ENERGY SAVINGS THROUGH RETROFIT FROM CONSTANT-VOLUME TERMINAL REHEAT TO VARIABLE AIR VOLUME SYSTEM

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Constant-volume air handling systems often present good opportunities for energy conservation by conversion to variable volume operation. The specific case offered by a constant-volume terminal reheat system is evaluated in this example.

Constant-volume terminal reheat systems supply conditioned air to the interior space of the building. Fresh outside air (ventilation air) is provided to these units from separate outside air dampers, which are split into fixed minimum and maximum air sections. The fixed minimum air section damper opens simultaneously when the fan is energized and the air is kept at around 55º F, which would require cooling the air stream in the summer and heating the air in the winter. When the outside air temperature is between 55º F and 60º F, no energy is added or removed from the fixed minimum air stream. The maximum air section of the outside dampers is interconnected to the return air dampers, and their motion is an opposing form of operation. This means that as one damper is completely closed, the other one is completely open, and any variation in between.

The position of the maximum-air-section damper and the return-air damper is determined by a mixed-air temperature controller. The mixed-air controller senses the temperature of the outside air and the temperature of the return air, and chooses the air stream with the greatest potential for heating or cooling. The fixed minimum-air streams and the maximum-air streams are combined before entering the supply-air fan, and from this point it flows throughout the air-distribution system. The air is then reheated at the various zones in the distribution system to get the desired discharge temperature of the air to satisfy the room load. The supply air is reheated with hot-water coils in the various zones, with the temperature of the air leaving the reheat coils determined by the sensor in the return-air stream, which tries to maintain a return-air temperature of approximately 75º F. This type of mechanical configuration is called a constant-volume terminal reheat system.

The constant-volume terminal reheat system is one of the simplest systems to design and does a very good job of controlling room comfort. However, this system wastes a relatively large amount of energy. The greatest waste of energy in this system is the continuous running of the supply and return fan motors at their full load. There is no need for a constant supply of conditioned air to the space when it is not required, based on the local demand. Also, the constant-volume terminal reheat system cannot be easily reset when there is a reduction in occupancy at night and during weekends. This system can be converted, however, to a Variable Air Volume system (VAV), which will save energy and satisfy the space needs.

As the name implies, the temperature of the space is controlled by varying the amount of air from the supply-air distribution system with a Variable Air-Volume system. This is accomplished by a space thermostat positioning the dampers in a VAV box to match the supply air to the space needs. This reduces reheat energy and fan energy. The reheat energy is saved because there will be moments when less supply air is needed than the minimum air supplies; therefore, a lower amount of energy will be needed to reheat the coils. A static pressure sensor will be installed in the duct system to transmit a signal to the frequency drive-type motor controller to reduce the fan speed in proportion to the decrease in air supply.

An alternating current fan motor works at its design speed and torque at 60 cycles per second, or 60 Hertz. A variable frequency motor controller controls the frequency of the alternating current supplied to the motor, thereby changing the speed of the motor. This saves energy and motor horsepower, which is equal to the speed-reduction ratio cubed times the original horsepower. This means that any reduction in supply air need translates into fan motor speed reduction, which translates into substantial fan horsepower reduction because of the cubed function. There are several methods that could be used with the VAV system to obtain savings in horsepower. However, the frequency-drive-type motor-controller method is the best technique for closely matching the cubed function in the horsepower savings equation. The VAV systems with the combination of lesser need for the reheat coils and the reduction in horsepower requirements will save a tangible amount of energy over the constant-volume terminal reheat system.

Variable-frequency drives can accomplish substantial energy savings, mainly for centrifugal loads with varying demands. A minor reduction of 10% in cubic feet per minute of air can yield a 27% reduction in energy savings. Furthermore, a 20% reduction in fan speed can reduce electric energy consumption by 50% (see illustration). Any equipment with variable loads such as fans, pumps, and others is a good candidate for retrofit with variable-frequency drive technology.

