

# MULTIFAMILY PERFORMANCE PROGRAM

## Technical Topic – Existing Buildings

### Using the SG Infiltration-Ventilation and Air-Sealing Worksheets

#### Summary

Precise assessments of infiltration rates in multifamily buildings require complex and expensive measurements that are not required of participants in the Multifamily Program. Section 9 of the Simulation Guidelines (SG) and its associated spreadsheet were developed to help make realistic estimates for energy savings that result from infiltration reduction, including the effects of mechanical ventilation.

#### Calculating the Overall Infiltration Rate

Fan operation affects the pressure relationship between the building interior and exterior and therefore affects natural infiltration. The infiltration rate that is input into TREAT or other modeling tools must be adjusted to include the effects of mechanical ventilation, which are expressed in an equation shown in Section 9.3 of the Simulation Guidelines:

$$Q_{comb} = Q_{bal} + \sqrt{Q_{unbal}^2 + Q_{infiltration}^2}$$

where  $Q_{comb}$  is the combined ventilation rate  
 $Q_{bal}$  is the balanced ventilation rate (cfm of supply equaled by cfm of exhaust)  
 $Q_{unbal}$  is the unbalanced ventilation rate (cfm of exhaust not equaled by supply, or vice versa)  
 $Q_{infiltration}$  is the natural ventilation rate

The approved modeling tools for the Multifamily Program do not calculate  $Q_{comb}$  for you. As a result, you must use the Infiltration-Ventilation spreadsheet to make this calculation.

#### Using the Infiltration-Ventilation Worksheet.

1. Decide whether the building is compartmentalized or non-compartmentalized. Compartmentalization means isolating apartments from each other and, most importantly, from the common spaces to eliminate all air communication between them. Unless there has been a deliberate interior air sealing effort to compartmentalize the building, treat it as non-compartmentalized.
2. Enter floor areas and ceiling heights for building spaces. The worksheet allows you to describe separate areas of the building that have different infiltration rates. Apartments typically have more operable windows than corridors and thus may be expected to have a higher infiltration rate.
3. Enter the infiltration rate for each area. Use your best judgment based on your observations of the building. After inputting your numbers, look at the calculated pre-retrofit infiltration rate. The overall infiltration rate for most multifamily buildings does not exceed 1.0 air changes per hour (ACH). If you think that the overall infiltration rate in your building is higher than 1.0 ACH, be prepared to support your case with photos or other documentation.

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## Technical Topic – Existing Buildings

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- Enter the pre-retrofit and post-retrofit supply and exhaust ventilation rates. The table assumes these ventilation rates apply 24 hours per day. If the fans in your building do not operate continuously, you will need to calculate the average continuous ventilation rate. If you do not know how to make this calculation, you can use the tables in the QC workbook<sup>1</sup> as shown in the text box.

#### Using the QC Workbook to Calculate the Continuous Mechanical Ventilation Rate

The relevant tables are on the Level 2 Reference Guide worksheet, Checklists for specific measures, Infiltration improvements. Click on “Expand for calculation assistance table (for items a & b).”

In the example below, one set of fans operates continuously while the other is assumed to operate two hours per day. Note that this table does not differentiate supply from exhaust cfm. You must clear the table after calculating supply cfm before entering the data for exhaust cfm (or vice versa).

*For observing total average ACH in base building model (natural + mechanical).*

Enter fan data as appears in TREAT 'Fans' Input Panel	Ventilation Rate CFM	Hours per Day Fan is On	(Enter notes here as needed)
Fan 1:	1100	24	bathroom fans -- operate continuously
Fan 2:	1600	2	kitchen exhaust -- manually switched by tenant
Fan 3:			
Fan 4:			
<b>Total constant hourly ACH in base model, all heated areas:</b>			
_expressed as total average (constant) CFM:		<b>1,200</b> CFM constant (24 hrs/day)	<b>CFM / apt, constant (24 hrs/day)</b> (includes common area infiltr.)
CFM:		<b>1,200</b> CFM constant (24 hrs/day)	

NOTE: Before using this table, you must enter the building volume into the Base Building Data table.

#### Pre-Retrofit Infiltration Rate

The pre-retrofit infiltration rate, corrected for the effects of mechanical ventilation, is shown in yellow at the bottom of the Infiltration-Ventilation worksheet. Use this number as the input to your modeling tool.

#### Using the Air-Sealing Measures Worksheet

The Air-Sealing Measures worksheet should be used to assess the effects of window replacement, sealing of air conditioner sleeves, and any other measures that reduce air leakage.

**Table 1**

- Following the instructions at the top of the worksheet, transfer the pre-retrofit Whole Building infiltration rate into Table 1. Enter the building height and gross conditioned floor area.

NOTE: The pre-retrofit infiltration rate used in Table 1 is not adjusted for mechanical ventilation.

<sup>1</sup> Distributed to Partners as part of the EB meeting agenda on 6-10-2009.

# MULTIFAMILY PERFORMANCE PROGRAM

## Technical Topic – Existing Buildings

### Using the SG Infiltration-Ventilation and Air-Sealing Worksheets

**Table 2**

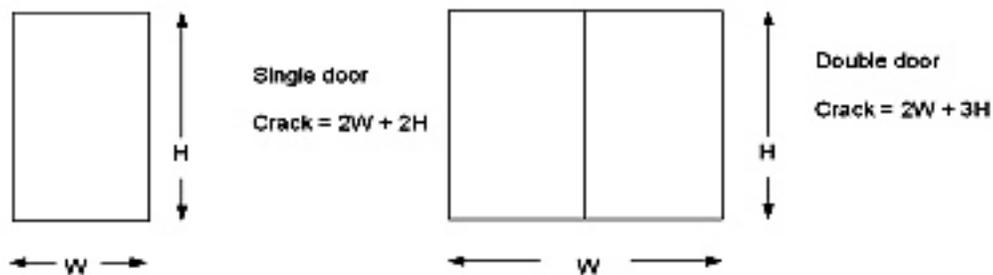
2. For each building component that will be affected by air-sealing improvements, enter the pre-retrofit and post-retrofit conditions into the appropriate fields of the table.

