Air Change, Ventilation, and Dehumidification for Multi-family Buildings

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for

Acknowledgments:
USDOE Building America
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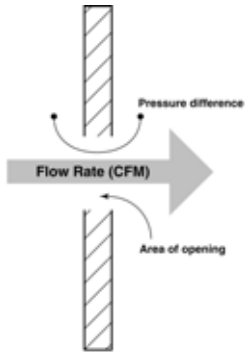

Air Flow

- Air flow depends on size of hole
- Air flow depends on pressure difference

Flow = Area x $\sqrt{\Delta P}$ x Coefficient

- Air flows from higher pressure to lower pressure

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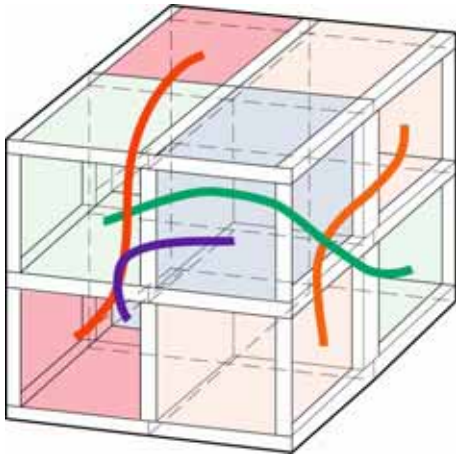

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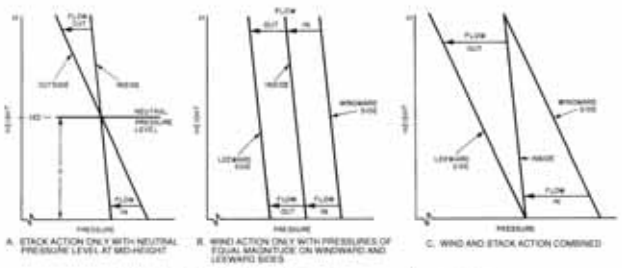

Fig. 6 Distribution of Inside and Outside Pressures over Height of Building

Source: 2009 ASHRAE Handbook of Fundamentals

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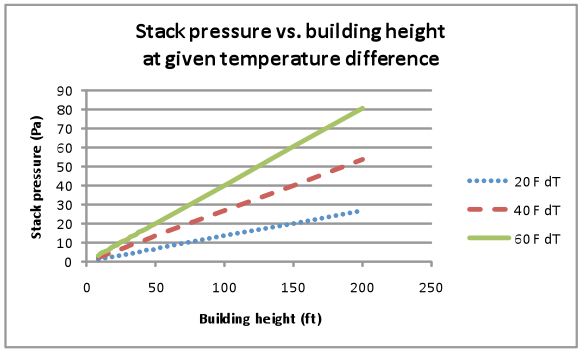

stack pressure (Pa) = (0.0067)(h)(dT)
where: h=building height (ft)
dT = inside to outside temperature difference (F)

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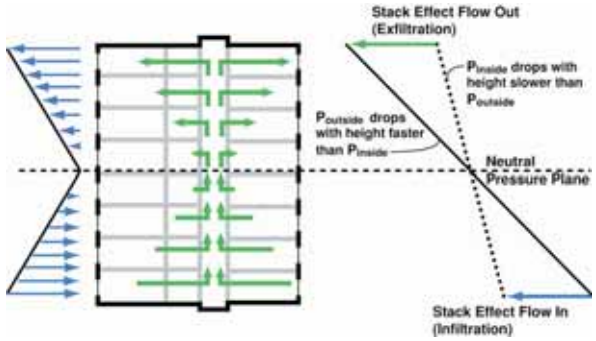
- Interior airflows in tall buildings compromises smoke control, fire safety, indoor air quality, comfort and energy use



