Air Sealing Existing Homes with Foam-in-a-Can Rivals Energy Cost Benefits of CFLs

Douglas V. Bibee
Member ASHRAE

Katherine L. Johnson

Donald R. Nelson

ABSTRACT

This study was undertaken to quantify the energy saving benefits of one component spray polyurethane foam in existing homes. It is well known that reducing the air leakage of a home reduces energy use of that home. And it is generally accepted that foam sealants reduce air leakage. However, it is not well known how much energy savings can be expected from installation of foam sealants in various air leakage locations in existing homes. This case study demonstrates that simple, quick air sealing of existing homes with one component spray polyurethane foam sealant (foam-in-a-can) provides an average payback of 4 months and a 7 year return on investment (ROI) of 4400%. Compact fluorescent lights (CFLs) reportedly have a payback of 6 months and a 7 year ROI of 1400%. CFLs have been heavily promoted as the first step for consumers to consider when improving the energy efficiency of homes. DOE states, "Compared to other energy efficiency improvements, CFLs require substantially less investment, have no installation costs, and pay for themselves much more quickly" (DOE 2009b). However, the results reported here show that quick, easy installation of spray foam sealant in existing homes provides energy savings and financial benefits exceeding CFLs.

INTRODUCTION

There are about 128 million housing units in the United States and about 80 million of those are single-family detached homes (HUD 2008). Residential buildings use about 21%, or 21 quads, of the energy consumed in the U.S. (DOE 2009a). A quad is a quadrillion Btu, or 10^{15} Btu. EPA estimates that homeowners can typically save up to 20% of heating and cooling costs (or up to 10% of total energy costs) by air sealing their homes and adding insulation in attics, floors over crawl spaces, and accessible basement rim joists (EPA/DOE 2010). So, existing homes provide a huge opportunity to save energy, along with collateral benefits to the economy and the environment. Compact fluorescent lights (CFLs) have been heavily promoted as the first step for consumers to consider when improving the energy efficiency of homes. DOE states "Compared to other energy efficiency improvements, CFLs require substantially less investment, have no installation costs and pay for themselves much more quickly" (DOE 2009b). This contention is based on a payback of 6 months and a 7 year return on investment (ROI) of 1400% for CFLs (DOE 2009b). However, the case study reported here indicates that simple air sealing with one component spray polyurethane foam sealant (foam-in-a-can) provides an average payback of 4 months and a 7 year ROI of 4400%. This study demonstrates that quick, easy installation of foam sealant in existing homes provides energy savings and financial benefits that rival CFLs.

This study was undertaken to quantify the energy saving benefits of one component spray polyurethane foam in existing homes. It is well known that reducing the air leakage of a home reduces energy use of that home. And it is generally accepted that foam sealants reduce air leakage. However, it is not well known how much energy savings can be expected from installation of foam sealants in various air leakage locations in existing homes. This study utilized three elements to estimate energy savings attributed to application of foam sealants in existing homes: (1) careful measurement of the time and material required to air seal a particular location in an existing house, (2) a blower door test before and after the air

Douglas V. Bibee *and* ***Katherine L. Johnson*** *work in Dow Building Solutions R&D, Dow Chemical Company, Midland, MI.* ***Donald R. Nelson*** *is president of D.R. Nelson & Associates, Inc., Lake Orion, MI.*

sealing work to quantify how much air leakage was reduced as a result of the air sealing work, and (3) energy use calculations (AEC 2009) for the house to estimate annual energy savings attributed to reduced air leakage.

The study involved 11 homes built between 1926 and 2001 in Michigan, Indiana, and Ohio, representing typical one- and two-story construction on basements and crawl spaces. The scope of the project was limited to air sealing work and testing that could be accomplished in one day using one component spray polyurethane foam sealants.

