HRV/ERV Performance Issues

Roundtable Discussion at:
NNCA Construction Workshop
Yellowknife, NWT
February 17 & 18, 2016
Possible Solutions to HRV Freeze-up During Winter Operation, or

“HOCKMAN’S RULES FOR USING HRVs/ERVs IN COLD CLIMATES”

Prime rule: Never install HRV/ERV units if you cannot guarantee that they will be maintained.
“HOCKMAN’S RULES FOR USING HRVs/ERVs IN COLD CLIMATES”

Second rule: If you want to protect buildings in the North (cold dry outdoor climate in winter) run a ventilation system at between 25 and 30 cfm continuously. Can be balanced (HRV) or exhaust only (if no spillage susceptible equipment).
Project Goal is to develop a survey to ask questions of researchers, designers, contractors/builders and housing maintenance people what are the key performance issues with current HRV/ERV installed units in the North and near North.
Today’s goal is to develop a list of issues affecting HRV performance.

DICOM

D - design
I - installation
C - commissioning
O - operation
M - maintenance
What are the performance Issues?
How do we get the 117 cfm Airflow when the unit is in defrost part of the time?

- Back in 1992, E. G. Phillips (You may recognize his name from):
- (El)Bert developed a procedure and Worksheet (W-4A – HRV Airflow Adjustments) for the HRAI Residential Ventilation Manual and Course.
HRV/ERV Airflow Adjustments.

- This procedure adjusts the HRV airflow to compensate for:
  - Very Low Temperature Ventilation Reduction (defrost time), and
  - Cross leakage (Gross Airflow Supply minus the Net Airflow Supply).
- All of the above information is contained in the HVI reporting of the CAN/CSA C-439 testing of HRVs/ERVs.
- Sadly this is only done down to -25°C as the test facility can only generate this low a temperature.
Very Low Temperature Ventilation Reduction (VLTVR): The percent reduction in airflow rate of the supply and exhaust systems at the end of the 72-hour test compared with operation under non-frosting conditions. The final airflow rate is taken as the average of the last 12 hours of the test. This reduction in airflow results from frost and ice buildup in the exchanger and variation in mechanical ventilation during defrosting.
How do we get the 117 cfm Airflow when the unit is in defrost part of the time?

Using this procedure for two common HRVs:

- Unit 1 has an adjusted Airflow of 141 cfm
- Unit 2 has an adjusted Airflow of 130.7 cfm

- The difference is because the two units have different reported VLTVR for their Supply and Exhaust Airflows
How do we get the needed Airflow when the unit is in defrost part of the time?

- The design of the system should use the above HRV Airflow Adjustment Procedure, or
- the ratio of defrost time versus the total cycle time (i.e. one manufacturer’s Cold Weather Defrost setting is 10 minutes out of 25 minutes total run time once it goes below \(-27^\circ C (-17^\circ F)\)), will require at least:

  \[117 \text{ cfm} \times \frac{25 \text{ min.}}{15 \text{ min.}} = 195 \text{ cfm when it is running.}\]

- The HRV/ERV will deliver on average the required 117 cfm every hour, even when in extended cold temperature defrost.
How do we get the needed Airflow when the unit is in defrost part of the time?

- Based on the timed defrost methods used today, this may **overventilate** whenever the weather is warmer than -27°C.

- Also, ducting must be sized based on this adjusted airflow rate, otherwise the airflow will be restricted, not providing the required ventilation rate and in some cases may also affect correct defrosting of the unit.
Likely Causes of HRVs/ERVs 
Freeze-up During Winter 
Operation in Manitoba using 
Current Models of HRVs/ERVs 

(In the opinion of JLHockman Consulting Inc.)
What we want to avoid:
Summary of 5 Likely Causes of HRV Freeze-up. HRVs freeze when:

1. The HRV is not balanced correctly for cold weather operation.

2. Cold supply air is drawn through the outdoor supply duct on the HRV when HRV is turned OFF and the furnace fan operates to provide house heating - (THIS ONLY OCCURS WHERE HRV/ERV CONNECTED TO FORCED AIR FURNACE OR AIR HANDLER).

