Fan Watt Draw and Air Flow

2008 California Building Energy Efficiency Standards

Furnace Fan Watt Draw and Air Flow in Cooling and Air Distribution Modes

July 12, 2006

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Purpose

The purpose of this proposal is to specify a new prescriptive requirement for central system air handler watt draw and air flow along with associated changes to the ACM Manual. Additional changes are proposed for ACM modeling of central system air handlers when used as Air Distribution Systems.

Overview

Description	Central system air handler (furnace, heat pump, combined hydronic system etc) fans consume large amounts of electricity both on and off peak in meeting new home heating and cooling loads. This energy consumption is much larger than assumed in the system efficiency rating (SEER, EER) because inefficient California new home duct systems require more fan power and allow less air flow than assumed in the ratings. These systems use even more peak and annual electricity when used hourly to circulate ventilation air. This proposed prescriptive requirement requires builders to improve air handler fan and air conditioner efficiency by improving their duct systems and/or installing higher efficiency air handlers.
Type of Change	This change replaces the existing compliance options for adequate airflow, air handler watt draw, and duct design with new prescriptive standards for air flow and fan Watt draw in for forced air central systems used in cooling and Watt draw for systems used in Air Distribution System modes. The ACM manual would be changed to reflect the prescriptive standard and new rules for modeling Air Distribution Systems would be added. This would apply to air conditioners in Residential New Construction and Additions. Prescriptive requirements may be traded off for other efficiency measures by builders using the performance compliance approach.
Energy Benefits	Reducing the Watt draw of furnace fans and other central system air handlers in California homes provides significant peak demand savings because they are generally running continuously on the hottest days when the California electricity system peaks occur. Adequate air flow also provides peak demand savings because it increases the sensible Energy Efficiency Ratio (EER) of air conditioning systems, particularly at the high outdoor dry bulb temperatures of California peak demand days. Adequate air flow and low Watt draw save electricity throughout the cooling season and low fan Watt draw saves electricity in the heating season as well. In homes where the central forced air system is used as an Air Distribution System to mix ventilation air on an hourly basis throughout the year fan Watts contribute to statewide demand by running on peak even if there is no cooling load. Low fan Watt draw systems in this application will save much larger amounts of annual electricity than when the system is used merely to meet heating and cooling loads. Analysis using TDV accounts for the peak and energy savings very well.

Non-Energy Benefits	Adequate air flow and low fan Watt draw improve the capacity of air conditioning systems and allow them to provide better comfort in the homw, particularly on peak days.
Environmental Impact	n/a
Technology Measures	Builders will meet these requirements using well designed and installed duct systems constructed from normal components and efficient furnaces widely available in the market today.
Performance Verification	This measure requires post construction testing by the contractor with HERS verification using the procedures in the 2005 ACM appendix Appendix RE – Field Verification and Diagnostic Testing of Forced Air System Fan Flow and Air Handler Fan Watt Draw.
Cost Effectiveness	This measure is cost effective in cooling climate zones (see Analysis and Results below).
Analysis Tools	Can be modeled with minor modification to existing software tools.
Relationship to Other Measures	Builds upon exiting requirements, compliance options and procedures for field verification.

Methodology

Field Tests

For split air conditioners without a specified air handler/furnace, the blower power draw is assumed in the SEER test to be 365 watts per 1000 cfm. Field data has shown median power draws around 510 watts per 1000 cfm (Proctor and Parker 2000). To verify this in California the PIER Research for the 2008 Standards project carried out a field survey in 2005 that included:

- 60 furnace systems in new homes
- 55 in production homes, 5 custom
- Measured air flow and fan watts by mode
- Measured pressure by mode and component

The field tests showed a median cooling fan power draw of 632 watts as illustrated in Figure 1.