The Energy Effects on Fan Horsepower by Reducing the Quantity of Air the Fan Supplies

Fan Law: $H_1 = H_2 \text{ x } (Q_1 / Q_2)^3$

H_1 = New Horsepower

H_2 = Original Horsepower

Q_1 = New CFM

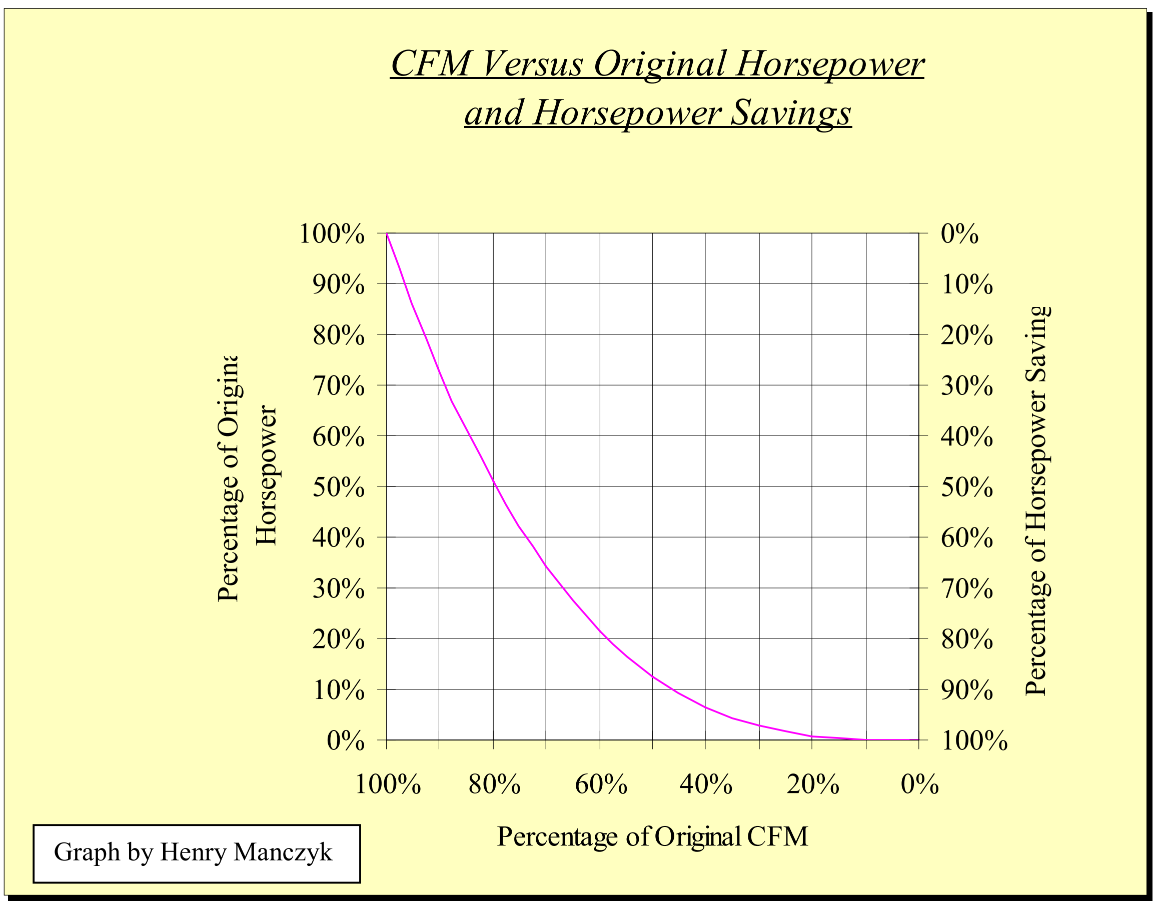
Q_2 = Original CFM

Example #1:

10% Reduction in CFM or 90% of Original CFM

$$H_1 = 1 \times \left(\frac{100\% - 10\%}{100\%}\right)^3 = 1 \times (0.9)^3 = 0.729$$

