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DEA Clandestine Laboratory Training Center
Quantico Marine Corps Base, Quantico, VA

Mechanical Project Proposal

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Executive Summary:

The DEA Clandestine Laboratory Training Center is located on the Quantico Marine Corps Base in Quantico, VA. It is a one-story building with a Mechanical Mezzanine Level that encompasses approximately 34,000 sq ft. The building spaces include multiple function types such as laboratories, classrooms, office space, and physical training areas.

The purpose of this document is to propose a redesign of certain aspects of the Training Center. The main focus of this proposal is on the redesign of the mechanical systems, but two other breadth areas will also be discussed. Other alternatives that have been considered for the redesign will be covered, as well as the reasons for not selecting those options. The final proposed selections will then be explained in detail, and the new design will be compared and contrasted with the one presently in place. Expected benefits of the proposed changes will be discussed. Finally, the process and methods that will be employed to achieve the proposed redesign will be described.

Alternatives Considered:

Dynamic Filtration:

The first alternative mechanical system design considered was the use of dynamic filtration. Conventional passive filters are used in the majority of commercial applications today and, when installed and changed properly, are effective at preventing large particles from clogging equipment. Dynamic filters ionize smaller contaminant particles so that they bond together, thus forming larger particles that are then removed from the air stream. In health care applications and buildings in which smoking is permitted, this technology could supplement the standard designs to improve air quality and remove harmful contaminants that conventional filters cannot.

According to the Indoor Air Quality method in ASHRAE Standard 62.1, such a technique could also be employed to decrease the amount of outdoor air required to the space. Possible benefits from this include decreased fan power requirements, as well as decreased heating and cooling loads. Although this could not be applied to the laboratory spaces because no air recirculation is permitted there, it does have possible relevance to the other spaces, particularly the classrooms and office areas. Upon further consideration, however, it is evident that this technology could be used as a supplement to the system in place to improve air quality, but should not be used to reduce OA in this case. Cutting back on the supply of fresh air could produce problems with bioeffluents and odors. Also, the Indoor Air Quality method requires that a list of contaminants be compiled and that their removal be verified for compliance with the standard. Because the list of potential contaminants is nearly endless, it is likely that not all of the possibilities could be considered, and the health of the occupants would be at risk.

Utilization of Condenser Water:

The second alternative mechanical system design that was considered made use of condenser water in heating applications. Air-cooled chillers are used in the existing design, so the first step would be the specification of water-cooled chillers. Condenser water, which contains heat rejected from the refrigerant, would normally be pumped to a cooling tower where its "waste heat" would be removed so that it could cycle back to cool the refrigerant again. Instead of just rejecting this heat to the environment, the energy contained in the condenser water could be utilized in several applications.

The first application considered was using condenser water to reheat supply air at the VAV terminal units. This type of reheat is needed when the air has been cooled below its intended supply air temperature to achieve a desirable humidity level. Reheat coils in the terminal units then bring the air back up to the correct temperature to be supplied to the space. In the present design, these reheat coils are served by heating hot water from the boilers. Instead, condenser water at approximately 95°F could provide the required energy, and it would also decrease the load on the boiler. However, due to the fact that the condenser water temperature is significantly lower than that of the heating hot water at 180°F, a larger volume of condenser water would most likely be needed to produce an equivalent rise in supply air temperature. This would require more pumping energy to distribute the condenser water out to the terminal units, and is the reason that this option was not explored further.

The other possible use of condenser water examined was to supplement the heating of domestic hot water via a heat exchanger. Domestic hot water is already being heated by heating hot water from the boiler via a heat exchanger in the existing design. Using condenser water would simply decrease some of the load on the boiler. However, the amount of useful energy that could be transferred from the condenser water to the domestic hot water would most likely not be significant enough to warrant this approach. This is due to the relatively low temperature of the condenser water in comparison with the higher temperature of the domestic hot water.

Proposed Mechanical Redesign:

The alternative that was finally selected for a mechanical redesign consists of several major pieces. The first segment replaces the wasteful overcooling and subsequent reheating currently in place for humidity control with a new means of dehumidification. The second investigates a utilization of chilled water in a manner that is somewhat unusual: the preheating of outdoor air. Using chilled water as preheat will be compared to heat recovery from lab exhaust air, a more common method of preheating outdoor air. Either of these methods, or possibly a combination of both, may be implemented in the final design.

