RESEARCH HIGHLIGHT

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Northern Mechanical Ventilation Equipment Design and Testing

BACKGROUND

At its January 2009 inaugural meeting, the Tri-Territorial Technical Subcommittee (composed of technical and program managers from the three Territorial Housing Corporations and CMHC) identified mechanical ventilation as the # 1 technical issue for Northern housing. Subsequent meetings further investigated the ventilation issues.

Ventilation of Northern houses can be problematic. The design winter temperatures in the Far North are much colder than the outdoor temperature of -25°C that is typically used by heat recovery ventilators (HRV) and energy recovery ventilators (ERV) manufacturers for their certified product ratings. As there are no basements in the majority of Northern homes, an HRV must be installed closer to the living quarters, which makes quiet operation especially important. In addition, fuel and electricity costs are much higher in the North, so low energy consumption and operating costs for a mechanical ventilation system are important.

A specific list of concerns was developed following further meetings of the Subcommittee in September 2009 and March 2010. They covered the gamut of ventilation issues—from equipment design and testing, to installation, maintenance, operation and training. This project was undertaken to conduct an independent analysis of the issues that had been raised and to assess whether existing codes or standards and/or currently available or emerging ventilation technologies are capable of addressing concerns. The project included a brief review of existing and upcoming changes in standards and technology. It also covered specific concerns with HRVs in the North, analysis of the need for a Northern HRV performance specification, and development of a draft of a Northern HRV technical specification.

METHODOLOGY

The research program was essentially a review, analysis and synthesis of available information related to the following:

1. Current and foreseeable changes in codes, standards and labelling programs.
2. Review of current technologies employed by the ventilation industry and assessment of their suitability for an extreme cold climate.
3. Review of technical ventilation issues.
4. Characterization of a hypothetical ideal northern HRV or ERV.
5. Development of a draft for a Northern HRV/ERV performance specification.

RESULTS

Detailed findings for each specific element identified above are provided in the research report. A few of the key findings from the investigation are summarized below.

Relevant North American and European testing and certification standards

In North America, residential HRVs and ERVs are tested and rated using a standard test procedure that is described in the *CAN/CSA C439—Standard laboratory methods of test for rating the performance of heat/energy-recovery ventilators*. C439 identifies a standard indoor condition of 22°C, 40% RH and

an outdoor (supply) temperature of 0°C. The standard also provides a test procedure for an optional low temperature performance/endurance test. The duration of the low temperature test is 72 hours, with the performance ratings determined from measurements recorded during the final 12 hours. C439 allows for the low temperature test to be performed at any temperature specified by the manufacturer; although the industry has since adopted -25°C as the default temperature.

In Europe, HRVs are rated using EN standard 13141-7 *"Performance testing of components/products for residential ventilation, Part 7: Performance testing of mechanical supply and exhaust ventilation units (including heat recovery) for mechanical ventilation systems intended for single family dwellings."* That standard identifies rating conditions and it references a separate standard, EN 308, which may be used to determine the performance of a wide range of heat recovery systems. For HRVs, tests are done with indoor conditions of 25°C and maximum wet bulb temperature of 14°C (maximum RH of 27%, equivalent to dew point less than 4.8°C) and outdoor dry bulb temperature of 5°C with no humidity specification. For systems that are designed for installation at locations with a design temperature below -10°C, an additional test is required as specified in EN 308. Materials relating to EN308 suggest that the additional test is a six hour test with indoor temperature of 15°C, 50% RH (5.3°C dew point) and outdoor temperature of -15°C. A six hour low temperature test at -15°C is considered to be an inadequate test for any HRV intended for use in the Canadian North.

Suitability of testing and rating standards for Northern HRVs

Overall, the North American testing, and rating standard based on CSA C439 is considered to be an appropriate procedure for Northern HRVs. The CSA C439 standard and its rating metrics are already being used for the Canadian ENERGY STAR program for residential HRVs and ERVs that has been in effect since January 2010.

To qualify for ENERGY STAR, an HRV must meet minimum thermal efficiency requirements at both 0°C and -25°C and also meet electrical performance limits (minimum cfm per watt) at 0°C. The results must be certified by an independent third party such as the Home Ventilating Institute (hvi.org). The Tier 1 and Tier 2 requirements are shown below.

The need for low temperature testing of Northern HRVs and ERVs at temperatures below -25°C

Winter design temperatures for Northern housing are well below the common industry low temperature rating point of -25°C; for example, the winter design temperature for Inuvik, Northwest Territories is -48°C. That might suggest that testing at lower outdoor temperatures would be a strong requirement. However, some context is needed to understand the current status quo.

When the first preliminary edition of the CSA C439 was published in 1985, it included a specification for a low temperature test using an indoor temperature of 22°C and 30% relative humidity (3.6°C dew point) and an outdoor

Tier 1 Canadian ENERGY STAR HRV SRE and Fan Efficacy Minimum Requirements (effective January 1, 2010)

Climate Zone	Zone Definition	Minimum SRE at 32°F (0°C)	Minimum SRE at -13°F (-25°C)	Minimum Fan Efficacy with 32°F (0°C) supply temperature	
Heating	Canada	60%	55%	SRE < 75%	1 cfm/W (0.47 L/s/W)
				SRE ≥ 75%	any cfm/W (L/s/W)

Tier 2 Canadian ENERGY STAR HRV SRE and Fan Efficacy Minimum Requirements (effective July 1, 2012)

Climate Zone	Zone Definition	Minimum SRE at 32°F (0°C)	Minimum SRE at -13°F (-25°C)	Minimum Fan Efficacy with 32°F (0°C) supply temperature	
Heating	Canada	65%	60%	SRE < 75%	1.2 cfm/W (0.57 L/s/W)
				SRE ≥ 75%	0.8 cfm/W (0.38 L/s/W)

temperature of -22°C. The test duration was not directly specified but the standard stated that the unit be tested until the performance had stabilized. Some early HRV units would slowly freeze in the laboratory over a period of five or six days. At the time, anecdotal reports from the field were indicating that there were operational problems with many of the installed HRVs during cold winter conditions.

The CSA C439 Technical Sub-Committee revised the low temperature test procedure to simplify the test, while making it more robust. Specific changes included making the test duration a fixed period of 72 hours; reporting the final 12 hours; and increasing the indoor RH from 30% to 40% (7.8°C dew point), which was believed to approximate a "worst case" for evaluation of frost control for HRVs.

The overall impact of these changes was to rapidly advance the industry's understanding of low temperature performance and frost control for residential HRVs. Units that had previously survived for several days with the less severe test conditions often froze within a matter of hours with the new test at -25°C. Problem reports from the field also decreased dramatically after the revised low temperature test came into effect and units that met the specifications started to be installed.

Recognizing that -25°C may not be representative of conditions in Northern Canada, in the mid-eighties NRCan encouraged some additional testing of cold climate HRVs. A handful of units satisfied the -40°C requirements from the NRCan testing program, but only one of those units has ever been listed in the HVI certified products directory. It was listed in the first HVI directory that included the HRV product category (June 1991). The -40°C certified performance rating for that product has subsequently been withdrawn by its manufacturer. There are currently no HRVs or ERVs with HVI certified ratings at a temperature below -25°C.

It should be noted that although HRVs are not actually tested at lower temperatures, many HRVs have been installed and operated in locations with winter design temperatures well below -25°C.

Characterization of the ideal Northern HRV

The ideal Northern HRV would be quiet and electrically efficient as well as efficient in terms of energy recovery. The efficiency would be high enough that tempering of the supply air would only be required in extreme cases. That would require a supply air temperature on the order of 15°C and provision for tempering by either blending the supply air with room air or a thermostatically controlled duct-heater.

It would be compact, use self-balancing fans and be equipped with a high-performance filter for the fresh air stream. It would be equipped with a durable, non-depressurizing defrost mechanism that had been performance validated through independent laboratory testing at the design temperature (or colder) for the location where it will be installed.

The installation would minimize the length of cold-side ductwork and possibly be provided with an optional through the wall-mounting configuration to avoid cold-side ductwork entirely. The cabinet would have an enhanced insulation package to prevent condensation. It would automatically sense the need for ventilation and operate when required using appropriate control sensors (occupancy, humidity, CO_2 or pollutant sensing as appropriate). Remotely located controls would enable occupants to over-ride automatic control functions. The unit would have self-diagnostics and provide an indicator (or indicators) to automatically signal when service (both routine and repair) is required to either the unit or its controls.

To date, an HRV that includes all of the aforementioned features and performance attributes does not exist.

Draft Northern HRV specification

A proposed Northern HRV specification would start with the recently implemented Canadian ENERGY STAR specification for HRVs and ERVs, with an additional performance test to be performed at a temperature lower than -25°C.

The existing ENERGY STAR specification requires that the unit provides a minimum fan efficacy and meets a minimum efficiency at -25°C. Clearly, using the ENERGY STAR criteria as a base requirement for a Northern housing specification immediately provides an effective and unbiased screen to select the top performers.

In addition to the above requirements, a minimum sensible recovery efficiency (SRE) during a low temperature test at -40°C is recommended for a Northern HRV specification. Ideally, the -40°C test would be performed in compliance

with CSA C439 for a time period of 72 hours at the same flow used for the other ratings. The minimum performance requirement might be set at a minimum of 50% SRE at -40°C.

A filter performance specification could be included in the specification if enough stakeholders feel that such a specification is warranted. Including a higher minimum filter performance specification than is currently used in most HRVs/ERVs would require more frequent maintenance and cleaning or replacement of the filter. Lack of maintenance has already been identified as a key problem for Northern HRVs.

Sound ratings for HRVs, ERVs or in-line ventilating fans are not normally provided in North America because it has generally been understood that properly ducted installations do not produce or transmit excessive sound levels. However, documented complaints for some Northern installations suggest that noise is indeed a problem. Therefore, consideration should be given to inclusion of some sound testing and maximum sound ratings the specification. CSA C439 does not currently include any procedures for sound testing of HRVs, but CSA C260 contains some sound testing procedures that could be called up.

IMPLICATIONS FOR THE HOUSING INDUSTRY

The development of a Northern housing HRV/ERV specification could become a key driver for the development of more efficient ventilation equipment that is better suited for the particular challenges for the Far North. This would lead to improved indoor air quality for Northern residents and improve the longevity of the buildings (through improved control of indoor humidity levels). Improvements in HRV components and controls that would be developed in response to a guidance level Northern HRV specification would likely find their way into more mainstream HRVs that are used in the Southern HRV marketplace. Further information is required to identify whether the size of the market for Northern HRVs is sufficient to warrant the investment in new product development that will be required by the industry to better meet the Northern performance requirements.

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Housing Research at CMHC

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