THE COLLEGE STATION RESIDENTIAL ENERGY COMPLIANCE CODE

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ABSTRACT

The City of College Station, Texas adopted a new Residential Energy Compliance Code in January, 1988. The code, which strengthens compliance requirements in several areas, has received broadly based support and acceptance from all major constituent groups. It is less than one-fourth the length of the code it replaced, and compliance is greatly simplified through use of a check-list compliance path supplemented by point system and energy analysis paths. Results of air leakage measurements used to justify the stronger infiltration requirements of the code are reported. The process used to develop consensus support and key features of the code are described.

BACKGROUND

The City of College Station has enforced the Model Energy Code [1] (MEC) since 1979. In recent years, the Energy Division and the Energy Management Committee of College Station have discussed the merits of a strengthened Residential Energy Building Code. But the Committee concluded they should find out whether there were any significant problems with current practice before modifying the Code. They voted in 1986 to conduct a thorough study of compliance with the MEC by houses and apartments built during the early 1980s. The City Council concurred, and a contract was awarded to the

College Station for 1981-1986. The major results of that study were presented earlier [2]. It was found, based on sample inspections, that

1. Code enforcement was thorough: the code provisions in effect at time of construction were virtually always met.

2. The 1986 Model Energy Code allows construction of multi-family units where energy cost is 25-40 percent of monthly rent in College Station. This was viewed as a major code deficiency.

3. The 1987 cost difference between electricity and gas appeared to warrant stricter standards for buildings using electric heat and hot water.

4. An upgraded code could reduce demand growth to the year 2000 by up to 14 MW.

5. Homeowners, tenants and apartment owners could all experience lower overall housing costs as a results of an upgraded code.

Fan door measurements of air leakage in housing were also conducted, with the results presented below.

Based on the conclusions of the study noted above, it was decided to proceed with development of a revised Residential Energy Compliance Code. This paper focuses on the objectives adopted for the new code, the process used to develop the code and key features of the code [3] as adopted.

AIR LEAKAGE IN COLLEGE STATION HOUSING

Air leakage was investigated in 26 houses built in College Station from 1981 through 1986 using a fan door. Letters were sent to occupants of approximately 200 houses built during this period seeking expressions of willingness to participate in the study. The 26 houses chosen were selected to provide a distribution with respect to year of construction, builder and floor area, which approximated that in all houses built in College Station during this period.

The fan door was used to measure the leakage of each house at pressures ranging from approximately 5 Pascals to 60 Pascals. The data obtained were used to find the "effective leakage area" [4] of each house. The ELA is a measure of how "tightly" a house is built; it approximates the area of cracks and holes through which air leaks into and out of a house. Typical values are from 1-3 square feet. The "specific leakage area" (SLA) normalizes the ELA

The results of the fan door tests are presented in Figures 1-3 as a function of three factors: year of construction, size of house, and builder.

Variation of the specific leakage area by year of construction is shown in Figure 1 where the closed squares represent measured values and the open squares represent the average of the houses built in that year. From 1981-1984, when most of the houses were built, there was very little variation in SLA; the average value for the houses tested is between 0.15 and 0.20 in^2/ft^2 for all four years. If results for the two houses which were built in 1985-1986 were averaged together as a single entry, it would also be consistent with the earlier years. It had seemed likely, based on interviews with builders, that there would be evidence of tighter houses in the later years. While the sample tested is too small to reach definitive conclusions, there is no obvious improvement in the leakage characteristics of the houses built later in the period 1981-1986.

