MEASURE 2.4.6 Avoid recirculation of air through the same or adjacent heat rejection units.

RATINGS

New Facilities	Retrofit	O&M
A	C	

SUMMARY

Corrections for common installation problems that waste fan energy, reduce chiller efficiency, and reduce capacity.

SELECTION SCORECARD

Savings Potential .... $

Rate of Return, New Facilities %%

Rate of Return, Retrofit .... %

Reliability .... ✓✓✓✓

Ease of Retrofit...................... ☺

The way a heat rejection unit is installed may cause air to circulate from the discharge back to the intake. The recirculated air has little remaining cooling capacity, so recirculation wastes fan energy, reduces the capacity of the cooling unit, and increases the increased condensing temperature.

A similar problem may occur where cooling units are installed adjacent to each other. In this case, the discharge from one cooling unit may be drawn into the intake of another.

Take a look at all your heat rejection units to see whether recirculation may be a problem. The possibility of significant recirculation varies with wind, temperature, and humidity. Consider all the possibilities.

How Much Energy is Really Being Wasted?

You may be able to spot a recirculation problem by observing the vapor plume of a heat rejection unit, but don't expect to judge the severity of the problem from the appearance alone. A few wisps of water vapor recirculating back to the intake do not necessarily indicate a significant problem, although they may. On the other hand, serious recirculation may occur invisibly during warm or dry weather, when the discharge is invisible.

Judge the potential for energy waste by examining the installation to see whether it has any of the characteristics that tend to cause recirculation, which are explained below. Then, if you suspect trouble, you can estimate the percentage of recirculation easily by taking air temperature or humidity measurements under a variety of typical wind conditions.

The air temperature and humidity at the intake of the heat rejection unit should be the same as the temperature and humidity of free air away from the unit. If the intake air is warmer or more humid, then some recirculation is occurring.

To estimate the amount of recirculation in dry coolers, use Formula 1, making the air temperature measurements indicated.

Formula 1 is not accurate for wet coolers, because they perform a large fraction of cooling by evaporation. Formula 1 may still give you a rough estimate of recirculation under humid conditions, when evaporation is limited.

For an accurate estimate of recirculation in a wet cooler, use Formula 2. Measure the humidity with a psychrometer (see Figure 1 in Measure 2.2.2.1) or relative humidity sensor, and convert to absolute units by using a psychrometric chart.

If the cooling unit does not have a localized intake point where you can take readings, take an average of

FORMULA 1

for dry coolers,

$$\textbf{Percent recirculation} = \frac{\textbf{intake temperature - ambient temperature}}{\textbf{discharge temperature - ambient temperature}} \times 100$$

where:

- **the temperatures can be expressed in any consistent set of units**

FORMULA 2

for wet coolers,

$$\textbf{Percent recirculation} = \frac{\textbf{intake humidity - ambient humidity}}{\textbf{discharge humidity - ambient humidity}} \times 100$$

where:

- **humidity is expressed in absolute units of moisture content, for example, grains of moisture per pound of air** readings around the unit, especially upwind and downwind.

If you find that significant recirculation occurs under conditions that exist often, consider corrective measures.

