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1-1-2003

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STARS Citation

Florida Solar Energy Center and Cummings, James, "Air Handler Leakage: Field Testing Results In Residences" (2003). *FSEC Energy Research Center®*. 564.
https://stars.library.ucf.edu/fsec/564

Reference Publication: Cummings, J.B., Chuck Withers, Janet McIlvaine, Jeff Sonne, and Matt Lombardi. "Air Handler Leakage: Field Testing Results in Residences". ASHRAE Transactions, Volume 109, Part 1, 2003.

Air Handler Leakage:
Field Testing Results in Residences

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FSEC-RR-138-03

Abstract

Testing was performed to characterize air leakage in 30 air handler cabinets and at connections to supply and return ductwork. Operating pressures were measured in the air handler and plenums. Q 0.1 (Q 25) in the air handler averaged 23.9 cfm (11.3 l/s) in 30 homes. Leakage at the return and supply ductwork connections averaged 3.9 Q 0.1 (1.8 l/s Q 25) and 2.2 Q 0.1 (1.0 l/s Q 25), respectively. Actual return side leakage of 77.5 cfm (36.6 l/s) and supply side leakage of 3.1 cfm (1.5 l/s) are calculated based on Q 0.1 (Q 25) and measured operating pressures, which is 6.4% of the system air flow.

Duct leakage (including the air handler) was also measured in a sub-sample. Return Q 0.1 (Q 25) for 21 homes was 88 cfm (42 l/s). Supply Q 0.1 (Q 25) for 11 homes was 132 cfm (62 l/s). Return leakage is estimated to be 170 cfm (80 l/s) or 13.4% of system air flow and supply leakage is estimated to be 167 cfm (79 l/s) or 13.2% of system air flow.

Keywords

air conditioning, air distribution, air flow, air handling, air leakage, duct system, efficiency, energy, pressure, residential

Background

Considerable research has been performed in recent years investigating the amount of air leakage into and out of duct systems, especially in residences, and rather high levels of duct leakage have been found throughout the United States. In response, a variety of utility and conservation programs have begun to address duct leakage, and home energy rating programs have included duct leakage testing into their protocols. Standards for high efficiency house design and construction in many cases now include duct airtightness as a performance criteria, and as a result, duct systems are becoming more airtight in some new homes. It is not an uncommon occurrence, however, that the ductwork is tight but the overall air distribution system cannot meet the standard because of air handler cabinet leakage. In a sample of 10 houses tested in 1997, duct leakage increased by a factor of 2.7 when only the air handler and grilles were added to complete the system.

Furthermore, considerable debate surrounds the issue of where air handlers should be installed; indoors, outdoors, garage, crawl space, or attic. The last three locations commonly contain air contaminants or excessive heat and humidity which can lead to IAQ, energy, or system performance problems.

Field Study

A study was designed and carried out to determine the amount of air leakage which exists in air handler cabinets as installed in new housing. A sample of 30 houses constructed since January 1, 2001 was selected, with 10 air handlers at each of three locations: indoors, garage, and attic. In addition to leakage in the air handler cabinet, the study also looked at the leakage at the connections of the cabinet to the supply plenum and the return plenum, since these connections would also be located in the zone where the air handler was located.

In order to assess air leakage at the air handler and two adjacent connections, Q 0.1 (Q 25) was measured at each of these locations. (Note that in this paper, Q 0.1 (Q 25) is total airflow leakage in cubic feet per minute (liters per second) when the ductwork or air handler is placed at 0.10 inWG (25 pascals) unless otherwise noted. In the ASHRAE Standard 152P nomenclature, this would be designated as Q 0.1,total (Q 25,total) . When leakage is measured to "out", then it will be listed as Q 0.1,out (Q 25,out)). While Q 0.1 (Q 25) is the measurement of airflow at a test pressure, it can also be considered to be a measurement of hole size. In order to obtain air leakage as the system is actually operated, it was necessary to also measure the operating pressure differential between inside and outside of the air handler and adjacent connections. In other words, it was necessary to know both the hole size and the operational pressure differential across that hole.

