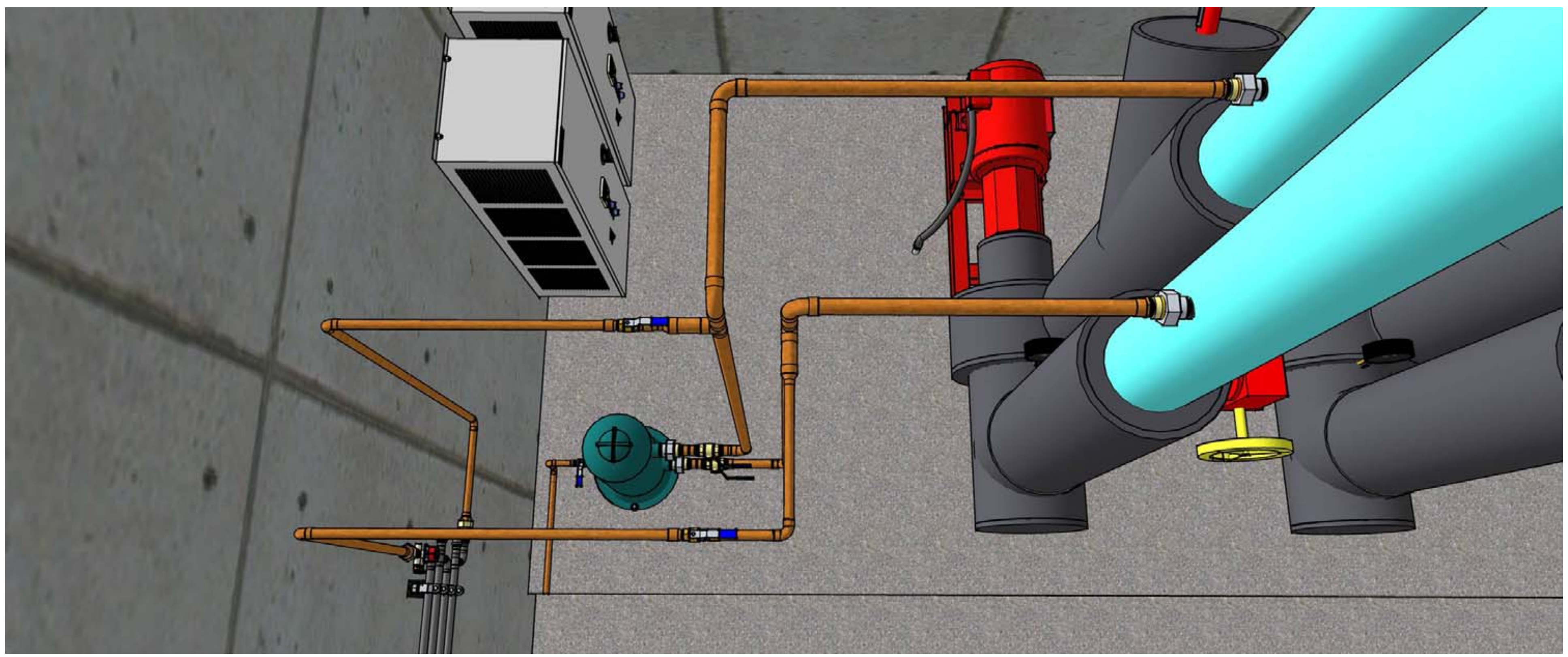
David Sellers

From: David Sellers
Sent: Monday, April 1, 2019 2:25 PM
To: jonathankocher@gmail.com
Cc: Ryan Stroupe (R2S2@pge.com)
Subject: Follow-up Information

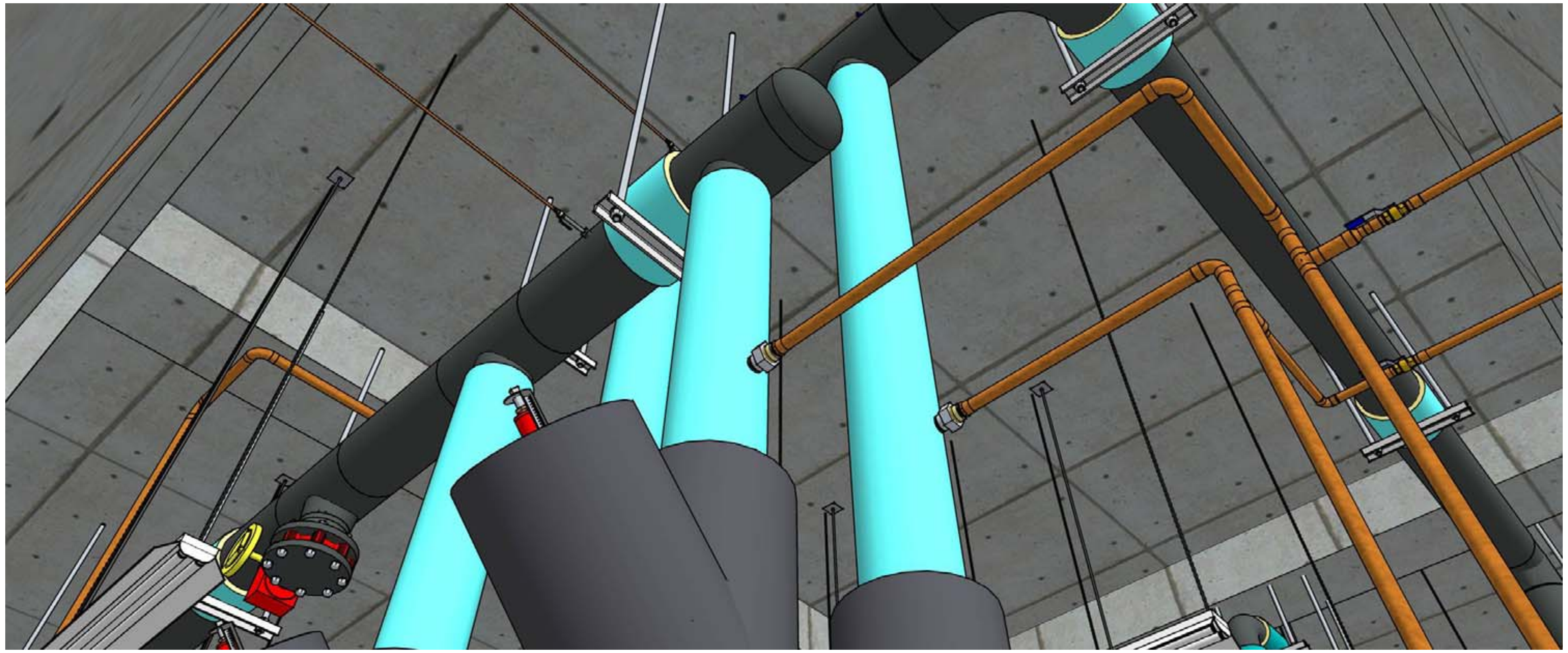
Hi Johnathan,

This is the follow-up information I mentioned I would send during our call last week.

One of the things we discussed was the shot feeder and coupon rack and my notes indicate I would send you some screen shots from the model to help you understand them a bit better. This first one is an overhead view and I think if you trace the pipe out, you can see how both the shot feeder and the coupon rack are piped across the distribution pumps.

