ENGINEERED AIR BALANCE CO., INC.

TESTING FOR DUCT LEAKAGE

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What Should Be Specified

	Associated Air Balance Council AABC Standard		ASHRAE 2012 Duct Construction Chapter Systems and Equipment Handbook		
Type of System	Minimum Test Pressure [1,7]	Maximum Allowable Leakage	System Condition	Test Pressure [1,7] in. wc (Pa)	Allowable System Leakage
1. Fractional horsepower fan systems; fan coils, small exhaust/supply fans, and residential systems	0.50" WC (125 pa)	2%	Operating System	Operating Pressure	5%
			During Construction	0.5 (125)	5%
2. Small systems; split DX systems – usually systems under 2000 CFM (940 l/s), and residential systems	1.00" WC (250 pa)	2%			

[1] Test pressure should not exceed the pressure rating of the duct.
[7]It is recommended that the pressure rating of the duct be equal to the fan shut-off pressure if the possibility of fan shut-off exists either in VAV systems or in systems with smoke/fire damper control.

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3. VAV and CAV boxes and associated downstream ductwork[2]	1.00" WC (250 pa)	2%	Operating System	Not Addressed	
4. Single zone, multi-zone, return ducts, and exhaust duct systems	2.00" WC (500 pa)	2%	Operating System	Operating Pressure	5%
			During Construction	2.0 (500)	5%

[1] Test pressure should not exceed the pressure rating of the duct.

[7]It is recommended that the pressure rating of the duct be equal to the fan shut-off pressure if the possibility of fan shut-off exists either in VAV systems or in systems with smoke/fire damper control.

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5. All constant volume ducts in chases and concealed spaces, main return ducts on VAV[8] and CAV[8] systems	3.00" WC (745 pa)	1%	Operating System	Not Addressed	
			During Construction	Not Addressed	

[1] Test pressure should not exceed the pressure rating of the duct.
[7]It is recommended that the pressure rating of the duct be equal to the fan shut-off pressure if the possibility of fan shut-off exists either in VAV systems or in systems with smoke/fire damper control.
[8] It is assumed that the primary air damper is located at the box inlet. If instead this damper is at the box outlet, then the box should be included in the upstream leakage testing.



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6. Supply ducts for VAV[8] and CAV[8] systems VAV and CAV terminal boxes tested with upstream ductwork	4.00" WC (995 pa)	1%	Operating System	Operating Pressure	5%
			During Construction	Upstream Box: 4.0 (1000) Downstream Box: 1.0 (250)	5%

[1] Test pressure should not exceed the pressure rating of the duct.
[7]It is recommended that the pressure rating of the duct be equal to the fan shut-off pressure if the possibility of fan shut-off exists either in VAV systems or in systems with smoke/fire damper control.
[8] It is assumed that the primary air damper is located at the terminal box inlet. If instead this damper is at the terminal box outlet, then the terminal box should be included in the upstream leakage testing.

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7. Dual duct systems, both hot duct and cold duct	6.00" WC (1495 pa)	1%	Operating System	Operating Pressure	5%
			During Construction	6.0 (1500)	5%
8. High pressure induction system	6.00" WC[5] (1495 pa)	0.5%	Operating System	Operating Pressure	5%
			During Construction	6.0 (1500)	5%

[1] Test pressure should not exceed the pressure rating of the duct.
[5] Large induction systems may have higher pressure requirements, i.e., 10" WC (2490 pa)
[7]It is recommended that the pressure rating of the duct be equal to the fan shut-off pressure if the

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9. Manifolded exhaust systems Exhaust systems for labs with air valves	6.00" WC[6] (1495 pa)	0.5%	Operating System	Not Addressed	
			During Construction	Not Addressed	
10. Grease duct systems	4.00" WC (995 pa)	0%	Operating System	Not Addressed	
			During Construction	Not Addressed	

[1] Test pressure should not exceed the pressure rating of the duct.
[6] Large manifold exhaust systems may have higher pressure requirements, i.e., 10" WC (2490 pa)
[7]It is recommended that the pressure rating of the duct be equal to the fan shut-off pressure if the possibility of fan shut-off exists either in VAV systems or in systems with smoke/fire damper control.

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11. VAV[8] and CAV[8] return systems	Not Addressed		Operating System	Operating Pressure	5%
			During Construction	Downstream box: 3.0 (750) Upstream box: 1.0 (250)	5%

[1] Test pressure should not exceed the pressure rating of the duct.
[7]It is recommended that the pressure rating of the duct be equal to the fan shut-off pressure if the possibility of fan shut-off exists either in VAV systems or in systems with smoke/fire damper control.
[8] It is assumed that the primary air damper is located at the terminal box inlet. If instead this damper is at the terminal box outlet, then the terminal box should be included in the upstream leakage testing.

