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Report to

# Southern California Edison

and

# Palm Springs Location Hospitality Company

on the

# NCBC 2003 Hospitality Company Acceptance Testing Research Project

submitted by

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# Introduction

The purpose of this document is to provide the technical details behind the results of the Palm Springs Location Hospitality Company Acceptance Testing Research project. This detail supplements the information presented in the informal summary report and will provide the basis and background necessary to allow the Hospitality Company facilities staff to move forward with the implementation of the recommendations.

# Findings Summary

Table 1 summarizes the savings projections for the project by targeted system. The report discusses each target area in detail, including the findings that were identified and used to generate the savings projections and the recommendations and cautions.

## Table 1 - Savings Summary by Targeted System

| Target Area | Savings Projection | | Comment |
|---|---|---|---|
| | Low End | High End | |
| Central Chilled Water Plant | $21,150 | $25,850 | Note 1 |
| Guest Housing Unit Water Source Heat Pump Loops | $10,901 | $19,055 | Note 2 |
| Meeting Room Air Handling Unit | $13,610 | $27,219 | Note 3 |
| Mysterious Black Domestic Water Pipe | $0 | $0 | Note 4 |
| Roof Ventilation Turbines | $5,000 | $15,000 | Note 5 |
| Heating Water System (Non-targeted finding) | $0 | $0 | Note 6 |
| Pool Water Slide Pump (Non-targeted finding) | $530 | $648 | |
| Meeting Room Area Rest Rooms (Non-targeted finding) | $1,094 | $2,187 | |
| **Total Savings for All Findings Identified** | **$52,284** | **$89,960** | |

Notes

1. This projection includes savings associated with the condenser water system
2. This projection extrapolates the savings potential identified in Loop 4 to all loops on the site
3. This projection extrapolates the savings potential identified in the Ball Room AHU9 to all air handling units on the site.
4. While no energy savings were associated with these findings, they significantly improved power quality, safety and code compliance for the site
5. Low end savings are based on non-power assisted flow patterns. High end savings potential are significantly impacted by now frequently the powered exhaust fans cycle.
6. Time constraints prevented sufficient analysis to develop savings projections. Base on past experience, savings potetials similar to the guest hou unit loops are anticipated.

Time constraints prevented a detailed analysis of the savings potential for each of the findings identified; thus a savings range was identified based on a variety of techniques including:

- Actual measured energy reductions based on equipment mounted metering prior and subsequent to implementing a change
- Calculations based on measured performance, which then inferred savings potentials
- Past experience with similar situations and systems
- Rules of thumb

Note that there has been a slight increase in these projections compared to what was presented at the closing session of the conference. This is because of last minute information that was developed subsequent to the preparation of the closing session's presentation, which has been incorporated into this report.

We believe that the low-end projection is a conservative estimate of the savings that will be achieved if the staff implements the low-cost and no-cost recommendations, such as modifying a set point, tuning and otherwise optimizing control loops, or throttling pumps. The high end projections could be achieve by slightly more aggressive efforts that may involve some modest capital expenditure for new pump impellers, improved controllers, or different hardware. In many cases, the expenditures will help ensure the persistence of the savings compared to what could be achieved by simply making adjustments. This is an important aspect of the implementation because persistence is improved by providing a more permanent solution or the ability to flag deviations when they occur. Generally, we anticipate the simple payback for these expenditures will be in the range of 2 years based on the information.

# The Teams

The teams involved were volunteers who responded to an e-mail that was sent out the week before the conference, soliciting participants. Table 2 lists the volunteers who replied to the solicitation.

Requirements to participate included:

- An interest in commissioning and a curiosity about buildings and their systems
- Plans to attend at the conference for all three days
- A commitment to the project including being willing to use some of the time at the conference to participate

The volunteers were sorted into teams by the PECI staff based on their project preferences as indicated in their response and the anticipated complexity of the targeted issue. Team leaders (the names in bold at the top of the list) were designated by PECI. Each team had a PECI staff member assigned to it to as an additional resource to help coordinate the process. Michael Ivanovich of HPAC magazine acted as roving reporter, observing the proceedings and documenting the results with photographs. All of the team members are to be commended for their enthusiastic participation and their willingness to give up free time and/or attendance at some of the sessions in order to make the project a success.

Table 2 - Palm Springs Location Hospitality Company Project Teams

| The Central Chilled Water Plant and Condenser Water System | The Guest Housing Unit Water Source Heat Pump Loops | The Meeting Room Air Handling Systems | The Mysterious Black Domestic Water Pipe | The Questionable Roof Ventilator Turbines |
|---|---|---|---|---|
| **Paul Tseng** | **John House** | **Ken Gillespie** | **Wayne Dunn** | **John Wood** |
| Barry Jones | Norm Hum | Pete Secor | Bob Atkins | Mike Purcell |
| Pat Miller | Tereasa Sweek | Deng Song | Bob Fuhr | Kathryn Schiedermayer |
| Guanghua Wei | Bill Phillips | Jeff Rees | Doug Cook | Kent Browning |
| Marvin Hullinger | Marcus Bianchi | Sunbelt | Ken Borruso | Doug Cook |
| Ron Bass | | Karl Stum | | |
| Darrent Goody (PECI) | Hannah Friedman (PECI) | Larry Luskay (PECI) | Hannah Friedman (PECI) | Larry Luskay (PECI) |

# Test Equipment

Test equipment for the project came from a variety of sources. Architectural Energy Corporation provided 13 data loggers with 52 sensors including temperature, humidity, current and static pressure transducers in conjunction in partnership with a program sponsored by Southern California Edison. This equipment was made available from late March through the week of the conference and was used to gather data before hand and for troubleshooting during the conference.

The Hospitality Company facilities group provided complete access to tools, equipment, documentation and archived data as soon as a need was identified. In some cases, this involved sharing their *only* set of documents for a particular building or system.

Field Diagnostics, Shortridge, and several of the other vendors at the trade show offered the project teams the use of their equipment as they became aware of the project. In addition, many of the team members and PECI brought their company or personal tools, computers and equipment with them for use on the project.

# The Facility

The Palm Springs Location facility provided an excellent setting for project. It includes a wide array of system types ranging from unitary equipment to central plant systems. And, even better, a facilities group who are innovative and motivated to improve things operates it.

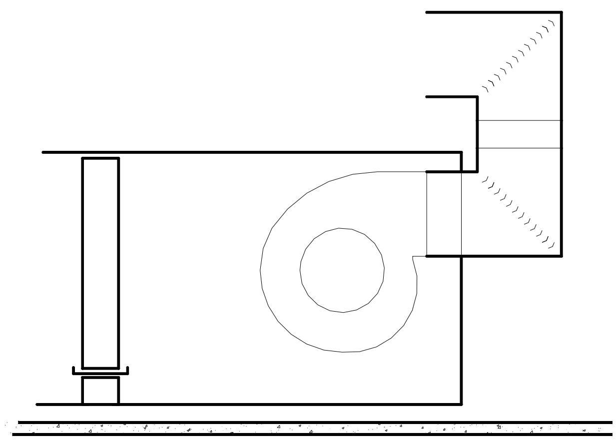


Figure 1 - Spa HVAC system AHU1 before (left) and after (right) modification by the facilities group

The air-handling unit shown in Figure 1 is a good example of the facilities team's ability to identify and analyze a problem and then implement an innovative, resource conserving solution. The unit servers the Spa area, a particularly sensitive portion of the facility in terms of the need to maintain precise comfort control over a wide range of conditions and constantly varying occupant tastes. The "as designed, as installed" fan discharge conditions resulted in excessive static pressure losses due to the configuration relative to the fan. As a result, the staff had to constantly run the fan at full speed and then juggle the set points in various zones in an effort to maintain comfort. After careful analysis, the staff concluded that reconfiguring the fan discharge would generate a significant improvement in performance. Rather than purchase a new fan, they removed the existing fan from its location in the casing, turned it around, and mounted it on top of the original housing. They then enclosed the fan in its new location and cut openings into the original housing to allow the air flow change in direction to occur in the low velocity air stream ahead of the fan rather than at the fan discharge. The result was the elimination of an estimated 1.25 to 1.50 inches in static pressure at the fan discharge based on calculations performed using data from the ASHRAE fitting database. This translated into thousands of dollars per year in operating cost reductions and a unit that now spends a great deal of its time running at 50 to 60% speed while generally meeting the critical comfort needs of the Spa area without constantly juggling set points. Clearly, this demonstrates that the staff at this facility will be able to take the ideas identified by the project and turn them into real savings if provided with the time and materials necessary to implement the recommendations.

# An Overview of the Project Process

The general steps used to accomplish the project were as follows:

## Inception

The project was conceived as a method of providing hands-on training and live demonstrations during the course of the National Conference on Building Commissioning. Past participants had repeatedly identified this sort of experience as a desirable part of future conference programs in the conference feedback surveys collected in previous years.

## Preliminary Site Assessment

Based on limited exposure to the site during the preliminary planning phases of the project, the conference management team initiated a discussion with the Hospitality Company Facilities Engineering team to determine their level of interest in the project. The facilities team quickly embraced the concept and provided drawings, specifications, and other information on the site to allow its suitability for the process to be verified by the PECI technical staff. The conference management team also approached Southern California Edison at this phase to determine if they would be interested in participating in the project by providing funding to help support the engineering effort necessary to perform the scoping study and identify targets for the focused efforts during the project. Southern California Edison responded with direct funding to partially offset some of PECI's engineering effort as well as data logging equipment via their connection with Architectural Energy Corporation.

## Pre-conference Site Visit

After verifying the suitability of the site for the project, a PECI engineer spent 4 days on the site assessing systems and deploying data loggers. The Hospitality Company staff worked with this engineer to help with the data gathering necessary to identify suitable targets including providing drawings, specifications, utility bills, and archived data. The Hospitality Company staff also took responsibility for regularly downloading data form the 13 loggers that were deployed and forwarding it back to PECI during the weeks between the site visit and the conference.

## Initial Assessment

Subsequent to the site visit, PECI's engineering staff analyzed the information collected and identified target systems for the project. Once the targets were identified, volunteer team members were solicited as described previously.

## Field Activity

The actual field activity occurred via a series of formal and informal sessions during the three days of the conference. The project was kicked off the first day with a session that highlighted the facility and provided background information on the targeted systems. The teams then met for the first time and began their efforts as time and schedule permitted. Late in the second day the teams lead an informal session where in they described their findings to that point and sought feedback from other participants. This information was used to focus their efforts for the remaining hours of the conference. The project culminated with an informal presentation of the results of the effort by the various teams during the closing session of the conference.

# Our Targets

The following systems were targeted:

# The Central Chilled Water Plant and Condenser Water System

## Central Chilled Water Plant and Condenser Water System Findings

## Overview

Many of the common areas in the complex are served from a central chilled water plant that rejects its heat via water-cooled condensers and cooling towers. The operating team had experienced some unusual problems off and on with the plant, especially at part load. One of the key discoveries that we made as we tried to understand the systems and deploy data loggers was that none of the drawings on site for the system actually reflected how it was installed. The piping plan did not agree with the system schematic on the drawing. The schematic presented on the control system screen did not match either of the presentations on the contract drawings. And, when we traced things out and made our own flow diagram, we discovered that the actual installation had some significant differences from any of the available documents. Figure 2 illustrates the system as installed based on our field observations.

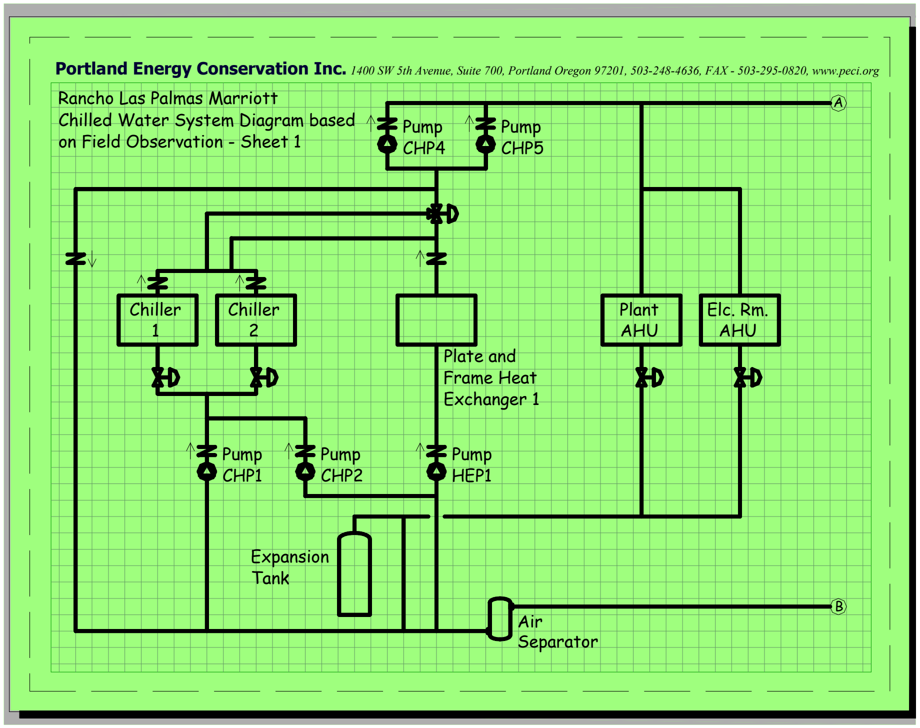
The project team identified and developed the following findings for the chilled and condenser water system. The anticipated savings potential projected if these findings are implemented is $21,150 to $25,850 annually.

## Finding CHW1 - Optimize condenser water supply temperature reset

Trend data and field observation indicated that the cooling tower fans were operating as necessary to generate condenser water in the 72ºF range. While lower condenser water temperatures are generally desirable because it will reduce the chillers energy requirement, there comes a point where the fan energy used at the cooling tower used to generate the lower temperatures can exceed the savings produced at the chiller. Testing performed during the conference revealed that this was indeed the case with the current set point at the Palm Springs Location chiller plant. As a result, the operating set point was raised incrementally to approximately 80ºF. This increased the chiller energy by approximately 14 kW but eliminated the operation of 2 twenty horsepower fan motors, which had been operating nearly continuously prior to the adjustment. The bulk of the savings associated with the retro commissioning efforts on this system can be attributed to this change. The team recommended that the plant staff continue to experiment with the condenser water set point to identify the optimum setting. Additional savings may be generated by:

1. Experimenting with increased set points upward to a maximum of 85ºF.
2. Experimenting with different set points for different outdoor air conditions. This may reveal that further improvements can be achieved by providing the control hardware necessary to reset the condenser water temperature based on outdoor ambient dry bulb temperature, wet bulb temperature, or relative humidity.

The condenser water system is illustrated in Figure 6.



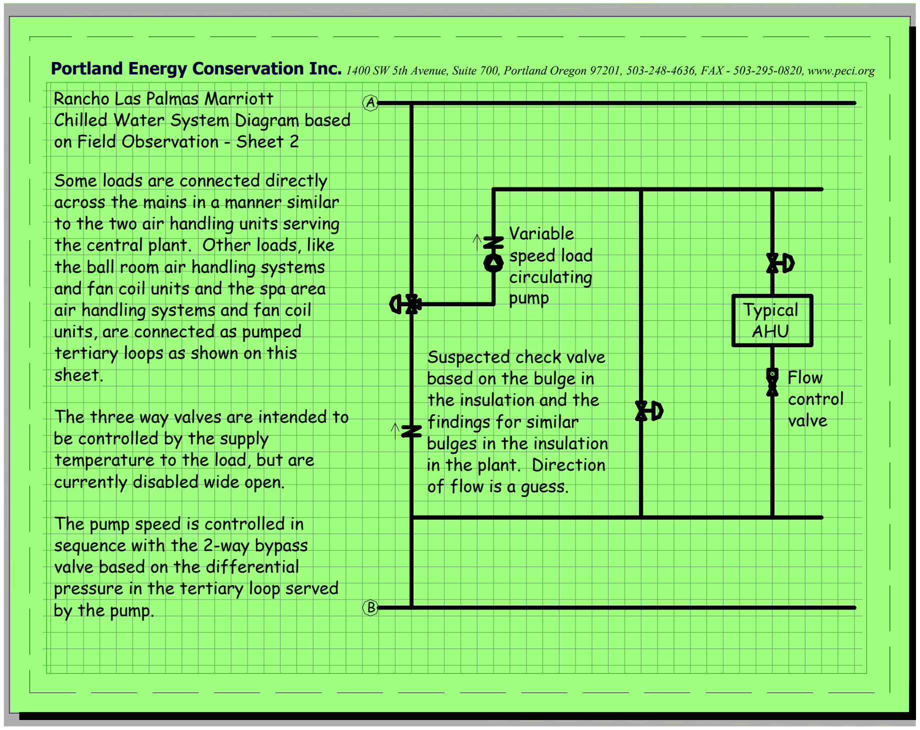




Figure 2 - Simplified chilled water system flow diagram based on field observation

## Finding CHW2 - Optimize evaporator pump performance

Analysis and field data indicate that the evaporator pumps are moving more water than is necessary based on the chiller's design requirements. Savings in pumping energy may be achieved by optimizing the pump performance to match the chiller design requirements.