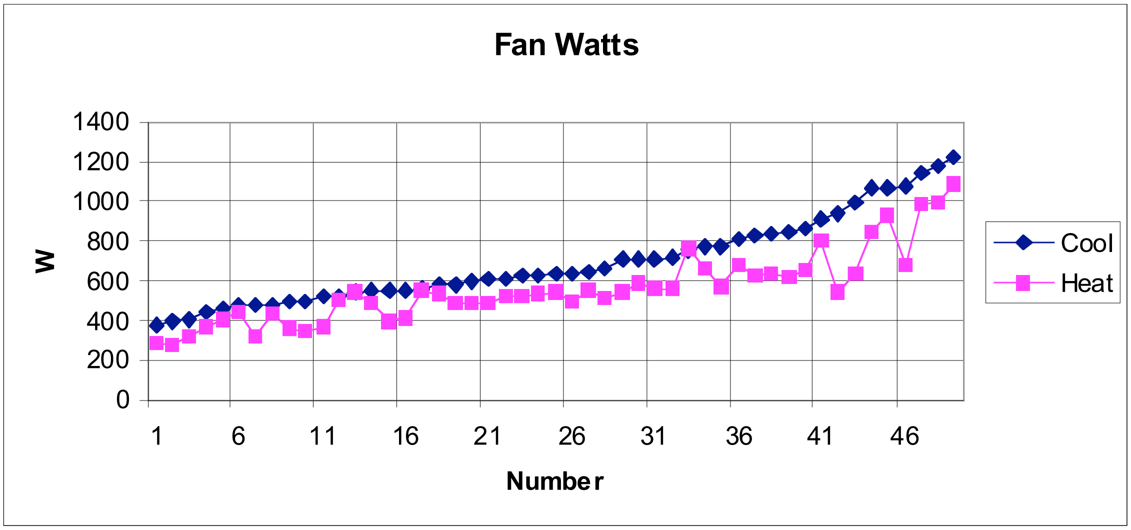

Figure 1. California New Construction Field Test Furnace Fan Watt Draw

As shown in Figure 2 the median watt draw for the furnace fans was 358 CFM per ton.

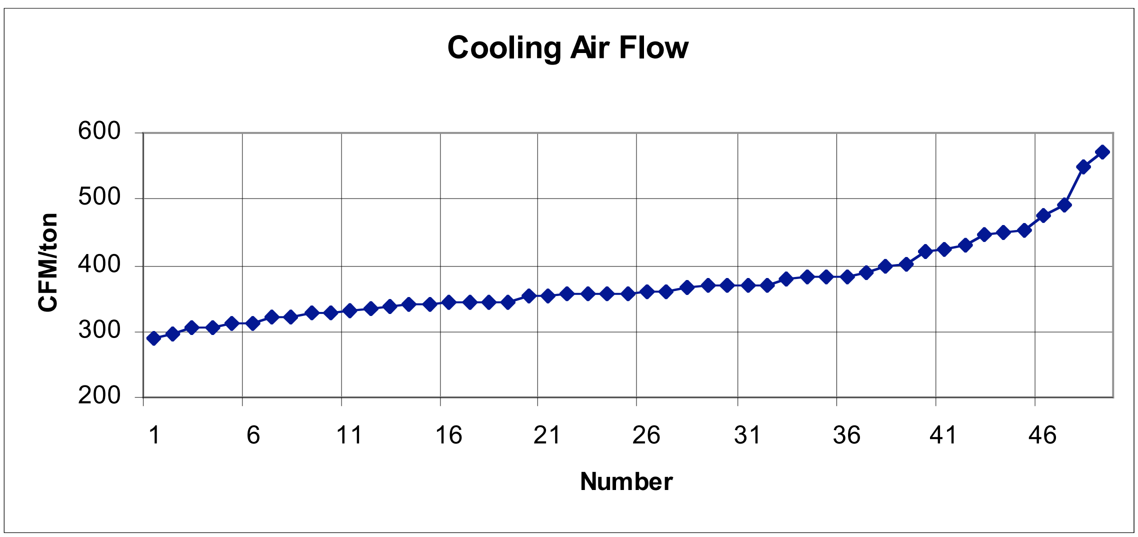

Figure 2. California New Construction Field Test Furnace Fan Cooling Airflow

Figure 3 illustrates that the median cooling speed external static pressure was 0.80 IWC.

