Whole-House Mechanical Ventilation

www.phrc.psu.edu

PennState College of Engineering | PENNSYLVANIA HOUSING RESEARCH CENTER

NARI CEU Approved

PREFERRED EDUCATION PROVIDER

PHRC

Description

- With the new requirement of adding whole house mechanical ventilation, builders are now potentially facing something new. In this webinar we will review the prescriptive requirements for mechanical ventilation, why mechanical ventilation is important and some potential solutions for achieving this requirement.

7

Learning Objectives

- Review the 2015 IRC and IECC sections regarding mechanical ventilation so we can understand why builders must introduce this design into their products.
- Review why mechanical ventilation is important for the health of the occupants and must be installed correctly.
- Review some inspections techniques to ensure the mechanical ventilation is installed correctly. Properly installed mechanical ventilation is key for the occupants as well as the sustainability of the building envelope.
- Understand there are many different ways to achieve mechanical ventilation. We will explore a few of these systems and explain pros and cons for each.

8

Why is Whole-House Mechanical Ventilation Needed?

10

The Needs for Ventilation

- Exchange of indoor air with fresh air
- Control the rate of air exchange
- Improve air quality
- Now required by 2015 IRC
  - 2015 IRC Section R303.4 Mechanical ventilation

11

2009 N1102.4.2: Air Leakage Demonstration

- N1102.4.2 – Air sealing and insulation. Building envelope airtightness and insulation installation shall be demonstrated to comply with one of the following options:
  - N1102.4.2.1 – **Testing option.** Tested air leakage is less than 7 ACH when tested with a blower door at a pressure of 50 pascals.

    OR
  - N1102.4.2.2 – **Visual Inspection**

12

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

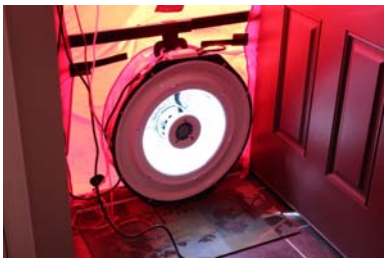
Infiltration Rate in PA

- 2015 IRC N1102.4.1.2 (IECC R402.4.1.2) Testing (of air leakage)
  - The building shall be tested and verified as having an air leakage rate of not exceeding 5 ACH50. Testing shall be performed at any time after the creation of all penetrations of the building thermal envelope.

13

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

Testing With a Blower Door



14

Blower Door Concept

- Depressurize the home to an exaggerated pressure difference to quantify air infiltration and compare with established benchmarks
- ACH_{50} = Air Changes per Hour at pressure difference of 50 Pa
  - Current limit in Pennsylvania is 7 ACH_{50} if tested
  - 50 Pa simulates roughly a 20 mph wind on all sides of the home

15

Image Source: https://www.naecl.com/blower-door-testing

Ventilation: Existing Requirements

- Ventilation requirements in Section R303 of the 2015 IRC can be met through installation of operable glazing in habitable rooms based on a percentage of floor area
- If operable glazing requirements cannot be met:
  - Mechanical ventilation capable of 0.35 ACH in the habitable room
    Or
  - Whole-house mechanical ventilation system capable of supplying 15 CFM of ventilation air per occupant (assuming 2 occupants in master)

16

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

2015 Ventilation Requirements

- R303.4 Mechanical Ventilation
  - Where the air infiltration rate of a dwelling unit is 5 air changes per hour or less where tested with a blower door at 50 Pa, the dwelling unit shall be provided with whole-house mechanical ventilation in accordance with Section M1507.3.
- If airtightness requirement is not to exceed 5 ACH_{50}, mechanical ventilation is required

17

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

M1507.3: Whole-House Mechanical Ventilation System

- Whole-house mechanical ventilation systems shall be designed in accordance with Sections M1507.3.1 through M157.3.3.

18

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

M1507.3: Whole-House Mechanical Ventilation System

- **M1507.3.1 System design.** The whole-house ventilation system shall consist of one or more supply or exhaust fans, or a combination of such, and associated ducts and controls. Local exhaust or supply fans are permitted to serve as such a system. Outdoor air ducts connected to the return side of an air handler shall be considered as providing supply ventilation.

19

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

M1507.3: Whole-House Mechanical Ventilation System

- **M1507.3.2 System controls.** The whole-house mechanical ventilation system shall be provided with controls that enable manual override.