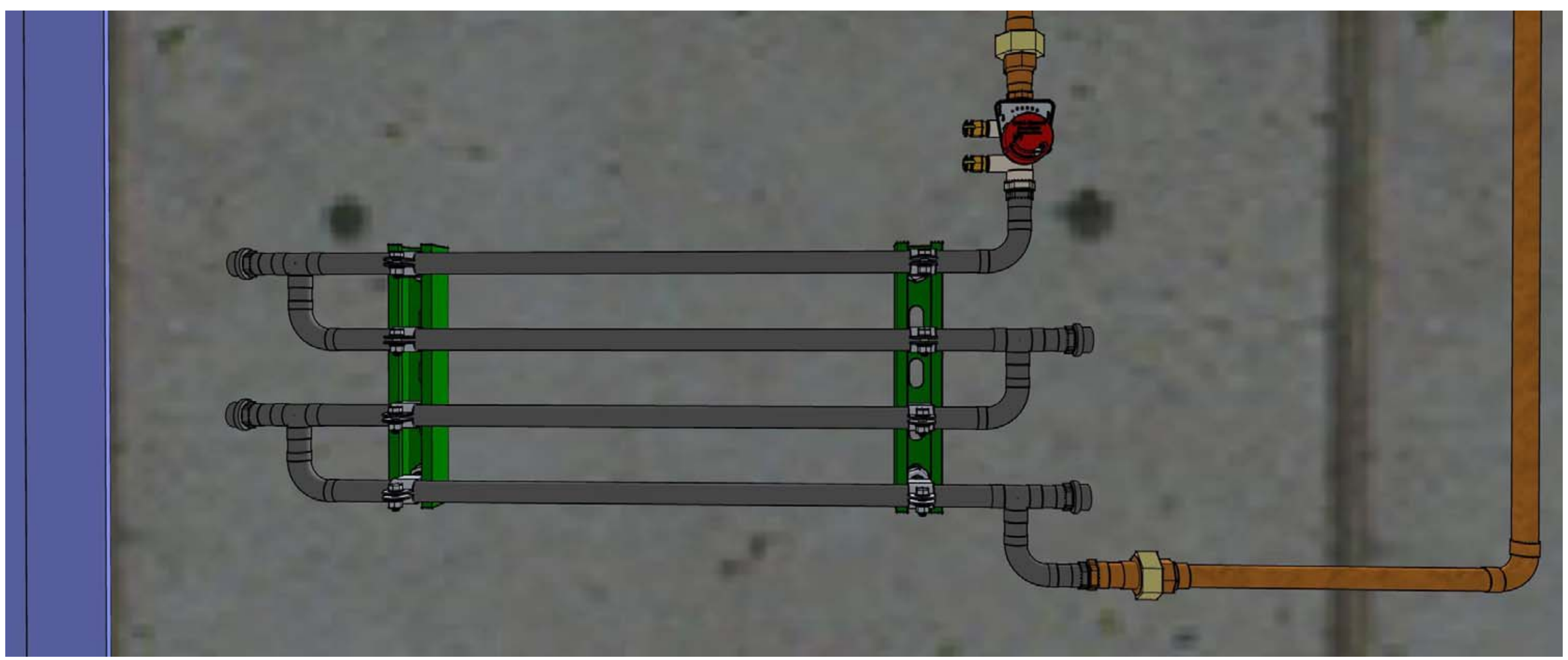


Since the connections are on the system side of the piping drop to the pump and head of the pump isolation valves, they will be available to flow no matter which pump is running, even though they are on the pipe drops to a specific pump.



I think if you study the first picture, you can also see that the service valves provided for the shot feeder will only isolate it while allowing the coupon rack to still see flow. This is important because while you don't need flow through the shot feeder whenever the system is in operation, you definitely want there to be flow through the coupon rack for all operating hours.

In addition to having its own service valves (which you need so you can pull out the coupons to test them) the coupon rack has a balance valve. That is the red valve in the image below.

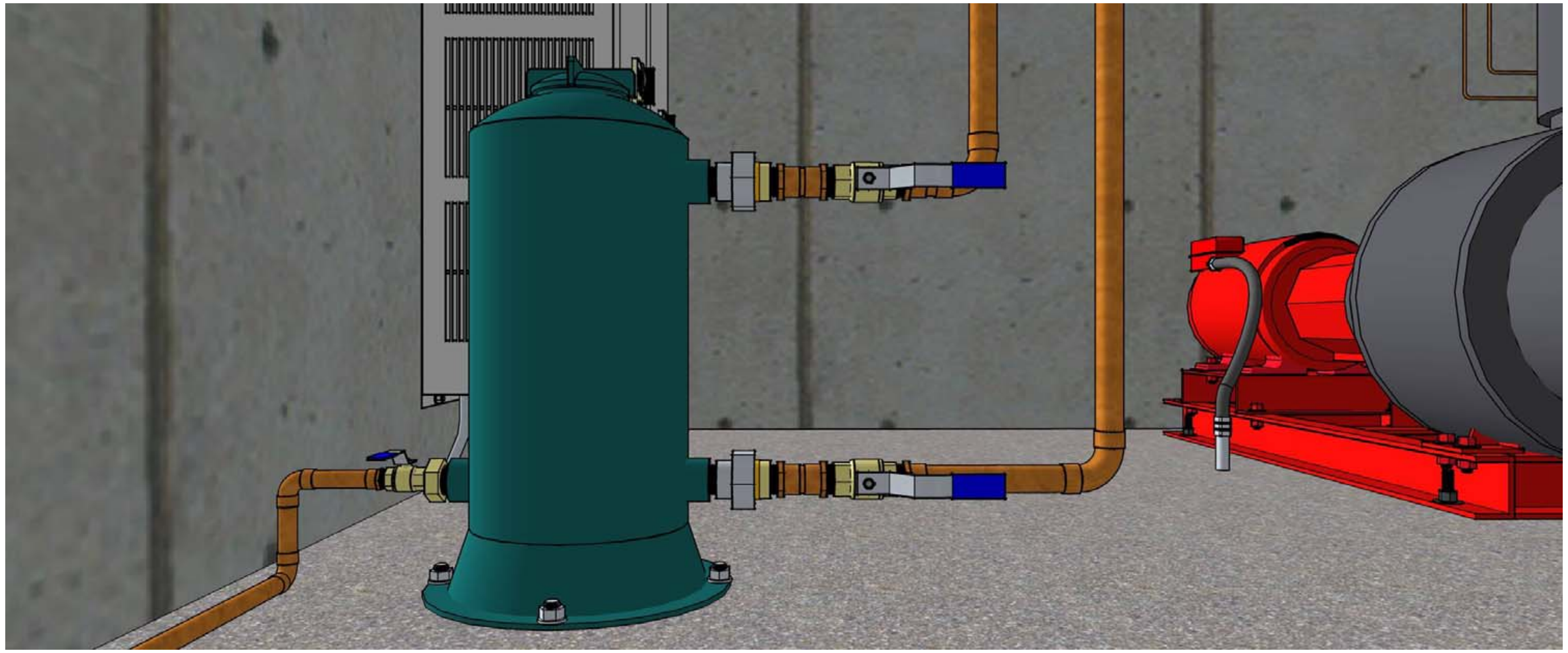


The balance valve should be set so that the velocity in the coupon rack piping is in the same range as the velocity in the distribution system. That way, you will simulate the effects of erosion properly. With out the balancing valve, with the coupon rack piped directly across the pumps, you would likely have very high velocities in the lines and thus, a lot more erosion than is really occurring out in the system.

The coupons themselves are strips of metal that are inserted into the horizontal legs of the rack and are trapped there by the tees and elbows. Generally, a coupon for each type of metal in the system is used so that the corrosion rates can be monitored on a metal specific basis. Here is a picture of what a typical coupon looks like.

In addition to giving you a visual on the state of the metal in the system, by weighing the coupons periodically using a precision scale you can assess the change in weight over time, which tells you the rate of corrosion and erosion going on in the system.

The shot feeder, a.k.a. as a pot feeder, is basically a tank with a drain, two piping connections, and a removable cap.



To use it, you isolate it from the system with the service valves, relieve the pressure with the drain valve, and then open up the cap and put in the water treatment chemical(s) you need. Then you put the cap back on, close the drain valve, and open the service valves. Since it is usually piped across the mains near the pumps, a lot of water flows through the feeder and the chemicals are dissipated to the system pretty quickly. So, once you are done, you can valve it back out and drain it until you need it again.

In the image above, assuming that the operating team did not just put chemicals into the system, the open service valves represent an opportunity to the pump energy associated with water recirculating through the feeder when that flow is not needed. This can be a surprising amount of energy. Gary Walters at 560 Mission Street got curious about it and actually measured the savings he achieved by simply closing one of the isolation valves and it came out to about $450 a year. That was in the Bay Area so high utility rates. But even in St. Louis, it would be worth a couple of hundred dollars a year and those savings could be achieved by simply closing the valve.

The other thing that the shot feeder can do to you in a small system is short circuit a significant amount of your capacity. For example, in the Pacific Energy Center's glycol system, which circulates in the range of 110 gpm, opening the shot feeder up steals about 30% of the capacity and just runs it around in a loop. It's not enough to trip the chiller flow switch, but it does degrade the performance significantly.