Initial implementation can be accomplished experimentally by throttling the pumps to the required flow rate and observing the results in terms of chiller and plant performance. Assuming the plant performs properly at the modified flow rates, the savings can be further optimized by trimming the pump impellers to deliver the required flow with out a throttled discharge. On a cautionary note, it is important that the system be evaluated with one and then two evaporator pumps operating prior to making an impeller trim. This is because both pumps share a portion of the piping circuit between their discharge and the chillers Thus the pressure drop generated by the flow of one pump will impact the head seen and flow produced by the other. The exact nature of this interaction will probably not be very significant given the limited length of common piping and can be readily evaluated by field tests when the measure is implemented. Based on the test results, the impellers can be trimmed so that design flow is produced through both chillers with both pumps operating. In all likelihood, this will mean that flow in excess of design is produced when only one pump and chiller are in operation. However, we anticipate that the excess will be less than is currently produced with one pump in operation.

## Finding CHW3 - Eliminate the wet economizer cycle and relocate the plate and frame heat exchanger to serve the spa pool heating requirements


Figure 3 - This plate and frame heat exchanger may be of more value elsewhere

One of the long-standing questions that the Hospitality Company operating team had was how to best utilize the plate and frame heat exchanger provided in the original plant design (see Figure 3). The intent appeared to be to allow the cooling towers to directly serve the chilled water system when the ambient wet bulb temperature was suitable for such an operation; a process typically referred to as a wet economizer or free cooling cycle. But, since the air handling systems served by the plant were equipped with air side economizers, there seemed to be a limited window of opportunity for using the wet economizer cycle. In addition, when they did initiate the cycle, the staff's observations indicated that it involved using a lot of fan and pumping energy for the modest benefit provided, regardless of how they adjusted the various initiating and control parameters. Additional analysis by the project team confirmed the operating staff's conclusions and the team recommended that the wet economizer process be abandon. Since the plate and frame heat exchanger installed to provide the cycle represents both a significant capital investment as well as a high performance heat transfer capability, the team also recommended that the staff review the processes on their site to see if the heat exchanger could be used to benefit elsewhere. The operating staff responded by indicating that the Spa pool heaters are currently electrically driven but that they had piping from the central hot water plant roughed in to the area to allow conversion to a hot water driven heater at some point in the future. Relocating the heat exchanger to perform this function will significantly reduce the electrical energy consumption at the Spa for very little first cost beyond final piping connections and perhaps modifications to the heat exchanger to ensure that the plates and gaskets are compatible with the chlorinated pool water.

Time constraints prevented a calculation of the energy savings associated with this improvement, thus it is not reflected in the savings summary in this report. But past experience indicates that they will be substantial (probably in the thousands of dollars per year range) because:

1. The pool is used year round and the low ambient wet bulbs that occur in Palm Springs necessitate that it be heated for a significant portion of the year.
2. At most locations, generating a btu of heat with electricity will cost two to three times what it would take to generate that same btu of heat by directly burning a fossil fuel on the site where the heat is required.

Data logging or engineering calculations using bin weather data and physical parameters associated with the Spa pool could be used to develop an estimate of the savings potential if so desired.

A long range benefit of using the plate and frame heat exchanger for heating the pool is that the device provides the ideal mechanism to integrate hot water solar collectors in to the pool heating strategy. Given the Palm Springs environment and the thermal flywheel represented by the volume of water in the pool, using solar collectors to heat it may represent an economically attractive capital improvement for considerations, especially if the capital cost associated with purchasing heat transfer equipment does not have to be factored into the equation.

In addition to the preceding findings, the following findings were identified during the initial site visit and by the team as the worked on the project. Some of the items are purely operational issues, but several have energy savings potential associated with them. Time constraints prevented analysis and development of savings projections, so the savings potential they represent has not been included in the summary in this report. Past experience indicates that they will yield benefits that will pay for themselves in less than two years if implemented.

## Finding CHW4 - Optimize the chilled water supply temperature

This finding is interactive with the air handling systems and was a joint effort by this team with the air handling team. Indications from personal observation, trend data and live data from the EMS indicated that it may be possible to serve the loads with higher supply chilled water temperatures, thus improving the efficiency of the chillers. Over the course of the conference, the team coordinated with the Hospitality Company staff to raise the chiller leaving water temperature set point and noted a reduction in the chiller kW demand with each incremental adjustment with little if any impact on the distribution pump operating speed. This was anticipated since issues associated with the air handling systems had caused most of the systems inspected to be asking for full chilled water flow. Thus the plant supply temperature generally was controlling the air handling system discharge temperature directly. After some of the tuning and integration issues identified for the air handling systems are addressed, additional increases by the operating staff may be possible. Give the dry climate in Palm Springs, dehumidification is generally not an issue, thus there is little risk of this process resulting in IAQ problems due to inadequate dehumidification. The process does have the potential to increase the system flow rate if carried to excess since the higher supply water temperatures will cause the air handling system to demand more water to satisfy the load. As a result the increase in pumping energy could erase any savings achieved in chiller efficiency improvements. Additional optimization efforts should monitor both the pumping energy as well as the chiller energy to ensure that a true optimization is achieved.

## Finding CHW5 - Cycle chiller pumps with the chiller

Trend data indicates that the chillers meet the load and cycle off at night during moderate weather (see Figure 4). In most instances, these pumps can be cycled along with the chiller with out adversely affecting the performance of the over-all chilled water system. This will save pump energy for the hours during which the chiller is off line. Implementing this change us typically straightforward, requiring only minor modifications to the control circuitry and/or programming. Cautions associated with implementation of this finding include:

1. Generally, it is best to <u>*not*</u> cycle the distribution pumps when the chiller is cycled. Maintaining the operation of the distribution pumps ensures flow through the loads that are active allowing the thermal capacity stored in the system to maintain comfort conditions even though the chiller has cycled off. Maintaining circulation also allows the plant control system to detect and respond to the need for cooling more rapidly and appropriately based on chilled water temperature. This will ensure that the chiller is promptly restarted when the stored capacity in the system can no longer maintain comfort and dehumidification.
2. To prevent problems with tubes frosting and oil pressure, time delays should be provided between when the chiller is commanded off and when the pumps are allowed to cycle off. Consult the chiller manufacturer's data to determine the

appropriate time delay interval. The delays can be accomplished in software or can be hardwired into the system using time delay relays. Software has the advantage of ease of installation, but wiring the time delay relays into the starter will on the common side of any selector switches will ensure that the delay is provided regardless of the method used to shut down the pump (i.e. the automation system or a manually initiated shut down). If the time delays are implemented in software, it may be desirable to placard the starters to ensure that a manually initiated shut down includes any appropriate delays between the chiller shut down and the shut down of its associated pumps.

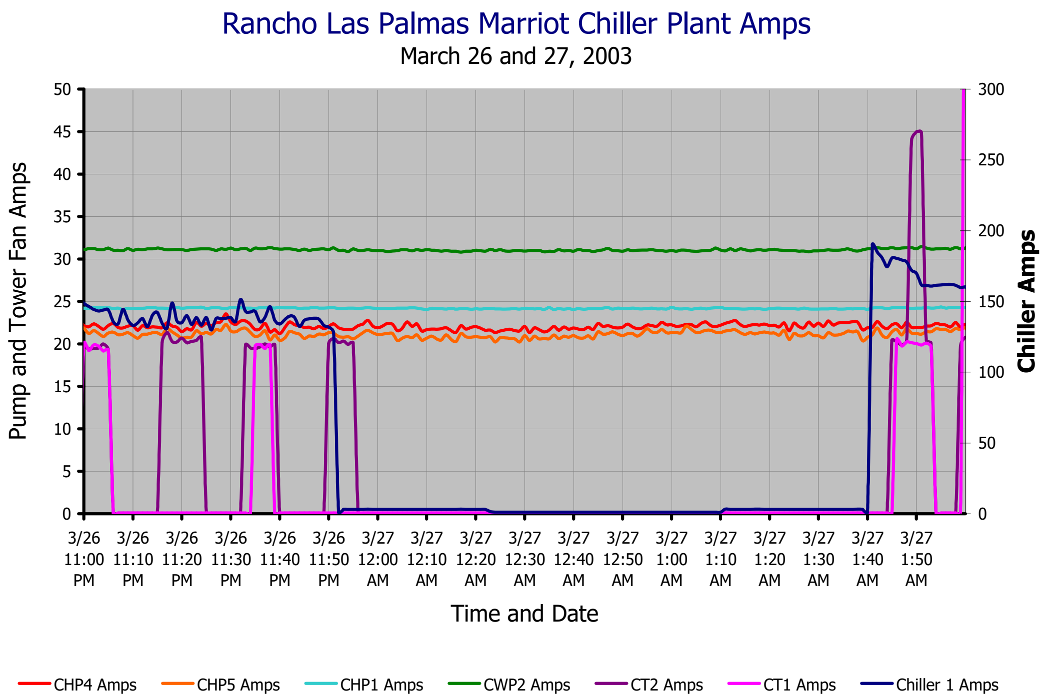



Figure 4 - Data logger data showing chiller off cycles at night in April with the evaporator and condenser pumps remaining in operation.

**3** Most chillers cycle based on their leaving water temperature controller, which monitors the temperature of the water leaving the chiller water box. Control logic in the chiller cycles its associated pumps off once the chiller has cycled off. If the evaporator pumps are cycled off, the chiller water box sensor will no longer provide a reliable means of restarting the chiller since the sensor will not have flow past it and is located in an insulated pipe. Thus, when modifying the system to cycle the evporator and condenser pumps along with the chiller, it is often necessary to modify the control circuitry to allow the chiller to cycle off based on the water box temperature sensor, while the pumps are cycled based on chiller operation after appropriate time delays. This allows the chiller to be restarted by cycling the pumps back on when the temperature in the distribution system has risen to the appropriate level. When the pumps come on, they establish flow through the evaporator and condenser, which, in turn, exposes the sensor that cycles the chiller to warm water, causing the machine to start. Consulting with the chiller manufacturer should allow you to determine the exact requirements for this interlocking strategy for the machines at Palm Springs Location.

## Finding CHW6 - Optimize or eliminate the spa and ball room booster pumps

Some of the loads on the chilled water system are equipped with tertiary pumping systems as can be seen from the illustration on the right side of Figure 2. The teams preliminary assessment is that it may be possible to completely eliminate these pumping loops and their related control systems and serve the loads directly with the distribution pumps in the central plant. Many of the loads on the loop are already served in this manner. Eliminating the pumps will save energy, maintenance costs, reduce system complexity, and eliminate several sources of potential instability in the system. Targeted functional testing techniques could be used to identify the feasibility of eliminating these pumps and controls.

If the tertiary loops are retained, there are several operational and energy efficiency issues related to there configuration that merit attention:

1 The three-way valve configuration associated with the piping connection makes temperature control in the tertiary loop difficult to achieve and has a failure mode that places the tertiary pump in series with the plant distribution pumps. At least one of the loops currently has failed to this state. When this occurs, the flows in the system become erratic and difficult to predict and the tertiary pump may actually become an impediment to flow rather than producing a benefit.

**2** There are indications that something is short-circuiting the supply main to the return main somewhere in the distribution system (see Figure 5). The tertiary connection configuration has the potential to do this under certain conditions. When this occurs, there can be problems induced at the central plant in terms of matching system flow to system load, which can reduce the efficiency of the chillers. The short-circuiting also has an adverse impact on the ability of the tertiary loop to meet the requirements of the air handling units it serves.

**3** Figure 5 also contains indications of instability in the control loops associated with the chilled water system, a condition that was also observed directly in the field. Tuning of the air handling system control loops is discussed in the air handling section of this report. The tertiary flow loops have a control loop that is associated with regulating the differential pressure in the loop by varying the tertiary pump speed and modulating a differential pressure control valve. Instability in this loop can ripple out to trigger instability in the air handling control loops as well as flow instability in the distribution system. At a minimum, these loops should be tuned to eliminate this instability. Further analysis may reveal that the automatic control bypass control valve can be completely eliminated and replaced with a small fixed bypass to maintain enough flow in the loop to ensure a rapid response to a load change and dissipate pump heat. Past experience indicates that this can be accomplished with a fixed bypass set for a very small percentage of the loops total flow.

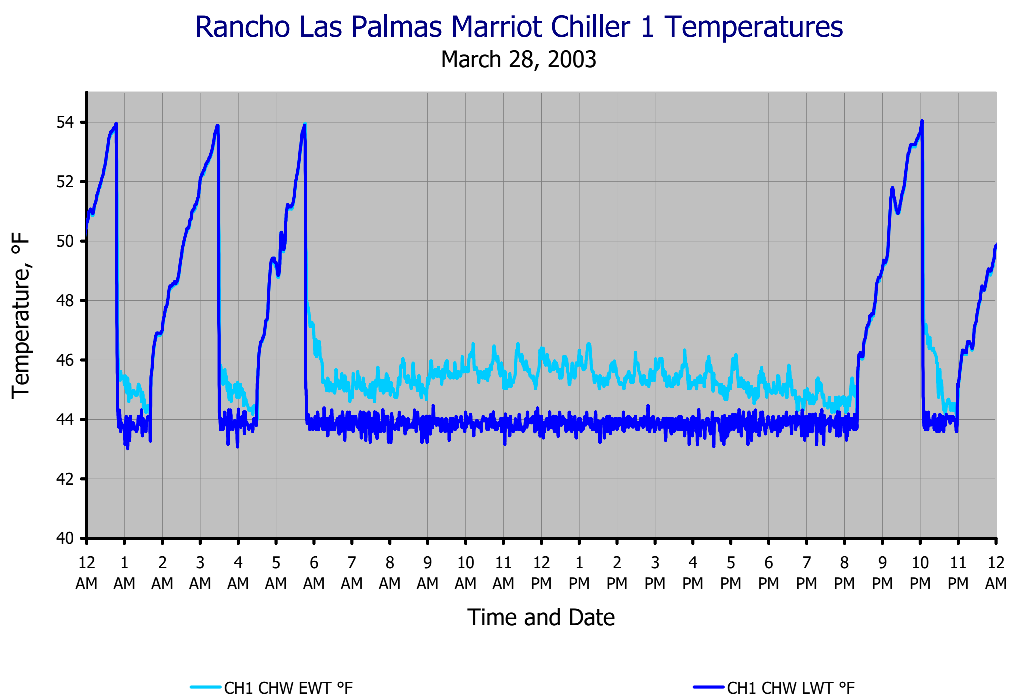



Figure 5 - Chiller 1 chilled water temperatures on a typical March day. Note the narrow temperature differential, which may indicate a mismatch between the loads and the plant that could be caused by problems with the configuration of the tertiary pumping circuits. The oscillation in return water temperature is most likely an indicator of hunting valves, either at the air handling units or at the pressure control valves in the tertiary loops. Both conditions were observed in the field when valves were inspected.

## Finding CHW7 - Optimize condenser pump performance

Evidence suggests that there are opportunities to optimize the performance of the condenser pumps via pump throttling or pump impeller trims. Considerations and savings potentials are similar to this discussed previously for the evaporator pumps. The opportunities can be further defined using pump testing techniques and analyzing the results on the pump's performance curves. Figure 6 illustrates the condenser water system as a simplified flow diagram.

