PHRC Webinar Series | Tuesday, November 14 @ 1pm

Residential Makeup Air Systems & Requirements

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Description

- There are a variety of factors that influence the environment within homes at any given time, including climate, building enclosure performance, and mechanical system operation. There are times when a specific system places this environment under conditions that are not ideal for occupants, including the operation of large kitchen range hoods and exhaust fans. This large exhaust systems (typically greater than 400 CFM) have the potential to substantially depressurize interior spaces. This webinar will take another look at residential makeup air systems, focusing on modern technologies and recent code requirements that dictate the design and construction of these systems.

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Learning Objectives

- Understand the impact that large residential exhaust systems, including kitchen range hoods, can have on the interior environment and the health and safety of occupants.
- Analyze current code requirements in Pennsylvania, including updated language from the 2015 IRC, and the impact they have on the implementation of makeup air systems.
- Examine current equipment options for providing makeup air systems that help to keep interior building pressures at safe and appropriate levels.
- Discuss the challenges installers face when trying to incorporate makeup air systems into overall HVAC systems from a constructability and cost standpoint.

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Outline

- Enclosure fundamentals
- What is makeup air?
- Code requirements
- Makeup air solutions

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PHRC Builder Briefs

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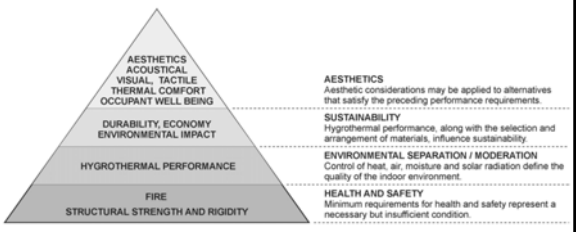
2009 IECC Definitions

- **Building Thermal Envelope. The basement walls, exterior walls, floor, roof, and any other building element that enclose conditioned space. This boundary also includes the boundary between conditioned space and any exempt or unconditioned space.**
  - Building Envelope
  - Building Enclosure

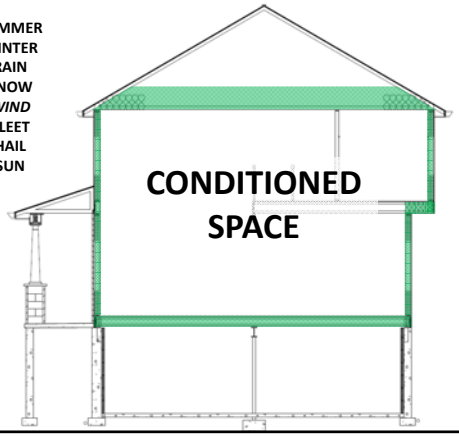
Source: International Code Council (ICC). (2008). 2009 International Energy Conservation Code, Country Club Hill, Ill.

Performance Hierarchy



Source: Development of a Wall Performance Classification System by Kesik, T. and David De Rose. Toronto ON: CIB World Building Congress 2004, May 2–7, 2004.

SUMMER
WINTER
RAIN
SNOW
WIND
SLEET
HAIL
SUN



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Exhaust Sources

- **Most homes contain several mechanical systems that exhaust interior conditioned air, including:**
  - Bath fans (40-200 CFM)
  - Clothes Dryer (100-225 CFM)
  - Kitchen range hood (100-1,500 CFM)



Source: Make-Up Air for Range Hoods, Musings of an Energy Nerd (GreenBuildingAdvisor.com)

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What is Makeup Air?

- **Any air exhausted through mechanical systems must be replaced by an equal volume of air from the outside**
- **This air is called "makeup air"**
- **Much of this air enters through cracks and gaps in the building envelope**
- **The main challenge associated with makeup air:**
  - Homes have become tighter, allowing for fewer cracks and gaps for makeup air to enter through

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Source: Make-Up Air for Range Hoods, Musings of an Energy Nerd (GreenBuildingAdvisor.com)

Pressure Differences

- **Whenever a difference in air pressure exists between interior and exterior environments, air infiltration or exfiltration will occur**
  - Positive pressure within the conditioned space will want to force air through the enclosure to the outside (exfiltration)
  - Negative pressure within the conditioned space (depressurization) will want to bring air in through the enclosure (infiltration)
  - These pressure differences can be caused by natural phenomena (wind, stack effect) or mechanical systems (exhaust fans, leaky ducts)