MATERIALS

- Four air sealing products, each a one-component spray polyurethane foam:
    1. Consumer Gaps and Cracks—12 oz can, straw applicator
    2. Professional Gaps and Cracks—20 oz can, gun applicator
    3. Consumer Window and Door—12 oz can, straw applicator, low expansion pressure foam
    4. Professional Window and Door—20 oz can, gun applicator, low expansion pressure foam
- Minneapolis Blower Door from The Energy Conservatory
- Energy analysis software (AEC 2009)

PROCEDURE

The same general procedure was used on each home:

1. Visually assess potential air leakage locations on the exterior and interior of the home.
2. Determine air leakage locations that may be candidates for air sealing within the scope of our project – accessibility, time to complete work, appropriate for air sealing materials
3. Conduct initial blower door test at negative 20, 30, 40 and 50 Pa. The air pressure on the interior of the house was 20, 30, 40 and 50 Pa lower than air pressure on the exterior of the house which caused air to leak into the house. The initial blower door test provided a baseline air leakage rate for the house and allowed further assessment of air leakage locations using smoke pencil, touch and sight.
4. Decide which air leakage location to air seal first and which air seal product to use. This decision varied from house to house, but when the study was completed we wanted to have data for several different air leakage locations and each of the four foam sealant products within the scope of the project.
5. Prepare the location to be air sealed. For instance, if the rim joist is going to be air sealed, it may be necessary to remove fiberglass batt insulation from the rim joist prior to installing the foam sealant. Preparation time was measured but was not included in installation time.
6. Install one component spray polyurethane foam sealant in the first air seal location, e.g., rim joist, plumbing penetrations under sinks, around windows, etc. Keep accurate measurements regarding amount of foam sealant material used, time it takes to install foam sealant material, and size of air leakage location, e.g., lineal feet of rim joist, number of windows.
7. Conduct a second blower door test at the same conditions as the initial blower door test. This allows determination of air leakage reduction resulting from installation of foam sealant in the first air seal location.
8. Decide which air leakage location to air seal second and which air seal product to use.
9. Prepare the location to be air sealed.
10. Conduct a third blower door test at the same conditions as the first and second blower door tests. This allows determination of air leakage reduction resulting from installation of foam sealant in the second air seal location.
11. Steps 8, 9, and 10 were repeated for up to 4 air leakage locations on a single house.
12. Gather detailed measurements, equipment descriptions, and characteristics of each home for required input into REM/Rate.
13. Use REM/Rate to calculate expected heating and cooling energy use and energy cost for the initial air leakage rate and each subsequent air leakage rate associated with installing foam sealant in an air leakage location.
14. A day of testing at each house provided the following primary data: amount of foam sealant material and time to air seal each air leakage location, size of air leakage location, air leakage reduction attributed to air sealing each air leakage location, and energy and cost savings attributed to air leakage reductions for each air leakage location.

RESULTS

On a single house, from one to four air leakage locations were sealed using foam sealant. The air leakage locations included rim joist, sill plate, penetrations through rim joists, plumbing penetrations under sinks, gap at wall/floor intersection, exterior underside of bay window, top of balloon frame stud cavities in attic, can lights sealed to gypsum board ceiling, and perimeter of windows. Figures 1–5 illustrate examples of air leakage locations and applied spray foam sealant.

Table 1 reports results from air sealing rim joists of 9 houses. Similar data sets were collected for other air leakage locations and other houses. Table 2 summarizes average energy savings, payback, and ROI data for all products for all air leakage locations on all houses.

CONCLUSIONS

1. Payback and ROI for spray foam sealants applied in existing homes indicate that simple, quick air sealing by

Figure 1 *Spray foam sealant applied to rim joist and sill plate.*

Figure 2 *Spray foam sealant applied to rim joist, sill plate, and penetration through rim joist.*

Figure 3 *Foam sealant applied to gap between recessed light and ceiling.*

Figure 4 *Foam sealant applied to perimeter of window.*

Figure 5 *Foam sealant applied to plumbing penetrations under sink.*

homeowners or professionals can yield very attractive energy savings and financial benefits.

2. Spray foam sealants had paybacks from 2 weeks to 9 months and a one-year ROI of 145%–2370%, depending on air leakage location and product used.
3. When all air leakage locations, products, and houses for this study were averaged together, payback for spray foam sealant was 4 months with a one-year ROI of 630% and a seven-year ROI of 4400%. CFLs reportedly have payback of 6 months and a seven year ROI of 1400% (4).
4. Air sealing of existing homes must include consideration of maintaining adequate ventilation in the home after the work is finished.
5. Spray foam sealants should be promoted with the same vigor as CFLs by utility companies and government agencies interested in motivating homeowners to reduce home energy usage.

