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Context

The Passive House Standard is possibly the most stringent energy efficiency building metric on the planet, and typically reduces heating and cooling consumption by upwards of 80% compared to conventional construction. A fabric-first approach 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 gotten a very strong foothold in the US. This article will focus on the issue of quality assurance relating to the both heat recovery ventilators (HRVs) and energy recovery ventilators (ERVs) used to provide fresh and tempered air to Passive House buildings.

Passive House – the Comfort Standard

Central to Passive House is assurance on providing comfort for building occupants, be they home owners, office workers or school-goers. Comfort in turn is greatly influenced by fluctuations in indoor temperature as well as air quality concerning both CO₂ as well as humidity. Essentially the objective is to avoid temperature asymmetry which can result from cold surfaces and un-tempered fresh air and also to maintain CO₂ and humidity levels at acceptable limits (< 800ppm and 35 – 55%...
The quality of H/ERV used in the project 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 overall space heating demand for the project.

**PHI Certification Protocols for Mechanical Ventilation Systems**

PHI has a database of certified mechanical ventilation systems for both smaller (<350 CFM or <600 m³/h) and larger (>350 CFM or >600 m³/h) projects. All of these certified units have gone through 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** according to PHI equation (see below), tested at 100 Pa, ≥75% 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 (imbalance < 10%).

- **Electrical consumption** for all fans 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 downstream hydraulic heater coils** (<41°F (5°C), for example if the exhaust fan fails)

- **Frost protection for heat exchanger** – must guarantee continued operation, with pre-heater (if required), tested for 12 hours at 5°F (-15°C). 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** – for example 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 cold 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 (if required this criterion can be achieved with an additional switch)

• **Automatic restart** after power failure

• **Hygiene** – easy inspection and clearing of central apparatus and homeowner able to change filters

• **Filters** - outdoor air ducts must accommodate a MERV 13 - 16, MERV 6 on extract air

• **Additional tests** might be required for unusual construction types

**Availability of Certified Ventilation Equipment in the US**

The availability of PHI certified H/ERVs in the US is still considerably less than it is in Europe. Whilst there is no difficulty in sourcing PHI certified ERVs for single-family residences (although the number of manufacturers / brands is still very limited), there are few certified H/ERVs for multi-family, offices or schools in the US to date. Manufacturers of larger H/ERVs are watching the market grow in the US with interest, but until such time as they establish a supply chain, US projects must rely on sourcing larger ventilation systems locally. Designers of these projects must exercise due caution to ensure that the H/ERVs they use will deliver on the promise of high thermal comfort and indoor air quality.

The very low heating load in Passive Houses (10 W/m²) require a particularly accurate energy balance calculation of the building. The Passive House Planning Package (PHPP) provides such an accurate calculation, but it requires reliable energy data of all of the components. It is critically important that all energy-related data (for example heat recovery rate of the ventilator) are determined under realistic boundary conditions and in case of H/ERVs are based on independent laboratory measurements of the whole device.

**Heat Recovery Efficiency Levels**

All Passive House projects must be modelled in the Passive House Planning Package, or PHPP. The heat recovery efficiency of the H/ERV must be entered into the PHPP energy balancing program, and **should** (for economic reasons - considering the electrical power consumption versus heat recovery rate) be a minimum of 75%. This 75% heat recovery efficiency as a minimum requirement has always been one of the central tenants to achieve the Passive House Standard to reduce the energy required for space heating. Nowadays, there are many PHI certified ventilation systems capable of providing more than 90% heat recovery efficiency. Please note that lower efficiency machines will not only significantly increase space heating 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 at all times). Such post-heating will significantly increase the source energy demand for the project and might thus lead to failing Passive House certification (Max source energy demand is 38 kBtu/ft².year). **In case of any doubt, we highly recommend the use of H/ERVs with a significantly higher heat recovery rate than 75%.**
So, what if the H/ERV that you wish to use on your project is not PHI certified?

If the manufacturer of your H/ERV provides independent laboratory testing with the recorded temperatures at each grill this can be used to estimate Hr eff for use in PHPP under the following conditions:

- Counter flow heat exchanger with decently insulated casing and reasonable internal and external airtightness provided (at least air tightness category A3 according to EN 13141-7, better A2, or <3% leakage according to HVR or AHRI)

Difference between US and PHI Testing Protocols

The testing protocols used by PHI and the general ventilation industry in the US to determine the heat recovery efficiency of mechanical ventilation systems differs significantly as depicted below.

PHI’s approach essentially focuses on the energy losses in the H/ERV that are exhausted to the outside as it exits the H/ERV, whereas industry standard looks to the temperature uplift of the supply air as it enters the building. The difference between the two methods might seem subtle, but if there are a lot of leaks in the ERV between the various air paths, then the heat from the extract air path will transfer into the supply air path, raising the temperature and, accordingly appearing to be of higher heat recovery efficiency. Leaky H/ERVs, therefore, will appear to perform better whereas what is actually happening is that heat (paid for by the occupants) is short-circuiting the H/ERV core. It is for this reason that one of the key testing protocols required is the internal and external leakage rate, which must be < 3%. This leakage rate is to ensure that stale and humid extract air is not recirculated back into the supply fresh air stream. This leakage rate is required for hr-rate calculation according to the formula below without correction.
Use of HVI and ARHI Efficiencies in the US

The two key independent ventilation testing labs in the US are Home Ventilating Institute (HVI) and the Air-Conditioning, Heating and Refrigeration Institute (ARHI). Both institutes have extensive database of their certified units which can be searched here and here respectively.

Passive House Academy in its Passive House certification work in the US decided in August 2015 to require at the very least testing certification results from either HVI or AHRI. PHA will not accept manufacturers own test data. This approach seems perfectly reasonable when you consider that these ratings are required by most if not all of the energy efficiency programs in the US. PHA will take the HVA or AHRI test data (temperature and flow readings) but use the PHI formula (not the ‘industry’ formula) to determine the H/ERV efficiency. Only ventilators that have a tested air leakage rate of <3% will be considered for use. As a further cautionary step, PHA will not include the heat generated by the fans in determining the efficiency of non PHI-certified H/ERVs. This approach implies in no way that the said H/ERVs are thereafter ‘certified’ for use in Passive House projects.

Achieving PHI Component Certification for North American Manufactured Units

PHI would like to engage directly with manufacturers of H/ERVs in North America so that there will be a local source of high quality equipment available to serve the growing interest in Passive House. 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 the US as part of the normal testing measurements, as long as the protocols listed earlier are included in the test. Passive House Academy is happy to facilitate a dialogue between PHI and NA manufacturers in this regard (contact Kevin Brennan in our New York office: kevin[at]passivehouseacademy.com or call 646 233 1365). At
Responsibility for Heat Recovery Efficiency

Manufacturers must take responsibility for their stated efficiency rates if their equipment has not been certified by PHI. Neither PHI nor PHA will accept responsibility should energy consumption, comfort or indoor air quality be compromised due to shortcomings in equipment efficiency.

Conclusion

- Efficiency and quality of H/ERVs are essential to ensuring comfort and low heating demand in Passive House projects.
- Heat recovery efficiency rates are greatly influenced by the testing protocols used – PHI uses a cautious approach which ultimately aims to safeguard occupant comfort.
- There is a limited availability of larger PHI certified H/ERVs in the US which must be addressed as a matter of urgency.
- Non PHI-certified locally manufactured H/ERVs can be used but at the very least they must have HVI or AHRI testing (including achieving <3% leakage) and the heat recovery efficiency rate will be determined using the PHI calculation (excluding heat from the fans) and not the normal industry method.
- For economic reasons alone, it is highly recommended to use ventilation devices with heat recovery rates much better than 75% at low power consumptions of less than ≤ 0.765 W/CFM (0.45 Wh/m³) (achieved with efficient EC fans).
- We strongly encourage North American manufacturers to have their ventilators certified by PHI to ensure the highest quality possible. Machines can be tested in North American as part of the normal required tests and do not need to be shipped to Europe for separate testing.
- In order to ensure occupant aural comfort, maximum noise levels in living and sleeping rooms must be < 25 dBA whether PHI certified or not.

References:

- [PHI09] Requirements and testing procedures for energetic and acoustical assessment of Passive House ventilation systems > 600 m³/h for Certification as „Passive House suitable component”, Passive House Institute; Darmstadt 2009
- [PHI frost] Supplementary test of frost protection, Passive House Institute, 2014