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WE WANT YOUR OPINION!

IEP has a big goal for 2021 to update their offerings to better serve its current and future PEMs. One of those offerings under evaluation is the quarterly newsletter. If you have any comments on the newsletter, including a "video" newsletter (vs traditional), desired topics, format/frequency, or others, we would love to hear them! Please drop us a note at contactus@theiep.org.

Seeing the Forest for the Trees

By: Walter Bright, PE, PEM

Recently, I had a conversation with a fellow PEM about a recent energy survey they had performed by a third-party. He had assisted the third-party with their preliminary walk-throughs, answering questions and showing them around the facility. During the survey, the auditor requested to see the transformer that served a particular piece of equipment which would be a potential candidate for an energy conservation measure (ECM). Somewhat curious, he led the auditor to the transformer. He knew that transformers were generally very efficient and surely, they were not thinking about replacing it for energy savings. My friend asked the auditor what his thinking was with regards to the transformer? The auditor said that if they decided to replace the equipment, they wanted to know if the transformer needed to be replaced as well. The last thing the third-party company wanted was for their new equipment to fail because of an aging transformer (Note: audit was for a potential performance contract).

While this example is not the most interesting energy survey story of all time, it did get me thinking about a theme I try to keep in mind during my own energy surveys: do not forget about seeing the forest for the trees. It is quite easy to walk into a survey and generally immediately identify ECMs. The next step is to take data, measurements, setup data loggers, and whatever else we think we might need to effectively go back to the office and calculate savings. However, it is worth taking a step back in between these two steps and asking "why?" Why is it being done this way? The answer might be the old adage of "because we've always done it that way." If that is the answer, then you've found something that no one else has identified because of (what I call) their "repetition blindness." But you might get a different answer.

Take for instance an audit you have been tasked with doing at a hospital's chilled water (CHW) plant. You have been told that the owner only has money for the CHW plant and not the whole building, so we have to keep our scope in check and stay within the owner's limits. You immediately discover that the CHW plant is making 40°F CHW.

Seeing the Forest for the Trees

(Continued)

Traditional logic would tell you that the CHW temperature could likely be increased, as 40°F is chilly. You might also identify that its 40°F year-round. Again, traditional logic would tell you that CHW reset is another opportunity, resetting the CHW setpoint upward during the winter when building load is less. At this point, with some assumptions about how the chillers operate and what their total tonnage is, you could likely make an ECM around a CHW reset strategy and potential savings. However, if we ask why its 40°F and why its not reset, we might uncover some interesting discoveries. It might be 40°F because they are struggling to dehumidify their operating rooms to a sufficient level during the summer. They had a glycol chiller dedicated for the operating rooms, but it broke years ago. When the board discovered they could use the “house” CHW system and not need to replace the glycol chiller, they opted for the cheaper solution. You might also discover that they have a process cooling loop that serves their imaging equipment, and it was designed for 44°F CHW. However, the associated heat exchanger is extremely clogged and cannot be cleaned because of lack of redundancy. The only way to keep the imaging equipment running is to make 40°F chilled water instead. All of this has nothing to do with the CHW plant, except it has everything to do with how the CHW plant must be operated. As such, your ECM must encompass issues beyond the CHW plant to be effective.

Keep in mind the “why” question might take a couple of tries. The CHW plant operator might give you the old adage of “because we’ve always done it that way,” so you might have to expand your resources. That might mean talking to other facility personnel that work inside the hospital itself, verses just the plant.

To some of you, this is a common practice during your surveys. If it is, I complement you on your forward-thinking vision. I still encourage anyone to keep it in mind however, especially when you might be in a “new” situation. That could mean a new type of facility (school, hospital, etc), which has a different usage and customer goal. It could mean a new climate (southern summers and dehumidifying verses northern winters and humidification). All these things can change your “standard assumptions” you would generally make and require the need to ask “why.”