Proposed Mechanical Redesign – New Means of Dehumidification:

As mentioned earlier, the supply air is initially overcooled in order to obtain a satisfactory humidity level. However, supplying this cold air directly to the space could pose thermal comfort problems unless high entrainment diffusers are utilized. These would make sure that the air is well mixed by the time it reaches the occupants. In the current design, however, reheat coils are present in many VAV terminal units to bring the air up to the correct temperature for supply. The first proposed redesign would be to dehumidify incoming outdoor air, thereby downsizing the cooling coils and eliminating the need for reheat coils (existing reheat coils are depicted in the *Parallel* and *Series System Option* schematics). Recirculated air would most likely not need to be treated because it is already at a satisfactory humidity state.

A smaller cooling coil and no reheat coils would have several energy and cost saving implications. Reduced air pressure drop across the coils means less energy from supply fans would be required. Energy needed to pump chilled water to the coiling coil would be decreased, and the pumping of heating hot water to the reheat coils would be completely eliminated. Also, pipe runs to the reheat coils would no longer be needed. The absence of reheat coils would lessen the load on the boiler, and the chiller load would also decrease slightly by eliminating the need for overcooling.

The tentative method chosen for this dehumidification is a "liquid spray-tower." This device sprays a liquid desiccant into the air that is to be dehumidified. Moisture in the air is absorbed by the desiccant which then falls and is collected. When the desiccant solution is thoroughly saturated, it is pumped to another device which rejects the moisture to another air stream, most likely the ambient air. A benefit of this type of system is that it can also be used to humidify incoming air when it is too dry, such as during the winter months. Although a first cost would be associated with the purchase of the equipment, the ultrasonic humidification equipment currently specified would no longer be needed, hopefully offsetting much of that cost. Another possible advantage to this type of system is that some desiccants are also capable of killing bacteria and other microorganisms. This could result in potential air quality improvement in addition to its humidity control.

Proposed Mechanical Redesign – Chilled Water as Preheat:

The second segment of the mechanical redesign will concentrate on using chilled water to preheat incoming outdoor air. This technique will be applied to AHU-2, the 100% OA unit serving the laboratory areas, and has the potential to decrease both chiller and boiler loads. In AHU-2, chilled water enters the cooling coil at 45°F. The dry bulb temperature of the air being supplied to the laboratory spaces ranges from around 55°F in cooling mode to near 75°F when heating is required. This means that, any time the ambient air is between its winter design low of 16°F and the temperature of the chilled water at 45°F, the chilled water is capable of preheating the outdoor air to a state nearer to its intended design supply condition.

The discussion above, using design setpoints currently in place, proves that using chilled water as preheat is possible. Whether or not it has a practical application to the DEA Clandestine Laboratory Training Center is now the question. As evidenced by the TRACE outputs in Mechanical Technical Report 2, simultaneous operation of the chiller and boiler is sometimes required in the current design. In the summer, the chiller and boiler were run concurrently for humidity control, and this will hopefully be eliminated by the proposed dehumidification device. In the winter months, however, heating of exterior zones near large expanses of glass (such as those served by finned-tube radiators) will be needed even when interior zones require cooling due to equipment and occupant loads. This is where the utilization of chilled water as preheat has potential merit: chilled water is already being produced for cooling of interior zones; and the incoming outdoor air is at a relatively low temperature, in perfect position to benefit from this "free" preheating.

Two different system configurations, each making use of the technique described above, will be considered in the redesign. The first, a "parallel" configuration, is illustrated in the *Parallel System Option* schematic ("parallel" describes the chilled water distribution to the air handling units). In this arrangement, chilled water supply leaves the chiller and splits, one branch serving AHU-2 and the rest serving the other four air handling units in parallel. This is similar to how chilled water is distributed in the existing design. When conditions are right for preheating, the chilled water serving AHU-2 will reject some heat to the colder outdoor air. The branches through the other AHU's, when performing their typical cooling duties, will return at 55°F based on a 10°F temperature drop across the coils. When the returning branches of chilled water mix, the resulting temperature may be very close to that of the 45°F design supply temperature. In this case, little or no cooling energy will be needed to maintain the chilled water supply temperature. At times, it may even be possible to simply circulate the chilled water without running the chiller at all.