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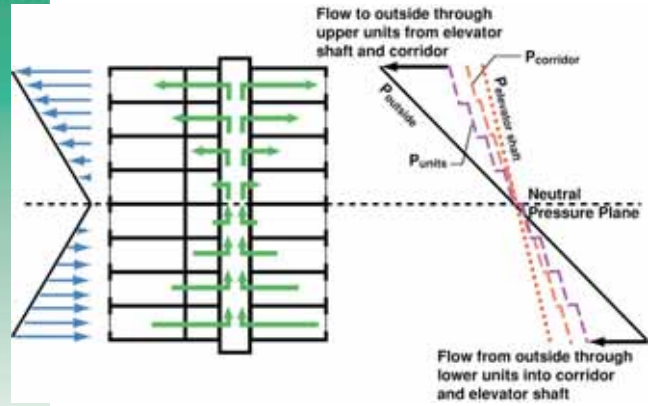

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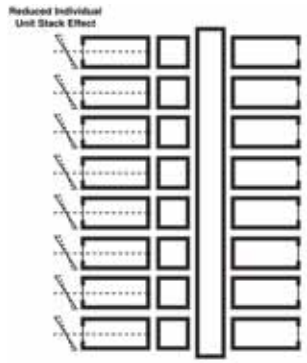

- Compartmentalization: Isolation of individual apartment units from corridors and corridors from shafts, elevators and stairwells reduces stack effect driven interior airflows

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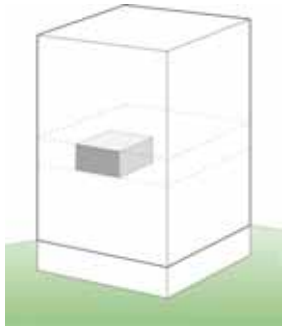

- Unit Air tightness: Each unit is isolated from adjacent units and from the exterior by an air barrier system (minimum recommended resistance or air permeance of 2.00 L/(s.m2) @ 75 Pa is proposed). The inter-unit separation must also meet the specific fire resistance rating requirement for the given separation

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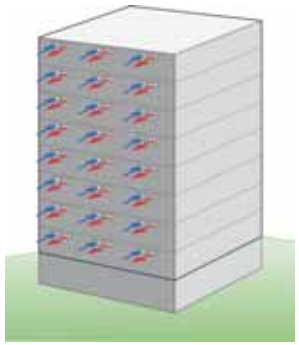

- **Distributed Ventilation:**
- Individual unit ventilation provided across exterior walls, not across interior pressure boundaries such as floors and corridor walls

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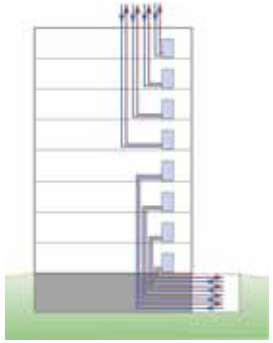

- **Gas Furnace Venting:**
Sealed combustion furnaces (two pipe systems – exhaust gases out and combustion air in) are vented to roof or down to dry well ("pit" with screen). Vent runs can extend up or down up to 100 feet

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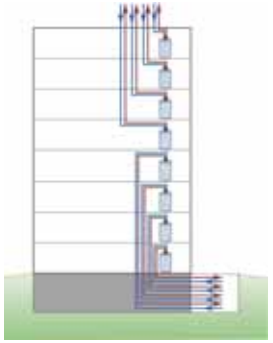

- **Gas Water Heater Venting:**
  Sealed combustion domestic hot water heaters (two pipe systems – exhaust gases out and combustion air in) are vented to roof or down to dry well ("pit" with screen). Vent runs can extend up or down up 100 feet.

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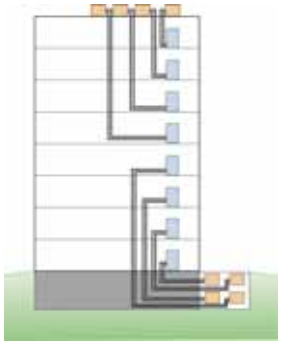

- **Air Conditioners or Heat Pump Configuration:**
  Individual units are located on roof or in drywell ("pit" covered with open structural grid/screen).

