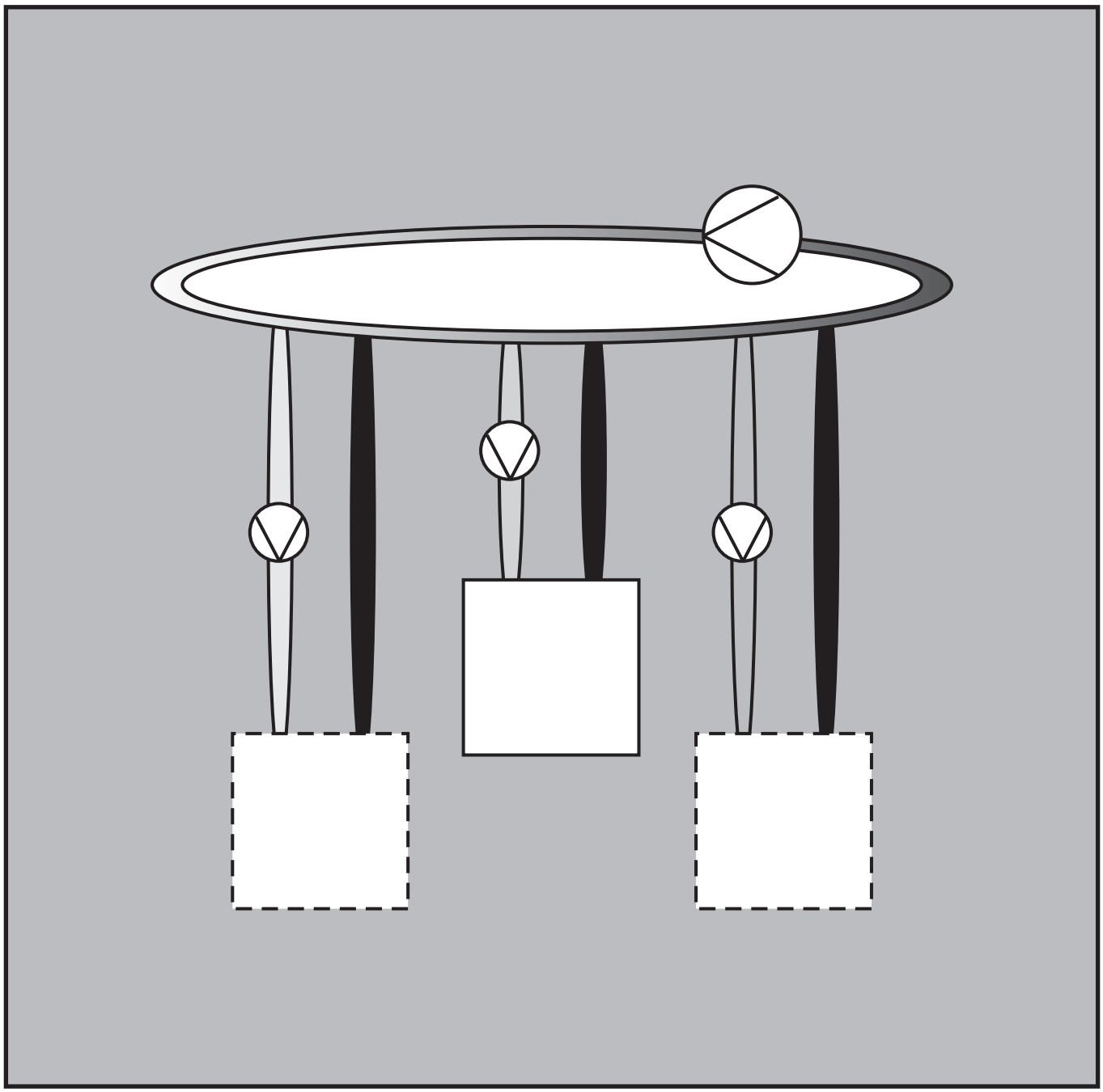
The Laars Heating Systems Approach to Primary/Secondary and Multiple-Boiler Systems



LAARS®
Heating Systems Company
A subsidiary of BRADFORD WHITE® Corporation

An Idea Whose Time Has Come

The Laars copper finned-tube boiler and the concept of primary/secondary pumping were born in America just after World War II. Both developed out of the need to solve a particular system problem. Over the years, the two concepts have proven themselves to be a powerful team. Taken together, they give you a way to build your business by offering solid, innovative solutions to your customer's problems.

Using Primary/Secondary Techniques, You Can:

- Match the building's load for improved comfort.
- Improve system efficiency.
- Avoid flow through un-fired boilers (which can reduce efficiency and,
- Quickly and easily retrofit any job.

Today, more than ever, the Laars boiler and the technique of primary/secondary pumping can give you, the heating professional, a real competitive edge. By applying the simple concepts in this booklet, you'll be able to offer your customers much greater control over the comfort level of their buildings while operating at much greater system efficiency.

And you'll be able to do all this with standard, off-the-shelf, easy-to-install components. You won't need any special tools. In fact, you'll probably find primary/secondary easier to work with than many of the systems you're installing now.

For the heating professional who is willing to work with his head as well as his hands, this booklet offers tremendous opportunity. Read on!

An Old Problem Solved

In the days before the development of the circulating pump, hot-water heating contractors faced a problem: How could they make water flow where they needed it when the only force they had going for them was the buoyancy of the hot water?

These were the days of "gravity" hot water heat. Hot water rose because it was lighter than cold water. But if the water found it easier to sail up a nearby riser, it would never wind its way through a radiator.

To stay competitive, most hot-water contractors wanted to work with single-pipe systems, as their competitors, the steam contractors, were able to do. But what would make the water flow through a radiator if it were connected like the one in Figure 1.

The laws of nature said water would go straight up the riser because that's the path of least resistance. The only way they could get it to make that turn into the radiator was to increase the resistance along the riser.

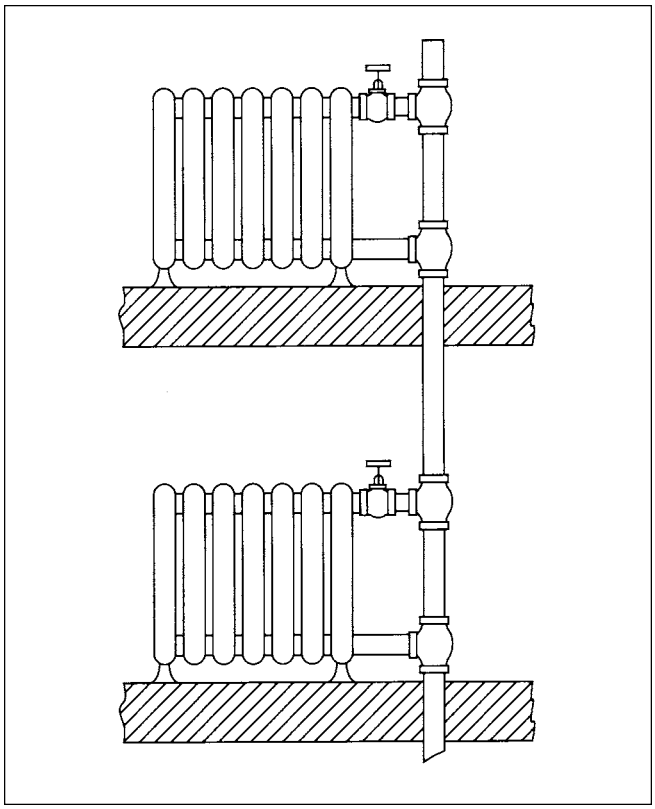


Figure 1.

