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**Ohio Department of Development
Office of Energy Efficiency
Home Weatherization Assistance Program
Field Site Investigation**

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Creators of CheckMe!®



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INTRODUCTION

In 1997, Proctor Engineering Group (PEG) conducted a field site investigation of participant houses for the 1994/95 program year Ohio Home Weatherization Assistance Program (HWAP). The study included site visits to 57 participant houses serviced by fourteen weatherization agencies. This report summarizes the results of the study.

Background

The Ohio Department of Development (ODOD), Office of Energy Efficiency (OEE), has oversight responsibility for the HWAP. In August 1995 the OEE issued an RFP for evaluation services. The goal of the evaluation was to gain the knowledge necessary to guide the OEE in making improvements to the program. The OEE selected PEG to provide an impact evaluation of the 1994/95 HWAP. A comprehensive impact evaluation was designed. The evaluation included extensive data collection and conditioning, a pre/post billing analysis, and a field site investigation.

Allowable Program Measures

The 1994/95 Ohio HWAP included basic weatherization measures and diagnostic procedures. The diagnostic procedures were used in assessing building shell leakage and heating system performance and safety. The allowable measures included:

- attic, sidewall, floor and perimeter insulation
- blower door guided air sealing
- heating system efficiency modifications (including system replacements, vent dampers, retention head burners, etc.)
- combustion system safety repairs
- general heat waste building repairs
- duct sealing and insulation
- water heater insulation and low flow shower heads

Goals

The primary goals of the site visits were:

1. assess the quality of the diagnostics performed by agency personnel for houses treated in 1994/95 program year in terms of potential missed opportunities for energy savings;
2. evaluate health/safety measures which were/were not installed;
3. evaluate the installation quality of the measures;
4. determine whether there are any characteristics of the buildings, occupants or work performed which can help identify houses that had either higher or lower energy savings than the norm;
5. enhance the process evaluation by providing in-field in-person feedback from the clients;
6. provide case-studies for use in training staff from the delivery agencies.

FIELD INVESTIGATION

Weatherization program delivery and housing stock characteristics can vary widely within a state. Potential savings differences realized by a weatherization program can vary not only due to type and quality of housing stock, but also by delivery of services by individual agencies, the technical expertise and application of measures by the staff implementing the program. The field investigation was designed to examine the work performed by the agencies and determine what practices/traits were common, if any, among the various saver groups.

Sample

The sample included 57 homes, serviced by fourteen weatherization agencies. Seven of the agencies service urban areas and seven service rural or small city areas. The high savers group contained 21 homes, the mid savers group contained 16 homes, and the low savers group contained 20 homes.

The overall sampling plan was to select 10 agencies that were representative of the program and then select six houses from each of these agencies. Agencies were selected to cover a mix of rural and urban areas with varying levels of perceived sophistication and differing housing types. The houses were selected from gas heated single family homes that did not receive joint utility weatherization and had reliable billing analysis savings results. For each agency, PEG planned to select two houses from each of the high, mid, and low savers groups to examine the range of outcomes. PEG defined low savers as houses with savings in the 5th through 25th percentile of savings (approximately -150 to +60 ccf/yr), mid savers as 40th through 60th percentile of savings (approximately 130 to 290 ccf/yr), and high savers as 75th through 95th percentile of savings (approximately 380 to 850 ccf/yr). The initial sample selection chose a random sample of houses meeting the criteria from each agency. Additional agencies and houses were added to the process as houses dropped out of the sample due to scheduling difficulties or changes in occupancy. The local agencies were very helpful in arranging the logistics of the site visits.

Table 1-1 further details the final sample for each savings group by the average savings level, pre-weatherization gas consumption, and cost.

	High Savers	Mid Savers	Low Savers
Average Pre-Weatherization Consumption (ccf/yr)	1769	1371	944
Average Gas Savings (ccf/yr)	555	210	- 22
Average Cost per House	\$1524	\$1067	\$489

Table 1-1 Sample Average Pre-Weatherization Consumption, Gas Savings Level, and Cost per House

Site Evaluation Procedures

A component of the impact evaluation was the performance of field site inspections to participant homes. The field site visits were completed by Don Michael Jones of Residential Building Analysis. Detailed data collection and diagnostic procedures were used in gathering the data. PEG accompanied Mr. Jones on the first six houses to test and refine the data collection and diagnostic procedures. The data collection and diagnostic procedures included:

- twenty question client interview;
- comparison of the original work order with the measures installed and still present;
- visual inspection of all work performed;
- combustion safety testing of all combustion appliances;
- efficiency testing of heating systems;
- blower door air leakage and pressure diagnostics testing;
- hot water flow rates (showerheads and leaks);
- infrared camera scan

Findings -- Client Interview

Clients were interviewed to determine what, if any, changes had been made that could account for their level of savings. The questions focused on occupancy changes, heating system usage, additional weatherization, remodeling or renovation to the home, overall satisfaction with the program, changes in comfort level since weatherization, and their recollection of the energy education component of the program. The high saver group includes 20 homes with completed client interviews (one interview was not completed).

Client reported occupancy changes should be viewed with some uncertainty. The clients may have not been completely honest due to concerns about eligibility criteria based on occupancy. Mr. Jones noted that in some situations it was obvious that the number of reported occupants was not correct based on his observations in the home. Having said that, the high savers group was more likely to have had a client reported occupancy change than either the mid or low savers. Thirty percent of the high savers group (6 of 20) had an occupancy change while the mid and low savers experienced only 6% (1 of 16) and 15% (3 of 20) respectively. Additionally, the high savers group was more likely to experience a negative occupancy change. Four of the six high savers homes reporting an occupancy change reported now having fewer occupants in the home. Figure 1-1 illustrates the change in occupancy by saver group.