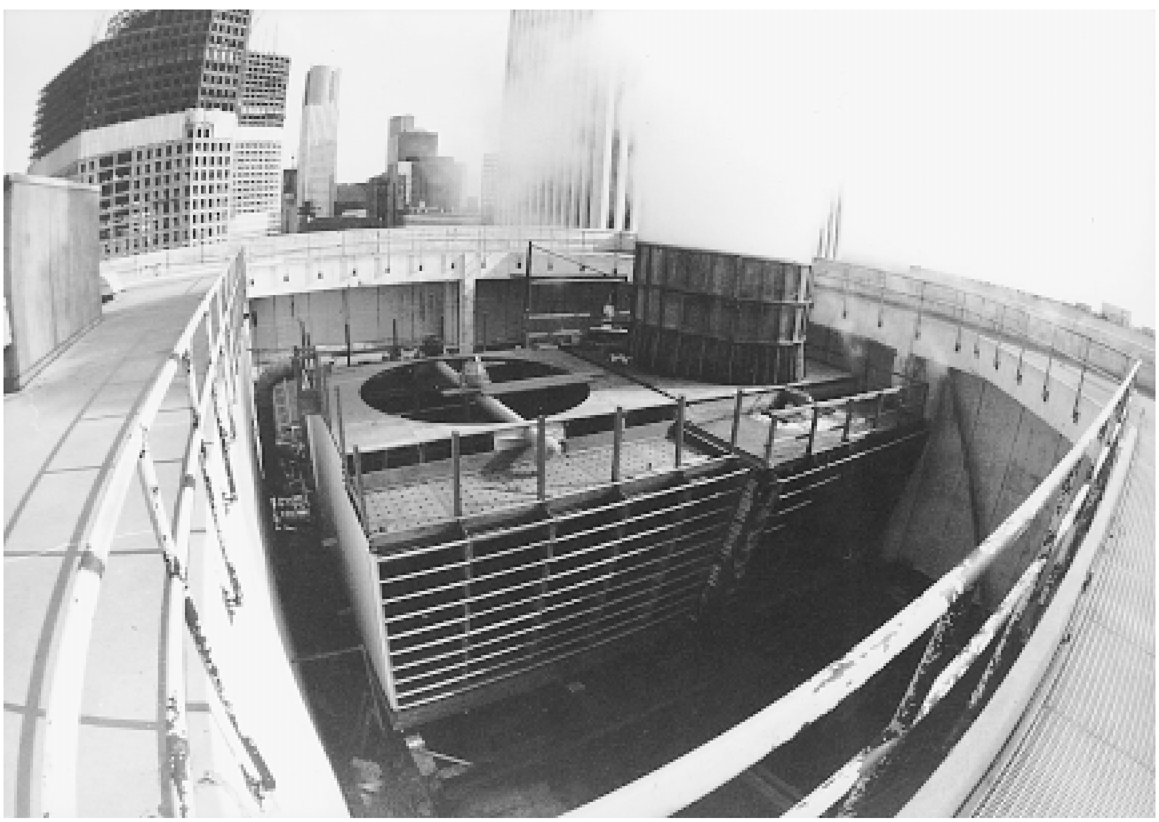
What Determines the Amount of Recirculation

The design of the cooling unit and the way it is installed tell whether the unit is likely to have recirculation problems. Consider these are factors:

- ***discharge velocity.*** Recirculation is reduced by high discharge velocity, which throws the discharge air away from the unit. The discharge air is warmer than the ambient air, so it tends to rise clear of the unit once it is beyond the influence of air currents in the vicinity of the unit.
- ***intake velocity.*** Recirculation is increased by high inlet velocity, which creates a low-pressure area near the inlet that attracts recirculation. High intake velocity may be caused by a small intake size in the cooling unit. It may also be caused by a tight air passage leading to the unit.
- ***fan modulation.*** A variable-flow fan may increase recirculation by reducing the discharge velocity, especially at low loads. However, the intake velocity is reduced in the same proportion, which tends to reduce recirculation into the same unit. Furthermore, fan speed is controlled in response to cooling load, so any loss of cooling capacity is compensated automatically by increased fan output. Fan power is wasted, but chiller efficiency may not be seriously affected. Fan modulation is not likely

WESINC

Fig. 1 Horizontal-flow cooling tower If wind blows opposite the direction of discharge, a certain amount of recirculation will occur. Recirculation is aggravated by the location of the tower alongside a wall. This type of tower causes serious recirculation to any other heat rejection units located in the general direction of the discharge.



WESINC

Fig. 2 Cooling tower installed in a well This installation invites serious recirculation. A stack has been installed on the fan on the right to minimize recirculation. Even so, you can see that some of the discharge is being drawn back down into the cooling tower. The discharge plume is visible because of the high relative humidity in this location.

to cause recirculation unless the air flow around the tower is confined.