20

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

M1507.3: Whole-House Mechanical Ventilation System

- **M1507.3.3 Mechanical ventilation rate.** The whole-house mechanical ventilation system shall provide outdoor air at a continuous rate of not less than that determined in accordance with Table M1507.3.3(1).
  - **Exception**: The whole-house mechanical ventilation system is permitted to operate intermittently where the system has controls that enable operation for not less than 25-percent of each 4-hour segment and the ventilation rate prescribed in Table M1507.3.3(1) is multiplied by the factor determined in accordance with Table M1507.3.3(2).

21

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

Mechanical Ventilation

- Main considerations:
  - System design (supply only, exhaust only, balanced)
  - Integration w/overall HVAC system(s)
  - Ventilation rate

22

Whole-House Mechanical Ventilation Options

23

3 Design Solutions For Whole-House Mechanical Ventilation

- Exhaust-only
- Supply-only
- Balanced system

24

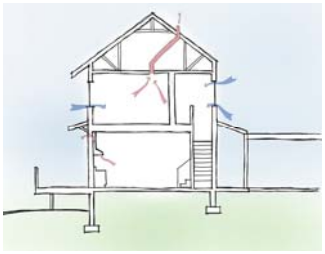
How Exhaust-only Ventilation Works

- Exhaust ventilation systems are usually seen as a spot ventilation through bathroom exhaust fans.

25

Source: Ventilation Requirements & Code Changes, Ventilation Science & Requirements; Hamer Center

Exhaust-only Ventilation



26

Source: Ventilation Requirements & Code Changes, Ventilation Science & Requirements; Hamer Center

Exhaust-only Option

- Programmable bath fan

27

Image Source: https://na.panasonic.com/us/whispergreen-selecttm-fan-50-80-110-cfm

Exhaust-only Placement Consideration

- Master Bath
  - Pathway from fan to remainder of the home
  - Noise
- Hall Bath
  - Pathway from fain to remainder of the home if Jack & Jill is the only option
  - More direct path for air flow

28

Exhaust-only Advantages

- Simple installation and minimal required duct work
- Affordable (Low installation and operating cost)
- Commonly used

29

Exhaust-only Challenges

- Potential for back-drafting when used with combustion appliances
- Lack of control over where the infiltrating air enters
- Outdoor air may not be evenly distributed
- Must install control switch for manual overide

30

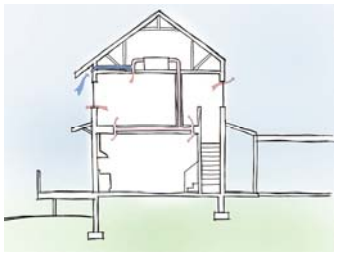
How Supply-only Ventilation Works

- Supply-only ventilation requires a central-fan-integration system connected to the ductwork supplying the air handler to bring in fresh outdoor air and integrates the air into the circulating conditioned air.

31

Source: Ventilation Requirements & Code Changes, Ventilation Science & Requirements; Hamer Center

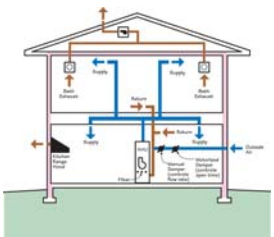
Supply-Only Ventilation



32

Source: Ventilation Requirements & Code Changes, Ventilation Science & Requirements; Hamer Center

Supply-only Option



33

Image Source: https://basc.pnnl.gov/sites/default/files/images/HVAC515_whlbldgvent7_Rudd_1-10-13.jpg?download=1

Supply-only Advantages

- More even air distribution
- Positive pressurization can reduce the risk of infiltration of pollutants & contaminates
- Minimal addition of ductwork
- Known fresh air source

34

Supply-only Challenges

- Potential to add warm, humid air into exterior wall during winter months due to pressurization
- Requires additional ductwork to HVAC system
- Adds additional loads to HVAC design
- Additional cost of dampers

35

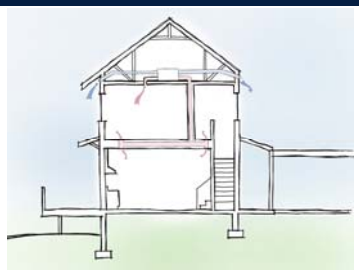
How a Balanced System Option Works

- Balanced ventilation systems combine supply and exhaust systems; most systems have built-in heat recovery capabilities so that heat from the exhaust air can transfer to the supply air; reducing the conditioning load.