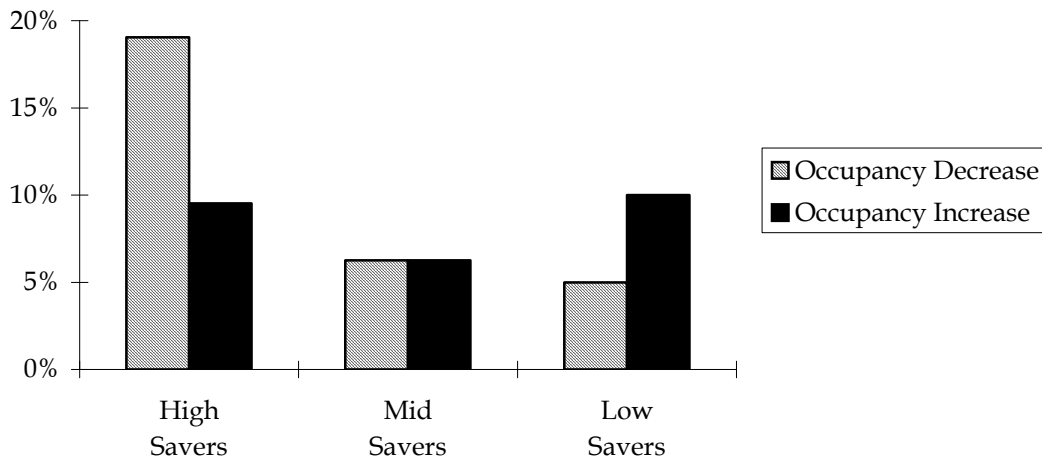


Figure 1-1 Occupant Reported Occupancy Changes Since Weatherization

As illustrated by Figure 1-1, a contributor to high savings may be the reduction in household occupancy.

Overall 29% of the clients (16 of 56) reported reducing their thermostat setting. The average reported reduction was almost 3°F. However, the change in thermostat setting was not seen as an indicator of savings. Thirty five percent of both the high and low saver groups (7 of 20) report reducing their thermostat settings by an average of 3°F.

Thirty percent of the clients (17 of 56) reported having at least one of their gas appliances serviced after weatherization. The low savers group was most likely to have had work performed on their gas appliances. Fifty five percent of the low savers (11 of 20) reported having work performed while the mid and high savers reported 19% (3 of 16) and 15% (3 of 20) respectively. A possible hypothesis is that work completed after weatherization altered the heating system and reduced the savings.

Thirty two percent of the clients (18 of 56) reported having a major gas appliance replaced or removed since weatherization. The most common change was the replacement of the gas water heater (8), followed by the replacement of the gas stove (6). No correlation was seen in the replacement or removal of a major appliance and the savings groups. The changes were evenly distributed across all three groups. The high saver group had one client that reported adding a 50,000 btu/hr furnace to handle a 600 square foot addition to their home.

Thirty percent of the clients (17 of 56) reported having secondary heating systems to supplement the primary system. Most of the secondary systems were electric space heaters. Three clients were able to remove secondary systems due to the weatherization work, while one elderly client added a secondary system. Low and mid savers were more likely to have supplemental heating systems than high savers. Low and mid savers reported 40% (8 of 20) and 44% (7 of 16) respectively while high savers only reported 10% (2 of 20). It is possible that the mid and low saver groups experienced less gas savings because the improvements were utilized to reduce electric supplemental heating.

Surprisingly, 51% of the clients (29 of 56) reported that the house had undergone a remodeling or renovation since the weatherization was performed. All three savings groups experienced roughly the same percentage of houses reporting renovations. The investigator concluded that the renovation would have an adverse effect on savings on 52% of the houses (15 of 29), a positive effect on 17% of the houses (5 of 29), and no effect on 31% of the houses (9 of 29). Renovations were not seen as a cause of low savings. Mid and high savers were more likely to be adversely affected by the renovations.

The retention of measures installed by the program appears to be good. Only 21% of the clients (12 of 56) report one or more of the measures being removed. For the most part the removed measures are inconsequential (i.e., door weatherstripping fell off, removed interior plastic storm window). Fifty percent of the houses reporting removal of measures (6 houses), reported that small areas of insulation were disturbed or eliminated by either renovations or roof leaks. There was no correlation between measure removal and savings group.

The energy education component of the program does not appear to provide a lasting impression. The field investigator made every effort to speak with the head of the household about the energy education they received. Only 38% of the clients (21 of 56) remember someone from the weatherization program speaking with them about ways to reduce their energy usage. Sixteen percent reported making changes based on the recommendations. There was essentially no difference in recollection of the energy education in the three groups of savers (40%, 38%, and 37%). Figure 1-2 graphically illustrates the proportion of clients remembering and acting on the client education.

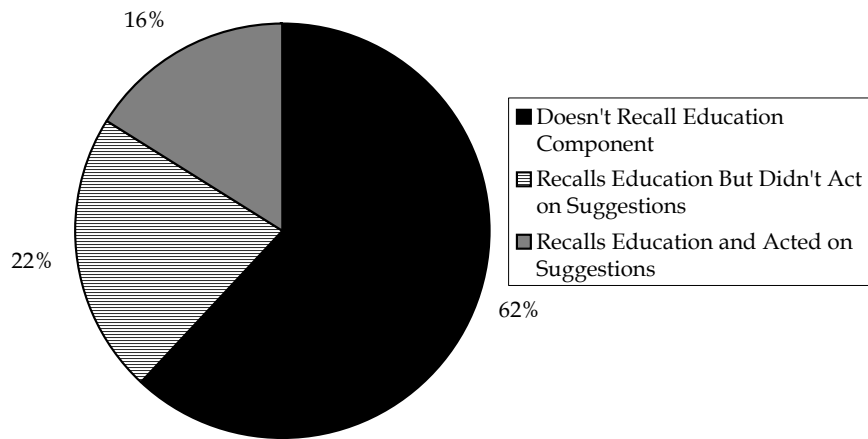


Figure 1-2 Occupant Reported Recall and Actions Based on Client Education Component

Clients were asked to rate the increase in comfort in their home using a scale of negative five to five, with negative five meaning that the house was now much worse, zero being no change, and five being a dramatic increase in comfort. Seventy one percent of the clients (40 of 56) reported that they felt their home was more comfortable after weatherization. Twenty six percent (15 of 56) reported no change in the comfort level. Only one client felt their home was less comfortable after weatherization. Overall the high savers reported a greatest amount of comfort increase, followed by the low savers, and the mid savers. Figure 1-3 illustrates the reported levels of comfort increase by savings category.