- ***wind speed.*** Wind blows the discharge air in a downwind direction. Wind also creates a suction on the downwind side of the cooling unit because the unit is not streamlined. Therefore, discharge air tends to tumble into the downwind side of the same or adjacent units. You can reduce this effect by shielding the unit from wind, but the structure used for shielding may cause recirculation itself, as explained below.
- ***orientation and wind direction.*** If a heat rejection unit does not discharge vertically, its orientation is important. Figure 1 shows a unit that discharges horizontally. If the unit discharges into the wind, a significant amount of recirculation is likely. Also, a unit that discharges horizontally is likely to inject warm air into adjacent cooling units.

  More generally, an air inlet located on the downwind side of any cooling tower tends to recirculate air. Wind direction is variable, so some recirculation is likely to occur for part of the time.
- ***enclosures and surrounding structures.*** Serious recirculation is likely if a heat rejection unit is surrounded. For example, the unit may be hidden by a decorative enclosure, or it may be installed in a well. The problem is especially severe if the enclosure rises to the top of the cooling unit or higher. Figure 2 shows an extreme case. This geometry forces the incoming air to pass near the exiting air stream, which invites mixing. This effect is aggravated by wind, which tips the discharge air column into the entering flow.
- ***adjacent structures.*** Tall parapets and adjacent buildings that are upwind of the cooling unit may have strong downdrafts that mix the discharge air with the entering air. In some cases, a downdraft may exist far downstream of its source.

All other factors being equal, the least recirculation occurs in induced-draft heat rejection units, i.e., units in which the fans are located at the discharge end of the unit. These units have relatively high discharge velocity and relatively low inlet velocity. Most dry coolers use an induced-draft fan arrangement, as do most crossflow cooling towers.

Updraft, or counterflow, cooling towers typically have a forced-draft fan arrangement, i.e., with the fan blowing into the tower. These units have relatively low discharge velocity and relatively high inlet velocity, so they are more susceptible to recirculation.

How to Minimize Recirculation

The following is a menu of techniques for reducing recirculation. The best solution for your equipment is a matter of layout, cost, appearance, and other factors. Consider combining some of these methods, if appropriate.

■ Modify the Enclosure to Reduce Recirculation

As explained previously, enclosures that surround a heat rejection unit tend to cause recirculation. The severity of this effect depends on the relative height of the enclosure. If the top of the enclosure is as high as the discharge point or higher, contact between the entering and leaving air streams is almost unavoidable. You can avoid this problem or reduce it by modifying the enclosure. Here are some ways to do this:

- ***install cutouts at the bottom of the enclosure*** to allow air to enter, as illustrated in Figure 3. Make the cutouts large enough. If there is a prevailing wind during the cooling season, try to install the cutouts on the windward side. This technique may be inexpensive, and it preserves the decorative screening effect of the enclosure, especially where the unit is installed on a roof.
- ***substitute open latticework*** for unbroken panels, as illustrated in Figure 3
- ***reduce the height of the enclosure*** as much as possible. If the unit is located well above viewers, the enclosure does not have to be as tall as the cooling unit to hide the unit completely. The esthetics of the building may even allow a glimpse of the upper portion of the unit.
- ***increase the clearance*** between the enclosure and the inlet sides of the heat rejection unit.

■ Install an Exhaust Stack on the Heat Rejection Unit

Adding a stack to the cooling unit is a way of raising the discharge point without raising the heat rejection unit itself. Figure 4 sketches how this is done. Figure 2 shows an actual retrofit of a stack to an existing cooling tower.

Figure 5 shows how a stack can reduce recirculation that is caused by the cooling tower being installed close to a wall.

The cross sectional area of the stack should be the same as the cross sectional area of the original discharge of the heat rejection unit. This is important to maintain the discharge velocity. A stack that is reasonably short, i.e., no taller than several diameters, does not significantly increase fan power.

