A Prototype Alternative Ventilation System
for
Retrofit, Rehab and Renovation of Rural Alaska Houses

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Abstract:

Bristol Bay Housing Authority (BBHA) currently has under development a model home project consisting of four prototype houses to be built in Dillingham, Alaska later this year. Included in this project is a prototype residential ventilation system developed by the author, intended to provide a simpler, lower cost alternative to traditional Heat Recovery Ventilation (HRV) systems while addressing the inherent limitations of passive, or exhaust-only systems. This paper briefly describes ventilation systems currently used in rural Alaska housing, discussing advantages and disadvantages of each. It then describes an alternative system intended to solve problems inherent to each. An interactive on-line Ventilation System Economic Calculator is provided at http://www.biorealis.com/wwwroot/VentLoadCalcs5.html, allowing users to evaluate ventilation system options for their own site-specific conditions.

HRV Systems:

Traditional HRV systems have been installed in hundreds, perhaps thousands, of rural Alaskan houses in the last twenty years or so -- long enough to get an idea of their long term performance under real-world conditions. Results are mixed. There continues to be a wide variety of opinion among designers, installers, vendors, policy makers, contractors, end-users, maintenance personnel, etc. regarding their effectiveness, operating costs, and the cause of reported problems.

Those who argue against HRV systems typically cite high installation costs, difficulty of installation, increased electric usage, and problems with frosting and condensation. Proponents, on the other hand, typically cite poor design, improper installation and/or lack of homeowner understanding as the cause of reported problems. In fact, both sides are probably right. The fact remains that (1) to work properly without problems, *all* of the pieces must be in place (including proper installation and homeowner education), and (2) in practice, history has shown that it can be very difficult to *put* all of the required pieces perfectly in place.

In moderate climates, and/or where homeowners clearly understand and appreciate their purpose and usage, HRV systems may be the recommended choice. However, in remote locations with extreme climates, poor cash economies and lack of technical support, the difficulty of installation, added cost and complexity, and lack of understanding may justify consideration of simpler systems even though they may not perform as well.

Retrofit, renovation and rehab projects present an even greater set of challenges. It can often be very difficult, if not impossible, to find adequate space to locate equipment, route the required ductwork, and/or properly locate inlets and outlets. Yet inadequate ventilation is one of the major contributors to moisture damage, mold, mildew, and associated health problems in existing, older housing stock. It is a prime candidate for inclusion in many renovation projects.

Passive Ventilation Systems:

In recent years, a variety of alternative ventilation systems and components, alternately described as "passive", "exhaust-only", or "hybrid" systems, have appeared on the market, in an attempt to fill the need for a simpler, lower cost alternative to conventional HRV systems.

These systems typically combine one of a variety of exhaust methods (wind, thermal or mechanical), with an independent passive make-up air system. There is no heat recovery per se, but some efficiencies can be achieved by providing tightly controlled spot ventilation - i.e. providing ventilation air only when and where needed (typically as determined by humidity or occupancy sensors in each room). Typical components include humidity-controlled air inlets and outlets which may be utilized on exhaust and/or supply air sides, and passive air inlets located on exterior walls or windows, which automatically regulate airflow in spite of variations in wind pressure.

Advantages over HRV systems typically include (1) greater simplicity, (2) lower first cost, and (3) reduced electric usage. Disadvantages include (1) dependence on external conditions which may be highly variable, (i.e. wind speed, outside air temperature), (2) higher heating energy costs, and (3) negative building pressures.

A passive air intake system is not recommended for arctic climate projects, for two reasons: (1) outdoor air temperature is too cold to introduce directly into the space, and (2) makeup air flow depends on negative indoor air pressures, which could create hazardous backdraft conditions in the woodstove and boiler. At arctic and subarctic interior Alaska design temperatures, condensation or frost would be likely to form on air inlets, and/or homeowners would experience cold drafts, and be likely close them off, defeating the purpose.