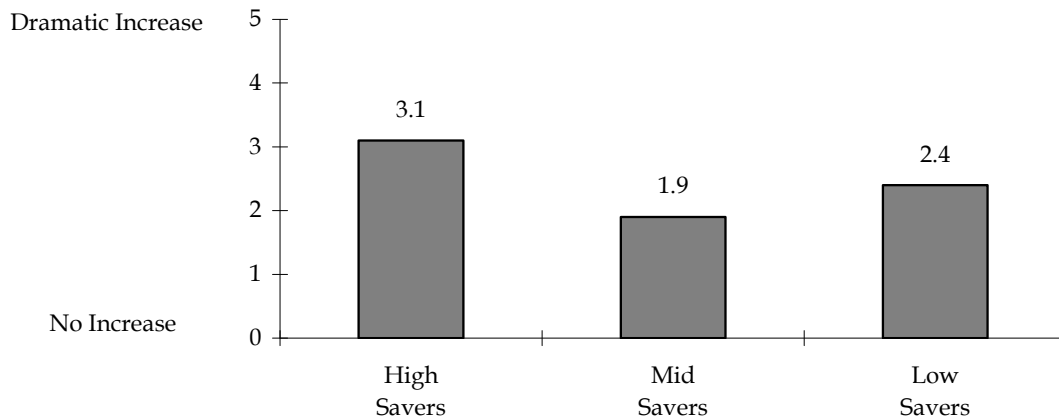


Figure 1-3 Occupant Reported Levels of Comfort Increase

Overall the clients were very satisfied with the weatherization work. Clients were asked to rate their satisfaction with the program on a scale of one to five with one being not pleased and five being very pleased. Not surprisingly, the high savers were the most pleased with the program, reporting an average rating of 4.5. Low and mid savers followed with ratings of 4.1 and 4 respectively.

Findings -- Air Sealing

The high savers tended to live in slightly larger houses with conditioned basements. The average high saver lived in a 1287 square foot home. High savers heated the basement in 84% of the cases. The average mid saver lived in a 1251 square foot home. Mid savers heated the basement in 93% of the cases. The average low saver lived in a 1126 square foot home. Low savers heated the basement in 62% of the cases.

The high savers had the highest reported pre-weatherization blower door measured air leakage. The high savers averaged 4912 CFM₅₀ pre-weatherization while the mid and low savers had reported leakage rates of 4117 CFM₅₀ and 3777 CFM₅₀ respectively. The agency reported post blower door readings matched well with the readings measured during the site visits in most houses.

The agency reported blower door readings indicate that they were most successful at reducing the air leakage of the high savers group. The mid savers group had nearly identical amounts of reduction while the low savers group did not fare as well. The agencies reported capturing 49% of the available reduction on the high saver group, 46% on the mid saver group and only 29% on the low saver group. Available reduction is defined as the amount of leakage reduction possible after subtracting the minimum ventilation required. Figure 1-4 shows the percentage of available reduction in air leakage captured for each of the savings groups.

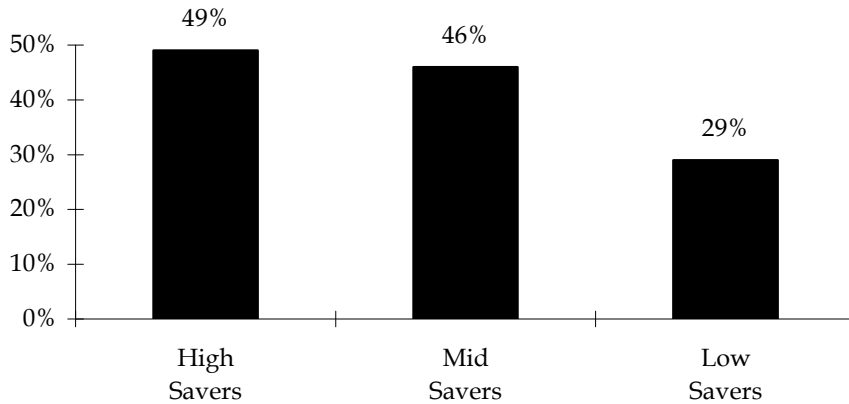


Figure 1-4 Percent of Reduction in Available Air Leakage

The site visit used pressure diagnostics to quantify the air leakage to the attic and basements. Figure 1-5 shows the percentage of air leakage to each area remaining after weatherization.

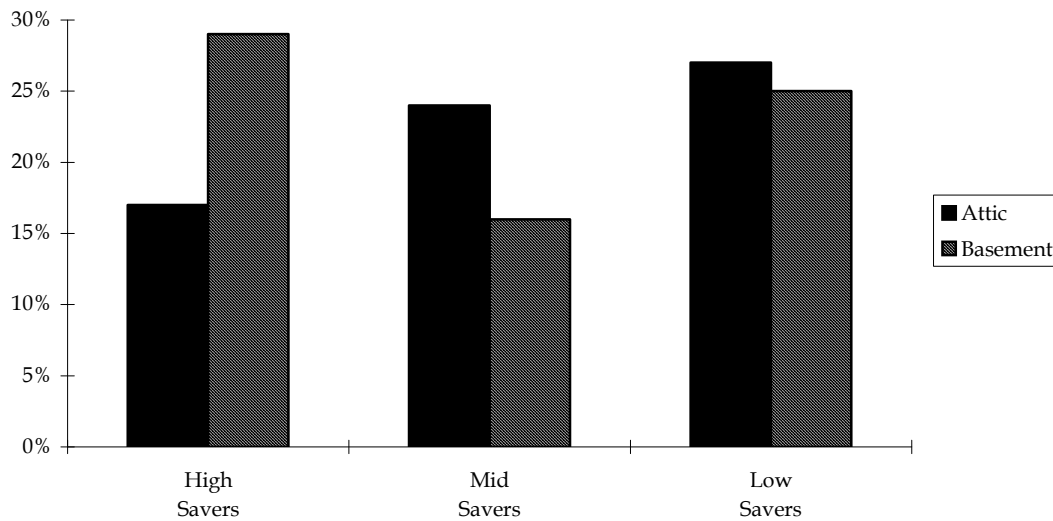


Figure 1-5 Percent of Remaining Air Leakage to Attic and Basement

Figure 1-5 demonstrates the agencies' success in reducing the leakage to the attics of the high saver group as compared to the mid and low savers. The choice to concentrate on air sealing the attic instead of the conditioned basement is also shown on the high savers.

The air sealing work performed by the agencies was examined and graded on a scale of 0 to 5, with 0 being very poor and 5 being excellent. Figure 1-6 presents the results of the assessment.