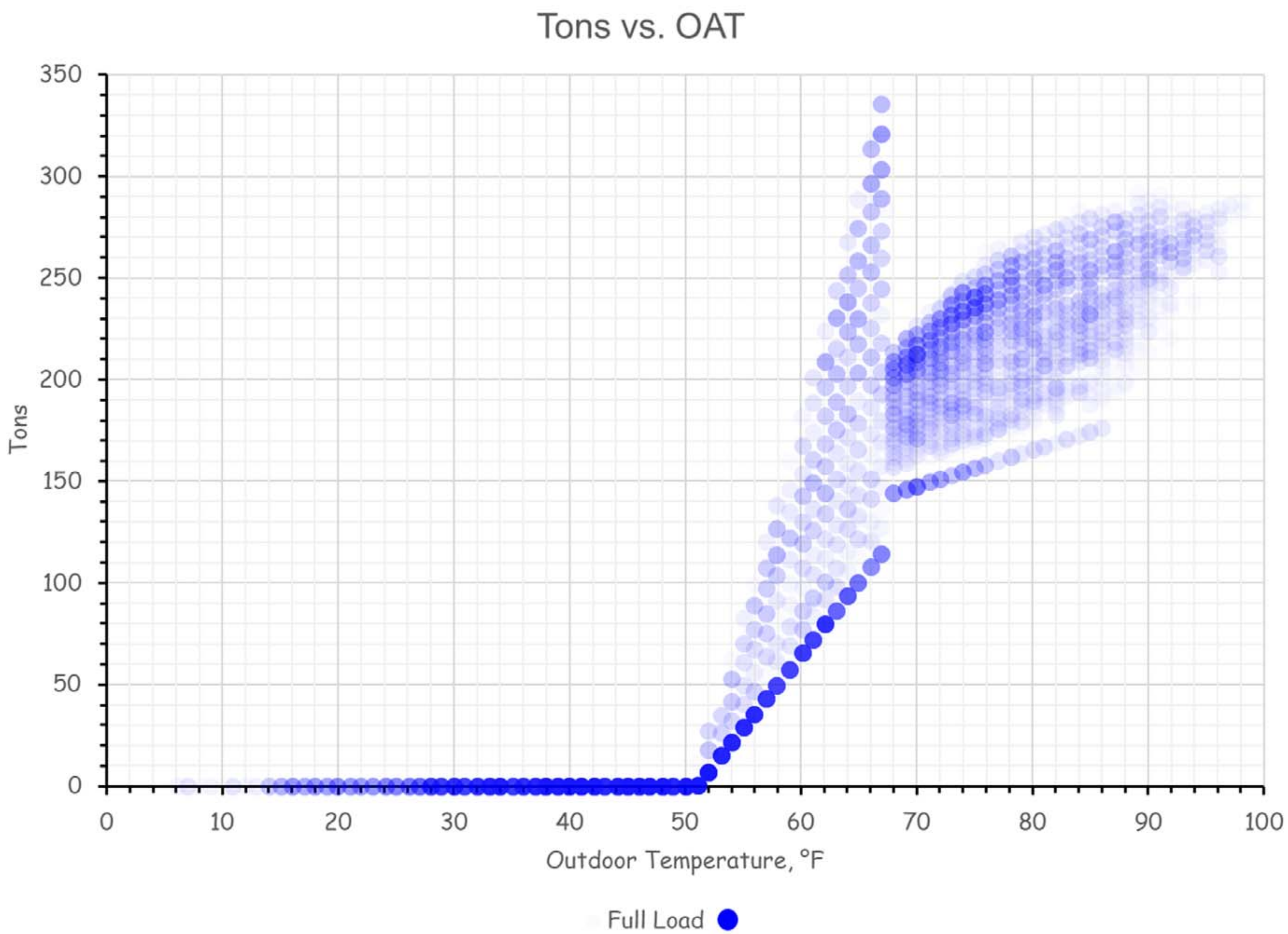
The amount of chemical you need is a function of a number of things including the volume of the system. Calculating that can take some time, which means one of the most valuable things you can due in a new construction Cx process (or any process where the piping system you are working in is drained and needs to be filled) is to read the water meter before and after you have the system filled and vented. Assuming the meter is dedicated to the system, then what you read is pretty much exactly how much water there is in the system and your water treatment guy will find that to be very useful information.

We also talked about how to piggy-back on to a 4-20 ma current loop and how those work in general. I have a string of blog posts that I think would get you to speed. This link should take you to them.

https://av8rdas.wordpress.com/category/4-20-ma-current-loops/

Finally, I talked about how plotting OAT vs tons on a chiller plant can give you some insights similar to those provided by the economizer diagnostic plot I discuss in class and that Ryan has built into the Universal Translator.

It turns out that if you look at what the load would look like on a chilled water plant that was serving integrated economizer equipped constant volume AHUs 100% outdoor air AHUs, in a perfect would, you would see a pattern something like this if you plotted tons vs. outdoor air temperature.

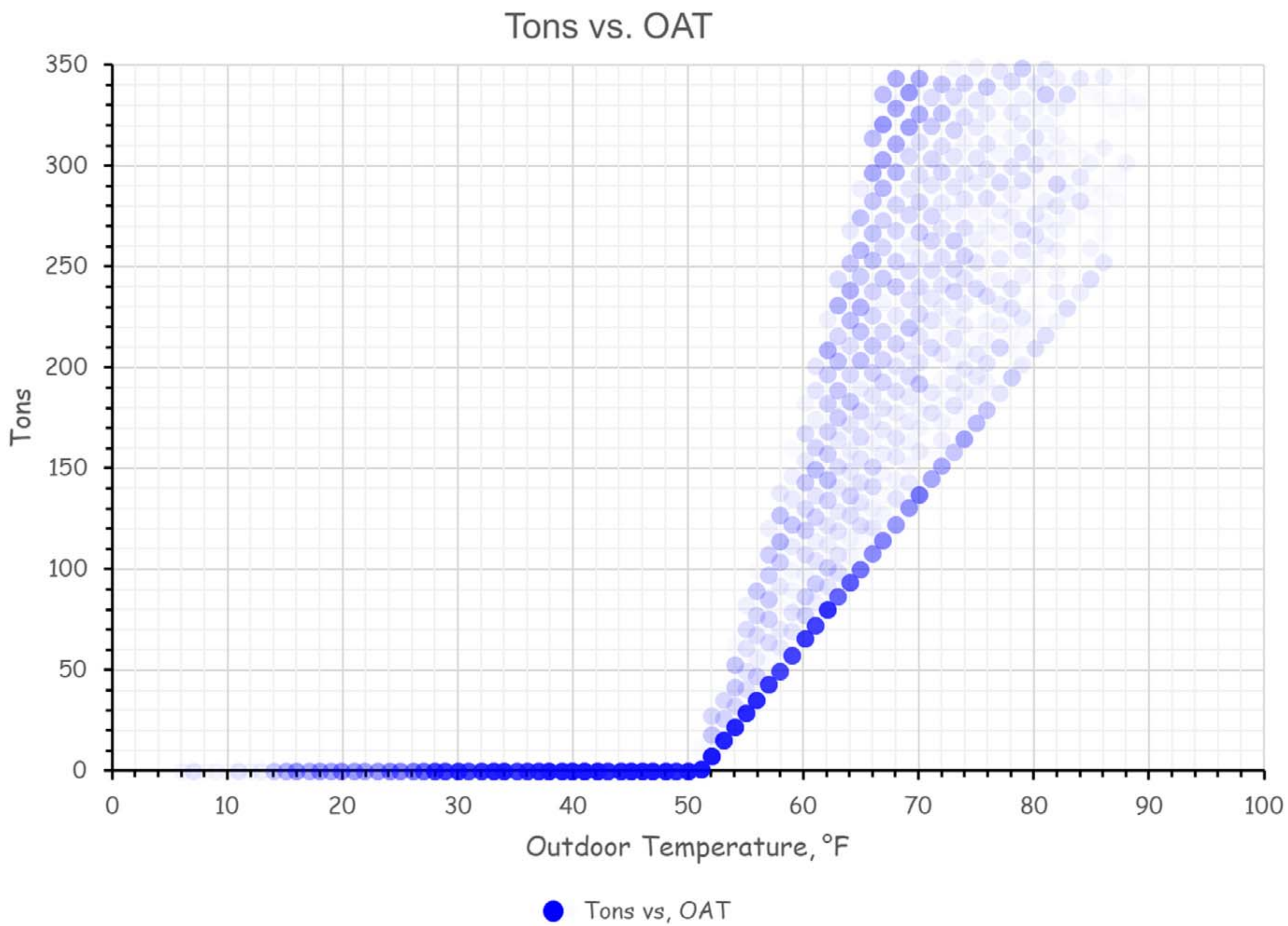


This particular plot is based on the Nashville, Tennessee climate, so a hot and humid environment.

The plant would have no load on it when the outdoor temperature was at or below the AHU discharge temperature (in the example above, 51°F). Above that temperature, the plant would be seeing a 100% outdoor air load and the load would pick up pretty quickly as the outdoor air temperature went up. Even with perfect sensors and a perfect system, there would be data scatter in this area because of the different outdoor air humidity levels.