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Depressurization

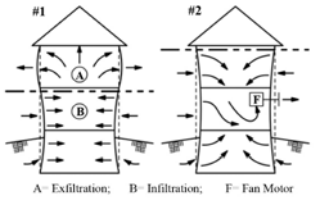

Figure 2. Air infiltration patterns with and without the operation of a kitchen exhaust system. Scenario #1 depicts the stack effect in a house under natural winter time conditions. Scenario #2 depicts how mechanical exhaust can alter the pressure pattern creating a negative pressure throughout the house.

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When is this a Problem?

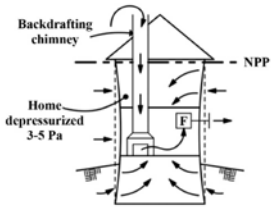

Figure 3. Certain levels of house tightness and exhaust rates may combine to create pressures high enough to cause the draft of combustion appliances to reverse.

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Kitchen Range Hoods

- **What do they exhaust?**
  - Heat
  - Moisture
  - Odor
  - Combustion gases

Image Source: Indiana Public Media

- **What happens when they are operating?**
  - As air is exhausted through a range hood at a rate dependent upon fan capacity, controls, and installation, makeup air attempts to enter the home through openings in the enclosure such as gaps, cracks, chimney flues, etc.

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2009 IRC Requirements for Range Hoods

- **Table M1507.3 – Minimum Required Exhaust Rates for One- and Two-Family Dwellings**
  - Area to be ventilated: Kitchens
    - Ventilation Rates = 100 CFM intermittent or 25 CFM continuous

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Source: International Code Council (ICC). (2008). 2009 International Residential Code, Country Club Hill, Ill.

2009 IRC Requirements for Makeup Air

- **M1503.4 Makeup Air Required**
  - Exhaust hood systems capable of exhausting in excess of 400 CFM shall be provided with makeup air at a rate approximately equal to the exhaust air rate
  - Such makeup air systems shall be equipped with a means of closure and shall be automatically controlled to start and operate simultaneously with the exhaust system

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Source: International Code Council (ICC). (2008). 2009 International Residential Code, Country Club Hill, Ill.

2015 Requirements Adopted in PA

- **Effective 12/31/15:**
  - 2015 IRC Section M1503.4
- **What changed?**
  - Makeup air shall be *mechanically or naturally* provided
  - Makeup air systems shall be equipped with not less than one damper
    - Gravity dampers
    - Electrically operated damper that automatically opens when the exhaust system operates

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Source: PA UCC Reference: Title 34, Chapter 403.21 (7)(iii)(AA)
International Code Council (ICC). (2014). 2015 International Residential Code, Country Club Hill, Ill.

2015 IRC Section M1503.4
Added text

- **M1503.4 Makeup air required.** Exhaust hood systems capable of exhausting in excess of 400 cubic feet per minute (0.19 m3/s) shall be mechanically or naturally provided with makeup air at a rate approximately equal to the exhaust air rate. Such makeup air systems shall be equipped with not less than one damper. Each damper shall be a gravity damper or an electrically operated damper that automatically opens when the exhaust system operates. Dampers shall be accessible for inspection, service, repair and replacement without removing permanent construction or any other ducts not connected to the damper being inspected, serviced, repaired or replaced.

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Source: PA UCC Reference: Title 34, Chapter 403.21 (7)(iii)(AA)
International Code Council (ICC). (2014). 2015 International Residential Code, Country Club Hill, Ill.