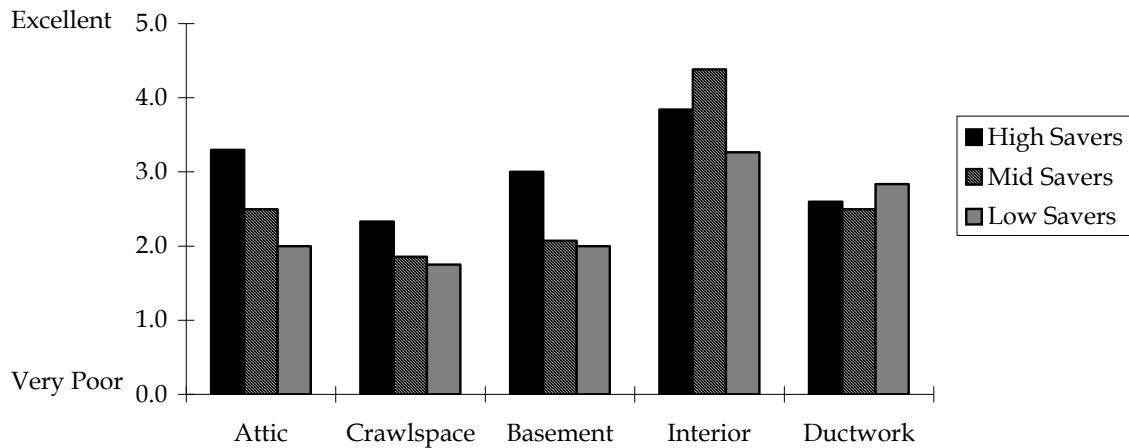


Figure 1-6 Quality of Air Sealing Technical Assessment and Work Performed

Figure 1-6 reveals the superior quality of technical assessment and work performed on the high saver group. The areas that are the most important in air sealing are at the top and bottom of the home. As shown in figure 1-6 the high saver group received the highest quality assessment and air sealing work in the attic and crawlspace/basement.

The opportunity for additional work was also assessed and graded on a scale of 0 to 5, with 0 being no missed opportunities and 5 being opportunities completely missed. Figure 1-7 presents the results of the assessment.

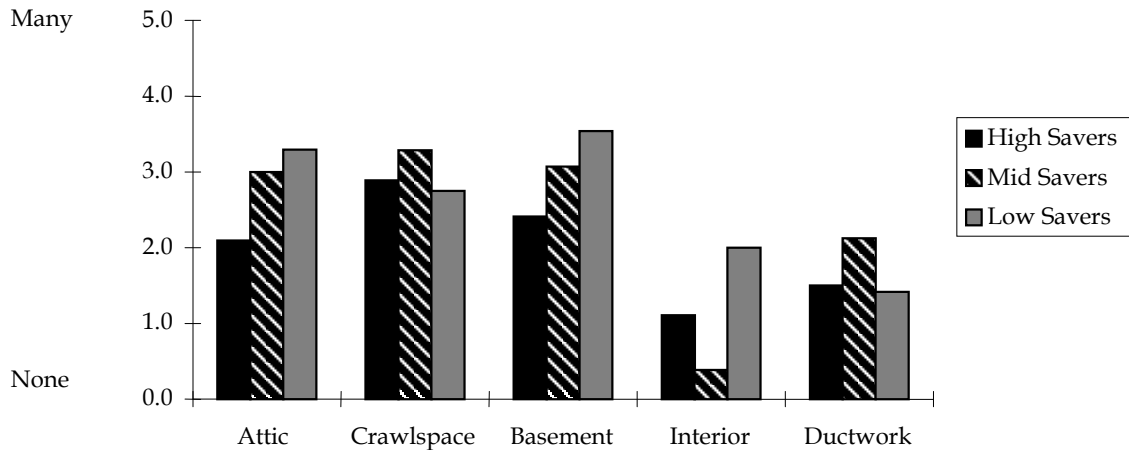


Figure 1-7 Missed Opportunities for Performing Air Sealing Work

Figure 1-7 indicates that generally the opportunities were better captured on the high savers, while the low saver group had more potential for effective work.

Findings -- Insulation

Overall the quality of the insulation work is good. The choice of whether or not to install insulation was usually correct, although the low savers did have more missed opportunities.

For the most part, the low savers consisted of homes with existing attic and sidewall insulation so little opportunity existed. When the low savers did present an opportunity it usually was not taken. The mid and high savers, on the other hand presented ample opportunities for both attic and sidewall insulation. These opportunities were taken.

The correlation between installation of attic insulation and saver group was good. On average the high savers had a pre-weatherization existing insulation R-value of R-8, while the mid and low savers had R-11 and R-22, respectively. Figure 1-8 illustrates the percentage of homes receiving attic insulation.

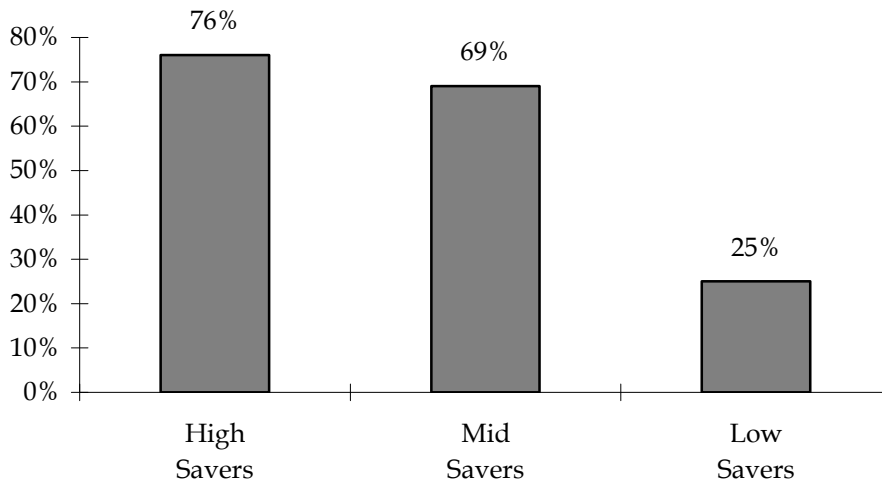


Figure 1-8 Percentage of Homes Receiving Attic Insulation

Seventy six percent of the high savers (16 of 21) and 69% of the mid savers (11 of 16) had additional insulation added while the low savers received additional insulation in only 25% of the cases (5 of 20). The agencies did a good job of identifying situations that called for attic insulation. There was a slightly higher rate of missed opportunities for attic insulation in the low saver group (25%) than in the mid and high saver groups (6% and 14%). Of the homes receiving attic insulation, the high savers were more likely to have had a thorough, high quality installation. The low savers tended to have a higher rate of problems. Forty percent of the low savers receiving attic insulation had major voids (greater than 10% of the area missed) in the coverage. None of the mid and high saver homes had major voids. The high saver group was more likely to need and receive kneewall insulation than either the mid or low savers.

Wall insulation is another common treatment received by the high savers. Figure 1-9 illustrates the percentage of homes receiving wall insulation.

