Advanced Building Science

Make-up Air

- Overview
- Pressure Fundamentals
- Code Requirements
  - Definitions
  - Make-up air openings
  - Performance option test procedure
- Applications
  - Design worksheet
  - Good design and installation

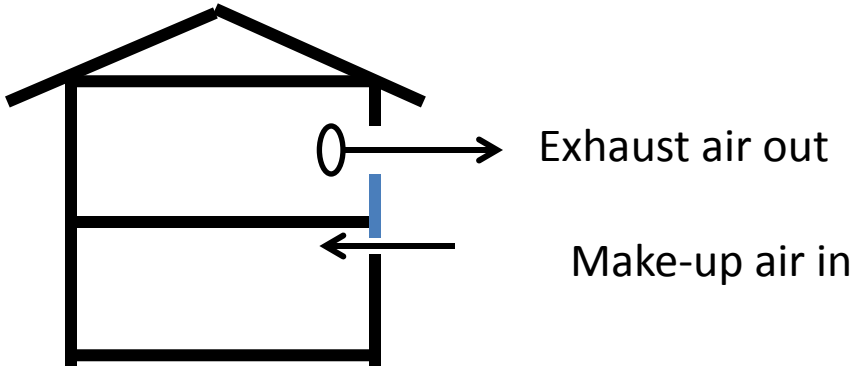
Readings

- HF: Chapter 16.17 to 16.31
- RVS Handout: Chapter 1 & 2 (focus on sections 1,2,4)

Make-up Air

Make-up Air is…

- Outdoor air needed to replace indoor air removed by a mechanical exhaust device



- Make-up air is intended to limit the negative pressure in the home during the operation of exhaust devices

Make-up Air

A context for make-up air

- Make-up air has been used in commercial buildings with large exhaust devices for several years
- Make-up air requirements were added for residential buildings in the 1995 National Code of Canada
- The 2004 Minnesota Energy Code was the first time that make-up air was mandated by code for residential building in the U.S.

Make-up Air

The key issue is combustion backdrafting

- Backdrafting is the reversal of flow in a chimney that brings combustion gases back into the home
- Backdrafting is dependent on
  - The type of combustion appliance
  - Venting options
  - House pressures
- Atmospherically-vented appliances are the most susceptible to backdrafting
  - Includes water heaters, furnaces, fireplaces

Make-up Air

Other depressurization concerns include:

- Entry of soil gases into the home
- Entry of garage gases into the home
- Poor fan performance
- Impact on door closure

Make-up Air

A historical look at depressurization

- Older homes typically ran slightly negative in winter due to
  - Large ceiling fans
  - Large chimneys
  - Large combustion devices

Make-up Air

However, it wasn't necessarily a problem because

- Large and inefficient combustion usually had a strong draft
- Winter infiltration provided drying potential for the building envelope
- There were few and/or small exhausting devices or fans
- Basements were not well connected to the house
  - Basements were typically leaky
  - Basement ductwork tended to be fairly tight
  - Basements were frequently negative with respect to the house

