Using Infrared for Residential Energy Surveys

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ABSTRACT

In the electric industry today, advising consumers on energy conservation has replaced selling energy use with the introduction of energy surveys and audits for commercial as well as residential accounts. Home energy efficiency evaluations for residential accounts are now the norm on a daily basis for most electric utilities.
Infrared scanning of residential homes to determine construction factors can pinpoint areas of heat gain and loss that were impossible to find using former methods. This paper shows how the energy efficiency of the home envelope and interaction with the air conditioning and heating equipment can be assessed with greater clarity.

Performing infrared scanning with thermal imagers gives us data that allows us to advise consumers on ways to increase the efficiency of the home, as well as pinpoint areas of maximum concern.

Keywords: infrared, heat gain, heat loss, insulation, duct work, supply leaks, return leaks, thermal ducting, pressurization, depressurization, temperature differentials

INTRODUCTION

This paper will discuss the advantage infrared thermography provides in audits and energy surveys that assess the energy efficiency of the normal residential structure and HVAC (heating, ventilating, and air conditioning) installation. In making these assessments, care must be given not only to insulation and infiltration issues, but to the interactional relationships between the building envelope and the mechanical air distribution parts of the HVAC system as well. If these interactions are not balanced and in harmony, energy efficiency suffers as well as the indoor air quality of the dwelling, causing excessive energy usage and potentially aggravating some health issues. Infrared scanning makes finding these problem areas much easier. Combined with digital photography, it can greatly enhance the consumer's understanding of just what the problem is and how to go about having it repaired. It also enhances the consumer's ability to deal with the contractors that may be performing the repair work.

Most of the problems we find are based in the following four areas:

1. Building envelope construction and insulation
2. Infiltration affected by the HVAC system
3. HVAC system supply leaks
4. HVAC system return leaks

The use of infrared thermal imaging cameras makes it easier to positively pinpoint problems in these areas instead of just making educated guesses. It also allows us to communicate these findings with greater understanding to the homeowner instead of just "speaking another language." As one homeowner put it, "This lets my eyes make sense of what my ears are hearing."

1. BUILDING ENVELOPE CONSTRUCTION AND INSULATION

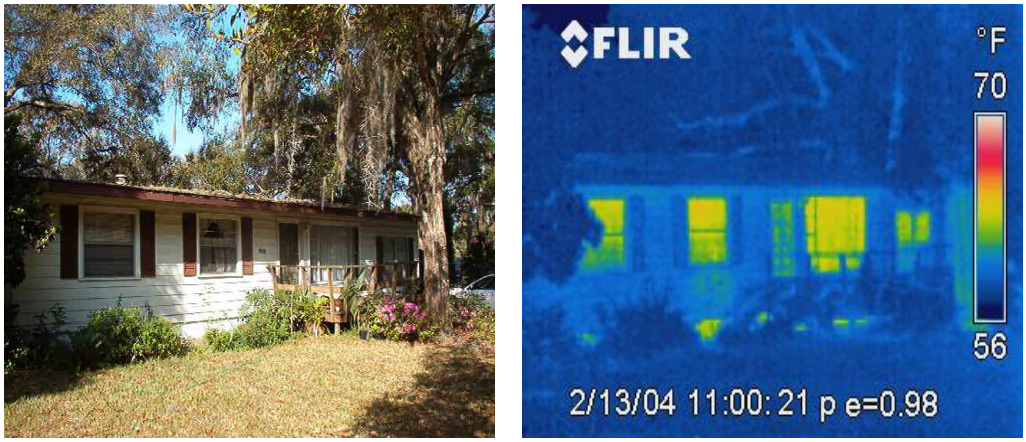

Figure 1. Areas of winter heat loss in a single-story existing dwelling

New home construction and insulation requirements have improved greatly over the last few years. Most states either have or are working on energy rating programs that conform with the Federal Environmental Energy Efficiency guidelines; however, most existing homes and quite a few of the new ones built today have areas that could be greatly improved. In Figure 1, this home looks cozy enough in this winter setting, but infrared shows areas of significant heat loss through the windows, doors, and even under the floor level in the crawl space. Ceiling insulation here appears adequate, but floor insulation is lacking.