Test Method

The following test method was used for determining Q 0.1 (Q 25) in the AH and at adjacent connections. A segment of the air distribution system (ADS) connected to the air handler was isolated, and a calibrated duct tester was installed onto this segment. Isolating the supply duct from the test segment involved cutting through the main supply plenum (typically foil faced fibrous board), inserting an air barrier through the supply plenum (such as a rigid sheet of plastic), and then sealing this air barrier to the exterior (typically foil) surface of the supply plenum. In this manner, the supply ductwork was removed from the tested segment. (Note, however, that the return side of the system was not removed from the test segment.) In a number of homes, it was not possible to cut through the supply plenum either because there was insufficient length of plenum before branch ducts or because the supply plenum was a flex duct. In these homes, all of the supply registers were sealed, in effect testing the entire duct system.

On the return side, the system normally has one return grille, often located within a few feet of the air handler. The duct tester was attached to the return grille, and the balance of the return grille was masked off.

An airtightness test was performed on the isolated portion of the ADS, obtaining Q 0.1 ((Q 25), total air leakage). Then leaks at the AH-to-supply plenum connection were repaired. The Q 0.1 (Q 25) test was repeated. Then leaks at the AH-to-return plenum connection were repaired. The Q 0.1 (Q 25) test was repeated. Then leaks in the AH cabinet were repaired. The Q 0.1 (Q 25) test was repeated. Leakage at each of the three indicated locations was calculated by subtracting one Q 0.1 (Q 25) value from the preceding Q 0.1 (Q 25) value. A vital factor underlying this method is the ability of the field test staff to eliminate essentially all leakage from the three repaired locations. Considerable attention was given to making sure that these repairs were in fact thorough and complete and were verified by inspection of a second staff member.

One issue that had to be addressed was accuracy of the calibrated blower at very low air flows. The duct test unit that was used has rated accuracy down to 30 cfm (14 l/s). In some cases, the Q 0.1 (Q 25) remaining after repairs was less than 30 cfm (14 l/s). Our response was to calibrate the duct test unit down to 10 cfm (4.7 l/s) against a wind-tunnel with rated accuracy of +1% of reading. We found a rather consistent 2 cfm (1 l/s) offset from reading (the tester was reading high) in the range from 10 cfm (4.7 l/s) to 38 cfm (17.9 l/s). Using this calibration therefore allowed a wider measurement range.

In addition to measuring Q 0.1 (Q 25), "as found" system operating pressures were measured with respect to the zone where the air handler was located. With the system operating, pressure measurements were taken at four areas; 1) the supply plenum to cabinet connection (usually on three sides), 2) in the air handler between the blower and coil (usually at two locations), 3) between the coil and the bottom of the air handler (usually at two locations), and 4) the return plenum-to-cabinet connection (usually at two locations). Note that in all cases, the tested air handlers are "up-flow" and in most cases the blower discharges at the very top of the unit.

Additional Field Data

- Based on dimensional measurements and inspections inside the air handler, we knew what portion of the AH is above and below the coil, so that Q 0.1 (Q 25) and pressure measurements could be properly weighted.
- Return and supply air flows were measured by means of a flow hood (with rated accuracy of +5% of reading +5 cfm (2.9 l/s) from 0 cfm (0 l/s) to 2500 cfm (1180 l/s)). Air handler flow rates were measured by means of an air handler flow plate device (per ASHRAE Standard 152P methodology; see Palmiter et al., 2000 for description). This calibrated flow plate device, which measures flow by measuring total pressure through a grid, is inserted into the filter access tray near where the return duct connects to the air handler. A manometer measures the pressure differential produced by the air velocity moving across the orifices of the flow device. This pressure differential is converted to an air flow rate for the specific flow plate configuration used. Since the flow plate creates resistance to air flow and therefore modifies the normal air flow rate, a correction factor is assigned by taking into account changes in supply plenum pressure.
- The location and type of filter was recorded. (Seven filters were located in the air handler and 23 were at the return grille(s). Filters for all 10attic units were located at the return grille. Note the following relevance: filters located at the return grille cause greater levels of return duct depressurization [and therefore potentially more duct leakage] and fail to filter return leak air.)
- The dimensions and the surface area of the air handler cabinet were measured and recorded. (Average air handler surface area was 29.4 square feet (2.73 square meters), ranging from 22.0 square feet (2.04 square meters) to

35.5 square feet (3.30 square meters).)