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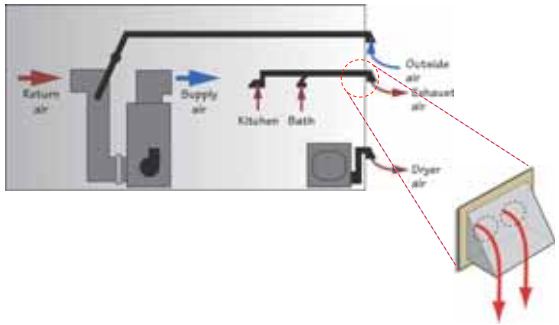

- **Mechanical Ventilation**
  Kitchen and bath fans controlled intermittently by occupant. Motorized damper in line with outside air duct connected to return side of air handler. Air handler fan and damper controlled to meet minimum duty cycle.

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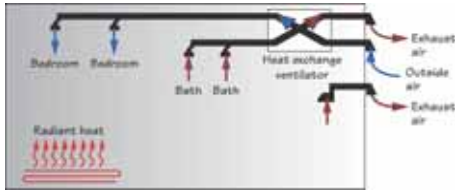

- **Heat Recovery Ventilator**
  Expensive to install, economical to operate

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- Located in East Orange, NJ
- Five floors, retail space on the first floor, 56 residential units with1000 - 1500 square feet of living area. There is a parking garage facility located below the first floor.
- Architect of record: Inglese Architecture and Engineering
- Constructed by RPM Development Group
- Design input, design and construction review, testing and modeling provided by BSC

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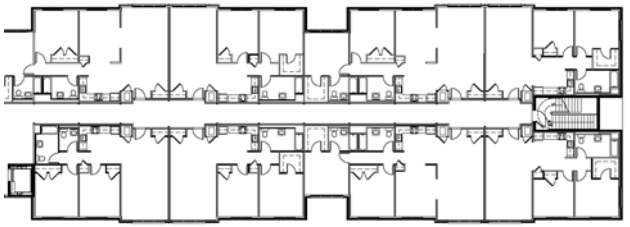

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- Unit-to-unit, and unit-to-corridor separation with floor-to-ceiling taped gypsum board and weather stripped doors

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- Sealed combustion furnace and hot water heater piped to roof or basement pit

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- Testing to quantify the air leakage characteristics of the dwelling units, corridors, and elevator shaft
- Normal operating pressure relationships between the living units, corridors, elevator shaft, stairwell, and outdoors were measured
- Then fan-forced air leakage testing on the stairwell, three corridors, seven living units on three different floors, and the elevator shaft with the coincident pressure response measured in the other zones
- Results were used to calculate air leakage metrics and to evaluate the effectiveness of air-sealing and compartmentalization of the building

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Normal operating conditions

2nd Floor		5th Floor	
Unit	Unit pressure wrt corridor (Pa)	Unit	Unit pressure wrt corridor (Pa)
201	-0.4	501	-0.5
202	-0.3	502	-0.8
204	+0.8	503	-0.4
205	-0.7	504	-0.3
206	-0.8	505	0.0
207	-0.3	506	-0.1
208	-0.2	507	+1.1
209	+0.2	508	-0.5
210	+0.2	509	-0.3
211	+0.6	510	-0.2
212	+0.4	511	-0.5
213	+0.3	512	-0.8
214	0.0	513	-1.4

- Most of the values are negative
- In a traditional multi-story building, one would expect that stack effect would cause the lower floors to be negatively pressured and the upper floors to be positively pressured, which is not seen here due to effective compartmentalization

