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Project Summary

Radon Pressure Differential Project, Phase I Florida Radon Research Program

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The report gives results of tests on 70 central Florida houses to assess and characterize pressure differentials in new (age 5 years or less) Florida houses. Blower door tests determined house airtightness and air distribution system leakage. The 70 houses had an average airtightness of 7.23 air changes per hour at 50 Pa(*) (ACH50). Significant leaks were found in the ductwork in most houses tested, both on the supply and return sides of the air handler. When the air distribution system was sealed off, house ACH50 decreased to 6.421, indicating that 11.2% of the house leak area is in the duct system.

Differential pressure measurements were taken between the main body of each house and sub-slab areas, outdoors, and many locations within the house. These measurements indicated significant pressure differentials in the house due to a number of factors. Return leaks produced a maximum whole-house pressurization of 5.5 Pa. Supply leaks produced a maximum whole-house depressurization of -4.8 Pa. Closed interior doors produced a maximum closed-room pressurization of 37 Pa and a maximum main-body depressurization of -14.8 Pa. Turning on all exhaust fans and interior dryers typically depressurized the house to 0 to -4 Pa, but one very tight house was depressurized to -37 Pa.

One of the most important findings of this study is that large-magnitude localized depressurization occurs because of return plenum leaks. Subslab depressurization of up to 6 Pa have been found 5.5 m(**) from the return plenum. Depressurization of -6 Pa in a garage and a -4 Pa in a utility room has been observed.

This Project Summary was developed by EPA's Air and Energy Engineering Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Radon intrusion into buildings is a function of radon resource strength in the soil, the permeability of the soil, the cumulative size of penetrations in the house/soil interface, and the pressure differences across the house/soil interface. Pressure differences are a function of the natural forces of wind and thermal buoyancy, and mechanical forces of air-moving equipment. This equipment includes central conditioning-air-moving systems, exhaust fans in the bathrooms and kitchens, cooktop grill exhausts, clothes dryers, whole-house fans, attic exhaust fans, and central vacuum cleaner systems.

The impact of these mechanical systems is a function of the volume of exhaust air flow, house airtightness, and the fraction of the time that they operate. Central air conditioning systems operate automatically according to thermostat control.

(*) 1 Pa = 0.004 in. WG

(**) 1 m = 3.28 ft

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Typical daily run times range from 20 to 60%, depending upon a number of variables: the size of the space conditioning unit in relation to the conditioning load, the thermostat setpoint, the mechanical condition of the space conditioning unit and the duct system, and the fraction of time that interior doors are kept closed. Operation time of other air moving equipment is a function of family demographics and lifestyle. The number of exhaust fans in a house and whether the clothes dryer is located within the house are obviously important variables as well.

An additional source of differential pressures in Florida houses is closure of interior doors. Since most houses have only one or two returns, and since generally both are located in the main body of the house, return air comes back to the air handler through open doors. If the doors are closed, much of the return air flow is blocked. The closed rooms go to high pressure and the main body of the house goes to negative pressure, as it is starved for air. The pressures significantly increase the infiltration rate of the house and increase the potential for radon to be sucked in from the soil. The pressure buildup in the closed rooms is a function of the amount of supply air to the room, the airtightness of the room, and the amount of door undercut. None of the 70 houses tested in this study had transfer registers to assist return air flow.

In this project, pressure differences have been measured across the house floor, from indoors to outdoors, from indoors to the garage, and from one area to another within the house with various combinations of mechanical systems operating. The main body of the house was considered the reference point for pressure differential measurement — this means that the main body was always considered to be at 0 Pa pressure. Pressure differentials reported assume the outdoors as the reference pressure (outdoors = 0.0 Pa) unless otherwise noted.

The airtightness of the house and the air distribution system has been measured by blower door testing. The location, type, and estimated size (cubic feet per minute) of duct leaks have been obtained from visual inspections using tracer smoke. The objectives of this study include characterization of pressure differences within Florida houses and across their slabs as a result of naturally and mechanically induced effects, and identifying the causes of these pressure differences.