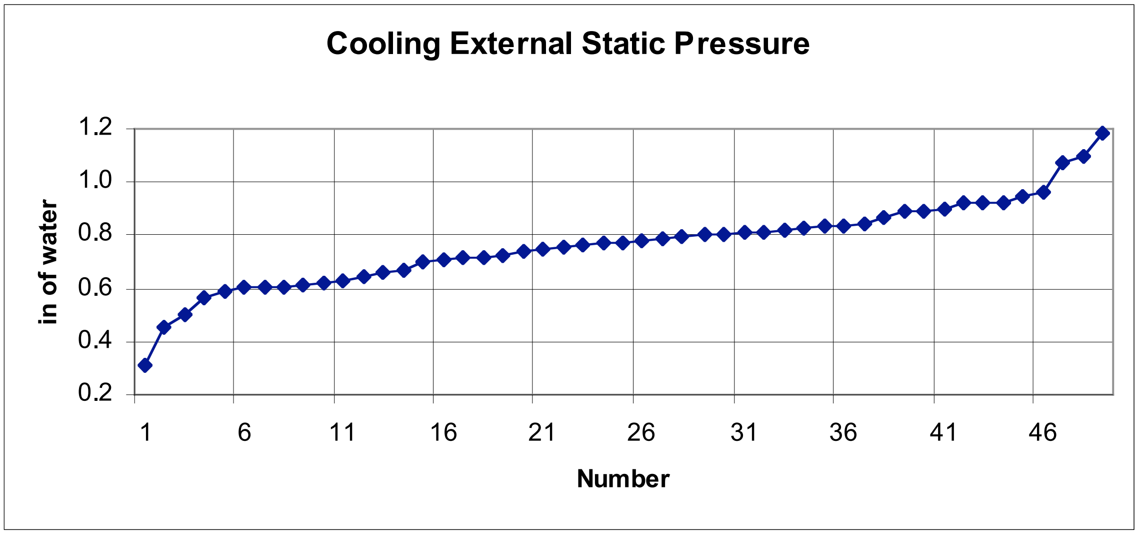

Figure 3. California New Construction Field Test Furnace Cooling External Static Pressure

Analysis of Manufacturers' Data

We analyzed manufacturers'data for 156 model numbers with PSC motors that had the airflow and blower fan watt draw listed at high speed and 0.50 IWC external static pressure. The median power draw for these units was 453 watts per 1000 cfm as shown in Figure 4.