3. Cold air is drawn in through the exhaust ducting going to the outside when HRV is turned OFF and the house is depressurized by clothes dryer, kitchen fan or other exhaust device.
Summary of 5 Likely Causes of HRV Freeze-up. HRVs freeze when: (continued)

4. Additional cold supply air is drawn through HRV when operating, especially in Low Flow (Principal) Rate when house is depressurized by clothes dryer, Kitchen or other exhaust fan(s).

5. One manufacturer also believes that significant temperature setback in the home (to $15^\circ C$ [59F] or even $17^\circ C$ [63F]) prevents proper defrost.
1. HRV Not Balanced for Cold Climate

In cold and very cold climates especially on the Prairies and in Canada’s North:

• It is best to balance the HRV with slightly more exhaust than supply (+/- 10% is permitted by manufacturers and Building Codes [MBC/NBC/OBC]).

• This keeps the core slightly warmer when the unit is operating at both Low and High Flow Rates and helps during defrost cycles.

• This also runs the house at a slight negative pressure (less than 1-2 Pascals) and this helps reduce potential for interior moisture condensing within the building envelope.
2. Cold Air Drawn in by Furnace R/A

Cold supply air is drawn through the HRV when the unit is OFF and furnace fan runs for heating supply.

• If there is no shut down/shut off damper on the supply air whenever the HRV is turned off, and a “direct connection” to furnace Return Air exists; when the furnace fan comes on to provide heating distribution the negative pressure in the Return Air duct will draw cold outdoor air through the HRV and chill the core down and cause freeze-up.
2. Cold Air Drawn in by Furnace R/A

EXHAUST AIR from various parts of home, i.e. bathrooms (if required), kitchens (if required)

No Shut down or shut off damper closed on cold supply air when HRV is turned Off.

Negative pressure in R/A duct when furnace fan runs for heating.
2. Cold Air Drawn in by Furnace R/A (continued)

• Installing an “indirect connection” or locating the connection to R/A duct far from furnace may reduce this problem but often it does not, and

• this “indirect connection” does not solve the next cause of freeze-up problems.
3. Cold Air Drawn in by House Depressurization

Cold air is drawn in through exhaust duct to outside when the house is depressurized by clothes dryer, kitchen or other exhaust device:

- If there is no shut down/shut off damper or **backdraft damper** in the exhaust air duct to the outside, then if the HRV is turned off and house is depressurized,
  - cold air can be drawn through the exhaust side into the home, chilling the core to the point where it frosts up and the defrost strategy often will never catch up, causing the core to freeze up,
  - Occurs in both furnace connected and direct ducted units.
3. Cold Air Drawn in by House Depressurization (HRV to Furnace)

EXHAUST AIR from various parts of home, i.e. bathrooms (if required), kitchens (if required)

No Backdraft or Shut-down damper on Supply air duct from outside.

Exhaust Air discharge becomes a cold air intake under house depressurization.

House and ducts under negative pressure

Dampers for balancing airflows

RETURN AIR

Cool Air Return

Forced Air Furnace

Outdoors
3. Cold Air Drawn in by House Depressurization (Direct Ducted HRV)

House and ducts under negative pressure

Exhaust Air discharge becomes a cold air intake under house depressurization.

Stale air from various parts of home. i.e. bathrooms (if required) kitchens (if required)

Fresh air to house: main living areas, bedrooms, living room, rec. room etc.

No Backdraft or Shut-down damper on Supply air duct from outside.

Dampers for balancing airflows
3. Cold Air Drawn in by House Depressurization (continued)

- Backdraft damper (butterfly damper) should be installed in the exhaust flex duct as close to the connection to the HRV as possible. **NOTE** that exterior backdraft dampers on HRVs **will** freeze shut in cold climates as shown below.

Butterfly backdraft damper - hinge should be vertical
4. Additional Cold Air Drawn in by House Depressurization

Additional cold air may be drawn in through the supply duct from the outside when the HRV is on Low or High flow and the house is depressurized by clothes dryer, kitchen or other exhaust device.