Hydronic Systems, an Energy Perspective, Part 2

By: Walter Bright, PE, PEM

****NOTE: In Part 1 of our previous newsletter, Figure 4 had a minor math error. The figure has been corrected and replaced on the website. We apologize for any confusion.*

In our previous newsletters, we presented a case study on the Belimo Energy Valve (Q2 2020) and took a step back to the basics for how hydronic systems are created, designed and balanced (Q3 2020, Part 1). In Part 2 of our series, we continue to look at hydronic systems with the ultimate goal of fully explaining low delta T and how to correct it. While this article is intended to be stand alone, we’ll be building on concepts and our simple CHW system created in Part 1.

While circuit setters have long been a prevalent component in hydronic systems (and continue to be even today), a more modern device is known as an automatic balancing valve (ABV). They are also frequently referred to as automatic flow limiters and AutoFlow (brand name) valves. An ABV differs from a circuit setter in the fact that it is not a fixed geometry. Instead, the ABV has a spring-loaded piston (also referred to as a cartridge) which moves according to the pressure drop across the valve.

The cartridge is designed so that even if the pressure drop across the ABV increases or decreases, the flow through the ABV remains the same. (For a good animation, see the "Additional Resources" section at the end of the article.) An ABV is selected based on the desired maximum flow. In essence, it "caps" the flow at the selection gpm. It can flow less, but not more. This is all done mechanically, without the need for electronics, a DDC system or any other "intelligence." Let's use the CHW system established in Part 1 of our series to show how this can be used to our advantage and eliminate some of the issues identified in Part 1.

Figure 1 – Automatic Balancing Valve, courtesy of B&G

In Figure 2, we replace the circuit setters in our system from Part 1 with ABVs. The ABV symbol is a rectangle with an angled arrow pointing in the direction of flow. Note that ABVs will have more pressure drop, albeit only slightly, than a circuit setter. As a result, the overall pumping head of our ABV system, as compared to our circuit setter system, is 3 feet higher. Also, we have had to increase the system DP setpoint by 3 feet as well. For ease of comparison, a summary of the circuit setter system is included as part of the following figures in purple text.

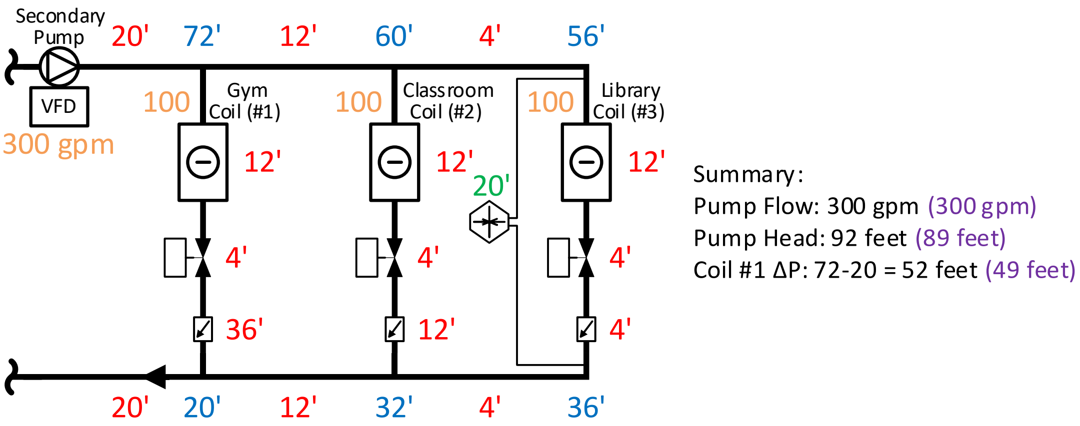

Figure 2 – Balanced ABV CHW System (at Full Load)

Next, let's look at the same part load case with each coil receiving 50 gpm. We can determine each of the numbers via the same logic as presented in Part 1. However, due to the variable nature of the ABV (spring-loaded piston), we will have to apply some different logic. Since a circuit setter is a fixed geometry, it limits flow at all flow conditions. Whereas with an ABV, it can "open up" during part load conditions. This should make sense: as the flow decreases the pressure drop across the ABV will decrease as well. This allows the spring to decompress and open further and further, until the spring is no longer compressed. So, with a circuit setter and 50 gpm to each coil, we still had 8.3 feet of drop for branch # 1. However, with an ABV, we only have 1 foot. This can be seen in Figure 3.