And that's exactly what the old-timers did (see Figure 2.)

They used special diverter tees which created more resistance in the riser than there was in the branch radiator piping. With these tees, a portion of the

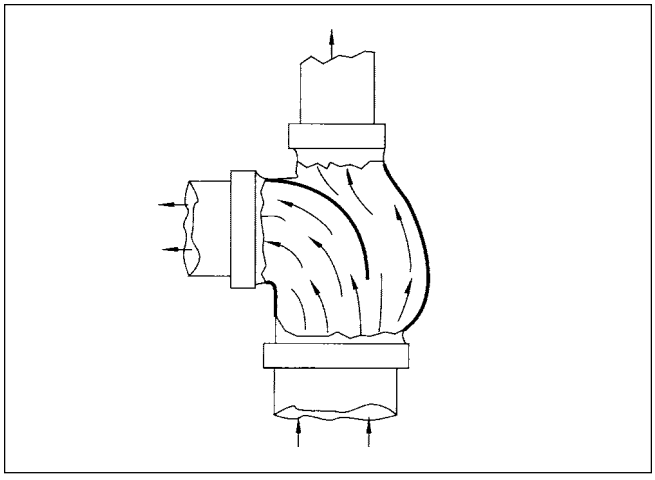


Figure 2.

water split off and moved into the radiator.

It was a simple idea (no moving parts!) but it did take some figuring. For instance, the contractor had to know whether to use one or two of those special tees. The answer depended on the size of the riser, the size

of the radiator and the length of piping between the two. After a lot of trial and error, the old-timers learned what they could and couldn't do.

By the 1930s, most hot-water contractors had moved away from gravity hot water heat. Circulators allowed them to work with much smaller (and much-less-expensive) risers and mains. But to divert the water through the radiators, they still needed special tees.

Several manufacturers made tees such as the one in Figure 3.

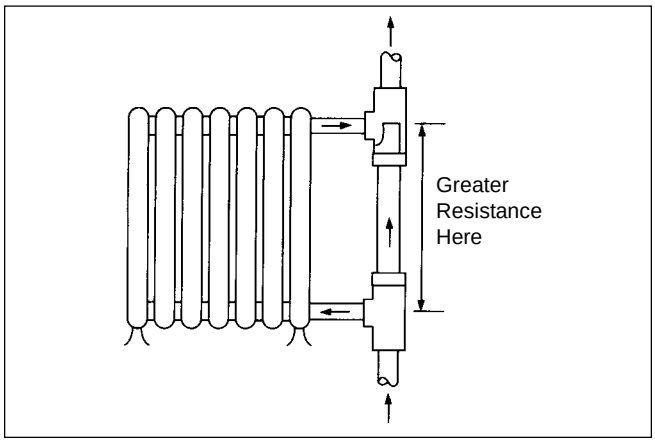


Figure 3.

This one has a cone pressed into the run of the tee. The cone creates a drop in pressure along the main. That makes it easier for some of the water to divert through the radiator. By using one tee, a contractor could get a certain flow through the radiator; by using two, he'd get more.

As you can imagine, without these special tees, the contractor would be faced with the same old problem: No flow through the radiator! That's because water will always follow the path of least resistance. So before long, most hot-water contractors were using these special tees. And then, quite by accident, along came a discovery.

In the early 1950s, a contractor had installed a diverter-tee system in a New York City office building. Unfortunately, he used very long runs to the radiators and, to his dismay, found that not enough water would flow to the radiators - even though he'd used the tees on both supply and return. You see, the pressure drop was greater in the branch run (because of its long length) than it was along the main (even with the two tees!).

The contractor, working with the design engineer and the manufacturer of the diverter tees, tried an experiment. He installed small circulating pumps on the radiator branch runs to assist the flow. He ran these circulators at the same time as the main system pump. To his delight, the radiators heated beautifully!

From this basic discovery, it was just a short step to figuring out that if they ran the "primary" (main system) pump continuously, they could cycle the "secondary" pumps on and off. By doing this, every branch run became an independent zone.

The science of primary/secondary pumping was born!

The Basic Principle

There's no heavy-duty engineering involved in primary/secondary. You can easily apply it on your next job and give yourself a real competitive edge.

Let's start by looking at this simple piping loop (see Figure 4).

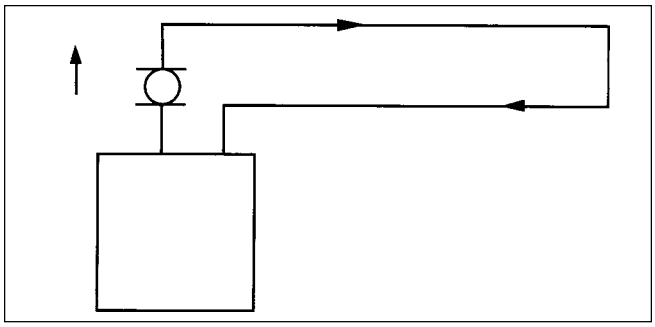


Figure 4.

Nothing complicated here. It's just a single loop system with a circulator. Obviously, when that circulator comes on , all the water will flow out of the boiler and around the loop. It does that because it has no choice. The circulator creates a difference in pressure and the water moves in response. It turns round and round, just like a Ferris wheel. And like a Ferris wheel, there's no lifting going on. In a closed system such as this, the weight of the water going up balances the weight of the water going down. There's no lifting, just turning. But suppose we add a second loop of piping to the main loop. We won't use those special diverter tees we talked about before, instead, we'll install standard tees and pipe a valve in the run of pipe between the tees (see Figure 5).

