TECH TIP #20

One of a series of dealer contractor technical advisories prepared by HARDI wholesalers as a customer service.

HEAT PUMP APPLICATION TIPS

In the beginning, designing and installing a heat pump system was considered by many to be no different than working with an ordinary air conditioner, or even the traditional warm air furnace. The factory package was said to be quickly fastened to a duct system, line power and thermostat leads easily brought to the unit, and that was it --- out, perhaps even in less time than it took to do a straight furnace job. If you knew furnace work you could handle heat pumps. Today, more people would be inclined to say if you know furnace work, you can readily learn to handle heat pump jobs.

Air handling is, of course, the common denominator. Knowing how to estimate building loads, locate and pick the correct diffusers, and size a duct system are essential skills in both heat pump and furnace work. But while fundamental principles of moving air are the same in both instances, practical considerations can bring about significant differences between systems. Let's consider a few of these practical necessities.

To begin with, a heat pump is more sensitive to variations in system air flow rates than a simple furnace. In furnace work the designer has considerably more latitude in his selection of maximum and minimum air volumes circulated before adversely affecting the furnace or system operation. Because the heating coil of a heat pump is in reality the condenser section of the refrigeration circuit, variations in system air flow directly affect head pressure and compressor efficiency.

This means that system resistance may be figured as accurately as possible to avoid reduced air flow through the heat pump. Streamlined, low loss fittings, graduated transitions, etc. should be used. Sometimes even slightly dirty filters can reduce air flow sufficiently to actuate high pressure cut-out controls. Any reduction in system flow reduces the Btu output of the machine --- highly undesirable when considering the cost to produce each Btu.

A narrow range of permissible flow rates also generally precludes the simple use of zone dampers for heat pumps -- unless a constant volume flow rate can be **guaranteed** when one or more zone dampers are closed. Furthermore, any outside fresh air or makeup air connection should be arranged so that the cold air/return air mixture is not below 65º F when blowing over the coil. Cold air lowers head pressure causing low suction pressure, which in turn may prompt unnecessary defrost cycles, thereby effectively reducing Btu output.

In straight furnace work, designers are usually working with an air rise of from 40º F to 60º F through the equipment. With heat pumps, 10º F to 30º F rises are typical -- although with auxiliary heaters energized, temperature rises up to 60º F between return intake and supply plenum are possible.

(continued)

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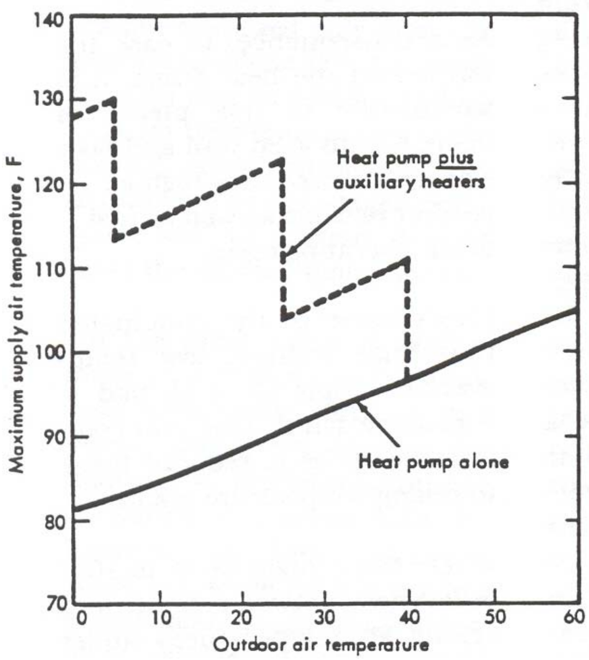

The solid line in Figure 1 shows the maximum supply air temperature leaving a typical 3 ton heat pump (1200 CFM flowing) as a function of outdoor temperature. Note that the values range from just over 80º F to about 105º F --- cold air, by furnace standards.

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The broken lines indicate supply air temperature as various stages of auxiliary heaters might be energized to augment decreasing air source heat pump output and in the face of increasing building losses. Three 6 Kw steps are indicated, although 3 and 4 Kw increments are frequently used as well.

All this means is that a heat pump circulates more air and at a lower temperature than a furnace to condition a building. But such conditions (high volume, low temperature air) suggest the need for greater care in locating, selecting and sizing supply outlets in order to avoid drafts and noise.

Furthermore, in the past, a warm air system has been known as a combination panel-convection heating system because the hot ducts running between joists and stud spaces cause a measurable panel heating effect. Heat pump systems appear to be more nearly convection only heating plants. And so, on many of those jobs when panel effect saved the day, say by keeping the floor over the unheated crawl space warm, the application of a heat pump system may prove to require a *directly* heated crawl space to achieve the same comfort vote from the occupants. In fact, the old **cold 70º F** complaint may at times arise again to haunt contractors installing heat pumps, only this time for a different reason -- little or no panel heating effect rather than only off-time of blower and burner.

As a consequence, to ease the burden on the heat pump, it is worthwhile to use plenty of insulation to keep wall and floor surface temperatures high for comfort reasons as well as just to cut operating costs.

Don’t come to the conclusion that high volume, low temperature supply air is all bad --- because it isn’t. One real comfort advantage is reduced floor-to-ceiling temperature gradients.