## Finding CHW8 - Optimize sequencing of the distribution pumps and their VFD settings

Currently the plant operates with both distribution pumps running simultaneously even though either pump was selected to handle the entire plant capacity on its own. There are pros and cons associated with running one pump vs. two pumps

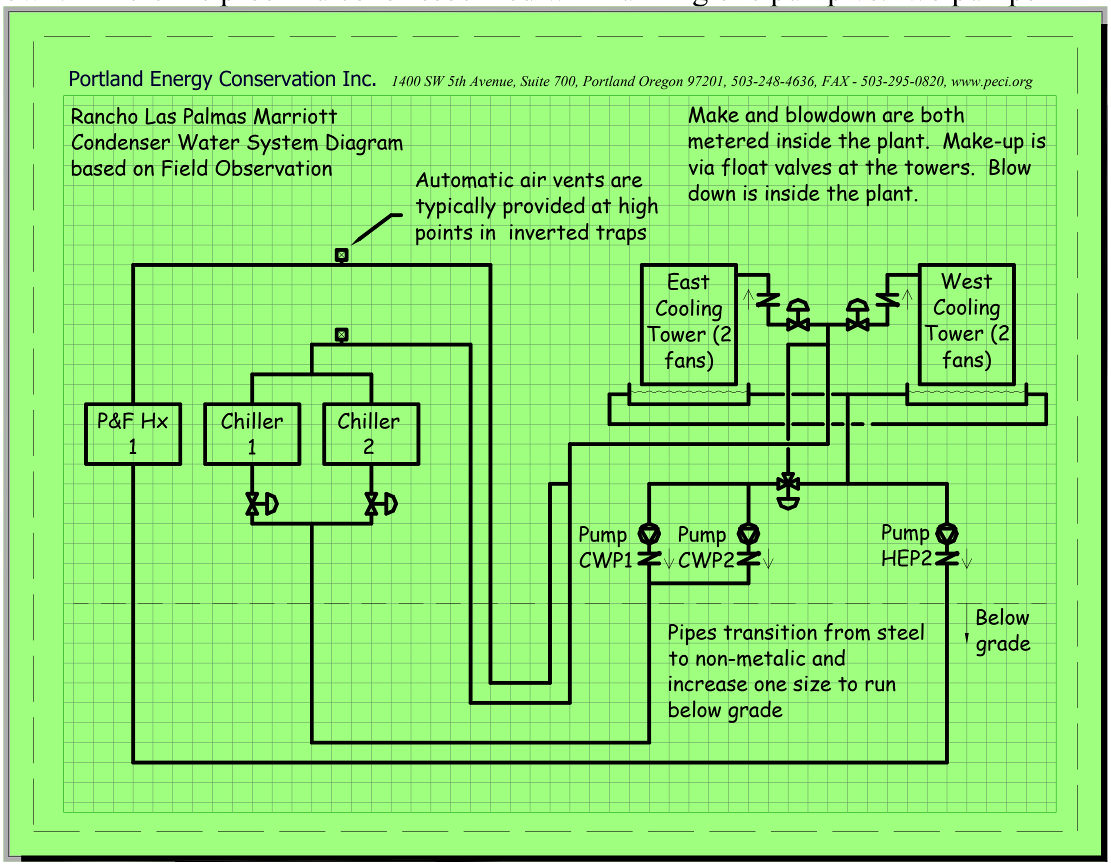



Figure 6 - Simplified Palm Springs Location Hospitality Company condenser water system flow diagram

in such a situation. Studies of similar systems indicate that the potential for a system outage that is the result of the failure of one pump are reduced by several orders of magnitude using the approach that is currently implemented at Palm Springs Location. And, in some instances, running both pumps simultaneously will actually use less energy under some load conditions as compared to running one pump. This phenomenon is impacted by numerous factors including the shape of the pump curve, the shape of the load profile, the efficiency of the variable speed drives serving the pumps and interactions between all of these elements. While difficult to assess via engineering calculations, focused functional testing usually allows the performance of the system to be optimized by letting the system “tell” you what its most efficient operating mode is under different load conditions. We suggest that the Hospitality Company team target some testing in this area after they have made some of the other improvements in the plant to further optimize its performance.

## Finding CHW9 - Eliminate unnecessary check valves

When the flow diagram in Figure 2 was developed, one of the things that became apparent was that the system contained several unnecessary check valves. Specifically, the check valves in the chiller discharge lines and the heat exchanger discharge line are redundant with other automatic valves and/or check valves, serve no useful purpose, and add pressure drop (i.e. pumping energy) to the system. We suggest that they be gutted[1] when the opportunity presents itself.

There also is a check valve located in the decoupling bypass associated with the variable flow aspects of the plant, as can be seen from Figure 2. This valve has serious operational implications because in certain operating modes, it will decouple the primary and secondary flow loops, placing the low capacity low head evaporator pumps in series with the high head high capacity distribution pumps. The result will be unpredictable performance, wasted energy, and potential chiller operating problems. These problems will not become apparent under the current load condition because of the flow conditions that exist. However, they will crop up as the load on the system begins to approach the capacity of one chiller or during a warm start. Thus we suggest that this valve be removed or gutted when the opportunity presents itself.[1]

## Finding CHW10 - Eliminate the three way valve associated with the plate and frame heat exchanger

There is a large, three-way butterfly tee type control valve located in the discharge piping from the plate and frame heat exchanger as can be seen from Figure 2. Forensic evidence suggests that the original intent of the valve was to provide for a mode selection between the chillers or the plate and frame heat exchanger as a source of cooling, or to provide a temperature control mechanism for the plate and frame heat exchanger when it was in operation. Unfortunately, the installed condition of the valve provides neither of these functions and it serves no useful purpose in the system, a conditioned previously identified by the operating staff and confirmed by the project team. Thus we recommend that it be removed and sold or re-used for

[1] By gutted, we mean that the internal, pressure drop generating components be removed at some point when the system is down and drained for service. This will minimize the cost associated with eliminating the pressure drop as compared to modifying the piping to eliminate the valve, which would require fabrication of a spool piece and possibly reconfiguring the existing piping. If the valves are gutted, it is important to affix a permanent placard to the valve body informing future operating personnel that the valve no longer contains the components that make it function as a check valve to prevent them from making bad operating decisions because they think there is a check valve in the line.

another application[2] when the plate and frame heat exchanger is removed. If the heat exchanger is retained, then the actuator for the valve could be removed and used elsewhere or sold.

## Finding CHW11 - Insert chilled and condenser water temperature sensors fully into the piping

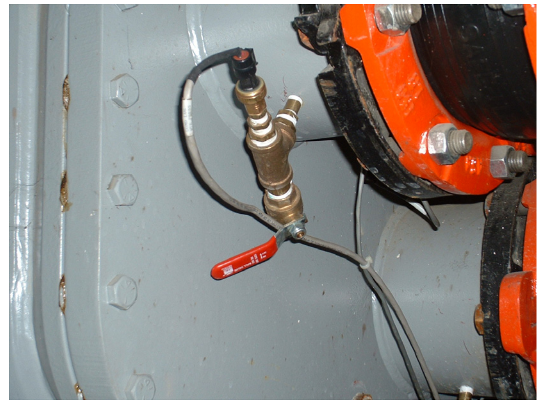


Figure 7 - Current installed condition of the temperature sensors for the chillers. The sensor head is the black portion of the assembly with the wires attached to it. The actual sensing element extends from the head into the tee towards the valve with the red handle. The temperature it is supposed to be sensing is the water inside the line above it.

While surveying the plant, we observed that the temperature sensors associated with the chiller had been removed from their original location and installed in tees in the line (see Figure 7). We suspect that at some point, someone needed to measure the exact pressure drop across the evaporator and condenser of the chiller to verify flow rate. To do this, they would have needed to know the pressure drop from water box to water box v.s. the pressure drop across the lines connected to the water box at the exact point the manufacturer used to document the machine's performance data.[3] So, it appears that they used the taps provided for the temperature sensors by removing the sensors, installing a tee, and reinstalling the sensors on one side of the tee and a gauge valve on the other side of the tee. Unfortunately, this takes the sensor out of the flow stream it trying to measure and introduces an error into the information being used by the control system. In the Las Palmas Environment this will generally tend to make the chilled and condenser water temperatures read high, with more error being introduced into the chilled water temperature reading than the condenser water temperature reading due to the larger difference from ambient. We recommend that the sensors be reinstalled so that they are inserted into the flow stream. It may be possible to do this by re-orienting the tee so the run connects to the water box with a close nipple rather than the branch with a longer nipple. It may then be possible to install the sensor through the run so that it protrudes into the water box and install the gauge valve on the branch of the tee. Insulating the fittings will

[2] New valves of this size and configuration are typically valued in the $2,000 to $3,000 range depending on the specifics of the actuator, and their pressure class.

[3] When using pressure drop of a chiller tube bundle as a flow indicator it is important to bear three things in mind. One is that the tube bundle must be clean for the data collected to have any meaning in terms of the pressure drop indicated on the shop drawings for the equipment. The second is that the pressure drop needs to be taken at the exact points used by the manufacturer for their pressure drop performance data. The pressure drop in an elbow or fitting ahead of the water box can introduce enough error to make the reading meaningless. The third is that a reading taken on the pipe immediately ahead of the water box will be different than a reading taking from a tap on the water box itself due to the velocity conversion that occurs as the water exits the pipe into the water box.

help ensure that heat transfer to the ambient environment does not affect the measurement if the sensor detects temperature over its length rather than just at the tip.

### Finding CHW12 - Fully grout pump bases

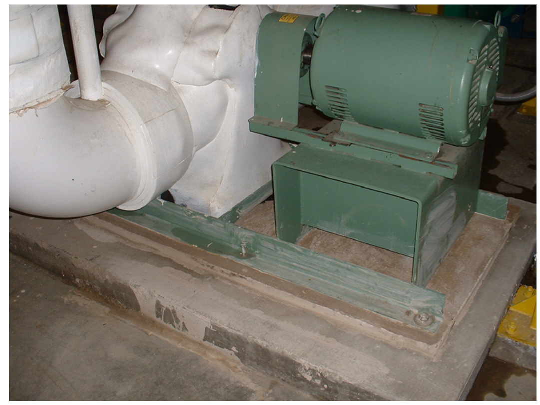


Figure 8 - Typical pump base grouting

The operating staff has experienced problems with pump alignment and traced the problem to a lack of grout in the pump bases. Unfortunately, it appears that the installing contractor only partially addressed the issue when it was pointed out, as can be seen from Figure 8. Notice that the grout has not been poured completely to the top of the pump support frame (the green, L shaped steel rails). This may be all that is necessary for this particular manufacturer's pump, but in our experience, pouring grout so that it completely fills the frame will enhance the rigidity of the frame and thus the persistence of the pump and motor alignment. We recommend that the pump manufacturer be contacted to obtain their recommendations regarding grouting their frames and that these recommendations be implemented on the pumps if they differ from what has currently been provided.

# Guest Housing Water Source Heat Pump Loops

## Guest Housing Unit Water Source Heat Pump Loop Findings

## Overview

The guest housing units in the complex are served by several water source heat pump loops. A closed loop circulates to the guest room units. Heat is rejected from the loop through a plate and frame heat exchanger that transfers heat to an open loop and cooling tower. Heat is added to the loop via a gas-fired boiler. Figure 9 illustrates a typical system as a simplified flow diagram.

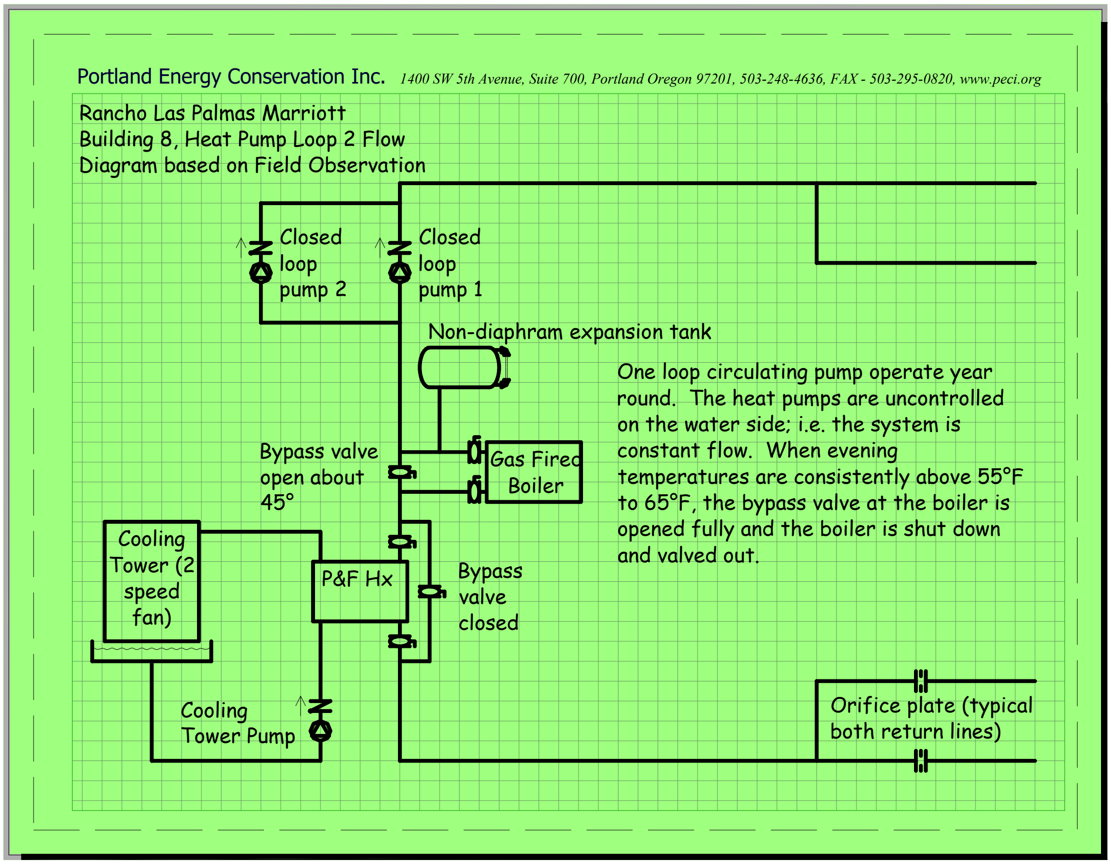



Figure 9 - Typical guest housing unit water source heat pump loop flow diagram

Because the site contains multiple loops, all similar in design and capacity, the savings potentials we identify on the system that was targeted by the project could quickly escalate by a factor of 4 or 5 as they are applied to the other similar loops. The savings projections included in this report make this assumption. Projections for the site were arrived at by taking the projections developed for the system we were working on, converting them to a per guest unit served by the system basis, and then multiplying the per unit value by the number of units on the site.

The project team identified and developed the following findings for the guest housing unit heat pump loops. The anticipated savings potential projected if these findings are implemented is $10,901 to $19,055 annually.