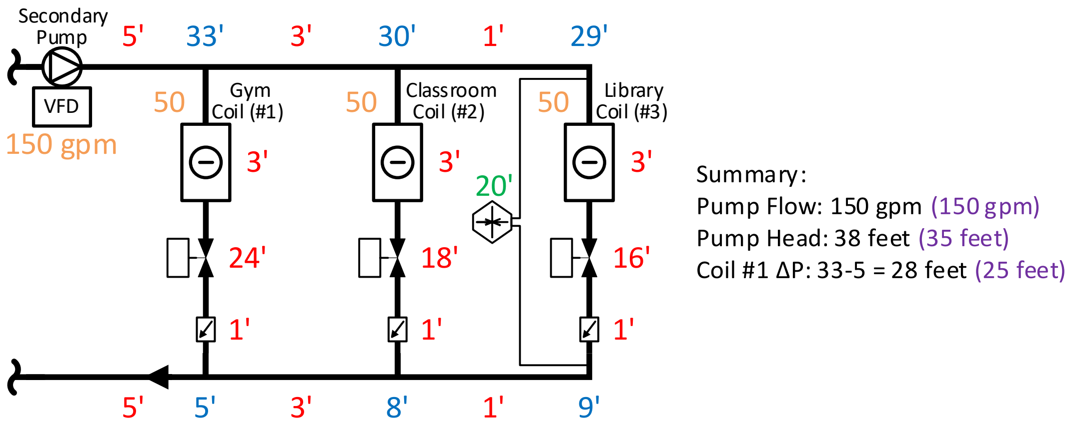

Figure 3 – Balanced ABV CHW System (at 50% Load)

It is worth noting that ABVs do not assist at all with balancing at part load. If you compare Figure 3 in Part 1 to the figure above, you can see that the circuit setter on branch 1 took 8.3 feet of the pressure drop, so the valve only needed to absorb 13.7 feet. Here, the valve is forced to absorb all the pressure drop since the ABV has opened up all the way. This in general is not a problem, however various situations could result in the pressure drop becoming high enough across the valve to cause noise. In short, most noisy valves are the result of other hydronic issues, versus the fault of the ABV.

A savvy reader would recall that higher head equates to higher energy usage, and they would be correct. Looking at the purple text, in both full load and part load cases, we have increased the required head of the pump. As a result, we have used more energy in both cases. This should be taken with a grain of salt, as it is only 3 feet higher in both Figure 2 and 3 compared to an equivalent circuit setter system. This is an exceedingly small amount of head increase (approximately 3%), and as such is almost negligible. However, the real value to ABVs can be seen with the following examples.

Recall our example from Part 1 where we had a Saturday basketball game. In short, we wanted full load on coil #1, and part load on coil #2 and 3. What happened was we were only able to get 70 of the 100 gpm through coil #1. To fix that, we had to either 1) open up the circuit setter on branch #1 and ruin our balance, or 2) increase the DP setpoint (in green). The second was our easiest option, so we did that. We also discussed that it was likely the DP would never get reduced back to the correct value, resulting in long-term energy losses. Let's look at the same situation with ABVs, shown in Figure 4.