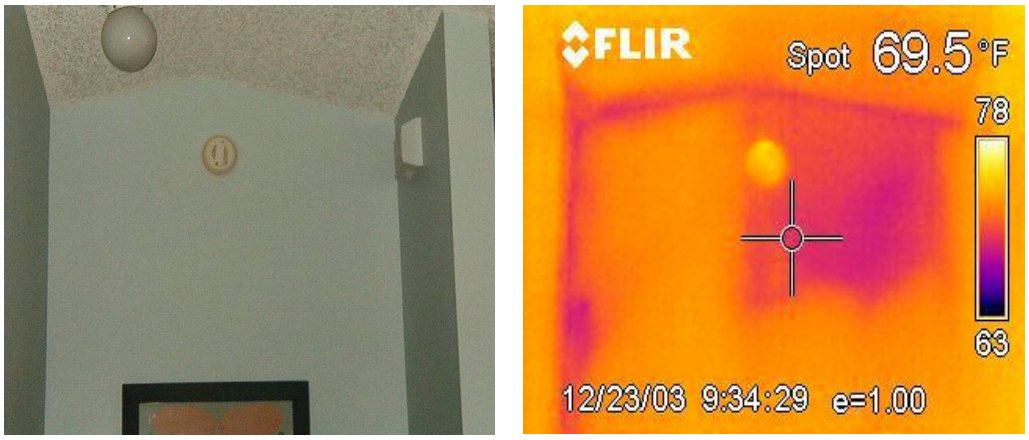

Figure 2. Areas of heat loss through a standing wall that is not insulated

Standing walls in a home that are not adequately insulated can be significant areas of heat loss or gain, especially when large temperature differentials occur on each side. Figure 2 shows large gaps in the standing wall insulation between different ceiling heights. Attic inspection revealed that the insulation had been pulled away from the wallboard, allowing cold attic air to get behind the insulation and cause heat loss into the attic. The problem was evident in several areas of the same home.

Figure 3. Ceiling penetration and insulation problem

Ceiling penetrations can be significant heat gain or loss areas if numerous and not adequately sealed. In Figure 3, the fixture was not on, and the thermograph revealed that the insulation around the fixture was not adequate. Attic inspection revealed that the insulation had been pulled away from the fixture on all sides and that the fixture was not sealed.

2. INFILTRATION AFFECTED BY THE HVAC SYSTEM

Pressure variances inside the home, i.e., pressurization or depressurization, can greatly affect the running time of the HVAC system. Since the HVAC is the largest energy user in the modern home, extended running time can be a significant factor in energy consumption.

Figure 4. Thermal ducting inside a hollow wall behind the thermostat

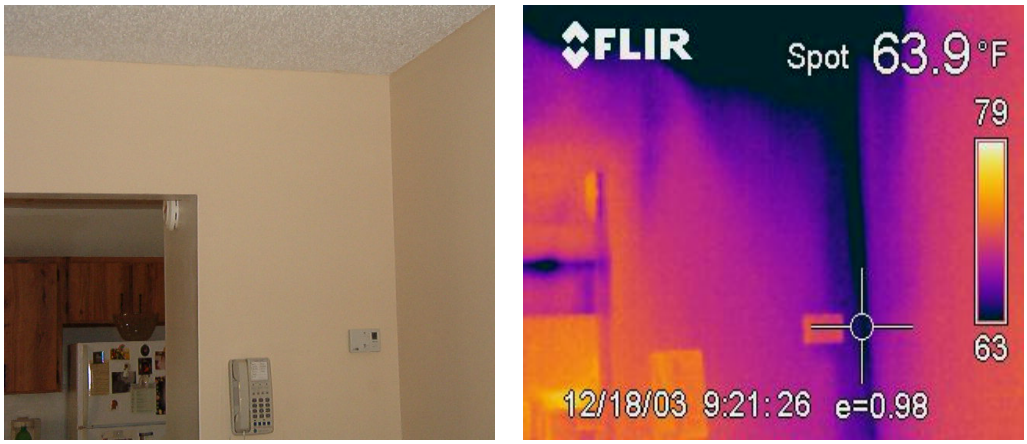

Figure 5. Cold air being drafted in a hollow wall behind the thermostat

Without the use of an infrared thermal imaging camera, one of the hardest problems to find in a home is the existence of thermal ducting inside the wall structure affecting the regulation of the system. This phenomenon affects the HVAC running time by infiltration of humidity and heated air into the conditioned space. It can also affect the thermostat by heating or cooling the wall behind it, thereby greatly extending the time the thermostat calls for conditioning. Figure 4 illustrates this phenomenon very clearly. The return was cut through a hollow wall, and the passage was not sealed from the wall cavity. When the unit was running, the resulting low pressure inside the return passage lowered the pressure inside the wall, and hot attic air moved in to replace it. The thermostat visible on the wall was set at 80°F, but the wall temperature just under it was 87°F. This caused the unit to keep running almost constantly. Without the thermograph, this problem would be difficult, if not impossible, to find. Figure 5 shows the same ducting situation in another home during the winter heating season. Notice the cooling of the wall behind the thermostat.