Make-up Air

An historical look at depressurization

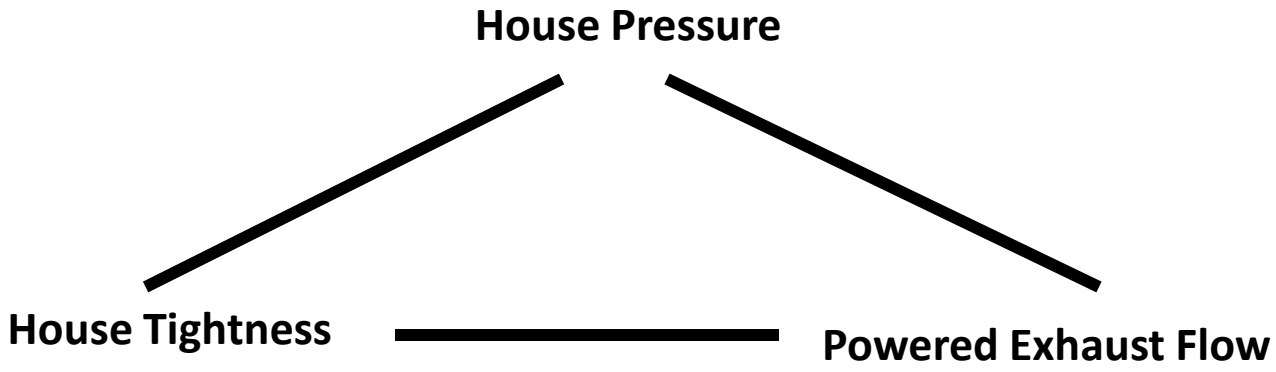
- What's the problem with negative pressure now?
  - Tighter houses and basements lead to larger negative pressures
  - Mid-efficiency appliances are more susceptible to bckdrafting
  - Larger exhaust equpment create larger negative pressues
  - Leaky forced air ducwork in basements
    - Increases the negative pressure in the basement
    - Effectively distributes basement air to the rest of the house
    - Can draw summer moisture into foundation insulation
- A growing concern about soil gases being drawn into the home
- Increased air-conditioning means more wetting potential in the structural cavities, especially with negative pressure

Make-up Air

- It's not just a new home problem
  - Metropolitan Airport Council (MAC) Sound Insulation Program
    - Homes surrounding the MPLS/St. Paul airport
      - Homes built from the 1920's to 1960's
    - Pre-tested for combustion venting, carbon monoxide, house ventilation, and moisture concerns
      - 88% failed on one or more conditions
    - For combustion venting alone…
      - Approximately 2/3 failed a worst case draft test
      - Approximately 1/3 still failed with exhaust fans OFF

Make-up Air

The Pressure Triangle



- The tighter the home the larger the negative pressure for a given powered exhaust flow
- The larger the powered exhaust flow the larger the negative pressure for a give house tightness

Make-up Air

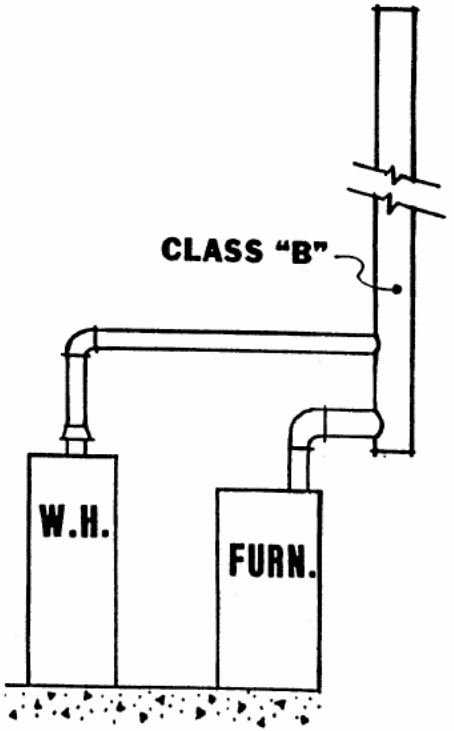
Negative Pressures of Concern

House Pressure

Pa	"w.g.	Description
-50	0.20	Threshold for sealed combustion appliances
-25	0.10	Threshold for some direct or power-vented appliances
-10	0.04	Threshold for a few atmospheric vented appliances
-5	0.02	Threshold for many atmospheric vented furnaces
-2		Threshold for most atmospheric vented water heaters

Depressurization Definitions

Atmospherically vented: A gas or oil appliance that is required to be vented through a chimney or vertical vent is neither direct or power vented.



Note: This type of appliance can usually vent against 2 to 7 Pa of negative pressure.