Section M1503.4 Makeup air required: *Details of change*

IRC RM 34-13

- **Reason:**

  "The first change adds the words 'mechanically or naturally'. It is important to explicitly state that both mechanical ventilation (i.e. a fan) and natural ventilation (i.e. a passive opening) is allowed by this provision for the following reasons. First of all, it is not being interpreted the same in all jurisdictions. Secondly, there is no precedence for mechanical makeup air in the IRC. The second change deals with the type of damper that is allowed. The only reason to require a 'means of closure' to the makeup air system is to limit the amount of conditioned air that leaves the building when the exhaust is not running. Both electrically-operated and gravity dampers achieve this goal, and it is important to clarify that both are allowed. Again, it is not being interpreted the same in all jurisdictions. (Some are allowing gravity dampers, but not all.) Secondly, allowing a gravity damper is in keeping with similar applications within the IRC—nowhere are automatic (motorized) dampers required for makeup or ventilation air. Finally, a gravity damper has the added benefit of equalizing depressurization in the house for any other reason (e.g. bath fans and clothes dryers). The last sentence was taken and modified from Section M1305.1 on appliance access. It emphasizes that both types of dampers, gravity and motorized, require maintenance and may need to be replaced at some time."
- **Cost Impact:** The code change proposal will not increase the cost of construction.
- **Proponent:** Dan Buuck, National Association of Home Builders (NAHB); David Hall CFM, Georgetown Texas representing the ICC PMG Code Action Committee

Source: International Code Council (ICC). (2013). 2013 Proposed changes to the International Residential Code RM34-13, Country Club Hill, Ill.

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Section M1503.4 Makeup air required: *Details of change*

- One example of providing make-up air through mechanical ventilation.

Source: Broan Universal Make-Up Air Damper

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Act 36 of 2017

- **By October 1, 2018, PA will be operating under a new set of building codes (dependent upon RAC review process)**
- **Some 2015 provisions (including those not previously adopted) may become enforceable in the Commonwealth**
  - Airtightness levels likely to increase
  - Additional makeup air requirements (location of entering air)

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2015 IRC Requirements Up for Review

- **2015 IRC Section M1503.4.1 Location**
  - Kitchen exhaust makeup air shall be discharged into the same room in which the exhaust system is located or into rooms or duct systems that communicate through one or more permanent openings with the room in which such exhaust system is located.
  - Such permanent openings shall have a net cross-sectional area not less than the required area of the makeup air supply openings

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Source: International Code Council (ICC). (2014). 2015 International Residential Code, Country Club Hill, Ill.

What is the Impact?

- **For homes with large ranges and subsequently large range hoods, makeup air must be taken into consideration in the design of the home**

Image Source: Fantech.net

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Range Hood Comparisons

- **NOTE: Range hoods exist that fall below the 400 CFM threshold**

Viking Professional 5 Series
Model No. VWH3610L
Exhaust rate: 390 CFM

VS

Viking Professional 5 Series
Model No. DEV1500
Exhaust rate: 1500 CFM

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Makeup Air Systems

- **Engineered openings**
- **Mechanical systems**
  - Unconditioned makeup air
    - Engineered openings in HVAC-integrated systems
    - Fan-powered supply
  - Conditioned makeup air
    - HVAC-integrated systems
    - Independent systems

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Engineered Openings

- **What is an engineered opening?**
  - Intentional opening in the building enclosure for the purpose of transferring air from the exterior to the interior of a building
  - These could be as simple as a hole in the enclosure, or could include ductwork to direct area to a specific location
  - Dampers are included to make sure air is only allowed to flow during times of exhaust system operation

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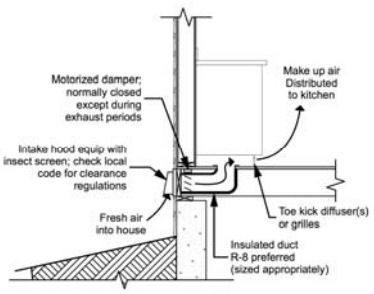
Engineered Openings



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Engineered Opening Size

- **Air flow through a duct (assuming damper is open) depends on the pressure difference caused by exhaust system operation**

Pressure (Pa)	Airflow (CFM) Based on Opening Size				
	4 in	6 in	8 in	10 in	12 in
1	14	30	54	84	122
2	19	43	76	119	172
3	23	53	94	146	211
4	27	61	108	169	243
5	30	68	121	189	272
6	33	74	132	207	298
7	36	80	143	223	322
8	38	86	153	239	344
9	41	91	162	253	365
10	43	96	171	267	384