- In this case even if the HRV has shut down dampers and/or the backdraft damper, the additional cold supply air can be drawn through the HRV core when the house is depressurized (may be additional 5-30 cfm).
- This unbalances the HRV and can cause freeze-up which may not be able to be defrosted by the HRV defrost cycle.
5. Significant Night Set-back of House Temperature Affects Defrost

Severe thermostat temperature set-back reduces the amount of energy in the house air:

- If the amount of energy in the house air is reduced through thermostat set-back, the timed cycle for defrosting the HRV core may not fully defrost the core before the end of each defrost cycle,
- This may leave residual frost within the core that may never be fully defrosted and which may continue to build up frost until it blocks the core.
Possible Solutions to HRV Freeze-up During Winter Operation, or

“HOCKMAN’S RULES FOR USING HRVs/ERV IN COLD CLIMATES”

Prime rule: Never install HRV/ERV units if you cannot guarantee that they will be maintained.
Possible Solutions to HRV Freeze-up

1. Use an HRV that has “shut down” dampers that completely block both incoming supply and outgoing exhaust ducts when the HRV is in the “off” mode. This prevents the furnace fan and R/A connection from drawing cold outdoor supply air through the unit when the HRV is turned off.

   This also prevents house depressurization from drawing in cold outdoor air through the exhaust side of the HRV when it is turned off.
Possible Solutions to HRV Freeze-up

2. Use a HRV that has a “damper defrost” system where the outdoor supply air duct is blocked when the HRV is turned “off”. If it does, make sure manufacturer has no objection, and add a “butterfly” backdraft damper in the exhaust duct to the outside as close to HRV as possible (some manufacturers insist on this damper in cold climates as shown below).
Possible Solutions to HRV Freeze-up

2. This butterfly type backdraft damper prevents the furnace fan and R/A connection from drawing cold outdoor supply air through the unit when the HRV is turned off.
Possible Solutions to HRV Freeze-up

3. If you must use a HRV that does not have any “dampers” that at least closes off the supply air duct when the HRV is turned “off” (i.e. a HRV with fan shut down defrost), then you could add an aftermarket motorized damper that blocks off the supply duct when the HRV is “off”, and add a butterfly backdraft damper in the exhaust duct.

These added dampers will prevent the furnace fan from drawing cold outdoor supply air through the unit and will prevent house depressurization from drawing in cold outdoor air through the exhaust side of the HRV when it is turned “off”.

Possible Solutions to HRV Freeze-up

4. None of the above solutions deal with the situation where the HRV is thrown out of balance (increased cold outdoor supply air) when the HRV is operating and house depressurization draws in additional air through the supply duct and possibly reduces the exhaust airflow at the same time.

This problem will need more study and research to determine how much of a problem this factor is, and what possible solutions (other than Make-Up Air for exhaust devices) may be available.
Possible Solutions to HRV Freeze-up

5. If the homes night set-back temperature is too low and the HRV is freezing up due to this cause, the set-back should be decreased or on some makes of HRV it may be possible to increase the length of time for each defrost cycle to give the HRV time to fully defrost.
Consumer Operation of HRV/ERV:

Tips on how to operate an HRV and ERV system

Heat Recovery Ventilator (HRV) or Energy Recovery Ventilator (ERV)

All modern homes need, and are required by Building Codes to have a mechanical ventilation system installed. In your home, the system may include a Heat Recovery Ventilator (HRV) or Energy Recovery Ventilator (ERV).

How does an HRV or ERV work?
This system brings in outside fresh air which, as it enters the home, is preheated by stale air that is exhausted from inside the home. The exhaust air is typically removed from kitchens and bathrooms.

The HRV or ERV system installed in your home allows you to control air quality in winter by exhausting excess moisture and odours when desired. Whenever the HRV or ERV is turned on, it exhausts air from the bathrooms and the kitchen and brings in outdoor “fresh” air to the furnace ducting and this is distributed to all the rooms in the home by the furnace fan which should automatically operate whenever the HRV or ERV is on.