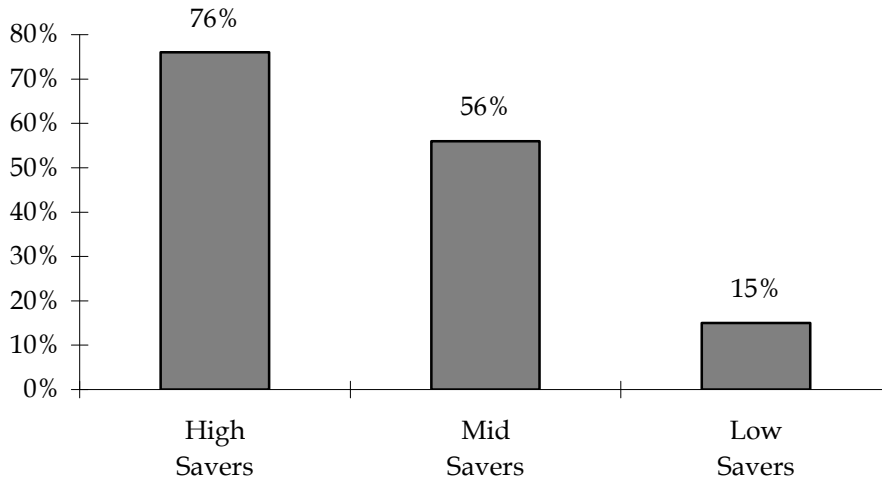


Figure 1-9 Percentage of Homes Receiving Sidewall Insulation

Seventy six percent of the high saver group (16 of 21) received sidewall insulation. The mid and low saver groups received sidewall insulation in 56% (9 of 16) and 15% (3 of 20) of the cases. On average, for the houses receiving sidewall insulation the high savers received 1326 square foot of treatment, while the mid and low savers received 841 and 501 square foot respectively. The agencies captured all the opportunities for insulating sidewalls in both the high and mid saver groups, while missing the opportunity in 33% of the low savers where the opportunity existed. The low savers did not present as many opportunities for sidewall insulation as the other two groups. Seventy five percent of the low savers (15 of 20) had insulation already installed in the sidewalls while the mid and high savers had 44% (7 of 16) and 24% (5 of 21) of the walls insulated.

The installation quality of the sidewall insulation was good for the most part. No problems were found in the work completed by the agencies on the low saver group. Most of the previously insulated low saver group also had good installation quality. The high saver group had good installation quality for both new and pre-existing installations.

The group with the most serious installation quality problems was the mid saver group. For the new installations, 66% (6 of 9) had significant missed wall areas. Four of the homes were missing more than 5% of the wall area. There was also a significant proportion (44%) with excessive settling in the wall cavities. In the mid saver previously insulated group 57% (4 of 7) had significant missed areas (>5%) or excessive settling.

The high saver group was the most likely to get a floor insulation treatment. Twenty four percent of the high savers (5 of 21) received floor insulation. The mid and low savers got floor insulation in 19% (3 of 16) and 15% (3 of 20) of the cases, respectively. Very little work is being done on insulating floors or foundations. Almost universally, basements are treated as a portion of the conditioned space, regardless of how the basement is used by the client. Missed opportunities are difficult to judge based on the varying opinions of how basements should be treated. The floor insulation installed was R-19 (one low saver got R-11). Foundation wall and rim joist area insulation were not items that received much application. None of the 57 cases received foundation wall insulation. Four homes had pre-existing rim joist insulation. Two homes received rim joist insulation in the program.

Duct insulation is an area that does not get much attention. Only 19% of the homes (11 of 57) received any duct insulation. Missed opportunities are hard to establish due to the various ways agencies classify basements. Using a liberal approach in classifying basements as heated spaces results in only 2 homes being considered as missed opportunities for duct insulation. Low savers received the most duct insulation followed by mid and high savers. However, of the six low saver homes that received duct insulation three were mobile homes. For the most part, mobile homes tended to have lower savings than site built homes. Only 3 mid savers and 2 high savers received duct insulation.

Findings -- Heating System Efficiency

It can be difficult to precisely quantify the appropriateness or quality of some heating system efficiency work when performing inspections three years after the work took place. However, most measures should not be adversely affected by the passing of time. Any deficiencies found should fall into one of three groups:

- The measure did not meet the standard when originally performed
- The measure has experienced degradation over time
- Someone has performed adjustments or work that has changed the results achieved by the program

The original work orders indicate that nearly all clients received efficiency or safety related repairs.

Duct systems are an integral part of the heating system. In order to be effective duct sealing must be directed at the portions of the duct system outside of the conditioned space with the highest leakage, for example, disconnected ducts, large holes, etc. in the attic, garage, or crawlspace. Second, the areas experiencing the highest operating pressures must be targeted, for example, leaks by the supply plenum. The duct sealing work when performed was of good quality but generally did not address the entire system nor was it targeted at the higher pressure areas of the system. Almost all the homes with duct systems had basements that were inside the pressure boundary. Whether or not the program will realize savings from sealing and/or insulating the distribution system in these homes is a question that remains to be answered. Some previous studies have indicated that these homes are not good candidates for duct sealing and/or insulating.

The majority of homes (88%) had forced air heating systems. The remaining homes had a mixture of boilers, gravity, space, and wall heating systems. Forced air heating systems provide a good opportunity for efficiency increase.

An efficient forced air system should have a heat rise that falls within the manufacturers' suggested range. Generally this is around 40°F to 80°F. Checking the heat rise was not part of the furnace efficiency procedure during the 1994/95 HWAP. This procedure has only recently been added to the standard HWAP furnace procedure. Overall, 35% of the systems (17 of 49) had heat rises of greater than 80°F. The low savers tended to have higher heat rises. Fifty three percent of the low savers (10 of 19) had high heat rises, while the mid and high savers had 14% (2 of 14) and 29% (5 of 17) respectively. Generally, high heat rises tend to be caused by either dirty blower assemblies or low fan speeds. Eighty seven percent of the systems (13 of 15 with measured static pressures) with high heat rises had acceptable return side static pressures (not exceeding -50 pascals). This indicates that the design of the return systems is not restrictive and probably not

the cause of the high heat rise. Figure 1-10 illustrates the percentage of clients with high heat rises in each savings group.