Proposed Alternative System:

Following is a description of a ventilation system which incorporates the basic features of the passive systems described above (i.e. spot ventilation, humidity controlled intermittent operation) but which overcomes some of their inherent limitations. With this system, cold supply air is tempered before reaching the space, and neutral air pressure is maintained in the building. The relative simplicity of a passive system is combined with the positive control provided by a balanced mechanical system. Installed cost should be similar to the passive system described above.

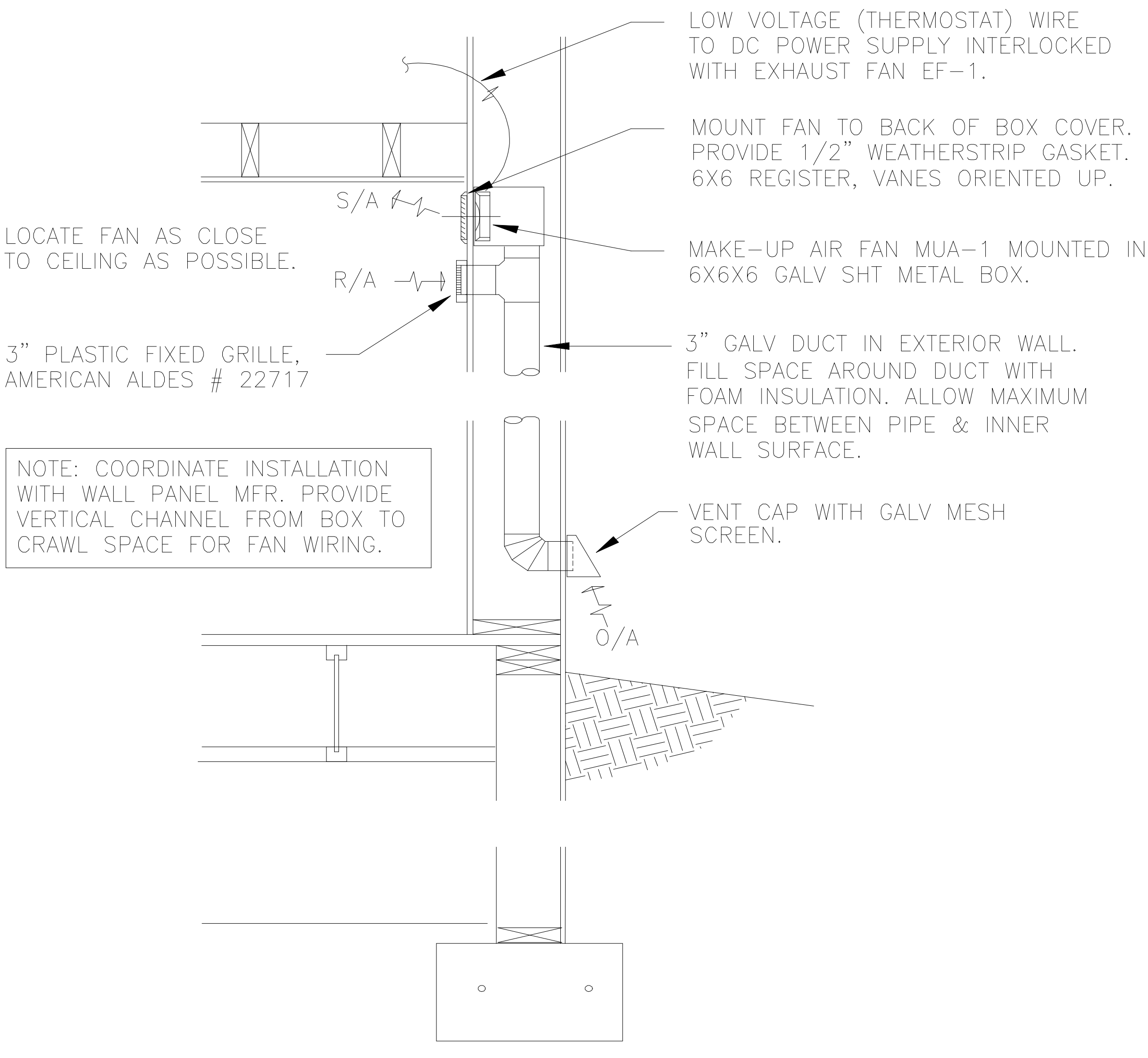
Exhaust Side:

A small central exhaust fan draws air from the bathroom. This fan is similar to a typical bathroom exhaust fan, but is specifically selected for continuous duty operation, longevity, quiet operation, and minimum energy use. The fan selected for the model home project (Panasonic FV-11VQL) provides 70 CFM at 0.3" S.P., 20.4 Watts, 1.5 Sones.

Makeup Air:

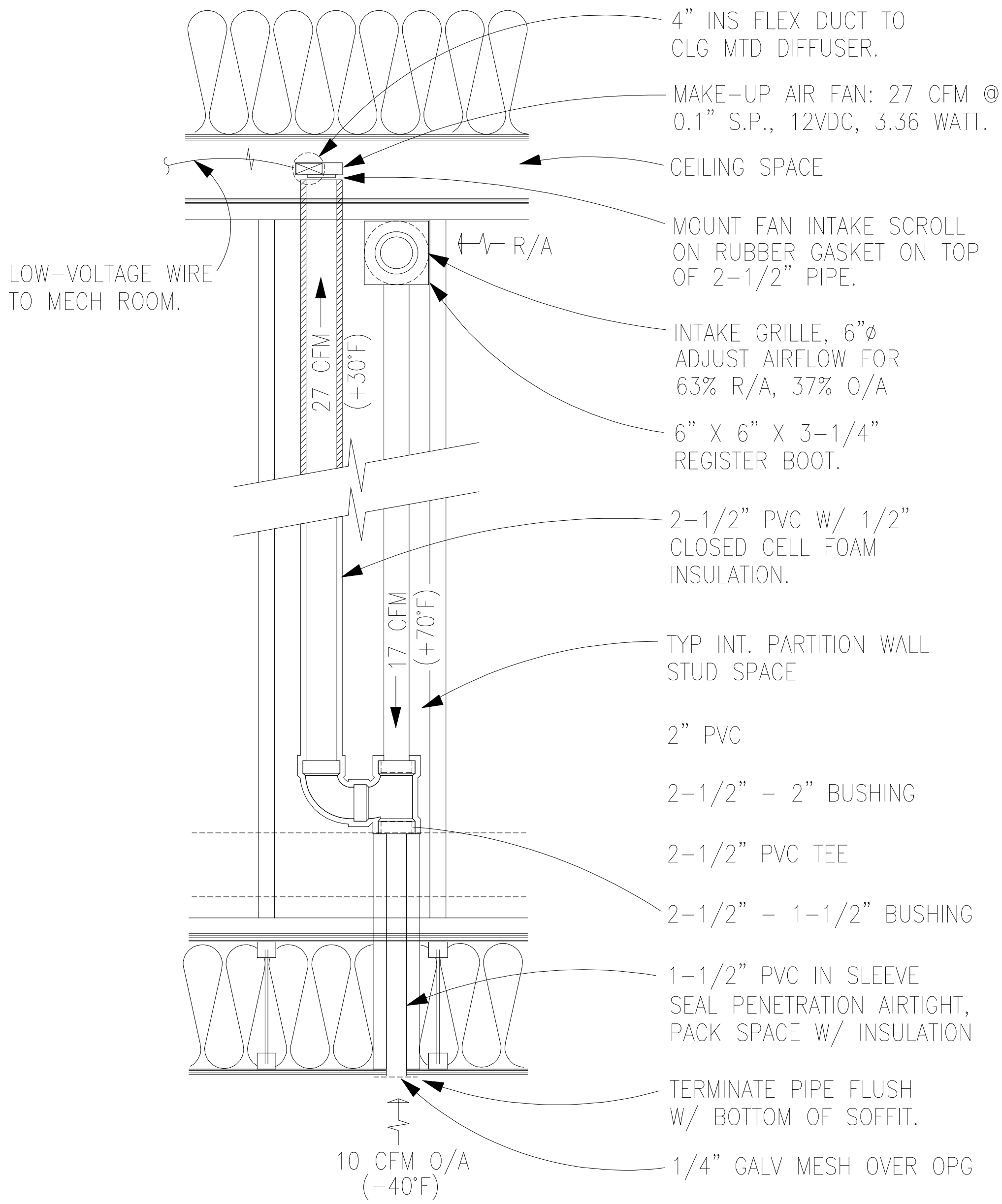
Makeup air is provided by individual small fresh air openings in bedrooms and living room, sized to balance the exhaust air flow, and keep building air pressure neutral. A small DC fan (Panasonic model FBA12G12L) on each makeup air assembly provides local recirculation, mixing room air with cold fresh air to temper it before discharge into room. The fan eliminates dependence on negative building pressures required to induce airflow in completely passive systems. Multiple, tiny air delivery systems, each with one inlet, one outlet, one speed, permanently set to provide a fixed very small amount of air, can be quite simple and inexpensive. Proper design & sizing of ducts & components eliminates the need for balance dampers, flow measuring stations, gauges and complex balancing procedures.