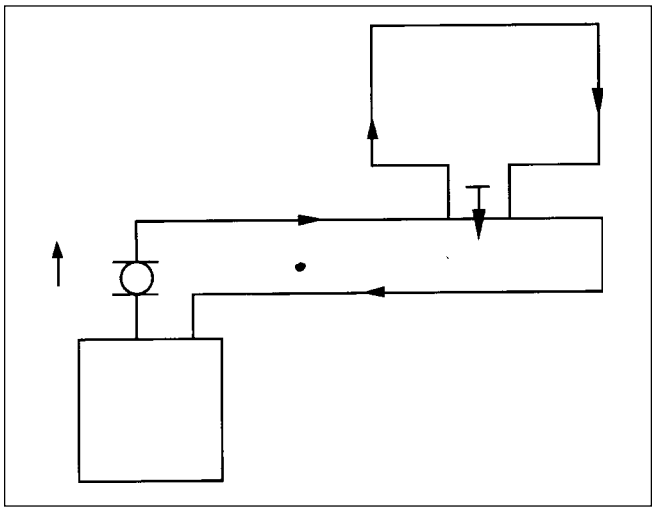


Figure 5.

Now, will water flow through that second loop?

It depends, doesn't it? It depends on whether you have that valve fully opened, completely closed, or somewhere in between. The valve is like a gate which directs the water one way or the other.

It can do this to the flow of water because it affects the difference in pressure drop between the bulls and runs of the two tees. Get it? Because the valve increases the pressure drop along the run, it determines how much (if any) water will flow through the secondary loop. Simple!

You could get the same effect with diverter tees. They're just like a valve that's stuck in an unmovable position. You could also get similar results by using a smaller-sized pipe between the tees. That's because, given the same flow, a smaller pipe will produce a greater pressure drop than a larger pipe. If you were feeling adventurous, you could crimp the copper pipe between the tees with a pair of pliers. That would work too — as long as you didn't crimp too much.

Yes, any way you arrive at it, it's all about pressure drop. But none of these methods gives you the ability to start, stop, or change the flow through the secondary loop very easily. So let's try something else (see Figure 6).

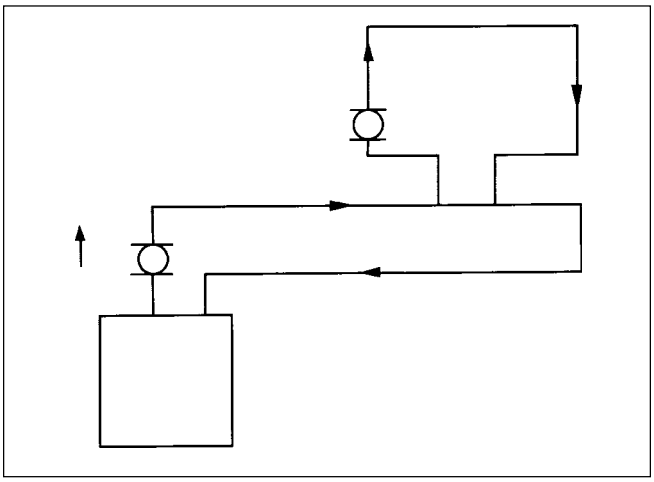


Figure 6.

Now we really have something we can work with! We'll run the boiler pump continuously. If the heating loop pump is off, no water will flow through its loop because the pressure drop across the heating loop is greater than the pressure along the run of the two tees. But when the heating loop pump is on, as much water as we need will enter the circuit and flow freely because the power of the pump changes the pressure drop relationship. Beautifully simple, isn't it?

In a primary/secondary system, the heating loop pump draws hot water from the main as though it were a boiler. In a way, the main actually becomes an extension of the boiler — a long "trough" from which you can extract heat whenever and wherever you need it.

The heat loss through the main is minimal because it doesn't pass through any radiation. Only the heating loops pass water through radiation. And these primary and secondary loops operate completely independent of each other.

The Common Piping

But what's going on in that piping between the two tees? That piping is common to both loops and it's very important. So let's take a closer look at it (see Figure 7).

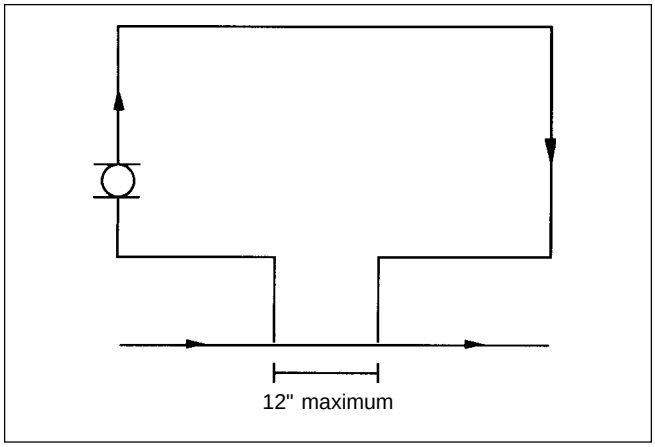


Figure 7.

We have to make sure the connection between the two tees is very short - somewhere between six and 12 inches. That's because we want the pressure drop in that piece of piping to be extremely low. How come? Because we want all the pumps to be able to get along with each other.

You see, if you have a system with two pumps and one happens to be more powerful than the other, you can have problems. You've probably seen this happen on zoned commercial jobs. The flow from a smaller pump might not be able to enter the common piping which it shares with a larger pump because of the difference in pressures each pump is capable of producing.

Here's an example of what we mean (see Figure 8).

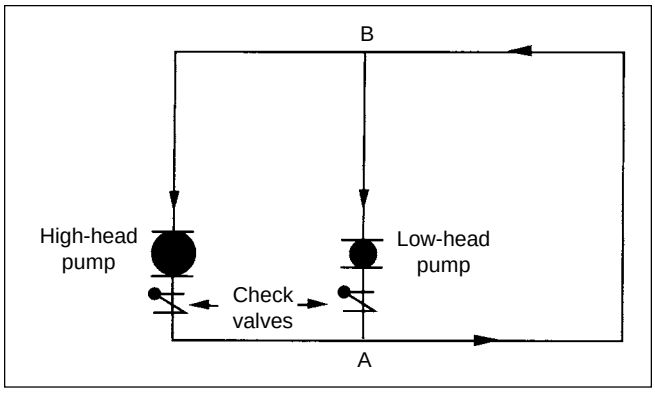


Figure 8.

These two pumps, one a high-head, and one a low-head, share all the piping in the direction of flow between points “A” and “B”. Let’s say the high-head pump is running and the low-head pump is off. The high-head pump produces a high pressure at “A”, but a much lower pressure by the time it reaches “B”. That’s because the pump’s pressure gets eaten up by the frictional resistance of the system piping. The water “wants” to flow backwards through the low-head pump’s piping because high pressure always goes to low pressure, but it can’t in this case because there’s a check valve in that line.

So now the low-head pump comes on. It, too, produces a pressure, but that pressure isn’t enough to open the check valve. It’s overpowered because there’s simply too much difference in pressure between points “A” and “B”.

Now look at the difference primary/secondary piping makes (see Figure 9).

