ENGINEERS NEWSLETTER

providing insights for today's HVAC system designer

How Low-Flow Systems Can Help You …

Give Your Customers What They Want

Throughput … fast-paced … downsized. We've all heard these terms and we know all too well their impact on our workload: there's more to do and less time to do it! The following table characterizes the daily dilemma that confronts us as we juggle many projects, i.e. what we're "forced" to do versus what we'd like to or should do. Does it strike a little too close to home?

"Forced" To …	But Would Like To …
■ Do it "close"	■ Do it right
■ Use rules of thumb	■ Use new technology when appropriate
■ Do it like I did the last time	■ Reengineer
■ Mundane work	■ Solve problems *and* have some FUN!
■ Get off the job	■ *Serve* the customer

The last point is perhaps the toughest to swallow because it suggests that we're allowing time constraints to compromise the service we render our customers. Given a lot more time per project, we could conduct an exhaustive analysis and arrive at a system design that optimizes the entire building. But investing even a little more time would enable us to serve each customer **better**. To get that extra bit of time means showing the customer that there's a sound business reason for making that investment. That shouldn't be difficult. After all, what are our customers really looking for? **Lower installed costs and lower operating costs.**

This newsletter describes an approach used successfully by some system designers to "buy a little more time" and better serve their customers. But first, a little history …

A Paradigm Shift

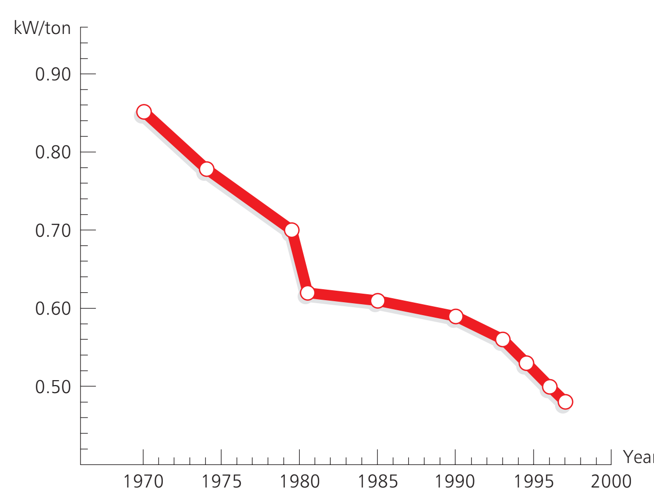
25 Years Ago … Many chilled water systems used a condenser flow rate of 3 gpm/ton. This yielded a temperature differential of approximately 10 F. Why did 3 gpm/ton and 10 F become the norm? We're not sure. But it worked, it became the "standard" test condition, and it's been that way ever since.

Yesterday … In the years that followed, chiller efficiency increased more than 75 percent: coefficient-of-performance (COP) ratings that were once 4.1 climbed to 7.2! However, that same period saw little improvement in the efficiency of cooling towers and pumps. Despite the significant improvement in chiller efficiency, 3 gpm/ton remained the "normal" condenser flow rate for chilled water plant designs.

With that brief history lesson, let's see how a small investment of time can help us do a better job of giving customers what they want.

Today … We can reduce system operating costs, sometimes dramatically, just by changing the amount of water

Figure 1
Centrifugal Chiller Performance History



flowing through the condenser. To demonstrate, let's compare a 450-ton chilled water system designed with "traditional" flow rates to one designed with lower-than-"normal" condenser water flow.

"Traditional" base design assumptions …

- 78 F wet bulb ("normal" for many humid climates)
- 85 F entering condenser water
- 2.4 gpm/ton evaporator flow rate (10 F ΔT)
- 3.0 gpm/ton condenser flow rate (~10 F ΔT)
- 30-foot pressure drop through condenser water piping
- 93-percent efficiency for pump and tower motors
- 75-percent pump efficiency

"Low-flow" design assumptions …

- 2.0 gpm/ton condenser flow rate (~15 F ΔT)
- same condenser water piping as base design
- same chiller as base design
- all other assumptions match those of the base design

Table 1 compares the operating conditions and resulting full-load energy consumption of the system. Notice that simply reducing the condenser water flow rate from 3 gpm/ton to 2 gpm/ton with the same chiller lowers the combined power consumption of the chiller, cooling tower and condenser water pump by nearly 2 percent!

(As we'll discuss later, "2 gpm/ton" isn't magic; but from a system standpoint, it often yields good performance.)

Another look at Table 1 reveals a second benefit of the low-flow design: it accommodates a smaller (less expensive) cooling tower and condenser water pump. What do our customers want? Lower installed costs and lower operating cost. The low-flow design delivers both.

Knowing that HVAC systems often operate at non-design conditions, let's see how the low-flow design fares at part load. Our example cooling tower and condenser water pump are constant-flow devices, so their power consumption remains unchanged. Table 2 indicates the example chiller's ARI-certified performance at several part-load conditions. Notice that chiller kW actually increases with the low-flow design.

But as Figure 2 (facing page) reveals, the low-flow system design costs less to operate at **all** load points. It also suggests that even if there's no savings at design conditions, the many hours spent operating at part load can still yield a significant cost savings. Your challenge is to "buy" enough time to explore this option on your next chilled water job. How much is "enough"? It shouldn't be more than 30 minutes—just long enough to select a chiller (ask the manufacturer), tower (ask the manufacturer) and pumps (ask the manufacturer); then add them up. The payoff is **value-added service for your customer** … and the likelihood of repeat business for you.