## Finding GHL1 - Throttle the closed loop pump or trim its impeller

All indications are that the closed loop pump is circulating more water than is necessary. There are two components to this:

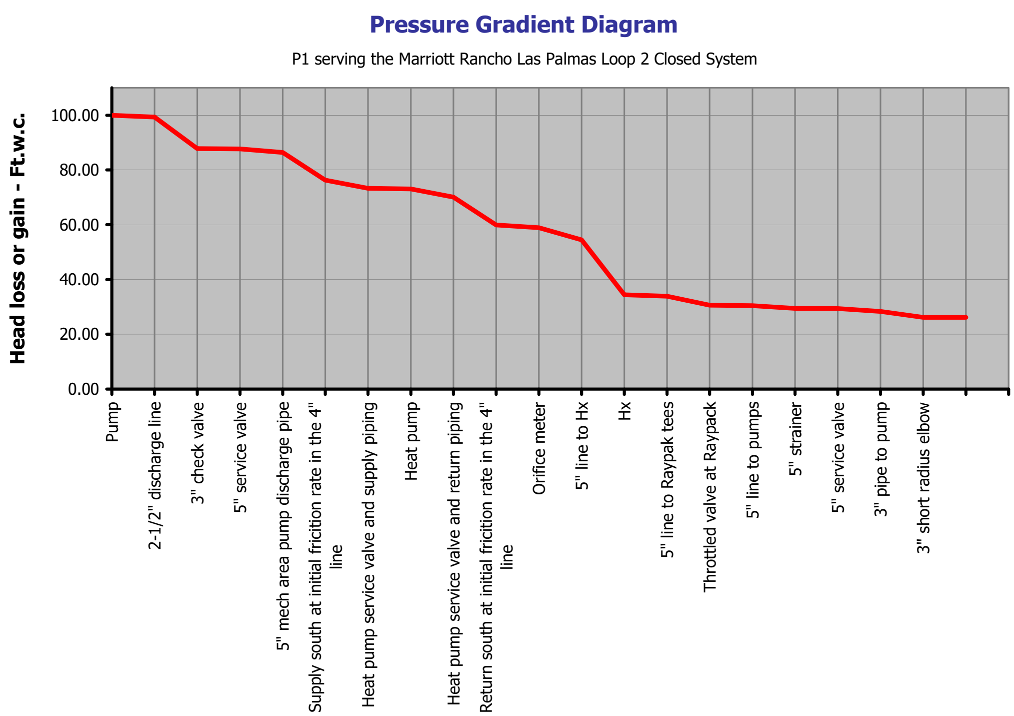



Figure 10 - Pressure gradient diagram for the Loop 2 circulating pump.

1 Nameplate data on the pump indicates that the system was designed for 320 gpm. This correlates closely with the "3 gpm per ton" rule when it is applied to the tonnage connected to the system; thus it would appear to be a reasonable assessment of the design intent for the system. Our analysis indicates that the pump is currently moving more water than the design flow rate. This is based on:

- A pump test performed using the existing gauges and a pump curve obtained from the manufacturer based on the pump's serial number: The results of this test are less than ideal because the pump has an elbow on its inlet and the existing gauges may not be accurate. However, it correlates well with the other indicators we used, which are listed next.

- An projection of the actual pumping head requirement based on the field observation of the existing equipment and loads served: We developed a very rough estimate of the pump head based on field data. The result is depicted in the pump pressure gradient diagram in Figure 10. Note that there appears to be over 20 feet of excess pumping head using the pumps design head of 100 ft.w.c. as a starting point.
- Temperature differentials observed on the system under part load and full load conditions: During out testing process, we observed temperature differentials in the range of 2º to 3ºF under light load conditions. Discussions with the operators indicate that the system's operating differential approaches 10º to 15ºF under full load conditions. When this information is cross checked against the catalog data for the equipment, it tends to support the conclusion that the flow is on the high end rather than the low end of the operating spectrum.

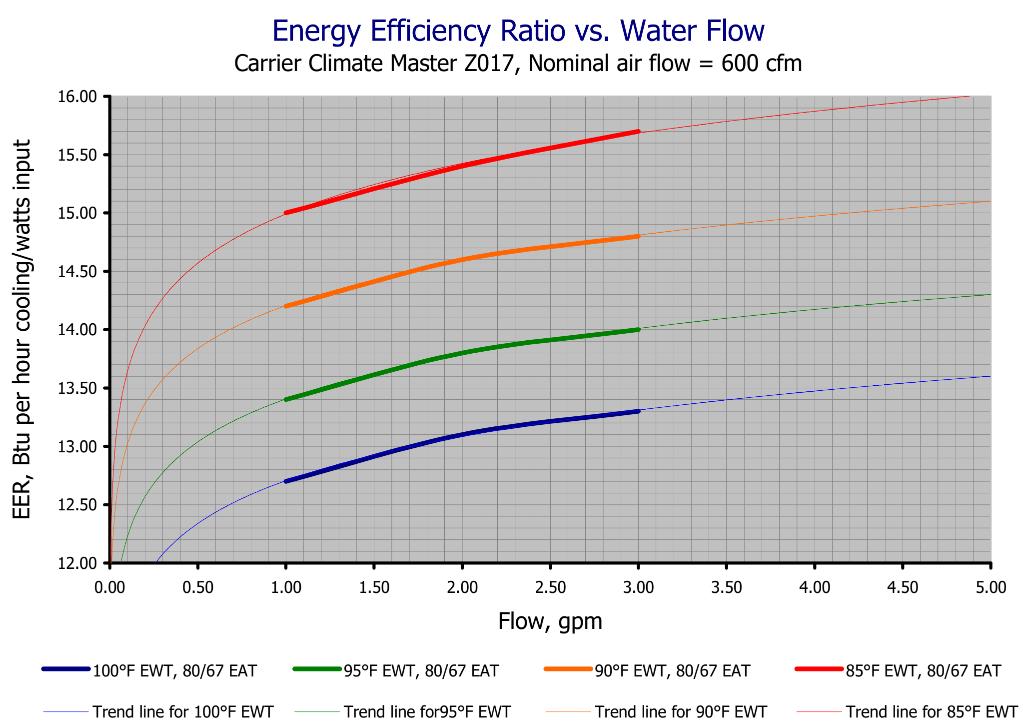



Figure 11 - Guest Housing Unit heat pump EER as a function of flow based on the manufacturers catalog data

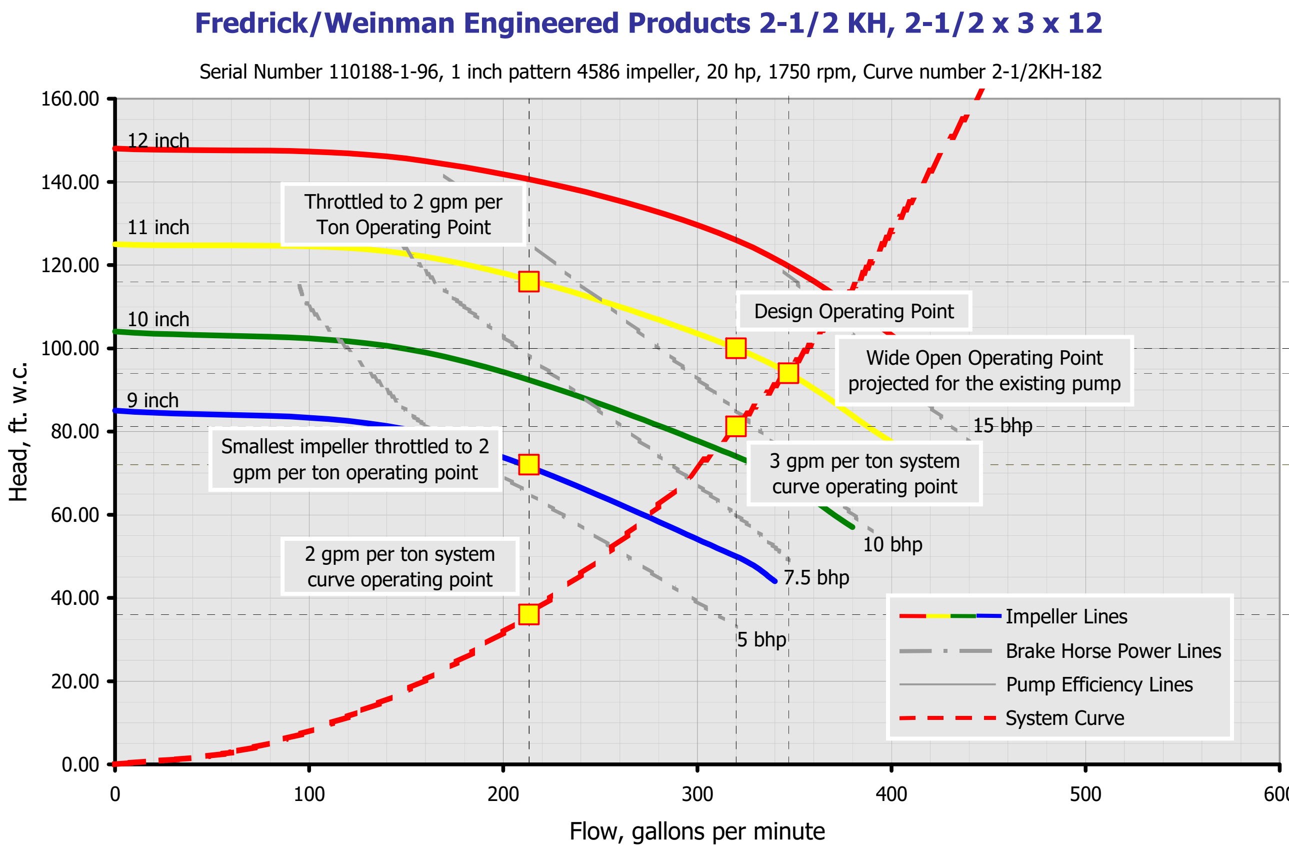
Thus we concluded that there was savings potential to be achieved by simply reducing the flow to the design value.

**2** Since the design flow appeared to be at the high end of the operating spectrum for the heat pumps, we decided to look at what would happen if the flow were reduced from the initial design point to a value somewhere in the middle of the heat pump's operating range. This will tend to reduce the Energy Efficiency Ratio (EER) of the equipment because it will tend to raise condensing temperatures. But, it will also reduce the pumping energy required to serve the machinery. When the team looked at the variation in EER with flow for the heat pumps, they discovered that the curves were relatively flat (see Figure 11). Further analysis indicated that the savings in pump energy associated with lowering the flow rate into the 2 gpm per ton range would outweigh by far any increase in compressor energy incurred by the minor reduction in EER.

Based on these observations, we are recommending that the flow in the system be reduced. There are several techniques that can be used to accomplish this which are illustrated and summarized in Figure 12.

- **Throttle the pump at its discharge:** This is the easiest option, but will add head back into the system to reduce the flow. For some pumps the increase in head will counteract the reduction in flow from an energy standpoint. But in the case of this particular pump the energy consumption reduction associated with the reduction in mass flow rate outweighs the energy consumption increase associated with an increase in pumping head for a net reduction in energy consumption at the throttled operating point. Observing the relationship between the impeller curves and the horsepower curves in Figure 12 illustrates this.
- **Trim the pump impeller:** This approach requires some minor pump disassembly and modification but substantially increases the energy reduction. This is because it matches the pump performance to the installed system requirements with out adding pressure to the system to force the pump up its curve. Thus energy is saved due to a reduction in mass flow rate *as well as* a reduction in pumping head. The square law relationship between flow and pump head associated with hydronic systems compounds the benefits significantly. The costs associated with this type of modification are:
  - $50 - $100 to have the existing impeller trimmed at a machine shop.
  - $250 - $500 for a new impeller if you want to minimize the down time or retain the existing impeller to get back to the original configuration.
  - $25 to $50 for a gasket and seal kit.
  - 4 to 8 man hours of labor

  In most instances, the payback for this type of modification will be less than two years and is frequently as low as 3 to 6 months if in-house labor is used and/or the savings potential is significant.




**Savings Potential Summary**

| Condition | Annual Savings Projected for Loop 2 | Annual Savings Projected site-wide |
|---|---|---|
| Throttled to design flow | $342 | $2,224 |
| Throttled to 2 gpm per ton | $1,597 | $10,378 |
| Impeller trip to design flow | $1,369 | $8,896 |
| Smallest impeller throttled to 2 | $2,851 | $18,533 |

The information on this pump curve was reproduced from the manufacturers certified performance curves for the purposes of analysis and illustration. To verify certified performance for this pump, refer to the manufacturers certified performance curve

Figure 12 - Guest Housing Unit closed loop pump curve illustrating the various energy saving possibilities.

- Change the pump speed: This approach usually requires a variable speed drive. Occasionally the incremental speed change available from a motor switch will solve the problem but that is mostly a matter of coincidence. If the new operating point can be achieved with a motor change, then that will be a better option than an impeller trim since it preserves the pump efficiency in addition to providing the required flow and head with out throttling. Variable speed drives are usually a less desirable option than a impeller trim if the only need is to change the speed for balancing purposes. This is because the drive is not 100% efficient, even at full speed and thus sacrifices some of the benefit. In addition, the drive adds complexity and failure potential to the system that will not be added by trimming the impeller.

For this project we recommend the following approach.

1 Immediately throttle the pump to the 2 gpm per ton operating point to allow savings to begin accruing immediately while over-all performance at the new operating point is assessed over the summer. It may be desirable to move to the final flow point in increments to allow the flow reductions to be assessed and ensure that problems are not induced at individual heat pumps as the flow is reduced.

While it is unlikely that there will be problems, this approach does assume that the flow provided by the pump is distributed proportionately to the various heat pumps. For this to be true, the system would have had to have been proportionately balanced when it was installed and/or the heat pumps would have to have a significant pressure drop relative to the distribution system.

Spot checks of several heat pumps indicated that they do not have balancing valves; just service valves. There could be balancing valves in the attic at the riser connections; i.e. the flow to groups of heat pumps in each housing unit was set vs. setting the flow to individual heat pumps. Or they simply may not exist. Thus the system may not have been balanced when it was installed. However, the heat pumps inspected by the team had service valves and flexible hose connections, which would tend to increase the flow resistance through the heat pumps. In addition, preliminary indications are that the friction rates for the distribution piping are relatively low, thus the heat pumps represent a significant pressure drop in the context of the distribution system. This will tend to help the system proportionately balance because its "equally difficult" for flow to go through any one load as compared to the piping leading to the load. Reviewing the pressure gradient diagram in Figure 10 may help give you a sense of this.

To minimize the potential for problems with the heat pumps related to flow reduction issues, we recommend that the following crosschecks be considered for implementation along with the flow reduction.

- *Field verify the pressure gradient diagram:* Assessing the actual pressure drops in the system and comparing them to the projection shown in Figure 10 will provide additional insight into the accuracy of the assumption that the friction rates for the distribution piping are relatively low and that heat pumps represent a significant pressure drop in the context of the distribution system and thus will tend to self balance. It will also document the initial condition of the system prior to the flow reduction. Existing access points where pressure measurements might be taken include drain fittings at the bottoms of risers, air vents at the top of the risers at each building and at gauge ports installed on the various pieces of equipment. Pressure readings should be taken with the same gauge to minimize the impact of gauge error.

- *Monitor heat pump pressure drops on units at the end of the piping circuit before, during, and after the flow reduction:* Monitoring the pressure drop at selected heat pumps and comparing them to the catalog data for different flow rates will allow the original and modified flow to be estimated. It would be reasonable to assume that if the units at the end of the mains have adequate flow, then the units closer to the distribution pumps also have adequate flow. It may be necessary to installed gauge cocks at some of the heat pumps to allow this to be accomplished, but the service valves that the team observed at the heat pumps should make this a relatively minor problem. Existing drain and vent connections at the unit may make the addition of gauge cocks unnecessary. If gauge cocks must be added, best accuracy will be obtained immediately up stream and down stream of the unit's field connection points so that the field measurements duplicate the factory measurements as nearly as possible.

- *Monitor selected heat pump head pressures on units at the end of the piping circuit before, during, and after the flow reduction:* The flow reduction will tend to raise the condensing pressure of the heat pumps when they are operating in the cooling mode.[4] Thus the modification will tend to raise the head pressure. Excessive flow reductions will result in the heat pumps operating at excessive head pressures and the potential for short cycling on the head pressure control. Monitoring head pressure on selected units with the potential for the lowest flow rates (i.e. the units that are hydraulically the most remote from the circulating pumps) will help ensure that this sort of problem is not introduced into the system as a result of the modification.

- *Monitor the heat pumps closely after the initial flow reduction for signs of short cycling and loss of performance:* The most likely problem that could occur subsequent to the flow reduction would be loss of capacity and/or short cycling due to safety trips on the high head pressure control. Ongoing monitoring for these symptoms in the days and weeks subsequent to the modification will help ensure that the flow reduction has not introduced other

[4] It will tend to raise the evaporating pressure if the heat pumps are operating in the heating mode since the circulated water is the source of heat instead of the sink for heat rejection in that cycle. This discussion assumes the modification effort will occur during the summer when the heat pumps are operating in the cooling mode and are using the circulating loop as a heat sink.

problems into the system. Data loggers strategically deployed at various points on the system may aid in this effort. The same program that supplied the AEC loggers for the project may be a means of obtaining loggers for this monitoring effort subsequent to implementation.