Conclusions

Testing has been done on 70 central Florida houses to assess and characterize pressure differentials in new (age 5 years or less) Florida houses. House airtightness is substantially greater than in older Florida housing. House airtightness for these houses was 7.23 vs. 12.58 ACH50 in a sample of 90 mixed-age central Florida houses. It was found that 11.6% of the house leak area is in the duct system, similar to the 12.2% found in the 90 older houses. However, since the houses are tighter, the duct systems are tighter as well. Ducts are looser in older houses in this study. Those 1 or 2 years old have duct ELA50 (equivalent leak area at 50 Pa) or about 0.013 sq m,* while those 4 or 5 years old have about 0.023 sq m ELA50. This can be interpreted either that duct air distribution systems are being constructed more airtight, or that tape closure systems deteriorate over a few years in a significant number of houses. In others, tape has not shown signs of failure. Mastic with fabric closure systems showed no signs of failure.

Pressure differentials, which have the potential to reduce or increase radon entry rates, are produced by natural forces of wind and temperature, and mechanical systems. Wind-produced depressurization in a house is typically in the range of -0.5 to -1.5 Pa. The greater the wind speed, the greater the depressurization.

Mechanical systems produced much greater pressure differentials than wind in many cases. Turning on the air handler produced pressure differentials from about -4 to +4 Pa. Supply leaks depressurize the house, while return leaks pressurize the house.

Return leaks depressurize local zones within houses. Garages and utility rooms, especially, experience depressurization because of return leaks. Seventeen of 41 garage units depressurized the garage to -1 Pa or more, and to more than -6 Pa in one garage. Leakage of the depressurization field from the return plenum into adjacent wall cavities, and through cracks and chases into the soil, also has the potential to draw radon into the air distribution system and thus into the house.

Closing of interior doors increased pressure differentials. Position pressure in nine closed rooms increased to as much as 38 Pa relative to outdoors in some houses, and the main body of the house depressurized to as much as -14.8 Pa relative to outdoors. Nearly a third of the house depressurized to -4 Pa or greater (in the main body of the house) when the interior doors were closed.

Exhaust equipment and appliances depressurize houses. The tighter the house and the larger the exhaust air flow, the larger the potential depressurization. One tight (2.4 ACH50) house depressurized to -376 Pa when four exhaust fans and a dryer were operating. More typically, operation of all exhaust equipment depressurizes houses to -1 to -5 Pa. Bathroom exhaust fans depressurize bathrooms by more than 1 Pa in more than half the houses. Dryers alone depressurize the entire house by -0.2 to -2 Pa in most houses, and in one house to -9 Pa.

Pressure differentials across the slab are similar in magnitude to those from indoors to outdoors. However, in some houses there is less of a pressure drop across the slab, indicating some communication through the soil to the outdoors.

The cause and effect relationship between depressurization and radon entry has not been investigated or demonstrated in this study. Consequently, it cannot be stated with certainty that duct leakage, closing of interior doors, and exhaust equipment operation increase radon entry rates. If, as most believe, radon entry is strongly related to pressure differential, then these mechanical systems may be significant contributors to radon in Florida houses.

Several recommendations follow from this. First, air distribution systems should be constructed to be airtight and durable for the life of the house. Materials and construction methods which produce airtight and durable ducts should be adopted. Second, return air pathways should be provided for each closeable room so that depressurization of the main body of the house can be minimized. Third, operation of exhaust equipment should be minimized. Alternatively, exhaust flow can be balanced by equal supply air to eliminate depressurization.

(*) 1 sq m = 1550 sq in.

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The complete report, entitled "Radon Pressure Differential Project, Phase I Florida Radon Research Program," (Order No. PB92-148 519/AS; Cost: $19.00; subject to change) will be available only from:
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