Enhancing the Performance of HVAC and Distribution Systems in Residential New Construction

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Introduction

Field studies have revealed significant opportunities for electricity savings and peak demand reduction by establishing a strategy for trained technicians to identify and correct performance problems in residential air conditioners, heat pumps and their distribution systems. Using a clear protocol and diagnostic tools, actual conditions are measured prior to and after system modifications and repairs to document the effectiveness of the treatment. This "diagnostic approach" provides a level of accountability and certainty that is often missing in conservation programs. This paper describes the results of a study to test whether this approach might be effective as part of a program to improve the efficiency of residential new construction.

Study Approach

Sixty-six new apartments and twelve new homes with heat pumps and duct systems in the Los Angeles area were selected to form a baseline representing the installation practices and performance of heat pumps and duct systems in new residences. Each residence was tested for potential problems in three major areas: duct leakage, improper air flow through the inside coil and improper refrigerant charge. The testing methodology is similar to that detailed in Proctor (1990).

Results

Even though the buildings were newly constructed and, in most cases, financial incentives and visual inspections of the energy-efficient heat pumps had been provided by the local utility, significant deficiencies were found in all three problem areas. These deficiencies led to substantially higher levels of energy consumption. Results for both single family and multifamily units are described in Proctor (1992). Key findings are summarized below.

Duct leakage was the predominant problem at the single family sites. For new construction it is reasonable to hold duct leakage to less than 50 cfm. However, over 85% of the homes in our sample had supply duct leakage and 90% had return duct leakage that exceeded this level. The resulting average cooling load increase for these homes was approximately 30% and the heating loss was about 18%. In addition, only 30% of the single family units met manufacturer's specifications for air flow through the inside coil.

Duct leakage was considerably lower at the multifamily sites. This was not due to higher quality ductwork, but to shorter duct runs and lower pressure levels in the ducts, chases and plenums. The reduced pressure means less leakage through imperfections in any component of the duct systems.

Low air flow through the inside coils was a more serious problem for the multifamily sites. As Figure 1 indicates, less than 15% of these units came close to the manufacturer's specified air flow through the inside coil. Many units were well below this level.

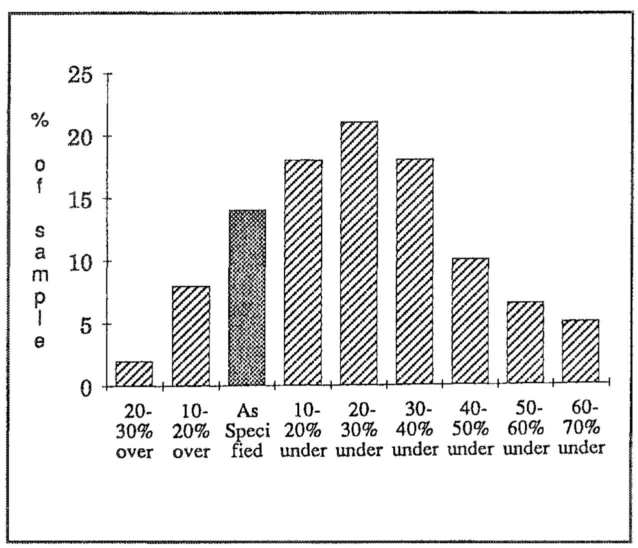

Figure 1. % of Mfg Specified Air Flow Multifamily Homes

Over two-thirds of the heat pumps in multifamily units had improper levels of refrigerant charge. Previous studies have found that in existing construction about the same number of heat pump units are undercharged as are overcharged. The results of this study suggest that when heat pumps are initially installed in new construction they are more likely to be overcharged. As shown in Figure 2, over 60% of the heat pumps were overcharged while less than 8% were undercharged. Overcharging should be of concern to utilities because it creates higher loads during system peak.