H_1 = 72.9% of the Original Horsepower
Savings in Horsepower = 1 - 0.729 = 27.1%



Constant Volume Terminal Reheat System

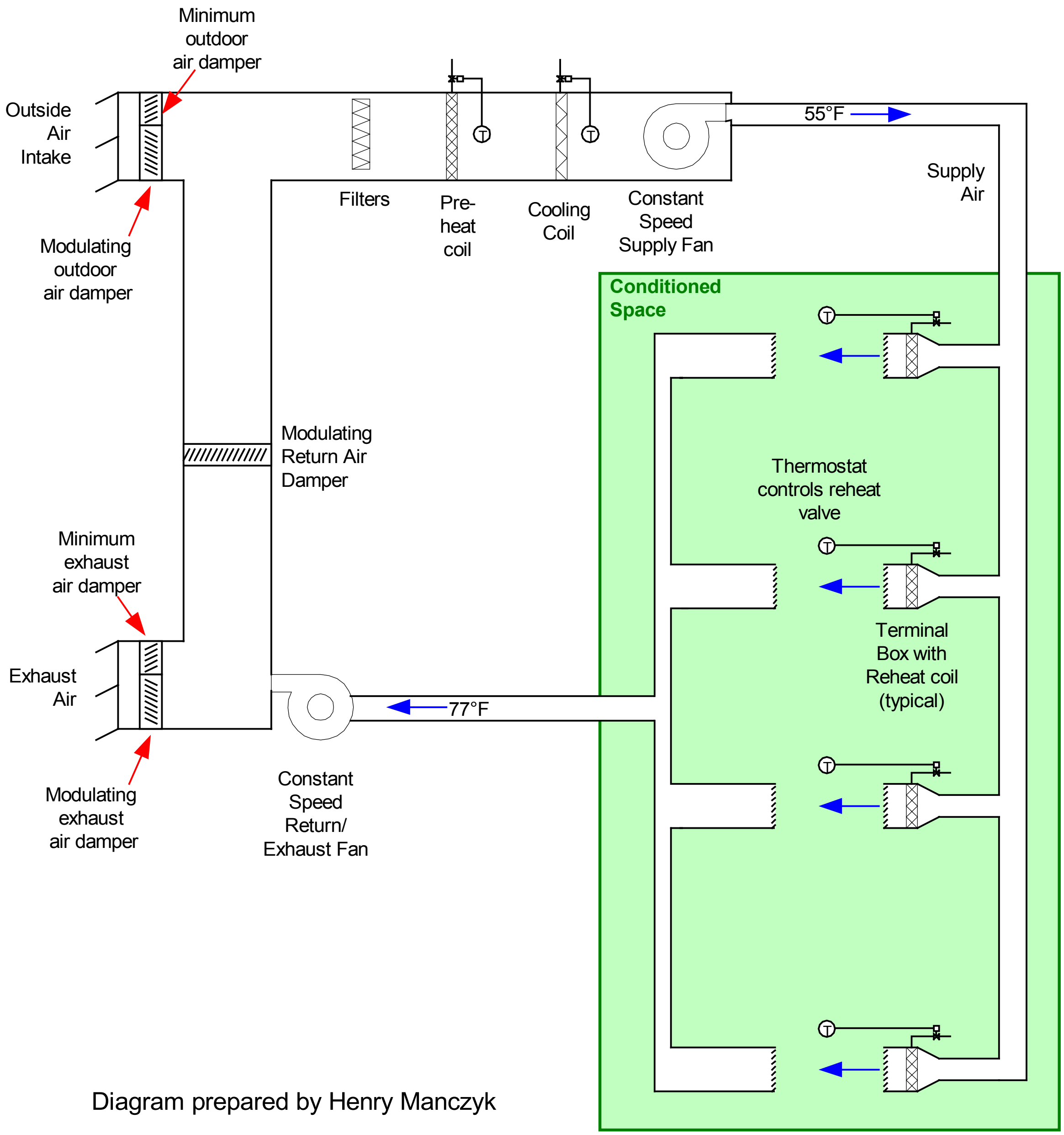
