Residential Evaporative Air Conditioning Design

*by W. T. Welchert, P.E.**

In the Southwest, summer cooling is as necessary as winter heating. Cooling by refrigeration is preferred for maximum comfort, but energy conservation and economy greatly favor the evaporative air conditioner.

The normal construction allowance for a medium-sized evaporative cooling installation varies from 300 to 500 dollars. This allowance covers the evaporative cooler, the roof jack and stand, a water supply line, damper slides for the cooler and furnace, and the electric service and control system.

The cost of electric and water consumption is about two dollars per month per thousand cubic feet per minute (CFM) of rated cooler capacity. Pad and cooler maintenance will average about 15 dollars per year. In contrast, the energy and maintenance cost of operating a home refrigeration system is about 5 times greater than an evaporative system.

*Extension Agricultural Engineer

Cooler Package Specifications

Air flow capacity, wet pad medium, and salt deposit control are important cooler specifications.

A professional engineer should be consulted to determine the capacity required for a complex design. Heat load analysis and other thermody-

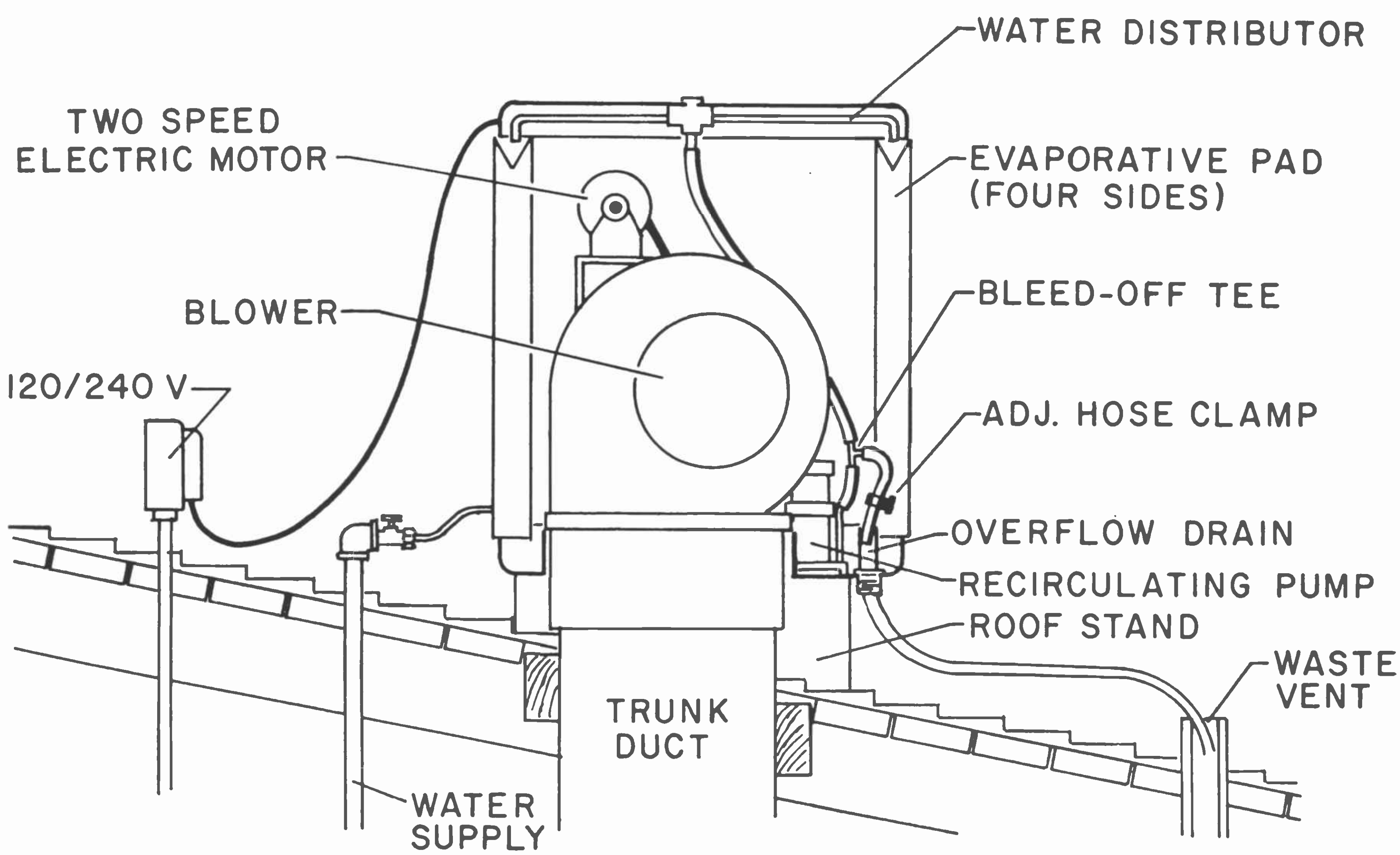

Figure 1. Typical Wet Pad Evaporative Air Conditioner.

