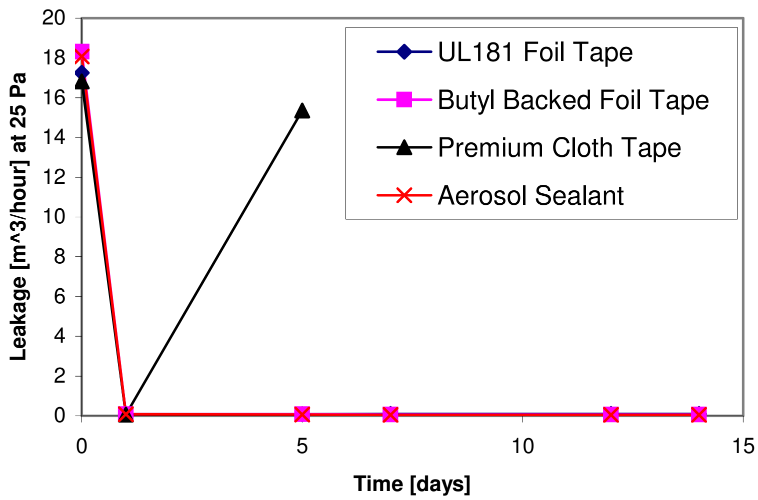

Figure 6b. Changing test sample leakage at 25 Pa from the aging apparatus

About 40 different samples have been tested in the three test apparatuses. Failure was determined either from visible catastrophic failure (e.g., the tape falls right off) or by a measurement that showed that the leakage was above 10% of the unsealed value. Because the only samples that have failed are duct tape, their results will be treated separately.

4.1 Duct Tape Results

Table 1 summarizes the 18 failed duct tape samples. Samples having the UL 181B-FX rating have been listed separately to determine if this rating can be used as an indicator of good longevity performance. The aging and baking test results indicate that there is no clear advantage for the UL 181B-FX listed tapes. Most of the duct tape samples failed within in a week in the aging test. One UL 181 rated and one non-UL 181 rated sample lasted for over a month.

Because the baking test does not stress the samples with either low temperatures, or more importantly pressure, time to failure is longer than for the aging test. There was a range of time to failure from a few days to several weeks. This indicates that some tapes have better longevity than others due to differences in materials or construction. Also, this indicates the possibility that manufacturers could reformulate existing duct tapes in order to improve their longevity performance.

Although the duct tape samples from the aging test have failed, some of the duct tape samples from the baking tests have not. A visual inspection of these baked samples reveals that most of the duct tape samples have delaminated and the heat has apparently caused the rubber adhesive to harden. It appears that some of the samples have hardened in such a way as to maintain their seal rather like a mastic material. Because this process of hardening to maintain the seal has happened without any pressure being applied, it is unlikely to happen similarly in real installations, as verified by the aging results. This hardening of rubber adhesives with application of heat is why silicone or urethane adhesives are used for more temperature resistant tapes.

Table 1. Summary of Duct Tape Failures

# of Test Samples	*Test Type*	*Description*	*Typical Failure Time*	*Final leakage at end of testing (fraction of unsealed leakage)*
8	Aging	5 different grades	7 days	20%-70%
5	Aging	181B-FX	10 days	70%-100%
4	Baking	3 different grades	34 days	30%-80%
1	Baking	181B-FX	60 days	25%

4.2 Other Sealant Results

Table 2 summarizes the results from all of the other sealants. These sealants did not fail after several months and can be considered to have good longevity performance compared with the duct tape. Significantly, the other tapes (butyl, foil and clear UL 181B) did not exhibit the shrinking of the backing and the delamination shown by the duct tapes. The aerosol and mastic showed no visible or measurable signs of degradation.

Table 2. Summary of non duct tape test results

# of Test Samples	*Test Type*	*Description*	*Duration*[1]	*Comments*
1	Aging	**Butyl Tape**	3 months	15mil; Foil Backed
1	Aging	**Aerosol**	3 months	
1	Aging	**Mastic**	3 months	181A
1	Aging	**Foil Tape**	3 months	181A-P [8] only
1	Aging	**Foil Tape**	1 month	181A-P & 181B
1	Aging	**Clear UL 181B Tape**	3 months	
1	Aging	**Clear UL 181B Tape**	1 month	181A & 181B
1	Baking	**Clear UL 181B Tape**	4 months	181 [9]
1	Baking	**Aerosol**	4 months	
1	Baking	**Foil Tape**	4 months	181A-P
4	Cycling	**Aerosol**	2 years	Pressure only
4	Cycling	**Aerosol**	2 years	Heat and Pressure

1- Note that duration does not indicate time to failure. It is the length of time the samples were tested in the apparatus.

5. Conclusions

Most duct tape fails prematurely when exposed for an extended period of time to elevated temperatures. Other sealants do not exhibit this premature failure. The test results did not show a correlation of longevity with mechanical strength, and the tapes with low strength (e.g., clear UL 181B tape) did well in this study. Because the purpose of a duct sealant is *only* to reduce leakage, the longevity test results are a better guide when selecting duct sealants than the mechanical properties currently given in manufacturers catalogues.

Future work will include

- a more detailed investigation of the effects of elevated temperatures by testing over a range of temperatures.
- testing of more sealants of all kinds
- development of an industry standard test method through ASTM.

6. Acknowledgements

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