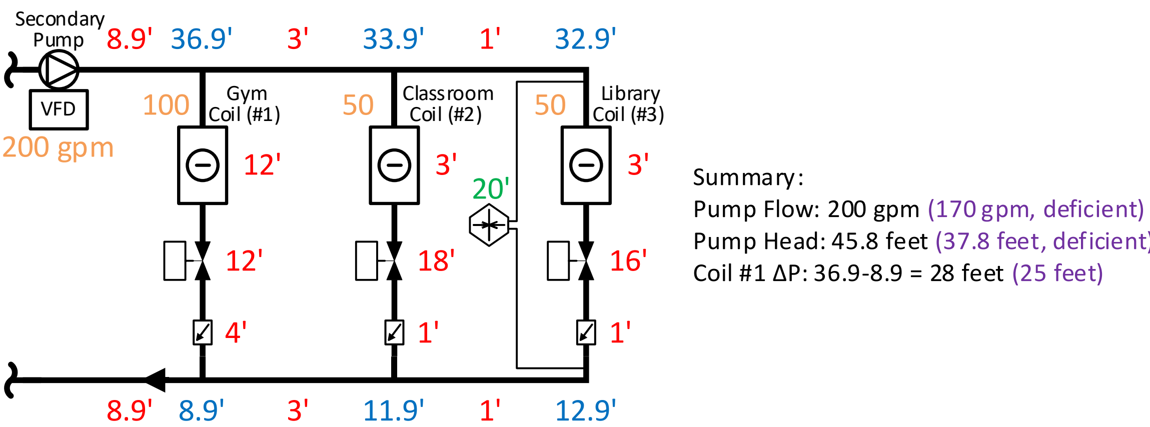

Figure 4 – Balanced ABV CHW System (Saturday Basketball Game)

Note how with the original 20 feet differential pressure setpoint, we are still able to maintain conditions on all three CHW coils! No need to increase the DP setpoint, which means that no one must remember to decrease the DP setpoint come Monday morning. This convenience results in energy savings with less user interaction. A rare energy win-win scenario.

One more "math" note: we do not for sure know the valve will absorb 12 feet and the ABV will absorb 4 feet. Consider the following, if the valve decided to open further (recall that it is a 4 feet pressure drop at 100% open), the ABV would see more flow than 100 gpm and begin to close. As such, a situation with 4 feet across the valve and 12 feet across the ABV is a possibility, as well as somewhere in between. It's not really that important (unless you are checking the math along with the article). The important thing is that the combination will absorb a total of 16 feet, which is what we need to achieve 100 gpm given the branch pressure drop.

While preventing underflow through the coil is a definite advantage, if we are focusing on energy efficiency, a bigger advantage is preventing coil overflow. To understand low delta T, you must understand the following: more flow does not always equal more cooling. Best to explain via example: let's say you have a CHW coil that is designed to have full cooling (100% capacity) at 100 gpm. If you increase the flow to 110 gpm, you won't get 110% capacity/cooling out of the coil. You might only get 101-102%. In fact, you might even get 1-2% less in some situations! We will look at this in greater detail in a future article, but the short answer for why this is, is simply "physics." Heat transfer between a CHW coil and air is not "linear." That same 100 gpm coil might get 60%-80% heat transfer at only 50 gpm! As such, you can see how you have "diminishing returns" with more and more flow. So, if we can keep a CHW coil from overflowing, that is a great advantage for many reasons.

In Figure 8 (*NOTE: to keep this article at a more reasonable length, the comparison to Part 1 Figures 5, 6 and 7 is continued as an appendix at the end of the article.*) we have returned to our circuit setter discussions. An operator has decided to increase the DP setpoint from 17 to 22 feet (an increase of 5 feet). This is not an uncommon decision during troubleshooting – sometimes it is justified, sometimes not. Regardless, let's look and see how that impacts our system balance.

