# ROCIS ISSUE BRIEF

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## Ducted Range Hoods: Recommendations for New and Existing Homes

### WHAT is a ducted range hood?

Ducted range hoods are metal or glass devices installed above stoves and ovens. Usually shaped like an inverted funnel or bowl to capture the cooking emissions, they employ a fan and ductwork to remove pollutants directly to the outdoors. Range hoods are also known as kitchen hoods, exhaust hoods, fan hoods, and extractor hoods. Some microwave ovens mounted above stovetops also have an exhaust fan and ducting to move cooking emissions outdoors. However, ductless (or recirculating) range hoods lack a vent to the outside and do not effectively remove cooking emissions, even if the hood has grease, particle, or charcoal filters. *(Note: the following recommendations will only be referring to **ducted (vented)** range hoods that exhaust to the outside of homes, unless specified otherwise.)*

### WHY do homes need a ducted range hood?

Cooking produces odor, moisture, and air pollutant emissions in homes, whether done with a gas or an electric appliance (Fortmann et al. 2001, Zhang et al. 2010; Dennekamp et al. 2001; Perrot et al. 2003; Fluckiger et al. 2000; Jørgensen et al. 2013; Svedahl et al. 2009; Arbex et al. 2007). Indoor pollutant levels from cooking can exceed health guidelines for particulate matter, nitrogen dioxide, carbon monoxide, and aldehydes, especially for gas stoves (Fortmann 2001; J.M. Logue et al. 2011; Singer et al. 2017). These pollutants can increase the risk of both short-term and long-term health effects (Coker et al. 2015; Belanger et al. 2006). Residential cooking or space heating with a gas stove has been associated with respiratory problems in children (Dekker et al. 2001; Coker et al. 2015), especially in unventilated kitchens (Kile et al. 2014). Cooking can also emit potent mutagens and carcinogens into the air (Sjaastad et al. 2010; Felton 1995; Knize 2006; FCI FAQ 2015; Poudel et al. 2017; Sohn 2017), and the large amounts of moisture emitted by cooking can increase the risk of bio-allergens such as mold, bacteria, and dust mites multiplying in a home (US EPA 2015).

Using a range hood can help reduce pollutant exposures and health impacts from cooking, by keeping emissions from spreading into and lingering in a home (Kile et al. 2014; Pacitto et al. 2018; Jacobs & Borsboom, 2017; Fortmann, 2001; Peters &

Borsboom, 2017; Fluckiger et al. 2000; Singer et al. 2017). Opening windows alone is not nearly as effective as a good range hood, especially when wind speeds are low or outdoor pollutant levels are high. Range hoods also help cool a house by removing excess heat and moisture from cooking. They are required for new home construction, major remodels, and additions, and recommended by green and healthy building programs (Build It Green 2017; EPA 2015; USGBC 2017), ventilation industry standards (ASHRAE 62.2), and state and local building codes (Stratton & Singer 2015).

## WHO needs a ducted range hood?

Everybody who cooks with a stove or oven needs to use a range hood – especially if your household includes children, persons with asthma or other respiratory diseases, the elderly, or persons sensitive to odors. The more burners you use, the longer you cook, and the more the cooking produces odors, smoke, or moisture, the more you need to use effective kitchen exhaust ventilation. Range hoods are also essential for smaller homes with less volume to dilute the cooking emissions. Anybody planning a new home, remodel, or replacement of any range hood should take advantage of the opportunity to install a better range hood system.

## WHEN AND HOW do I need to operate a ducted range hood?

- Use the hood whenever you use the stove or oven, and especially when cooking at high temperatures or producing large quantities of steam, smoke, or odors. Examples of “high emitting” cooking activities include grilling, frying, stir-frying, broiling, and roasting. Operate the hood fan at the speed that seems to best remove smoke, odors, and steam at the highest noise level your household can tolerate.

- Use a back burner whenever possible. Use lower cooking temperatures, and cover pots and pans as much as possible.

- Leave the fan on for at least 10-20 minutes after the cooking ends, or until the cooking surfaces have cooled, whichever comes first ( Sjaastad & Svendsen 2010). Continue using the fan if odors or smoke are noticeable when you enter from outdoors or a distant part of the house. (For airtight homes, see SUPPLEMENT: Caveats and Cautions.)