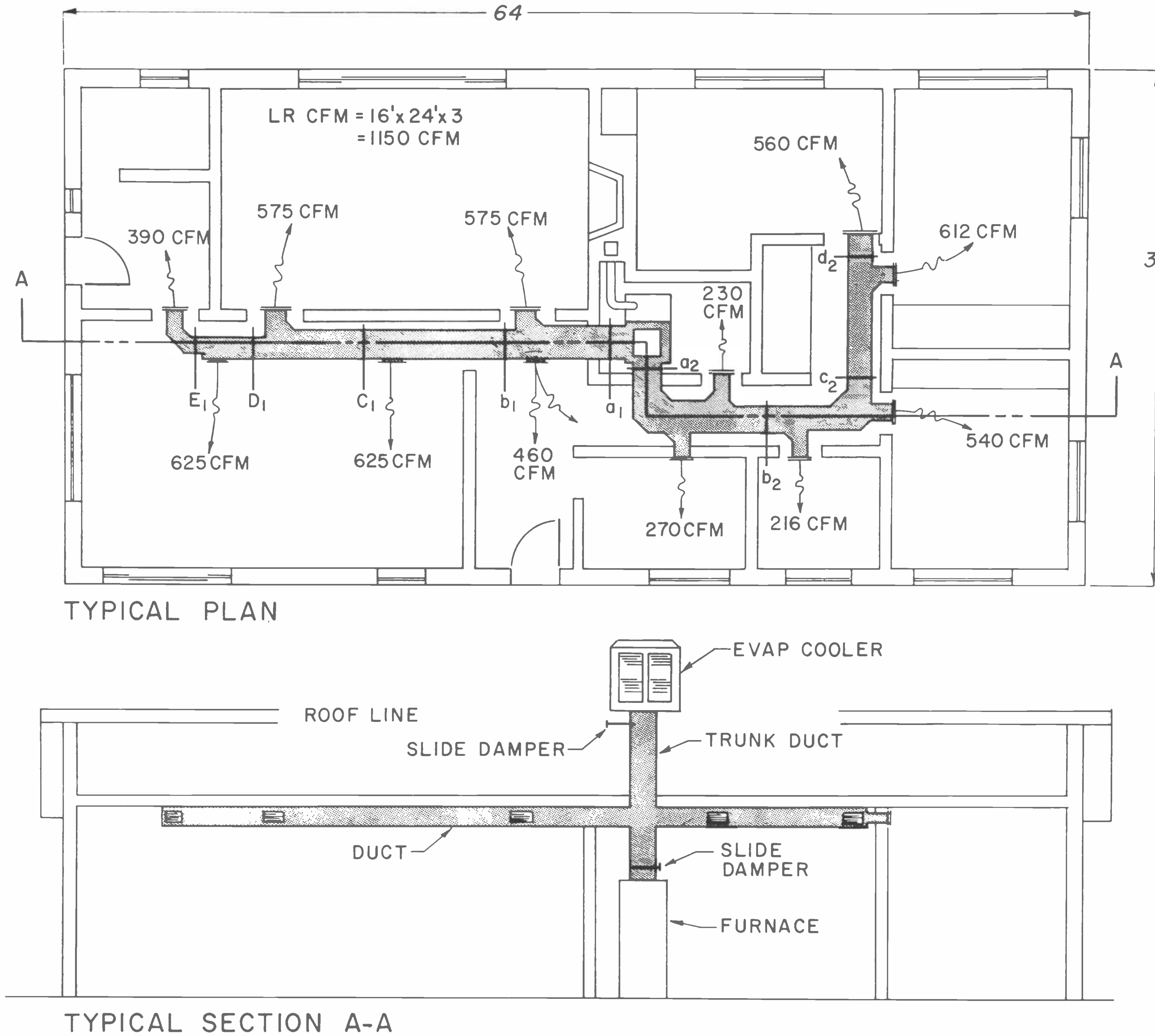

Figure 2. Typical Duct and Register Layout Example.

namic procedures are available in the ASHRAE[1] Guide. However, for residential evaporative cooling, a shortcut sizing method is adequate. Calculate the volume of the house or space to be cooled. Specify one air change every 2½ minutes at free air delivery or one air change every 3 minutes at ⅛″ water guage (⅛″ W. G.).

Most manufacturers rate package evaporative coolers at free air delivery or zero static pressure. When operating near the normal residential pressure of ⅛″ W. G. the air delivery is about 85 percent of the free air or catalog rating.

Where comfort control is important specify a two-speed cooler package. High speed is used during the heat of the day and low speed at night when the cooling load is reduced. Moreover, low speed provides ⅔ the air flow for about 30% of the high speed power input. The 3 phase 220 volt motor option is more efficient and economical.

The most effective pad material is aspenwood fibers commonly referred to as excelsior. To reduce salt accumulation, install a "Tee" in the sump supply line equipped with a "bleed off" adjustment[2] and sufficient drain line to connect with a waste vent pipe on the roof (Figure 1).