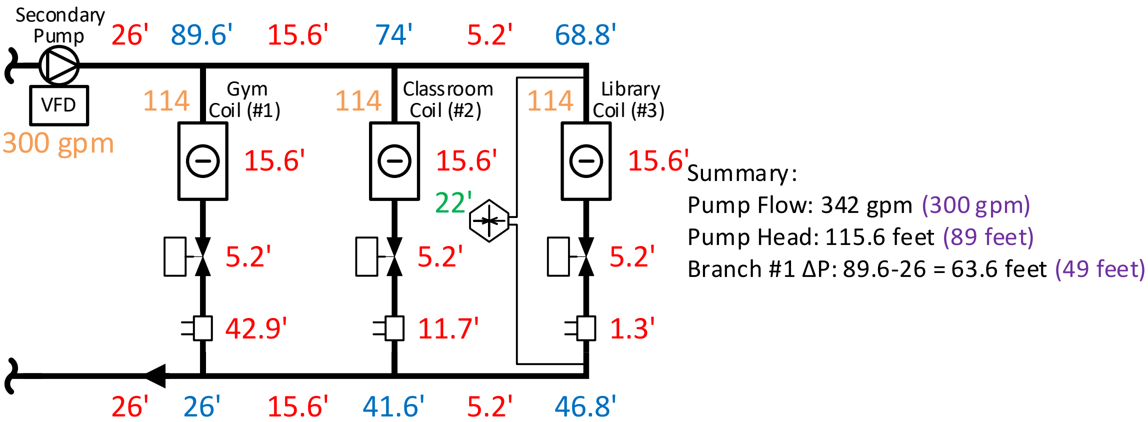

Figure 8 – Balanced Circuit Setter CHW System with Increased DP Setpoint (at Full Load)

As you can see, the increased DP setpoint has allowed us to force more water through each branch. Because the valves remain at 100% open, all components in the system are a fixed geometry, so using the affinity laws we can easily calculate the resulting increases in flow. You might be thinking that if the coil saw this increase in flow, it would result in colder air temperatures leaving the AHU. You might be right, but keep in mind the capacity at 114 gpm vs 100 gpm is essentially the same. As such, the air temperature leaving the coil is likely the same and the valve will remain open as a result. If the coil was selected such that at 114 gpm we got 114% capacity, then the valves would close to get us back to essentially 100 gpm. However, this is usually not the case – most of the time the extra 14 gpm does not benefit the system. We can see the results in the summary to the Figure's right. It does not take a great deal of convincing to see how the increased gpm and head will result in greater pumping energy consumption. Its also possible you would trip a pump's breaker. If you know hydronic systems well, you will also know this operating condition will decrease the delta T across the CHW coil and as such reduce the efficiency of the chiller – a different discussion entirely for future articles.

What if we had ABVs instead of circuit setters? That is shown in Figure 9 below. Note we have again increased the DP setpoint by 5 feet, this time from 20 to 25 feet.

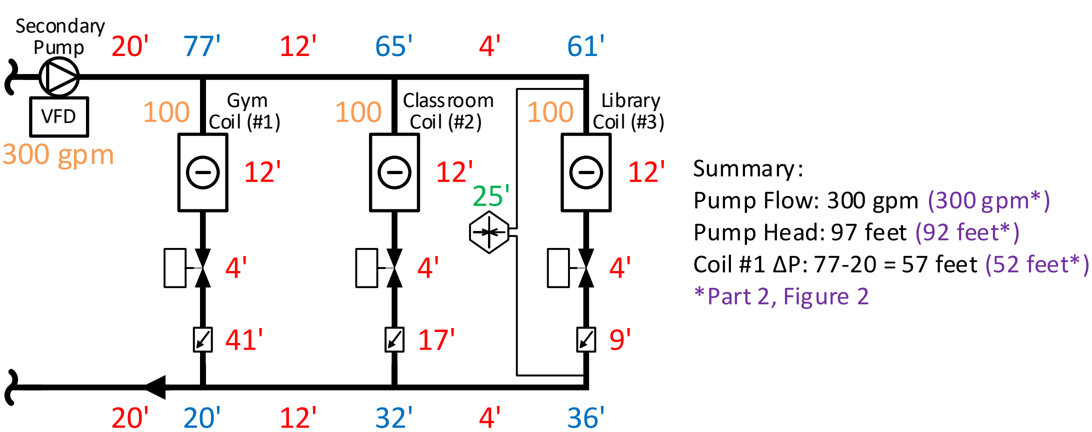

Figure 9 – Balanced ABV CHW System with Increased DP Setpoint (at Full Load)