- When using the oven cleaning cycle, evacuate the house and operate the range hood at maximum speed. Also, clean the hood’s grease filters afterwards.

## HOW do I select a “good” ducted range hood?

The best range hood to meet your needs depends on your building and appliance characteristics, your type of cooking, your household’s sensitivity to odor, pollutants, and noise, and your budget. (See SUPPLEMENT: Criteria for Selecting an Effective Ducted Range Hood.)

- Determine the airflow rate you need for your hood type, stove size, building airtightness, and type of cooking. Airflow rates for typical homes should be 200-350 cubic feet per minute (cfm). Island installations will require higher flows than will wall installations.

- Check range hood listings for a Capture Efficiency (CE) rating from the Home Ventilating Institute (HVI) or the manufacturer if necessary. A standard test method for CE is expected by 2018. Select a hood with a CE of at least 75%, or more if possible. If CE ratings are not available yet, pick a deep, wide hood that has an open bottom and that covers all the burners. (Singer et al. 2012)

HOME VENTILATING INSTITUTE **Certified Home Ventilating Products Directory**

HVI provides third-party, certified test results for airflow (cfm) and noise (sone) for range hoods. Manufacturers may also conduct tests at multiple fan speeds. but the results may not be accurate.

- Select a range hood that is quiet: Look for a hood with an HVI noise rating of less than 3 sones at an airflow rate of 200 cfm or more. If you need a larger capacity range hood that does not have a sone rating at 200 cfm, choose one that has a lower sone rating than others at equivalent speeds.

- Select a multispeed fan that can be used at lower flow rates and sound levels when cooking with low emissions or on small burners.

- Make sure the hood and ducting will fit. Ensure that the hood dimensions from the manufacturer and the duct layout can be accommodated in the available space. Double check that the hood and ductwork are installed properly, and measure the flow rates of the installed hood. (See SUPPLEMENT: How to Install Ducted Range Hood Systems.)

Some cautions:

- High airflow rates (and even low rates in airtight homes) can depressurize a home, potentially pulling in unwanted pollutants from combustion appliances, outdoor air, soil, or attached garages, basements, or apartments, which may create a need for make-up air. (See SUPPLEMENT: Caveats and Cautions.)

- Flat “designer” style hoods are not very effective. Many existing range hoods with propeller-type fans and small diameter ducts are not very effective and are too noisy.

- Some over-the-range microwaves can effectively remove indoor pollutants, but only at very high (and noisy) fan speeds and flow rates.

- Large “power” burners produce much more heat and pollutant emissions than typical gas burners, and may need a wider range hood and higher airflow rates.

## WHAT ELSE can I do?

Regardless of whether you have an effective vented range hood, there are some easy ways to further reduce indoor pollution exposures from cooking and to improve pollutant removal by the hood, including reducing cooking emissions and funneling the plume into the hood. (See SUPPLEMENT: Easy Ways to Reduce Exposures to Cooking Pollutants.)

# SUPPLEMENT:

## Easy Ways to Reduce Exposures to Cooking Pollutants

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In addition to operating a ducted range hood, using a kitchen exhaust fan, removing children and sensitive persons from the kitchen and adjoining areas, or opening windows, you can take some simple actions to further reduce exposure to indoor pollution from cooking. These steps are relatively easy and are summarized below.

### REDUCE COOKING EMISSIONS

- **Remove the indoor emission source:** Consider moving cooking activities that produce a lot of smoke or odors outdoors if you have an outdoor grill or a solar oven (CantinaWest 2014).

- **Contain the emissions:** Temporarily close doors to living areas and open windows in those areas to assist with keeping the emissions contained in the kitchen (Poon et al. 2016).

- **Reduce the cooking temperature and burning:** Avoid grilling, charring, and frying meat at high temperatures and over prolonged periods. Using lower cooking temperatures and marinating meat reduces the formation of potent carcinogens (heterocyclic amines) in the fumes and the food (Felton 1995). An induction stove is another option for reducing burner temperatures and particle emissions (it also reduces energy use and greenhouse gas emissions) (Rosenbaum 2012; Jacobs & Borsboom 2017; Logue & Singer 2014). Also consider using a microwave oven for cooking and pre-cooking food.

Using induction electric stoves and covering pots and pans can help reduce cooking emissions. Image: Jacobs et al. 2016. PM2.5 in Dutch Dwellings due to Cooking. AIVC 2016.

