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Final Report

Air Change Rate Tests of Aura Vent

For: Horton Homes Inc. 101 Industrial Blvd.

Eatonton, GA 31024

November 7, 1996

Conducted by: Chris Downing, P.E.
Georgia Institute of Technology
Economic Development Institute
Griffin Regional Office
118 North Expressway
Griffin, GA 30223

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1. Introduction

At the request of Mr. Carl Brorup, Horton Homes, Inc., a series of air change rate tests were conducted by Mr. Chris Downing, P.E., Georgia Institute of Technology, to determine the air change rate achieved by installation of an 8" Aura Vent on a manufactured home. The Aura Vent is a passive exhaust vent manufactured by Aura Ventilation, Inc., Mamaroneck, NY. The tests were conducted on a newly manufactured 76' x 16' single wide home located on the grounds of the Horton Homes Inc. facility in Eatonton, Georgia, on October 10, 1996. Mr. Carl Brorup, Horton Homes, Inc. and Mr. Les Orenstein, Aura Ventilation, Inc. were present as observers during the testing.

2. Test Method

Air change rates were determined using tracer gas decay methods. The tracer gas decay measurements were conducted in accordance with ASTM Standard E 741-83. For each test, a tracer gas, sulfur hexafluoride (SF6), was released into the home and then the decay in SF6 concentration over time was measured. The concentrations of SF6 were measured with a photoacoustic meter (Bruel & Kjaer Model 1302) which has an accuracy of + 1% of the measured value and a lower detection limit of 6 parts per billion for SF6.

Based on the tracer gas decay measurements, the air change rates for each test were calculated by conducting a least square regression analysis of the concentration decay line. The air change rate equals the slope of the decay line when plotted on a natural log scale. Three sampling points were measured within the home at a level of four feet above the floor. SF6 concentration measurements were conducted at intervals of two minutes, rotating between the three sampling points. The ambient concentration of SF6 outside the home was also measured before and after each test.

Tracer gas decay tests were conducted at three conditions.

- Test 1 - Baseline, No Vents
- Test 2 - Aura Vent Only
- Test 3 - Aura Vent with Inlet Vent

Ambient windspeed and temperature, and inside temperatures were monitored at 10-15 minute intervals with a TSI Inc. Digital Anemometer, Model 8350. Visual air flow direction through the Aura Vent, inlet vent, kitchen and bath exhaust, around windows and on the exterior of the home were conducted with ventilation smoke tubes. Smoke tube tests were conducted without the mixing fans operating.

Test Site Description

The subject test were conducted on a newly built manufactured home by Horton Homes, Inc. This home was single story with an exterior dimension of 16' x 76'. No special consideration during construction including sealing methods were provided to this home. The ceiling height averaged 8' due to sloped ceilings in the dining and living areas. The house was located outdoors at the Horton Homes facility more than 75 feet from any buildings. A floor diagram of the manufactured home is provided in Figure 1. The home was orientated in an approximately east-west direction as shown in the diagram. The sampling points were located in the center of the 2nd.

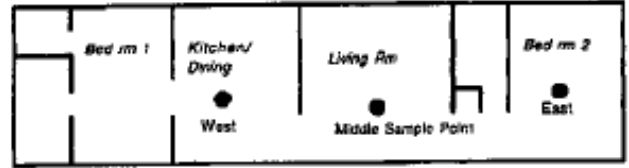
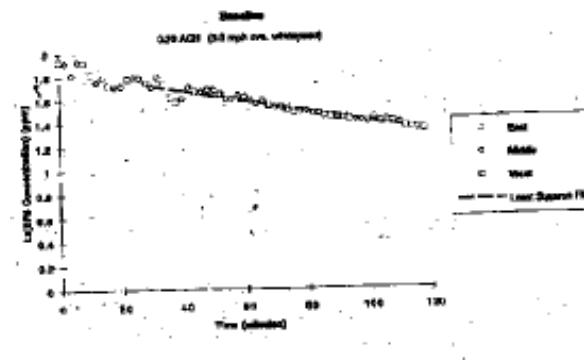


Figure 1 - Floor Layout, 16 x 76, Manufactured Home



The bedroom (East) is the center of the living area (Middle), and center of the dining area (West). The air-conditioning and heating system (HVAC) fan was not activated during the tests. Two portable fans were placed at floor level within the home to ensure good air mixing throughout the tests. The kitchen and bathroom exhausts fan were not operated during the tests. The attic was naturally vented with ridge and soffit vents. This home had a fireplace pre-installed; however, it was sealed during these tests. All interior doors

were blocked into an open position.

The Aura Vent was installed through the ceiling and roof just off the dining room and the Inlet Vent was installed through the ceiling and roof in the Bedroom - as shown in Figure 1. Schematic drawings of the 8" Aura Vent and the Inlet Vent are provided in Figure 2. The Aura Vent and Inlet Vent were installed prior to testing and were taped off to conduct the Baseline and Aura Vent Only tests, respectively.

3. Results and Discussion

A summary of the test results and test conditions is provided in Table 1. This table provides the average air change rate measured for each test. The error in air change rate measurement, based on a 95% confidence level, was plus or minus 0.01 ACH for all tests. Average temperature differences between indoors and outdoors for all three tests were quite small ranging between 2°F and 3°F. Ambient wind was approximately northwest in direction and light and variable, averaging between 3.3 and 4.6 mph throughout the tests. Plots of the tracer gas concentrations over time are provided in Figures 3, 4 and 5. The air change rates shown in Table 1 are equal to the slope of the decay plot for each test. In each test, the air change rate was constant and the interior air was well-mixed. This is reflected in the straightness of the decay lines.