Where there might be 8º F to 10º F difference between floor and ceiling air temperatures under ordinary flow conditions, high volume, low temperature air can very often limit variances to 4º F to 6º F.

The subject of cold 70º F logically leads to the control of heat pump equipment. Basically, packaged air source units are controlled by 1) a two-stage room thermostat actuating the compressor on the first stage, and several stages of auxiliary in conjunction with outdoor thermostats set to close at selected outdoor temperatures on the second stage; 2) same as before, only with a single-stage thermostat; and 3) a single-stage thermostat operating a sequencing device --- say a motor-driven switching arrangement that energizes compressor and auxiliary heaters in steps according to demand time of the thermostat.

Figures 2 and 3 illustrate these basic circuits

Fig. 2

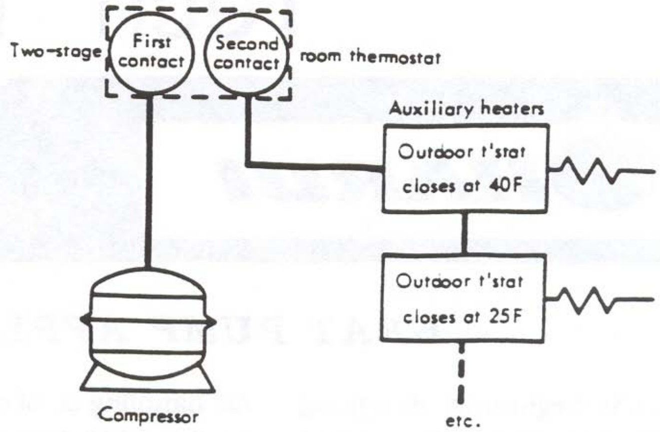
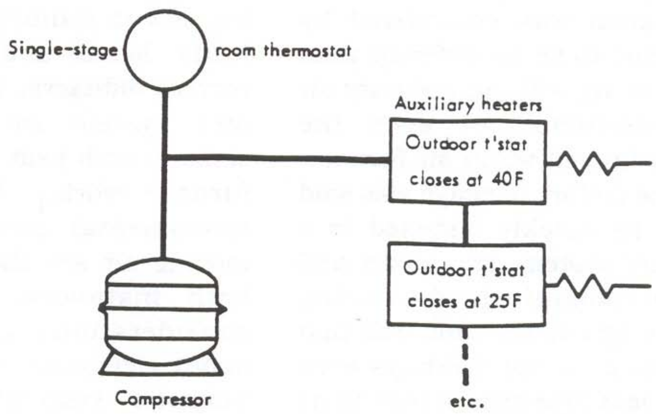


Fig. 3



TWO-STAGE thermostat (top) is the most economical way to operate heat pump, but the single-stage model (above) provides closer temperature control. For both, adding strip heaters in cold weather increases temperature swing.

The two stage system (Fig. 2) is the most common, as it offers the most economical method of control. Costly auxiliary heaters are energized only after the heat pump alone fails to satisfy the load and an additional drop in room temperature closes the second stage contacts. The actual number of stages energized will of course depend upon the outdoor temperature.

On the other hand, a single stage control initiates auxiliary heat right along with the heat pump, with every demand for heating --- providing outdoor thermostats in series with the heaters are closed as well. While two-stage control is more economical, single-stage operation provides closer control of room temperatures.

In furnace work, it is normally expected that room temperature variations (peaks and valleys) will be smaller in colder weather than on mild days because of longer periods of burner operation with increasing loads. Under the control methods depicted in Figures 2 and 3, tests have shown that the heat pump experiences an opposite effect. That is: in colder weather, variations are greater than on milder days.

The reason for this reverse effect appears to be that on cold days all the auxiliary heaters *plus* the compressors are cycled on-off, and the heat pump package acts like a huge oversized furnace that must blast on and off rapidly. Consider the performance if all 18 or 20 Kw of an electric furnace was cycled on and off. In one test where three 6 Kw stages of auxiliary heat were cycled with a 3 ton machine, room temperature variations increased from less than 1 degree in mild weather to 3 degrees in cold weather when all three stages were required and cycled together. A 3 degree swing is obviously considerably more than would be expected of a simple warm air system.

Not surprisingly, there is no furnace analogy to the need to periodically defrost a heat pump. Frost accumulation on the outdoor coil must be removed to obtain peak heat transfer efficiency from the unit.

Once feared as a real problem, it has been demonstrated that a defrost cycle does not have any significantly adverse effects on the room comfort in a home. One test has shown that on a day when over 35 defrost cycles were initiated, the effect on indoor comfort was much less than a normal temperature swing during an ordinary on-off cycle. Under the worst of conditions (no strip heater energized) the room temperature dropped less than 0.7 degrees during a defrost cycle that was quickly regained. With auxiliary heat energized during defrost, a 0.2 drop in room temperature was observed or for practical purposes, no change occurred.

In addition to the factors already discussed, other details such as how to protect the outdoor coil against snow drifts; how to provide good drainage so that water from defrost cannot refreeze and build up at the base of the unit, also help to make the heat pump a different application. The heat pump is no furnace. But contractors with a good background in warm air fundamentals can easily acquire that extra know how to do a proper heat pump design.