Essentially, the ABVs have prevented any CHW coil overflow! We have slightly increased energy consumption due to the higher pump head, but that is relatively minor as compared to the circuit setter example above. We can also say confidently the delta T across the CHW coil remained the same compared to Figure 2, so we did not decrease the efficiency of the chiller due to our increased DP setpoint.

There are a lot of advantages to ABVs, but the biggest one in the authors opinion is this: a balanced system is generally an efficient system. Our HVAC systems are constantly changing. Whether it be because of a renovation or addition, or because of maintenance, or because of dirt/scale build-up. They are constantly being altered. Any change to a circuit setter system means it needs to be rebalanced. Something as minor as replacing a control valve, strainer or other component changes the pressure drop and as such change the balance on the entire system. Since the ABV is dynamic, it can respond to these changes without the need for a TAB specialist.

It is worth noting that ABVs can have a "love/hate" relationship with some people. A lot of individuals have sworn to never use them, whether due to high failure rates, lack of flexibility, or prevalence to clogging. While this is at least in part true, the benefits often outweigh the cons. At the very least, they should be considered and discussed before dismissing them outright.

As you recall from Part 1, there are still several things remaining to discuss before we finally get to the ultimate goal of fully explaining low delta T and how to correct it. Remaining discussions include no balance valve systems, DP setpoint reset based on valve position, sensor-less pumping… The list goes on; we will get to those in future newsletters. For now, the takeaways are: 1) whether you have circuit setters or ABVs, the takeaways from Part 1 still apply. 2) If you have a new facility, ask your design team about their preferences between circuit setters and ABVs. 3) If you are an avid circuit setter or ABV fan (or the opposite), reach out to us and share your opinions. A spirited debate is always a good way to learn about pitfalls of different technologies.

Additional Resources

Caleffi Hydronic Solutions ABV Animation https://youtu.be/PlbesL6PhfQ?t=104

James M. Pleasants Flow Limiter Presentation https://www.youtube.com/watch?v=6fVfgOdY6Nw

Griswold Manual vs Automatic Flow Limiting Valves https://griswoldcontrols.com/wp-content/uploads/2018/10/F-5586.pdf

IMI Hydronic Engineering Automatic Flow Control Valves http://www.flowdesign.com/wp-content/uploads/2016/04/F10-AutoFlow-Automatic-Balancing_4.16_SinglePage.pdf

Hydronic Systems, an Energy Perspective, Part 2 – APPENDIX

By: Walter Bright, PE, PEM

If you a true junky on this stuff and you want to see what happens with various DP configurations like we did in Part 1, except with ABVs in place of circuit setters, this appendix is for you. The logic behind why those situations are not of benefit still applies here with ABVs. If you want to prove that to yourself, you can see Figures 5 through 7, which correspond with the discussion presented in Part 1, Figures 5 through 7.