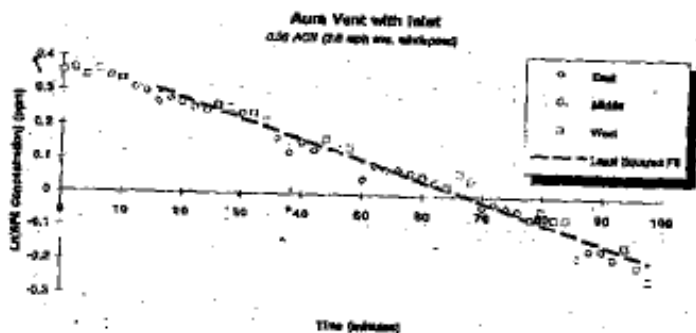
The Baseline or natural air change rate measured in Test 1 was 0.26 air changes per hour (ACH). This establishes a base of natural infiltration and exfiltration for this home under the conditions tested. This is quite close to the assumed 0.25 ACH stated by the U.S. Department of Housing and Urban Development (HUD) for manufactured housing. During periods of greater temperature, differences and higher wind speeds and with the HVAC fan operating, it is expected the natural air change rate would be greater. For this configuration, ventilation smoke tube tests around the kitchen exhaust vent confirmed some air from indoors to outdoors. Smoke tests around the bath exhaust vents and fireplace indicated no air movement. Smoke tests around the supply air vents of the air conditioning and heating system indicated a small amount of air movement either inward or outward depending on the vent. Smoke tests around the windows, doors, electrical panel, electrical outlets all showed no air

leakage.

Test 2 with the AuraVent Only measured an air change rate of 0.42 ACH at a slightly higher ambient windspeed of 4.6 mph. This is 0.16 ACH greater than the Baseline or natural ventilation amount. Some amount of this may be due to additional natural ventilation caused by the slightly greater windspeed during this test. The 0.42 ACH is equivalent to approximately

68 cubic feet per minute (cfm) of total ventilation for this home size. Smoke tests with this configuration indicated very apparent exhaust flow through the Aura Vent and a slight infiltration flow through the kitchen exhaust opening and ventilation n system supply ductwork vents. This indicates that the Aura Vent is drawing ventilation into the home through natural ventilation pathways such as the leakage areas of HVAC ductwork and powered exhaust vents such as the kitchen exhaust vent, and that no positive or negative pressurization of the home is occurring.

Test 3 with the Aura Vent and Inlet Vent measured an air change rate of 0.36 ACH with an average ambient windspeed of 3.6 mph, approximately the same windspeed speed as the Baseline test. This air change rate is approximately equal to 59 cfm of total ventilation. Smoke tests with this configuration again indicated very apparent exhaust flow through the Aura Vent and a slight infiltratin flow through the kitchen exhaust opening. Smoke tests on the Inlet Vent indicated primarily infiltration flow;



however, it periodically indicated exfiltration. This variation was likely due to wind gusts. The slightly lower rate of air change measured for this test compared with Test 2 is consistent with the lower windspeed. The additional Inlet Vent likely had little effect, since Test 2 showed that this home had enough natural openings to make up the Aura Vent exhaust.

4. Conclusions

The air change rate tests indicated that the 8" Aura Vent resulted in increased overall air change rates through passive exhaust. For light wind speeds of less than 5 mph, the 8" Aura Vent provided at least an additional 26 cfm of passive exhaust resulting in an overall air change rate of at least 0.41 ACH, assuming a natural ventilation rate of 0.25 ACH, for a home with a volume of approximately 9,730 ft. Since average windspeeds are greater than 5 mph and average temperature differences are much greater than 3°F, throughout North America, actual additional passive exhaust ventilation would be greater than 26 cfm. Table 2 is provided as an estimate of the minimum additional passive and total air change rate which would be achieved by the installation of one or two 8" Aura Vents on different size manufactured homes. This table is based on assuming a natural or baseline air change rate of 0.25 ACH and a passive exhaust now of 26 cfm from each 8" Aura Vent.

Test Number 1: Air Change Rates

Test Number	Description	Test Conditions	Air Change Rate
Test 1	Baseline or Natural Ventilation	Ave. Temperature Difference=3°F, Ave. Windspeed-3.3 mph	0.26 ACH
Test 2	Aura Vent Only	Ave. Windspeed = 4.6 mph, Ave., Temperature Difference-2°F	0.42 ACH
Test 3	Aura Vent and Inlet Vent	Ave. Windspeed-3.6 mph, Temperature Difference-2°F	0.36 ACH

Table 2 - Predicted Minimum Passive Exhaust & Total Air Change Rates

Number of 8 Aura Vents Installed	Manufactured Home Floor Area	Volume (8 ft. ceilings)	Passive Exhaust	Total Air Change Rate
1	1216	9,730	26 cfm	0.41 ACH
2	1216	9,730	52 cfm	0.57 ACH
1	2050	16,400	26 cfm	0.35 ACH
2	2050	16,400	52 cfm	0.44 ACH
1	3000	24,000	26 cfm	0.31 ACH
2	3000	24,000	52 cfm	0.38 ACH

Note: Predicted minimum passive exhaust and total air change rates are based on tests with average windspeeds of less than 5 mph, temperature differentials of less than 3F, and an assumed natural ventilation of 0.25 ACH. Performance will be greater at increased average windspeeds and temperature differentials.