Table 1. Example of Data Set for Air Sealing Rim Joist

Home Location	Year Built	Rim Joist Sealed, lineal ft	Air Seal Product Used	Quantity of Air Seal Product Used, cans	Price of Air Seal Product, $/can	Cost of Air Seal Product Used, $	Labor to Install Air Seal Product, man hours	Base Whole House Air Leakage at 50 Pa, cfm	Air Leakage Reduction by Sealing Rim Joist, cfm	Base Whole House Heating and Cooling Estimate, MMBtu/yr	Heating and Cooling Savings as a Result of Sealing Rim Joist, MMBtu/yr	Base Whole-House Heating and Cooling Estimate, $/yr	Whole-House Heating and Cooling Savings as a Result of Sealing Rim Joist, $/yr
Cedaridge Dr.	2001	57	Con G&C 12 oz can	6	3.79	$22.74	4	2455	144	133.9	2	1932	$26
Dilloway St.	1975	202	Pro G&C 20 oz can	5	7.26	$36.30	3	2500	189	187.9	3.2	2097	$33
Sharon Valley	1961	149	Con G&C 12 oz can	9	3.79	$34.11	3	2600	250	98.7	2.2	1357	$27
Kingsville	1947	107	Con G&C 12 oz can	5	3.79	$18.95	2	3100	225	181.9	3.5	2078	$36
St. Andrews	1939	108	Con G&C 12 oz can	6	3.79	$22.74	1.3	2990	290	157.9	3.6	2206	$48
Cornelius Av	1931	106	Con G&C 12 oz can	9.3	3.79	$35.25	1.5	5243	462	262	8.1	3300	$96
Canyon Road	1992	110	Pro G&C 20 oz can	3	8.7	$26.10	2	5100	225	159.4	2.5	3574	$55
Wimpole	1963	80	Pro G&C 20 oz can	2	8.7	$17.40	0.75	4150	325	159.4	15.2	1883	$157
Charles St.	1926	95	Pro G&C 20 oz can	2.5	8.7	$21.75	1.75	5520	745	254.2	12.2	3383	$163

Table 2. Savings Summary

Air Sealing Product Used Air Sealing Location	Average Energy Saved Per House, MMBtu/yr	Average Energy Saved Per House, Kwh/yr	Average Energy Cost Savings Per House, $/yr	Average Number of Cans Per Application, cans	Average Investment in Material Per Application, $	Average Payback Time, months	Average 1 Year Return on Investment, %	Average 7 Year Return on Investment, %
Consumer Gaps & Cracks								
Rim Joist/Sill Plate/Penetrations	3.8	1113	44	6.7 (12 oz)	28.34	9.4	160	1086
Plumbing Penetrations Under Sink	2.8	820	45	0.5 (12 oz)	1.9	0.5	2370	16500
Gap at Wall/Floor Junction	0.5	146	6	0.15 (12 oz)	0.57	1.1	1055	7368
Professional Gaps & Cracks								
Rim Joist/Sill Plate/Penetrations	10	2930	125	2.5 (20 oz)	21.75	2.8	600	4000
Exterior of Bay Window/Cantilever	0.4	117	5	0.25 (20 oz)	2.18	5	230	1600
Top of Ballon Frame Wall Cavities in Attic	4.1	1201	53	2.5 (20 oz)	21.75	5	240	1700
Consumer Window & Door								
Can lights sealed to gypsum ceiling	1.1	322	12	0.5 (12 oz)	2.49	2.5	480	3300
Two Windows	1.6	469	27	1.25 (12 oz)	6.23	2.7	430	3000
Professional Window & Door								
Four Windows	0.3	88	4	0.25 (20 oz)	2.75	8	145	1000
Average for All Applications						**4**	**634**	**4395**

6. Observations during the study identified other large opportunities to save energy in existing homes, which were outside the scope of this project, e.g., a scope of work that included two days of work or use of two component spray polyurethane foams and rigid foam insulation boards to cover larger areas could also provide attractive energy savings and financial payback.

FUTURE RESEARCH OPPORTUNITIES

1. Return to the same houses and quantify energy savings of additional air sealing measurers (attics, ducts, etc.)
2. Conduct a similar study in a warm climate to include slab-on-grade foundations.
3. Use a larger population of houses to confirm conclusions of this case study (university, government agency, utility, etc.).

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