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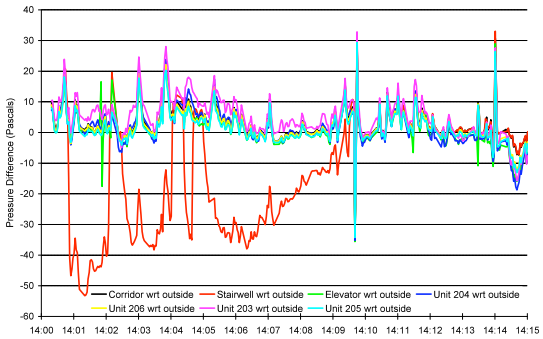
Depressurization of stairwell to outdoors



- The corridor, elevator, and living units do not respond to the changes in pressure of the stairwell, indicating that they are uncoupled from the stairwell. At -45 Pa the flow is about 2400 cfm

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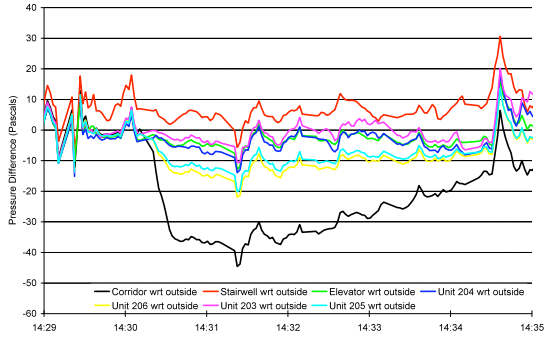
Depressurization of 2nd floor corridor into open stairwell



- Units 205 and 206 are more connected to the corridor than units 203 and 204 or the elevator shaft. Even so, all units are still more connected to outside than to the corridor.

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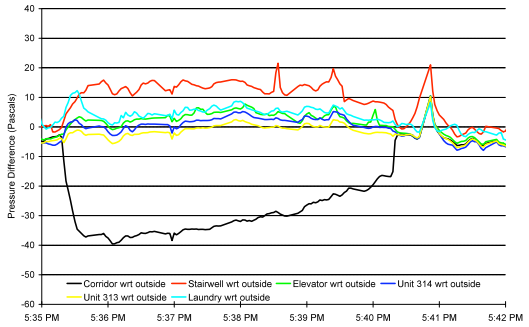
Depressurization of 3rd floor corridor into open stairwell



- The units and elevator shaft do not respond to the change in pressure of the corridor, indicating that they are uncoupled from the corridor

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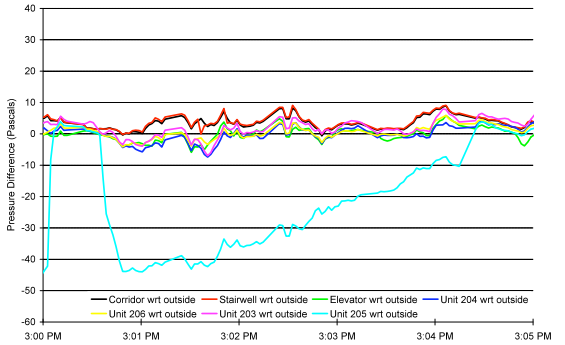
Depressurization of unit 205 into closed corridor



- Unit 205 is depressurized to -44 Pa with airflow of about 820 cfm. There is little direct pressure tracking/response from any of the adjacent units.

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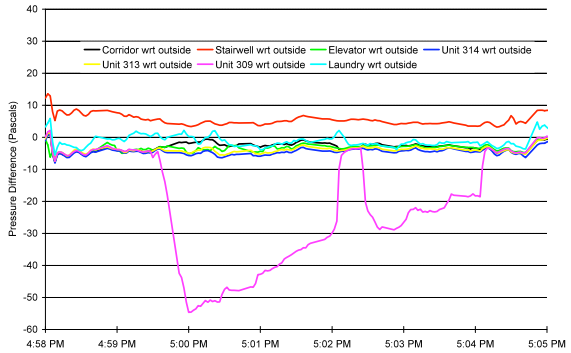
Depressurization of unit 309 into closed corridor



- Unit 309 is depressurized to -50 Pa with airflow of about 1240 cfm. There is very little pressure response in any of the adjacent units.