- **Trap the emission source:** Whenever possible, cover pots and pans with a lid, or partially cover if necessary, to help trap much of the moisture and fumes from

cooking (Jacobs et al. 2015). This will also enable you to turn down the heat (and save energy) and perhaps direct cooking fumes towards the back of the range hood.

- **Keep it clean:** Clean stovetop burners and oven interiors periodically, and especially after major spills. Dirty burners and ovens tend to emit more pollutants.

- **Stay safe:** When using the oven cleaning cycle, ALWAYS evacuate the house. Clean the grease filters before running the cycle, and clean them afterwards. Ventilate the house with outdoor air thoroughly before re-entering.

**FUNNEL THE PLUME (Improve Pollutant Capture Efficiency of the Range Hood)**

- **Use the back burner:** This helps keep pollutants under the hood and is very important for cooking activities that produce a lot of emissions, or that are operating for long periods (Delp & Singer 2012; Rim et al. 2012).

- **Clean the hood's grease mesh filters:** To prevent cooking fumes from backing up and spilling outside the hood, clean the grease filters about four times a year to maximize airflow through the ducting. These metal mesh filters are usually dishwasher safe.

- **Reduce crosscurrents and fume drift:** Do not open nearby windows if it is windy, and do not operate a ceiling fan in the same room if cooking is producing a lot of smoke or odors.

- **Use fireproof side shields (vertical extensions):** Make side shields yourself from lightweight metal panels or cookie sheets. Side shields help contain the fume spillover from the hood cavity, especially for high emission activities. (Kuehn et al. 1989; Fortmann 2001; Fluckiger et al. 2000; Jacobs et al. 2015). They also help improve pollutant removal for hoods installed on islands or peninsulas, where rear shields help funnel the cooking plume. The shields can be hung on magnetic hooks on the overhead cabinets next to the hood and stored on the side of a refrigerator, in cabinets, or in other convenient areas. Rectangular shield shapes are preferred, but triangular shapes also help (Fisher 2015).

# SUPPLEMENT:

## Criteria for Selecting an Effective Ducted Range Hood

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### LOW NOISE

Noise is the main reason hoods are not used. Select the quietest range hood at a comparable airflow rating that you can afford. Noise ratings (in “sone” units) are published by the Home Ventilating Institute (HVI) but may not be available for all fan speeds(HVI 2018). Some manufacturers also publish sone ratings, but they may not be consistent with HVI test methods and ratings. One sone roughly equals the sound of a refrigerator running (Grainger 2017). Normal conversations produce about 4 sones, and light traffic produces about 8 sones.

Choose a range hood with an HVI noise rating of 3 sones or less at 200 cubic feet per minute (cfm) or more. These are fairly quiet and recommended for home applications. The low fan setting should be 100 cfm or lower with a sone level of 2 or lower (MSHI 2018). Unfortunately, field studies indicate that all the hoods with high Capture Efficiency (CE) were also noisier at higher fan speeds, including the microwave exhaust systems (Delp & Singer 2012). Listening to noise levels of range hoods in showrooms may not be a realistic test, but it is a good start.

For context, ASHRAE Standard 62.2-2016 recommends no more than 3 sones at 100 cfm for occupant-controlled residential range hoods, and no more than 1 sone for continuously operating, whole-house exhaust ventilation (Karg 2016). Furthermore, multispeed exhaust fans (demand controlled) must have at least one speed that operates at less than 3 sones.

If you are very sensitive to noise, consider an in-duct fan mounted in the attic, or an external fan (installed on the roof, or in the attic, basement, or crawlspace), along with noise-dampening bushings and brackets.

### GOOD POLLUTANT REMOVAL (CAPTURE EFFICIENCY, CE)

The hood’s overhang above stove burners, its height from the stovetop, and its internal volume are important factors in achieving good CE. Select a range hood deep and wide enough to cover all the burner areas, and with a large internal volume (height) and an open bottom area.

Lab and field studies of several residential range hoods by Lawrence Berkeley National Laboratory (LBNL) have assessed the factors that affect CE. Study results showed that most hoods do not effectively remove pollutants, and that many are too noisy. Flat, “designer” style hoods and over-the-stove microwave oven exhaust systems have much lower CEs than range hoods (Singer et al. 2012). The researchers also found that the range hoods with more internal volume and better coverage of the cooking surface had better CEs.