Table 1
Comparison Of System Design Conditions And Power Requirements[a]

System Component		Base Design	Low-Flow Design
Chiller …	Power consumption	**256.0 kW** (0.569 kW/ton)	**275.0 kW**[b] (0.611 kW/ton)
	Condenser pressure drop	19.9 ft	9.6 ft
Cooling tower …	Fan horsepower	30 hp **(24.1 kW)**	20 hp **(16.0 kW)**
	Static head	19.1 ft	12.6 ft
Condenser water (CW) circuit …	Piping pressure drop	30 ft	13.3 ft[c]
	Pump power	31.4 hp **(25.2 kW)**	10.8 hp **(8.7 kW)**
Chiller + Tower + CW Pump Power		**305.2 kW**	**299.7 kW**

[a] The chilled water pump was omitted to simplify this comparison since its power requirement is identical in both example systems.

[b] Yes, the chiller draws more power *but the meter is on the building.*

[c] Pressure drop through a pipe changes with the square of the flow: $30 \times (2/3)^2 = 13.3$.

Table 2
Chiller Power At Various Loads

Load	Base Design	Low-Flow Design
100%	256.0 kW	275.0 kW
75%	181.5 kW	193.5 kW
50%	125.0 kW	132.0 kW
25%	74.5 kW	79.0 kW

System Considerations

Low-flow designs are appropriate for both new and existing systems. Applications with long piping runs offer the greatest potential installed and operating cost savings.

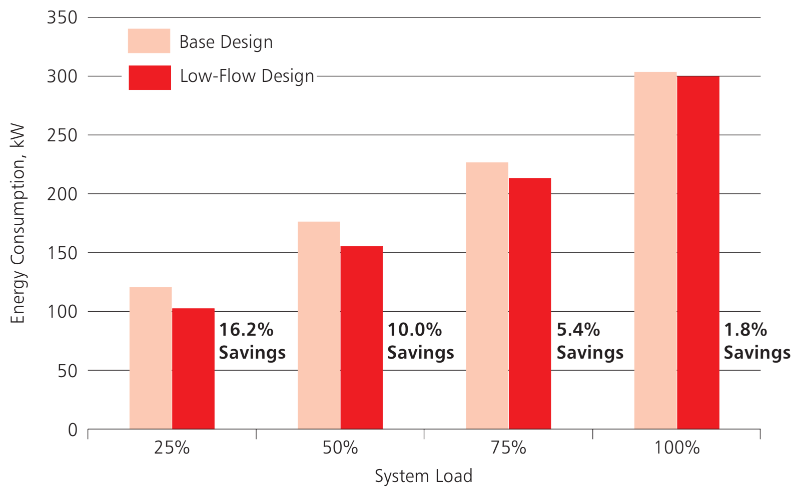
While our example was based on a fairly humid climate, many designers achieve comparable savings with low-flow applications in dry climates.

Note: *In existing systems, be sure to determine the minimum water flow rate needed to maintain efficient heat transfer at the cooling tower.*

Additional Design Options

Evaluating the options associated with an "untraditional" design concept such as low flow requires an additional investment of time. As system designers, we need to make sure that we're

Figure 2
System Energy Consumption Comparison



compensated for the value (i.e. reduced first costs and/or operating costs) we add when we make that investment.

Here are several options to consider as you evaluate the benefits a low-flow design can give the customer of your next chilled water plant project.

Option 1. The condenser water flow rate that yields the greatest operating cost savings isn't necessarily 2 gpm/ton. It depends on a number of variables and must be calculated for each job. Determining the optimum rate is an iterative task that can take hours if done manually. With the help of a PC-based tool like System Analyzer™, Trane's HVAC energy and economic analysis software, a preliminary examination should take just 30 to 60 minutes.

Note: *Significant operating cost savings are often achieved by reducing the condenser water flow rate. However, additional cost savings may be possible if you reduce the chilled water flow rate as well. Don't overlook this possibility when making your analysis.*

Option 2. Is a pipe size reduction practical? If so (and that's often the case, though it wasn't warranted for our example), you can also reduce the size of the valves. Both reductions lower the system's installed cost. The potential savings can be particularly substantial in applications with long piping runs (e.g. chiller in the basement, cooling tower on the roof).

One caveat: Reducing the pipe size increases pipe friction, so operating costs will increase.

With rare exception, the electrical meter measures building consumption. If you really want your design to add value, don't let anyone convince you or your customer to ignore any part of the system.

Our job, as system designers, is to present our customers with Option 1 **and** Option 2, and allow them to make the business decision between installed costs and operating costs.

Option 3. If sufficient, use the installed cost savings from the downsized pumps, towers and/or piping to purchase an even more efficient chiller. There's simply no substitute for raw efficiency.

Summary

All our customers really **want** are lower installed and operating costs.

- Low-flow systems allow you to offer your customer both lower installed and operating costs.
- It doesn't take long to examine the benefits of a low-flow system.
- Always remember: **the meter is on the building.**

Armed with this knowledge, let's shake off the "forced to" mentality and do what we'd like to: do it right … take advantage of new technology … reengineer … solve problems (having fun while we do) … and **really serve** our customers. ■

By Mick Schwedler PE, applications engineer, and Brenda Bradley, information designer, The Trane Company.

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