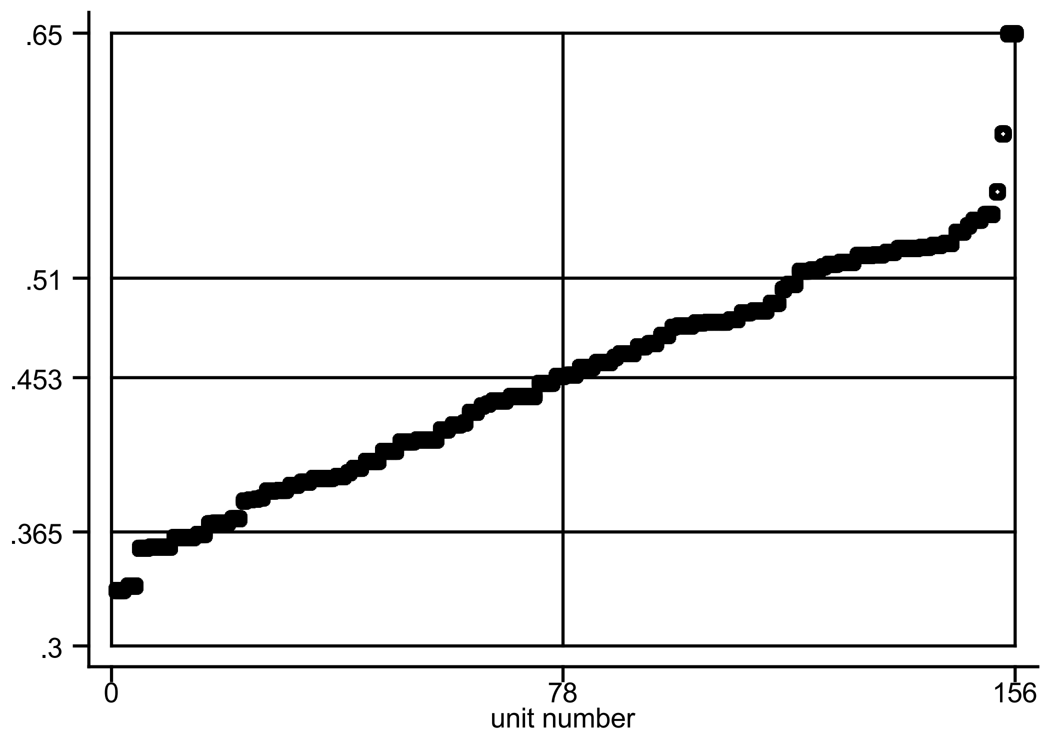

Figure 4. High Speed PSC Air Handler/Furnace Power at 0.50 IWC External Static

As shown in Figure 4, the median power draw is substantially higher than the default 365 watts per 1000 cfm. The median power draw is also lower than the typical field measured power draw (510 watts per 1000 cfm).

Field data show higher external static pressures around 0.80 IWC. The 146 units with manufacturers' data for 0.80 IWC at high speed are displayed in Figure 5. The median is 496 watts per 1000 cfm, very close to the field measured 510 watts per 1000.