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Pros & Cons

- **Pros of engineered openings:**
  - Relatively inexpensive
  - Air can be directly introduced to the space where it is needed
  - Little strain on HVAC systems. Air has the opportunity to mix and temper with interior air before returning to central HVAC equipment
- **Cons of engineered openings:**
  - Additional load on central HVAC equipment
  - Varying degrees of effectiveness, depending on placement of the opening
  - Could introduce drafts, if misplaced
  - Limited to lower exhaust rate applications

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Mechanical Systems - Unconditioned

- **How do you integrate engineered openings with your central HVAC system?**
  - Unconditioned makeup air is typically added upstream of the air handler, where it can mix with return air and become tempered before reaching the central conditioning unit.
  - The central conditioning unit then filters, conditions, and distributes makeup air throughout the house along with the return air.
  - When the range hood is not in operation, the opening is typically closed automatically by a motorized damper that is interlocked with the range hood on/off switch, or by a gravity damper.

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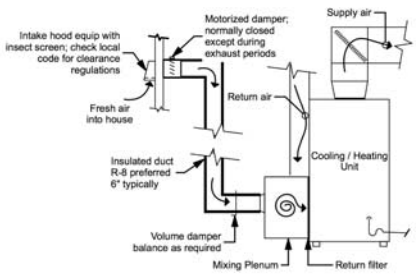
Integration with Air Handler



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Pros & Cons

- **Pros of HVAC-Integrated Air Systems:**
  - Relatively inexpensive
  - Air is conditioned and filtered by HVAC unit
  - Air is evenly distributed throughout house
- **Cons of HVAC-Integrated Air Systems:**
  - Additional load to central HVAC equipment
  - Only limited quantities can be introduced to the central HVAC without requiring additional design assistance and equipment capacity
  - Difficulty meeting peak heating/cooling loads without over-sizing central HVAC equipment

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Air Handler Limitations

- **Temperature**
  - Most gas furnace manufacturers limit the temperature of mixed return air to 55°F

Source: ABT Systems, LLC. (2015). Residential Exhaust Makeup Air: Explanations and Solutions, Annville,PA.

- **Additional air flow**
  - In Climate Zone 5, outside air volume as a fraction of the overall air handler design flow should be limited to ~20%

Source: Broan-Nutone Makeup Air Fact Sheet. (2012).

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Mechanical Systems - Conditioned

- **How do you condition incoming makeup air?**
  - Fan-powered makeup air supplies can incorporate heating elements, dehumidification, and filtration systems

Image Source: Fantech MUAS - Fantech.net

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Makeup Air Conditioning Components

- **Heating**
  - Electric resistance heating elements are readily available that can bring incoming supply air to a temperature ~ 55°F
- **Dehumidification**
  - In-line dehumidification can help to avoid spikes in relative humidity within the home during operation, but capacity of available systems is limited (<500 CFM)
- **Filtration**
  - Various filtration elements can be added to the system depending on environmental factors and occupant needs

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Source: ABT Systems, LLC. (2015). Residential Exhaust Makeup Air: Explanations and Solutions, Annville,PA.

System Implementation

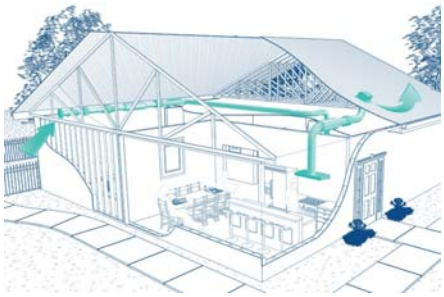

Image Source: Fantech MUAS - Fantech.net

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Pros & Cons

- **Pros of conditioning systems**
  - Capable of supplying a known amount of tempered makeup air to a specified location
  - Independent systems do not impact central HVAC system design
- **Cons of conditioning systems**
  - High cost
  - Complex system requires space for installation
  - Homeowner must maintain another system

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Source: ABT Systems, LLC. (2015). Residential Exhaust Makeup Air: Explanations and Solutions, Annville,PA.

Conclusions

- **Makeup air systems are crucial to ensuring code compliance and occupant health/comfort when installing large exhaust systems**
- **Recommendations:**
  - Consider installing an appropriately sized range hood
  - When installing large range hoods (>400 CFM), install options that meet client needs and budget
  - When makeup air systems involve HVAC systems, refer to your HVAC consultant

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