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12. Chilled-beam primary supply	2.00" WC (500 pa)	1%	Operating System	Operating Pressure	5%
			During Construction	4.0 (1000)	5%

[1] Test pressure should not exceed the pressure rating of the duct.
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L3. Supply and return ductwork located outdoors	3.00" WC[4] (745 pa)	1%	Operating System	Operating Pressure	2%
			During Construction	3.0 (750)	2%
L4. Exhaust ductwork ocated indoors	2.00" WC (500 pa)	2%	Operating System	Operating Pressure	2%
			During Construction	3.0 (750)	2%

Test pressure should not exceed the pressure rating of the duct.
It is recommended that the pressure rating of the duct be equal to the fan shut-off pressure if the possibility of an shut-off exists either in VAV systems or in systems with smoke/fire damper control.

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15. Air handling units	10.0” WC (2500 pa)	1%	Site test by Manufacturer	Specified design pressure Operating Pressure 2.0 (500)	

[1] Test pressure should not exceed the pressure rating of the duct.
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16. Multizone supply systems; Multizone return systems; Multizone exhaust systems	Item 4 above 2.00" WC (500 Pa)	2%	Operating System	Operating Pressure	5%
			During Construction	2.0 (500)	5%

[1] Test pressure should not exceed the pressure rating of the duct.
[7]It is recommended that the pressure rating of the duct be equal to the fan shut-off pressure if the possibility of fan shut-off exists either in VAV systems or in systems with smoke/fire damper control.

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- For Air Handling Units (AHU)with total static pressures (TSP) below 4”WCI would suggest the test requirement be 2 x TSP not to exceed 10”WC. Suggest panel deflection be tested during the AHU pressure test.
- Instrumentation used to measure the pressure across the orifice tube must have .01” WC resolution.

Deflection Testing

- Deflection limit of L/250 shall be demonstrated. Measurements shall be taken at mid point of ‘L’ using dial indicators reading in 1/1000ths. Mounting of dial indicators shall be independent of the unit casing. Multiple measurements shall be made. Dial indicator shall be mounted at mid point of ‘L’ on the seams. ’L’ is defined as the height of the largest panel on the sides of the AHU, width of the largest panel across the top of the AHU, and the smaller of width or height of the largest panel for the ends of the AHU. These are known as the governing panels.

Deflection Testing

- Measurements shall be spaced along the sides, ends, and top at mid point and quarter points of the unit. Spacing shall be adjusted to fall on the nearest flange or panel joint. Any side, top or end of unit of less than five feet shall require only one measurement at the center. In order to reduce the number of pressure cycles, it is recommended that multiple dial indicators be used at the measurement points.

Issues of Sealing Duct to a Leakage Class and Seal Class

Case 1: Prior to SMACNA HVAC Air Duct Leakage Test Manual, 1985 two identical phases of a research building were built by different contractors. The AHU systems were dual duct. Phase 1 by contractor A required increasing the RPM and loading the 125HP motors (156 amps)to maintain the static pressure at the end of the system. Phase 2 by contractor B required decreasing the RPM which lowered the amp draw (92 amps) to maintain the static pressure at the end of the system.

Issues of Sealing Duct to a Leakage Class and Seal Class

Case 2: Two identical ten story office buildings were built by the same contractors. The outside air (OSA) and toilet exhaust duct risers in the shaft were to be sealed to seal class A and leakage class 6. The ducts were identical sizes and had the same rated design airflow. The specification required a pressure test of 3.0” and leakage to not exceed 2%. Building A duct sealing by team A passed on the first test in each duct. Building B duct sealing by team B failed many times and finally passed after 3 weeks of extra sealing.

Issues of Sealing Duct to a Leakage Class and Seal Class

Case 3: A 96” x 96” main exhaust duct was designed for 180,000 CFM. The seal class was A and the leakage class was 6. The specifications required 1% leakage at 6”WC. The contractor tested several sections of the duct and found the leakage to be between 8% to 15%. The duct was installed in an interstitial space and the top of the duct ran between the beams. An investigation determined the duct sealant was only applied to the sides and not the top and bottom.

Issues of Sealing Duct to a Leakage Class and Seal Class

Case 4: Connection of plenum boxes to diffusers. On a hard ducted system the diffusers were connected to plenum boxes. The diffusers were installed with zip screws on each side. Our testing found 15% leakage. The plenum boxes had to be disconnected from the branch duct and the diffuser and plenum removed to properly seal the connection. After the diffusers and plenum boxes were reinstalled no leakage was detected.