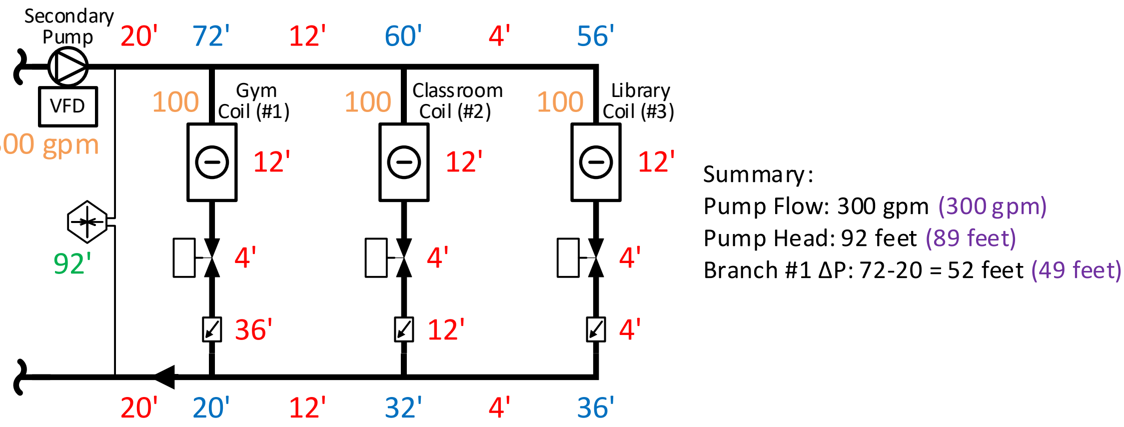

Figure 5 – Balanced ABV CHW System, Relocated DP Sensor (at 100% Load)

Not surprisingly, much like we had to increase the DP setpoint in Figure 2 due to the increased pressure drop across the ABV, we have had to increase the DP setpoint in Figure 5. Otherwise, the system is identical to Part 1, Figure 5.

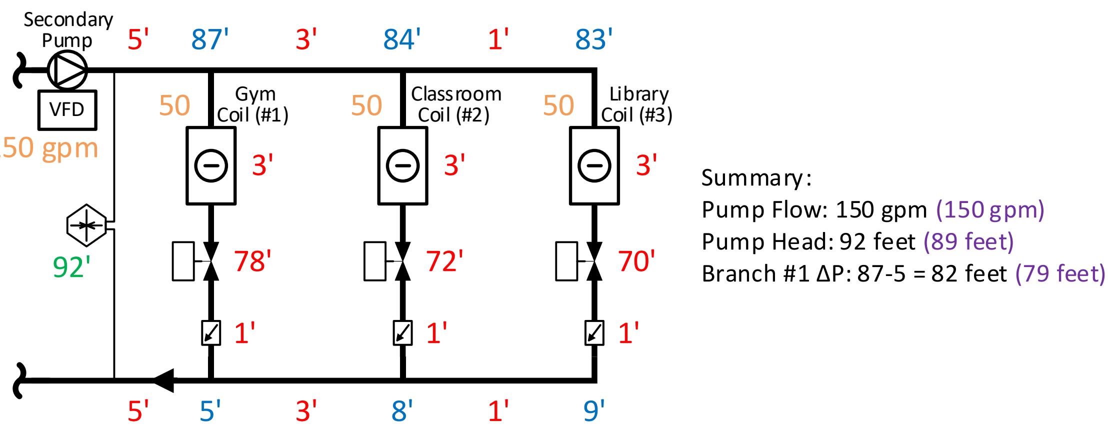

Figure 6 – Balanced ABV CHW System, Relocated DP Sensor (at 50% Load)

Again, just like in Part 1, Figure 6, there is no benefit to having the DP sensor relocated with ABVs.