When running a system with a single return and the interior doors closed, pressurization occurs within the closed rooms. This also causes exfiltration of conditioned air in the pressurized rooms and infiltration of outside non-conditioned air in the depressurized area.

3. HVAC SYSTEM SUPPLY LEAKS

HVAC system supply leaks are one of the most significant problems causing higher energy usage in today's homes. The leaks in a ductwork system outside the conditioned space allow air to be lost to the outside and will depressurize the entire home, as in Figure 6. This will pull in outside air from all the infiltration routes in the home previously mentioned. This adulteration of the conditioned space can be significant enough to greatly extend the running time of the unit, since most of the make-up air is usually brought in from the attic.

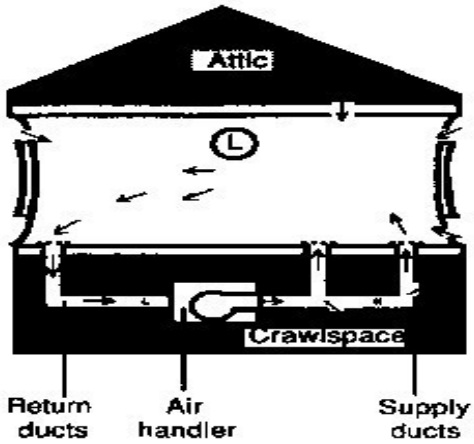

Figure 6. House depressurization due to supply duct leaks [1]

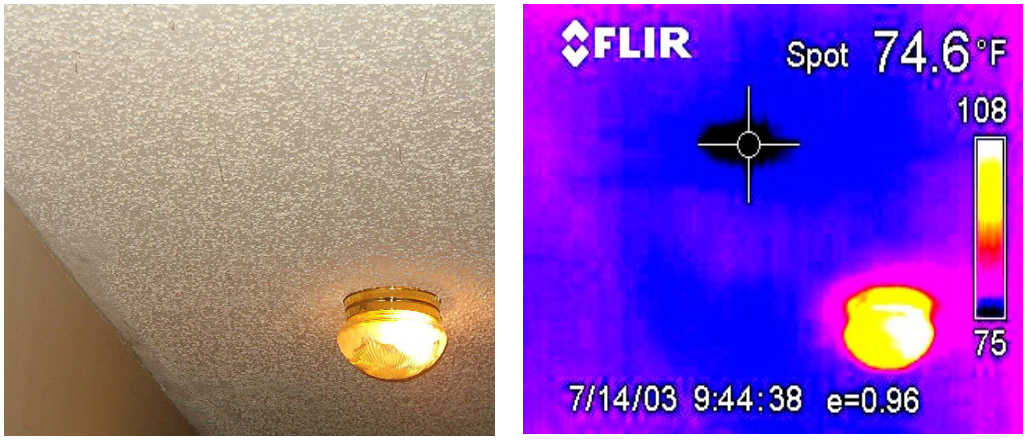

Figure 7. Cold spot on hall ceiling caused by supply junction leak in attic over ceiling board

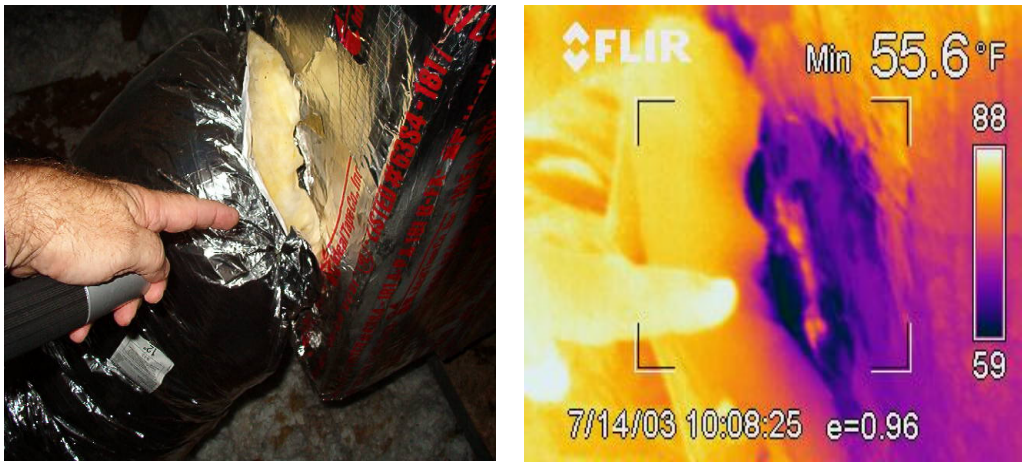

Figure 8. Supply junction of flex duct and disbursement box that was not sealed or taped

