MECHANICAL VENTILATION OF HIGH PERFORMANCE PASSIVE HOUSE BUILDINGS IN NORTH AMERICA

May 2016

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Mechanical Ventilation of High Performance Passive House Buildings in North America, May 2016

Passive House Institute-accredited Passive House building Certifiers in North America collectively ("Certifiers") in cooperation with the Passive House Institute (PHI) and the North American Passive House Network (NAPHN) announce protocols regarding mechanical ventilation equipment in Passive Houses they certify in North America.

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1. Context

The Passive House Standard is the most stringent energy efficiency building standard on the planet, and typically reduces heating and cooling energy consumption by upwards of 80% compared to conventional construction. An efficient building envelope is central to Passive House, ensuring a highly insulated, thermal bridge free and super airtight envelope with mechanical ventilation used to ensure high indoor air quality. The standard was developed in 1991 by the Passive House Institute (PHI) and over the past five years has gained a very strong foothold in the US. This article focuses on quality assurance of both heat recovery ventilators (HRVs) and energy recovery ventilators (ERVs) used to provide fresh and tempered air to Passive House buildings.

2. Passive House – the Comfort Standard

Central to Passive House certification is assurance of comfort and indoor air quality for building occupants, be they home owners, office workers or students. Comfort in turn is greatly influenced by fluctuations in indoor temperature as well as air quality concerning both CO_2 as well as humidity. Essentially the objective is to avoid temperature asymmetry which can result from cold surfaces and untempered fresh air. And also to maintain CO_2 and humidity levels at acceptable limits (< 800ppm and 35 – 55% respectively). The quality of a building's H/ERV has a significant influence on both temperature and air quality (including pollutant levels in supply air stream due to internal leakage in the H/ERV), not to mention the building's overall space heating/cooling demand.

3. PHI Certification Protocols for Mechanical Ventilation Systems

PHI maintains a database of mechanical ventilation systems it has certified for buildings of all sizes; both smaller capacity (<350 CFM - <600 m³/h) and larger capacity (>350 CFM - >600 m³/h) ventilators. All of these certified units have undergone rigorous, independent physical testing in accredited laboratories in accordance with PHI testing protocols [PHI09], a summary of which is provided below:

- Determine upper and lower limits of operational **range – at least 3 controllable levels** must be possible (set-back (54%), normal (77%) and boost (100%))
- **Airtightness** testing (external and internal leakage) based on at least 4 testing pressures between 50 Pa and 300 Pa. Leakages ≤ 3% at mid-flow range.
- **Heat recovery efficiency** ≥75% according to PHI equation (see Section 7 below), tested at 100 Pa, at outdoor temperatures of between 32°F and 50°F (0 – 10°C) at the following two modes:
    - Dry operation mode (without condensation); and
    - Balanced operation mode (both supply/extract and intake/exhaust imbalance < 10%).
- **Electrical consumption** for all fan motors and controls at upper limit of operational range ≤ 0.765 W/CFM (0.45 Wh/m³) at 100 Pa external pressure difference (with frost protection disabled).
- **Sound emission** at upper limit of operational range (≤ 35dB(A) in installation room) including recommendation for silencers to achieve ≤ 25dB(A) in living areas and ≤ 30dB(A) in extract rooms.
- **Frost protection shutdown for protection of downstream hydraulic heater coils** (at <41°F (5°C), for example if the exhaust fan fails).
- **Frost protection for heat exchanger** by continued operation, with pre-heater (if required), at 5°F (-15°C) for 12 hours. Frost protection must not be

achieved by reducing the supply air flow rate; the unit must remain continuously in balanced operation. An efficient frost protection strategy is especially important in cold climates; the average exhaust air temperature therefore should not exceed 51°F (5°C).

- **Comfort criterion** –minimum supply air temperature at the room air inlets of 62°F at external 14°F (-10°C). Depending on the specific frost protection strategy the comfort criterion can be achieved with the use of a pre-heater or a supply air (post) heater if required (applicable in heating dominated climates) although do bear in mind that pre-heaters (especially in very cold climates) will adversely affect the overall source energy demand in Passive House projects.
- Maximum **standby losses** when in purely-stand mode of 1W (this criterion can be achieved with an additional switch)
- **Automatic restart after** power failure
- **Hygiene** – easy inspection and cleaning of entire apparatus and homeowner able to change filters
- **Filters -** outdoor air ducts must accommodate a MERV 13 - 16, MERV 8 on extract air
- **Additional tests** might be required for unusual construction types

4. Availability of Certified Ventilation Equipment in the North America

The availability of PHI-certified H/ERVs in North America is still considerably less than it is in Europe. While there is no difficulty in sourcing PHI certified H/ERVs for single-family residences (although the number of manufacturers / brands is still very limited), there are currently few PHI-certified H/ERVs for multi-family, office, or school buildings in North America to date. Project developers opting for locally sourced large ventilation systems without PHI certification must exercise due caution to ensure that the H/ERVs they install will deliver on the promise of high thermal comfort and indoor air quality and efficient operation.