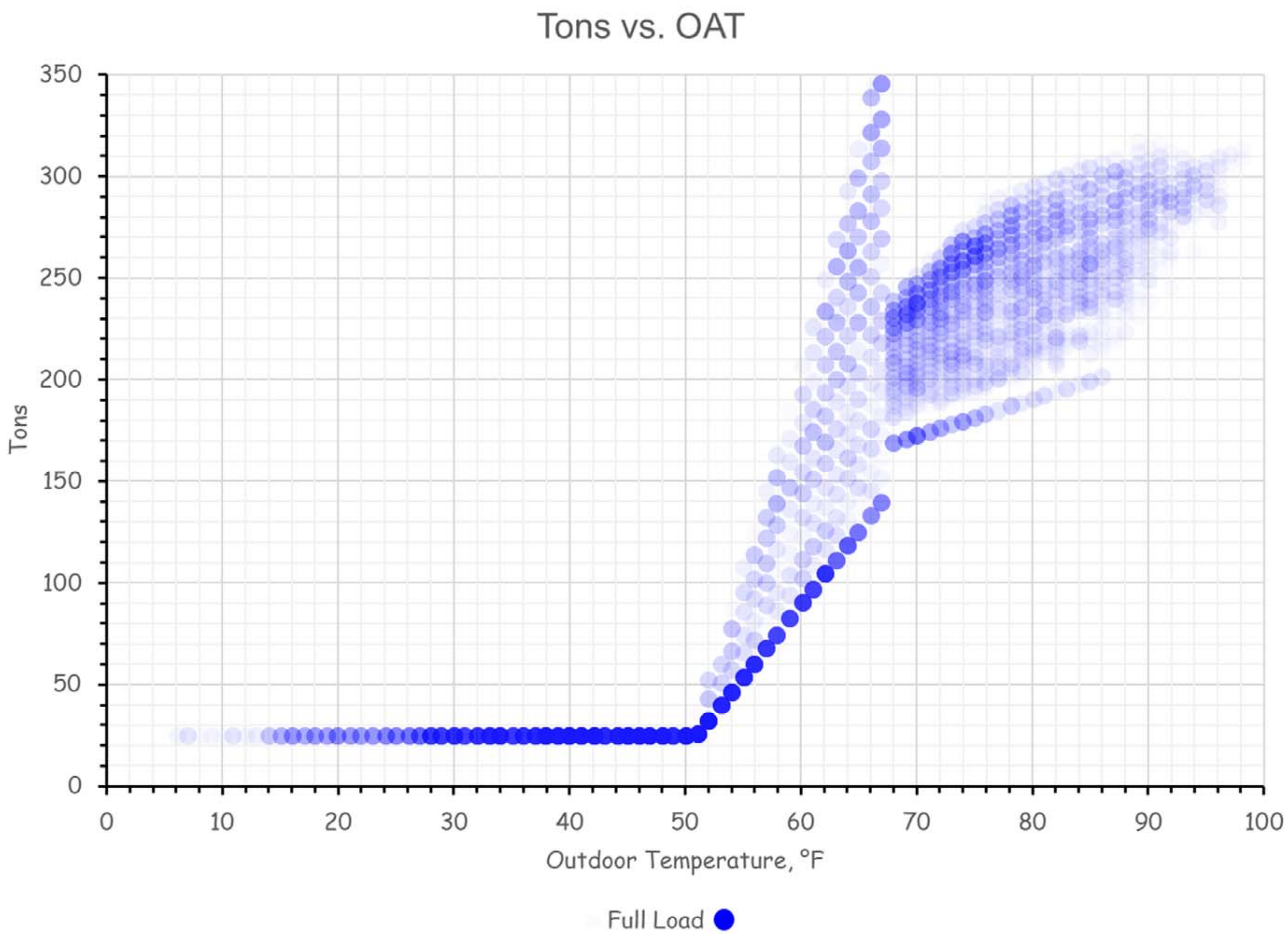
When the outdoor temperature reached the economizer high limit setting (68°F in this case), the rate of load increase would flatten out with the slope of the line being related to the minimum outdoor air percentage (25% in this example).

For 100% outdoor air systems, there would not be a point where the slope of the cloud tended to drop; the cloud associated with the plant loading up as the outdoor air temperature increase would just extend upward with a wider scatter as it went due to outdoor humidity variations.

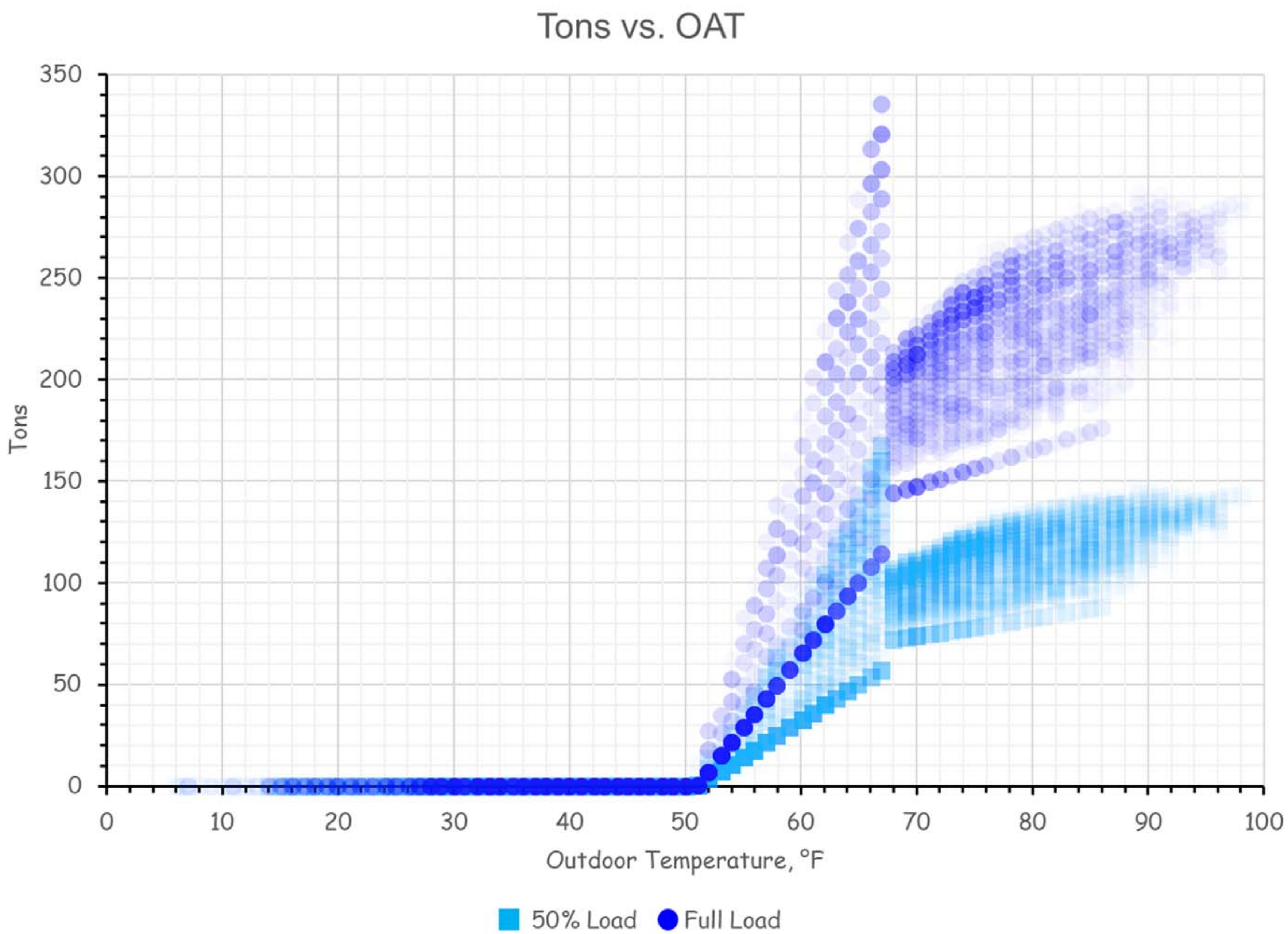


For a plant serving a mix of economizer equipped systems and 100% outdoor air systems, the cloud pattern would be something between the two previous images with the slope of the cloud above the economizer high limit set point being a function of the over-all building wide outdoor air percentage. The width of the scatter in the cloud would be related to how variable the outdoor humidity was over the course of the year.