36

Source: Ventilation Requirements & Code Changes, Ventilation Science & Requirements; Hamer Center

Balanced System Option



37

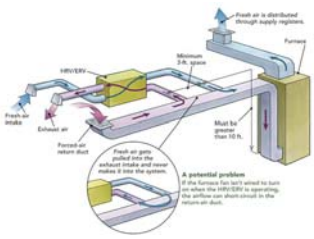
Source: Ventilation Requirements & Code Changes, Ventilation Science & Requirements; Hamer Center

Stand Alone ERV

38

Image Source: https://na.panasonic.com/us/home-living-solutions/ventilation-indoor-air-quality/energy-recovery-ventilators/whispercomfortm

Integrated HRV System



39

Image Source: https://www.finehomebuilding.com/2014/11/05/ducting-hrvs-and-ervs

Balanced Ventilation Advantages

- A balanced system transfers heat which increases comfort and decreases the load on the HVAC system
- A balanced system maintains a neutral pressure difference which in turn reduces the strain on the building thermal envelope
- Can be ducted with or independent from the HVAC system

40

Balanced Ventilation Challenges

- Highest installed cost option for whole-house mechanical ventilation
- Requires regular maintenance and filter changes

41

Mechanical Ventilation Rate

43

M1507.3: Whole-House Mechanical Ventilation System

- **M1507.3.3 Mechanical ventilation rate.** The whole-house mechanical ventilation system shall provide outdoor air at a continuous rate of not less than that determined in accordance with Table M1507.3.3(1).
  - **Exception**: The whole-house mechanical ventilation system is permitted to operate intermittently where the system has controls that enable operation for not less than 25-percent of each 4-hour segment and the ventilation rate prescribed in Table M1507.3.3(1) is multiplied by the factor determined in accordance with Table M1507.3.3(2).

44

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

2015 IRC Table M1507.3.3 (1) & (2)

TABLE M1507.3.3(1)
CONTINUOUS WHOLE-HOUSE MECHANICAL VENTILATION SYSTEM AIRFLOW RATE REQUIREMENTS

DWELLING UNIT FLOOR AREA (square feet)	NUMBER OF BEDROOMS				
	0 - 1	2 - 3	4 - 5	6 - 7	> 7
	Airflow in CFM				
< 1,500	30	45	60	75	90
1,501 - 3,000	45	60	75	90	105
3,001 - 4,500	60	75	90	105	120
4,501 - 6,000	75	90	105	120	135
6,001 - 7,500	90	105	120	135	150
> 7,500	105	120	135	150	165

TABLE M1507.3.3(2)
INTERMITTENT WHOLE-HOUSE MECHANICAL VENTILATION RATE FACTORS

RUN-TIME PERCENTAGE INEACH 4-HOUR SEGMENT	25%	33%	50%	66%	75%	100%
Factor	4	3	2	1.5	1.3	1.0

45

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

Continuous Ventilation Example

1st. FLOOR	784	SQ.FT.
2nd. FLOOR	840	SQ.FT.
TOTAL	1624	SQ.FT.

FINISHED SQUARE FOOTAGE CALCULATIONS FOR THIS HOUSE WERE MADE BASED ON PLAN DIMENSIONS ONLY AND MAY VARY FROM THE FINISHED SQUARE FOOTAGE OF THE HOUSE AS BUILT

46

2015 IRC Table M1507.3.3 (1)

TABLE M1507.3.3(1)
CONTINUOUS WHOLE-HOUSE MECHANICAL VENTILATION SYSTEM AIRFLOW RATE REQUIREMENTS

DWELLING UNIT FLOOR AREA (square feet)	NUMBER OF BEDROOMS				
	0 - 1	2 - 3	4 - 5	6 - 7	> 7
	Airflow in CFM				
< 1,500	30	45	60	75	90
1,501 - 3,000	45	60	75	90	105
3,001 - 4,500	60	75	90	105	120
4,501 - 6,000	75	90	105	120	135
6,001 - 7,500	90	105	120	135	150
> 7,500	105	120	135	150	165

47

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

Example: Continuous Exhaust Product

- Continuous rate set to 60 CFM

48

Image Source: https://na.panasonic.com/us/us/home-living-solutions/ventilation-indoor-air-quality/ventilation-fans/whispergreenr-selectm-0

Intermittent Ventilation Example

1st. FLOOR	784	SQ.FT.
2nd. FLOOR	840	SQ.FT.
TOTAL	1624	SQ.FT.

