The Bayview Marquis Hotel and Marina Ball Room AHU

Assessing Air Handling Findings

If you are using the electronic version of this document, you can quickly navigate through it by opening up the bookmarks feature for the .pdf version or the navigation pane for the Word version. Note that if you do this, you will see the headings that are tied to the questions associated with this exercise so you can easily jump to them if you want to.

Overview

In this exercise, you will go back and work with the Ball Room AHU model that we used for the SketchUp Model Exercise 2 – Scoping a Ball Room AHU to develop some of the findings that you observed. I am still working on commenting on the answers provided by the various teams but in the file you will download for this exercise, I will include the "official" list of the 22 or so items I know of that are opportunities you could discover in the exercise so you have that for reference[1].

For this exercise, we will focus on a few of the more common air handling system opportunities. As a first step, working with the model, I will ask you for information you can pick up by looking at the indicators in the model along with rules of thumb and other things we have (hopefully) learned over the course of the class so far to make a field assessment of what the next steps need to be and maybe even what the issue is costing you.

Then, we will take some of the field data a step further and project the annuals savings associated with one of the opportunities. To do this, you will need to build on the calculation techniques we have been exploring in the past two exercises by dealing with a variable load profile instead of a steady state load profile.

The exercise materials are in the form of two packages because to simulate the field situation and the information you would have available standing in the mechanical room. I want you to only open up and use the information in Package 1 to answer questions .

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[1] I believe some of you found this already since it is posted on the website with the SketchUp model exercises that are generally available to the public. But the version of the model you worked with had one or two more opportunities in it so you may want to look at what I include in the zip file.

Once you have answered those questions, you can open package 2 and use that information to further develop you're your observations.

Field Assessments – Package 1

Economizer Status

Many of you noticed that the economizer appeared to be on minimum outdoor air and that maybe it should not be (Finding 15). To do that, you had to connect a few dots including the following.

Dot 1

It is a foggy cool day outside as you may recall from Figure 1 and the fog tells you the RH is 100%.

Figure 1 - The Hijend Bayview Marquis emerging from the fog as you approach on your first day on the job as the new DOE.

Dot 2

You can pick up a specific outdoor temperature from Scene 10, which, along with Dot 1, gives you the outdoor air condition on the psych chart.

Dot 3

You can estimate that the ball room condition is at the Marriott design target of 72°F, 50% RH for a number of reasons including:

1. You can assume the temperature is in the 72°F range because Sue (the chief engineer) told you she and the tech had gone by the room and checked it out on her way down to the plant to meet you, and
2. You can assume the space RH was on target or maybe even a little below target because the cooling coil was condensing, and,
3. The AHU was delivering air at about the design condition specified for the cooling coil at the fan discharge if you look at the plans on the plan table in the chiller room, and
4. The fan heat between the sensor you are looking at and the cooling coil means the coil is making air a degree or so colder than what is indicated, and
5. Most of the time, the cooling coil leaving air temperature is set based on the space design dehumidification requirement by making near saturated air at the targeted temperature.

Dot 4

You can assume the return air dew point is about the same as the ball room dew point because while there is probably some heat added to the ball room air as it comes back to the mechanical room, there probably is not much moisture added to it. This along with the return air temperature gives you the point on the psych chart associated with the return air condition.

Dot 5

With the outdoor air and return air psychrometric conditions identified, you can use the iPhone psychrometric app in scenes 11, 12, and 13 to compare the enthalpy of the two air streams (you could also have done this with your psych chart tool).

When you do that conclude that the unit really should be on 100% outdoor air since the outdoor air enthalpy (energy content) is less than the return air enthalpy. That means you have found a contributor to the unnecessary load on the chiller plant.

From the model, you don't know why the dampers are locked on minimum outdoor air[2]. But there will be a clue about that in the information I am providing with this exercise.

Question 1

What are some things you could do/safeguards you could put in place to keep this problem from happening again?

Economizer Improvements

Aside from the fact that the economizer is not in the correct operating state for the current outdoor conditions, many of you noted several other issues and opportunities associated with it. You can review the ones I intentionally built into the model by reviewing findings 3, 7, 8, 12, 13, 17, 18, and 20.

Bottom line, if you were the new DOE in our imaginary hotel, there are obviously a number of things you might want to apply your new found AEP skills towards correcting.

Question 2

Pretend you are standing there in the field with Sue and Fred (Fred is the engineering technician Sue brought along on the tour with her) with a clip board. Based on what you are observing, make a list of issues you would target to improve the performance of the economizer, including releasing the override we discussed above. For each item on the list, identify:

1. The indicator that led you to it, and
2. If you think it will be a major energy savings improvement, and
3. Why it will or will not be a major energy savings improvement, and
4. What, if any other benefit(s) will be realized by addressing the issue, and
5. If you think it will be a low cost/no cost fix or not.