A standard test method for CE is expected to be finalized by the American Society of Testing and Materials (ASTM) by early 2018, and CE ratings for range hoods should be available subsequently from manufacturers and the HVI (ASTM 2017; Kim et al. 2018). In any case, hoods with designs similar to those shown to have high CEs (at least 75%) in research studies should be very effective.

Deep hoods with large internal volumes, and full coverage of cooking surface, are more effective at capturing cooking emissions. Left: Ducted (vented) range hood. Right: Wall installation. Images: B. Singer, LBNL.

In summary, avoid the low profile, “designer” type hoods, and pick a range hood that is at least 7 inches in vertical height to help contain cooking fumes. Also select a hood that is roomier inside, with recessed grease filters and blower entries well inside the hood. The hood should have a CE of 75% or higher if possible.

*(Note: Regarding energy efficiency standards, many range hoods are Energy Star rated by the federal government for environmental performance. However, most range hoods simply do not use very much energy compared to other residential appliances. Furthermore, Energy Star for range hoods does not currently consider CE.)*

**AIRFLOW RATE**

The airflow rate needed to capture and remove cooking emissions effectively depends on not only the CE, but also the type of cooking, the walls and cupboards adjoining the hood, building characteristics, local climate, and the design of the hood and ducting. For frequent high emitting cooking activities your hood should have a rated airflow rate of at least 300-400 cfm. A multispeed feature is also recommended to allow lower fan speeds (and less noise) during light cooking or when the fan is used as part of the house ventilation system.

Other guidelines for hood flow rates have been proposed, but they are not based on measured CE. For example, the HVI recommends 100-250 cfm airflow rate for a 30-

inch wide range hood that is wall-mounted over a 30-inch wide stove, with the higher flow rate being more effective. Even higher flow rates are recommended for wider range hoods, and for island and peninsula installations (not wall-backed). For new, airtight homes with kitchen exhaust fans that run on demand (presumably for a 30-inch stove width), ASHRAE and other groups recommend a minimum of 100 cfm.

No microwave range hoods (over-the-range microwaves) currently comply with ASHRAE Standard 62.2-2016 requirements for airflow or noise. In addition, few microwave range hoods currently have sound or airflow ratings certified by HVI. Consequently, microwave range hoods would not yet be a good choice for households sensitive to noise, odors, or air pollution or for those who cook frequently or for long periods.

Kitchen exhaust fans and range hoods can also be designed to run continuously for whole house ventilation. ASHRAE Standard 62.2-2016 recommends that such fans achieve 300 cfm or 5 kitchen air changes per hour (5 complete turnovers of the room's air volume per hour). Thus, the appropriate hood flow rate would be calculated based on the kitchen volume. Homes that have natural draft combustion appliances such as furnaces, water heaters, and fireplaces should not use exhaust fans for whole house ventilation.

# SUPPLEMENT:

## Caveats and Cautions

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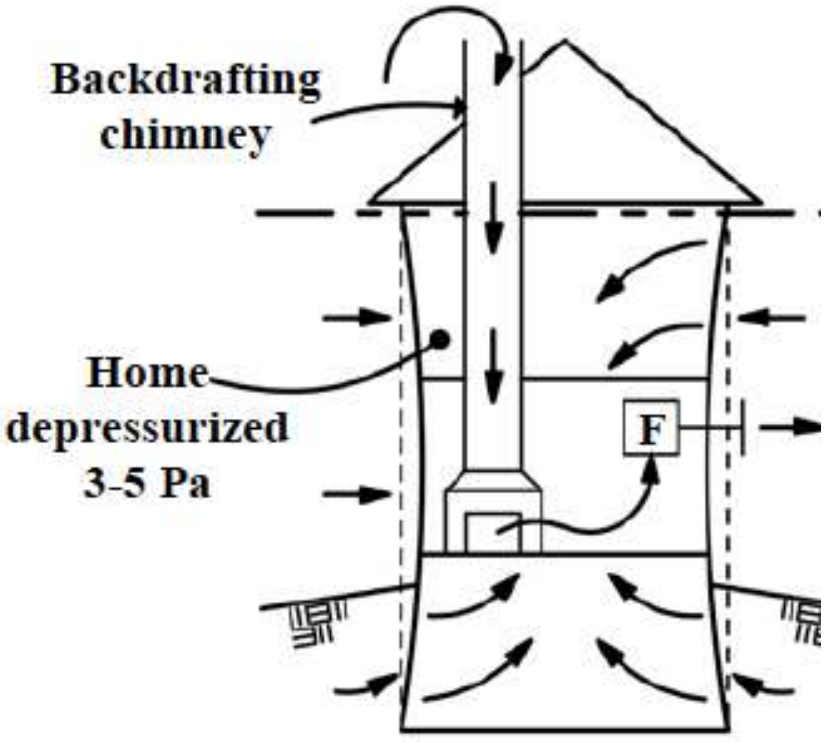
### PREVENT EXCESS DEPRESSURIZATION