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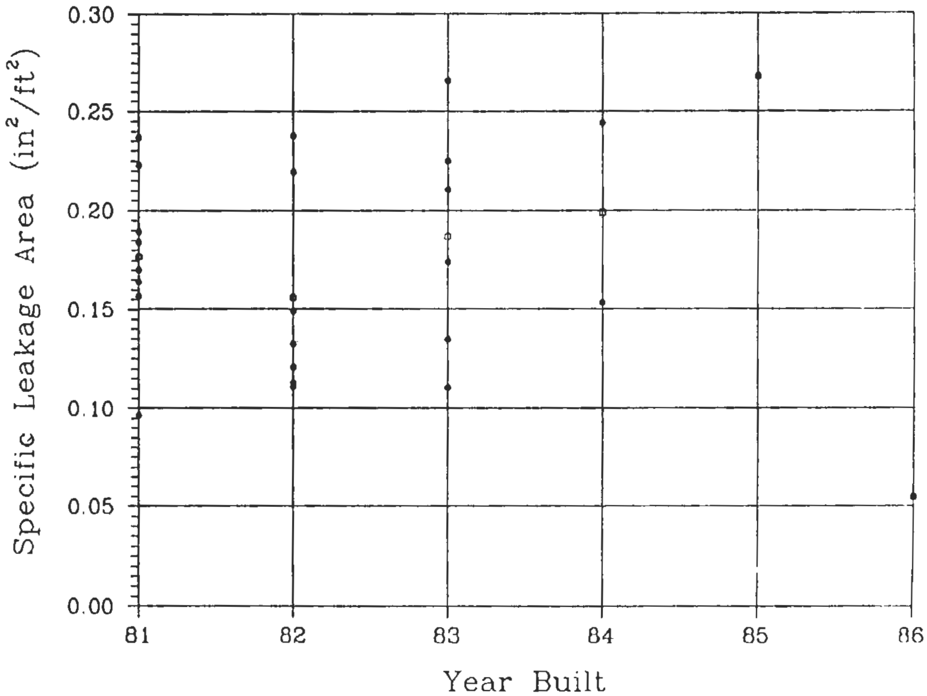

Fig. 1 **Specific leakage area of 26 houses by year of construction.**

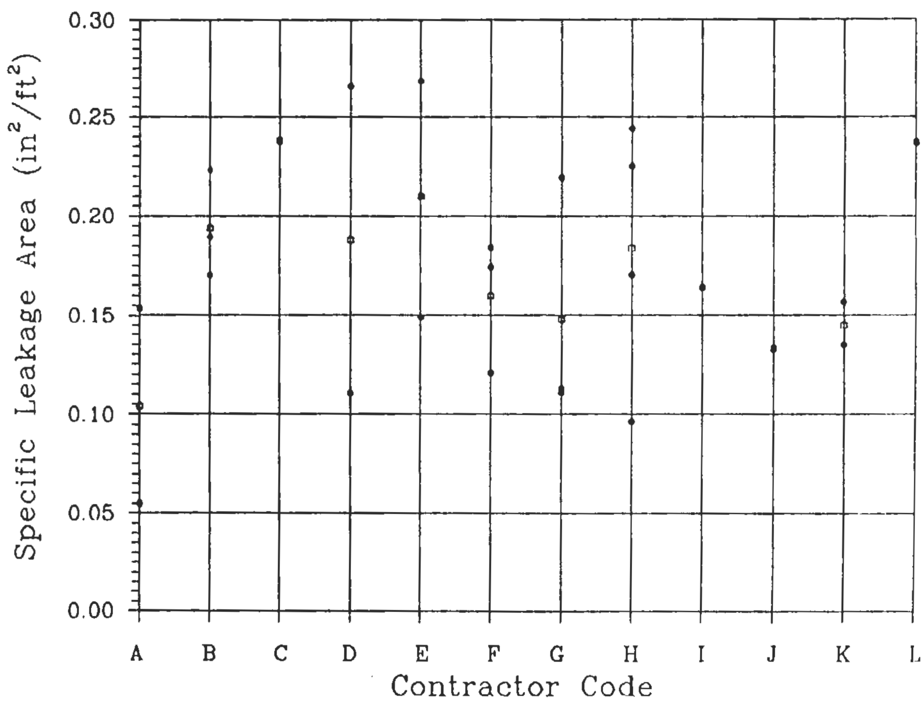

Fig. 2 **Specific leakage area of tested homes built by 12 different contractors.**

The variation in the specific leakage area by the contractor building the homes is shown in Figure 2. The average SLA for the 26 houses is 0.174+/-0.055 in^2/ft^2. Only one contractor with two or more houses in the sample had an average SLA more than one standard deviation above or below the average (contractor A) and one of his houses was near the average (0.157). Only one other contractor with two or more houses in the sample did not have houses on both sides of the average (contractor K). It is plausible that contractors A and K build tighter houses than the average contractor in College Station, but the sample is too small to attach real significance to the differences among contractors shown in Figure 2.

Figure 3 shows the specific leakage area as a function of floor area. There is enough scatter to introduce some ambiguity, but the expected decrease in SLA for large homes is evident. Four of the five 2500 square foot or larger homes had SLA below the average of 0.174 in^2/ft^2.