Duct Design

Evaporative coolers move about five times as much air as the heater fan. Hence, ducts and registers are designed to fit the cooling require-

[1] *American Society of Heating, Refrigeration and Air Conditioning Engineers.*

[2] *Adjust "bleed off" to flow one quart per minute for a 5000 CFM cooler (.05 GPM per 1000 CFM).*

ments. This results in low register velocities when the system is used for heating. To reduce this conflict, registers with adjustable blades set on one-inch centers are available. For cooling, the blades are fully open to minimize the resistance to air flow, and for heating, half or more of the register area is closed.

Manual slide dampers are installed in the cooler and furnace plenums so that each can be isolated from the other.

Duct sections can be sized by several methods. For simple residential systems (50′ or less center duct system), the modified velocity reduction method is adequate. Beginning with the design velocity of the fan outlet, the velocity in each section of the duct is assumed in accord with good design practice and these velocities are reduced in each succeeding section after various branches or outlets are taken off. The following is a simple example of this method based on dimensions of a typical floor plan shown in Figure 2.

1. Determine cooler capacity at 1/8″ W. G.

   Air change capacity = 32′ x 64′ x 8′ x 1 CHG/3 minutes = 5500 CFM

   From catalog:
   a typical 6500/4500 CFM model on high speed delivers about 5600 CFM at 1/8″ W.G.

2. Plan the duct and register layout

3. Calculate room register capacity at 3.0± .3 CFM per square foot of floor area. Calculate net register area at one square inch for each 5.5± .5 CFM of air flow. To compensate for bars and blades divide the net area by the fractional free area listed in the catalog to get gross register area.

   For living room in Figure 2:
   Room Register Capacity = 16 x 24 x 3 = 1152 CFM

   Net Register Area = 1152 CFM ÷ 5.5 CFM/in^2 = 210 in^2

   For a 75% free air register:
   Register area = 210 in^2 ÷ .75 = 280 in^2

   Select one 10″ x 28″ or two[3] 10″ x 14″ registers

4. The cross-section of each duct is designed for a specific air velocity. The manufacturer has fixed the cooler outlet cross-section to exhaust at about 1600 feet per minute (FPM). Beginning at the cooler outlet, the trunk duct should be the same dimension as the cooler outlet. Proceeding to the largest branch, design the the section at 1400 FPM. This section must carry all the air serving the rooms to the left, a total of 3250 CFM. At the second, third, and fourth sections, reduce the section velocity to 1200, 1000, and 800 FPM respectively. Assume a constant duct depth compatible with available register size and construction convenience. Proceed in the same manner for the second branch.

   The table below lists the calculated values for each duct section for the example shown in Figure 2.

[3] *For more uniform air distribution select two registers when convenient.*

Table 1. Examples of Calculated Values for Each Duct Section.

Section	*Flow CFM*		*Velocity FPM*	*Area ft.^{2}*	*Duct Dimension inch x inch*
Trunk	**5600**	÷	**1600**	**3.50**	**22.5 x 22.5**
a_1	**3250**	÷	**1400**	**2.32**	**12 x 28.0**
b_1	**2215**	÷	**1200**	**1.86**	**12 x 22.3**
c_1	**1590**	÷	**1000**	**1.59**	**12 x 19.1**
d_1	**1015**	÷	**800**	**1.27**	**12 x 15.2**
e_1	**390**	÷	**800**	**.50**	**12 x 6.0**
a_2	**2428**	÷	**1400**	**1.74**	**12 x 21.0**
b_2	**1928**	÷	**1200**	**1.60**	**12 x 19.2**
c_2	**1172**	÷	**1000**	**1.17**	**12 x 14.0**
d_2	**560**	÷	**800**	**.70**	**12 x 8.5**

Exhaust Area

Evaporative coolers bring fresh air into the house, all of which much be exhausted at the same rate. The effectiveness of the cooling is largely dependent on the uniform distribution of the required exhaust area. If the air is not readily removed, there will be a noticeable build-up of humidity and little effective cooling. It is good practice to provide an exhaust area of about three times the discharge opening of the cooler. Windows can be cracked open uniformly throughout the house or opened proportionate to the desired cool air distribution. If the cooler is undersized, reduce the air flow through the bedrooms during the day and open the windows slightly more in the living area. An excellent method of air exhaust is through the attic, to cool it and thus reduce another heat influence. A "helper" fan can also be added to exhaust air from a poorly ventilated area.

Controls

Evaporative coolers are usually operated with manual switch controls. The lowest temperature that can result is several degrees above the prevailing wet bulb temperature, so overcooling occurs only during periods of very low humidity.

Automatic control can be provided by inserting a thermostat in the electric lines to the blower motor. Two stage thermostats are available for two speed motors. A time clock can also be used to operate the cooler for predetermined periods of each day when cooling is likely to be needed.

Control capabilities can be further enhanced by providing a separate switch for the water circulation pump so the cooler can also be used for ventilation.

Ventilation only for an hour or so during early morning hours will dry out the pads and help control pad odors.