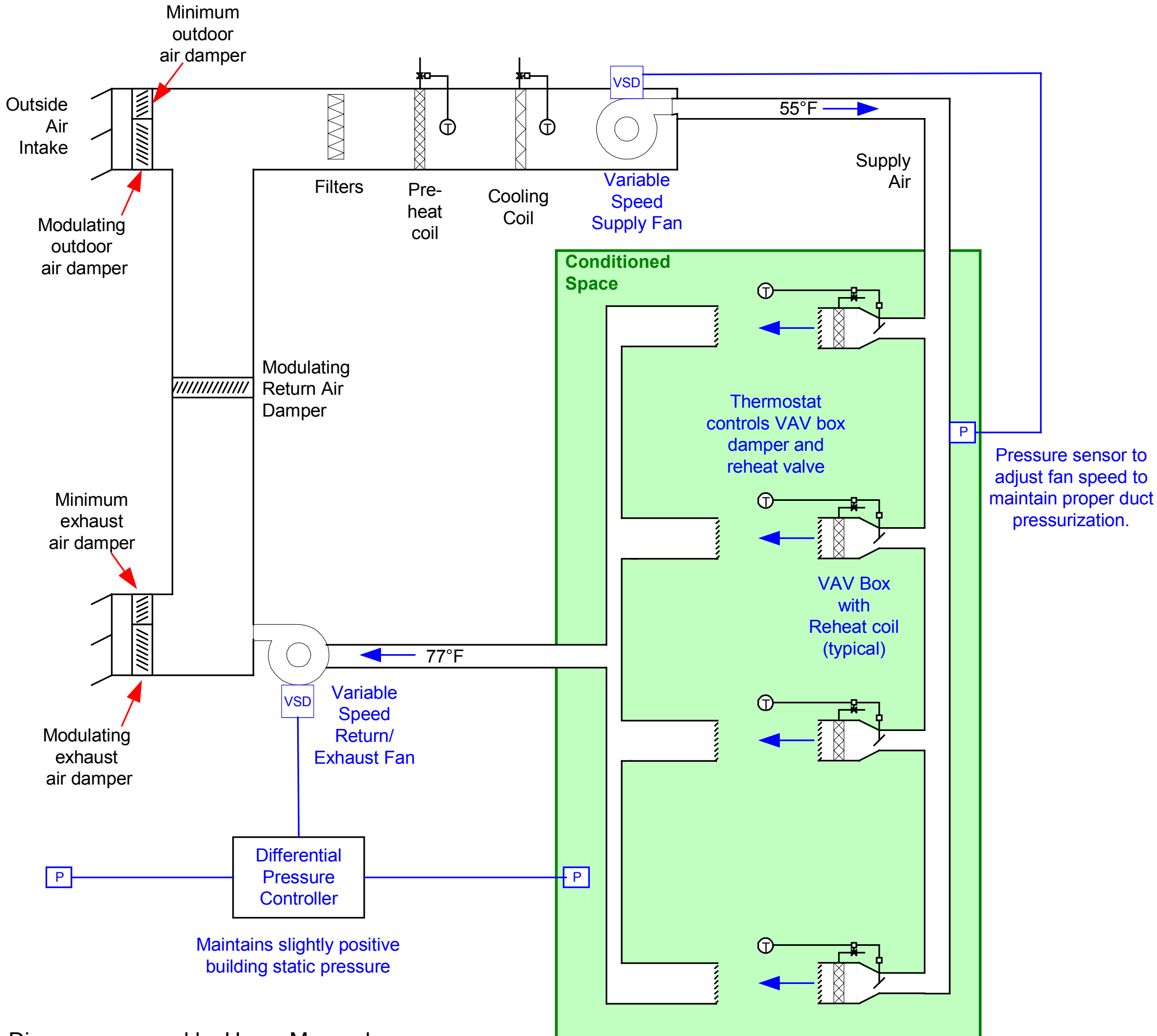


Diagram prepared by Henry Manczyk

Modifications to Terminal Reheat System for Variable Air Volume Operation



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