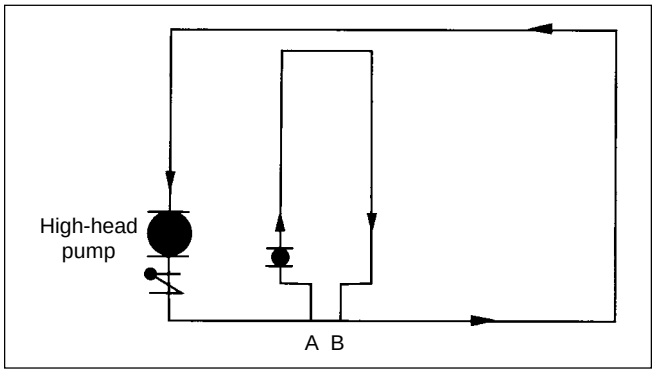


Figure 9.

The pressures produced by the high-head pump at points “A” and “B” are nearly the same because the tees are so close together. (This is why that six to twelve-inch spread between the tees is so important.)

The high-head pump won’t move any water through the zone because the main (the common piping between the tees) is the path of least resistance. When the low-head pump comes on, it pumps away from the common piping, around its loop (which includes the common piping) and back to its own suction side. It can do this because the pressures at “A” and “B” are practically the same.

In other words, the high-head pump can’t shut down the low-head pump. The two operate as though they were in different systems. They get along - finally!

The Flow Across Common Piping

What goes on in the common piping can be pretty interesting. Depending on the flow rates of the pumps, we can have water moving forward, backwards (that’s right!) or not at all. These are things you can’t see from the outside when you’re on the job. You have to “see” them in your imagination. And on paper.

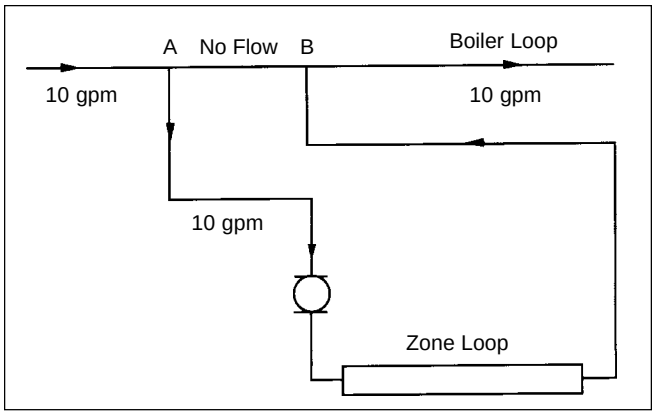


Figure 10.

Here, look at Figure 10.

Let’s say we’ve sized both pumps for 10 gpm. When the zone pump is off, the boiler pump’s 10 gpm flow will move across points “A” and “B”. There won’t be any flow at all in the zone.

Now when the zone pump comes on, all the flow will move from the boiler to the zone loop. No water will flow across the common piping. This is because of a simple principle: Whatever enters a tee, must leave a tee. But here, it has two ways it can leave. What happens depends entirely on that secondary pump.

Let’s change things around a bit (see Figure 11).

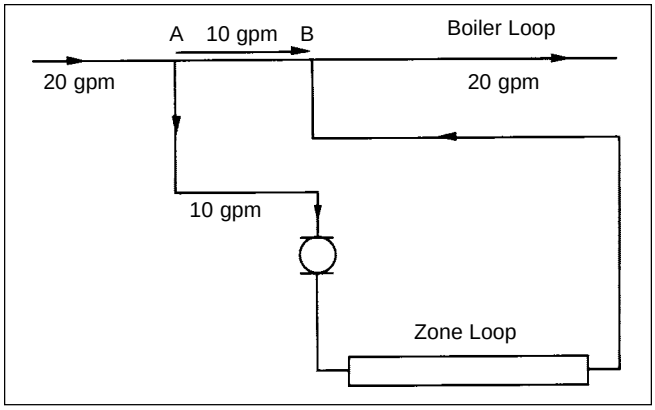


Figure 11.

Here’s a small commercial job. Suppose the boiler pump can move 20 gpm and the zone pump, only 10 gpm. When the zone pump is off, the full 20 gpm from the boiler pump will move across the common piping.

Now the zone pump comes on. It draws 10 gpm through the bull of tee “A”. The other 10 gpm goes across the common piping to rejoin with the zone's 10 gpm at tee “B”.

“Whatever enters a tee, must leave a tee.”

The rule, "What enters a tee, must leave a tee," still applies. Only now, we've split the exiting flow in two directions. We do have flow across the common piping-but it's only half of what it was when the zone pump was off. (What's happening here is very similar to what happens in a diverter-tee system.) Simple, isn't it?

But wait, we're not done yet because with primary/secondary, there's one other way water can flow in the common piping. Here, suppose we switch the two pumps we just used. Let's put the 10 gpm pump on the boiler loop and the 20 gpm pump on the zone loop (see Figure 12).

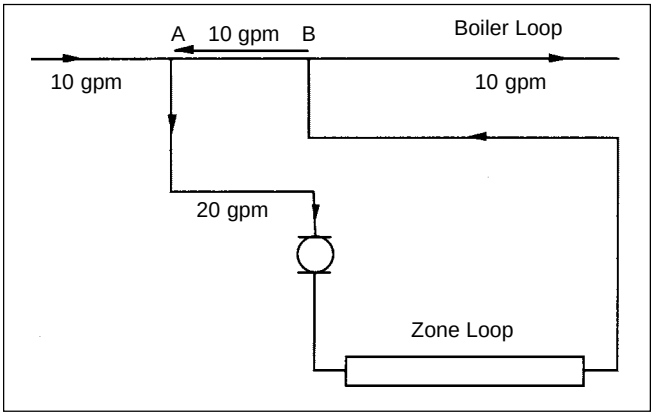


Figure 12.

Now watch closely. This gets a bit tricky.

When the zone pump is off, 10 gpm will flow across the common piping because that's what we've sized the boiler pump to move. The zone pump comes on and draws 20 gpm off the bull of tee "A". But how can it do that? There's only 10 gpm flowing into it.

This is where you have to remember that simple principle: "Whatever enters a tee, must leave a tee." But here, we have to state that principle in a different way: "Whatever leaves a tee, must enter a tee."

You see, if we draw 20 gpm from the bull of the tee, 20 gpm has to enter from the other two sides. Since the boiler pump can only supply 10 gpm the zone pump has to take the other 10 gpm from the opposite side. In other words, from its own flow! In this case, water will flow backwards across the common piping when both pumps are running.

Just think of the possibilities! You can blend return water with supply water and have a two-temperature system (without a three-way valve!), if that's what you need. Primary/secondary opens up a world of opportunity for you if you're willing to work with your head as well as your hands.

Consider, for instance, what happens when we start to apply this technique to the boiler side of the system.

Primary/Secondary Boilers?

Avy Lewis Miller, a California engineer and inventor, came up with the idea of a high-flow, low-mass, copper-finned-tubed boiler in 1946. He believed his concept would eliminate the scaling and electrolytic corrosion problems which typically shorten the life of cast-iron and steel-tube boilers when they're applied to water heating so he founded Laars Engineering and put his ideas to the test.