The Dillingham model homes are built on perimeter foundations, and exterior walls are premanufactured panels, so in this project, makeup air assemblies are incorporated into the exterior wall panels.



Exterior Wall Makeup Air Assembly Detail - for Houses on Perimeter Foundations

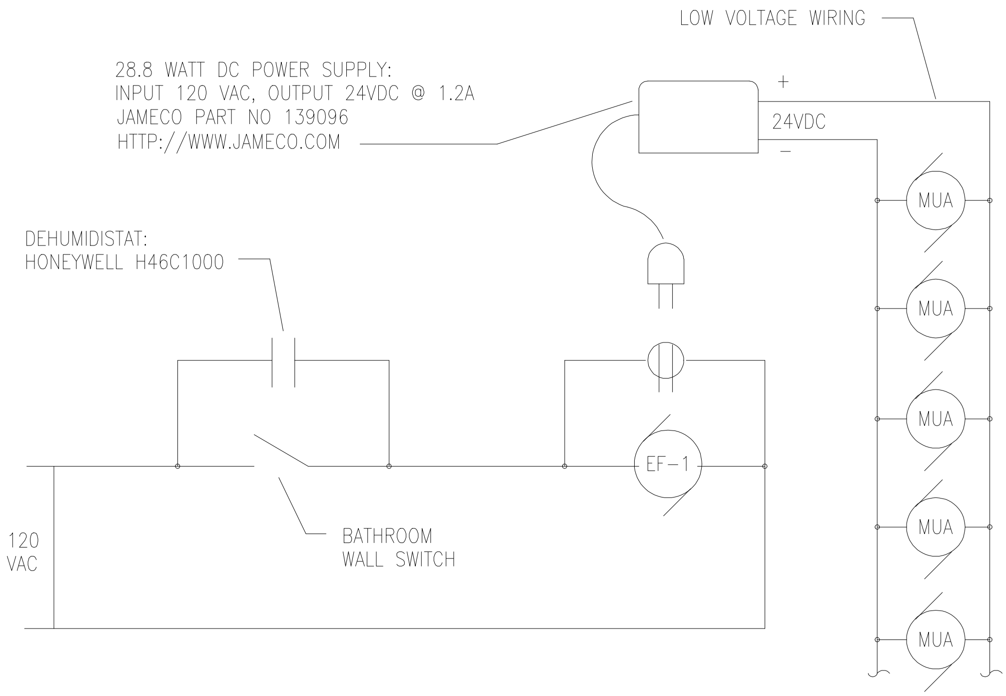
On houses built on pilings, or post and pad foundations, intake and exhaust openings can be located on the underfloor soffit. Contrary to typical design, we do not recommend terminating the ducts with complicated hoods, baffles, or arctic tees. Terminating openings flush with a smooth wind-scrubbed surface minimizes wind effect. (Note that a pitot tube works on this principle: the low pressure probe which terminates flush with the duct wall theoretically sees zero velocity pressure.) Locate the intake upwind and as far away as possible from of outlets (for prevailing winds). Provision must be made to insure that air intakes will not be located where snowmobile exhaust or other noxious fumes could be drawn into the building.