2. **Assess the operation of the system at the reduced flow rates provided by the throttling process through the peak-cooling season this summer.** If the system performs satisfactorily during the peak cooling season subsequent to the flow reduction, it is quite likely that it will perform satisfactorily for the rest of the year. It may also be desirable to continue the assessment of the flow reduction into the peak heating season prior to making the reduction permanent via an impeller trim.
3. **Once a satisfactory operating condition has been established, trim the impeller to provide the revised flow with the discharge valve in the wide-open position.** As can be seen from Figure 12, we suspect that you will not be able to trim the impeller to the ideal size since it is projected to be smaller than the smallest impeller size for the pump. We anticipate that you will end up installing the smallest available impeller and then throttling the pump slightly to achieve the desired energy reduction as illustrated in Figure 12.

## Finding GHL2 - Cycle the cooling tower pump as a first stage in the cooling process

For the system we were monitoring, the cooling tower pump runs continuously as can be seen from Figure 13. When the pump is operating, water is flowing over the cooling tower fill and some cooling occurs even with out fan operation. This is evidenced by the difference between the supply temperature from the tower and the return temperature to the tower in Figure 13. An opportunity exists to further optimize the energy efficiency of the system by cycling the cooling tower pump as a first stage in cooling rather than allowing it to run continuously. Not only will this save pump energy, it will also minimize the potential for the problem discussed under below in the next finding.

## Finding GHL3 - Adjust control set points to eliminate cooling tower and boiler control system interactions

A close examination of Figure 13 will reveal that the operation of the cooling tower fan frequently triggers the operation of the boiler. Specifically, the cooling tower fan cycles and drives the system supply temperature (red line) down. But, immediately thereafter, the system supply temperature becomes elevated above all of the other temperatures in the system. The only way that this could occur (given the location of the various sensors we were using) is if the boiler fired and added heat to the system. This implies that at low load conditions, the thermal characteristics and flywheel of the system combined when combined with the current set points cause the heat that was eliminated from the system by the cooing tower being to be immediately returned to the system by the boiler; in effect, simultaneous heating and cooling is occurring.

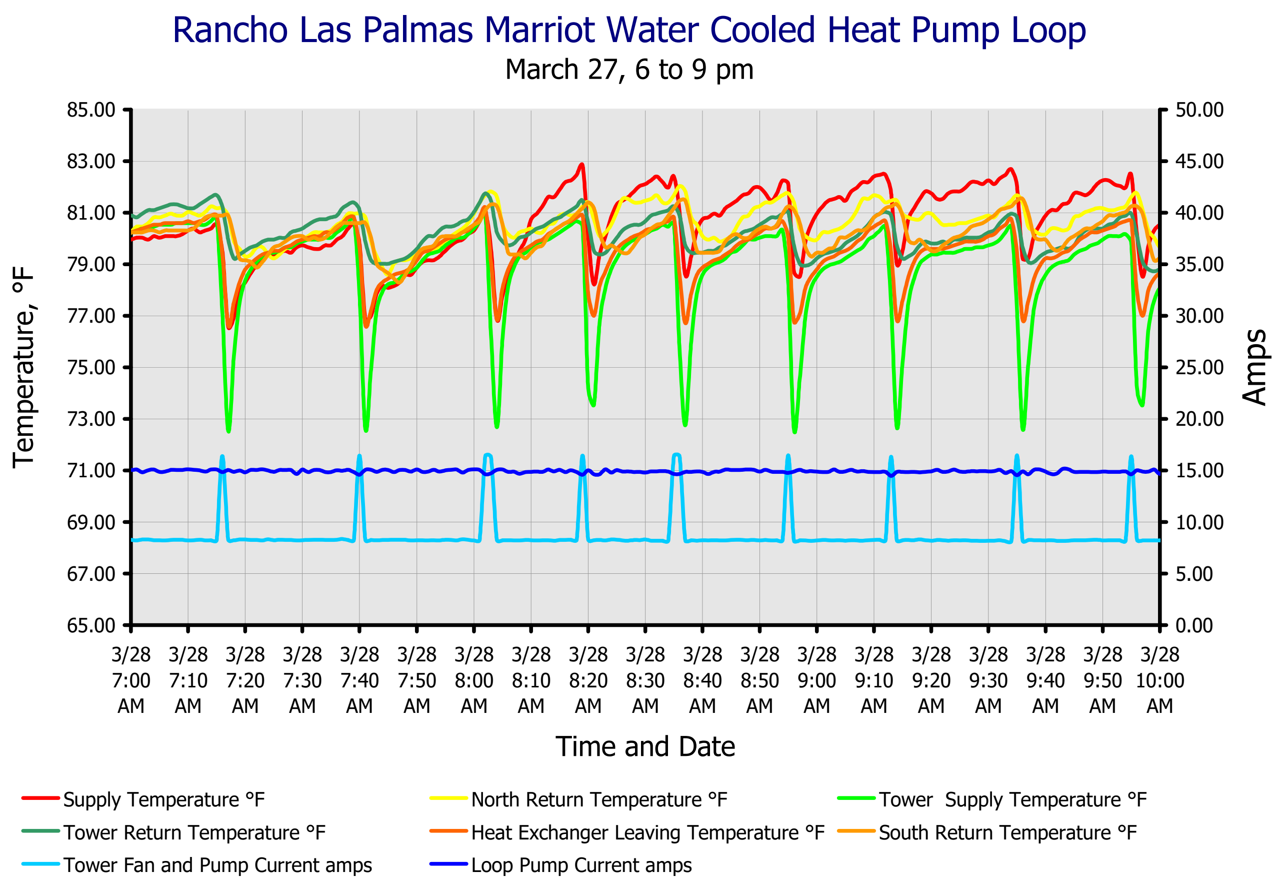



Figure 13 - Typical Guest Housing Unit Heat Pump Loop equipment operation on a day in later March

In general, the intent of the heat pump loop is to allow energy that is rejected by loads with a need for cooling to be recovered and utilized by other loads with a simultaneous need for heat. The cooling tower should only function when the heat rejected by some of the loads exceeds the demand for heat by other loads. Similarly, the boiler should only need to fire when the demand for heat by some loads can not be matched by the heat rejection rate from loads that are concurrently cooling the areas they serve.

Given the nature of the Palm Springs environment and the loads served by the heat pump loops,[5] it is unlikely that there will be much need for concurrent heating and

[5] Generally the internal gains in the guest housing units are modest and most housing units have an exterior exposure on at least two sides. Units on the upper levels will also see a roof load. As a result, the heating and cooling requirements in the rooms will tend to be driven more by the ambient environmental conditions and the

cooling by the various units on the loop. When it does occur, it will probably occur during the swing seasons, but generally, the loops will most likely be operating with most of their units in the same operating mode; cooling when the ambient temperatures exceed the normal comfort envelope and heating when ambient temperatures fall below the normal comfort envelope. The staff's operating experience confirms this in that they have found that they can manually valve the boiler out of the circuit once the nighttime temperatures remain above the 55º to 65ºF range. This operating strategy eliminates the potential for the problem that we are observing during the summer months and may also save some pump energy by eliminating some pressure drop from the system.

A contributing factor to the problem illustrated in Figure 13 is that even though the goal of the control system is to maintain the supply temperature to the heat pumps, the sensing elements associated with the controllers that are intended to accomplish this function appear to be located at three different points in the system. While time constraints prevented us from absolutely verifying the sensing element locations for the system's controllers, our observations indicate that one of the sensing elements for the cooling tower fan control panel is in the heat exchanger leaving water line, while another element is in the discharge line of the cooling tower pump (a thermally related by independent piping circuit). The boiler controller appears to be sensing it's own leaving water temperature or may be sensing the actual system supply temperature (the desired parameter to maintain).

While it is possible to coordinate the set points of the various controllers to achieve a satisfactory sequence even though they are not all sensing the same temperature, the variety of sensing element locations makes this more complex than simply making sure the controllers are calibrated and set properly. Thus we recommend that the controller sensing elements be located to a common point so that they all sense the supply water temperature to the loads and can be coordinated based on this single parameter. This will require a short duration shut down to allow thermal wells to be installed, which could be a problem during the summer months if the resort heavily booked. As an interim step, the sensing elements could be set up to control based on pipe surface temperature by taking the following steps.

1. Thoroughly clean the pipe in the area where the sensing elements are to be installed.
2. Coat the cleaned pipe with thermal heat transfer grease.
3. Securely tie-wrap the sensing elements to the pipe with the sensing element horizontal axis parallel to the pipe axis, thoroughly embedding the elements in the heat transfer grease.

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tastes of the current occupants than by need to offset significant internal gains in some areas while offsetting significant envelope gains and losses in other areas. While the roof load may impact the exact requirements necessary to maintain comfort for any given tenant to some extent, past experience indicates that if the ambient temperatures are above what people normally would consider to be "comfortable" then they will have the system indexed to cooling. If the ambient conditions are below what is normally considered "comfortable" the units will be indexed to heating.

4 Enclose the elements inside waterproof insulation to ensure that they are primarily influenced by the conditions inside the piping vs. ambient conditions.

For this approach to be successful, it is critical that the thermal path from the pipe to the elements be free of thermal resistance; thus cleaning the pipe and embedding the elements in heat transfer compound is a crucial step to success. The waterproof nature of the insulating enclosure provided is essential to the persistence of the thermal conductivity because entrapped water could quickly degrade the heat transfer performance of the assembly.

With regard to set points, we suggest that the set point associated with the cooling tower temperature controllers and the boiler temperature controller be separated to provide a wider dead band for the system. The best set points for the boiler and tower will be a function of multiple parameters including the performance of the heat pumps with different water temperatures in the cooling and heating mode, the performance of the cooling tower under different ambient conditions, and the cooling and heating requirements of the guest rooms themselves.

Figure 14 illustrates the performance of the heat pumps. Note the following:

- The cooling and heating capacities as well as the power requirements are relatively unaffected by the flow rate to the unit if the water temperature is held constant.
- The entering water temperature does have a significant impact on both the capacity as well as the power requirement for the units if the flow rate is held constant.
- In the heating mode, at a fixed flow rate, increasing the entering water temperature increases the capacity and power consumption of the unit, with the impact on capacity being much more pronounced than the impact on power consumption.
- In the cooling mode, at a fixed flow rate, increasing the entering water temperature decreases the capacity but increases the power consumption with the impact on power consumption being much more pronounced than the impact on capacity.

Given the climate in Palm Springs, the systems most likely spend many more hours cooling as compared to heating. This fact, when combined with the performance characteristics illustrated in Figure 14 points towards selecting the cooling tower set point for the lowest possible water temperature than can be achieved by the cooling tower with out excessive fan energy and then lowering the set point for the boiler to a value far enough below the cooling tower setting to prevent the system interaction observed in Figure 13. Since the tower fan appears to have the ability to drop the water temperature nearly 10ºF when it cycles, a dead band in excess of this would seem desirable. For initial starting points we would suggest the following. (This sequence assumes that the recommendation discussed in Finding GHL2 - Cycle the cooling tower pump as a first stage in the cooling process has been implemented, that the sensing elements are all located to sense the heat pump loop supply temperature to the heat pumps, that the controllers have all be calibrated to the same standard and relative to each other, and that all of the controllers have adjustable set points and dead bands[6].)

[6] The controller we looked at in detail did in fact have both an adjustable set point and dead band. If the controllers have fixed dead bands, the proposed sequence can still most likely be achieved but it will not be possible to fine tune things by adjusting the dead band.

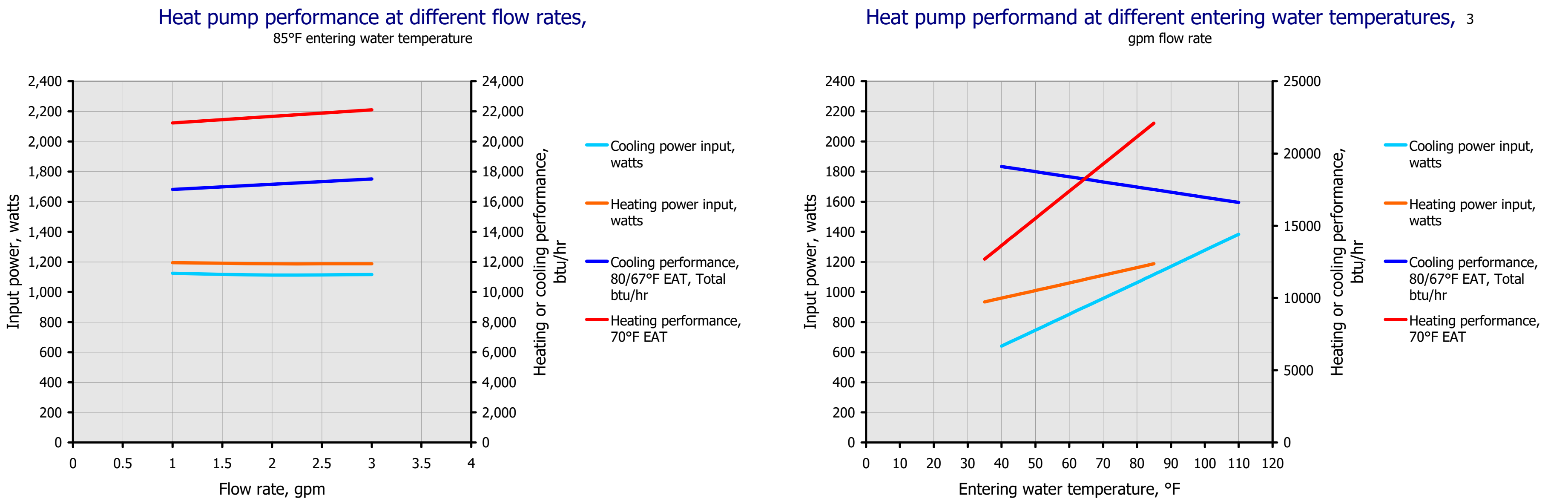


Figure 14 - Guest room heat pump performance with different flow rates and entering water temperatures

- Cycle the boiler off when the supply water temperature rises above 63ºF.
- Cycle the cooling tower pump on when the supply temperature exceeds 80ºF.
- Cycle the cooling tower fan on to low speed if the supply temperature continues to rise and reaches 85ºF.
- Switch the cooling tower fan to high speed if the supply temperature continues to rise and reaches 90ºF.
- Switch the cooling tower fan back to low speed when supply temperature drops back down to 87ºF.
- Switch the cooling tower fan off when the supply temperature drops back down to 82ºF.
- Switch the cooling tower pump off when the supply temperature drops back down to 77ºF.
- Cycle the boiler on when the supply temperature drops below 60ºF.[7]

Data logging and functional testing techniques can then be used to optimize these parameters to minimize tower fan energy and maximize system stability under all load conditions.

Given the savings potential associated with the findings for the guest housing units, it may be desirable to upgrade the control system to a DDC controller that is compatible with the DDC system that is currently used to control the chilled water plant and the loads connected to it. This could be accomplished using stand-alone controllers or the controllers could be integrated into the network via phone modems or network extensions using some of the empty conduits that are said to exist between the various buildings on the site. The DDC controllers would help ensure the persistence of the control settings and when integrated into the network, could be provided with diagnostic alarms to alert the operating staff to problems that were wasting energy impacting performance and guest comfort. Even with out a network connection, the alarm and diagnostic improvements could be partially realized in the stand alone configuration by using push to test pilot lights driven by software and outputs from the controller and located so as to be easily visible to the operating staff on daily rounds.

In addition to the preceding, the following findings were identified during the initial site visit and by the team as they worked on the project. Time constraints prevented

[7] Since the capacity of the heat pumps is strongly related to the supply temperature (see Figure 14), it may be necessary to raise the boiler setting to achieve more capacity if experience shows that the heat pumps can not match the load during the winter. If this step is taken, the interaction with the cooling tower controllers should be checked. If problems similar to those illustrated in Figure 13 return, then it will be necessary to raise the cooling tower controller set points a commensurate amount or to seasonally change the boiler set point during the colder months.

analysis and development of savings projections, so the savings potential they represent has not been included in the summary in this report.