If the stack is tapered toward the outlet, the discharge velocity is raised. The higher velocity reduces recirculation. However, the fan power requirement increases because the fan must add more kinetic energy to the discharge air. The reduction of recirculation probably does not justify the increase in fan power, except in specialized circumstances.

If you install a stack, brace it well to withstand wind. You may have to brace a stack directly to the building structure, rather than to the heat rejection unit itself, if the heat rejection unit does not provide a strong attachment point.

■ Raise the Heat Rejection Unit Above Surrounding Structures

Raising a heat rejection unit may be the only available option if the unit is tightly enclosed within a well, or if you want to exploit wind to aid evaporation. Figure 4 sketches this solution. The cost of the supporting structure and the cost of modifying the piping makes it expensive.

The change in height does not affect cooling water pumping. The increased pressure needed to pump water to the top of the tower is balanced by the increased pressure in the return leg.

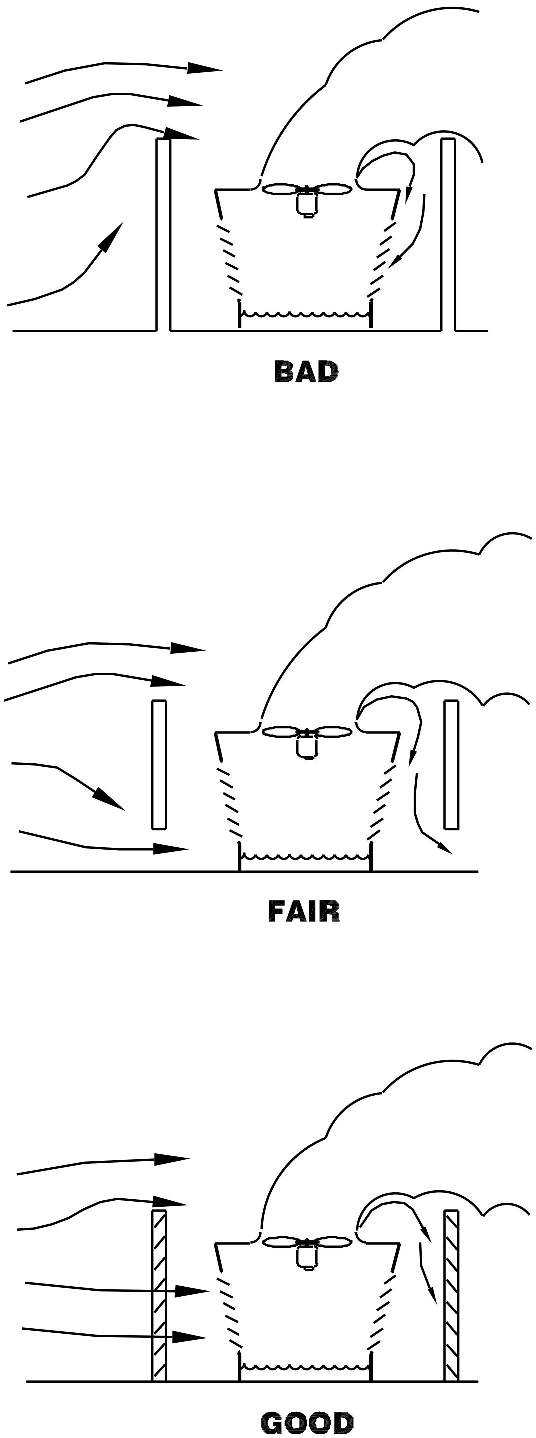


Fig. 3 How to reduce recirculation in an enclosure

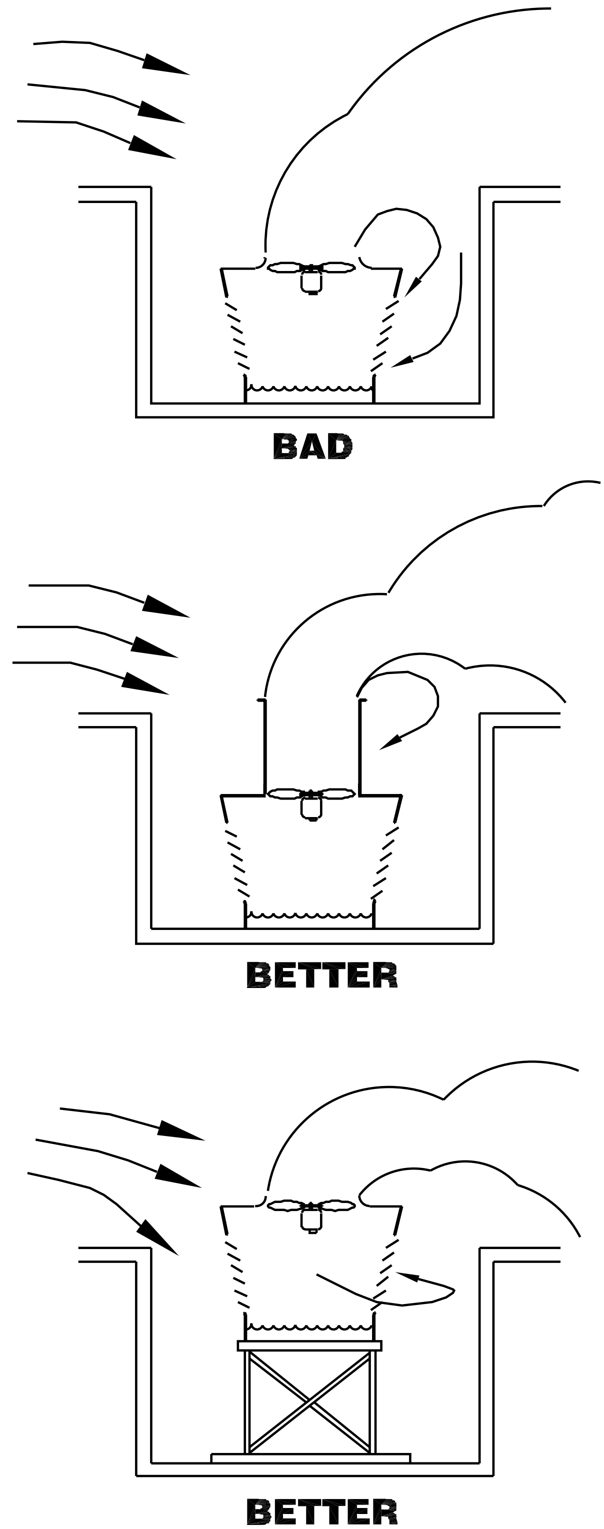


Fig. 4 How to reduce recirculation in a well

■ Isolate Adjacent Heat Rejection Units

If one heat rejection unit discharges toward the intake of another, install a barrier to deflect the discharge. Figure 6 sketches an example.

If adjacent heat rejection units all discharge vertically, a recirculation problem is not likely unless there are aggravating factors, such as those discussed previously.

■ Relocate the Heat Rejection Unit

An approach of last resort is to move the heat rejection unit to some other location. This is very expensive because of the costs of rigging, piping, and fabrication of support structures.