The very low heating load (0.93 W/ft^2 - 10 W/m^2) and/or annual heating energy demand (1.39 kWh/ft^2.year – 15 kWh/m^2.year) in Passive Houses require a particularly accurate calculation of the building's energy balance. The Passive House Planning Package (PHPP) provides such an accurate calculation, but it requires accurate performance data for all of the components of a Passive House. It is critically important that all energy-related performance data (for example, the heat recovery efficiency of the ventilator) are measured under realistic boundary conditions, and in case of H/ERVs, there are independent laboratory measurements of the device as a whole.

5. Heat Recovery Efficiency

All Passive Houses must be modelled in PHPP. The heat recovery efficiency of the H/ERV must be entered into the PHPP and *should* (for economic reasons - considering heat recovery is not free but has an electrical power consumption cost) be a minimum of 75%. This 75% heat recovery efficiency as a minimum requirement for achieving the Passive House Standard has always been one of the central tenants since reducing space conditioning energy is at the core of the Passive House approach. Nowadays, there are many PHI-certified H/ERVs providing more than 90% heat recovery efficiency.

Please note that lower efficiency H/ERVs will not only significantly increase space heating loads and demand, but they will also require the use of a post-heater downstream of the H/ERV in order to ensure that fresh air delivered to living and work spaces is adequately tempered (minimum 62°F - 16.5°C at all times). Such post-heating will significantly increase the source energy demand for the project, potentially exceeding the maximum specific source energy demand limit for Passive House certification: 11.14 kWh/ ft^2/year - 38 kBtu/ft^2/year -120 kWh/m^2/year. **In case of any doubt, we highly recommend installing H/ERVs with a heat recovery rate significantly higher than 75%**.

6. Determining the Heat Recovery Efficiency: Differences between PHI and North American Industry Testing Protocols

PHI's testing protocols for determining the heat recovery efficiency of mechanical ventilation systems differs significantly from the protocols which the North American ventilation industry generally uses. A full comparison is beyond the scope of this document. Please stand by for a forthcoming comprehensive review by Andrew Peel of Peel Passive House Consulting.

In brief, the differences stem from where air temperatures are measured during testing. Thus, it is important to consistently describe the four air streams:

1) Fresh outdoor air intake (from outdoors to H/ERV), hereunder labelled '**ODA**';
2) Exhaust air (from H/ERV to outdoors), hereunder labelled '**EHA**';
3) Supply air (fresh air from H/ERV distributed to rooms in the building), hereunder labelled '**SUP**'; and
4) Extract air (stale air collected from rooms in the building and pulled back to the H/ERV to be exhausted to outdoors), hereunder labelled '**ETA**'.

PHI's method (Figure 1(a)) leads it to compare the exhaust air temperature (T_{EHA}) with the outdoor fresh air temperature at the intake (T_{ODA}). If T_{EHA} is higher than T_{ODA} then some of the heat in the warm, stale air that the H/ERV is exhausting from the building is not being recovered by the H/ERV and transferred to the fresh, cold air entering the H/ERV. This means that the heat recovery is less than 100%. The North American ventilation industry method (Figure 1(b)) compares the supply air temperature (T_{SUP}) with the extract air temperature (T_{ETA}). If T_{SUP} is lower than T_{ETA}, then not all of the heat has been transferred from the extract air to the supply air and heat recovery is less than 100%.

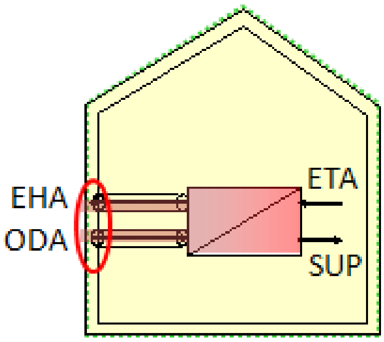

Figure 1(a) PHI calculation of heat recovery rate based on the **exhaust air side**

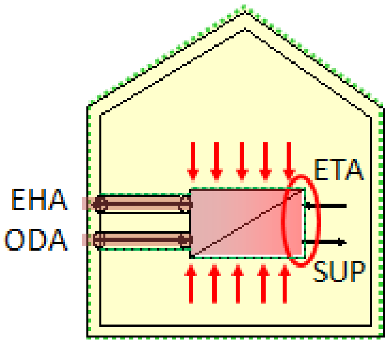

Figure 1(b) Industry calculation of heat recovery rate based on the **supply air side**

H/ERV imperfections allow air leakage between the air streams or between warm air inside the building and the air streams within the H/ERV case. And heat inside the building conducting through the H/ERV case and interior components to the air streams within the case is accidental heat transfer to the air streams instead of designed heat recovery. Both PHI and the North American ventilation industry account for these imperfections, but differently since they compare air temperatures at different locations. Mr. Peel will report these differences and their consequences in his forthcoming report.

7. Use of HVI and ARHI Certification in North American Passive Houses

The Home Ventilating Institute (HVI) and the Air-Conditioning, Heating and Refrigeration Institute (ARHI) are independent North American ventilation equipment certification bodies. Both institutes have extensive, free, searchable databases of H/ERVs they certified (HVI and AHRI).

Passive House Institute- accredited building Certifiers operating in North America agreed in December 2015 to require testing certification results from either HVI or AHRI for all H/ERVs which are not PHI-certified as the basis for their Passive House building certification beginning with buildings first submitted to them for certification after December 30, 2015. **Thereafter, they will <u>not</u> certify buildings based on manufacturers' own test data, unless agreed with PHI**.

Additionally, the Certifiers will not certify buildings with ventilators unless they have independently-tested internal and external air leakage <3%. This is necessary to insure good indoor air quality and to protect occupant health.

The Certifiers will accept HVI or AHRI test data (temperature and flow readings) **<u>but use the PHI formula</u>** to determine the H/ERV efficiency. Consistent with PHI's protocol, Certifiers will not include the heat generated by the fan motors in determining the efficiency of non PHI-certified H/ERVs.

Please note: The Certifiers' approach implies in no way that the said H/ERVs are thereafter "PHI-certified components." The Certifiers encourage PHI component certification for the many benefits it offers the Passive House design and construction industry as well as simplifying Passive House building certification.

The Certifiers' approach is consistent with most North American energy-efficiency programs which require independent testing and certification.

8. Achieving PHI Component Certification for North American Manufactured H/ERVs

PHI wishes to engage directly with North American H/ERV manufacturers so that there will be a local source of high-quality equipment available to serve the growing Passive House market. Please note that manufactures do not have to ship their ventilation units to Europe for testing. Instead, their units can be tested in an accredited laboratory in North America as part of the normal testing measurements, as long as PHI's protocols listed earlier are included in the test.

Certifiers operating in North America will facilitate a dialogue between PHI and NA manufacturers in this regard. At PHI, Kristin Bräunlich (Kristin.braeunlich[at]passiv.de) is available to work with North American H/ERV manufacturers. Kristin can be contacted by telephone (0049 - 6151 - 82699 - 20) between 9am and 5pm Central European time Monday to Friday.

9. Responsibility for Heat Recovery Efficiency

Manufacturers must take responsibility for their stated efficiency rates if their equipment is not certified by PHI. Neither PHI nor the Certifiers accepts responsibility for increased energy consumption, discomfort, or poor indoor air quality from H/ERV shortcomings.

10. Conclusions and Commitments

- Efficiency and quality of H/ERVs are essential to ensuring comfort and low heating demand in Passive House buildings.
- For economic reasons alone, we highly recommend using ventilation devices with 1) heat recovery rates much better than 75%, 2) low power consumptions (less than or equal to 0.765 W/CFM - 0.45 Wh/m³) achieved with efficient, electronically-commuted fan motors, and 3) less than 3% internal and external air leakage.
- Heat recovery efficiency ratings are greatly influenced by the testing protocols. PHI uses an approach which ultimately safeguards consumers and occupant by ensuring both comfort and energy efficiency.
- We urge North American manufacturers to have their ventilators certified by PHI to ensure high quality in operation. Machines can be tested in North American as part of the normal required North American tests and do not need to be tested in Europe.
- Even if North American manufacturers do not have their ventilators certified by PHI, we hope they will request independent testing laboratories include testing according to the PHI protocols and report the results.
- Both the PHI and PHI-accredited building Certifiers operating in North America are committed to cooperation with North American H/ERV manufacturers.
- Non PHI-certified H/ERVs manufactured in North America can be used in PHI-certified Passive Houses, but at the very least they must have HVI or AHRI testing (including both internal and external air leakage), and Certifiers will use the heat recovery efficiency rate determined according to PHI calculation protocols instead of the customary North American industry method.
- In order to ensure occupant aural comfort, maximum noise levels in living and sleeping rooms from ventilation systems must be < 25 dBA.
- The limited availability of larger volume PHI-certified H/ERVs in the US limits development of larger-scale buildings meeting the Passive House Standard. The North American Passive House Network and PHI-accredited building Certifiers operating in North America are committed to support the supply and manufacturer of these components in North America

11. References:

- [PH15] Criteria for the Passive House, EnerPHit and Low Energy Building Standards, Passive House Institute; Darmstadt, Germany; September 29, 2015
- [PHI09] Requirements and testing procedures for energetic and acoustical assessment of Passive House ventilation systems > 600 m^3/h for Certification as „Passive House suitable component", Passive House Institute; Darmstadt 2009
- [PHI frost] Supplementary test of frost protection, Passive House Institute, 2014

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