- The fraction of the air handler under negative pressure and under positive pressure was determined by measured dimensions of the air handler cabinet sections. (On average, 6% of the air handler cabinet was under positive pressure and 94% was under negative pressure. 26 of the 30 AHs were 100% depressurized, while four were on average 58% depressurized.)
- An estimate was made of the fraction of the initial air handler leak area that was sealed "as found". (19 of the 30 air handlers showed some evidence of sealing. Our evaluation considered "what is the hole size and what portion of that was sealed". On average, 20.4% of air handler leakage had been sealed, based on our visual observation estimates. In one case, 90% was estimated to have been sealed. Therefore, in the absence of air handler cabinet sealing, air handler cabinet leakage would be about 25% greater than what is reported in this paper.)
- The types of sealants used at AH connections were recorded. Space conditioning equipment model numbers were recorded.
- Rated cooling and heating system capacity was determined.
- At 11 of the 30 houses, overall duct system and house airtightness was measured (see section 2.3).

Test Results for 30 Systems

A total of 30 air handlers were tested in 29 houses. (At one house, both an attic and indoor air handler were tested.) Ten air handlers were located in the house, ten were in the garage, and ten were in the attic. All 30 were located in central Florida and were constructed in the year 2001.

The airtightness results from all 30 air handlers are as follows (note that the units for Q 0.1 (Q 25) is cfm (l/s)): 23.9 Q 0.1 (11.3 l/s Q 25) in the air handler cabinet, 3.9 Q 0.1 (1.8 l/s Q 25) at the return connection, and 2.2 Q 0.1 (1.0 l/s Q 25) at the supply connection. These measured leakage amounts were "as found", that is, the leakage of the system was measured without making any changes to the system with one exception. If the filter access door was off or ajar, then it was placed in its proper position. The filter access door was found to be removed or ajar in two homes, both interior air handlers. For reference, Q 0.1 (Q 25) was also measured before adjusting the filter access doors. In one case, a missing filter access door represented 189 Q 0.1 (89 l/s Q 25). In the other case, an ajar filter access door represented 37 Q 0.1 (17 l/s Q 25).

Pressure differentials were measured at four locations under normal system operation, as described earlier. The lower portion of the air handler was always under negative pressure. The upper portion of the handler was under negative pressure in all but four cases (the exceptions were furnaces or hydronic coil units). In those four cases, on average, 42% of the unit was under positive pressure. On average, operating pressures were –0.327 inWG (–81.6 pascals) at the return connection, 0.538 inWG (-134.2 pascals) in the lower portion of the air handler, 0.713 inWG (-177.7 pascals) in the upper portion of the air handler (between the blower and coil) in all but three units, 0.528 inWG (+131.7 pascals) between the blower and supply plenum connection in three units, 0.237 inWG (+59.1 pascals) at the supply connection, and 0.277 inWG (+69.1 pascals) in the supply plenum. The weighted air handler negative pressure zone was 0.627 inWG (-156.3 pascals). (The pressures measured in each region of the system were weighted by the surface area that region represented.)

Based on the measured operational pressures and the Q 0.1 (Q 25) for each location, estimated air leakage has been calculated for both the negative pressure and the positive pressure zones of the "air handler plus", where "air handler plus" means the cabinet plus two plenum connections. The calculation method (Equation 1) comes from ASHRAE Standard 152P.

$$Q = Q_{0.1} (dP_{actual}/0.1)^{0.6} \qquad \text{Equation 1 (IP)}$$

$$Q = Q_{25} (dP_{actual}/25)^{0.6} \qquad \text{Equation 1 (SI)}$$

where Q is the duct leakage air flow and dP actual is the operating pressure where the leak is located.

The negative pressure zone (in cabinet and return connection) had an average leakage of 77.5 cfm (36.6 l/s), or 6.1% of the average 1266 cfm (598 l/s) of air handler air flow. The positive pressure zone had an average leakage of 3.1 cfm (1.5 l/s), or 0.25% of air handler flow.