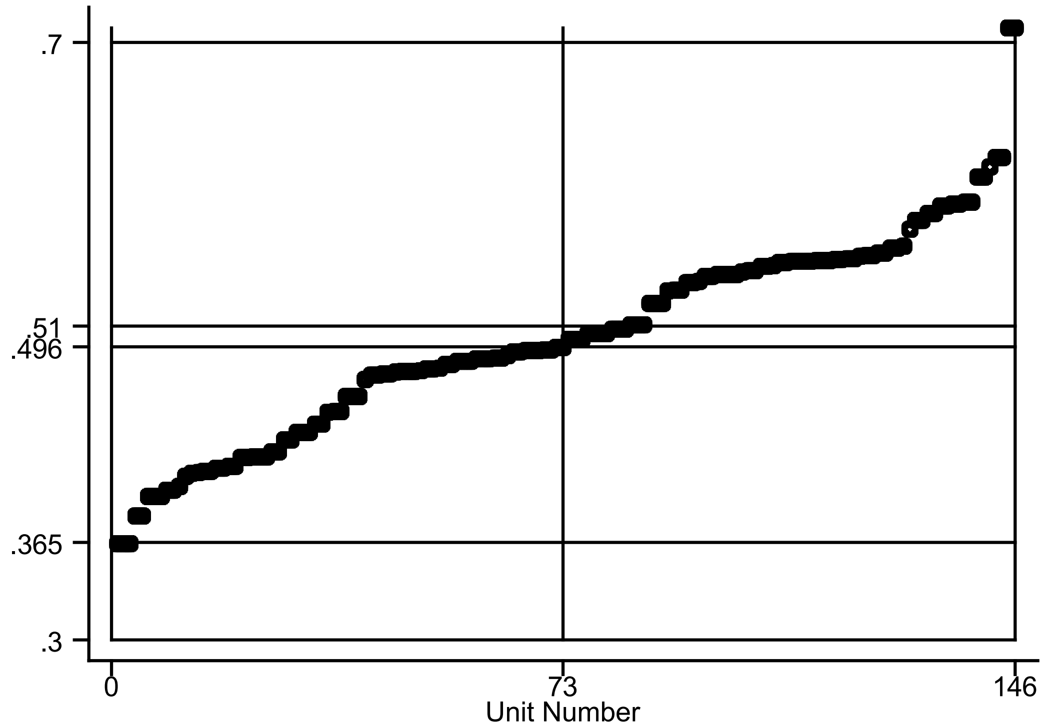

Figure 5. High Speed PSC Air Handler/Furnace Power at 0.80 IWC External Static

There are definite differences associated with air handler size (eg. 3 tons vs. 5 tons) in blower performance. Figure 6 displays the blower performance of the 3 ton PAC units in the data base at 0.8 IWC. The median is 453 watts per 1000. Figure 7 displays the performance of 5 ton systems at the same conditions. The median for the 5 ton units is 546 watts per 1000 cfm.

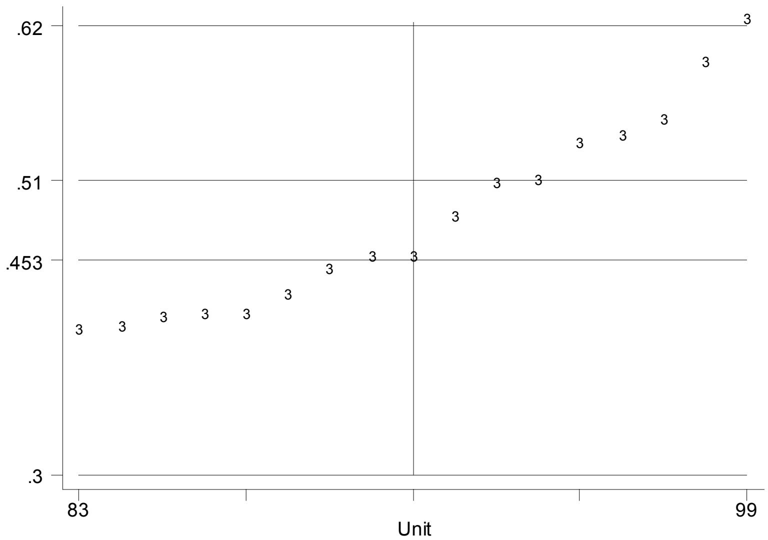

Figure 6. Three Ton High Speed PSC at 0.80 IWC

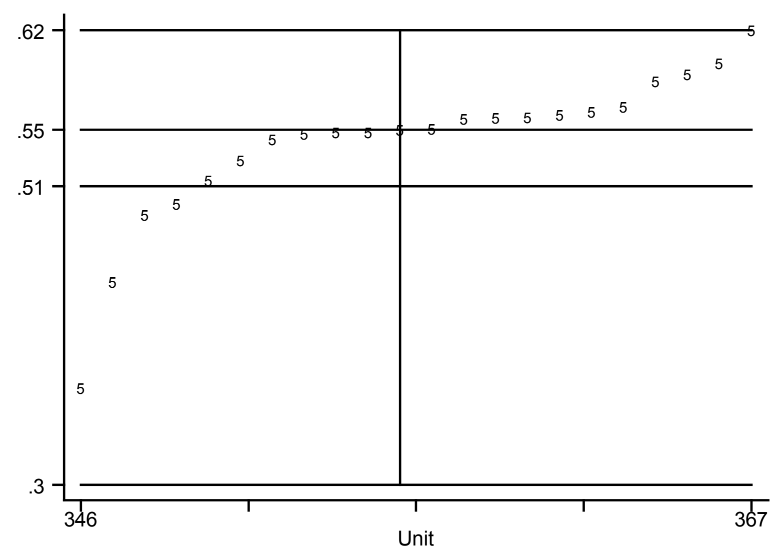

Figure 7. Five Ton High Speed PSC at 0.80 IWC

Laboratory Tests

Laboratory tests were run over the full range of external static pressures and blower speeds. Figure 8 shows the power draw of the six tested furnaces at 0.50 and 0.80 IWC.

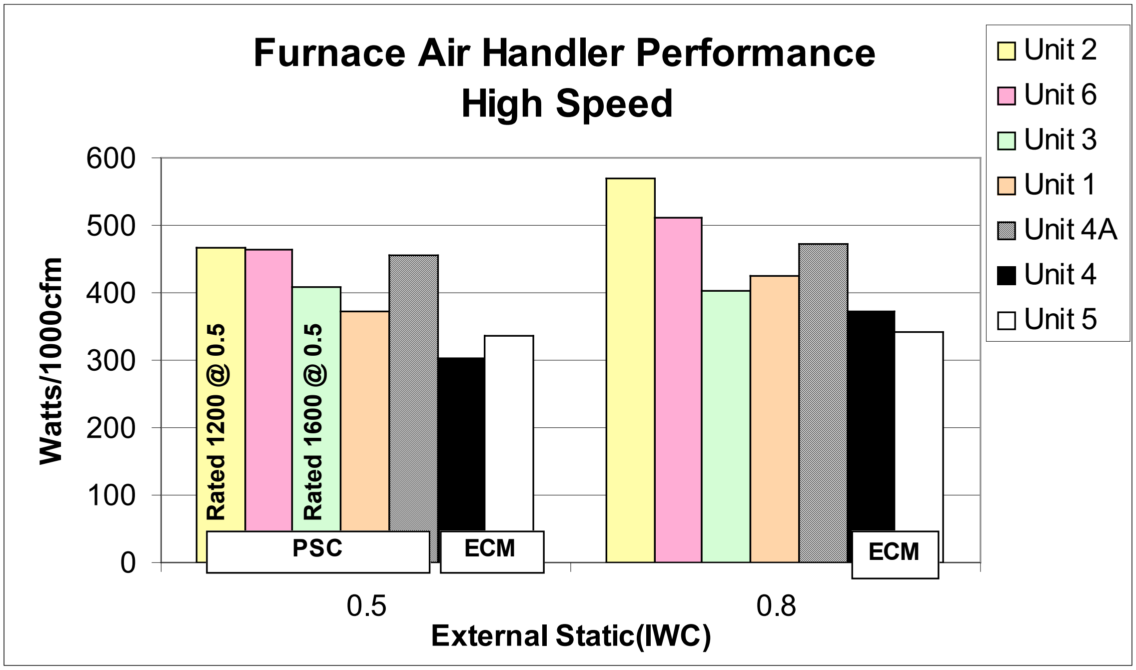

Figure 8. Furnace/Air Handler Performance Results at .50 and .80 IWC

Figure 8 shows that the tested performance of these furnaces ranged from 569 watts per 1000 cfm to 403 watts per 1000 cfm for the tested units with permanent split capacitor (PSC) motors at 0.80 IWC. These data are at high speed, which is the most common speed in the cooling mode.
The units with the ECM motors performed better even at 0.80 IWC. Their performance was 371 and 341 watts per 1000 cfm. Unit 4 was an ECM unit that was also tested with a PSC motor. The ECM version used 18% less watts per 1000 cfm in the same furnace at 0.80 IWC. The difference between the PSC and ECM was much larger at 0.50 IWC.

Analysis and Results

Life Cycle Cost Calculation

Life Cycle cost was calculated for the proposed air flow and fan Watts prescriptive requirement based on Micropas UZM runs for the 1761 house, assume that the base case system has 300 CFM/ton and 0.61 W/CFM. The Prescriptive Standard Case has 350 CFM/ton and 0.5 W/CFM. The current EER multiplier relationship for air flow is used with a new value for 350 CFM/ton interpolated. The standard TDVkBtu value of $0.24374 was used to calculate the TDV savings. The table below shows that if the cost to improve the duct system is $123 and the cost of testing and verification is $300 or less the measure is cost effective in Climate Zones 10 through 15.

