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Prepared by:
Proctor Engineering Group, Ltd.
San Rafael, CA 94901
(415) 451-2480

Pacific Gas and Electric Company Appliance Doctor: Implications For Residential Air Conditioning System Installation Practices

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Contributors:
John Proctor, P.E.
Amy Polak

Creators of CheckMe!®

PG&E APPLIANCE DOCTOR:

IMPLICATIONS FOR RESIDENTIAL AIR CONDITIONING SYSTEM INSTALLATION PRACTICES

JOHN PROCTOR, P.E., AND AMY POLAK
PROCTOR ENGINEERING GROUP

Introduction

Of all the uses for electricity in the home, air conditioning is most responsible for driving up peak demand. Curbing this peak demand is increasingly critical to utility companies.

Field studies of residential air conditioners across the nation indicate that with standard installation and maintenance, air conditioners perform significantly below their rated efficiencies. A 1987 study estimated a lost efficiency on the order of 30% to 40%, not including duct losses (Neal, 1988). Utilities nationwide, among them Pacific Gas and Electric Company (PG&E), have taken great interest in this lost efficiency, implementing a variety of programs to try to reverse the loss.

In 1989, Proctor Engineering Group (PEG) began working with PG&E to investigate the potential energy savings and peak reduction available by making repairs to existing residential air conditioners and gas forced air furnaces. During the course of several studies, a number of problems emerged, many of which were clearly present at the time of installation. Examining a large number of existing units, PEG found these problems to be largely the same for both new and used systems. Many of the repairs PEG made would have been unnecessary had the units been properly installed.

PEG examined over 1,250 homes in three different California cities to determine both peak and energy savings available: in 1989, 51 heat pumps were tested in Auburn; in 1990, 15 air conditioners and gas furnaces were tested in Fresno; in 1991, 250 air conditioners were tested in Fresno; and in late 1991, testing began on 14,000 air conditioners in Antioch -- test results are now in for 1,000 of those units. In all these studies, the predominant problems were the same, namely: 1) Low airflow through the inside coil, 2) Improper refrigerant charge, and 3) Duct leakage. Following is a summary of the methods used to ascertain the results, specific results in the areas of airflow, refrigerant charge and duct leakage, and recommendations on improvements to be made during installation, thus avoiding the lost opportunity and additional cost of repairing problems on improperly installed systems.

Methodology

Each location was visited by a team of technicians who used specially designed forms to test, record, and repair each duct system and air conditioner. An interview was also conducted with the homeowner during the initial site visit. This interview assisted in determining what problems existed, their possible causes, and how use patterns of the occupant might affect the efficiency of the system.

To quantify problems with the ductwork and the building shell, each of the sites was inspected and tested using a blower door and a flow hood.

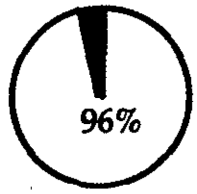
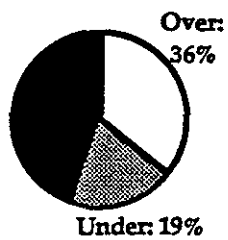
To quantify problems on the air conditioner itself, initial measurements were made of airflow, cooling capacity, and electrical input. The air conditioning technician also measured the discharge line temperature, superheat, subcooling, compressor megohms, and compressor amp draw. These tests allowed the technician to determine the condition of the compressor, the adequacy of the charge, and the air conditioner efficiency.

In the Fresno studies, submeters were used to record the air conditioner kWh consumption for every 15-minute period, both before and after repairs were made. The data was analyzed to determine the peak electrical load for each house and to identify how the residents adjusted their thermostat controls.

Results

The major problems identified at the sites are listed in Figure 1.

Figure 1

Excessive Duct Leakage	Duct Leakage exceeded 150cfm in 96% of the units. It averaged 367cfm and ranged from 31-1690cfm.	
Low Airflow	Low airflow (less than 350cfm/per ton) was found in 24% of the new units. Airflow was found as low as 196cfm/ton.	
Incorrect Charge	Over half the houses had improper refrigerant charge.	

Duct Leakage

Duct leakage was the most prevalent problem in the new homes studied. Duct leakage averaged 367 cfm and ranged from 31 to 1690 cfm. For construction in progress, ducts are tested alone by sealing the registers, pressurizing or depressurizing the system, and measuring the resulting flow.

Duct leakage is more important than other building shell leaks. This is true for three reasons:

1. The highest pressure differential across leakage sites occurs at ductwork cracks when the inside fan is on (pressures of 50 pascals are common). For homes in the study these pressures occur during about 30% of the cooling hours.

2. Leaks in the supply duct expel air that is cooled below house air temperature. A 10% supply duct leak to the outside is a 10% cooling capacity loss.

3. Superheated attic air leaking into the return system further increases the cooling load.

As a result of the above three items the average cooling load increase from duct leakage alone was approximately 23% for the newly constructed homes in the Antioch area.

