Variable speed circulation – the simple facts

BY JOHN VASTYAN

Rnowned Taco trainer John Barba opened a recent webcast this way: “I’m John Barba, and today’s topic is variable speed pumping. It’s not a new concept and it’s not very hard to do.

Well, I’m not John Barba, and that’s why the topic of variable speed hydronic circulation has been something of a mystery for me. But being the talented educator that he is, I’ve come to learn a lot more about the technology. I’m eager to share it with you.

John goes on to point out that 2004 was the year Britney Spears got married and broke his heart, twice. Also in 2004, America’s domestic engineer, Martha Stewart, was sent up the river for crimes against humanity. And, 2004 was also the year that Taco introduced the world to a full line of residential variable speed circulators. That was five years ago, but we’re still grappling with this “new” technology.

Let’s take a closer at the concept of variable-speed pumping. I’ve asked Barba and professional contractor Bill Riley (www.rileyplumbing.com) to explain when it’s best to apply the technology, where you’d use it, and what the key benefits are.

The universal hydronics formula

The purpose of a variable speed circulator is to automatically adjust its speed based on heating load demands, or how many BTUs are needed in a structure. To understand how it does that, let’s take a quick look at the universal hydronics formula for head loss of nine feet.

To size the pump for the total flow rate needed for the job, we know the need is for 7.5 GPM at nine feet of head to deliver 75,000 BTUs. Size for the worst-case head loss zone. If the circuit can overcome the head loss of the worst-case baseboard zone, it can certainly overcome the head loss of all the others.

System curve

According to Barba, we already know how to locate two points on the system curve. At 7.5 GPM we have a head loss of nine feet and, for clarity, at 0 GPM we have a head loss of 0 feet of head. Using a formula, we can calculate other head-loss points at other flow rates, and then plot them on the pump curve graph against a pump performance curve. Once we do that, we can

Pipe sizing guidelines are all based on minimum and maximum flow velocities, a minimum of two feet per second (FPS) and a maximum of four FPS. If we exceed the maximum of four FPS, flow velocity noise will occur.
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see that the actual operating point of
the system will be where the system
curve intersects a pump curve. Ah!,
but the system requires 7.5 GPM only
when all zones are calling, and only
when it’s zero degrees outside,” added
Barba with a wild variety of facial ex-
pressions and the waving of hands.

“The building will need fewer
BTUs when the zone valves begin to
close,” continued Riley. “If just two
zones are calling, we drop to 50,000
BTUs. If only one zone calls, we’re
down to a need for only 25,000 BTUs.
If only one zone is calling, the delta-T
drops again to 12 degrees . . . a whoppin’
40% difference.”

“All of this can happen, even when
it’s zero degrees outside,” asserted
Riley. “What if it’s, say, 35 degrees
outside and the heating load at that
temperature is only 38,000 BTUs
with all zones calling? As you can
see, the potential for smaller and
smaller delta-T’s, over 60% differ-
ences to design, can quickly lead to
inefficient boiler short-cycling and
plenty of velocity noise.”

Barba’s waving his arms again to
emphasize his point: “Solve the
dilemma of dropping delta-Ts by
using a fixed delta-T, variable-speed
circ,” he said.

Looking back at the universal hy-
dronics formula, we know that if we
fix the delta-T at 20, and divided the
total load of 75,000 by 20 times 500
or 10,000, we find that the flow rate
has to be 7.5 GPM. With two zones
calling, a load of 50,000 BTUs, and a
fixed 20-degree delta-T, we find that the
flow rate has to be 5 GPM. And with
one zone calling, the flow rate has to
be 2.5 GPM. Clearly, with a fixed delta-T,
flow will vary automatically to the
zones, it has to. You’ll never have to
worry again about over-sizing a circ.

Another concern is pressure dif-
ferential within the system. As zone
valves close, the system curve inter-
sects the pump curve at higher and
higher pressure differentials. This
greater pressure differential can
cause higher flow velocities within
the system, and that can quickly
lead to velocity noise. It’s the perfect
hydronic storm: with a fixed-speed
circulator, it’s easy to
have poor heat transfer
and inefficient, noisy
operation, all at once.

One way to deal
with the noise would
be to install a pressure
differential bypass
valve, like the Taco
3196, which prevents
flow when all of the
heating zones are call-
ing. But as those zone
valves close, increas-
ing pressure different-
ential within the system, the 3196
bypass valve opens to allow
excess pressure and flow to pass through
back to the suction (inlet) side of
the circulator.

A better solution for noise would be
to use a mid-flow, low-head, flat-curve
circulator like the Taco 007. With
such a pump, system pressure rises
minimally, mixing the need for a
bypass valve. But — if the job has higher
head requirements than the 007 can
deliver, we may need another solu-
tion: a variable speed pump.

With all of the zones calling, we
know that delta-T = 75,000 ÷ 9 ÷ 500.
“So, we find that the actual system
delta-T at this point may be closer to
16 degrees, not the 20 we designed
for,” said Barba. “Doesn’t sound like
much, right? But that also equates to
about a 20 percent difference. With
only two zones calling the delta-T
drops to about 15 degrees (a 25% dif-
ference), and with only one zone
calling, the delta-T drops again to 12
degrees . . . a whopping 40% differ-
ence.”

So, rather than searching for the
point where the system curve inter-
sects the pump curve, we know that
the pump curve will self-adjust
every moment and every day of the
heating season.

In a variable speed circulator, the
delta-T control is built in. They’re sim-
ple to install and easy to program.
There’re no surprises during instal-
lation. The only difference is the
need to wire the sensors on the sup-
ply and return.

Variable speed circs, by design,
are also easy to set up. You simply dial-
in the pump to meet the delta-T you
want. Just remember that the delta-T
is directly related to flow rate. It’s part
of the universal hydronics formula:
GPM = BTUH ÷ the
delta-T × 500.

Another pump control concept on
the streets is Delta-P (ΔP), or pres-
ssure differential. But where is P in
the universal hydronic formula?

What we’re trying to do here is to
satisfy the heat loss of the structure
in the most efficient way. The best
way to do that is to allow the circu-
lator to adjust its speed to deliver the
required BTUs. By maintaining a
consistent delta-P (10 for radiant, 20 for
baseboard, higher for panel radiator
systems, etc.), we can vary the flow
as needed to ensure optimal per-
formance and heat transfer. And, the
delta-P is always on, always drawing
power, 24/7/365.

One final thing about delta-T: it
doesn’t flat-line. A delta-P circ is not
only on always, always drawing
power, 24/7/365 but it will always
maintain a constant delta-P in the
system regardless of what the system
actually requires. If the pro-
grammed-in delta-P isn’t accurate, ac-
tual system flow rates may be much
higher than required, and that will
mean a smaller delta-T than designed
leading to much less efficient system
operation. A Delta-P pump, on the other
hand, will always run at the lowest
possible speed, maximizing system
performance and efficiency.

Now, that’s a hydronic recipe Barba
says is better than Martha Stewart’s
best, and a thing of even greater
beauty than Britney Spears.

John Vastyan is president of Man-
heim, Pa.-based Common Ground,
Uncommon Communications, LLC. He
specializes in communications
for the hydronics, radiant heat, ge-
othermal, plumbing and mecha-
nical and HVAC industries.