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[2] Some of you postulated that the dampers were stuck because the actuators were not wired. While that would be true for a real system, one of the constraints I mentioned for the exercise in the document I passed out to set up the initial exercise was that missing control wiring was not an opportunity for the version of the model you were working with because I still am getting that drawn. In other words, I was telling you to assume the conduit was there. (I almost have it drawn in now and will issue a new version of the model soon with that detail covered.)

Preheat Coil Real Time Impact on the Chilled Water Plant

I believe just about everyone realized that the preheat coil was active and then concluded that it probably should not be. There were several ways you could realize it was active, including:

1. The fact that the pipes are hot (scene 6); given that this is a branch off the mains, it is unlikely that the pipes would be at operating temperature if there was not some flow through them, even though they might be warm due to conduction if the piping they are fed from has flow (for instance, if there was legitimate flow to the reheat coils served by the branch upstream of the preheat coil connection or other loads further down the pipe).
2. The fact that there is a temperature difference across the coil on the water side. Granted, this is not a huge difference and it could be sensor error in the thermometers. But,
3. There also appears to be a temperature difference on the air side if you compare the return and mixed air temperature indications to the indication on the sensor leaving the preheat coil.

The reason you would not expect it to be active was that the system was trying to make cold air, not hot air. Granted, the potential exists that there was something wrong with the cooling process and the unit was cooling when it should not have been, and was trying to heat, which would explain the economizer dampers being on minimum outdoor air.

But given the location of the ball room (it is mostly an internal space) and that there is an event going on, it is pretty unlikely that it needed heat (air hotter than the room being supplied to it). That said, depending on the current state of affairs in the space, it might need some reheat (air that is cool but less cool than the discharge temperature air being delivered to it). But a coil doing reheat has to be downstream of the cooling coil, not upstream.

If you climbed up the ladder to see what the valve was doing, in the current version of the model, you can't specifically tell the valve position and the missing conduit is not the clue either[2].

If you do that in the next version of the model, you will discover that the valve appears to be fully closed, meaning the valve seat is leaking by, which is the premise in this exercise. This is a fairly common issue that often goes unnoticed because it does not generate a huge temperature rise, just a modest one. But a little bit over a long time can add up to a lot, which leads to the next few questions.

Question 3

Recognizing a teaching moment, you decide to share some of your AEP knowledge by working with Sue and Fred to estimate the approximate load being imposed on the chilled water plant by the errant preheat coil at the current time. To do this, in addition to the field data available from the sensors, you will need to share some rules of thumb and a basic HVAC equation.

Specifically, you will need to remember (hint, hint):

- How to estimate the nominal flow rate associated with an air handling system based on some of its physical dimensions, and
- How to estimate the humidity level of air leaving a cooling coil that is condensing if you know the dry bulb temperature, and
- What is a typical temperature rise due to fan heat for the types of systems we deal with.
- Which of the basic HVAC equations we have been working with will apply.

When you complete your assessment, how many tons of unnecessary load have you estimated that the leaking valve imposing on the chilled water plant as you stand there?

Question 4

Sue informs you that the Bayview Hijend currently heats water using district steam, which they purchase for about $26 per 1,000 pounds of steam (specifically, $26.03732 if you look at the utility tariff sheet). Given this information, how many pounds of steam are being consumed by the errant preheat valve and what is the cost of the steam being consumed per hour at the current condition?

Question 5

Are there any other unnecessary costs being imposed on the facility by the leaking steam valve and if so, what are they in general terms?

Question 6

Including the issue with the economizer, what percentage of the total false load on the chilled water plant have you found at this point in your exploratory process?

Field Assessments – Package 2

Expanding the Savings Projection to an Annual Savings Number

Several of the teams picked up on the fact that the filter bank for this unit would have a significant pressure drop through it because there are both prefilters and final filters. While I believe current Marriott standards would only require the MERV8 prefilters, facilities targeting LEED indoor air quality credits may use higher levels of filtration, typically up to MERV 11.

The higher quality filters also preserve the equipment and finishes by keeping them cleaner. Facilities in urban settings, especially near airports may also find benefit from higher levels of filtration and even from chemical filters to manage odors like jet exhaust. So, it is not particularly surprising to find higher levels of filtration installed in your systems than the Marriott minimum standards would require and is probably desirable from an equipment life and indoor air quality standpoint.

As an AEP graduate, the new DOE recognizes that there are a number of things to consider when you deal with systems with deeper, higher pressure drop filters.