Hoods with higher maximum airflow rates (over 300-400 cfm) can often cause imbalances in airflows in and out of the home. Professional style gas stoves with large burners and downdraft exhaust systems typically require high airflow rates. When insufficient air is brought into the home to balance exhaust flows from exhaust fans and other appliances, depressurization (negative air pressure, or suction) of the home occurs. This can cause combustion equipment to backdraft carbon monoxide and other combustion pollutants into the home. It can also pull unwanted pollutants from adjoining spaces and the outdoors. If naturally vented combustions appliances are present, a combustion appliance safety test is recommended in such situations and is required in most home weatherization programs (BPI 2012; US EPA 2014).




Exhaust air flows can create excessive vacuum pressure (suction) in a home, unless the exhaust flow is balanced by make-up air. Certain airflow rates of exhaust fans (F) can combine with house airtightness to depressurize a house enough to backdraft chimneys and flues from combustion appliances and to pull in soil gases. This can lead to indoor pollution hazards and moisture condensation problems. Image: Jellen et al. 2012 (a or b?). Kitchen Ventilation Systems: Part 1.

Make-up air devices are available to prevent depressurization problems; some can be integrated with central air or ventilation systems. The International Mechanical Code used in some regions requires make-up air if the fan has a rating of 400 cubic feet per minute (cfm) or more and natural draft appliances are present (International Mechanical Code 2018). Minnesota requires make-up air for hood flows of 300 cfm or more in alterations of some types of older homes' exhaust flow calculations for multiple appliances, and a backdraft and spillage test in newer homes. However, both natural draft and induced draft appliances can easily backdraft, so the more efficient direct-vent (sealed combustion) appliances are recommended (Minnesota 2015; Bohac & Cheple 2002).

Downdraft stovetop exhaust systems are an example of fans with very high flow rates. They often produce flows of over 500 cfm in order to effectively overcome the hot, buoyant plume generated by cooking. Commercial style stoves and ovens also require very high flow rates, in order to remove the large amount of heat produced. High flow hood systems that are used frequently can also substantially increase building energy use for meeting cooling, heating, or dehumidification needs.

For airtight homes and homes with high flow exhaust hoods, test the pressure difference between indoors and outdoors when the range hood is on. The graph below (Exhibit 1) illustrates how much house depressurization could be anticipated from various sizes of kitchen exhaust fans at different levels of home airtightness. The hood airflow rate of 400 cfm is also highlighted (the International Residential Code requires make-up air above that airflow rate). A tight home is defined there as one with a blower test rating of 1,500 cfm at 50 Pascals pressure (cfm50).

For example, the fireplace diagonal line in Exhibit 1 indicates that a fireplace in a tight home would potentially backdraft at a hood flow rate of 250 cfm or less, whereas a gas-fired appliance (natural draft) would potentially backdraft at a hood flow rate of 350 cfm or less. Local weather conditions can also affect house pressures. Note that many homes have blower door ratings of less than 1,000 cfm50 and would backdraft at even lower airflow rates for the hood.