ENERGY COMPLIANCE CODE DEVELOPMENT

The College Station Residential Energy Compliance Code [3] was developed with repeated input and review from several key groups. These included the College Station Energy Division, the College Station Energy Management Committee, the Bryan/College Station Home Builders Association, the College Station Building Inspection Division, a local HVAC contractor, Lone Star Gas Company, and the College Station Building Code Board of Adjustments.

Prior to beginning code development, individual meetings were held with the president of the Bryan/College Station Home Builders Association and three other local builders active in residential construction. The discussions included their current energy-related construction practices, thermal characteristics or systems they would consider upgrading, and any concerns about the Model Energy Code and the proposed revisions. These builders all used practices which exceed the MEC; so while there was reluctance to favor a stricter code, they all perceived an advantage in such a code. Since many energy conservation measures are not visible to the buyer, low-end builders can cut costs in this area in ways that are not readily apparent to the buyer. This becomes more difficult with a stronger code. The builders interviewed were all interested in some type of rating system that would allow them to exceed the code and obtain a marketing advantage.

Additional meetings were held with Charles Shear of the College Station Energy Division and with the College Station Energy Management Committee before the following objectives were adopted for the new code:

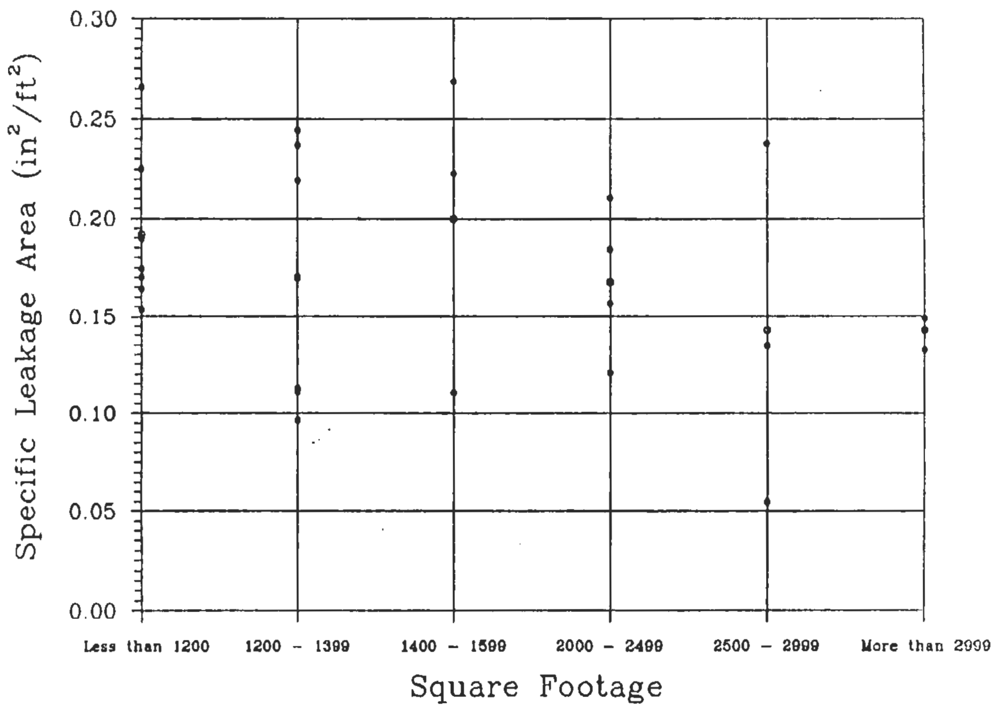

Fig. 3 Specific leakage area vs floor area for 26 houses.

1. Make the code easier to understand and administer.

2. Upgrade the Model Energy Code wherever cost-effective in College Station.

3. Bring utility costs of new multi-family housing nearer to those of single-family housing.

The draft code was developed in accord with these guidelines using continued input from the College Station Energy Division and the Energy Management Committee. The draft was then given to the President of the Bryan/College Station Homebuilders Association for distribution to individuals of his selection. A meeting was held with eight local builders/contractors to solicit comment and input. The only major concern was that a restriction on window-area within the prescriptive compliance path would require a significant number of houses to follow the component-performance or "point-system" compliance path. Examination showed that this requirement could be relaxed slightly while still meeting or exceeding the MEC. Helpful comments were received in several other areas including duct sealing and water heater specifications, some which resulted in further tightening of the code.