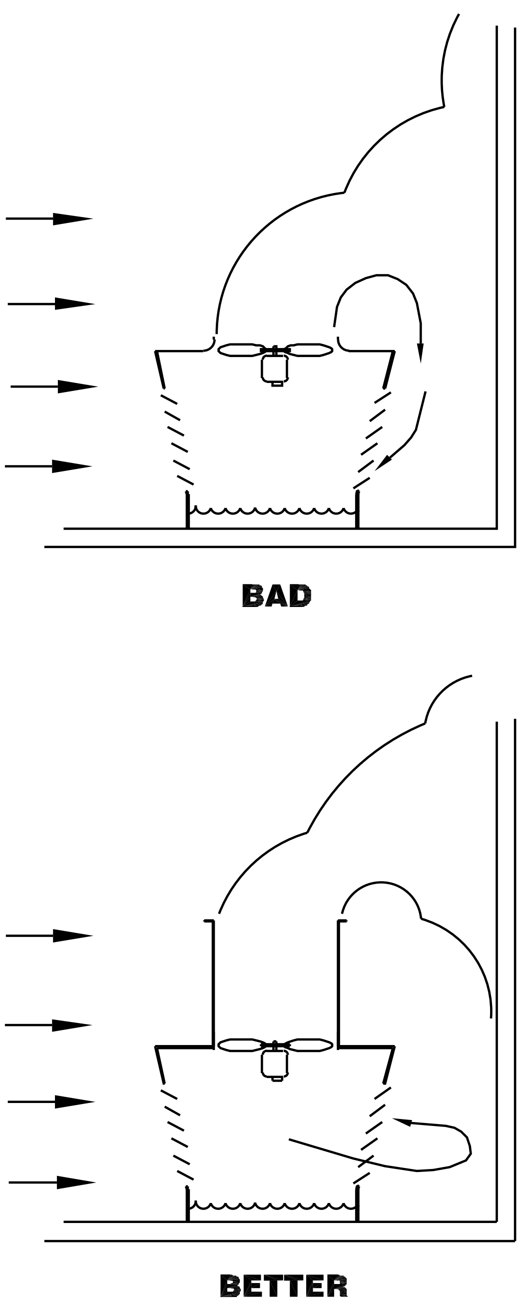


Fig. 5 How to reduce recirculation against a wall

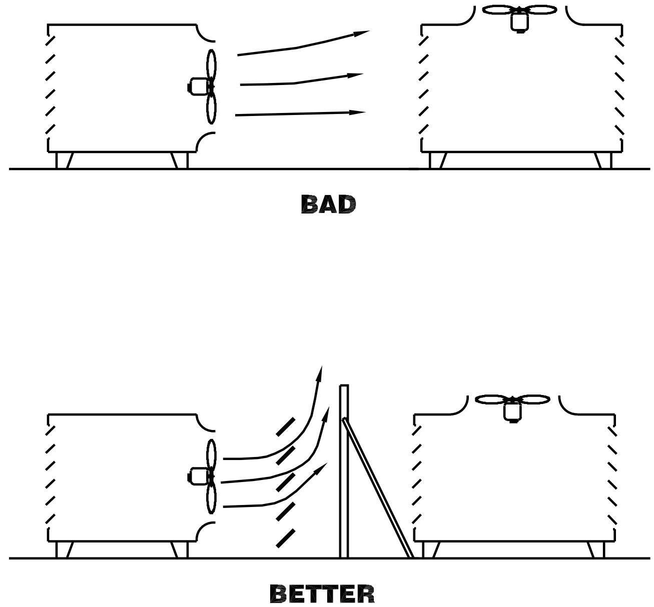


Fig. 6 How to reduce recirculation from one heat rejection unit to another

In deciding whether to move a heat rejection unit, consider whether you have an opportunity of moving the unit to a location where the ambient air is cooler, such as the shaded side of a building. This would be most valuable with dry coolers, whose condensing temperature relates directly to the dry-bulb temperature. Location is less relevant with wet coolers, whose condensing temperature depends on the wet-bulb temperature. The wet-bulb temperature of the air is not affected by shading.

Especially with wet coolers, consider any possibility of exploiting ambient wind to reduce fan power requirements.

ECONOMICS

SAVINGS POTENTIAL: *5 to 30 percent of the fan energy of the heat rejection unit. 0.1 to 2 percent of chiller energy consumption.*

COST: *In new construction, there may be little or no additional cost. In retrofit, modifications may cost less than one hundred dollars, to several thousand dollars.*

PAYBACK PERIOD: *Short, in new construction. One year to many years, in retrofit.*

TRAPS & TRICKS

ANALYZE THE PROBLEM: *Before you go to a lot of effort, make sure that you really have a problem. For example, do not worry about recirculation caused by strong north winds in winter if your chiller is loaded only during warm weather. Calculate the actual recirculation under conditions that matter. Then, if you have a problem, make sure that your intended solution will actually solve it.*