The second possibility to be considered is the "series" configuration, illustrated in the *Series System Option* schematic. In this arrangement, the chilled water is first supplied to AHU's 1-4 in parallel. The leaving temperature of the water from these coils will be 55°F. Some of this warmer water will then supplied to AHU-2, providing a greater preheating potential than in the parallel arrangement. This configuration may also allow for preheating to take place at higher ambient temperatures than would be possible in parallel. However, unless a large chilled water temperature drop was achieved across the preheat coil, this arrangement would most likely not provide cool enough return temperatures to allow the chiller to shut off completely, as may be possible in the parallel arrangement.

After being preheated, the outdoor air passing through AHU-2 will experience a heat gain of several more degrees via the draw-through centrifugal supply fan. When cooling is required, the air may now be near its intended supply temperature, especially if the series configuration is in place. If heating of the laboratory spaces is required, the air is most likely still several degrees away from its intended supply temperature. Here, several options can be considered.

The first option is to keep the reheat coils already in place in the lab areas, but perhaps upsize them slightly to provide the rest of the necessary heating. This means that the heating coil in AHU-2 could possibly be eliminated entirely (as illustrated by the dashed-line heating coil in the schematics). However, if lab spaces require heating and no other interior areas require any cooling, no chilled water would be produced and there would be no preheat. This means that the reheat coils would have to be capable of all the necessary outdoor air heating and may become excessively large, requiring substantial amounts of pumping energy for heating hot water distribution.

Another option is to leave the existing heating coil in the air handling unit and remove the reheat coils at the terminal units. In this case, even if no preheat is performed by chilled water, the heating coil will be capable of meeting the space load. This alternative would have the benefits mentioned earlier for removing the reheat coils; would add no extra cost because no new components are included; and would be consistent with the first segment of the proposed redesign. In addition, this could prevent air-side freezing on the coils that may occur without a heating coil in the unit.

Proposed Mechanical Redesign – Lab Exhaust Heat Recovery:

The last segment of the mechanical redesign investigates the applicability of heat recovery from lab exhaust to perform preheating of incoming outdoor air. The principle of this technique is similar to the one discussed above. However, in this case, the exchange of heat would be air-to-air instead of water-to-air. Due to the nature of the hazardous chemicals being removed through the lab fumehoods, the air streams exchanging energy must not be allowed to mix. This would contaminate the supply air creating potential health risks to occupants. For this reason, an enthalpy wheel is most likely not the best choice, as toxins could be transferred from one air stream to the other via the desiccant.

Other possible air-to-air heat exchanger designs will be researched and considered. A trade-off may be present between effectiveness and the likelihood of cross-contamination of streams, as in a double-walled heat exchanger. Once the best alternative has been selected, the system will be analyzed to determine which has greater benefits: using chilled water as preheat or recovering energy from the lab exhaust air. Perhaps, a method of utilizing both (either simultaneously or in separate modes) can be implemented.

Proposed Breadth Topics:

The breadth topics were selected with the intent to integrate the various building systems and the knowledge that, if one of the systems is modified, the other systems are sure to reflect that change. Both of the proposed redesigns that follow depict this principle.

Proposed Breadth Redesign – Electrical:

The electrical portion of the redesign follows naturally as a result of the inclusion of the new dehumidification equipment. Upon specification of the liquid spray-tower, the various components will need to be connected to the electrical service. The conditioner removes moisture from the air to be supplied to the spaces; the regenerator rejects the moisture in the desiccant to the ambient air; and the desiccant cooler and heater ensure that the vapor pressure of the solution is conducive to either absorption or desorption of moisture, respectively. The electrical connection to each of these devices will be specified, and the corresponding panel boards will be examined to determine if they are sufficient to safely serve the added load. If they are undersized, the panel boards will be reselected to accommodate the new equipment. Finally, the same process will be repeated with the main distribution panel and utility feeders to ensure that no adjustment is needed in the electrical supply to the building.