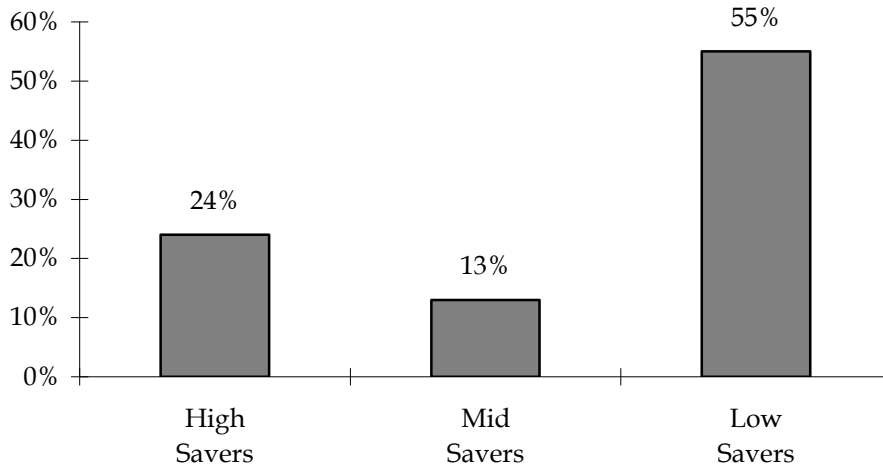


Figure 1-10 Percentage of Systems with a Measured High Heat Rise

Efficient forced air heating systems should have a fan off temperature of 100°F or less. The fan off temperature is the temperature of the air in the supply plenum when the fan shut off. Studies have shown savings by lowering fan off temperatures. Checking the fan off temperature was not part of the furnace efficiency procedure during the 1994/95 HWAP. This procedure is not part of the standard HWAP furnace procedure in the current program.

Sixty four percent of the systems (30 of 47) had fan off temperatures of 100°F or greater. Figure 1-11 shows the distribution of measured fan off temperatures.

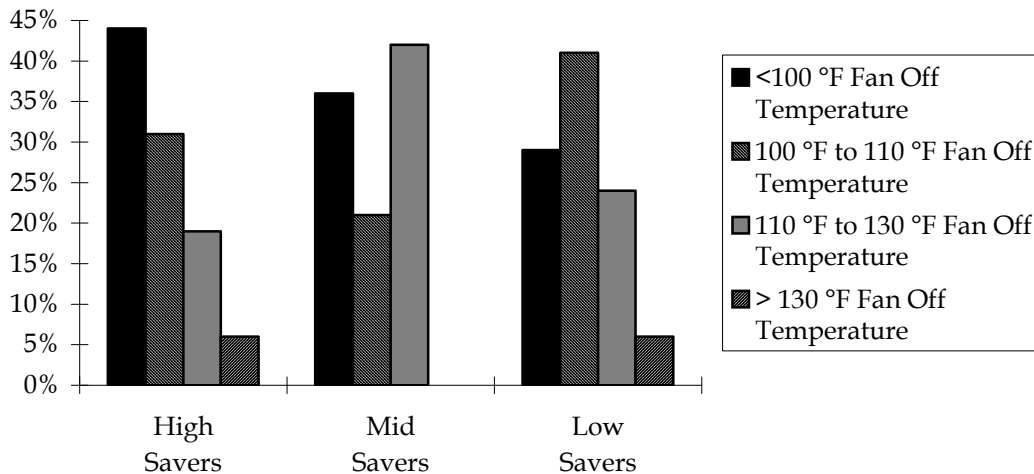


Figure 1-11 Measured Fan Off Temperatures by Savings Group

The high saver group did tend to have lower fan off temperatures.. The mid saver group had a large portion of systems with fan off temperatures greater than 110°F. But the savings or lack of savings for any group can not be attributed to fan off temperatures since none of the participants had reported fan off temperature modifications.

Findings -- Hot Water System Efficiency

The average measured hot water was 131°F. Seventy five percent of the clients (41 of 55) maintain their hot water temperature at greater than 120°F. High and low savers were both likely to have high hot water temperatures. Seventy six percent of high savers (16 of 21) and 85% of low savers (17 of 20) had hot water temperatures of greater than 120°F. Figure 1-12 shows the distribution of measured hot water temperatures.

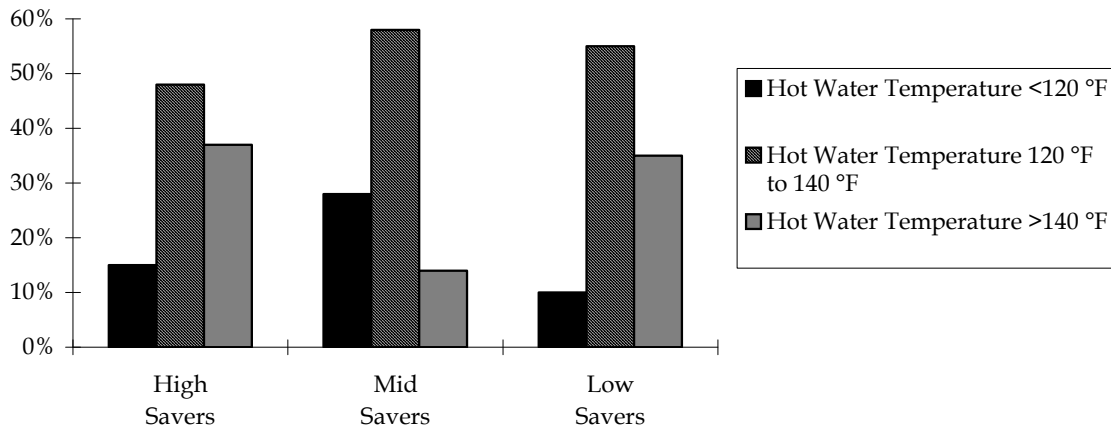


Figure 1-12 Measured Hot Water Temperatures by Savings Group

Only one hot water leak was found in the entire sample. One of the high saver homes had a 7 gallon per hour hot water leak. Bathtub shower diverters were also checked for excessive leakage (>1 GPM). Only one home was found to have a serious shower diverter leak. The leak was greater than 3 GPM and was found in a high saver home.

Shower head flow was also examined. It appears that savings are available in changing out shower heads. The mid saver group was the worst, with 23% (3 of 13) of the homes having at least one shower head with a flow of greater than 3 GPM. High flow shower heads were found in 17% (3 of 18) of the high saver group homes and 6% (1 of 17) of the low saver group homes.

Findings -- Heating System Safety

All homes had extensive combustion system testing performed to determine if any safety problems existed. Combustion safety problems examined include:

- gas leaks
- inadequate venting of water heater or heating system
- excessive carbon monoxide generation
- heating system cycling on the high temperature limit switch

Combustion appliance safety repairs have been found to be durable. Generally once a venting system or carbon monoxide problem is fixed it will not soon reoccur. The condition of the combustion appliances tested in this study is assumed to be similar to the condition in which they were left by the program. Table 1-2 shows the distribution of combustion safety problems.