FINISHED SQUARE FOOTAGE CALCULATIONS FOR THIS HOUSE WERE MADE BASED ON PLAN DIMENSIONS ONLY AND MAY VARY FROM THE FINISHED SQUARE FOOTAGE OF THE HOUSE AS BUILT

49

2015 IRC Table M1507.3.3 (1)

TABLE M1507.3.3(1)
CONTINUOUS WHOLE-HOUSE MECHANICAL VENTILATION SYSTEM AIRFLOW RATE REQUIREMENTS

DWELLING UNIT FLOOR AREA (square feet)	NUMBER OF BEDROOMS				
	0 - 1	2 - 3	4 - 5	6 - 7	> 7
	Airflow in CFM				
< 1,500	30	45	60	75	90
1,501 - 3,000	45	60	75	90	105
3,001 - 4,500	60	75	90	105	120
4,501 - 6,000	75	90	105	120	135
6,001 - 7,500	90	105	120	135	150
> 7,500	105	120	135	150	165

TABLE M1507.3.3(2)
INTERMITTENT WHOLE-HOUSE MECHANICAL VENTILATION RATE FACTORS

RUN-TIME PERCENTAGE INEACH 4-HOUR SEGMENT	25%	33%	50%	66%	75%	100%
Factor	4	3	2	1.5	1.3	1.0

50

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

Example: Intermittent Exhaust Product

- 60 CFM x 2 Rate Factor = 120 CFM 50% run time
  - One fan capable of 120 CFM
  - Two fans each capable of 60 CFM

51

Image Source: https://www.honeywellhome.com/en/products/ventilation/digital-bath-fan-control
Image Source: http://www.bvaan.com/Bath-Vent-Fan/Fans-Only

System Verification

52

Testing Whole-house Mechanical Ventilation

- Certificate of compliance is *not* required
- Performance verification can be performed
  - Home Energy Raters
  - Some HVAC contractors

53

Testing: Exhaust-only

- Powered flow hoods are typically used to verify CFM rate for exhaust air systems

54

Testing: Supply-only

- Verification of CFM rate for supply-only systems will typically be done by the HVAC subcontractor due to duct sizing, connection to the HVAC system and direct loading which will need to be incorporated into the heat loss calculations.

55

Testing: Balanced System

- Stand alone ERV systems can be tested by a qualified professional such as a Home Energy Rater who has a powered flow hood.
- Integrated ERV/HRV systems can be very difficult to test due to the variables that come about when connecting to the air handler. Refer to the manufacturers guidelines, system static pressure and duct sizing.

56

Homeowner Education

57

What, Why, Where & How?

- Homeowner education is vital to the functionality of the whole-house ventilation system.
- 3 key items of interest
  - What is it?
  - Why do you need it?
  - Where is it located?
  - How does the homeowner interact?

58

What is it?

- **Explain to the homeowner what whole-house mechanical ventilation system is.**
  - Explain the entire system
  - Continuous or intermittent fan
    - Supply, return or balanced

59

Why?

- **Explain to the homeowner why this system is needed.**
  - Help improve IAQ
  - Help remove or replace stale air with fresh air
  - Dilutes indoor contaminants, such as formaldehyde, cleaning agents, odors, and allergens, which now take longer to dissipate in a tighter house. *(NAHB TechNote, October 2013)*

60

Where is it?

- **Show the homeowner where the system is located.**
  - Bath fan
  - Duct into return
  - ERV / HRV

61

How do they Interact?

- Explain how the homeowner my need to interact with the system.
  - On / off switch
  - Filters

62

Summary

- Whole-house mechanical ventilation systems are mandatory for home equal to or less than 5ACH50
- 3 main types of systems
  - Exhaust only
  - Supply only
  - Balanced system
- All systems have their advantages. Choose the system that fits your need and business model

63

Summary

- Homeowner education
  - What is it?
  - Why is it needed?
  - Where is it?
  - How to interact

64

Questions?

www.phrc.psu.edu

65