Air Leakage Variations by Air Handler Type and Location

When planning the project, it was intended that six gas furnaces would be tested, two from each air handler location. However, only three furnaces were tested, all in the garage because no furnace units were found in our sample of interior or attic units. In addition to the three furnaces, one hydronic gas heating system was tested (this air handler was also located in the garage). The hydronic system uses a hydronic heating coil with hot water supplied by a gas water heater. The remaining 26 air handlers were heat pumps. Table 1 presents airtightness results by air handler location and fuel type. The three gas furnaces were found to be much more leaky than the non-furnace units; 51.8 Q 0.1 (24.4 l/s Q 25) versus 20.8 Q 0.1 (9.8 l/s Q 25). The hydronic unit had air handler leakage of 31.6 Q 0.1 (14.9 l/s Q 25) closer to the leakage of the standard electric air handlers. When converted to normal operation leakage using Equation 1, the three furnace units experienced 145 cfm (68 l/s)of return leakage and 13 cfm (6 l/s) of supply leakage. By comparison, the 27 non-furnace air handlers experienced 70 cfm (33 l/s) of return leakage and 2 cfm (1 l/s) of supply leakage.

Table 1a (IP)

Operating pressures, Q 0.1, and calculated operational leakage for 27 electric and 3 gas air handlers (furnaces). Note that "leak cfm" includes leakage in the air handler cabinet and the return and supply connections to the cabinet.

	dP return connect. (inWG)	dP AH (-) region (inWG)	dP AH (+) region (inWG)	dP supply connect. (inWG)	Q 0.1 ret. Connect (cfm)	Q 0.1 air handler (cfm)	Q 0.1 sup. Connect (cfm)	operation leak (cfm) (-) region	operation leak (cfm) (+) region
Attic	-0.297	-0.552	NA	0.175	0.9	21.3	2.6	61.3	2.4
Garage	-0.459	-0.783	NA	0.264	2.6	20.8	1.6	78.6	2.7
Interior	-0.275	-0.675	NA	0.243	3.5	20.4	1.2	72.8	1.3
Avg. (27 AHs)	-0.331	-0.658	NA	0.223	2.3	20.8	1.8	70.0	2.0
Furnace (3 AHs; all in garage)	-0.293	-0.349	0.482	0.362	18.2	51.8	5.3	144.7	12.7
Avg. (30 AHs)	-0.327	-0.627	0.398	0.237	3.9	23.9	2.2	77.5	3.1

Table 1b (SI)

Operating pressures, Q 25 , and calculated operational leakage for 27 electric and 3 gas air handlers (furnaces). Note that "leak cfm" includes leakage in the air handler cabinet and the return and supply connections to the cabinet.

	dP return connect. (pa)	dP AH (-) region (pa)	dP AH (+) region (pa)	dP supply connect. (pa)	Q 25 ret. Connect (l/s)	Q 25 air handler (l/s)	Q 25 sup. Connect (l/s)	operation leak (l/s) (-) region	operation leak (l/s) (+) region
Attic	-74.1	-137.7	NA	43.7	0.4	10.1	1.2	28.9	1.1
Garage	-114.4	-195.1	NA	65.7	1.2	9.8	0.8	37.1	1.3
Interior	-68.6	-168.4	NA	60.5	1.7	9.6	0.6	34.4	0.6
Avg. (27 AHs)	-82.5	-164.0	NA	55.6	1.1	9.8	0.9	33.0	0.9
Furnace (3 AHs; all in garage)	-73.0	-87.0	120.1	90.3	8.6	24.4	2.5	68.3	6.0
Avg. (30 AHs)	-81.6	-156.3	99.1	59.1	1.8	11.3	1.0	36.6	1.5

When gas furnaces are excluded, there were only minor variations in cabinet airtightness by air handler location. Q 0.1 (Q 25) is essentially the same for each air handler location; 21.3 cfm (10.1 l/s) for attic, 20.8 (9.8 l/s) for garage, and 20.4 (9.6 l/s) for indoors. However, there is a noticeable difference in operational leakage because return side pressure is substantially lower for attic installations. While air handler pressure for garage and interior units are 0.674 inWG (-168 pascals) and 0.782 inWG (-195 pascals), respectively, it is 0.554 inWG (-138 pascals) for attic units. As a result, return side leakage for attic units (just air handler cabinet and return connection) is 22% less compared to garage units and 16% less compared to interior units.