	High Savers	Mid Savers	Low Savers	All
No problem	14%	31%	40%	28%
Water heater problem	43%	25%	15%	28%
Heating system problem	57%	38%	35%	44%
Oven problem	29%	31%	20%	26%
Problems w/ 2 appliances	24%	25%	10%	19%
Problems w/ 3 appliances	10%	0%	0%	4%

Table 1-2 Occurrence of Combustion Safety Problems

As illustrated in Table 1-2 there are some serious problems with the houses that were treated by the program. The high savers group was the most likely to have combustion safety problems while the low saver group was the least likely.

Gas leaks were quite common. Twenty five percent of the homes (13 of 54) examined had a gas leak at either the water heater or heating system. Seventeen percent of the water heaters (9 of 54) and 9% of the heating systems (5 of 57) had a gas leak. No significant difference in occurrence percentages was seen across savings groups. It can not be determined if the gas leaks were present at the time of weatherization, only that they are now present.

Combustion product spillage after five minutes of operation occurred in 19% of the homes. As in previous studies, the water heaters were far more prone to spillage problems than heating systems. Nineteen percent of the water heaters (10 of 54) had combustion product spillage, compared with 2% of the heating systems (1 of 57). The average draft on water heaters (over a wide variety of outdoor temperatures) was - 4.9 pascals, compared with - 10.7 for the heating systems under the same conditions. One water heater had total spillage and 92 ppm of CO in the flue. The spillage was caused by a negative pressure from the duct return system and exhaust appliances. When the basement window was opened the water heater draft increased by 7 pascals and the spillage was eliminated.

The majority of the carbon monoxide problems were associated with the ovens. None of the water heaters had CO generation above 100 ppm. Only 7% of the heating systems (4 of 57) had CO generation above 100 ppm, although two of them were quite serious (3500 ppm and 1800 ppm). Twenty seven of the homes had gas ovens. Fifty six percent of the gas ovens (15 of 27) had CO generation above 100 ppm. Measured CO in the ovens ranged from 0 to 410 ppm.

Checking the Carbon Monoxide levels in the heating and water heating systems was a part of the combustion safety procedure during the 1994/95 HWAP. Checking gas oven CO was not a part of the procedure. The oven CO check has been added the standard HWAP combustion safety procedure in the current program.

Many heating systems were cycling on the high temperature limit. This is not surprising considering the high frequency of heating systems with high heat rises. Cycling on the limit occurs when not enough air is passed over the heat exchanger. The temperature around the heat exchanger increases and the limit switch shuts the gas off to prevent over-heating and fires. Thirty one percent of the systems (15 of 49) were cycling on the limit. If the limit switch was to fail the potential for a fire is greatly increased. Checking for cycling on the high temperature limit switch was a part of the 1994/95 HWAP procedure. The steady state combustion efficiency test cannot be completed at ten minutes of burn time if the heating system is cycling on the limit switch.

Work by Others

Work by others (utility weatherization programs, rehabilitation programs, pre 1980 DOE weatherization, or work by the clients) impacts the amount of savings obtained by the program. Previous effective work limits the amount of savings potential. This problem can be avoided by targeting clients based on recent billing histories.

Previously installed measures can make potential work more difficult. For example, previously insulated attics are difficult and time consuming to air seal. Many times the insulation is not effective due to the air leakage, but locating and addressing the air leakage is made difficult by the presence of the insulation.

Table 1-3 shows the distribution of homes, by savings group, receiving no other work and previous weatherization.

	High	Mid	Low	All
No other work	43%	0%	0%	16%
Previously weatherized	29%	88%	95%	68%

Table 1-3 Work Affecting Savings Potential

CONCLUSIONS

The gas savings vary significantly from home to home in the ODOD HWAP program. While some of the savings differences are due to the occupants, the majority are due to the selection of homes and the services provided by the agencies.

Considering the information gathered in these site visits, Proctor Engineering Group draws the following conclusions:

Missed Opportunities

- The heating system efficiency work by the agencies did not capture all of the savings available. Many systems had high heat rises and high fan off temperatures. Duct sealing and insulation work was being performed only on a very limited basis.
- Basements were not being treated as effectively as they could be. For the most part basements were being ignored.
- A moderate number of high flow showerheads were still in these homes and represent available savings if the clients would agree to the change.

Health/Safety Measures

- Gas leaks were quite common. Twenty five percent of the homes had a gas leak at either the water heater or heating system.
- Combustion product spillage occurred in 19% of the homes.
- Carbon monoxide problems were found and were generally associated with the ovens.

Installation Quality

- Generally, the attic and wall insulation was of good quality.
- Most attic air sealing was of good quality.

Characteristics of High and Low Savers

- High savers obtain better than average savings due to high initial consumption and more effective treatment.
- High savers tend to get attic and sidewall insulation treatments while low savers already have existing insulation.

- High savers had slightly larger homes, the highest pre-weatherization air leakage, and air sealing concentrated on the attic.
- Targeting clients based on the usage level and screening for previous weatherization treatment would help ensure higher savings.

Client Feedback

- The energy education component of the program does not appear to provide a lasting impression. Only 38% of the clients remember someone from the weatherization program speaking with them about ways to reduce their energy usage.
- After weatherization, high savers reported a significant comfort increase.
- Overall 29% of the clients reported reducing their thermostat setting. The average reported reduction was almost 3°F. However, the change in thermostat setting was not an indicator of savings.

Case-Studies

- The site visit project was successful in gathering and summarizing data on 57 homes for use as case studies in training program personnel. The data has been forwarded in electronic format to the ODOD.

APPENDIX A

Customer Interview

- Note:** 1 For all questions concerning the customers energy usage; -1 = the customers usage would have decreased due to the change, + 1 = increased usage, - 9 = N/A or no change .
2 For all yes/no answers, Y = yes and N = no.

Has the number of people living in the house changed since shortly before or after the weatherization work took place? If yes, how many people moved into or out of the house and when? (i.e. - 2 if two occupants have moved out, + 1 if one occupant has moved in). When did change occur? _____

What is your normal winter time thermostat setting?
 Has your thermostat setting changed since the weatherization service took place?
 If yes, indicate the average degrees increase or decrease in t-stat set point. (i.e. + 3 if setting increased by 3 degrees)

Have you had any of your gas appliances worked on since the weatherization services took place?
 If yes, decide how the work would impact the customers gas usage.

Have any of your major gas appliances been replaced or removed since the weatherization services took place?
 If yes, decide how their replacement might affect the customers gas usage.
List the appliances. _____

Have any of your major electric appliances been replaced or removed since the weatherization services took place?
 If yes, decide how their replacement might affect the customers gas usage.
List the appliances. _____

Do you use any secondary heating systems to supplement the main heating system?
 Have any secondary heating sources been added or removed since the weatherization work took place?
 Are the secondary heat sources electric?
 Has your control of the secondary heating system changed since the weatherization work?
 If the control pattern has changed decide how the change would impact the customers gas usage.
 If the control pattern has changed decide how the change would impact the customers electric usage.