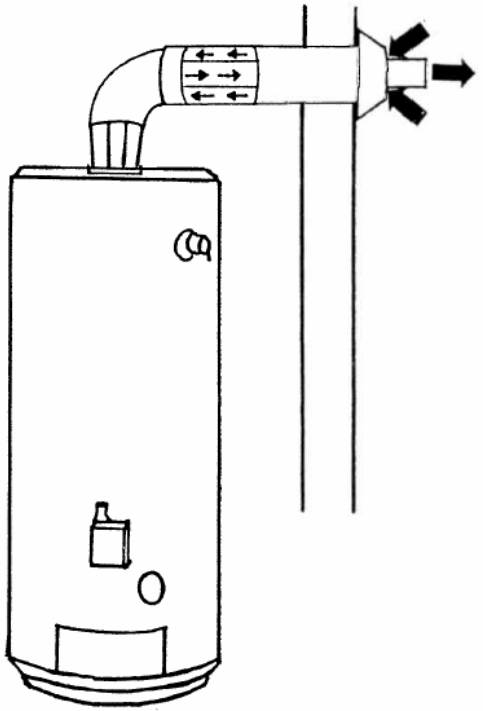
Depressurization Definitions

Power-vented appliance: A system that depends on a mechanical device to provide a positive draft within the venting system.

Note: This type of appliance can usually vent against 15 to 25 Pa of negative pressure.

Depressurization Definitions

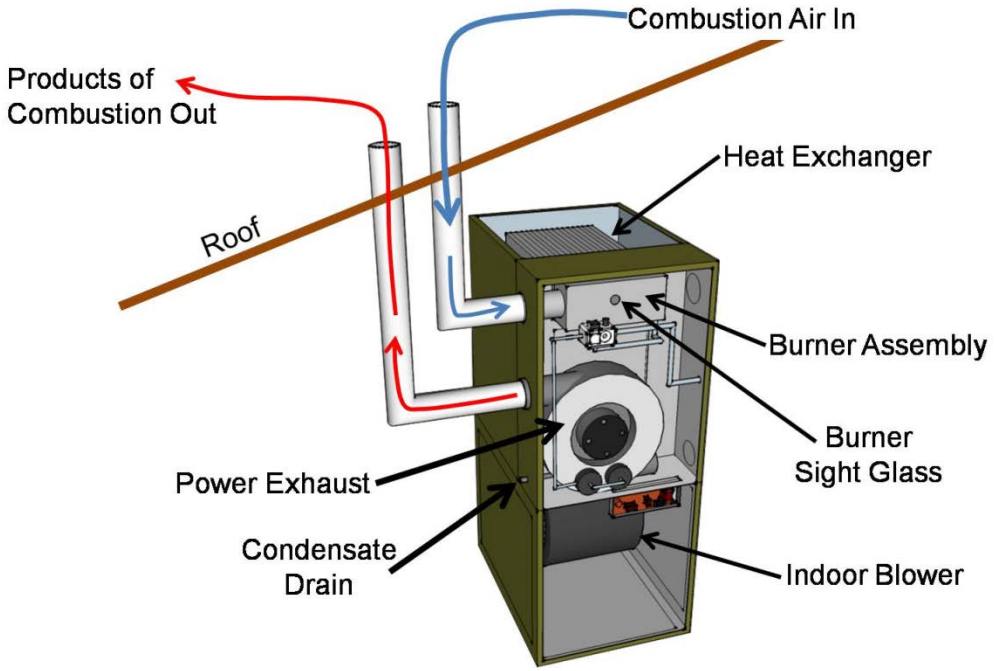
Direct vented appliance: Appliances that are constructed and installed so that all air for combustion is derived from the outside atmosphere and all flue gases are discharged to the outside atmosphere.



Note: This type of appliance can usually vent against 20Pa or more of negative house pressure.

Depressurization Definitions

Sealed combustion appliance: A listed appliance that acquires all air for combustion through a dedicated, sealed passage from the outside to a sealed combustion chamber. All combustion products are vented to the outside through a dedicated sealed vent.



Note: These appliances must be able to function and draft properly at a negative pressure of 50 Pa.

Depressurization Definitions

Sealed combustion appliance: A standard for sealed combustion appliance does not exist at this time. Until such time, equipment may be approved under Chapter 1346 of the Minnesota Mechanical Code when a manufacturer certifies that the equipment meets the requirements of this definition according to the manufacturer's instruction.

