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Modeling the PentaCare-V12

The Minotair PentaCare-V12 is a unique machine that plays the roles of several equipment in one (i.e., HERV, Heat Pump, Dehumidifier, High Efficiency Air Filtration). Consequently, trying to input it into a modeling software is nothing but trivial. To that end, this paper provides guiding principles for modeling the PentaCare. Though the PentaCare was tested per the CSA439 standard and further certified by the HVI (Home Ventilating Institute), in real-life installations the PentaCare will not behave like what is presented in the HVI listing. In reality it will use much less electricity for ventilation than the 740 watts indicated on our brochures or the HVI product directory. The following points speak to the difference between real-life installations and controlled testing environments, the concept of operations and the best approach to modeling the PentaCare.

When undergoing its tests under the CSA439 standard on which the HVI listing is based, the PentaCare had to operate 100% in ventilation mode; no recirculation allowed. This made sense because the machine was being evaluated under the realm of it behaving as a traditional HERV (i.e., HRV/ERV) at a constant airflow. However, in a real-life installation, the PentaCare will not continuously operate in ventilation mode nor at a constant airflow. Sometimes, it will need to run in recirculation and would then behave like a conventional heat pump.

To implement this complex mix of possibilities, we start by dividing the hour into three 20-minute windows. Then to ensure the required amount of fresh air is provided, the PentaCare will ventilate at a higher airflow than its Fresh Air setpoint to allow it to free up time to do other things. For instance, if the Fresh Air setpoint is set to 100 CFM (e.g., a 1700 sq ft house), the PentaCare will ventilate at 160 CFM. This will lead to a ventilation ratio of 0.63 (i.e., 100/160). In other words, the PentaCare will ventilate for 12.6 minutes (i.e., 0.63 x 20) in the 20-minute window, leaving 7.4 minutes for recirculation operations.

However, worth noting from the previous paragraph is that this is the worst-case scenario. As a rule of thumb, yes, the machine will add a minimum of 60 CFM to the Fresh Air setpoint, but in reality, this could be higher and up to 250 CFM, but never less than Fresh Air setpoint + 60 CFM. Having noted that, what this leads to is the requirement to multiply the power consumption by the ventilation ratio in order to decouple other activities from the ventilation activity. The ratio in the previous paragraph is thus the **first** of two important ratios required to model the PentaCare in any software.

One feature central to the PentaCare is that when it operates in ventilation, it will recover 3 types of heat from the stale airstream leading to recovery values exceeding 100%. As will be seen in this document, this will lead to the second important ratio. For now, it is essential to understand the 3 types of heat handled by the PentaCare:

1. **Sensible heat**. This heat is pumped out of the stale airstream and moved to the fresh airstream via the refrigeration cycle, typical to a heat pump. In comparison, a traditional HERV recovers sensible heat through its heat recovery core.
2. **Latent heat**. This is the heat contained in the moisture of the stale airstream. What is unique to the PentaCare is the fact that the **latent** heat contained in moisture is converted into **sensible** heat during the refrigeration cycle, allowing to recover heat in excess of the original sensible heat contained in the stale airstream. In comparison, HRVs are not capable

of recovering moisture nor the latent heat contained in it. ERVs, however, do recover a certain percentage of moisture from the stale airstream and move it to the fresh airstream, but the moisture remains in the form of moisture and is not converted into sensible heat[1].

3. **Compressor heat**. This is the heat generated by the compressor motor windings that is rejected into the refrigerant fluid coming from the evaporating coil in order to keep the compressor cool when running. The rejected heat is added to the sensible heat to further increase the fresh airstream temperature in winter. In summer, the rejected heat is simply exhausted outdoor via the condensing coil. The compressor rejected heat must not be confused with the heat radiating from the compressor shell itself, whose effect on heating and cooling operations is negligible.

The descriptions and explanations of the aforementioned 3 types of heat come to support the capability of the PentaCare to exceed 100% of sensible heat recovery, essentially allowing the machine to heat while doing ventilation. Moreover, under certain outdoor conditions, the PentaCare will produce more heating energy than it consumes, leading to net-zero ventilation episodes during the year.

Two important outputs of the CSA439 are the Apparent Effectiveness and the Sensible Recovery Efficiency (SRE). In the planning of the HVAC equipment, the former is used in the calculation of the heating load while the latter – the SRE – is used in the calculation of the ventilation system efficiency.

However, most modeling software cannot cope with heat recovery values greater than 100%. Therefore, the excess heat must be deducted from the maximum 100% recovery and moved to the heating load column. This will thus generate the **second** important ratio, namely the power energy ratio. For instance, at 32˚F (0°C) outdoor and 68˚F (20°C) indoor, the PentaCare will supply air at 92˚F (33.4°C), which at 160 CFM (i.e., 100+60) translates into 3036 watts. Of these 3036 watts, 1822 watts is required to raise the fresh air intake from 32˚F (0°C) to 68˚F (20°C), leaving 1214 watts of extra heat that must be accounted for under the heating load column, not ventilation. In this example, the ratio would be 0.6 (i.e., 1822/3036) and the remaining 0.4 must be taken from the ventilation column and moved to the heating load column.

Strictly speaking in ventilation terms and for modeling purposes, the PentaCare will consume 740 watts × 0.63 × 0.6 = 280 watts once the two ratios are applied. This is thus the power that needs to be associated to the Ventilation Column of the modeling software. Yes, the machine will consume 740 watts, but only 280 watts will be associated to ventilation while the remainder will act on meeting the heating load. Again, this is the worst case as in reality it is not desired to overheat the indoor. So, the machine will turn the compressor on/off intermittently to charge the condenser coil with heat and let that captured heat simply preheat the fresh airstream. Over the year, there will be episodes such as during shoulder seasons and during free cooling periods when the compressor isn't solicited at all, leading to even lower power consumption. However, these episodes would be difficult to model, so it is best to simply assume the compressor will be running. If your modeling software agrees with our calculator worst-case results, you will do fine and potentially better in real life installations.

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[1] Worth noting is the fact that, during dryness conditions such as in winter, the PentaCare can operate in recirculation to recover 100% of the moisture generated from taking showers to help keep the indoor relative humidity to healthy levels. Note that this is not taken into account in our calculator, however.