Were you satisfied with the weatherization work performed? Rate on a scale of 1 to 5.

Did you notice a change in the comfort level of the home after the weatherization work? Rate on a scale of - 5 to + 5.

Has there been any remodeling or additional weatherization work performed on the house since the agencies weatherization work was performed?
 If yes, decide how the work would impact the customers gas usage.

Have any of the weatherization measures that were installed by the agency been removed?
 If yes, describe what was removed and why. _____

Do you remember one of the agency personnel talking with you about your energy usage and recommending things you could change to decrease your energy usage?
 If yes, did their suggestion seem reasonable and useful?
 Did you make the changes that were recommended? if not, describe why.

Comments _____

Job # 123-94-XXX

COMBUSTION SAFETY TESTING

For all yes/no questions, Y = yes, N = no.

ALL DRAFT, SPILLAGE & CO MEASUREMENTS ARE TAKEN AT 5 MINUTES

Set up the house in a worst case winter situation. All exterior windows and doors closed, interior bedroom doors closed, all exhaust appliances on (including air handler), and door to combustion appliance zone either open or closed, whichever creates a more negative pressure in the zone. (Relocate draft hole if in an elbow)

Record Pressures	Zone 1	Zone 2	Zone 3
Zone (which appliance)			
House WRT Outside			
CAZ WRT Outside			
CAZ WRT House			
CAZ Door Open?			
Fireplace Present in House			
Wood Stove Present in House			

Test water heater first (with furnace off), take draft CO and spillage measurements after 5 minutes of run time

Water Heater #1

Hot Water Temp	
Gas Leaks	
Draft WRT CAZ (low range)	
Spillage present	
CO (highest reading)	

Leave the water heater turned all the way up, get your thermometers in the supply and return plenums, turn the furnace to the warmest setting, measure the fan on temp as soon as the fan comes on, take draft, CO, spillage and heat rise measurements after 5 minutes of run time, measure static pressures, and then measure fan off temp when fan turns off.

Heating System #1

Original T-Stat Setting	
Fuel Type	
Gas Leaks	
Draft WRT CAZ (low range)	
Spillage Present	
CO (highest reading)	
Supply Plenum Temp	
Return Plenum Temp	
Cycled on Limit	
Temp Cycled on Limit	
Return Plenum Pressure	
Fan Off Temp	

Heating System #2

Original T-Stat Setting	
Fuel Type	
Gas Leaks	
Draft WRT CAZ (low range)	
Spillage Present	
CO (highest reading)	
Supply Plenum Temp	
Return Plenum Temp	
Cycled on Limit	
Temp Cycled on Limit	
Return Plenum Pressure	
Fan Off Temp	

Shut off both the water heater and the heating system, warn the customer about the hotter than normal water temp.

Oven

CO	
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Comments

Job # 123-94-XXX

Note: Rate insulation work based on visual observations and IR scan results.

Quality rating scale is 0 to 5 with 0 being very poor and 5 being excellent. Missed opportunity rating scale is 0 to 5 with 0 being no missed opportunities

and 5 being opportunity completely missed. N/A = -9

INSULATION	Quality of Technical Assessment & Work Done	Missed Opportunity	Previous Insulation R-Value	Additional Insulation R-Value	Previous Work Limits Retrofit	Square Footage
Attic 1						
Attic 2						
Kneewall						
Wall						
Floor						
Foundation Wall						
Rim Joist						
Cantilever						
Ductwork						
Water Heater						
Comments						

IR Scan Information	Inside Temp	Outside Temp	House Pres WRT Outside	Scan Quality OK
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Answer all spaces w/ Y = yes or N = no

	Missed	Settling	Splits	< 5%	5 - 10%	> 10%	100%	Comments
Voids in Attic Spaces								
Voids in Sidewalls								
Voids in Floors								

INSULATION RELATED MEASURES	Quality of Technical Assessment & Work Done	Missed Opportunity	Comments
Attic Venting			
Crawl Floor Covering			

WINDOWS & DOORS	Quality of Technical Assessment & Work Done	Missed Opportunity	Comments
Replacements			
Repairs			

OTHER MEASURES	Flow (cups)	Time (sec)	# w/Flow > 3 GPM	# w/Flow > 1 GPM	Comments
Hot Water Leaks					
Shower Head					
Diverter Leaks					

Job # 123-94-XXX

House Information	Square Footage	Volume	# of Stories	N Factor						
	Square Footage	Volume								
Basement	Agency Reported Pre	Agency Reported Post	Basement Door Open CFM	House Pressure WRT Outside	Basement Door Closed CFM	House Pressure WRT Outside	House Pressure WRT Basement	Basement Heat Registers	Customer Heats Basement	Comments
Shell Leakage CFM 50										
MVG (Volume X N Factor X 0.35) / 60			Available Reduction (Measured CFM 50 Minus MVG)					Basement Included?		

AIR LEAKAGE	Baseline House WRT Zone	Zone Pressure WRT Outside	House Pressure WRT Zone	Add a hole (size sq in)	Zone Pressure WRT Outside	Method 2 CFM Zone Closed	Method 2 CFM Zone open	CFM House to Zone	CFM Zone to Outside	Comments
House/Basement										
Attic 1										
Attic 2										
Kneewall 1										
Kneewall 2										
Addition										

Measure duct leakage on at least one house for each agency. Pick a house with high pressure pan reading (i.e. >5). Measure duct leakage on all houses with the majority of the duct system located in an unconditioned crawl space or attic (unless all PP < 1).

DUCT LEAKAGE	Leakage to Outside	Half Nelson Supply	Half Nelson Return	Supply Duct Location 1	Location 1 %	Supply Duct Location 2	Location 2 %	Return Duct Location 1	Location 1 %	Return Duct Location 2	Location 2 %
Measured CFM 25											

Note: All pressure pan measurements are done with the basement door open. Comments

Pressure Pans	Highest PP Measurement	Number of PP Measurement >2 Pascals
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Note: Rate air sealing of all areas based on visual observations, pressure diagnostics results, and IR scan results. Quality rating scale is 0 to 5 with 0 being very poor and 5 being excellent. Missed opportunity rating scale is 0 to 5 with 0 being no missed opportunities and 5 being opportunity completely missed. N/A = -9

AIR SEALING	Quality of Technical Assessment & Work Done	Missed Opportunity	Comments
Attic			
Kneewall			
Crawlspace			
Basement			
Interior			
Ducts			