Zone	$ TDV savings	$ Improve	$ Verification	$ NPV	Cost Effective?
1	69	123	300	354	
2	331	123	300	92	
3	107	123	300	316	
4	197	123	300	226	
5	124	123	300	299	
6	99	123	300	324	
7	142	123	300	281	
8	335	123	300	88	
9	403	123	300	**20**	
10	622	123	300	-199	Yes
11	811	123	300	-388	Yes
12	515	123	300	**-92**	Yes
13	931	123	300	-508	Yes
14	846	123	300	-423	Yes
15	1,734	123	300	-1,311	Yes
16	382	123	300	41	
Ave	478				
CIRB	517				

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Measure First Cost

The increased flow and reduced fan Watts is achieved by improving the distribution system to reduce pressure drop. The cost of doing this is estimated based on the median values measured in PIER08 field survey and estimates for improving a 3 ton system.

Component	Survey Median	Target
Supply Duct	0.18	0.18
Cooling Coil	0.27	0.20
Return Duct	0.15	0.05
Filter	0.15	0.07
Total	0.75	0.50

	Modification	Cost increase		
Component	Strategy	Labor	Material	Total
Supply Duct	No Change			
Cooling Coil	5 ton coil		40.00	40
Return Duct	Increase diameter	11.76	20.75	32
Filter	25% Larger area		15.00	15
Overhead and profit	30%			37
Total				123

It is possible to meet the proposed requirement using many alternative approaches to duct system design and installation and component selection.

Recommendations

Standards Addition

Add a new definition of Air Distribution System:

A central forced air system which is intended to operate regularly to distribute air for comfort and ventilation when heating and cooling are not needed. The Air Distribution System may be part of an Indoor Air Quality Ventilation System.

Add a new prescriptive requirement in Table 151-C of Section 151 of the Standards as follows:

SUBCHAPTER 8
LOW-RISE RESIDENTIAL BUILDINGS— PERFORMANCE AND PRESCRIPTIVE COMPLIANCE APPROACHES

SECTION 151 – PERFORMANCE AND PRESCRIPTIVE COMPLIANCE APPROACHES

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TABLE 151-C ALTERNATIVE COMPONENT PACKAGE D

Climate Zone	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
…																
Central Forced Air Handler																
Cooling Air Flow and Watt Draw	NR	NR	NR	NR	NR	NR	NR	NR	NR	REQ[15]	REQ[15]	REQ[15]	REQ[15]	REQ[15]	REQ[15]	NR
Air Distribution System Watt Draw	REQ[16]	REQ[16]	REQ[16]	REQ[16]	REQ[16]	REQ[16]	REQ[16]	REQ[16]	REQ[16]	REQ[16]	REQ[16]	REQ[16]	REQ[16]	REQ[16]	REQ[16]	REQ[16]

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Footnote requirements to **Error! Reference source not found.**and TABLE 151-C

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15 Central forced air system fans shall simultaneously demonstrate, in every zonal control mode, a flow greater than 350 CFM/ton of nominal cooling capacity and a watt draw less than 0.5 W/CFM, except systems with a nominal cooling capacity of 5 Tons which shall demonstrate a watt draw less than 0.55 W/CFM.

16 Central forced air system fans used in Air Distribution Systems shall demonstrate, in Air Distribution Mode, a watt draw less than 0.5 W/CFM, except systems with a nominal cooling capacity of 5 Tons which shall demonstrate a watt draw less than 0.55 W/CFM.

ACM Modifications

Add a new algorithm to model air distribution systems with a fixed 33% on time each hour. Possible variants include systems which keep track of the on time meeting loads and do not run the fan if the minimum on time has already been met.

Air Distribution Systems with outdoor air inlets that have dampers and controls to open them only when useful for IAQ ventilation will have no additional energy impact beyond the IAQ ventilation already included in that calculation. Air Distribution Systems with outdoor air inlets that do not have dampers and controls shall have the building Specific Leakage Area increased by the Effective Leakage Area of the air inlet and the return duct leakage for distribution efficiency calculations increased by the intended operating outdoor air flow rate.

Other ACM details to be added as required.

Material for Compliance Manuals

Not developed at this time.

Bibliography and Other Research

Appendices

None