The draft was submitted next to the College Station Building Inspection Division where concern surfaced that the revised code would result in significant additional inspection requirements. Some adjustments were made, and it was finally agreed that one additional inspection would be needed to check compliance with some of the infiltration requirements of the new code.

The draft was revised to incorporate the comments received, reviewed again by the Energy Management Committee, and was submitted to the Building Code Board of Adjustments where it was approved without change. Before submission of the new code to the City Council for approval, copies were sent to 10 local builders and a meeting was scheduled at a mutually convenient time to discuss any final issues which might surface. All significant concerns had apparently been resolved at the earlier meeting, since none of the builders came to this meeting, or to the subsequent City Council meeting where the new Code was unanimously approved.

COLLEGE STATION RESIDENTIAL ENERGY COMPLIANCE CODE

The code contains the three compliance paths common to nearly all current energy codes:

1. Prescriptive or "Acceptable Practice"
2. Component Performance or Point System
3. Energy Analysis

As a result of its application to a limited class of buildings (residential construction of three stories or less) in a single climate, the code is much shorter than the Model Energy Code. The entire code is 22 pages, including seven pages of compliance forms.

PRESCRIPTIVE COMPLIANCE PATH

The prescriptive path is intended to meet the needs of 95-99 percent of all homes built. (All homes inspected during the first six months after the new code was implemented used this path). The compliance form is a checklist of 31 items on three pages; a portion of the form is shown in the appendix. Only 24 of the items apply to most homes. These include:

1. Insulation levels for walls, ceiling and floors - the same as required by MEC, except that R-11 wall insulation is always required.

2. Seven areas/items which must be sealed, caulked and/or weather-stripped. These requirements exceed MEC.

3. Fireplace damper.

4. Six requirements for swimming pools: a time clock and self-priming pump and for heated systems, a heater on/off switch, directional inlets, pool cover and gas heater AFUE rating of at least 78%.

5. Nine requirements on the hot water system, five of which apply only to electrically heated systems. Water heater efficiency is specified in terms of the "Energy Guide Rating" to simplify compliance. Electric water heating systems are required to insulate pipes near the heater and use bends to limit losses from convective flows in the pipes and install aerators to limit water waste, since electric water heating is much more expensive than gas in College Station. Requirements to limit use of electric resistance water heating were considered, but dropped, since there is virtually no local experience with heat pump water heaters or air-conditioner desuperheaters.

6. Space Conditioning: requirements for insulation on ducts and Freon lines and minimum air conditioner, heat pump and furnace efficiencies, specified in terms of SEER, HSPF and AFUE ratings. Resistance heating is not allowed on this performance path.

All equipment efficiency ratings are higher than the current MEC and merge with the National Appliance Efficiency Standards when they take effect. Standards were set higher than MEC to avoid installation of bottom-of-the-line equipment which will likely be dumped by many manufacturers just before the new national standards take effect. Gas AFUE was set at only 68% since typical heating bills in College Station are about $100 and payback on more efficient furnaces is generally 10 years or greater.

COMPONENT PERFORMANCE PATH

The component performance path permits deficiencies in the performance of a particular component to be compensated by other components which exceed code. It awards points for each component and requires every house to achieve a total of at least 100 points to comply with the code. It is really a system requiring a minimum score of zero, since each house is awarded 100 points to start the calculation and components which minimally comply with the code are awarded zero points. For example, R-11 ceiling insulation receives -6 points, R-19 receives zero points, and R-30 receives 3 points as illustrated by the partial form in the appendix. Similar point schedules are provided for each area or system listed below:

1. Glass area as a percent of wall area for single, double and triple glazing;
2. Exterior Doors
3. Insulation Levels
4. Infiltration Control
5. Fireplaces
6. Air Conditioning SEER
7. Heating Equipment
8. Water Heating Equipment/System

Based on past construction practices, the most likely buildings requiring use of the point system are multi-family buildings which wish to install resistance heating (which receives -25 points) or custom homes with very large windows (more than 25% of the wall area with double glazing or 15% of the wall area with single glazing).

The point system was developed based on simulation of annual energy use with the CIRA Program [5]. One point corresponds approximately to $10 in annual energy cost for a typical house, so a house of average size which passed the compliance code with 110 points could expect operating costs about $100 below the norm (note that 100 points corresponds to the typical house).