## Finding GHL4 - Investigate the potential for conversion to variable flow operation on the closed loop

Given the intermittent operation of the heat pumps during non-peak heating and cooling seasons and the variable occupancy rate associated with a resort environment, the potential exists to save additional pumping energy on the heat pump loops by cycling flow. Currently, water flows through all units, all of the time regardless of their operating status. Retrofitting a Belimo™ style actuator onto the existing ball type service valves and wiring it so that a call for heating or cooling opened the valve and an end switch on the valve cycled the heat pump may provide a cost effective retrofit that would save pump energy and could be implemented by the operating staff on as a fill-in project. Maintaining one or two units at the end of the runs with continuous flow would address any issues related to maintaining a minimum flow level in the system to ensure rapid response and dissipate pump heat. If the pump impellers are trimmed per the previous finding then it is unlikely that a variable speed drive would be necessary or justified since the valves could simply push the pump up it curve.

Self-contained head pressure actuated control valves similar to those employed on the facilities ice machines may also be a viable way to achieve this objective although the differences between the heat pump operating cycle for cooling vs. heating may make this approach unviable or impractical.

## Finding GHL5 - Trim or throttle tower pump impeller

There is some evidence to suggest that significant pumping energy could be saved in the open cooling tower loop by throttling or trimming the pump impeller for the circulating pump. A pump test would need to be performed and then the pump curve consulted to determine the exact savings potential and best implementation strategy.

## Finding GHL6 - Verify the boiler tolerance for flue gas condensation

Given the supply temperatures associated with the heat pump loop, the boilers most likely condense moisture out of the flue gasses when they are firing.[8] The good news is that condensing this moisture out of the flue gasses recovers the heat of vaporization associated with the moisture in the combustion products. The design of some boilers makes them more impervious to this sort of damage than others. For example, cast iron boilers can tolerate significant corrosion with out failure due to the thickness of their heat exchangers and newer technology boilers use exotic metals for

[8] Water is a byproduct of most combustion processes. If the temperature of the heat exchanger associated with the combustion process drops below the dew point of the products of combustion, the water will condense from a vapor to a liquid. Typically, this will occur at or below 130-140ºF. The heat pump loops must and do run well below this temperature.

their heat exchangers and are designed to condense moisture out of the flue gas in order to achieve combustion efficiencies in the 95-98% range. However, if a boiler has not been designed to tolerate this phenomenon, then damage can occur when the moisture combines with the carbon that is present in the flue gasses and forms carbonic acid. The acid will corrode the heat exchanger and flue pipes and can rapidly destroy a boiler. Boilers that are susceptible to this sort of damage need to be configured properly to work at low temperatures like those associated with the requirements of the heat pump loop. Usually, this involves providing an independent boiler circulating pump and a control valve that allows the boiler loop to run at a higher temperature than the loop it serves.

Since the systems we looked at did not have boiler circulating pumps and since the boilers did not appear to be condensing boilers, we are suggesting that the manufacturer's literature be consulted to determine if the low operating temperatures that the units typically see are in fact a problem. Preliminary information available to us indicates that there could be a condensation issue if the boilers operate with an entering water temperature below 105ºF, which is significantly above the supply temperatures used for the heat pump loop. Raising the heat pump loop set point to this value would have a major impact on the efficiency of the units in the cooling mode as can be seen from Figure 14. Specifically, changing from the current nominal 80 - 85ºF supply temperature to 105ºF would increase the cooling power consumption by 18 - 20% while reducing the cooling provided by 3 - 5%. Since the units spend a significant number of hours in the cooling mode, it is quite likely that such a change would result in a significant net energy consumption/operating cost increase although it would preserve the boiler and improve the heating performance of the heat pumps. If boiler condensation does turn out to be an issue, we suggest:

1. Only raise the system set point on a seasonal basis, for the months when the boiler must be operated.
2. Take advantage of the thermal flywheel in the loop and the wide entering water temperature range operating capabilities of the heat pumps to minimize the number of months that the boiler must be operated.
3. Program an alarm into the control system or Outlook to generate seasonal reminders regarding changing the set point to ensure that the higher operating temperatures are used only when necessary and are not inadvertently forgotten. The alarm could be based on date or outdoor air temperature.
4. When boiler replacement becomes necessary, select boilers and/or reconfigure the boiler connection to allow the loop to operate at a more optimal temperature for cooling performance, regardless of the entering water temperature requirements of the boilers.
5. When evaluating the payback potential associated with upgrading to condensing boilers or a solar heating source (see Finding GHL7 - Consider condensing boilers when the existing Raypack units are replaced and Finding GHL9 - Consider solar water heaters and a storage tank as a heat source for the heat pump loops in the

winter months), don't forget to include the elimination of the cooling operating cost penalty imposed on the system by the need to operate at the higher entering water temperature in the payback calculation.

## Finding GHL7 - Consider condensing boilers when the existing Raypack units are replaced

At some point, the existing boilers will require replacement. At that time, it would be desirable to consider condensing boilers. Given the low water temperatures associated with the heat pump loop it is possible that such a change would result in an improvement in efficiency in the range of 14 to 16%, which would translate directly to a reduction in the gas bill for the system by this percentage. Installation of a gas meter on one of the boilers prior to this winter would allow the exact value of such a reduction to be assessed.

## Finding GHL8 - Bypass flow around the heat exchanger on the closed loop side during cool weather

Depending on where the pump ends up operating after the recommendations associated with the previous finding are implemented, there may be some additional energy savings that can be achieved by opening the bypass valve around the heat exchanger when it is not required, thus removing pressure drop from the system. This could be accomplished manually on a seasonal basis or automatically based on the cooling tower operating cycle if an actuator were added to the bypass valve.

This option should be approached with caution because depending on where the pump is actually running relative to its performance curve, reducing the resistance in the system with out making any other change could actually increase the pump energy requirement.

## Finding GHL9 - Consider solar water heaters and a storage tank as a heat source for the heat pump loops in the winter months

The local Palm Springs environment coupled with the low operating temperature associated with the heat pumps makes using solar energy as the heating source for the loops attractive from a theoretical standpoint. The operating staff had already identified this potential but had not had time to pursue it or understand all of the implications. There are several very compelling features that are unique to the location and site that make this option particularly attractive.

1. The generally clear skies make solar energy readily available.
2. The low supply water temperature requirements of the heat pump loop would tend to optimize collector efficiencies as compared to applications which require higher supply temperatures.

3. The mild wintertime environment tends to minimize the need for heat, minimizing the size of the collector arrays and any storage tanks required to flywheel the system through the night time hours.
4. The service courts associated with the cooling tower and other central equipment appear to have sufficient real estate to house a collector array and storage facility.

Key to this discussion is the actual requirement for heat. An assessment of the actual guest housing unit space heating loads may reveal that they are so low that they simply do not justify the expense and complexity associated with a solar collection system and that the condensing boilers discussed under Finding GHL7 - Consider condensing boilers when the existing Raypack units are replaced are the most economically and environmentally viable option. Installing a meter on an existing boiler as mentioned above, may allow such an assessment to be easily and quickly made based on the real system loads in addition to providing useful operating data.

# The Meeting Room Air Handling Systems

## Meeting Room Air Handling System Findings



## Overview

The variable volume air handling unit serving the meeting rooms is typical of many on the site. It is equipped with an economizer cycle, a chilled water coil, and a heating water coil. Variable air volume fan terminal units serve the zones themselves. Some of the other units serve pure variable air volume terminal units (no fans). Time constraints prevented developing a lot of data logger information for the air handling systems, but data from the EMS was available for diagnostics. The project team focused primarily on Ball Room AHU 9 and also spent some time looking at Spa AHU1. Many of the findings identified, while developed based on data from these two systems, most likely apply to the other similar systems on the site. Thus the savings projections have been extrapolated based on past experience to reflect the savings that could be achieved site wide if these issues are addressed in all of the units. The anticipated savings for these findings is in the range of $13,610 to $27,219 annually in gas and electricity.

## Finding AHU1 - Shut down economizer when the system is off

Figure 15 illustrates some of the trend data used to assess the operation of AHU9, including annotations regarding some of the observed issues and operating features.

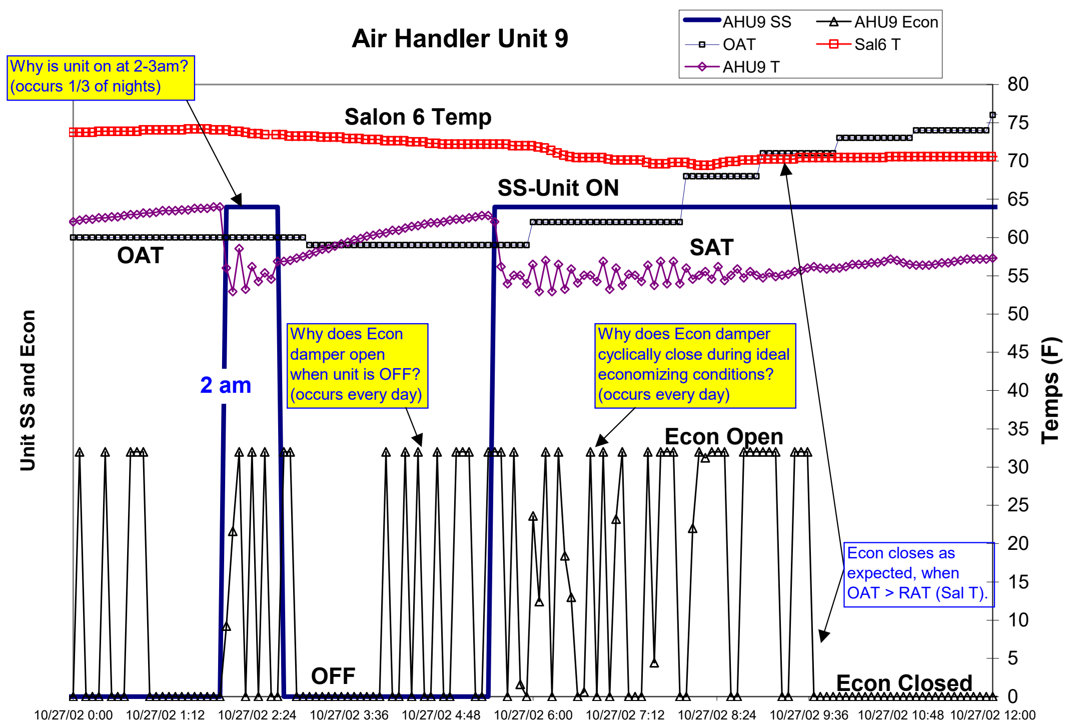


Figure 15 - Ball room AHU 9 trend data with problems annotated (5 minute sampling rate)

Notice how the economizer damper opens even though the unit is not operating. While the consequences of this are not as severe as they would be if the unit was in a climate with subfreezing winter temperatures, it still represents a potential to waste energy due to the migration of unconditioned air into or out of the building due to non-system generated pressure differences and thus should be addressed. Several options exist for accomplishing this.

1 A software interlock could be provided based on the fan status signal that closed the damper any time the fan status showed that the fan was off. This option has the advantage of low cost but has some potential problems that could occur if the fan were operated manually or by a safety; i.e. via the a hand-off-auto switch on the starter instead of a command from the control system or via a fire alarm shut down relay.

2 A hardware based hardwired interlock could be provided to ensure that the damper closed regardless of the cause of the fan shut down. It may be possible to pilot this interlock using the same sensor that provides the fan status feedback.[9] This approach has the advantage of ensuring that the dampers close any time the fan is off, regardless of the reason, but will have a larger first cost than the preceding option.

## Finding AHU2 - Shut down control valves when the system is off

This finding has the potential to save energy and improve the performance of the chilled water and heating water plants. The central plants are variable flow plants. One of the fundamental design concepts behind the variable flow concept is that it allows the pumping energy in the plant to vary with the load.[10] An open control valve associated with a coil in a unit that is off represents unnecessary pumping energy since the distribution pumps are moving water through the unit's piping circuit when there is no need to do it.

From a thermodynamic standpoint, water moving through the inactive unit dilutes the central system return temperature from what it would actually be under the current load condition. In chilled water plants, it tends to depress the return temperature as compared to what the plant would see if the valve to the inactive unit were closed. In heating water plants, it tends to raise the return temperature.

From a flow rate standpoint, the system pumps attempt to operate as if there were a larger thermodynamic load than actually exists. Because this thermodynamic load does not actually exist, the sequencing and efficiency of the central plant equipment is degraded from what it could be if the unnecessary flow did not exist.

The active coil element inside of an inactive air handling unit can also lead to operational problems and energy waste. Because there is no air flow, the surface temperature of the cooling coil in the air handling unit[11] is reduced. This will cool

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[9] The control drawings indicate that a current switch is used for this function. The switch may have a spare set of contacts or the switch could be wired to pilot a relay and one set of relay contacts could be wired to provide the status information to the DDC controller while another set could be used to close dampers and valves on the unit when the unit was not running.

[10] This is in contrast to a constant volume system, which always moves the same amount of water, regardless of the load condition. The energy associated with moving water around a piping circuit can be a significant component of the system's over-all cost. Variable flow systems save significant amounts of energy by only moving the amount of water necessary for the current load condition.

[11] Technically, this would be called the coil's apparatus dew point.

and dehumidify the air in the unit casing when it is not necessary and the casing will attempt to cool the local environment, thus wasting energy.[12] Similar problems occur with the heating coil. However, the block of very warm air that can be generated inside the fan casing when it is off can also cause operational problems like nuisance fire damper drops or false rate of rise detector trips when the unit first starts and moves the warm air out of the casing and through the distribution network.

Modifying the air handling unit software to eliminate unnecessary flow when the unit is off will optimize the performance of the central heating and cooling plants, eliminate energy waste, and minimize the potential for related operational problems at the air handling system.[13]

## Finding AHU3 - Tune the various control loops to minimize hunting

Both the trend data and observation in the field revealed considerable hunting and instability in many of the control systems. This is not an unusual problem in HVAC equipment. In fact, in many cases, instability in one control loop can ripple out and drive other related control loops into erratic operation. Fixing one loop has the potential to fix all of the related loops; the trick is figuring out which loop is driving the problem and which loops are being driven by the problem.

In any case, eliminating the instability can save energy and maintenance costs. Energy will be saved because the deviations above and below the process requirement will be eliminated; only as much energy as is required to meet the load will be used; no more and no less. Frequently, these deviations can trigger simultaneous heating and cooling as one element attempts to compensate for the over-reaction of a different element. This obvious energy waste will also be eliminated if the systems are tuned for stable operation. Maintenance costs will be saved because wear on the system control elements, actuator, and linkages will be minimized. An undetected, unstable control loop can dish out what would amount to several years worth of wear to a valve packing in a matter of days.

In addition to the preceding, the following findings were identified during the initial site visit and by the team as they worked on the project. Time constraints prevented analysis and development of savings projections, so the savings potential they represent has not been included in the summary in this report. These problems are not uncommon and experience indicates that in most instances, correcting them will

[12] In fact, the active coil with no air flow will cool the casing and the air it contains to a much lower temperature than it could with airflow. This can lead to excess condensation problems in hot and humid environments, both inside the unit as well as on the exterior of the casing. The excess condensate, in addition to representing wasted energy, can ripple out into water damage and corrosion problems. This scenario is probably not an issue in the Palm Springs environment but may be a consideration at other Hospitality Company locations.

[13] In some instances, it may be deemed desirable to somehow minimize casing temperature deviations when the unit is inactive. For example one may wish to prevent freezestat trips or to minimize the pull down load for rooftop equipment or prevent fire damper or rate of rise detector trips at start-up. These features can be accommodated with out the energy waste and operational problems described in this section by programming the unit to briefly open or modulate the appropriate valve based on the temperature indicated by a sensor inside the casing like the mixed air sensor during its off cycle.

require little if any capital expenditure and will generate a savings of 5% to 25% in utility cost for the system or systems on which they are implemented. They will also generate improvements in performance, maintainability and reductions in repair costs.

## Finding AHU4 - Verify that the FTU fans are started in a manner that prevents reverse rotation

The fans in most fan terminal units are forward curved fans powered by single phase motors. To understand this finding, you need to be familiar with two pieces of information related to this fan-motor combination.