While "total" return leakage of the air handler cabinet plus two connections is approximately 20% less for attic units compared to other air handlers, return leakage from outdoors is greater for attic units. That is because the fraction of the return leakage that is "to outdoors" (or in this case to attic) is much higher for attic units. This is documented in the "extended test results" presented in the next section. When the leakage of the entire return system is considered, total return side leakage from "outdoors" is much greater for units located in the attic, because essentially all of the return ductwork (and therefore leakage) of the attic units is in the attic space.

Extended Testing in 11 Houses

In 11 of the 30 houses, additional (extended) testing was performed. This extended testing included measuring the airtightness of the entire duct system (both "total" and "to outdoors") and of the house airtightness, following the test methods of ASHRAE Standard 152P (ASHRAE, 2001). First, the air handler was turned off and masking material was placed over supplies and returns. Second, the ductwork was split (sealed or blocked) at the air handler, either by placing masking over the blower intakes (preferred method) or inserting a barrier into the filter track in the bottom of the air handler. Two duct testers were installed, one at a return register and one at a supply register. With all other registers masked off, both sides of the system were taken to -0.1 inWG (–25 pascals) at the same time. ASHRAE 152P allows both sides of the system to be tested separately. There is benefit, however, to running the test with both sides depressurized simultaneously. When performing the Q 0.1,total (Q 25,total) test (leakage to both indoors and to out), any leakage which might exist across the seal or at fan mounts would be very small, and therefore would have essentially no impact on the test results. Furthermore, any leakage past the seal in the air handler would only “steal” from the leakage of one side of the system and “give” it to the other side of the system. By contrast, if only one side of the system is tested at a time, then there is a 25 pascal pressure differential across the seal in the air handler. Therefore, the measurement error could be substantial, and this error gets added to both sides of the system. This test yielded Q 0.1t,s (Q 25t,s) and Q 0.1t,r (Q 25t,r), where ”t” refers to total leakage (leakage to both indoors and outdoors), “s” refers to supply, and “r” refers to return (Table 2).

The duct airtightness tests were repeated with the house depressurized to the same -0.1 inWG (–25 pascals) as the duct system. This test yields duct leakage to outdoors (Table 2). The test results are Q 0.1o,s (Q 25o,s) and Q 0.1o,r (Q 25o,r), where ”o” refers to leakage to out (“out” defined as outside the conditioned space, including buffer spaces such as attic or garage). By having the house at the same pressure as the duct system, leakage of the ductwork to the house is eliminated.

Some observations can be made from the extended test data in 11 houses. Total leakage on the return side of the system (including the air handler and return connection) was 58 Q 0.1 (27 Q 25). Weighted operating pressure on the return side was measured at 0.401 inWG (-100 pascals) (including both return ducts and air handler), indicating operating return leakage of 106 cfm (50 l/s), or 8.4% of system air flow.

Table 2a (IP)
Extended test results, including total duct leakage (Q 0.1t), duct leakage to outdoors only (Q 0.1o), and house airtightness (Q 0.2 and ACH 0.2) in 11 houses.

house no.	Q 0.1t,r (cfm)	Q 0.1t,s (cfm)	Q 0.1t (cfm)	Q 0.1o,r (cfm)	Q 0.1o,s (cfm)	Q 0.1o (cfm)	Q 0.2 (cfm)	Q 0.2 sealed (cfm)	ACH 0.2
1	30	98	128	30	48	78	1288	1187	5.33
3	143	308	451	64	154	218	3643	3096	8.81
4	45	116	161	34	81	115	1627	1545	5.91
5	41	115	156	33	57	89	1317	1269	4.51
10	61	189	250	41	129	170	1121	1056	3.72
11	80	141	221	73	73	147	1470	1369	4.58
12	79	161	240	47	67	114	1919	1884	4.90
17	36	146	182	15	1	16	1068	992	4.73
18	64	93	157	19	42	61	1555	1487	9.98
19	42	41	83	4	29	34	3040	2755	6.04
27	20	45	65	17	21	38	1912	1899	4.26
avg.	58	132	190	34	64	98	1814	1685	5.71