Proposed Breadth Redesign – Structural:

As with the electrical redesign, the structural breadth topic is a product of the mechanical proposal. The liquid spray-tower to be specified will be located in the Mechanical Mezzanine Level. At this time, the size of the components and their exact positions is unclear. Some pieces of equipment such as the conditioner may need to be mounted in line with the outdoor air intake louver, which is elevated several feet above the mezzanine floor. Other components will most likely be placed on equipment pads atop the concrete slab of the mezzanine floor. In all cases, the bearing capability of the structural element, be it beam or slab, will be evaluated in regard to the additional weight. Similar to the electrical equipment, if the existing elements cannot tolerate the new load, they will be resized. This process will be repeated with joists and columns that support those elements providing the initial bearing.

<u>Discussion</u>:

Integration and Coordination with Existing Systems:

Aside from the electrical and structural breadth topics discussed earlier, relatively little integration will be required as a result of the new mechanical system. The redesign should actually eliminate more system components than it introduces. Coordination with the existing system is a must, however, as far as control logic and the sequence of operations is concerned. In the event that the loads on the chillers and boilers are dramatically reduced, there is a possibility that the equipment would then operate inefficiently for extended periods of time. Consideration could then be given to reselecting these components, particularly looking at the number and sizes of the machines. Currently there are two identical chillers and boilers in place, and this may not prove to be the most efficient selection.

Tools and Methods to be Utilized:

For the mechanical redesign, the existing mechanical system will be compared to the proposed revision by simulation using the Engineering Equation Solver (EES) software program. Using average weather data for the Quantico area, both parallel and series configurations will be modeled. As a base case, the thermodynamic setpoints specified in the original design will be used. These will then be allowed to vary to optimize total energy usage and operating cost. Perhaps the most difficult part of the process will be writing control logic to determine when preheating will take place in AHU-2, and integrating that with the other air handling units' regular and economizer modes. The projected advantages of the new system will be analyzed.

Desiccant types will be investigated to determine the best fit for this system.
After the new dehumidification system is specified, it will be integrated with the structural and electrical systems. The cost of the new components will be compared to that of the existing ultrasonic humidifiers, reheat coils, and piping that are being replaced. The EES simulation will be adjusted to reflect the new incoming air conditions, and the credibility of the proposed dehumidification benefits will be evaluated. Finally, the entire redesign will be compared to the existing system in a life-cycle cost analysis.