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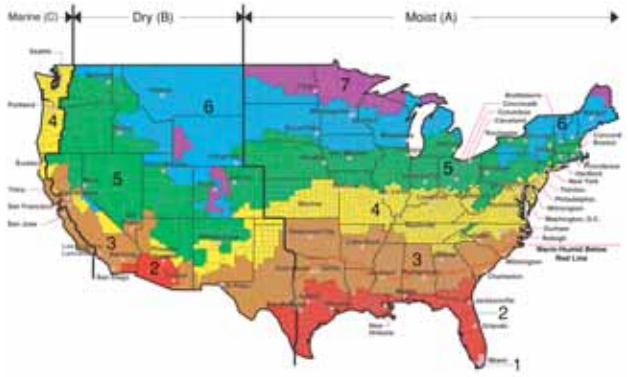

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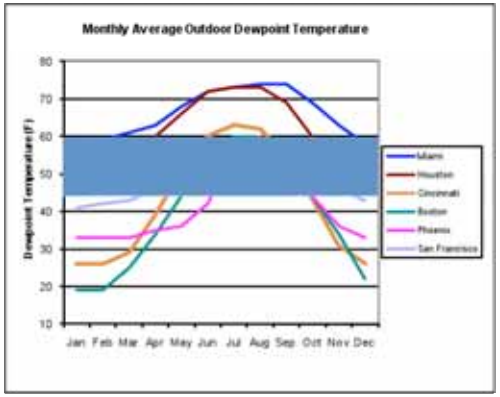

	Interior threshold		
	Tdb	RH	Tdp
winter	72	35	43
spring	75	45	52
summer	77	50	57
fall	75	45	52

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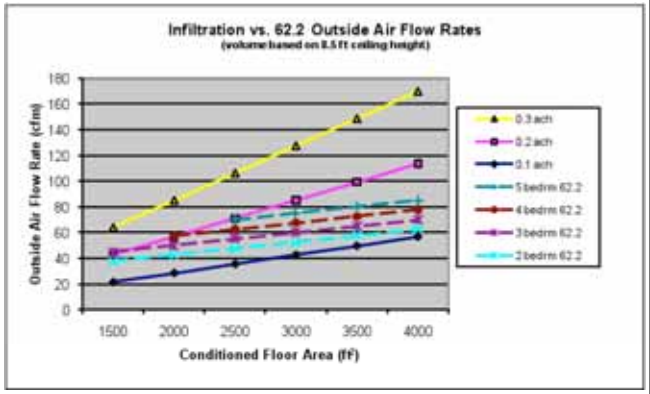

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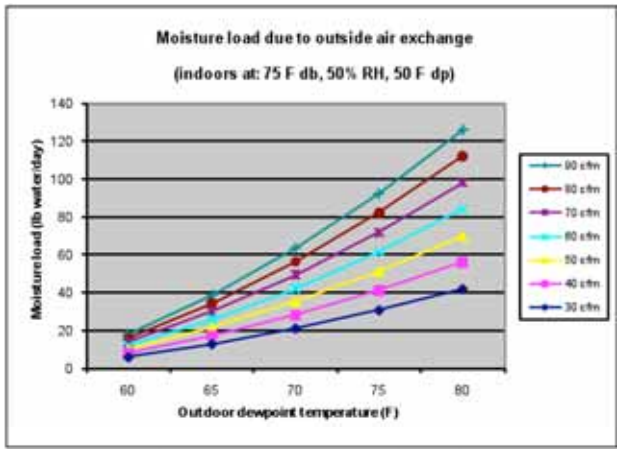