Depressurization Definitions

Decorative wood-burning appliance: An appliance, usually a fireplace that is intended for viewing of the fire. It may or may not incorporate doors that substantially close off the firebox opening when the appliance is in operation.

Note. This type of appliance can usually vent against 2 to 15 Pa of negative house pressure.

Depressurization Definitions

Closed controlled combustions solid fuel burning appliance: A wood stove, pellet stove, or fireplace capable of efficient heating and controlled combustion. The appliance must include doors with gaskets or flanges that permit tight closure and glass or ceramic panels that must be tightly sealed or gasketed at their frames.

Note. This type of appliance can usually vent against 5 to 20 Pa of negative house pressure.

Make-up Air Strategies

Opening up to the combustion room

- Probably the most desirable location for the homeowner
- A mechanically interlocked damper is recommended
  - Especially for non-ducted passive openings
- May need tempering depending on
  - Size
  - Frequency of use
  - Duration of use

Make-up Air Strategies

Opening to the laundry area, kitchen, or living space

- Probably the least desirable location for the homeowner
- A mechanically interlocked damper is highly recommended
  - For both passive openings and powered
- Will probably need tempering unless it is
  - Very small
  - Used frequently
  - Only used for short periods

Make-up Air Strategies

Connection for the forced air ductwork

- Can be a very desirable and unobtrusive location
- May be more difficult to design and control
- Forced air fan may bring in excess make-up air when open/on
  - Passive openings must be properly sized and located
  - Passive openings may need to include flow controllers
  - Powered make-up air is less sensitive to ductwork pressures
- Forced air fan may cause leakage when closed/off
  - Must have a good mechanically interlocked damper
  - Required one more component and control
- Can take advantage of the forced air fan for mixing/tempering

Make-up Air Strategies

Connection to the force-air ductwork…

- Forced air fan must run when make-up air is cool
  - To provide adequate mixing
  - Depends on size (% of outside air)
- Furnace must run when the make-up air is cold
  - To provide both mixing and heating
  - Depends on size (% of outdoor air)
  - Must establish an outdoor temperature where the heating must occur
  - May cause overheating with oversized heating equipment or long make-up air use
- Air conditioning may need to run when the make-up air is humid
  - To prevent condensation in the ductwork
  - May be difficult to develop a control strategy

Combustion Make-up Air Equipment

- Mixing box
  - Usually limited to applications under 100 cfm
  - Automatically provides tempering
- Inline fan
  - Generally limited to 100 – 150 cfm of outdoor air
  - May blend in house air to temper as needed
- Heat recovery ventilator
  - The exhaust stream is turned back to the home
  - Can provide flows up to 200 cfm or more
  - Automatically provides tempering
- Make-up air furnace
  - Can provide very large flows
  - Is capable of tempering as needed

Make-up Air Good Practice

Select a good location for the air intake

- Best possible air
  - Good separation from exhausts, vents, etc.
  - Avoid external pollutants (garbage, compost, kennel, auto exhaust
  - Prevent stagnation (under decking/overhangs, inside corners, landscaping)
  - Easily accessible for cleaning
- Properly insulate hood and dectwork
  - To prevent condensation and frost

Make-up Air Good Practice

Introduction of outside air

- Select a location where it won't
  - Freeze pipes
  - Cause condensation (summer or winter)
  - Cause discomfort
- Consider tempering
  - Blending
  - Heat recovery system
  - Preheat or make-up air furnace
- Prevent airflow when it isn't needed
  - Limit pressure across opening
  - Use blackflow or mechanical damper

Make-up Air Good Practice

- Labeling
  - Clearly label intake hood
  - Label air supply
  - Include a caution regarding the serious nature and importance of make-up air
- Homeowners instructions
  - Emphasize the importance of proper operation and maintenance
  - Instructions for cleaning hoods
  - Reminders to service fans, dampers, etc.
  - Reinforce importance of make-up air in tight houses