**NOTES:**

- Enter only the areas or crack lengths that will actually be affected by the improvement.
- Remember to include all locations that will be affected by the improvement. For example, a thorough window replacement should include sealing at the frame and sill.
- Pay close attention to units of measure. Some building components are described in square feet of area, some in linear feet of crack or linear feet of sash, some as “each” (e.g., each recessed light fixture). If new windows are being installed, the National Fenestration Research Council (NFRC) AL rating is provided as cfm leakage per square foot of window area, whereas leakage at the existing window is described (except for awning and hopper-style windows) in terms of cfm per linear foot of crack or sash.

Linear feet of crack or sash refer to the movable portions of a window or door. The Components table preserves the terminology from the ASHRAE Fundamentals table that was used as a source for the reference table of leakage by component. For the purpose of this worksheet, sash length and crack length can be considered identical.

Figure 1 shows how to calculate crack length for single and double doors. In the double door, the two halves of the door meet at a single crack without being separated by framing. A sliding glass door is analogous to a single horizontal sliding window, if one section of the sliding glass door unit moves and the other section is fixed; the crack length is equal to the perimeter of the sliding section.



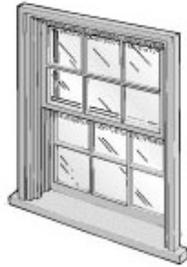
**Figure 1: Calculating Crack Lengths for Doors**

Figure 2 illustrates several common window styles and shows the inputs needed for Table 2 of the Air Sealing Measures spreadsheet. Crack length refers to the operable portion of the window. Non-moving sections that are sealed in place, as with a picture window, are assumed to have no crack.

# MULTIFAMILY PERFORMANCE PROGRAM

## Technical Topic – Existing Buildings

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#### Single or Double hung

Single - top section is fixed and sealed.

Double - top section is movable or unsealed (may be held in place with stops).

Double-hung crack =  $(3 \times \text{width}) + (2 \times \text{height})$

Single-hung crack = perimeter of movable section.

For the purpose of calculating crack length, think of a horizontal sliding window as a single or double hung window, just turned sideways.

Double horizontal slider crack =  $(2 \times \text{width}) + (3 \times \text{height})$

Single horizontal slider crack = perimeter of movable section.



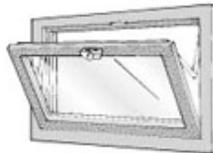
#### Casement

Crack =  $(2 \times \text{height}) + (2 \times \text{width})$



#### Awning

For this window style, leakage is calculated per square foot of window area.



#### Hopper

For this window style, leakage is calculated per square foot of window area.

**Figure 2: Calculating Leakage for Common Window Styles**

### Table 3

Table 3 of the Air-Sealing Measures worksheet. shows infiltration reduction without correcting for the effects of mechanical ventilation. Note that the average percentage reduction is capped at 38% based on the assumption that even extensive air sealing will not reduce infiltration by more than 38%.

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## Technical Topic – Existing Buildings

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#### **Model Inputs**

Use the pre- and post-retrofit infiltration rates from the Infiltration-Ventilation worksheet (the yellow cells at the bottom of the worksheet) as inputs to your model.

#### **Modeling Air Sealing with No Change in Mechanical Ventilation**

To model air sealing with no change in the mechanical ventilation rate, use the pre-retrofit infiltration rates to represent the base building ACH. Input the post-retrofit ACH as an Infiltration Reduction Improvement.

#### **Modeling Mechanical Ventilation Changes with No Air-Sealing**

Even if no air-sealing improvements are recommended, changes in mechanical ventilation will affect the building infiltration rate. A change in mechanical ventilation should be modeled by creating a package that includes the following improvements:

- **Fan Improvement:** Describe the change in cfm.
- **Infiltration Reduction:** When mechanical ventilation decreases, ACH increases. Use the pre-retrofit and post-retrofit ACH shown in the yellow cells of the Infiltration-Ventilation Worksheet as inputs to model changed infiltration.
- **Appliance Replacement:** Model fan motor energy use as an appliance and the change in annual kWh on the appliance worksheet. The calculations for changes in kWh are developed outside of TREAT.

#### **Modeling Mechanical Ventilation Combined with Air-Sealing**

Changes in ventilation can be combined with air sealing in a single ventilation package, in which case the approach is the same as for modeling mechanical ventilation with no air sealing.

- **Fan Improvement:** Describes the change in cfm.
- **Infiltration:** Uses the pre-retrofit and post-retrofit ACH from the Infiltration-Ventilation Worksheet to model changed infiltration.
- **Appliance:** Input the change in annual kWh on the appliance worksheet. The calculations for changes in kWh are developed outside of TREAT.

#### **Modeling Mechanical Ventilation and Air-Sealing as Separate Improvements**

Savings from mechanical ventilation and air sealing improvements can be calculated separately as described above. It is probably simplest to calculate the change in ACH for the mechanical ventilation changes first, then reset the post-retrofit ventilation rate to equal the pre-retrofit ventilation in order to calculate the effects of the air-sealing improvements. Note, however, that ultimately these improvements must be modeled as a package so that the savings in the ERP reflect their interaction with each other and with other improvements.