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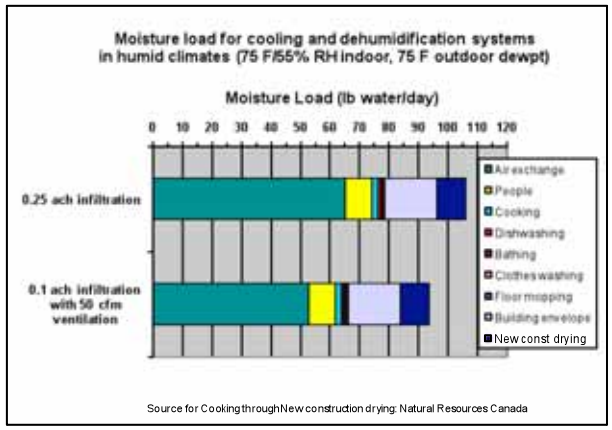

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Stand-alone dehumidifier installed in mechanical closet, in central system return air path

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Stand-alone dehumidifier, installed in conditioned space, Ducted and integrated with central system

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DX cooling system with modulating hot gas condenser reheat providing dedicated dehumidification mode

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Thank you!

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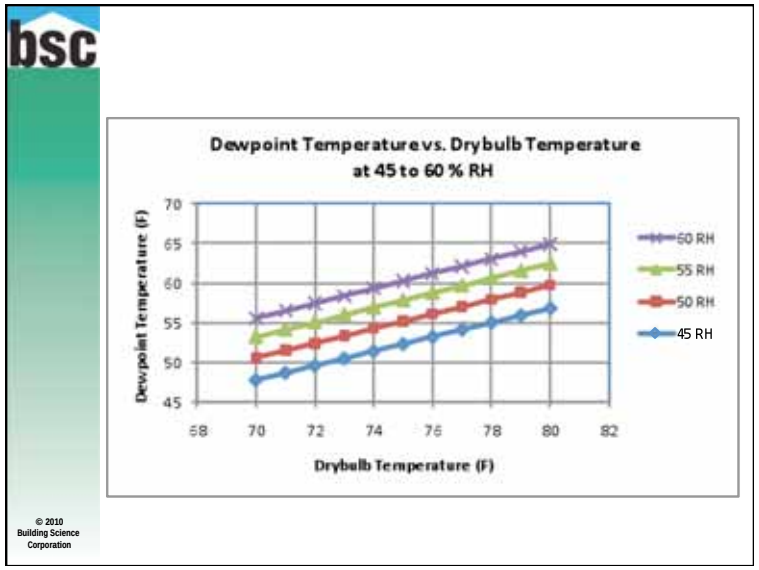

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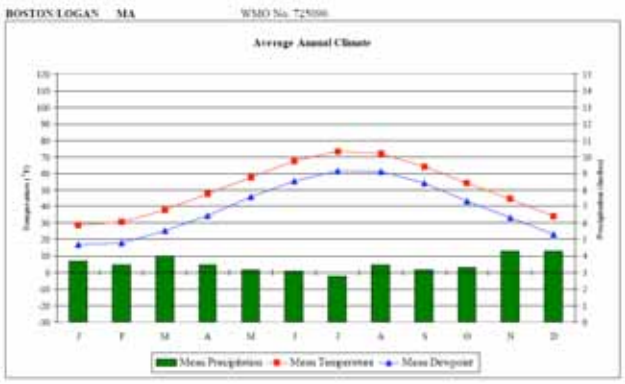

Source: NOAA climate data reports

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Table 11.1 Proposed Standard test conditions

	Outdoor T/RH/Tdp (F/%/F)	Indoor T/RH/Tdp (F/%/F)	
Test 1	95/58/78	80/60/65 78/55/61 75/50/55	cooling design conditions
Test 2	80/85/75	80/60/65 78/55/61 75/50/55	cooling part-load: summer nights/rainy periods
Test 3	75/85/70	78/60/63 78/55/61 75/50/55	cooling part-load: spring/fall
Test 4	65/90/62	72/60/57 70/52/52 68/45/46	no cooling: spring/fall/winter
Test 5 (opt)		65/55/49[1]	cold climate basement conditions

[1] Single unit basement dehumdifier condition

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