Interior Partition Makeup Air Assembly - Typical for Houses with Exposed Floor Soffits

Controls, Sequence of Operation:

Bathroom exhaust fan is controlled by a wall mounted switch in the bathroom, and a line voltage dehumidistat located in the main living area, so that fan runs whenever either is activated. Makeup air fans are powered by a wall-mounted 24V DC power supply located in the mechanical room. The power supply is connected to the exhaust fan circuit so that makeup air fans run whenever exhaust fan is running.



Schematic Wiring Diagram

Estimated Costs:

Installation cost for the exhaust fan, ductwork and wall cap should be similar to typical residential bathroom fans, plus an additional $100 or so for the higher quality, higher efficiency fan.

Total material cost per makeup air assembly should be about $35 for the ductwork, grilles and hood, $20 for the fan, and < $45 for the fan enclosure. (Note: For the prototype project, we were unable to find a suitable off-the-shelf fan enclosure, so we had a custom box fabricated by a local sheet metal shop. With further research and/or refinement, we would expect to reduce this cost significantly. In quantity, a complete assembly should be able to be made for < $100 materials, and less than 1 hour labor per assembly.

Controls consist of a $50 DC power supply, a wall switch and a line-voltage dehumidistat. Low voltage fans can be wired by mechanical contractor, using inexpensive "thermostat wire". The electrical installation is subject to less stringent requirements: (conduit, J-boxes, UL listing, electrician, etc. not required.)

A complete system should be able to be installed for less than $2,000.

Energy Use:

The selected exhaust fan draws 20 watts. Each DC makeup air fan draws 1.8 watts. Assuming 6 Each makeup air fan assemblies per household, total electric energy consumption will be about 20 + (6*1.8) < 32 Watts. If the system operates 16 hours per day, total energy use will be about 32 X 16 = 512 Watt-hours, or about 1/2 KWH per day.

Biorealis Systems has developed a web-based ventilation system economic calculator, available at http://www.biorealis.com/wwwroot/VentLoadCalcs5.html. Using this tool, you can enter your own values (in the yellow highlighted cells), and instantly see the results of any changes you make.

Building Information			
Length	28	LF	
Width	50	LF	
Ceiling Height	8.0	LF	
Floor Area	1,400	SF	
Heated Volume (VOL)	11,200	Ft^3	
Temperature Data			
Heating Degree Days (HDD)	11,000	HDD$_{65}$	
Desired Indoor Air Temp (IAT)	70.0	DegF	
Average Outdoor Air Temp (OAT)	34.9	DegF	
Energy Information			
Heat Value of Fuel	140,000	Btu/Unit	
Heating Fuel Cost	$1.76	$/Unit	
Cost of Electricity	$0.28	$/KWH	
Heating System Fuel Efficiency (EFF)	80.0%	AFUE	
Ventilation System Information	**HRV**	**ALT**	
Air Changes/Hour (ACH)	0.35	0.35	ACH
Continuous Air Flow Rate (CFM)	65	65	CFM
Hours per Day of Operation (Avg)	24	16	HRS
Electricity Usage	105	32	Watts
Sensible Recovery Efficiency (SRE)	65%	0%	%
Supply Air Temperature (SAT)	57.7	34.9	DegF
Temperature Difference (TD)	12.3	35.1	DegF
Installation Cost	$4,000	$2,000	$
Ventilation System Cost Comparison			
Heating Fuel	$119.45	$227.53	$/Year
Electricity	$257.54	$52.33	$/Year
SubTotal Operating Cost:	$377.00	$279.85	$/Year
Difference: HRV Costs $97.14 More per Year to operate.			
Simple Payback on Initial Investment: Never			

Ventilation System Economic Calculator: