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Case Study:
Houston, Texas

Home Construction Type:
Existing Residential Construction

Houston, We Have A Solution

Comfort and Energy Savings With Open Cell Spray Polyurethane Foam

Uncomfortable rooms and high energy bills are common problems. Some of these problems can be found in homes that are 100 years old. But, many of these problematic homes were built just 5, 10 or 15 years ago. This two-story home near Houston, Texas is a perfect example of a relatively new, poorly performing home. Like most frustrated homeowners, the first call went to heating, ventilation and air conditioning (HVAC) contractor. According to the HVAC contractor, a newer, more efficient unit would improve the energy bills and an extra half ton of cooling capacity would solve the comfort issues. However, one quick look in the attic would have revealed a number of insulation issues that were affecting both the bills and occupant comfort level.

Behind the Building:
Location: Houston, Texas
Home Size: 3,782 sqft.
Climate Zone: 2
Home Construction: Wood Frame

Dollars & Common Sense:
- ~20% reduction in heating and cooling costs
- 36% reduction in the natural air changes per hour
- > 2 metric tons of CO_2 emission reductions per year*

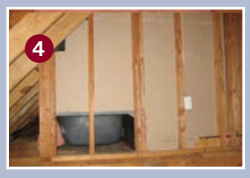
*Based on EPA e-grid 2006 and data from CarbonFund.org

The solution was not to replace the HVAC equipment, but to fix the attic insulation. The choice was obvious, use open cell spray polyurethane foam (SPF). However, there was a decision about the foam configuration — should it be applied to the attic floor or should it be applied to the underside of the roof deck to create an unvented attic assembly?

This case study explores what decision was made, its ramifications on the house as a system, and finally the energy savings.

There were numerous insulation problems found in the attic, only some of which are noted here:

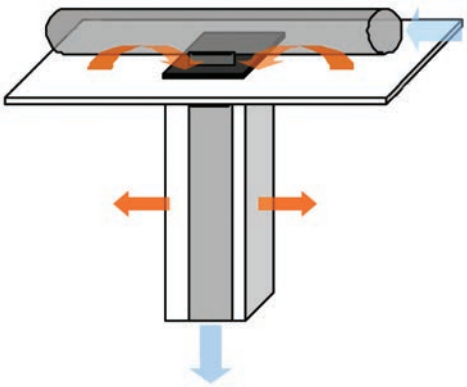
1. **Open walls at furr downs**
2. **Open flooring system**
3. **Insulation on the garage ceiling, but not on the bedroom floor**
4. **Bath tub area**
5. **Open duct chases**



Existing Conditions

This home, like many in Texas, was built on slab with a vented attic. The unconditioned attic space had two water heaters, furnaces, air handlers and duct systems. Both the hot water heaters and furnaces utilized natural draft combustion. The summer attic air temperature averaged 112°F, with a number of days reaching over 120°F.

Many insulation problems in an attic start with a misunderstanding of how insulation works. If air is able to move through or around the insulation, the insulation is not performing. This home had open duct chases — hot air filled the duct chase (or open wall cavity), transferring heat to the conditioned space.



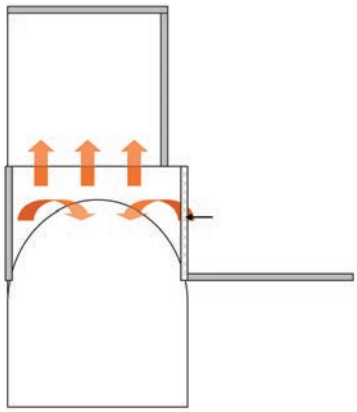
Heat transfer through open chases

In another example, a huge amount of surface area was left uninsulated as unsupported fiberglass batts were placed in between the vertical studs, rather than against the gypsum board. Hot attic air easily passed to the other side of this insulation through massive openings in several areas leaving both the home's dining room ceiling and the play room floor completely uninsulated.

In addition to poor insulation, the home was found to be leaky. A blower door test measured 6,358 cubic feet per minute (CFM) @ 50 Pascals or 0.52 natural air changes per hour. This means that 52% of the air in the home is replaced with outside air every hour, resulting in higher heating and cooling costs.

Approximately $3,500 - $4,000 was spent in energy costs per year, not including service charges. A little less than half, or $1,650 - $1,900, was spent on heating and cooling. Spray foam allows for retrofitting of attics in both vented and unvented configurations.

While converting to an unvented attic was preferable from an energy reduction standpoint, there were other issues to consider:



Uninsulated open flooring system

Vented or Unvented

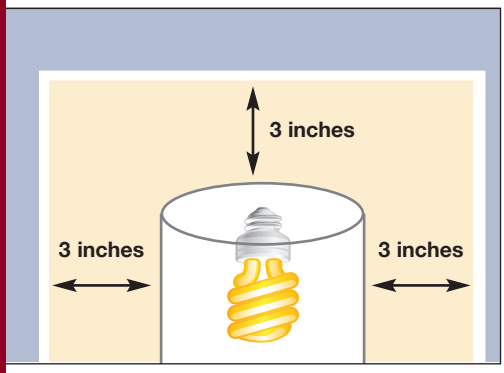
1. Since the open combustion appliances would now be located within the pressure envelope of the house, they would need to be replaced with sealed combustion equipment. This would prevent spillage, back drafting or flame roll-out.
2. The attic's geometric shape would have required additional work to completely and efficiently seal the attic.

While a vented attic would not have the same energy benefits that an unvented attic would have, it would fix the insulation issues. Additionally, it would add R-value and tighten up the home.

Unvented Attic Pros	**Vented Attic Pros**
• Puts ducts and equipment in conditioned space • Reduces radiant load • Air seals • Provides additional R-value • Fixes existing insulation issues	• Less expensive – less area to insulate • Relatively straight forward application • Air seals • Provides additional R-value • Fixes existing insulation issues
Unvented Attic Cons	**Vented Attic Cons**
• More expensive • Replacement of two open combustion furnaces and two open combustion water heaters ($$) • Attic geometry made certain areas difficult to address	• Ducts and equipment still outside conditioned space • No reduction of radiant load on attic • Addressing can lights

Attic complete after blown-in fiberglass install

Spray foam seals open duct chases



Ideal method for insulating around can lights with SPF

The decision was made to spray the attic floor with five-and-a-half inches of open cell SPF. Three-and-a-half inches of fiberglass was blown-in on top of the spray foam. Utilization of the fiberglass provided not only R-13 of insulation, but also the ignition barrier required by code. For vertical sections, an intumescent coating was sprayed onto the foam as the ignition barrier.

Starting the Job

The existing insulation was removed. Open cell SPF was then applied to the depth of the 2X6s, followed by an application of intumescent coating on vertical surfaces. During application, the HVAC system was shut down, the combustion appliances were switched off and a ventilation fan was used to pull air from the attic and out through a soffit. The occupants spent the night away from the house, entering no sooner than 24 hours after completion of the spraying. The blown-in fiberglass was installed the following day.

This installation fixed all of the attic issues. For the open duct chases and open walls, polyiso board was used to provide a surface to apply the SPF. The result was an airtight chase and a significant reduction in heat transfer area. In addition, it also resulted in a decrease in duct leakage to the outside.

For the open flooring system, polyiso boards were used to close off the space between the dining room ceiling and the playroom floor. Spray foam was then applied directly to the gypsum board ceiling, the floor of the playroom, and along the polyiso board bridge between the two.

Ultimately, the savings for this configuration would be slightly less than converting to an unvented attic, but the installation was done at a much lower cost, while still saving money and increasing comfort.

Addressing Recessed Lighting

There were 11 recessed lights in the attic floor that had to be addressed. Each light was covered with a non-combustible sheet metal box giving a minimum three inches of clearance to the light. Each box was then air sealed with one to two inches of open cell spray foam. Lastly, the homeowner switched all the bulbs to compact fluorescents, greatly reducing the heat generated by the bulbs and the temperatures surrounding the fixtures.

Air Tightness

Air leakage is a key factor in the overall energy usage of a home. In hot humid climates, like Texas, air leakage from the outside can introduce moisture into assemblies. Once there, it could possibly condense and create mold and durability issues on the backside of the interior sheathing. Because SPF expands rapidly to fill gaps and cracks, it can significantly reduce air leakage in retrofit applications.

During the initial blower door testing, a third party energy auditor found the home to measure 6,358 cubic feet per minute (CFM) @ 50 Pascals or 0.52 natural air

changes per hour. After the SPF application, the blower door test measured 4,038 CFM @ 50 Pascals, a reduction of 36%. With this improvement, only 33% of the home's air will be changed out every hour, saving energy, reducing uncomfortable drafts, and lowering the potential for moisture problems.

Open cell foam being installed

Mechanical Considerations

Since the house works as a system, the mechanical systems were evaluated along side the insulation and air sealing activities. In this case, no combustion safety concerns were introduced by leaving the attic in a vented configuration. A switch to an unvented attic system would have necessitated new sealed combustion furnaces and water heaters.

Lastly, the short cycling potential of the A/C units was evaluated because short cycles shorten equipment life and reduce the unit's ability to remove moisture and keep indoor humidity in a comfortable range. Given that the existing A/C units could barely keep up in the summer, there was little risk that the A/C units would begin to short cycle due to the reduced load.

Spray foam fixes open flooring system

Comfort

Studies show that comfort goes beyond just the indoor air temperature. Comfort is affected by humidity, drafts, and the mean radiant temperature (MRT). The occupants of this home suffered from poor comfort. It always felt cold in the dining room. The play room was always the most uncomfortable room in the house. Additionally, the A/C was not able to keep the upstairs cool in the summer. Properly insulating these surfaces with SPF greatly increased comfort.

In addition to improving comfort by eliminating uninsulated surfaces, the upstairs A/C can now easily keep up with the reduced load in the summer. Now, the uncomfortable playroom is one of the most comfortable rooms in the house.

Savings

An analysis was conducted based on real first year utility bills to determine energy savings resulting from the SPF application. Adjusting for weather using heating and cooling degree days, the retrofit is estimated to annually save 145 ccf of natural gas and ~2100 kWh of electricity, translating into:

- **$355 of savings per year**
- **~20% reduction in heating and cooling costs**
- **Over 2 metric tons of CO_2 emission reductions per year***

* Based on EPA e-grid 2006 and data from CarbonFund.org

Conclusion

While it may be tempting to call a HVAC contractor to solve high energy bills and comfort issues, the problem may in fact lie somewhere else, such as poor attic insulation. Simply changing out the A/C units would have saved energy dollars, but it would have failed to solve the comfort issues. A properly insulated attic via a combination of SPF, fiberglass and polyiso board provided a reduction in energy demand, reduced air infiltration and lower bills. Most importantly, it lead to an increase in occupant home comfort.

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