ENERGY ANALYSIS COMPLIANCE PATH

It is anticipated that 99+ percent of all residential construction will use the prescriptive path or the point system. For that rare project which cannot readily comply with either system or uses a renewable energy source, compliance can be demonstrated by an annual energy use estimate meeting specified maximums using an analysis procedure "approved by the Energy Division and Building Inspection Division of College Station, Texas". It is believed that this simple procedure for approval of analysis procedures is appropriate for a small city like College Station. For a normal house with gas heating and hot water and electric cooling, the standard which must be met is 6.9 kWh/SF electricity and 41,800 Btu/SF gas. The operating temperatures, appliance gains, infiltration levels, etc. which can be assumed are specified quite closely. Different compliance levels are specified for other combinations of gas and electricity use.

CONCLUSIONS

The code developed and adopted has met the initial objectives. It is about one-fourth the length of the Model Energy Code and compliance for most houses is extremely simple. All residential construction inspected during the first six months of enforcement of the new code has used the simplest "check-list" compliance path and enforcement has been easier than expected by the Building Inspection Division. The upgraded code will reduce the energy cost of multi-family construction, since nearly all multi-family units built in the 1980s have used electric resistance heat. The use of input from all major affected constituencies during development of the code was extremely important to the development of a workable code.

ACKNOWLEDGEMENTS

A large number of people and groups were essential contributors to the development of the College Station Residential Energy Compliance Code, including Charles Shear and the College Station Energy Division, the College Station Energy Management Committee, Coy Perry and the College Station Building Inspection Division, Danny Borski and the Bryan/College Station Homebuilders Association, and Lone Star Gas Company. Their contributions are gratefully acknowledged. The members of the Spring, 1987 MEEN 489 Energy Management class at Texas A&M conducted the fan door measurements, and their work was also an essential part of the process.

REFERENCES

1. Council of American Building Code Officials, Model Energy Code, Falls Church, VA, various years.

2. Claridge, D.E., Neidinger, P. and Schrock, D., "Thermal Characteristics and Systems of Residential Construction in College Station, Texas: 1981-1986," Proc. of Fourth Annual Symposium on Improving Building Energy Efficiency in Hot and Humid Climates, Houston, TX, Sept. 14-15, 1987, pp. 32-40.

3. College Station Residential Energy Compliance Code, City of College Station, TX, 1988.

4. American Society of Heating, Refrigerating and Air Conditioning Engineers, ASHRAE Handbook: 1985 Fundamentals, Chapter 22, Atlanta, GA, 1985.

5. Lawrence Berkely Laboratory, CIRA 1.0 Reference Manual, Berkeley, CA, March, 1982.

Appendix

Partial Code Compliance Forms

A. "Check-list Form

SHORT INSPECTION FORM - Page 3 of 3
(MECHANICAL INSPECTOR)

SPACE CONDITIONING

	Approved	Rejected
Air Conditioning SEER ______		
Heat Pump HSPF ______ SEER ______		
1" Insulation on the Freon Lines		
Duct Insulation: a) 2 inches of duct wrap or b) 1 inch of duct board or c) 1 1/2 inches of flex duct		
Gas Heaters: AFUE Efficiency 68%		

B. Form for "Point System

This chapter of the Residential Energy Compliance Code presented herein is an alternative method of determining whether a single family or multi-family residential building meets the minimum requirements of the College Station Energy Compliance Code. This point system covers both gas and electric dwellings. Record, in the spaces provided, the number of points corresponding to each component or characteristic of the building being evaluated.

1 - Initial Point Value

Every house is awarded 100 points to begin the compliance calculation.
Initial Points..................................100

2 - Glass Areas

The term glass area includes all external windows, sliding glass doors, french doors, etc. The exterior wall area includes walls between conditioned and unconditioned spaces such as garages, etc.

Table for Glass Area Point Values						
Window Type	Percent of Wall Area Which is Glass (%)					
	0-10	11-15	16-20	21-25	26-30	31-35
Single Pane	14	0	-11	-20	-29	-38
Double Pane	16	6	0	-8	-15	-21
Triple Pane	18	10	5	-2	-7	-12

Glass Area Point Value ________

3 - Exterior Doors

A. Solid or Hollow Core.................... 0
B. Insulated or Storm...................... 1

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