TECH CORNER

Makeup Air Requirements for Direct Kitchen Hood Exhaust

Lisa White, September 18, 2019

Per PHIUS balanced ventilation requirements, outlined in the PHIUS+ Certification Guidebook v2.1 Section 3.5.3.3,

> Regardless of type, the ventilation system must meet one of the following requirements for balance:
>
> 1. Total measured supply and exhaust airflows are within 10% of each other. (Use the higher number as the basis of the percentage difference.)
> 2. The total net pressurization or depressurization from the un-balanced ventilation system does not exceed 5 Pa. The net pressurization/ depressurization that the ventilation system imbalance causes on the building is determined using the multi-point air-tightness test results graph.

Intermittent exhaust airflow rates for kitchen exhaust hoods are generally much higher than a continuous exhaust airflow rates in the kitchen. For example, a whole house may have a total of 150cfm continuous, balanced ventilation, and may have a 125cfm kitchen intermittent exhaust hood. With this combination, option 1 above would likely never pass.

Therefore, this article establishes a method for determining compliance with option 2 during design. A stress test must be used to see if this intermittent ventilation system would cause more than 5 Pa of depressurization in the building.

- For a single unit building, the stress test is simply measuring the effect of turning on the range hood. If that airflow rate causes more than 5 Pa of depressurization in the building, there must be a provision for makeup air.

- For multi-unit buildings, an appropriate 'stress test' must be defined. The stress test must be conservative, but also realistic. Building America House Simulation protocol has determined a typical daily hourly profile for range hood use, copied in the chart below.

Hour	Hourly Ratio	Hour	Hourly Ratio	Hour	Hourly Ratio
1	0.007	9	0.046	17	0.092
2	0.007	10	0.048	18	0.15
3	0.004	11	0.042	19	0.117
4	0.004	12	0.05	20	0.06
5	0.007	13	0.057	21	0.035
6	0.011	14	0.046	22	0.025
7	0.025	15	0.057	23	0.016
8	0.042	16	0.044	24	0.011

Table 1: BAHSP Daily Internal Gain Load Profile for Kitchen Range Hood

For Building America, the maximum usage would be at hour 18 (6:00PM), with 15% of total range hoods in operation.

LBNL also has conducted research on the use of kitchen exhaust in an indoor air quality study, which found that 24% of the homes studied reported to use the range hood "most times". If the buildings that reported no exhaust fan were removed, that is about 30% of the total. Alternatively, 32% of the homes studied reported to use the range hood "infrequently, only when needed", and if the buildings that reported no exhaust fan were removed, that is about 40% of the total.

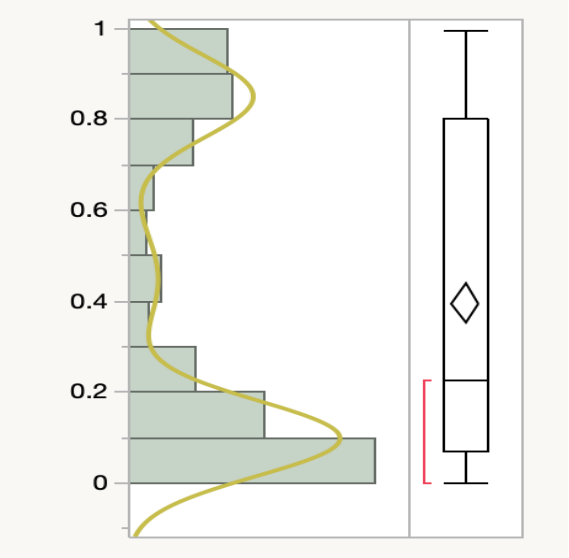
Self-reported usage	Number	Percent
Most times (>75%) when cooktop or oven used	44	13%
Most times when cooktop used, but not oven	39	11%
About half the time	45	13%
Infrequently, only when needed	**113**	**32%**
Never	35	10%
No exhaust fan	73	21%

Singer - 9/6/2018 Mullen et al. LBNL-5970E

Figure 1: Figure 1: LBNL-5970E Mullen et al.

Figure 2 shows an interpolated distribution matching the LBNL survey data, omitting the cases with no exhaust fan. This was generated assuming that 44+39 people responded

with numbers between 75-100%, 45 people responded with numbers between 25-75%, and so on.



QUANTILES		
100.0%	Maximum	0.9949
99.5%		0.9940
97.5%		0.9787
90.0%		0.9210
75.0%	Quartile	0.7998
50.0%	Median	0.2254
25.0%	Quartile	0.0698
10.0%		0
2.5%		0
0.5%		0
0.0%	minimum	0

Figure 2. Synthetic/interpolated range hood usage distribution matching LBNL survey

For a stress case, it would be conservative to assume 80% of the installed exhaust fans were being used (top quartile). Therefore, an appropriate stress case can be defined using a combination of the peak hour (15%, according to BAHSP protocol) and a conservative estimate (80%) for actual range hood usage of the total potential use. This comes out to (15% x 80%) = 12% of the maximum potential intermittent kitchen exhaust as the stress case.

Additionally, one can estimate the exhaust airflow rate that would cause more than 5 Pa depressurization on the building envelope by using the predicted tested result at 50 Pa, based on PHIUS' required air-tightness limit (which is a pass/fail requirement for certification). If the total intermittent kitchen exhaust airflow rate during the stress case is lower than the exhaust airflow rate that would cause 5 Pa depressurization, then the building does not need a dedicated makeup air exhaust system.

To determine if a building must provide makeup air relief, follow the steps below or Use the Online Calculator -- 'Intermittent Kitchen Exhaust Allowance Calculator' linked on this page: https://www.phius.org/software-resources/wufi-passive-and-other-modeling-tools/calculators-and-protocols

1. First, determine the maximum leakage at 50 Pa, based on the PHIUS+ air-tightness limit, using the equation below:

   Building Envelope Area (ft2) x Air-tightness Allowance (CFM50/ft2)
   = Total Allowance (CFM50)

2. Next, convert the result from Step 1 from 50 Pa to 5 Pa to estimate the airflow rate that would cause 5 Pa of depressurization on the building envelope. Use the equation below.

   CFM5 = CFM50 x (5/50)^n
   where n = flow exponent from air-tightness test (if unknown, use 0.75)

3. Then, determine the maximum potential intermittent exhaust flow rate by adding up all intermittent exhaust fans in the building.

   # Units x [intermittent exhaust flow rate per unit] (CFM)
   = Total potential intermittent exhaust (CFM)

4. Multiply the result from step 3 by 12% to predict the stress case intermittent exhaust rate, accounting for the variability in hourly usage and user behavior, as described above.

   Total potential intermittent exhaust (CFM) x 12%
   = Stress case intermittent Exhaust (CFM)

5. Lastly, compare the result from step 2 with the result from step 4 to determine if the exhaust range hoods potentially cause 5 Pa depressurization on the building envelope.

   If: **CFM5 (Step 2 result) > Stress case intermittent exhaust (CFM) (Step 4 result), the building does not need a dedicated makeup air system.**

Example Calculation:

Building Envelope Area: 38,536 ft2
Air-Tightness Allowance: 0.06 CFM50/ft2
Units: 28
Kitchen Exhaust Airflow per unit: 150 CFM

1. 38,536 ft2 x 0.06 CFM50/ft2 = 2312 CFM50
2. (2312 CFM50) x (5/50)^0.75 = 411 CFM5
3. 28 Units x 125 CFM/unit = 3500 CFM
4. 3500 CFM x 12% = 420 CFM
5. 411 < 420, make-up air required