The swimming pool industry was in its infancy in southern California in those post-World War II years, and Avy Miller's boiler turned out to be the perfect pool-water heater. *His boilers would, in most cases, sit outside, exposed to the elements. They'd handle highly oxygenated and chlorinated water. They'd see conditions worse than any hydronic heating boiler would ever experience. And they'd last for years and years.*

Based on the torturous service they'd seen with chlorinated and oxygenated pool water, they seemed a natural for hydronic heating as that science grew during the Fifties. In fact, when it comes to a simple, closed-system, hydronic heating system, Laars boilers are probably a lot better than they have to be!

And because of their small size and low-water content, Laars boilers lend themselves perfectly to primary/secondary systems. To see what we mean, you have to think about a hydronic heating system as having three major parts:

The Boiler, which we'll consider the "Heat Generator" because it injects heat into the secondary loop as you need it. We'll call boiler loops primary loops.

The Secondary Loop, which for our purpose, we'll call the "Heat Transport System" since it delivers the heat from the "Heat Generator" (or primary loop) to the people occupying the building, and finally...

The Radiators, or in this case, the "Heat Distributors" because that's exactly what they do - they distribute heat where and when it's needed. We'll call the radiator zones the tertiary loops.

Now let's take a close look at each part of our system.

The Heat Generator (The Boiler)

You have to size your boilers for the worst-case conditions. When the wind is howling and the outside air temperature is at or below zero degrees that boiler has to generate enough heat to make your customer comfortable. If you've done your sizing well, the boiler should run continuously on that coldest day of the year. This is what heat-loss calculations are all about.

But now consider this: *just about every other day of the year that boiler is capable of doing a lot more than you need it to do*. Think about it. Does it make any

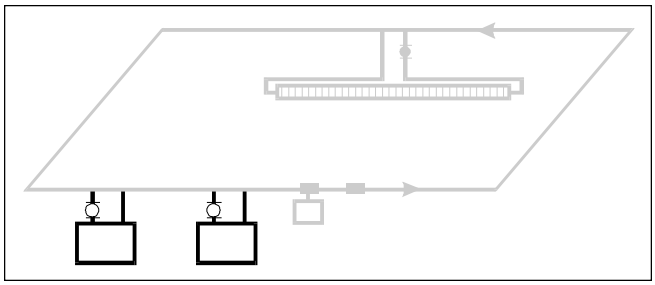


Figure 13.

sense for a boiler to generate its maximum heat on a 30- or 40-degree day? Of course not.

And it's on these less-severe days that boilers piped in primary/secondary shine because you can have them generate just the right amount of heat to match the building's heat loss at any given moment. It gives you two things to talk about that are in your customer's best interest: comfort and economy. It gives you a better story than the next guy, and that all-important competitive edge.

For instance, suppose the total net heat need of a building (space heating and domestic hot water) is 500,000 BTU/h. You could size a single boiler for that load. It would heat the building and provide domestic hot water on any day of the year, however on most days, it would be oversized.

But by splitting the total load between two boilers, each capable of generating, say, 250,000 BTU/h, you've accomplished several things:

***FIRST**, as we've said, by splitting the load, you've recognized that not every day is the coldest of the year*. Your customer will agree with you on this because it's common sense. On an "average" winter day, you can probably fire just one boiler and still be able to heat his building. In fact, since this smaller boiler is sized more closely to the actual heat loss of the building on that day, chances are it will run longer than a single larger boiler would. *That improves your overall operating efficiency by cutting the smaller boiler's stand-by losses*. *It also reduces your customer's fuel usage.*

Naturally, as the weather gets colder, the second boiler will come on in series to help the first maintain the required secondary-loop temperature. *In other words, the two smaller boilers act as one-but only on those frigid days.*

***NEXT**, by using two boilers, you've built-in a stand-by feature which you don't have with a single large boiler.* The chances of both boilers needing repair on the same day are remote. You know that. Your customer will also intuitively know it. *He'll be pre-sold on the idea that he'll probably never be without heat and hot water when he uses your system.*

This key feature is the reason you see so many of these types of systems in hospitals, schools and nursing homes. Those folks simply can't afford to be without heat.

***IN ADDITION**, by piping the boilers in primary/secondary, no system water will flow through an "off" boiler.* That means you've reduced the heat losses through the stack and the boiler jacket. The "on" boiler will generate the heat your system needs while the "off" boiler sits idle. It's as though that "off" boiler were valved off from the system-even though it isn't.

This benefit, when combined with the low-water content (and low stand-by losses) of the Laars boiler, increases overall system efficiency even further (again, giving you that competitive edge.)

BUT WE'RE NOT THROUGH YET. Let's take it to an even higher level by adding a Laars EM^2 control to the system. This simple and inexpensive control runs the primary-boiler circulator for several minutes after its burner has shut down. The circulator removes the residual heat from the copper heat exchanger and puts it into the secondary water flow. *In doing this, EM^2 completely eliminates boiler stand-by losses!* That's certainly to your customer's advantage, isn't it?

When you work with primary/secondary boiler piping, you can split the total load into more than two boilers, if you wish. We've found, however, that four boilers is the maximum you should use in a primary/secondary, multiple boiler system. The reason is simple: the economic return on more than four boilers is so small that it's just not worth the extra effort.

But imagine the possibilities if each of those four, primary/secondary boilers was capable of shifting from high-fire to low-fire and back again! You'd have four, very responsive boilers sharing the total system load. One or two burners can be running on high-fire while a third is on low-fire and a fourth is at rest. *With this strategy, you'll be able to fine-tune your customer's heat and domestic hot water needs to any day of the year.* You'll be directly addressing the two things he's most interested in: comfort and economy.

Another consideration with primary/secondary multiple boilers is the advantage their small size gives you. You can easily get them into the building (Laars boilers are remarkably maneuverable!). You can also pipe them with ease (usually in copper). *In fact*, *if you can pipe a residential-size system, you can also pipe a large multiple-boiler, primary/ secondary system. It's that simple.*

And because of their compact size, you'll be able to install two (or more!) Laars boilers in the same space a cast-iron sectional or steel fire-tube boiler would occupy. You'll find your material costs will be comparable to the single boiler installation. *These boilers fit through just about any door, making them perfect for retrofit jobs. Your labor costs will most likely also be less because of the decreased size and weight of the Laars boiler.*

The Boiler's Flow Needs

Flow across the boiler is important in any system, but here we pay very special attention to it since the boiler in a primary/secondary system is the "Heat Generator." It has to inject just the right amount of heat into the system at just the right time.