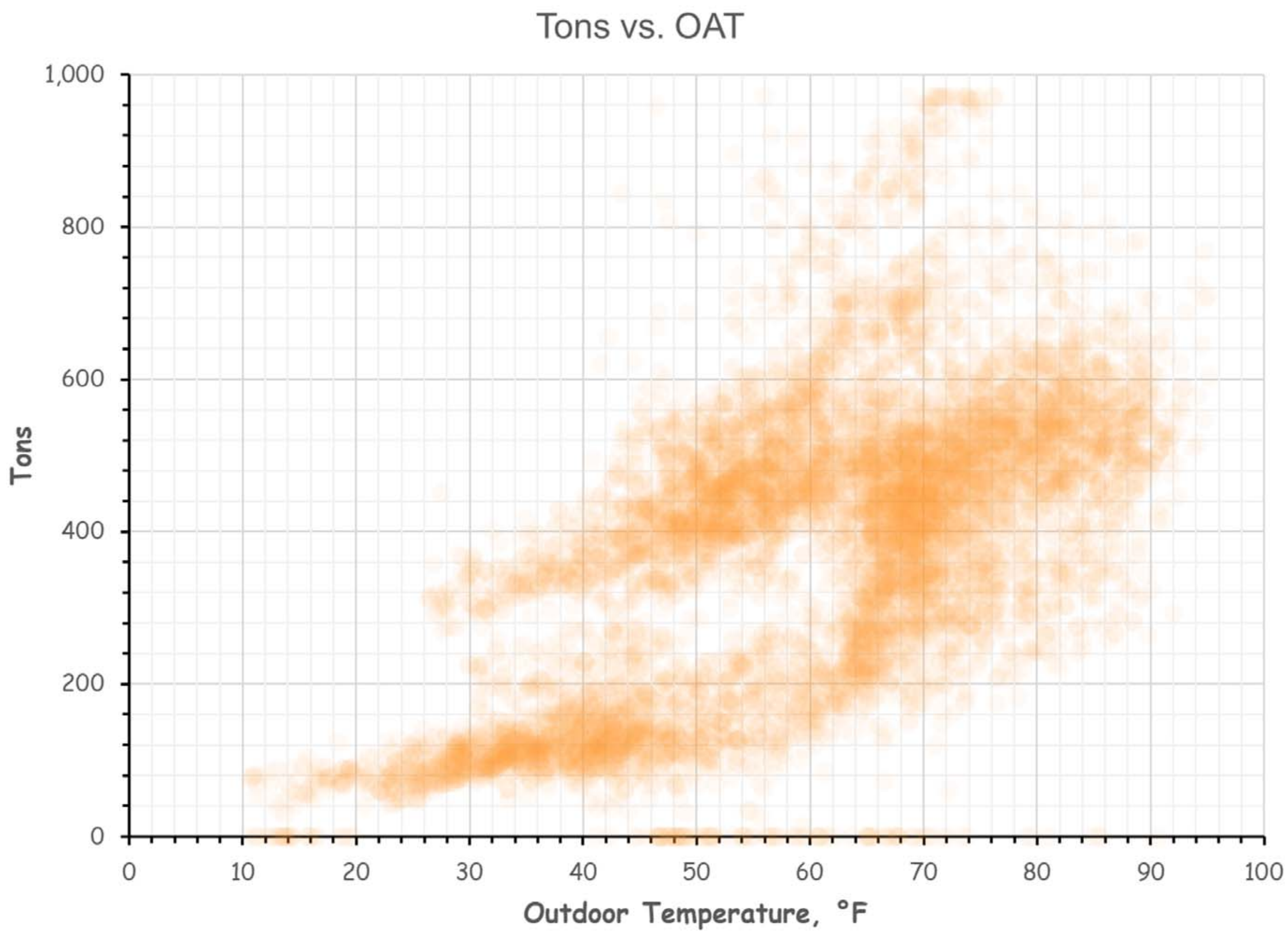
If the plant had a steady base load on it, the horizontal line would be shifted up from 0 but the amount of the base load (25 tons in the example below).



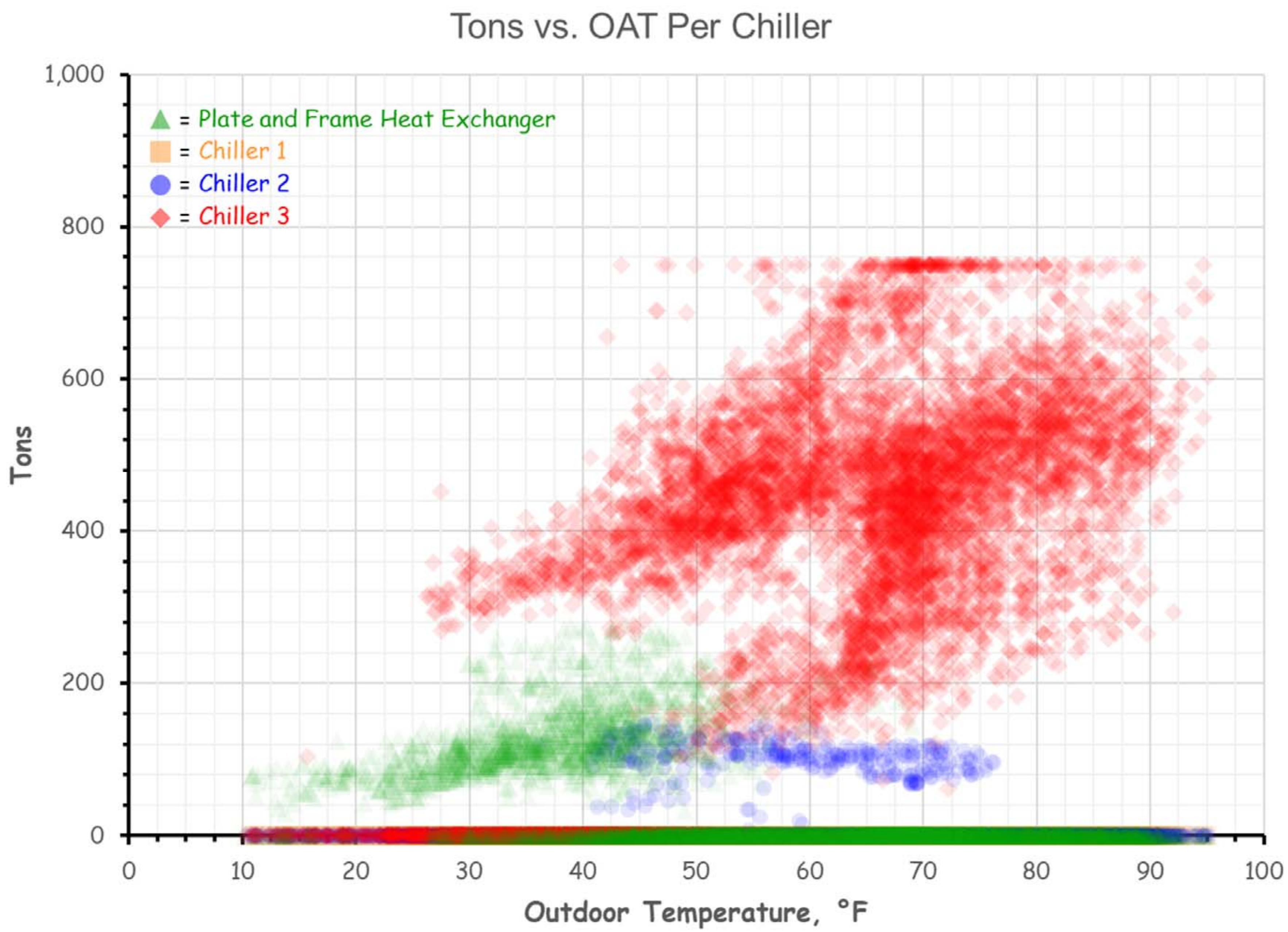
For VAV systems, the operating cloud would vary between a cloud associated with the design flow rate and a cloud associated with the minimum flow rate. Both clouds would be shifted up by a base load if one existed (there is none in the example below).



Once you a have gained some familiarity with what the perfect patterns should look like, I have found that it can be useful to look at a real plant this way because it frequently will point you at issues and opportunities and even give you a way to quantify them in the general sense pretty quickly.   For example, I am working on a plant down in Atlanta and the data cloud looked like this. This plant is in a Hotel and serves mostly integrated economizer equipped VAV AHUs. But it also serves some 100% outdoor air loads associated with kitchen and corridor ventilation.



When you filtered out transient, high loads created by warm sensors when a chiller started or shut down and the plotted the data by cooling source, the chart looked like this.



