

# VENTILATING AN ENERGY EFFICIENT HOUSE USING AN AIR-TO-WATER HEAT PUMP

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## SUMMARY

### INTRODUCTION

Throughout North America the most frequent technological solution employed to ensure adequate ventilation in new "air tight" residences has been the use of ducted, air-to-air heat exchangers (AAHX). An alternative heat recovery ventilation (HRV) system for providing fresh air while recovering heat from stale exhaust air employs an air-to-water heat pump.

This paper provides a brief overview of the design, installation and typical operation of a U.S. made, air-to-water heat pump ventilation and heat recovery system (HPHRV).

### SYSTEM DESIGN CONDITIONS

The HPHRV was designed for installation in a newly constructed, all-electric, energy efficient home located near Portland, Oregon. Due to the relatively mild climate, the HPHRV system was designed to provide exhaust heat recovery, but not to temper incoming make-up air. Outdoor air is supplied to the structure through both natural infiltration and deliberate vent openings (i.e. "slot vents").

The HPHRV was designed to provide approximately 100 cfm (as installed) of mechanical ventilation when operating. The HPHRV unit was a 52 gallon capacity prototype model manufactured by DEC, International in Madison, WI.

### SYSTEM INSTALLATION CONSIDERATIONS

Four primary factors were considered in the installation design of this system. No furnace ductwork was available that could have served as a stale air return to the unit. This meant that either separate ductwork had to be installed which was dedicated to the HPHRV or that the house itself would have to serve as the return air "plenum". The latter approach was taken.

The second factor that entered into the design of the installation was the need to provide for condensate disposal. This was accomplished by

plumbing the HPHRV's condensate drain tube into the home's washing machine drain. This avoided the cost of installing a separate drain for the unit.

The two other factors that influenced the systems installation were the desire to minimize operating noise and water heater tank "standby" losses. The design of the house was modified so that the HPHRV was located in an insulated utility closet in a corner of the unheated garage. This design minimized heat loss, while buffering the living area from the units fan and compressor noise.

Figure 1 shows a schematic of the system as installed.

#### INSTALLATION AND START UP PROBLEMS

There were three significant problems encountered during system installation and start-up. The first related to fact that the metal sleeves on each of the four slot vents (which were made in France) had to be shorten prior to their installation in the walls. This more than doubled the time required for installation.

The second problem stems from the fact that heat pump water heaters are not frequently installed in the Northwest. The plumbers who installed the unit managed to drill a sheet metal screw through a refrigerant line, causing the release of the freon refrigerant charge. The solution to this second problem was to simply repair the refrigerant leak and "recharge" the system.

The third problem occurred when my wife consistently noted that despite the new refrigerant charge after two loads of laundry there was insufficient hot water to give our youngest daughter a bath. Upon investigation I discovered that the HPHRV's compressor would shut down for 45 minutes to defrost its evaporator coil during its make up for the second wash load.

#### DESIGN MODIFICATIONS

As a means of ensuring an adequate supply of hot water two design modifications were made to reduce the number of defrost cycles and to shorten their duration. To shorten the defrost cycle, the fan control was rewired to fan-force defrost by continuing fan operation while the compressor was shut down due to evaporator coil icing. This modification causes warm air to be blown over the evaporator coils, thus defrosting the unit faster.

In addition to modifying the unit's control strategy, the system's ductwork and filter design were modified to reduce static pressure drop to the unit. A new fan motor was also installed to slightly increased the flow rate of the fan.

As a consequence of the above modifications, the recovery time of the unit was substantially reduced. The unit rarely shuts off for defrost, and hot water supplies are adequate to serve a family of four.

### TYPICAL OPERATION

The HPHRV is designed to operate only when there is a need to supply hot water or make up tank standby losses. On a typical day the unit operates 10 to 12 hours to supply hot water and to make up tank "standby" losses. One time hot wire anemometer air flow measurements on the stale air intake and exhaust streams indicate that the unit is exhausting 90 to 100 cfm when in operation. Given typical operating hours and the house's volume, it appears that the unit is supplying between 0.5 and 0.55 ach when it is operating. Since the unit only operates 10 to 12 hours during the day this results in a between 0.2 and 0.25 ach on an average daily basis. This ventilation, plus whatever natural infiltration is occurring in the house appears to be sufficient to remove excess humidity, cooking and other occupant generated odors. No energy performance data nor indoor air quality data (e.g. radon or formaldehyde measurement have) been made.

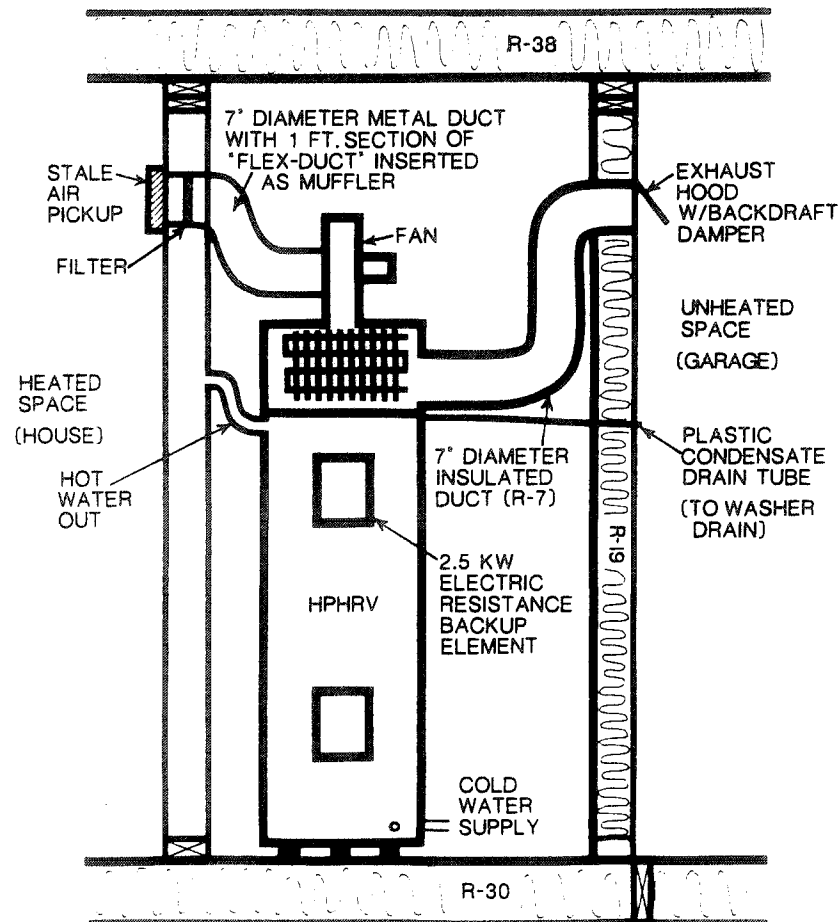


FIGURE 1 SCHEMATIC OF HEAT PUMP HEAT RECOVERY VENTILATOR AS INSTALLED