And since the boiler's on its own loop, we'll size the piping and circulator to meet its needs only. (We'll handle the flow needs of the system and the radiation in a similar way.) *By following this strategy, you'll usually wind up with a small, readily available in-line circulator for the boiler. You'll also be using boiler piping that will most likely be smaller than you'd need for a single large boiler.*

We recommend a 25-degree temperature rise through the Laars boiler. Our Series PH boilers come with factory-mounted circulators which are pre-sized for primary/secondary systems. (This is the easiest way for you to go.)

If you choose to order your Laars boiler without a factory-mounted circulator you'll find Table 1 useful.

Boiler (indoor)	Flow Rate (gpm)	Tapping (inches)	Head Loss (ft.)
175	11	1.5	0.6
250	16	1.5	1.2
325	20	1.5	2.1
400	25	1.5	3.4
500	33	2	1.1
600	39	2	1.4
715	47	2	1.9
850	55	2	2.5
1010	66	2.5	3.4
1200	78	2.5	4.8
1430	93	2.5	6.5
1670	109	2.5	8.8
1825	119	2.5	10.0
2000	131-2P*	4	7.4
2450	161-2P	4	10.2
3050	200-2P	4	16.4
3500	230-1P	4	8.7
4050	266-1P	4	11.9
4500	295-1P	4	13.2
5000	328-1P	4	16.8

**2P=Two pass heat exchanger.*
1P=Single pass heat exchanger.

Table 1. Primary flow rates (at 25° F) and pipe sizes.

As we've said, keep the two tees which connect the boiler supply-and-return piping to the secondary system loop about six inches apart (never further than a foot apart). Piped this way, no water will flow through the boiler when the primary pump is off.

And always pump down into the boiler with your primary boiler pump. In other words, away from the common piping between the primary and secondary loops. The boiler pump uses this common connection as its "expansion tank."

You see, with a primary/secondary system, you only need one compression tank location, regardless of how many boilers you use. And you should always place that one tank in the secondary loop. You can use multiple tanks, if you wish. The trick is to manifold them together so they connect at one single point in the secondary loop. (More on this in a little while.)

That secondary loop is the transportation system for the heat. It's the second element in the total system. Let's take a closer look at it.

The Transportation System (The Secondary Loop)

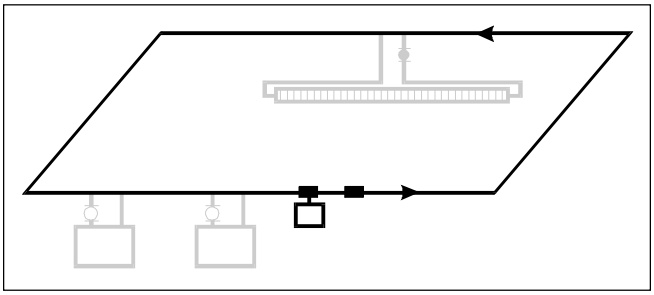


Figure 14.

Think of the secondary loop as a monorail which skirts the outer edge of the building and transports heat from the boilers to the radiators. It's a large racetrack of pipe with a relatively small circulator driving the water around and around. *If the secondary flow temperature drops, the boilers send some heat into it. If the zones call for heat, their circulators draw heat out of it, as though the secondary loop were an extension of the boiler*. See why we call it the "transportation system" for the heat?

You'll operate the secondary loop circulator continuously during the heating season since you never know when any zone will call for heat. You'll size this circulator for the flow and head-loss needs of this loop alone. You'll usually wind up with a small, off-the-shelf, in-line circulator for this duty since the secondary loop contains few turns and no boilers or radiators. There's very little resistance to flow here. The secondary loop is like a freeway for water flow.

This is another one of the often-overlooked advantages of a primary/secondary system. With commercial, single-boiler/single-pump systems, you almost always wind up with a large base-mounted circulator. These pumps cost more to buy and install than smaller, in-line pumps. You also have to mount them on heavy concrete bases, grout them in place and periodically align them. They take up valuable floor space and usually require long approach piping to prevent pump bearing failure.

You avoid all these hidden costs with primary/secondary because you're working with a series of small, in-line circulators.

A wall-mounted controller (the Laars Mighty Matic) turns the secondary circulator on in the fall (in response to outdoor air temperature), and keeps it running as long as there's a need for heat in the building (more on this controller later).

The Secondary Loop's Flow Needs

You'll size the primary loop to the flow needs of all the zones. You can estimate your flow by using this:

RULE OF THUMB: One gallon per minute of secondary-flow will transport 12,500 BTU/h to the system. *(We've based this on a 25° temperature drop across the system)*

So, for instance, if your total heating load was 500,000 BTU/h, you'd get the flow rate for your secondary circulator by dividing 12,500 BTU/h into the total load (500,000 BTU/h).

$$\frac{500{,}000}{12{,}500} = 40 \text{ gpm}$$

Again, this considers a 25-degree temperature drop across the system.

To size the copper secondary main, use the guidelines in Table 2.

Main Size	Flow Rate	BTU/h
1"	8 gpm	100,000
1¼"	14 gpm	175,000
1½"	22 gpm	275,000
2"	45 gpm	562,000
2½"	85 gpm	1,062,500

Table 2. Sizing Copper Secondary Main Guidelines

We based this table on industry-accepted flow rates for the size pipes shown.

Now, once you know the flow rate for the secondary circulator, you'll have to find its pump head To do that, you can use this:

RULE OF THUMB: For each 100 feet of secondary-loop piping, allow six feet of pump head. For instance, if the total secondary loop measures 300 feet, size your circulator for the proper flow rate at 18 feet of pump head. *(We've based this on the flow rates shown above)*

That's simple enough, isn't it? You now have the flow rate and head loss. All you need to do is select the secondary pump from the pump manufacturer's catalog.

Now, in addition to the secondary circulator, the loop is also home to the system's compression tank, air separator and fill valve. **Always install the circulator pumping away from the compression tank**, **and fill the system at the point where the compression tank is located**.

Since we base compression tank sizing largely on the volume of water in the entire system, you gain a real advantage by using low-mass Laars boilers instead of high-water-content, cast-iron sectional or steel, fire-tube boilers. Laars boilers contain a faction of the volume you'll find in these large boilers, and yet they produce the same amount of heat. **This important feature keeps the size (and the cost!) of those diaphragm tanks down. And it adds to your bottom line.**

A Crucial Detail

The compression tank is the "point of no pressure change" in any closed hydronic system. It's the one place the circulator's differential pressure can't affect. In fact, the circulator uses the tank as a reference point to "know" what to do.

If you pump away from the compression tank, the pump will add its pressure differential to the system's fill (static) pressure. If you pump toward the compression tank, the pump will remove its pressure differential from the static fill pressure.

For example, let's say you have a circulator capable of producing 10 psig of differential pressure (23 feet of pump head). Let's also say you've filled this system to 15 psig pressure (see Figure 15).