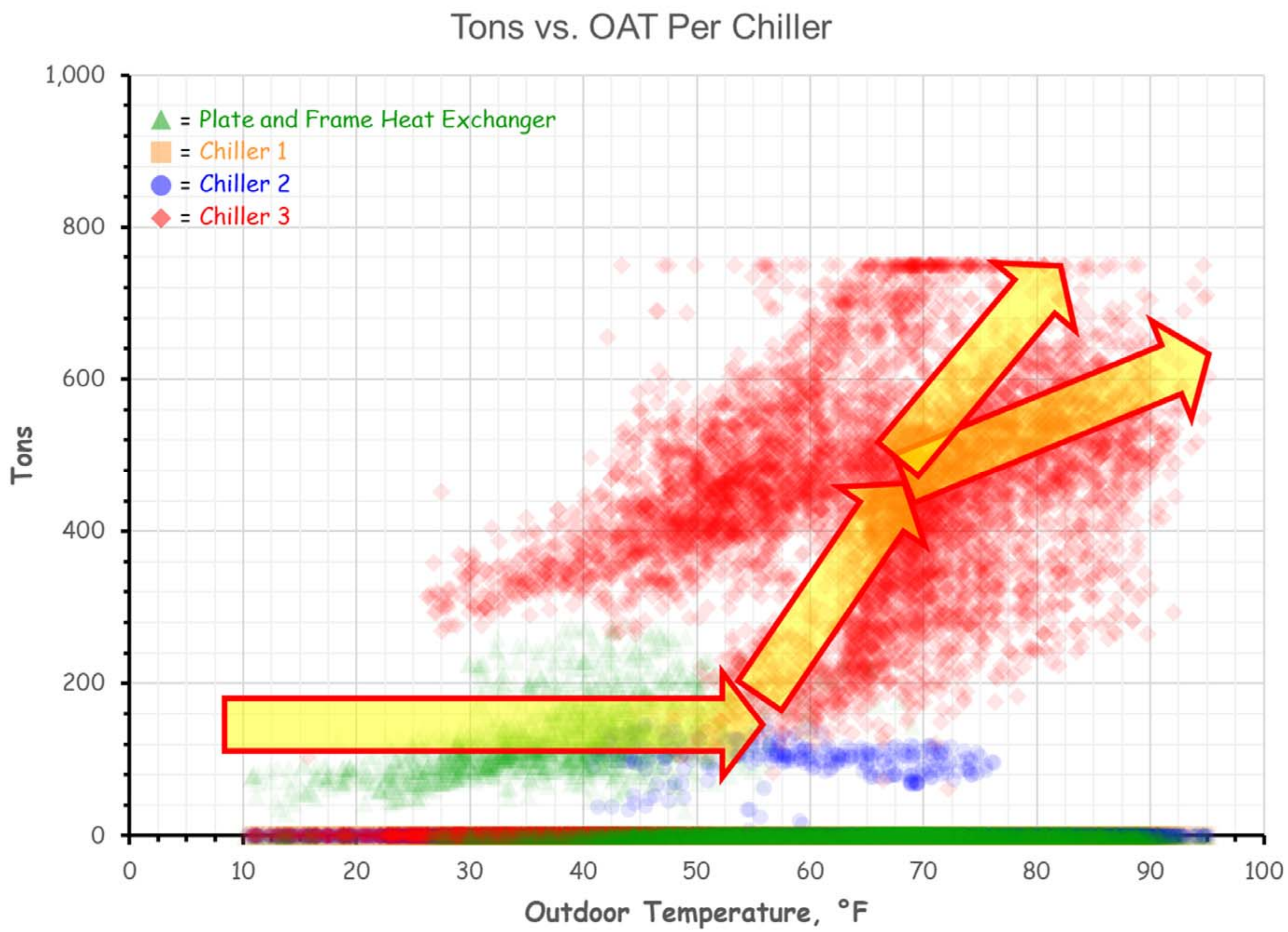
Given the patterns we have discussed, a number of things become fairly obvious.

1. The plant sees a fairly steady 100-150 ton base load the horizontal cloud around that level). Much of the time, this his handled by a plate and frame heat exchanger (the green cloud) but occasionally a chiller is operating to handle it (the blue cloud). There are two opportunities here.

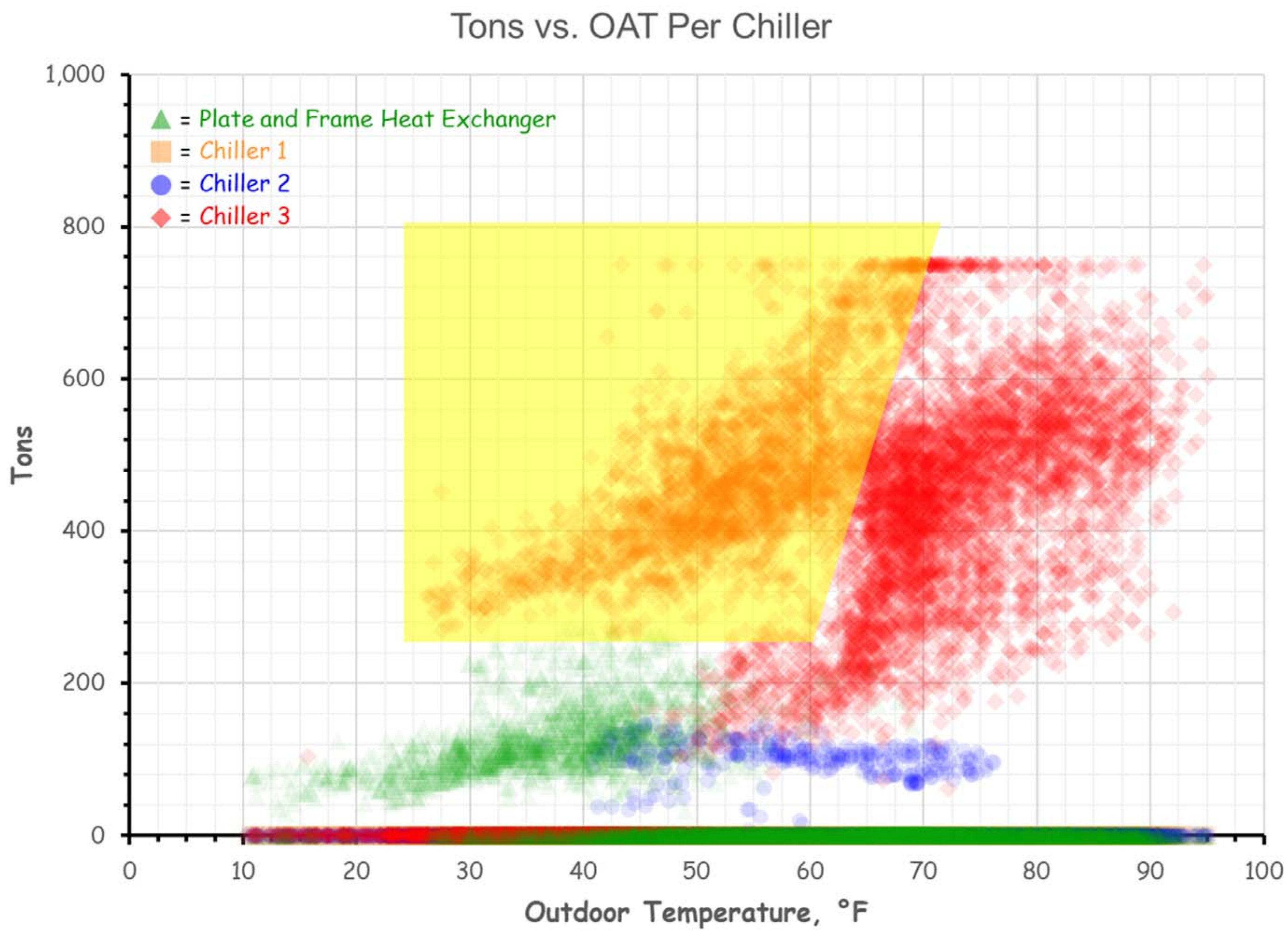
    a. Should there be a steady 150-250 ton base load given the nature of the equipment connected to the plant. In this case, the answer is probably not once it gets below the low to mi 50°F range outside. On a sunny day, there might be some solar load at those conditions. And, there is probably occasional instances of a guest entering a room that is 72°F and wanting it to be 68°F, which would put a short, transient pull-down load on the system. But it was surprising to see a steady 150-250 ton base load and when we went looking we found a number of issues like preheat coils that were active when they didn't need to be.

    b. What ever the base load is, optimizing the operating sequence so that the water side economizer can handle it as much as possible will be beneficial; i.e. see if you can get rid of the blue dots below about 50°F. We think we can because most of the time, the wet bulb at those conditions is low enough that the towers should be able to provide cold enough water to do the job.

2. The plant also sees a load in the 300 – 600 ton range during hours when you would expect outdoor air to provide some of the cooling. In other words, you would tend to expect the cloud to follow the path highlighted by the yellow arrows below with the steeper arrow on the right side being associated with the 100% outdoor air systems and the shallower arrow being associated with the economizers on minimum outdoor air.