Table 2b (SI).
Extended test results, including total duct leakage (Q 25t), duct leakage to outdoors only (Q 25o), and house airtightness (Q 50 and ACH50) in 11 houses.

house no.	Q 25t,r (l/s)	Q 25t,s (l/s)	Q 25t (l/s)	Q 25o,r (l/s)	Q 25o,s (l/s)	Q 25o (l/s)	Q 50 (l/s)	Q 50 sealed (l/s)	ACH50
1	14	46	60	14	23	37	608	560	5.33
3	67	145	213	30	73	103	1719	1461	8.81
4	21	55	76	16	38	54	768	729	5.91
5	19	54	74	16	27	42	622	599	4.51
10	29	89	118	19	61	80	529	498	3.72
11	38	67	104	34	34	69	694	646	4.58
12	37	76	113	22	32	54	906	889	4.90
17	17	69	86	7	1	8	504	468	4.73
18	30	44	74	9	20	29	734	702	9.98

19	20	19	39	2	14	16	1435	1300	6.04
27	9	21	31	8	10	18	902	896	4.26
avg.	27	62	90	16	30	46	856	795	5.71

Total leakage on the supply side of the system was a very large 132 Q 0.1 (62 Q 25). Operating pressure measurements were taken in the supply plenum but not throughout the supply ductwork. ASHRAE 152P suggests using half of the supply plenum pressure as an estimate of overall supply ductwork operating pressure. For these 11 systems, average supply plenum pressure was 0.30 inWG (74 pascals). Based on a supply pressure of 0.15 inWG (37 pascals), actual leakage would be 167 cfm (79 l/s), or about 13.2% of air handler air flow. (Even if actual supply pressure was lower by factor of two, or 0.074 inWG (18.5 pascals), the resulting operational leakage would be 110 cfm (52 l/s) or 8.7% of air handler flow, which is still large.)

In addition to the extended testing results from these 11 units, return side leakage (including the air handler and return connection) is available for 10 additional systems. Therefore, return side leakage is available for 21 of the 30 systems. Airtightness for this larger sample of 21 was 88 Q 0.1 (42 Q 25), considerably greater than the 58 Q 0.1 (27 Q 25) for the 11 homes. Operational leakage for these 21 systems was found to be 170 cfm (80 l/s; based on Q 0.1 (Q 25) and operational pressure), or 13.4% of system air flow.

Duct Leakage to "Out". In 11 homes, duct leakage to "out" was measured (Table 2). On average, about 50% of the leakage of the return ductwork (including air handler) and supply ductwork was to "out" ("out" defined as outside the conditioned space, including buffer spaces such as attic or garage). The fraction of the leakage that was to "out" varied considerably by air handler location. For attic, 66% of the total leakage was to out. For garage, 53% of the total leakage was to out. For indoor units, 34% of the total leakage was to out. The sample size is small, so the conclusions regarding "leakage to out" must be considered preliminary. The biggest variable seems to be the fraction of the return ductwork that is in the attic, since nearly all of the supply ductwork is in the attic regardless of air handler location. Based on our visual inspections, the fraction of the return ductwork that was in the attic has been estimated; 100.0% for attic air handlers, 44% for garage air handlers, and 21% for indoor air handlers. From a cooling energy point of view, the fact that all return leaks -- whether in the air handler cabinet, the return connection, or the entire return ductwork – of attic systems originate in the attic means that the energy consumption, peak electrical demand, and peak period system performance is much more dramatically impacted for attic air handler systems compared to the others.

In summary, extended testing finds that there is a very substantial duct leakage problem with the new homes that were tested in this study.