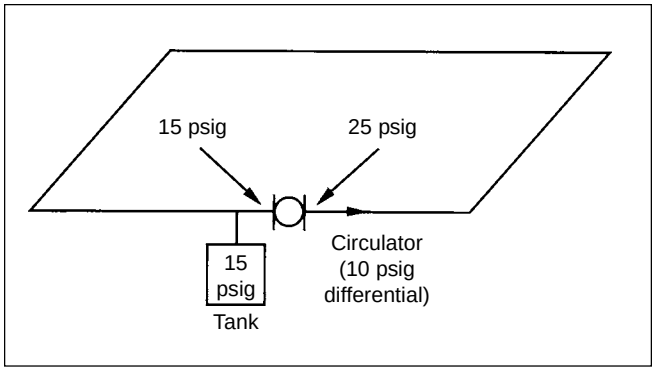


Figure 15.

If you pump away from that tank, the pressure at the circulator's discharge flange will be 25 psig when the circulator is running. The pressure at its suction flange will be 15 psig (assuming its discharge is right next to the point where the compression tank is connected.)

Now move the circulator to the other side of the compression tank. You're going to pump right at the point where the tank is connected to the primary loop. Under these conditions, when the circulator comes on, its discharge pressure will remain at 15 psig, but the pressure at its suction side will drop to 5 psig!

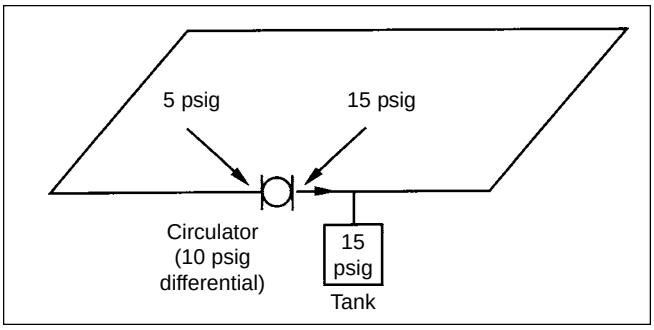


Figure 16.

See? Piped as shown in Figure 16, the pump's pressure differential shows up as a drop in suction pressure. Water continues to flow because there's still a 10 psig pressure differential across the circulator, but that drop in pressure can create air problems out in the system.

Air is always dissolved in the system water, and when the pump drops the pressure, the air comes out of solution and forms bubbles.

It's very similar to what happens when you shake a bottle of soda and then open the cap. The sudden drop in pressure caused by opening the cap releases the dissolved carbon-dioxide bubbles in the soda. (You know what happens next.)

We like to avoid system air problems and that's why we recommend you always pump away from the compression tank. (And remember, the primary circulators take as their "compression tanks" the common piping between the primary and secondary loops.)

For this same reason, you should always bring your feed water into the point where the compression tank is connected. That's the only place in the system where the pressure can't be changed by the circulator. It's the only place where the feed valve can get a true reading of what's really going on in the system.

Now let's take a look at how we're going to distribute all this comfort we've been producing.

The Radiators (The "Heat Distributors")

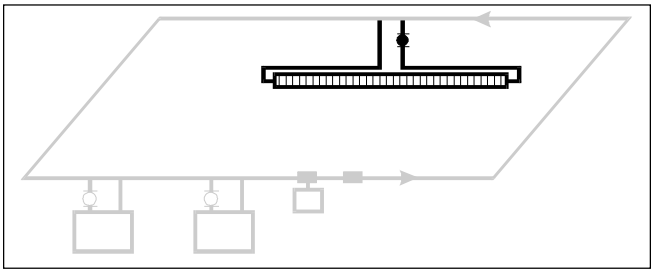


Figure 17.

To put it in its simplest terms, the radiator's job is to remove the heat we injected way back in the boiler room-the heat that's been orbiting in the secondary loop-and put it into the places where the people are. The radiators (the tertiary piping loops) become the final part of our primary/secondary system. If you've done a good job of sizing so far, there will always be the right amount of heat available between those two closely installed tees which the secondary loop and the radiator's tertiary loop share.

The tertiary circulator will come on at the call of a zone thermostat to change the pressure-drop relationship between the secondary and tertiary loops at the point where they come together. When needed, this circulator will inject the right amount of heat into the radiators.

You should size the radiation piping to match the flow-rate needs of the individual tertiary zones. Using the same 25° temperature difference we've been working with so far, we came up with Table 3:

Zone Pipe Size	Flow Rate	Load (BTU/h)
½"	1½ gpm	18,750
¾"	4 gpm	50,000
1"	8 gpm	100,000

Table 3. Sizing Your Radiation Loops

So if you sized a length of copper baseboard to put, say, 15,000 BTU/h into a zone, you'd look at the chart and select 1/2" copper tubing. Simple, isn't it? Just bring your two, half-by-whatever-size tees off the secondary loop, keeping the distance between them at about six inches. Then install your tertiary (zone) circulator pumping away from the tee and wire it into the zone thermostat.

If you need low-temperature water in your zone because you're installing a radiant heat panel, you'd use a three-way valve to adjust the temperature of the water flowing through the radiant zone. The three-way valve should be outdoor-temperature-responsive. (Radiant tubing manufacturers generally have this control available as a part of their system.)

Pipe the three-way valve on the secondary-loop side of the circulator to keep the flow through the radiant panel stable. Just like Figure 18.

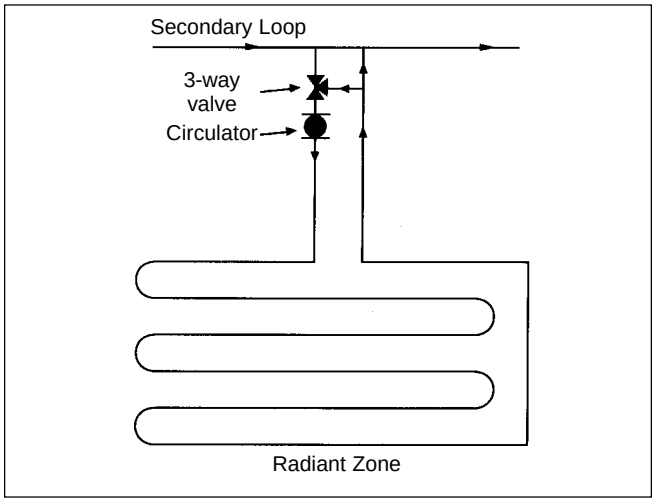


Figure 18.

The three-way valve, responding to outdoor-air temperature will sense the temperature needs of the room and adjust the temperature, but not the flow rate, of the radiant panel. That's important.

The simplest way to handle any type of radiation is a loop off the main. Just have the circulator come on in response to a room thermostat and it will act as your "on/off" control. Naturally, you'll base the size of the radiation on the heat loss of the zone it serves.

You can also pipe the radiators off of diverter tees within the tertiary loop, if you wish. This gives you the option of using non-electric zone valves on each radiator. That further increases the level of control throughout the system, but consult the valve manufacturer if you decide to go this way. The pressure drop through each thermostatic radiator valve becomes very important in this application. For best performance, look for valves with as low a pressure drop as possible.