1. If you blow air through a forward curved fan when it is not running, it will tend to spin in a direction that is the opposite of its normal direction of rotation.
2. Because single phase motors lack rotating magnetic field created by the phase relationship between the different phases in a 3 phase power network, they can run in either direction, with their direction of rotation being set using starting capacitors, shading poles, or other techniques to create an artificial rotating field when they are started. If they are already spinning when power is applied, they will simply run in what ever direction they happen to be spinning in, right or wrong.

Because fan terminal units are generally ducted to the discharge of an air handling system, the potential exists for the air handling system to pressurize the casing of the fan terminal unit when the air handler is running. If the fan terminal unit casing is pressurized and the fan is not running, air might exit the casing through the fan, which will cause it to spin in the wrong direction as indicated above. If the fan motor is then energized, the fan will continue to spin in the wrong direction. Air will still flow in the proper direction, but the performance of the fan will be radically different than what it would be if the wheel were spinning in the direction intended.

Thus, an important consideration with regard to the interlocks between fan terminal units and their associated air handling systems is to be sure that the fan terminal unit fan is started before the primary damper to the fan terminal unit is allowed to open in order to ensure that the fan spins in the correct direction and the unit delivers its design capacity and performance. Failure to do this can significantly degrade the performance of the unit.

In a cursory review of the information available to us, we could not ascertain if this issue had been addressed in the control programming and interlocks provided for the fan terminal units on the project. Because this contingency is often overlooked, yet does not prevent the unit from delivering air, and thus provide an obvious indicator of a problem, we suggest that further investigation be targeted at this area to ensure that things are correct. A simple functional test could be used to assess the situation by shutting down an air handling unit and its associated terminal units and then allowing them to restart and observing what happens. If the problem exists, correcting it will improve the performance and efficiency of the terminal units, improving comfort and lowering energy costs.

## Finding AHU5 - Optimize static pressure and reset routines

We did not have a chance to look into the details of the method used to control static pressure and discharge temperature on the air handling systems at the project site. However, we did note several instances where there appeared to be opportunities to optimize in these areas. This is a common finding at for many project sites, so based on past experience and our limited observations, we suggest that the following be considered to the extent they apply for the systems at Ranchos Las Palmas.

- **Consider resetting fan discharge static pressure based on load or a remote indicator out in the system.** This approach controls for discharge pressure, as is the current design in most cases, but optimizes the set point of the control loop based on the current operating condition. It maximizes the energy savings to be achieved in most VAV systems by taking advantage of the square law relationship between pressure drop and flow in a duct system and only producing the pressure necessary at the fan discharge to move the air to the most remote terminal unit under the current flow condition. This approach will yield its biggest benefits on systems with long and/or high pressure loss duct systems that see significant flow variations over the course of an operating cycle or over the seasons. Systems with low static requirements, short duct runs, or relatively flat load profiles may be better targets for some of the other optimization strategies instead of this one.

The actual reset function can be accomplished many ways including resetting based on a measured pressure, resetting based on the terminal with the highest demand or resetting to maintain at least one terminal at a near open state.

- **Perform field measurements and additional troubleshooting to identify why some systems do not seem to be able to meet their static pressure set point requirement.** Discussions with the operating staff indicated that many systems do not seem to be able to achieve the required static set point. There are a variety of reasons that this could be occurring including:

  1. **Design issues similar to those identified by the staff for Spa AHU1:** Field pressure measurements taken at various points in the system using a manometer or magnehelic gauge can pinpoint duct segments with high pressure losses relative to the system. Once identified, these areas can be targeted for additional investigation and perhaps, modification to eliminate the excess static.

  2. **Calibration issues:** Investigation may reveal that the actual problem is related to the calibration of the sensor controlling the system or the location of its sensing ports. Correcting these issues will provide a better input to the

control system and allow it to modulate fan capacity based on actual performance.

3. **Improper set point selection:** In some instances a system can not meet a set point because the set point has not been properly selected. In other words, the system may not have the capacity necessary to meet the set point because it does not need to meet that set point in order to perform adequately. Engineering techniques can often be used to reverse engineer the current process and system back to a correct set point.

4. **Conflicting reset strategies:** It is not uncommon to encounter variable air volume systems that reset both discharge temperature and discharge static pressure. While this is possible in theory, if the strategy is not implemented carefully based on the right parameters, the effect of one strategy can counteract the other strategy[14] and the systems end up operating as large constant volume systems. Thus it is important to assess systems that implement both strategies to be sure the desired result is achieved. It is not unusual to discover that best over-all performance is achieved with one or the other but not both strategies in place.

## Finding AHU6 - Investigate the potential for zone level scheduling

One advantage of DDC equipped terminal units that is often overlooked is that they will allow schedules to be implemented at the zone level rather than at the air handling unit level. If a VAV air handling system serves multiple zones with different operating schedules, the traditional approach has been to operate the entire system any time any of the zones requires service. Zones that were unoccupied tend to drive to minimum flow over time, which reduces but does not eliminate the unnecessary air flow. In addition, they often end up in a reheat mode once they reach minimum flow to prevent over-cooling the area served.

Terminal unit DDC technology can be used to advantage to eliminate much of this wasted air flow and unnecessary reheat on systems serving zones with different operating schedules. The terminal unit controllers can be programmed to *fully close* (0 cfm, not minimum cfm) the damper on zones when they are unoccupied.

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[14] If you increase the supply temperature to a zone and do nothing else, the zone will require more air. As a result its terminal unit damper will open which will tend to lower the duct static pressure and cause the fan to speed up. It is not out of the question that the energy required to move more air exceeds the savings associated with the minor supply temperature increase that triggered it by orders of magnitude. Similarly, if you lower the discharge static pressure to a system and do nothing else, the flow will be reduced. If one of the zones was already at full capacity with the current supply temperature, then the only way to maintain the load will be to lower the system supply temperature. Depending on the characteristics of the cooling source, this may cost more energy than was saved by the flow reduction.

## Finding AHU 7 - Coordinate minimum outdoor air requirements with the actual load served

The widely variable occupant loads in many areas of the facility, like the dining areas or meeting areas, provides an excellent opportunity to employ demand controlled ventilation. An approach that is rapidly gaining acceptance in the industry involves using carbon dioxide sensors ($CO_2$) to reset the minimum flow rates at terminal units and air handling equipment based on $CO_2$ levels, which are directly related to occupant load. This approach saves:

- Fan energy due to the reduced minimum flow rates.
- Reheat energy duo to the reduced minimum flow rates
- Heating and cooling energy at the central air handling unit due to the lower outdoor air load.

Additional information in this technology can be found in the following references.

### Articles available at www.ASHRAE.org

- *Minimum Outside Air Damper Control, b*y Larry Felker, Associate Member ASHRAE, ASHRAE Journal, April 2002.
- *Demand Control Ventilation Using $CO_2$*, by Mike Schell and Dan Int-Hout, Member ASHRAE, ASHRAE Journal, February 2001.

### Articles available at www.HPAC.com

- *Indoor Air Quality Primer*, by Terry M. Brennan, Heating, Piping and Air Conditioning (HPAC) Ventilation Guide, Spring 1999
- *Real Time Ventilation Control*, by Mike Schell, HPAC, April 2002

# Black Domestic Water Pipe

## Spa Electrical Distribution System Findings



## Overview

The Spa at the complex is a fairly recent addition. Shortly after this area was opened for business, the facilities group noticed that one of the domestic water lines was starting to show evidence of severe, quickly spreading corrosion. Further investigation revealed that the electrical distribution system was grounded to the line. In an effort to correct the problem, the staff installed a grounding rod and re-routed the ground from the domestic water line to the grounding rod. This modification seemed to eliminate further blackening of the domestic water line. But, the staff suspected that they may have fixed the symptom, not the problem and raised the issue for consideration by the project.

This type of problem can be caused by chemical reactions or by currents flowing in the grounding conductors. There was a tendency for sewer gas to be present in the room where the domestic water piping in question was located and one of the team members with experience in waste water plants had seen sewer gas turn copper piping black, much like the problem under investigation. However, the team noticed that a loop in the piping had not been blackened, even though the piping it was connected to and other piping at elevations higher than the loop had been blackened (see Figure 16), thus leading to the conclusion that the problem was more related to electrical currents than chemical reactions. However, it was noted that the presence of the sewer gas may have accelerated and accentuated the corrosion, bringing it to the operating staff's attention much sooner than might have otherwise been the case.

Poor grounding practice or unintentional connection of the neutral conductor and grounding conductor at some point in the distribution network typically cause current flow in the grounding system. Generally, the neutral conductor and grounding conductors in a power distribution system should only be connected at the service entrance and main transformer secondary, as illustrated in Figure 17. If the neutral is grounded at more than one point in the system, either intentionally or unintentionally, then the grounding conductor between that point or points and the service entrance becomes a current carrying conductor operating in parallel with the neutral conductor, as illustrated in Figure 18. This can cause a variety of power quality and ground fault problems in the power distribution system and can become dangerous if the neutral conductor is broken for some reason.

Figure 16 - Blackened domestic water piping in the Spa area

The project team identified the following findings relative to the problem indicated by the blackened pipe. While no direct energy savings are associated with these issues, correcting them will improve safety and power quality for the area and eliminate several code problems.

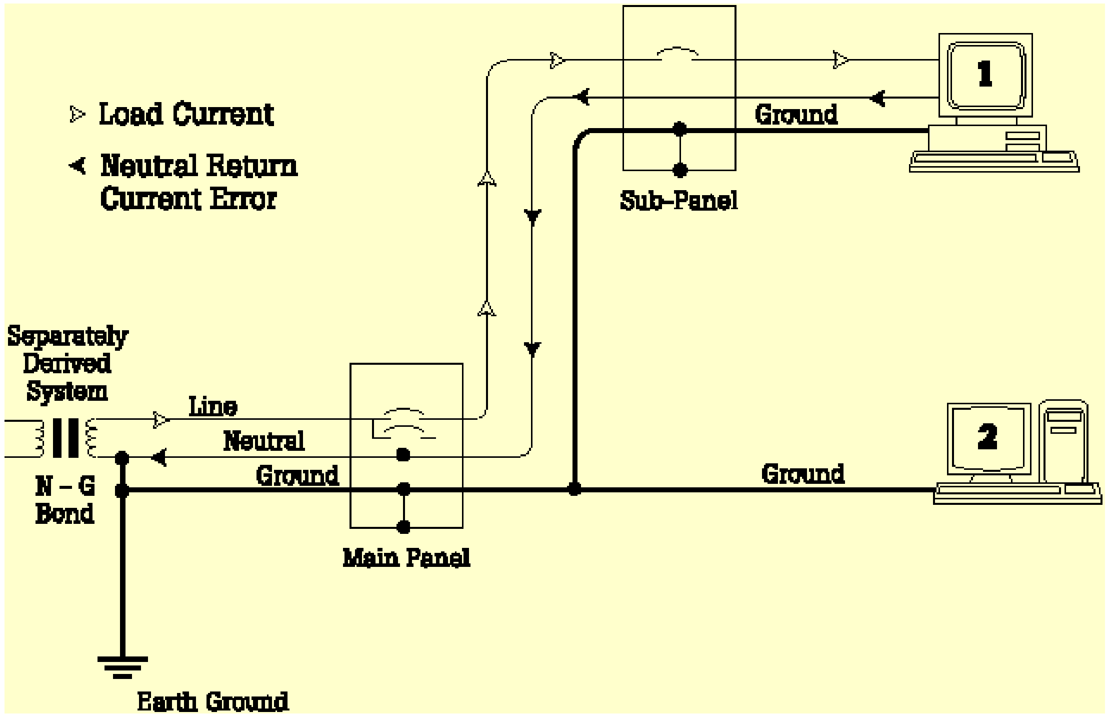


Figure 17 - Proper grounding practice

## Finding SED1 - Investigate and eliminate equipment grounding current problems on Circuit #33 / Panel board L1A and in Panel board L1B

When the facilities group installed the grounding electrode, they minimized the current flow on the domestic water pipe.  While this did stop the corrosion, the real issue is that there really should not be any current flow in the ground conductor; its only a reference point.  Since the project team suspected grounding problems as the root cause of the domestic water pipe corrosion, they began looking for current flow ion the grounding system associated with the spa.   The investigation lead to the discovery of approximately 1 to 2 amperes of current circulating on equipment grounding conductors serving panel boards L1A and L1B.

Further investigation traced the majority of this current flow to Panel board L1B in the circuit #33 equipment grounding conductor, which serving a piece of mechanical equipment.  The facilities group should investigate this equipment and eliminate the source of the undesirable ground.  They should also continue to investigate the system to identify the other sources of ground current.  The equipment connected to circuit 33 does not account for all of the current detected in the system.

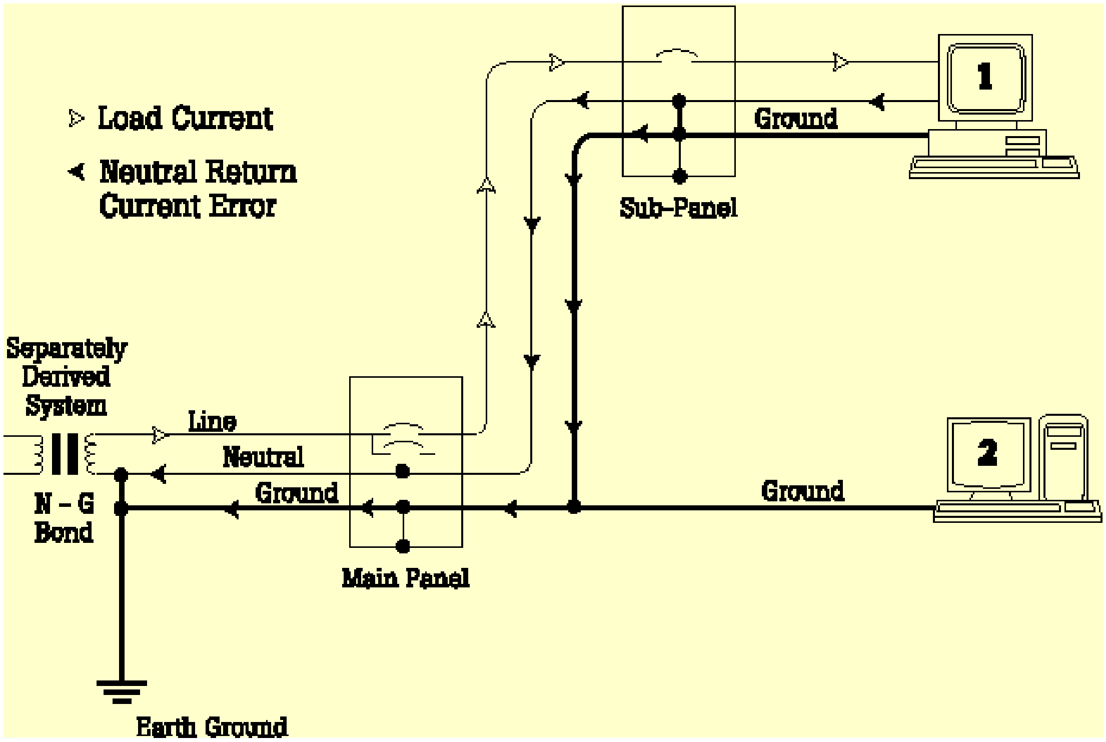


Figure 18 - Improper grounding practice

## Finding SED2 - Correct 225 kVA transformer grounding problems

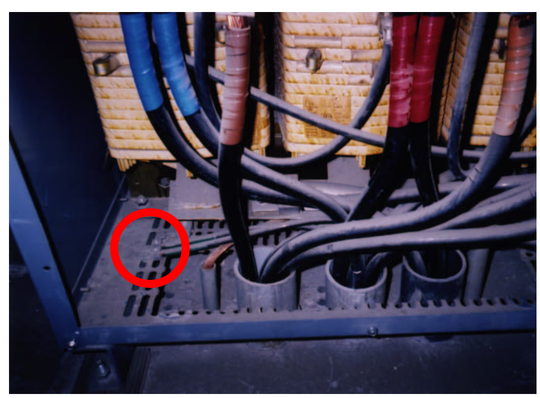

Figure 19 - Poor transformer grounding connections

While investigating the grounding issues associated with the blackened pipe, the team noted poor grounding practices in 225-kVA 480-208/120 volt transformer (see Figure 19).