1. One is that not all filters are created equal. Filters rated for the same effectiveness or efficiency can have radically different first costs and operating costs. Thus, there may be a benefit to exploring other options and operating the filters on a life cycle cost basis.
2. Higher pressure drop filter banks can impact the flow rate the systems sees as they load up. Typically, the fan static includes an allowance for dirty filters. That means that when clean filters are installed, the static on the system is reduced and the fan will run out its curve and move more air than is necessary.

If you want to know more about item 1, you will find some information in the presentation at this link, including links to other resources.

In the context of our exercise, the new DOE wants to project the annual cost associated with the leaking preheat valve. But after observing that the filters probably impact the system flow rate, he wants to address the variation in flow that will be created by the loading of the filters over their life cycle in his calculation if it is significant.

Since the current set of filters were just installed, he can get a sense of the clean flow rate in the system along with the clean filter pressure drop by doing a traverse of the filter bank with a hand-held velometer and using the HVAC shop's portable magnehelic to measure the clean filter pressure drop. So, he and Sue use the HVAC shop's 4-in-1 tool, which has a rotating vane anemometer and a built in temperature sensor to traverse the filter bank while Fred checks out the valve.

The results of the travers are included in the Package 2 handout materials. The concept is to try to use the traverse information along with filter pressure drop data and fan curve to get a sense of how the system flow rate varies as the filters load. Even though the filter bank is missing a pressure drop indicator, the operating team regularly documents the filter pressure drop on a log sheet, which Sue retrieves along with the fan curve for the air handling unit. These are also included in the Package 2 handout materials.

As you may recall, the engineering team has their TAB contractor come on site to verify minimum outdoor air flow and total flow rates occasionally. More specifically, they do this when they change filters in their major air handling systems. Sue intended to give the new DOE a copy of their field report so they would have that information, but it has been misplaced.

However, since she did the filter change herself and was with the TAB contractor at the time, she is confident that they verified the minimum outdoor air flow rate was at or about 25% of the design flow, which is the design target for the system. She also remembered that the total flow rate with the dirty filters was just below the design flow rate for the system.

Figure 2 – The Shop's 4-in-1 Tool

As most if not all of you observed, the Ball Room AHU has a variable speed drive that appears to be serving no useful function. In fact, it probably represents an efficiency loss if it is not being used to modulate the fan capacity for some reason.

As you may recall, I mentioned that the "back story" on that is that the local utility at one point ran an incentive program where they offered the Owner a cash incentive based on a per motor basis, based on motor size for every air handling system motor they added a variable speed drive to. While in the general case, variable speed drives have the potential to save energy, it is not the drive itself that accomplishes that. Rather it is how the control system manipulates the system flow rate by using the VFD that saves energy.

Unfortunately, the utility program was not very well designed and did not directly address the need to control the drive properly to achieve savings. The Owner, thinking they were doing the right thing, leveraged the program to add variable speed drives to all of their air handling systems. But for constant volume systems like the ball room AHU, if there were no controls in place that varied fan capacity prior to adding the variable speed drives (inlet vanes for instance), none were added when the drives were installed.

More specifically, the drives were installed, set for full speed and that was that. Our new DOE hero has realized the drive represents an asset that will allow him to achieve energy savings on the system by adding some controls and maybe making a few minor modifications to the system. The ROI for doing this will be much more favorable than it would have been had the project needed to support the VFD in addition to the control modifications.

Question 7

Many of you identified the opportunities for savings associated with leveraging the VFD when you did the Ball Room AHU scoping exercise[3], including flow variation associated with the filter loading cycle that was discussed previously.

Using the filter data, the traverse results, and fan curve estimate, the annual fan energy and cost savings you would realize if you added controls to manage the existing VFD so that it held the system at the design flow under all conditions.

Assume a blended electric rate of $0.1621 per kWh for the cost calculation.

Question8

Describe what you would you need to do to control the variable speed drive to maintain a constant flow rate? In other words, in general terms, what data point or points would you need and what would the control logic look like. What would your options be for implementing the improvements and approximately what would it cost to do it?

Question 9

Meanwhile, Fred discovered that the valve must have something lodged in its seat or a worn seat because the actuator is energized and commanded fully closed, but there is obviously hot water flowing through the valve.

Fred was about install the spare valve and actuator they had in stock and thus, resolve the leaking preheat valve issue. Is there a reason you would have him delay

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[3] They are enumerated in the findings list in Package 2 for your reference.

making the repair? More specifically, if the utility was offering an incentive of $0.24 per kWh of savings and $1.00 per therm of savings, how much money would you be leaving on the table if you fixed the valve with out baselining the problem?

Question 10

What was the reason the economizer was on minimum outdoor air?