Reporting Duct Leakage

- Job Number
- Job Name
- Description of Duct Tested
- Performed By and Witnesses
- Equipment tag or designation of the primary mover
- Design CFM of Test Section
- Test Equipment Orifice Size and Calibration Date
- Required SP Actual SP
- Allowable Leakage in CFM Determined by % of Duct Being Tested
- Actual Leakage CFM
- Pass/Fail
- Date

Anticipated Cost

- These costs are based on the assumption that buildings are designed on the average of 1 CFM / Ft^2 and the cost is approximately \$2.00 / Ft^2

Type of System From What Should be Specified Above	Maximum CFM	AABC Standards Cost / Year= Leak % x CFM x \$2.00	ASHRAE 2012 Duct Construction Chapter Cost / Year = Leak % x CFM x \$2.00
1. & 2. Small Systems (multiples)	2000	\$80	\$200
3.Terminal Box Downstream Ductwork (multiples)	1570	\$62.80	\$157.00
4. Systems Below 2” WC , MZ, VAV, CAV	25000	\$1000.00	\$2500.00

Anticipated Cost

Type of System From What Should be Specified Above	Maximum CFM	AABC Standards Cost / Year= Leak % x CFM x $2.00	ASHRAE 2012 Duct Construction Chapter Cost / Year = Leak % x CFM x $2.00
5. Ducts in Chases	50000	$1000	$5000
6. VAV and CAV Supply Ducts	80000	$1600	$8000
7. Dual Duct Systems	150000	$3000	$15000
8. High Pressure Induction	100000	$1000	$10000
9. Manifold Exhaust System	200000	$2000	$20000
10. Grease Ducts	10000	$0	Not Addressed
11. VAV & CAV Return Systems	100000	$1000 used 1%	$10000

Anticipated Cost

Type of System From What Should be Specified Above	Maximum CFM	AABC Standard Cost / Year= Leak % x CFM x $2.00	ASHRAE 2012 Duct Construction Chapter Cost / Year = Leak % x CFM x $2.00
12. Chilled Beam	20000	$200 used .5%	$2000
13. Supply & Return located Outdoors	30000	$0 used 0%	$3000
14. Exhaust Ductwork	200000	$4000 used 1%	$8000
15. AHUs	150000	$3000	$3000
16. Multizone Systems	25000	$1000 used 2%	$2500

Anticipated Cost

- The $2.00 per CFM came from an estimated value when TC 5.2 was analyzing terminal box leakage. The same cost per CFM was found to be true in a 7400 ft^2 office with 5 rooftop single zone units. Research building operators have stated their cost per CFM ranges between $4.00 to $8.00 per CFM depending on how many 100% OSA systems are serving the building and how many spaces have high air change rates.

What Does ASHRAE Standard 90.1 Addendum cq add

6.4.4.2 Ductwork and Plenum Leakage

6.4.4.2.1 Duct Sealing. Ductwork and all plenums with pressure class ratings shall be constructed to seal class A, as required to meet the requirements of section 6.4.4.2.2, and was standard industry practice (see Informative Appendix E). ..... All connections shall be sealed, including but not limited to spin-ins, taps, other branch connections, access doors, access panels, and duct connections to equipment. Sealing that would void product listings is not required. Spiral lock seems need not be sealed. All duct pressure class ratings shall be designated in the design documents.

What Does ASHRAE Standard 90.1 Addendum cq add

6.4.4.2.2 Duct Leakage Tests. Ductwork that is designed to operate at static pressures in excess of 3 in. wc and all ductwork located outdoors shall be leak tested according to industry – accepted test procedures (see Informative Appendix E). Representative sections totaling no less than 25% of the total installed duct area for designated pressure class shall be tested. All sections shall be selected by the building owner or the designated representative of the building owner. Positive pressure leakage testing is acceptable for negative pressure duct work. The maximum permitted duct leakage shall be $L_{max} = C_L P^{0.65}$,where L_{max} =maximum permitted leakage CFM/100 ft^2 duct surface area. C_L = for, duct leakage class, CFM/100 ft^2 duct surface area at 1 in. wc. P = test pressure, which shall be equal to the design duct pressure class rating, in. wc

Summary

- I have seen on several projects sample leakage testing of the ductwork specified and the sealing of the sample duct to be better than the remaining ductwork. I would suggest that 100% of the ductwork be tested.
- To save energy I would suggest that ductwork above 3” WC be tested at the duct rated pressure and not exceed 1% leakage.
- The duct rated pressure should be what the rated fan system shut off pressure would be if a damper failed. The static pressure setting for the limit switches must be set below the maximum test pressure of the duct.
- To not pressure test ductwork and assume the sealant will be applied properly has saved money on the front end but cost the owner dearly throughout the life of the system.



QUESTIONS