Repairing duct leaks after construction is difficult. After an initial learning period, technicians were able to seal almost 65% of the measured duct leakage. This despite the fact that often, though the location of the leak could be determined, that location was inaccessible to repair. Building a sound duct system from the beginning would result in higher savings at lower cost. Correcting the nearly universal problem of duct leakage would reduce the necessary size of the unit, thus lowering the total cost.

Airflow

Twenty-four percent of the houses studied had airflow below 350 cfm per ton, some as low as 196 cfm per ton. In most cases, the primary cause of inadequate air flow was restricted return systems, followed by restricted supplies. Because large air conditioners move more air than smaller ones, both conditions were aggravated by oversized air conditioners. Also, indoor coils were often inaccessible, making cleaning unlikely and long term efficiency degradation inevitable.

In cases where high air flow was found, units usually had massive return leaks through open wall cavities into the attic. Those leaks provided very little restriction to the suction side of the blower; as a result higher than normal airflow occurred. When the airflow is too high the results are excessive noise, less moisture removal and increased duct leakage.

Insufficient air flow through outside coils is also a problem. Contractors commonly place outdoor coils under decks, which causes recirculation, and near obstructions which limit the draw of the system.

Refrigerant Charge

Improper charge occurred on a majority of the units studied. Thirty-six percent of the split units were overcharged while 19% of those units were undercharged.

It is assumed that new units are properly charged. This is not necessarily true. In the field, most technicians make the determination of proper refrigerant charge through guesswork. One common technique is to "feel the lines" to determine charge.

Checking for correct refrigerant charge is a task that is straightforward given proper training and adequate time. For the most common system (capillary tube flow control) charging is a well defined process. A single generic chart can be used to determine whether the unit has proper superheat -- indicating the correct level of charge. This method is quite accurate, but it takes more time than "feeling the lines."

For proper charging, then, complete training and adequate time to charge the system will assure greater efficiency. Proper charging is estimated to save 11.5% on overcharged units.

Conclusion And Recommendations

Building It Right The First Time: Installing For Efficiency

Proctor Engineering Group has tested and repaired over a thousand home air conditioning units in California. And while it's fair to say that substantial energy and kWh savings are possible from repair, it's at least as vital that home cooling systems be installed properly in the first place. Time and again, our teams found that the repairs they were able to perform were circumscribed by the limitations of poor installation.

It is also clear is that utility companies like PG&E will continue to be held hostage by increasing peak demand. It is therefore imperative to implement not only programs of repair like the ones PEG has been working on, but also new programs that insure adequate installation. When a utility considers incentives for new or replacement high efficiency air conditioner installations, these installations should be held to strict criteria, including:

1. The measured airflow must be between 5% below and 15% above the manufacturer's specification. This includes assuring appropriate duct size, and assuring that ducts are installed without kinks.

2. The installed Energy Efficiency Ratio must be tested on site and be within 10% of the manufacturer's specification.

3. The inside coil and filter must be accessible for cleaning.

4. The outside coil must receive adequate airflow.

5. The technicians installing the system must be adequately trained in charging it, must consistently rely on the manufacturer's particular specifications for that unit, and must be given adequate time to perform all of the above tasks thoroughly.

6. The ductwork must be sealed with mastic at every joint, the duct leakage tested, and proven to be less than 50cfm at 50 pa. house pressure. Experience has shown that tape is not an adequate seal for ductwork.

7. Ducted and return systems must be employed. Building cavities must not be used as return ducts.

Addressing the issues of adequate design and installation assures a system that runs efficiently, and lasts longer than systems commonly installed today. This efficiency, in turn, allows for one more change in system installation that has far-reaching ramifications for peak reduction: appropriate system sizing.

Sizing It Right

Only when air conditioning systems are running efficiently does it become clear that many units are oversized. Load management programs often overlook the dramatic KW savings possible through appropriate sizing of residential air conditioning units. Running at full capacity, an oversized air conditioner can use many more KW than an appropriately sized unit, and at the same time can actually reduce the comfort of the occupants in the house. The combination of decreased efficiency and excess load can be deadly to a utility.

Nevertheless, contractors install oversized units quite commonly. Oversized systems are installed due to a lack of understanding of proper sizing, and because an oversize system will hide mistakes which would mean callbacks. One of the biggest mistakes hidden is poor quality duct installation. Unfortunately, oversize units run short cycles causing lower efficiency and reduced latent capacity. This leaves the customer with a high electricity bill, and a cold damp house.

Occupant behavior is a major determinant of peak usage. In over half the homes tested, occupants routinely override the thermostat controls of their system, choosing instead to turn the system on when they feel too warm, and off again when they are comfortable. This behavior becomes more apparent as the outside temperature increases. However, given the routine oversizing of systems discussed above, this manual control can severely affect the utility: larger systems use substantially more KVA due to increased capacity. For this reason, two additional criteria are necessary:

1. For new construction, the size of the unit must not exceed the size specified from the ACCA Manual J calculations.

2. For replacement units, the size of the new unit must be the same or less than that of the existing unit.

3. Selection of replacement units must consider peak KVA and latent capacity of the unit.

Proper installation of cooling systems results in substantial energy and KW savings, which benefits homeowner and utility alike.

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