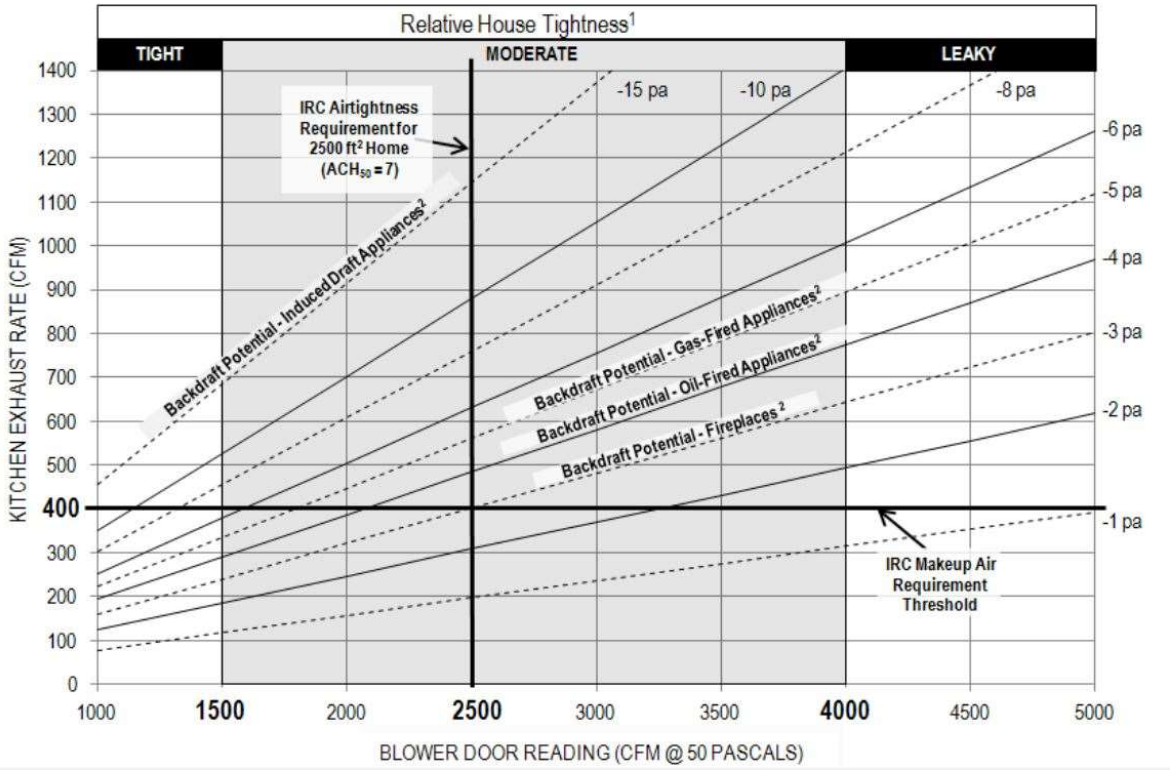



*Figure 1: ACH = air changes per hour. cfm= cubic feet per minute. ft2 = square feet. IRC = International Residential Code. pa = pascals. (Jellen, A.C., Wolfgang, B.M, and Turns, M.A., 2012a. Kitchen Ventilation Systems: Part 1. Evaluating the 2009 IRC Requirement for Makeup Air. The Pennsylvania Housing Research Center, Builder Brief)*

Consult building officials and building performance experts to determine what local depressurization limits are and how to best meet them. These range from -2 to -50 Pascals, depending on the type of combustion appliance, airtightness, and regional climate(BPI 2012; Nelson 2010; Jellen et al. 2012).

Make-up air systems can also cause thermal comfort problems (cold drafts) and humidity problems. In order to avoid cold drafts from make-up air, some designers recommend supplying 70% of the make-up under the stove and 30% to a common area, in order to create negative pressure near the stove and minimize draft problems (Lstiburek 2014).A designer of very airtight homes (near Passive House criteria) in California has successfully used ducted range hoods with make-up air with little impact on energy use or comfort (Barry 2017). European researchers have recently recommended that low energy, airtight homes use either 1) a motorless range hood, with a high quality grease filter, that can be connected to a common exhaust system using a balanced ventilation system for the house, or 2) a ducted exhaust vent used with a supply ventilation system at specific design pressures (Jacobs & Borsboom 2017). This is an evolving area of healthy building design, so proceed with caution.

In order to provide reliable operation, gravimetric or barometric dampers are not recommended for use in make-up air systems, according to ASHRAE 62.2-2016. Rather, an automatic (interlocked) motorized damper and fan-powered system is

recommended (Karg 2016). In addition, make-up air systems should have an air filter to help keep outdoor air pollution, allergens, and dust from entering the home.