In almost all cases, the circulator you'll use for the tertiary radiation loop will be a small one such as the Taco 005 (or 007), the Bell & Gossett SLC, or the Grundfos UP.

This is because the zone circulator sees only the flow rate and pressure drop through the tertiary loop. Typically, this is no greater than you'd find in a small hydronically heated home.

Controlling the Primary/Secondary System

Figure 19. 4-Stage and 8-Stage Controllers.

We'd like you to consider the Laars Mighty Matic controller for your new primary/secondary system. We've selected two controllers with these systems in mind and we don't think you'll find better controls anywhere. The Mighty Matic comes in two sizes to control 4 or 8 burner stages.

That means you'll be able to fire this boiler on high-fire, and that boiler on low-fire while those other boilers are on stand-by. This feature let's you give your customers extremely close control over their level of comfort (and their fuel bills!). All you have to do is select and pre-set one of the controller's heating curves and you're done. Mighty Matic automatically tracks the needs of the system from that day on.

Selecting the right heating curve is easy. You base it on the conditions you want your system to meet on the coldest day of the year. For instance, let's say you've sized your radiation to provide 70-degree comfort on a zero-degree day. To do this, you may need to have 180-degree average water temperature inside your radiators on that very cold day. You'd then select the heating curve which coincides with 180-degree water and zero-degree outdoor temperature.

On any other day of the year, the system will track up and down the heating curve in response to the needs of that day. If it's warm outside, the secondary water temperature will cool off. If the temperature drops below your pre-set minimum, the Mighty Matic will sense this and shift the heating curve upward. By doing this, it allows the system to operate at temperatures higher than your pre-set maximum. Pretty smart, isn't it?

But that's not all. Say the building is filled with people and, as a result, the indoor temperature goes up. With the addition of an indoor thermostat, the Mighty Matic will sense this as well and shift the heating curve downward to compensate. In other words, it overrides the outdoor-air sensor and says, "Even though it's cold outside, it's warm in here so let's turn down the temperature!"

If someone should suddenly open all the windows and doors on a very cold day, Mighty Matic will sense this as well and, once again, instantly shift the heating curve to compensate. The result of all this is an unprecedented level of human comfort.

Mighty Matic can also set back the temperature at night, or it can keep the primary loop temperature at a fixed point. Your choice; all you have to do is tell the controller what you want.

If you choose, Mighty Matic will also stage the order in which the burners fire. You can have each come on in turn and run for an equal amount of time, or you can have the one closest to the flue be the first to fire and the last to shut down each time, thus ensuring you'll always have a warm flue and good draft. Again, it's your choice.

You can also set Mighty Matic to sense minimum and maximum water temperatures and shut the system down if that's a concern. This controller is so smart it will also spin the idle circulators and open any vent dampers (if you're using them) for a couple of minutes every few days during the summer. This makes sure those key components won't get stuck stick during the idle, off-season months. What more could you ask for?

An Independent, Comparative Study

We realize we're not the only company offering a multiple-boiler system today. There are many other systems available to you and the claims can be confusing.

We've come to believe the primary/secondary approach is the best way to go. Some people offer systems which have hot return water flowing through idle boilers. This seems wasteful to us, but the proponents of these systems insist there's no difference between the performance of their system and a primary/secondary system. They talk about the savings from "not having to use all those little pumps."

We disagree, but rather than take our word for it, we'd like you to consider an independent study which the National Bureau of Standards conducted in 1988. The NBS compared these systems and came up with some interesting results:

1. A multiple-boiler system in which they allowed return water to flow through all the boilers, regardless of whether they were firing or not firing. The pilots burned continuously in all these boilers.
2. The same systems as #1, except the pilots were turned off in the idle boilers.
3. A multiple-boiler system piped as primary/secondary (the Laars approach). Because of the primary/secondary piping, the idle boilers had no flow moving through them. And as with #2, the pilots were turned off when a boiler was idle.
4. A single large boiler.
5. A multiple-boiler system run continuously, as though it were a single large boiler. In other words, all the boilers were either on or off.

Figure 20 shows the results of the National Bureau of Standards' test.*

The curve at the top (#3) represents the Laars approach. It shows a higher overall efficiency when compared to the others.

The lower curve represents all the other systems. As you can see, there wasn't enough of a difference between any of them to warrant separate curves. They all produced basically the same results.

This study clearly shows that pumping hot return water through idle boilers wastes enough heat up the flue and through the jacket to offset any saving from reduced cycle losses. We think common sense tells you that as well.

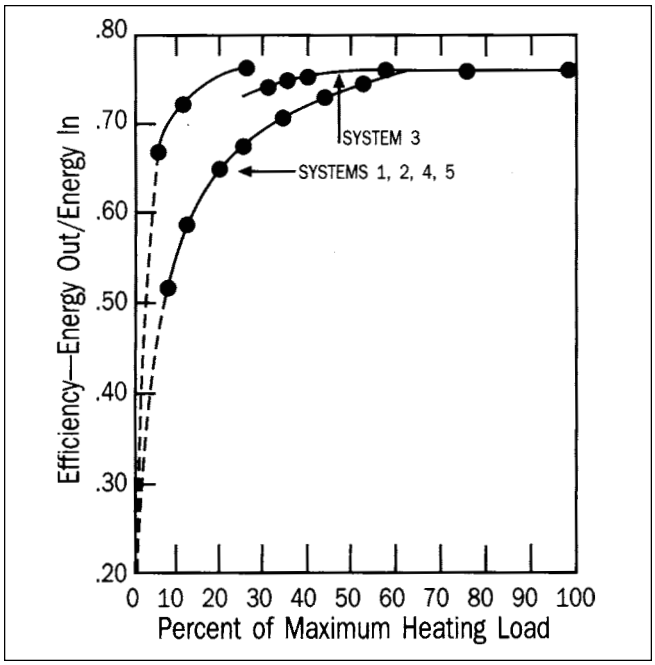


Figure 20.

This is why we recommend you use primary/secondary pumping techniques on all your multiple-boiler systems. It's in your customer's best interest. And in yours!

We're Here To Help You

At Laars Heating Systems, we pride ourselves on being a "systems" company. We're here to help you, and we encourage you to call us or our local representative for help with that next job. Our engineers and field representatives are well versed in primary/secondary, multiple-boiler systems. They've designed, supervised and troubleshot many of them over the years. They're a powerful team, and they can make you look really good on that next proposal.

Take advantage of our experience.
Get to know us better.
We can make your life a lot simpler.
And a lot more profitable.
That's the Laars approach!

*The break and drop in efficiency at about 25 percent load occurred when the second unit started to cycle and carry part of the increasing load. Similar drops can be expected at 50 percent and 75 percent of design load when units three and four start, but this was not included in the test program.

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