Figure 7 shows a cold spot on the hallway ceiling that indicated a possible leak in the supply system in the attic of this home. Attic inspection showed exactly that, as seen in Figure 8. In fact, the entire supply ductwork system in this home was leaking significantly at every junction, as well as the connection with the ceiling supply inlets, losing conditioned air into the attic. The thermograph, showing a cold spot where none should be, led to a significant find that otherwise could easily have been missed.

The most difficult supply leaks to find are those that are buried under the blown-in insulation. These can go undetected very easily, but in Figure 9 we see that the infrared will pick up the conditioned air infiltrating the insulation and indicate the leak. This leak was found in January during the heating season and was substantial, as seen by the amount of heated air shown infiltrating the insulation.

Figure 9. Supply leak showing heat loss under blown-in insulation

4. HVAC RETURN SYSTEM LEAKS

Return system leaks can greatly increase the amount of time that the HVAC system runs. If the return ducts are in the attic space, very hot, moist air can be drawn into the system, causing extended running times. In this situation the supply air will be significantly warmer than required, causing the unit to run longer to reach the thermostatic cut off. Also, because of the higher moisture, the unit must also run even longer to reach the dew point for conditioning the air. Figure 10 shows a leak in the return plenum at the air handler in the attic of a home in summer pulling in hot, moist air. The infrared shows the temperature of the coil that is visible inside the air handler at 44.2°F. The air in the attic was over 80°F. This leak was found by scanning the plenum with the infrared thermal imaging camera and noting the cold spot. Visual inspection with a flashlight found the problem. This home had all the symptoms: high humidity, unit running constantly, and very high utility bills.

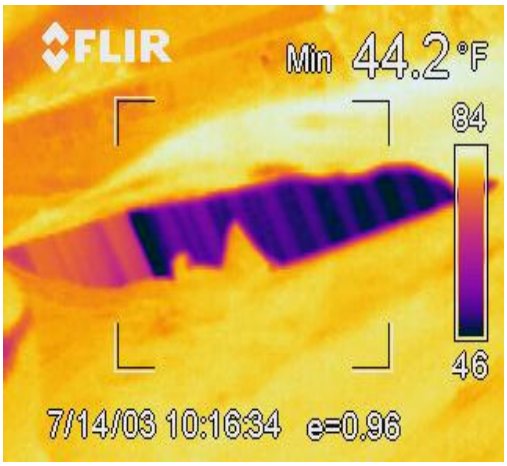

Figure 10. Large leak in return plenum at air handler

Return leaks also significantly increase the pressure inside the house by drawing in air from outside the system as shown in Figure 11. This excess air is drawn in and compressed by the large blower in the air handler. This causes the increased pressure of the conditioned air inside the home to seek equalization by escaping through the normal infiltration routes to the outside.

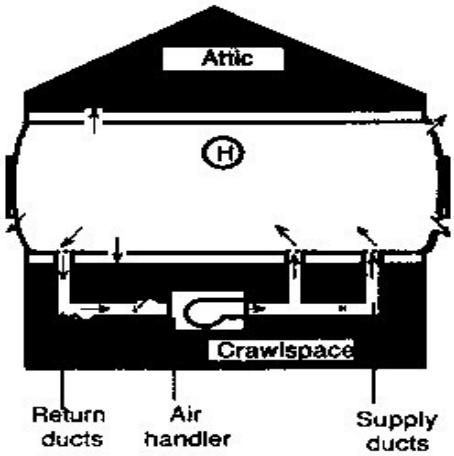

Figure 11. Home pressurization due to return duct leaks [2]

SUMMARY

As the costs of maintaining a home increase in today's market, the number of residential energy survey requests has risen dramatically. Infrared thermography imaging integrated into a comprehensive energy survey program is proving to be a definite value-added service for our consumers.

REFERENCES

Illustrations of pressure changes in homes:

[1], [2] Falk, Katherine. September/October 1993. “Discovering Ducts, An Introduction.” *Home Energy Magazine.*

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