System Air Flow Rates

Air flow rates were measured for each system. Using a flow hood, air flow was measured at each supply and each return. Using a flow plate device, the air handler flow rate was measured in 24 of 30 air handlers. In 17 of the 24 cases, the flow plate was installed in the filter tray, the intended location for the flow plate. In 7 of the 24 cases, the flow plate was installed at the single return grille because it could not be placed into the air handler. In the 6 cases where the flow plate measurement was not performed, either there was no access to the filter tray or the flow plate would not fit the air handler dimensions (most often because the filter access at air handler was sealed closed with mastic).

A "best estimate" of total air handler air flow is based on the flow hood at the return(s) and addition of estimated return leakage (including the air handler and connections). (In calibration work, we have found the flow hood used for these measurements to be very accurate when measuring return air flows, while significantly overestimating supply register air flows. For those cases with both flow plate and flow hood measurement at the grille, the average was 1131 cfm (534 l/s) for the flow hood and 1164 cfm (549 l/s) for the flow plate, with the flow plate higher in each case.) Our best estimate of total air handler air flow was 1266 cfm (598 l/s) per system. With average nominal cooling capacity of 38,800 Btu/hr (11.4 kW) per system (ranging from 16,000 (4.7 kW) to 56,000 Btu/hr (16.4 kW)), this converts to 392 cfm per ton (52.5 l/s per kW), or nearly right on target with the nominal 400 cfm per ton (53.6 l/s per kW) normally indicated by manufacturers as design flow.

Return air flow was measured at 1107 cfm (523 l/s), or 159 cfm (75 l/s) less than the total air flow. This 159 cfm (75 l/s), or 12.6% of the return air flow, is return leakage, including return leaks in the air handler, the return connection, and the return ductwork.

House Airtightness

House airtightness was also measured in 11 houses using a blower door (Table 2). On average, house airtightness was found to be 5.7 ACH 0.2 (5.7 ACH50), in line with test results on other samples of homes built in the past decade in Florida.

Since the registers were already masked off to perform the duct airtightness test, the house airtightness test was performed once with all registers masked off and again with all registers open (normal status). The difference between the two tests (registers masked and unmasked) yields a measurement of duct system airtightness. On average, 7.1% of the house envelope leakage was found to be in the duct system. The amount of air leakage into and out of the house through duct leaks is of course proportionally much greater than 7.1%, because most of the ductwork operates under pressures of 0.12 inWG (30 pascals) to 0.48 inWG (120 pascals).

Conclusions

Leakage in the air handler averaged 23.9 Q 0.1 (11.3 l/s Q 25) in 30 homes. Leakage at the return and supply plenum connections averaged 3.9 Q 0.1 (1.8 l/s Q 25) and 2.2 Q 0.1 (1.0 l/s Q 25), respectively. Using the operating pressures in the air handler and at the plenum connections, these Q 0.1 (Q 25) results convert to actual air leakage of 77.5 cfm (36.6 l/s) on the return side (negative pressure side) and 3.1 cfm (1.5 l/s) on the supply side (positive pressure side). The combined return and supply air leakage in the air handler and adjacent connections represents 6.4% of the system air flow. This is a concern when one considers that a 6% return leak from a hot attic (peak conditions; 120 oF (48.9C) and 30% relative humidity) can produce a 23% reduction in cooling output and 31% increase in cooling energy use (Cummings and Tooley, 1989). The total energy, peak demand, and peak system performance consequences are much greater for attic air handler systems since all the return leakage comes from the attic. While houses with air handlers indoors and in garages may have some return ducts in the attic, not all leakage comes from the attic.

Additional conclusions about duct leakage can also be drawn from the extended test results. Return Q 0.1,total (Q 25,total) for 21 homes is 88 cfm (42 l/s). Supply Q 0.1,total (Q 25,total) for 11 homes is 132 cfm (62 l/s). Using measured operating pressure in the return ducts and estimated operating pressure in the supply ducts, return leakage is estimated to be 170 cfm (80 l/s; 13.4% of system air flow) and supply leakage is estimated to be 167 cfm (79 l/s; 13.2% of system air flow). This level of duct leakage continues to be a point of concern.

Acknowledgements

Thanks to the Florida Department of Community Affairs, Brookhaven National Laboratory, and the U.S. Department of Energy for funding to carry out this research, and to U.S. DOE Funded Building America Industrialized Housing Partnership (BAIHP) for additional resources.

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