Using the resources in Package 1 and Package 2 along with what you have learned from this narrative and other resources like your AEP psych chart tool, project the annual steam savings that will be realized by fixing the leaking hot water valve. Perform the calculation for the San Diego climate (where the Bayview Hijend Hotel is located).

You can make the following assumptions.

- The economizer high limit control is based on outdoor air dry bulb temperature and is properly set for the climate and Ball Room design condition
- The issue causing the economizer to be locked on minimum outdoor air has been resolved, meaning the high limit control is fully functional and returns the system to minimum outdoor air when its set point is exceeded.
- The mixed air temperature is controlled for a fixed set point of 51.4°F (the design leaving air temperature set point).
- The Ball Room is used on average for 5,300 hours per year based on information Sue retrieved from event planning.
- The system is operated for 2 hours prior to the scheduled occupancy time to cool down or warm up the space to set point.

Question 11

If the hotel was located in Fredericton, New Brunswick, Canada, that would probably change some of the assumptions you are making for your calculated preheat energy savings. Adjust the calculations you did for Question 1 to reflect the savings in Frederikton. Assume the same cost for thermal energy.

Question 12

Using the information in the following table, estimate the potential annual energy and cost savings at the chilled water plant associated with eliminating the unnecessary preheat.

Chilled Water Plant Equipment Summary								
Item	**Tons**	**Flow**	**Head**	**Pump Eff.**	**Motor Eff.**	**Drive Eff**	**kW**	**kW Variation**
Chiller 1 (Lag)	570						286.0	Linear
CHWP-1		1,100	40	82.1%	92.4%	100.0%	14.6	Constant
CWP-1		1,650	84	85.9%	93.0%	100.0%	43.8	Constant
CT-1						100.0%	11.0	Linear
Chiller 2 (Lead)	570						309.0	Linear
CHWP-2		1,100	40	82.1%	92.4%	100.0%	14.6	Constant
CWP-2		1,650	84	85.9%	93.0%	100.0%	43.8	Constant
CT-2						100.0%	11.0	Linear
CHWP-3		1,100	90	72.0%	90.2%	96.0%	40.1	Linear
CHWP-4		1,100	90	72.0%	90.2%	96.0%	40.1	Linear

Figure 3 – Chilled Water Plant Equipment Summary

Leveraging Opportunities

At this point, you will have assigned a value to only a few of the many findings that were identified by clues in the model. But, you will also have (hopefully) observed that what it take to extrapolate the instantaneous savings potential associated with a clue (i.e. how much energy is being wasted in the current moment) becomes much more complex if:

1. You have to deal with a load profile; for instance, for the chiller plant findings we looked at, the pump ran at a steady state condition, so once you identified the instantaneous energy waste and cost and the number of hours it ran, you had your answer.

   For this example, the system flow rate will vary as the filters load and to get an accurate answer, you somehow have to address that in your calculation.

2. You have to deal with a complex process; for instance, for the chiller plant findings we developed, we were looking at energy savings associated with reducing the pressure drop in a circuit where the flow was constant under all operating conditions, even though the chiller entering and leaving water temperatures varied.

   For this example, not only does the flow vary over time, there could be a warm-up cycle and the preheat valve leak may not represent an energy waste for those hours. And there is an economizer cycle, which, if it was cold enough, might mean that the preheat valve leak was not an energy waste. It also means that some of the energy waste happening at the preheat coils will not necessarily show up as load at the chilled water plant. To accurately reflect the savings potential, your calculations would need to address this.

3. The issues are interactive; We saw this a little bit in the chilled water plant discussion because as several of you pointed out, there would be savings associated with optimizing both evaporator pumps, not just the one I focused you on. But the amount of savings and the cost benefit relationships would vary depending on which pump was the lead pump and how you switched the lead/lag pumps.

   For the air handling unit example, making the assumption that the economizer was fully functional (even though it is not in the moment captured in the model) likely impacted the savings numbers you identified for the preheat coil and chilled water plant relative to what you came up with based on that assumption.

In light of these observations, consider the following questions.

Question 13

There are other issues with the economizer and discharge temperature control that would need to be addressed to allow the system to operate at peak efficiency. Hopefully have thought about some of them in answering Question . Do you think the additional calculations you would have to do to quantify the savings associated with addressing the various issues (for instance the single point sensor vs. an averaging sensor) would be simple or complex?

Question 14

Do you think these calculations would involve making a number of assumptions beyond the ones made so far and if so, how does this impact the accuracy of your results?

Question 15

Do you think it is absolutely essential that you do the calculations to justify the work you would need to do capture all of the savings potential that exists for this system based on your scoping observations? Either way, explain your reasoning.