A high quality equipment ground bus needs to be installed in the transformer. The following steps are recommended:

- Call the Utility
- Deenergize the utility transformer
- Have the utility inspect and verify that their transformer neutral and grounding connections are adequate and tight.
- Inspect, and tighten Switchboard neutral and equipment grounding bus.

### Finding SED3 - Correct the main switch board grounding problems

While investigating the grounding issues associated with the blackened pipe, the team discovered that the main switchboard grounding bus does not appear to be connected to grounding electrodes correctly. National Electric Code (NEC) Section 250-24(a)(2) requires two grounding electrode systems. Examples of acceptable grounding electrodes include:

- Grounding rods driven into the earth (as installed by the facilities engineering group).
- Building steel
- Domestic water pipe
- Sprinkler water pipe
- Natural gas piping
- 30 ft. UFER ground in the footing structure

In addition, it is recommended that the facilities group further investigate and trace blackened domestic water piping system to determine where is changes from black to copper color. This may reveal other ground issues and connections that are currently unknown. They should also install a bare stranded copper conductor between each grounding electrode so that all electrodes are bonded together. This is not required by the NEC but is preferred practice. (The NEC requires only two systems to be used and bonded.) Based on the team's observations in the Spa, this would include:

- The domestic water system piping
- The natural gas piping system
- The sprinkler system piping
- The building steel
- The recently installed electrode system

## Roof Ventilator Turbines

One area of the facility is equipped with approximately 30 turbine style roof ventilators that appear to exhaust air from a ceiling return plenum. The staff has a number of concerns with this arrangement including:

- Each opening represents a 2-foot by 2-foot penetration of the roof membrane, insulation, and structural system. At a minimum, the openings represent a the potential for water damage, and given the climate, the radiant heating that occurs through the turbine and opening could represent a significant cooling load. In addition, when it is time to re-roof, the openings represent an added cost.

- Exhausting air from a ceiling return plenum would seem counter-productive to the efficiency of the system serving the area and could be causing pressurization problems.

Figure 20 - Above ceiling openings between return plenum and the area served by the turbine ventilators

The project team investigated these issue and discovered the following:

- In addition to the 30 turbine vents, the roof contained 30 gravity vents and 15 power vents. The power vents appeared to be thermostatically controlled. While the area immediately below the turbines had a ducted return, there were openings between this area and the plenum return in the adjacent area (see Figure 20)

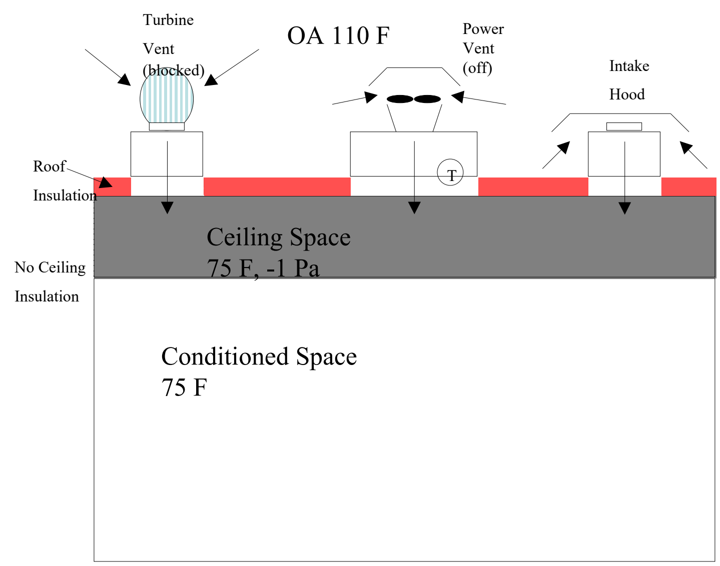


Figure 21 - Typical conditions on the days of observation

- During the period of time that the team was working on the project, the attic space associated with the vents was depressurized at 1 Pascal. They measured approximately 70 CFM being drawn into building through one of the vents (see Figure 21). It is anticipated that this flow rate would increase very significantly if one of the powered vents were to cycle on.
- The return temperature tended to track the attic temperature for one of the systems associated with the plenum return. Thus, the vents appear to be adding to the space cooling load.

Generally, there is some contention in the industry contention regarding attic ventilation practice. Many consider it standard design/construction practice. The Uniform Building Code (UBC) gives attic ventilation area requirements, but states that they only apply <u>*IF*</u> the attic is vented. The requirement is not mandatory.

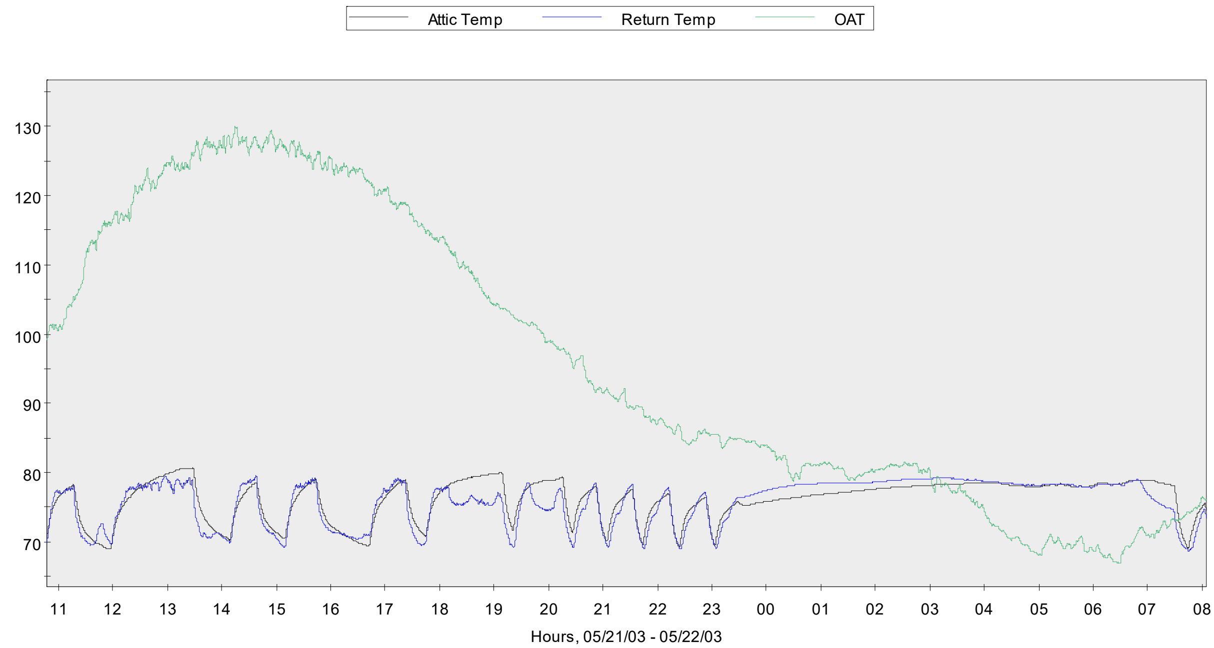


Figure 22 - Temperature data for the attic area and a air handling system using the plenum

Given the load that the attic ventilation system appears to represent in terms of additional cooling energy due to the plenum return system, as well as other issues, the team recommends that the Hospitality Company close and seal all roof openings, including the turbine vents, the gravity vents, and especially, the power vents. The savings are difficult to quantify, since there was no data available on the amount of time the power vents operated. But, based on measured air flows and temperatures observed during the test, it is anticipated that the savings will be at least $5,300 in electrical energy with the potential to be much higher if the powered exhausters run much. There will also be additional savings in terms of lower maintenance costs and lower re-roofing costs.

# Non-targeted Findings



## Overview

Over the course of the project, several findings that were not originally targeted by the project were developed to some extent. These ideas evolved from insights and suggestions made by conference attendees who were not directly involved with the project and Hospitality Company staff and from observations made during the initial site assessment visit by PECI in late March.

## Finding NTF1 - Install Waterless Urinals for the Meeting Area Restrooms

One of the conference attendees noted the relatively heavy use of the restrooms during the breaks between sessions and suggested that waterless urinals at the meeting room restroom location might represent a significant dollar savings, especially in the desert environment. Savings would be seen both in water consumption as well as sewer costs. This calculation is highly dependent upon the water consumption of the existing urinals, the number of urinals actually replaced, the actual number of flush operations, and water and sewer costs. While we lacked good information on many of these variables, a very rough calculation based on rates from water bills and the conference break schedule and attendee count indicated a savings potential in the $1,000 to $2,000 per year range. Thus, this option may merit further evaluation, especially when and if remodeling is contemplated in any public restroom area. *Green Restroom* in the April 2003 issue of Heating, Piping, and Air Conditioning provides information and resources regarding this concept in addition to other resource conserving ideas for restrooms which may be applicable at Palm Springs Location.

## Finding NTF2 - Trim the Water Slide Pump Impeller

While working with the teams on the pump analysis for the guest housing water source heat pump loop, the facilities group realized that a problem they had dealt with by throttling the water slide pump may yield energy savings if they trimmed the pump impeller instead. Specifically, the water slide pump would trip on its motor overloads unless its discharge was throttled significantly (in the range of 70% closed). This problem and its solution indicate that the pump is significantly oversized for the system and that it runs out its curve and overloads the motor that it was provided with if allowed to operate with an unrestricted discharge. Calculations based on the pump nameplate data, the water slide flow requirements, and the physical arrangement of the piping circuit indicate that this may in fact be true. The facilities staff can confirm this by performing a simple pump test and plotting the results on the water slide pump's operating curve. Assuming that the test proves the theory, then trimming the impeller to deliver the required flow with the discharge valve wide open will save roughly $500 to $600 per year in electricity based on the current operating schedule.

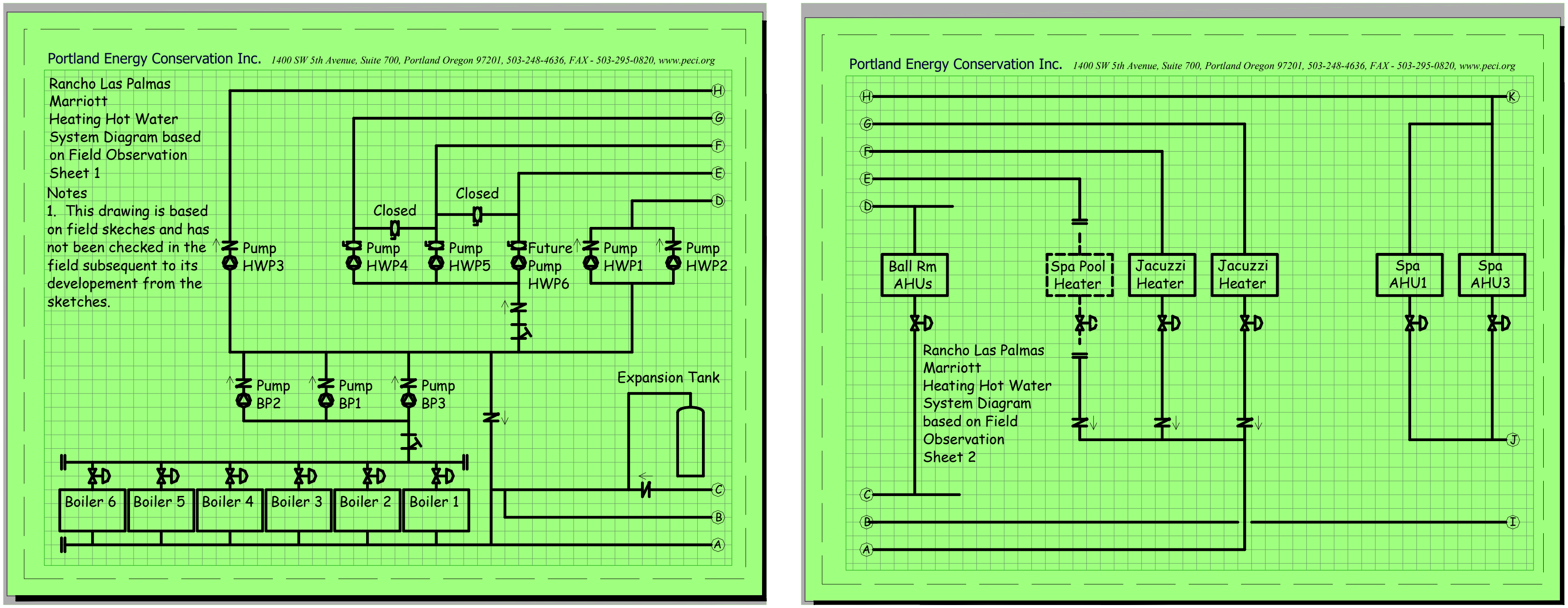


Figure 23 - Simplified Heating Water System Flow Diagram, Sheets 1 and 2

## Finding NTF3 - Reduce the Pumping Energy for the Heating Hot Water System

The heating water system serving a significant portion of the project is quite complex and contains numerous pumps, as can be seen from the rough flow diagrams presented in Figure 23 and Figure 24. While time precluded any sort of meaningful analysis of the system the information gleaned in preparing the flow diagram, discussions with the facilities group and past experience indicate that a savings and operational improvement potentials exist. Specifically:

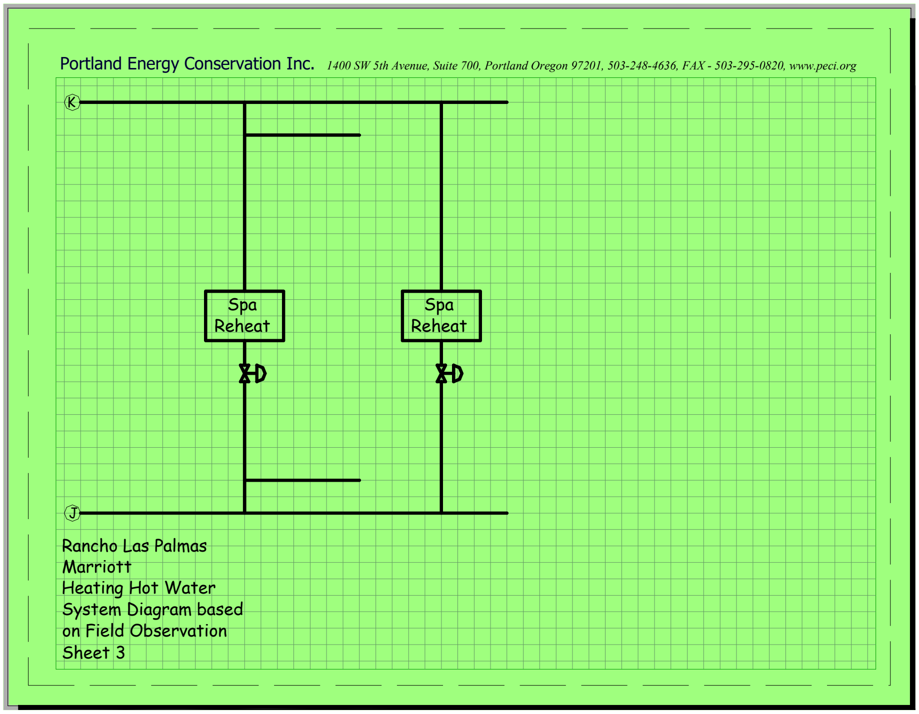


Figure 24 - Simplified Heating Hot Water System Flow Diagram, Sheet 3

- Some of the pumps that are piped in parallel have radically different performance characteristics. In some instances, operating one of the pumps would produce enough head to prevent the others from moving any water. If the pumps were operated simultaneously, the lower head pumps would simply spin but not move water, wasting energy and raising the potential for damage due to accumulated pump heat.
- The current operating hardware, operating sequence, and configuration make it difficult to document compliance with emissions regulations related to fuel burning equipment.

We recommend that an engineering analysis project be implemented to further study the system and identify ways to reduce its complexity, consolidate pumping requirements and add the sensors and sequences necessary to demonstrate/ provide compliance with emission regulations. It is quite likely that the sensors required for the emissions related work would also provide benefits in terms of improved efficiency and diagnostics, thereby saving energy in addition to ensuring compliance.