In your home you will see that the HRV and ERV is controlled by an ON/OFF wall switch (Figure 1) or timer switch (Figure 2) installed in the bathrooms and kitchens. These switches may look like a wall light switch, but their purpose is to switch the HRV and ERV fans to high speed and draw exhaust air through the grille normally located high on the wall (you may or may not be able to hear this exhaust air) in the bathrooms or kitchens. This air is ducted to the HRV and ERV where it is used to pre-heat the incoming outdoor air before being exhausted outdoors.
Operating your HRV/ERV during cold and warm months

During the coldest weather in winter, most homes need to limit the indoor relative humidity to prevent visible moisture (condensation) from occurring on the inside surface of windows. Depending on the indoor room temperatures, furniture placement and window coverings; the indoor relative humidity may need to be reduced to prevent this window condensation. The relative humidity can be allowed to increase to higher levels as long as there is no visible moisture on the windows or other cold surfaces within the house.

During the winter, the dehumidistat should be set low enough to keep condensation from occurring on your windows. The table below, (provided by Manitoba Hydro), outlines the recommended Maximum Indoor Relative Humidity (RH) levels for double-glazed windows with low E glass. Other glazing types may require different RH levels.

<table>
<thead>
<tr>
<th>Outdoor Temperature</th>
<th>Maximum Relative Humidity</th>
<th>NOTE:</th>
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<tbody>
<tr>
<td>- 30°C or below</td>
<td>25%</td>
<td>• This table assumes that airflow across the window glass is adequate and is not restricted by window coverings.</td>
</tr>
<tr>
<td>- 29°C to – 240°C</td>
<td>30%</td>
<td>• If airflow is restricted or condensation occurs on the window, lower the relative humidity setting until window condensation stops.</td>
</tr>
<tr>
<td>- 23°C to – 180°C</td>
<td>35%</td>
<td></td>
</tr>
<tr>
<td>- 17°C to – 120°C</td>
<td>45%</td>
<td></td>
</tr>
<tr>
<td>- 110°C to + 180°C</td>
<td>Above 50%</td>
<td></td>
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</tbody>
</table>

If you notice moisture on the windows during cold weather, lower the dehumidistat setting gradually (5% at a time) until there is no moisture on the windows. Setting the furnace fan to run continuously may also help to reduce the amount of condensation that will occur on your windows. The furnace fan should be running whenever the HRV/ERV is operating at either high or low speed, and this should also help to reduce condensation.
HRV/ERV Installation Inspection Checklist -

Checklist items are taken directly from Code.
Installation Checklist:

Building Inspectors in many Provinces - Territories use this Installation Checklist during site inspections.

### Inspection Checklist - NBC HRV Main Requirements

1. Outdoor air intake and exhaust openings are protected from weather (they have hoods or weather cowls)?
2. Exterior fresh air intake hoods are located at least 450 mm (18") or more above finished grade level, any permanent horizontal surface or above expected height of snow to prevent blockage?
3. Exterior fresh air intake hoods are labeled and are accessible for cleaning?
4. All fresh-air intake hoods are 900 mm (36") away from sources of stale or polluted air?
5. Outdoor air intake hoods, and exhaust hoods without backdraft dampers, have corrosion-resistant screen to keep out small animals. If mesh is less than 6mm (1/4"), gross area is 2 to 3 times the duct area?
6. Exhaust outlets are at least 100 mm (4 inches) above finished grade (more if possible as HRV exhaust may not melt the snow)?
7. Exhaust hoods located where dripping and icing below hood will not be a problem?
8. Each exhaust hood for kitchen and bathroom fans has a backdraft damper (not required for HRVs)? Either a backdraft damper or rodent screen [6mm (1/4") metal mesh], is located at the outside wall?
9. Combustion air has been provided for vented combustion appliances as required by fuel codes?
10. CO alarm meeting CAN/CSA-6.19 installed in each room with a solid-fuel burning appliance (on or near the ceiling unless manufacturer suggests different location when used for solid fueled appliances), and within 5 m (16') of each bedroom door if any type of combustion appliance or an attached garage is present?
11. Make-up air provided for exhaust devices if non-solid-fuel burning appliances are vented through a chimney? Make-up air tempered to at least 12°C or delivered to a normally unoccupied area?
12. HRVs are HVI-certified and meet NBC requirements for airflow capacity. Do HRV/ERV ventilators meet the efficiency requirements specified in section 9.36 Energy Efficiency requirements, if 9.36 was adopted by the Province/Territory.
Installation Checklist:

Building inspectors in many provinces and territories use this Installation Checklist during site inspections.

- **13.** HRV vibration isolation mounting used and preferably unit is suspended away from mid-span of joists?
- **14.** A label been applied to the HRV and the label displays the Code required measured, set and balanced (+/- 10%) Low (PVF) and High airflow rates (2.5 times minimum PVF rate if there is no separate kitchen exhaust, and any balanced high airflow rate if there is a separate vented kitchen exhaust)?
- **15.** On HRV/ERV units without built-in flow measuring devices, there are indications that a flow measuring station has been able to be installed into the duct or that holes have been drilled in correct locations to permit an insert flow measuring station to be used to provide accurate air flow measurement, setting and balancing.
- **16.** Air flow through the HRV can be adjusted with dampers built into the HRV, dampers installed in the main exhaust and supply ducts on the dwelling side of the HRV, or with motor speed controls? Indications are the dampers have been moved and adjusted and then screwed, locked or taped in place to set correct air flows?
- **17.** Ventilation equipment is accessible for inspection, maintenance, repair, and cleaning?
- **18.** Ventilation ductwork sized using Section 9.32 tables or detailed design according to Section 9.33. In any case, ductwork not smaller than recommended by manufacturer’s literature?
- **19.** Joints and seams of all ventilation ducts installed throughout the house have been sealed with duct mastic or aluminum foil duct tape as per the code?
- **20.** Has insulated duct minimum RSI 0.5 (R 3.0) been installed on the “cold-side” between the HRV and where the ducts extend through the exterior wall to hoods?
- **21.** Has the inner duct and exterior air/vapour barrier on the duct been sealed correctly to the HRV and at the exterior wall and has all flex and metal duct been supported to avoid sagging and compression of the insulation?
- **22.** Outdoor air supply connection to furnace return is at least 3m (10’) upstream of furnace or connected to return drop though an acceptable mixing device?
- **23.** There is an exhaust intake grille to the HRV, or an outside vented exhaust fan in each bathroom, Water Closet and kitchen?
- **24.** Are exhaust grilles or fans in bathrooms located 2.0 m (6.5’) above the floor or in the ceiling?
Installation Checklist:

- 25. Any outside vented kitchen exhaust discharges directly to the outdoors through non-combustible ducting?
- 26. All exhaust grilles in the kitchen located within 3 m (10’) of the cooktop have a grease-filter in the exhaust grille and is it 2.0 m (6.5’) above the floor?
- 27. Have fresh-air supply grilles on any direct ducted HRV systems been located in ceiling or high wall 2m (6.5’) off the floor to adequately disperse air into a room without leading to occupant discomfort?
- 28. In direct ducted ventilation systems is there good cross-flow of air in the bedrooms between supply grille and door undercuts, transfer or return air grilles to adequately flush night-time stale air from the room?
- 29. Is there a control switch, labelled "VENTILATION FAN", located in the living area of the dwelling that allows the HRV to be turned on to the PVF airflow rate and which activates any forced air system fan to distribute the supply air?
- 30. Are there local switches or timers in any bathroom, WC or kitchen that can activate any exhaust fan in the room or an HRV with an exhaust grille in the room?
- 31. Has the clear plastic HRV condensate drain tube been installed on the underside of the HRV; including a minimum 50 mm (2”) loop trap that contains water?
- 32. Was ventilation system literature supplied to homeowner/occupant or left on HRV?

There is a presentation of good and bad photos used to illustrate the 32 point checklist.