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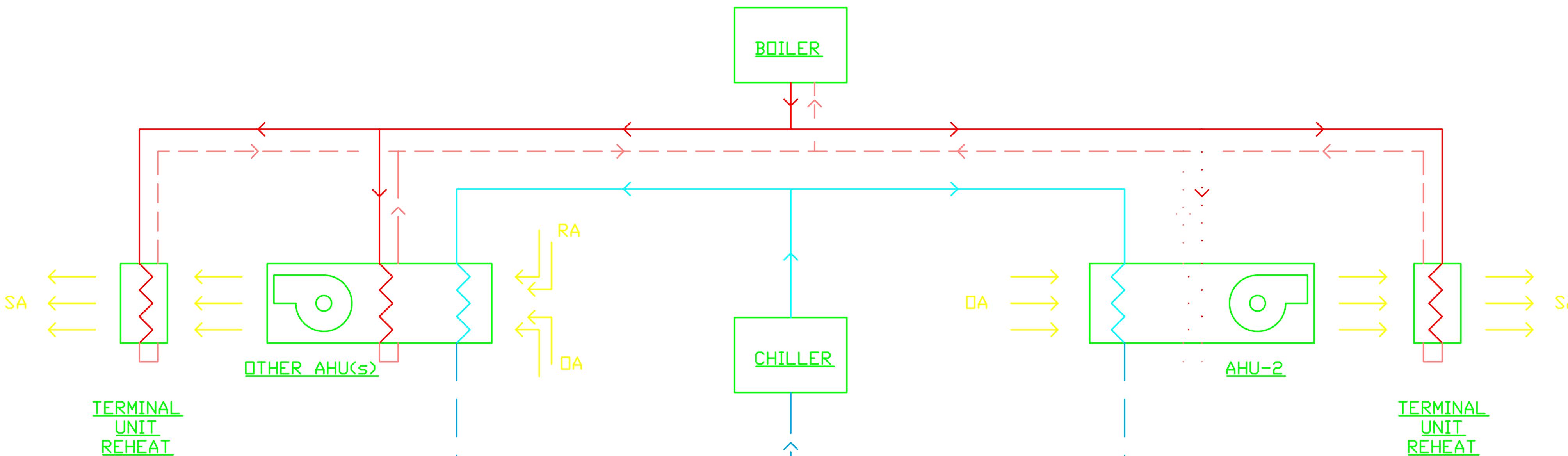
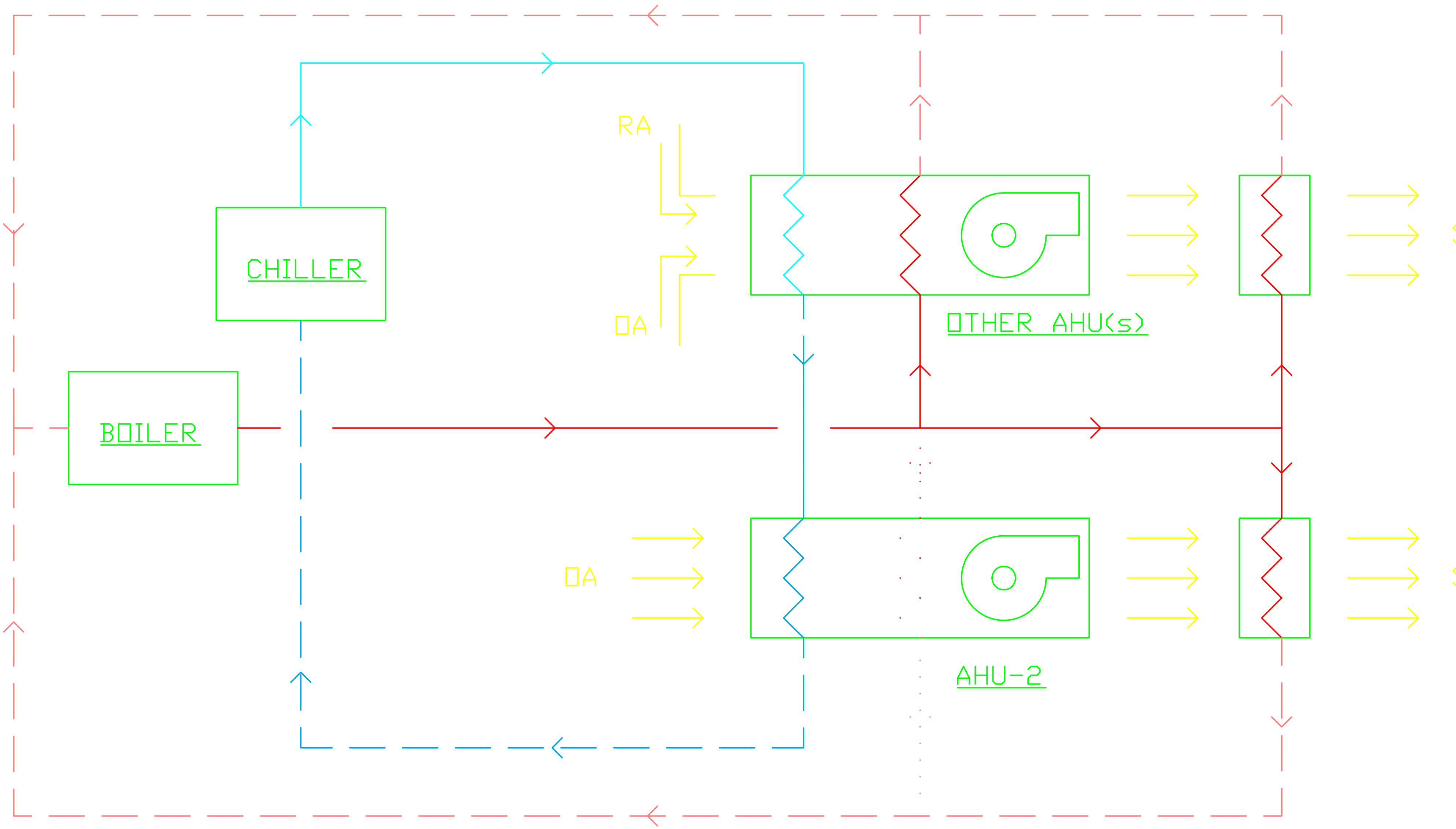


PARALLEL SYSTEM OPTION



SERIES SYSTEM OPTION