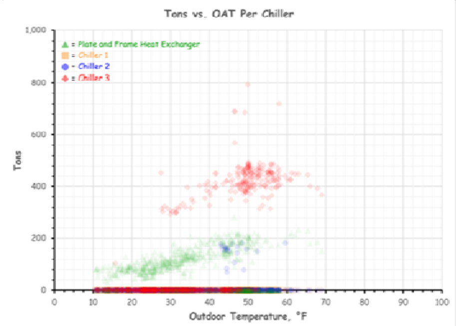


And in fact, the plant seems to do that some of the time. But there are also hours when the minimum outdoor air condition seems to persist (the yellow box in the image below).

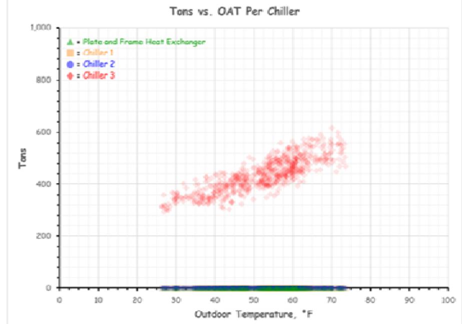


3. Since each dot on the scatter plat is associated with a particular tonnage for a particular amount of time, if you filter out the dots associated with the normal patter and do the math for each data point, you can come up with the ton hours or errant operation. If you then multiply that by the nominal plant kW per ton, you can come up with kWh and assign a value to the disfunction. This is a rough value but it is pretty easy to grab and in this case, it came up to about $50,000 - $70,0000 per year if we could figure out what the issues were.

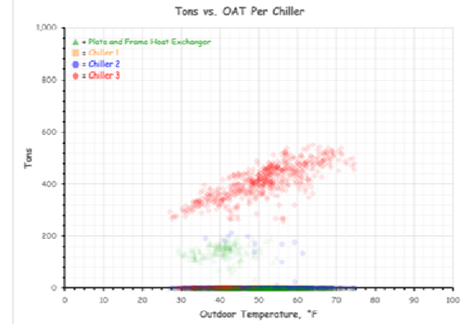
4. The obvious potential issue from the patter is that the economizers are not working and are remaining on minimum outdoor air some times. I suspect that might have something to do with cold weather and trying not to freeze coils and sure enough, when I filtered the data by month, a pattern emerged that basically supported the hypothesis (top image) especially when you compared it to the annual typical climate pattern (bottom image).