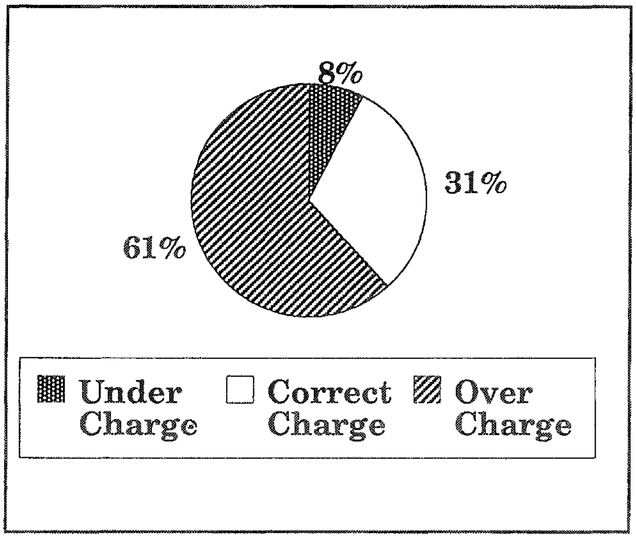

Figure 2. Condition of Refrigerant Charge Multifamily Homes

Tables 1 and 2 indicate the estimated energy savings and peak reduction benefits that would result if the major problems identified in the baseline survey were properly addressed. These savings estimates are based on combining the survey results with engineering calculations documented in Proctor (1990) and Palmiter (1991).

When interactive effects are taken into account, the average energy savings opportunities that would result from measures to address all three problem areas (duct integrity, charge and airflow) for single family dwellings are 38% for space cooling and 28% for space heating. The average savings opportunities for multifamily dwellings are 18% for space cooling and 19% for space heating.

Table 1. Savings and Peak Reduction Estimates for Individual Measures - Single Family Units

Measure	Cooling	Peak (Watts)	Heating
Ensure Correct Airflow	9.7%	147	9.7%
Ensure Correct Charge	11.5%	348	11.5%
Ensure Duct Integrity	30.1%	1,026	18.4%

Table 2. Savings and Peak Reduction Estimates for Individual Measures - Multifamily Units

Measure	Cooling	Peak (Watts)	Heating
Ensure Correct Airflow	11.7%	86	11.7%
Ensure Correct Charge	11.5%	170	11.5%
Ensure Duct Integrity	6.1%	101	6.3%

Barriers to Proper Hvac System Installation

Personal experience and focus groups with HVAC industry, builders and architects, suggest five major barriers to proper HVAC system installation and performance. These are: (1) a builder/HVAC contractor relationship based on a low-bid, least-cost system that does not reward quality work, (2) insufficient appreciation of HVAC and building science principles by all parties, (3) a premium placed on living and storage space at the expense of adequate room for duct systems, (4) lack of coordination among building trades resulting in dislocated or crushed ductwork, and (5) codes and inspections that focus on products and rated efficiency levels on HVAC units rather than the actual performance of the system.

Program Design Considerations

Utilities should consider incorporating a "diagnostic approach" to encourage proper installation and performance of HVAC and duct systems as part of their residential new construction programs.

Here are some guiding principles for utility program design to help address the barriers listed above.

- Establish a well controlled and documented system with on-site inspections using diagnostic tools to verify proper installation and performance of a significant percentage of these units.
- Provide sufficient economic incentives to motivate both builder and HVAC contractor to follow the system and spend the time necessary to perform tasks properly. These incentives should not be released until inspected units meet established performance criteria.
- Sponsor training for HVAC technicians, builders, and designers to ensure that all parties can perform the required tasks. Training sessions can be co-sponsored with local HVAC industry organizations. Regular reinforcement of training sessions is critical.
- Provide utility certification of trained HVAC contractors. Certification should be based on written tests and actual performance on the job.

A successful strategy to promote efficient HVAC and distribution systems requires making substantial changes to current construction practice. This involves a major commitment by the utility and many other parties. Fortunately, the potential benefits to most utilities and their customers are very high. Proper installation will promote improved customer comfort and satisfaction, longer equipment life, reduced load growth, and lower power plant emissions.

References

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