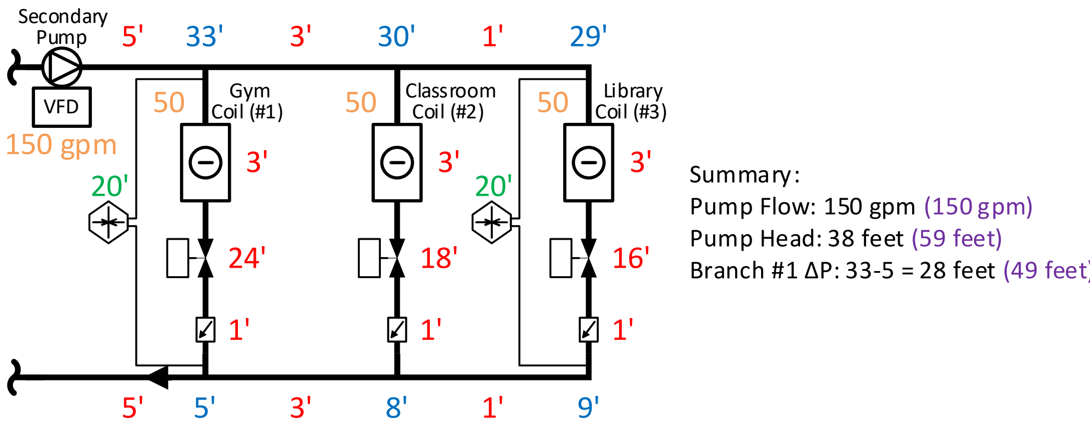

Figure 7 – Balanced ABV CHW System, Dual DP Sensors (at 50% Load)

Note that in Figure 7, we do have some interesting differences, vs Part 1, Figure 7. Due to the fact the ABV on branch #1 can "open up" at different operating points, we only need a 20 feet setpoint (vs the 49 feet setpoint for the corresponding circuit setter example). As such, you may note that Figure 7 is the same as Figure 3 in the article above! In other words, you have spent the additional monies for a DP sensor that is not needed for control (could be a nice "for reference only" data point however). As further proof of the DP sensor being unnecessary, see Figure 10.

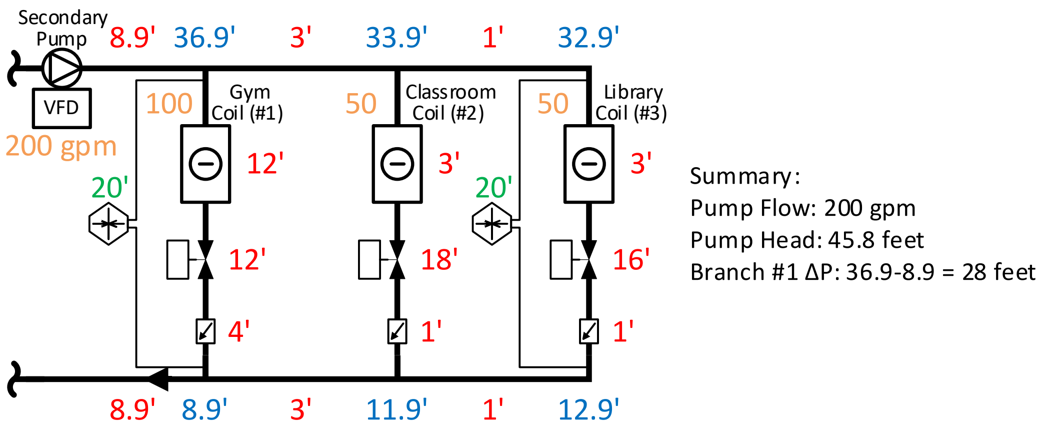

Figure 10 – Balanced ABV CHW System, Dual DP Sensors (Saturday Basketball Game)

Much like Figure 7 is the same as Figure 3, Figure 10 is identical to Figure 4. The actual pressure drop across branch #1 is 28 feet (vs the setpoint of 20 feet), so the pump is controlling to the original DP sensor on branch #3. In fact, if you want to further prove this, you can do your own figure with 0 gpm to coils #2 and 3 and 100 gpm to coil #1. The 20 feet setpoint on coil #3 is still sufficient to cause coil #1 to operate at 100 gpm as desired. The only situation where that would not be the case would be if the coil #1 pressure drop was greater than the pressure drop of coil #3. In that situation, a second DP sensor could be of benefit. However, this is such a rare operating condition that the added cost is likely not justified given the fact it might never happen.