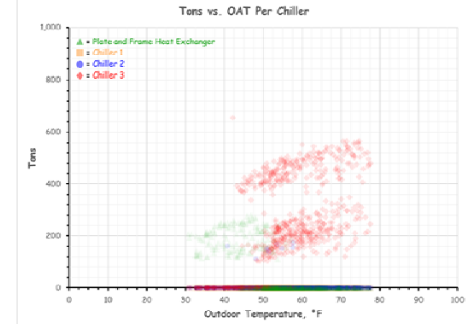
January



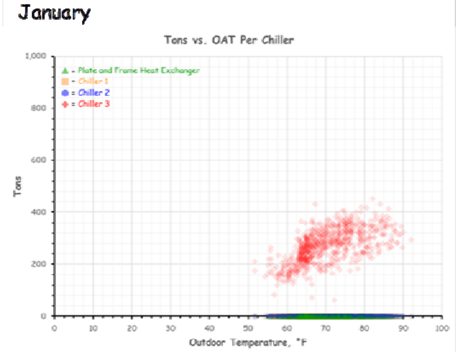
February



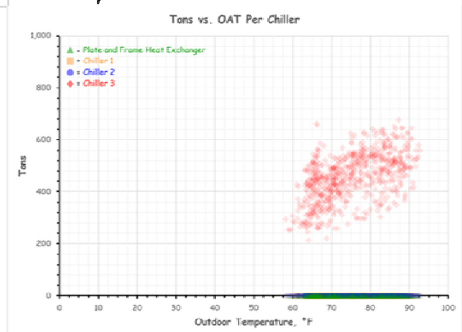
March



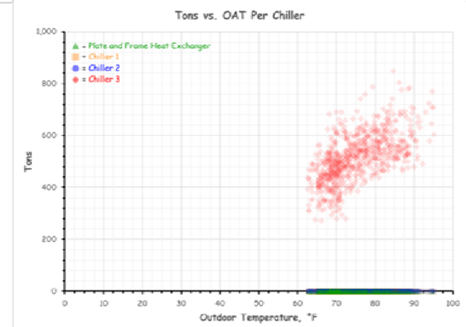
April



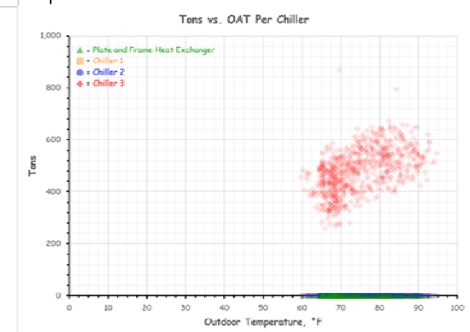
May



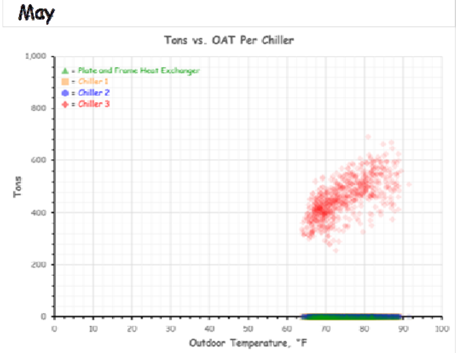
June



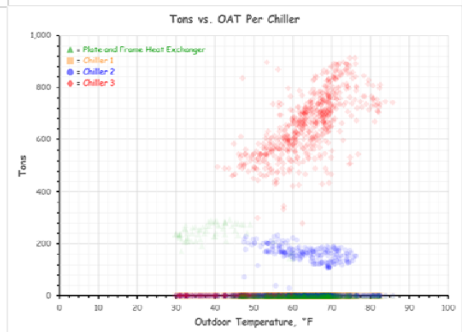
July



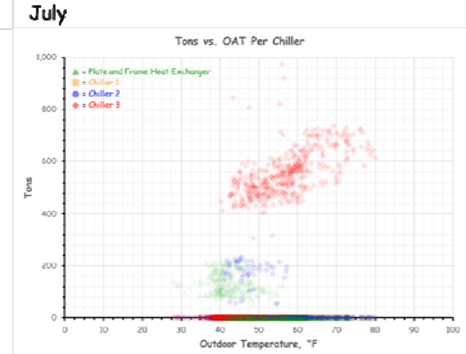
August



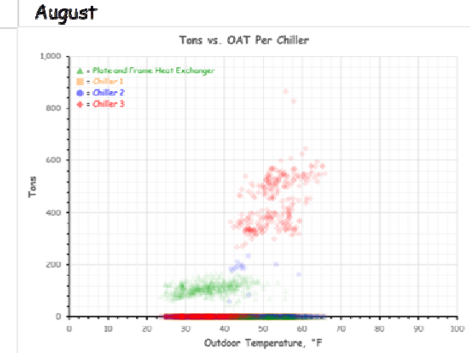
September



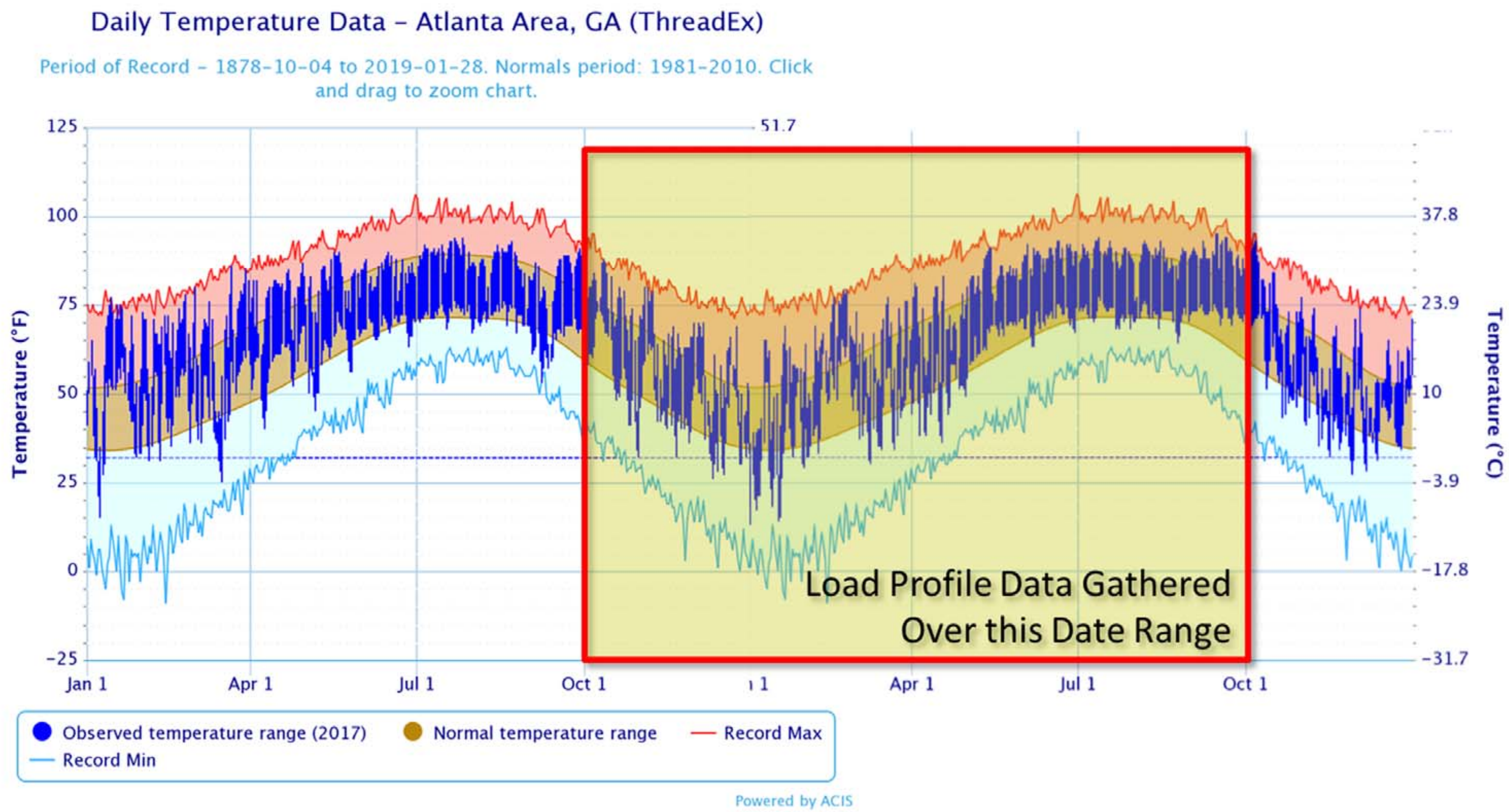
October



November



December



Notice on the climate chart how the really cold weather that existed for the data period we were using did not show up until late December and then lasted through February into March.

Notice how in the monthly tonnage charts, the high load at low ambient outdoor temperature data shows up in January and persists through March. When we checked into it, it turned out that they had in fact locked the economizers out to protect their coils and kept them that way until they were confident they were out of the temperature range where they could freeze a coil.

Freezing a coil can easily cost about $5,000 or more per instance depending on how much water damage happens, etc. Their units are configured in a way that makes it almost impossible to get good mixing, so it is very likely that you will freeze a coil even if everything else was just right. Reconfiguring the units is cost prohibitive (until they need to be replaced, so this is a lesson to carry forward for sure). But what we realized we could do was adopt an "if you can't beat 'em, join 'em" strategy. Meaning:

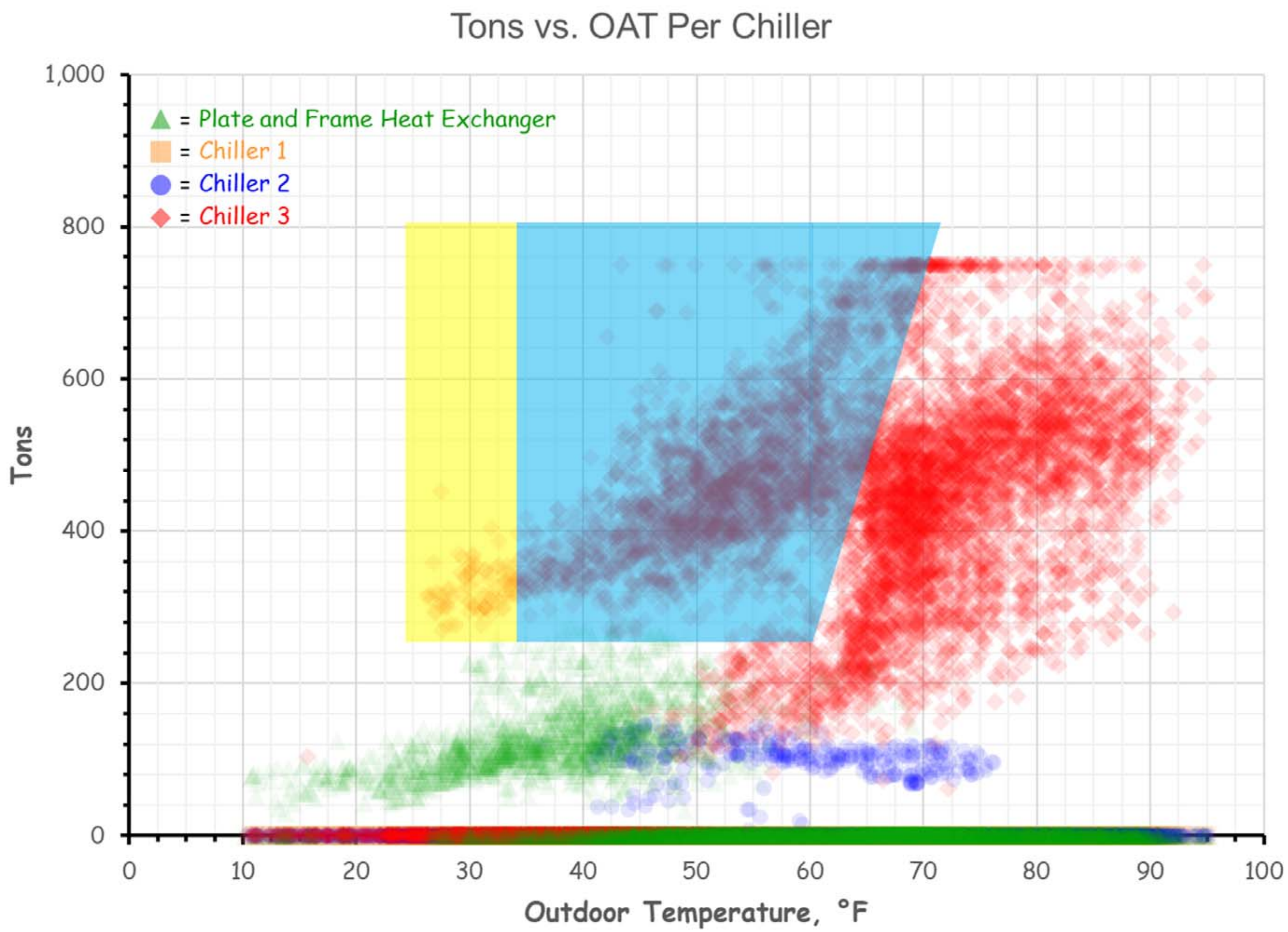
a. We will add and calibrate sensors so we know we have good information to control with.

b. We will repair dampers to restore blade seals and linkage systems so we know that the dampers move when we ask them to and are not leaking when they are closed.

c. We will verify the minimum outdoor air settings so we know we are not bring in any more air than we need.

d. We will modify the control sequence so that once the outdoor temperature drops below 33-34°F or so, we revert to minimum outdoor air and use chilled water for any additional cooling we need. Under those conditions, the cooling towers can provide that cooling via the plate and frame heat exchanger, especially once we get rid of the unnecessary base loads like preheat coils leaking by, etc.

So we basically are trading an air side economizer for a water side economizer when we are at risk of freezing the coils. But, but only doing it when the conditions are such that we could freeze a coil and allowing the economizer to function otherwise, we avoid the chiller operation associated with the blue box below and use the plate and frame heat exchanger to provide chilled water for the points in the yellow box.



My recollection is that you have a ton vs. OAT graph or if not, you have the data you need to make one. And given some of the other patters we discussed, I would not be surprised if doing an analysis like this would not provide some similar insights for you. Meaning it would be a good natural response functional test that would set up some cost benefit calculations for you.

The files behind the charts above are pretty big so I will send them via Hightail.com. And the project specific one has not been sanitized, so please don't directly share the data and sanitize anything you do share.

Let Ryan and I know if I forgot something or if you have questions and want to further discuss any of this. I'm pretty sure Ryan would be happy to set up another meeting. Or we could just do it when you send me your system diagram and we set up that discussion.

Take care,

David
Senior Engineer

Facility Dynamics Engineering
Northwest Satellite Office
8560 North Buchanan Avenue
Portland, Oregon 97203
Office - 503-286-1494
Cell - 503-320-2630
DSellers@FacilityDynamics.com
http://www.facilitydynamics.com/
Visit my Commissioning Resources website at www.Av8rDAS.com
View *A Field Perspective On Engineering* and past posts from
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