## PREVENT CARBON MONOXIDE (CO) POISONING

- Never heat the house with a gas stove or oven. This can be fatal or cause permanent damage to your health. It can also increase the risk of pneumonia in young children (Coker et al. 2015).

- Have a technician check the gas pressure and burner adjustments, especially in propane stoves or if the flame is mostly yellow, erratic, or causing sooting on pots and pans (Appliance411 FAQ 2018). Gas stoves and ovens often produce excessive amounts of CO, but regular testing and maintenance can greatly reduce this hazard (Birkby 2008).

- Do not cover the bottom of natural gas or propane ovens with aluminum foil. Doing so blocks the combustion airflow through the appliance and can produce CO.

- If you are cooking on several burners or over extended periods and do not have a working range hood, open some windows to create a cross draft to remove the indoor pollutants, or use a kitchen exhaust fan.

- Install a CO alarm if you have a gas stove or oven. This is required in many jurisdictions.

# SUPPLEMENT:

## How to Install Ducted Range Hood Systems

- Plan for room above the stove (32 inches or less), the width of the hood, and the routing of the exhaust duct run when designing kitchen cabinet layout. Route the ducting through the roof or outer wall, not into the attic space, in order to avoid moisture problems. For cold climates, route the ducting downwards and outwards to prevent continuous convection and condensation.

- Locate the hood on a wall between cabinets to improve pollutant removal. In comparison, island and peninsula installations have lower effectiveness, and corner installations have higher effectiveness (Sjaastad & Svendsen 2010). Consider adding horizontal spacers on the sides of wall-mount hoods. If gaps exist between the range hood and adjoining cabinets or walls, consider adding horizontal spacers to help funnel airflow towards the hood.

- If the system is not installed immediately upon arrival, then cover and seal all openings in range hoods, ductwork, and adaptor joints until installation. This will avoid build-up of dust, debris, and other contaminants in the system.

- Use 8-inch round smooth metal ducts (NOT FLEX DUCT). Smooth ductwork has less air resistance and is less likely to collect dirt and grease than flex duct, which has ribbing. In many installations, rectangular ducts may be needed; they come in various configurations.

- Minimize bends in the duct layout, and avoid 90 degree. Two 45-degree fittings are less restrictive than one 90-degree fitting.

- Mechanically fasten all duct joints. Draw bands, external clamps, or rivets are preferable to sheet metal screws. Seal all duct and adaptor joints from exhaust fan to roof cap with metal tape (NOT DUCT TAPE) or mastic.

- Avoid reductions in the cross-section area at the vent cap and duct transitions or adaptors.

- Use an 8-inch diameter roof cap for sloping roofs – it has screen mesh built into it and it has equivalent surface area for the roof vent. Where deep snow is usually expected, a wall vent well above record snow depths may be a more practical approach.

- For exhaust vents on exterior walls, keep birds and rodents out by inserting a corrosion-proof, cleanable screen (e.g., copper or stainless steel mesh) in the vent opening.

- Insulate any ductwork above the ceiling insulation, at insulation levels that meet current building energy standards in your area, to avoid condensation inside the ducting in cold weather. For ducting that exits through an exterior wall, insulate

the outside of the duct and completely air-seal the gap between the duct and the wall.

- For an in-duct or in-line fan, mount it at least 4 feet away from the range hood. Use a vibration-dampening bracket and a fan made of metal (not plastic).

- Locate exhaust vent terminations at least 3 feet from any operable or inoperable openings in building, and at least 10 feet from air intakes unless the exhaust is at least 3 feet above the intake (International Mechanical Code 2018).

- Inspect and test the entire fan, duct, and control system before contractors close up the wall or install attic insulation. It is difficult to reach and fix equipment in the attic. Make sure the backdraft damper in the hood fully opens upwards or outwards, and that the knockout panel has been removed.

- Finally, test the airflow rate of the installed hood. Many installed hoods do not perform nearly as well as rated or designed (Singer et al. 2010; Delp & Singer 2012). Building performance contractors and energy auditors can test using devices such as flow hoods or blower doors. If you can't test the flow, feel the airflows at the hood and at the roof or wall vent at all fan speeds, before the vent cap is put on. Make sure the airflow is noticeable, stronger at higher fan speeds, and moving away from house. (See also pressure testing recommendations for homes in SUPPLEMENT: Caveats and Cautions.)

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