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ANDERSON BROTHERS electric, LLC

11-30-2020

## Petersburg Pool Repairs and Rebuild

To whom it may concern,

There have been great strides by my team in getting the pool back up and running, some of which I thought were impossible to accomplish within the time frame. Considering the relevant findings, there is an opportunity to create both a permanent fix and meeting current code. In restarting the systems and checking their components, we discovered additional items needing repaired, replaced, or modified to function properly and efficiently. We have the team in place that, I believe, will give you the best quality, and value with the least disturbance and outages to your pool schedule and entire facility.

We propose the most economical way to proceed would be to do the work directly related to the fire covered by insurance, as well as deferred maintenance, and energy savings concurrently to save time, cost of mobilization and long lead times for parts and systems, etc.

We suggest an energy audit to identify exactly where the inefficiencies are and how to capture those savings, so as not to entirely rely on good faith. Please see attached reports by Alaska Energy Engineering, LLC that explain this in better detail.

### Tasks identified by our team during startup of the pool

#### Renew to pre-fire condition (Paid for by the Insurance company)

Clean, repaint, and fix damaged piping insulation

Bring electrical gear up to code which requires it to be outside of the boiler room due to egress codes

Replace balance of damaged items, air handling, elevator, HVAC controls, and any undiscovered items

#### Deferred Maintenance

Boilers need work, elements, burned wires, relays, etc.

Pumps and fan motors that make unusual sound and leak

Energy Savings/Properly functioning Systems/Code compliance

Hot water mixing valve has issues that need addressed for safety

Many of the pumps are sized incorrectly and need addressed

The most urgent items:

Fire Alarm System fixed

Boiler wiring fixed

Hot water mixing valve fixed

New electrical gear to get boiler off the house panel so elevator can run, sauna, etc.

Please see attached update by Morris Engineering Group, inc. which also outlines the process we see going forward to assist the Petersburg Borough in selecting what work is to be done, estimating the cost for that work, and how best to perform that work in the soonest possible time period as we have the building in a temporary configuration to allow immediate safe operation.

November 30, 2020

Kyle Hardin
Alaska Public Entity Insurance
Property/Casualty Claims Manager
2233 Jordan Avenue
Juneau, Alaska 99801

Stephen Giesbrecht
Borough Manager
Petersburg Borough
PO Box 329 Petersburg, Alaska 99833

RE: Petersburg Aquatic Center Electrical Fire Update

Kyle and Stephen,

This is an update report on the Petersburg Aquatic Center:

**WHAT HAS BEEN DONE**

On November 11-17, a team compromising Anderson Brothers Electric, Alaska Energy Engineering LLC, Inside Passage Integrated Control Systems, and Morris Engineering Group, Inc. worked together to determine the damage to the mechanical systems, controls, and to restore electrical power to the facility in a safe, temporary configuration.

Anderson Brothers Electric removed the circuit breakers out of the 277/480V, 800 amp switchboard, cleaned the buss, inspected the switchboard, meggered the buss' and installed new circuit breakers in the switchboard. The electrical service to the switchboard was reconnected by Petersburg Municipal Power and Light (PMPL) on Thursday, 11/12. An 800 amp circuit breaker was installed in the switchboard and parallel 4 no. 4/0 type W portable power cables were used to connect the circuit breaker to boiler no. 2. After working on the controls (See attached report by Alaska Energy Engineering, LLC), the boiler was returned to service.

The other panels fed by the switchboard were restored to power (panels H1A, H1B, and H2A). Panel H1A's circuit breakers were removed, panel cleaned, inspected and meggered, and new circuit breakers were installed. The same was done for panels L1A, sections 1 and 2. The step down transformer L1A was inspected and returned to service temporarily. This work was done on Thursday and Friday.

Once power was restored, Jim Rehfeldt (Ak Energy), Bret Burnett (Inside Passage), Pete Anderson (Anderson Bros) and I went through the building turning on equipment. We found the starters for the HRVs were damaged and other mechanical controls components (See Ak Energy report). As additional equipment was turned on, other issues became apparent. The building has some deferred maintenance that needs to be done. There are operational issues with the mechanical systems that need to be corrected. The configuration and operation of the mechanical ventilation system could be modified to take advantage of energy savings and provide better function to the facility and it's patrons. These are highlighted in the Ak Energy report.

Once the mechanical systems were operational to the point of being able to serve the facility, the process of reheating the pool was begun on Friday 11/13. It quickly became evident that 95% of the energy output of boiler no. 2 which was running at approx. 360KW (out of 460KW rating) was required for the air ventilation system and thus the pool would take a very long time to reheat. We decided late Friday that we needed another boiler to reheat the pool in a timely manner.

Therefore, we had additional equipment shipped from Juneau and set up to energize the second service to the building. This involved removing the damaged 277/480V, 1,600 amp switchboard. Anderson Brothers then installed a service rated, 480V, three pole, 600 amp fuse disconnect with 500 amp fuses in it's place. After inspecting and meggering the existing 500 mcm service lateral conductors, we reused two sets to feed the disconnect. PMPL provided donut style CTs for Anderson Brothers to install inside the fuse disconnect as for temporary metering. These were connected to the existing remote meter on the building exterior that used to be connected to the CTs in the 1600 amp switchboard. The parallel 500 mcm feeder conductors from the removed 1600 amp switchboard to boiler no. 2 were removed, inspected, damaged portions cut off, and then reused to feed boiler no. 1 from the fuse disconnect. The original parallel 500 mcm conductors that fed boiler no. 1 were removed and the conduit cut back with a portion of flexible conduit added back to connect to the fuse disconnect. The boiler no. 2 original feeders were significantly longer than the ones for boiler no. 1. That is why they could be reused in a temporary manner. PMPL arrived Monday morning and energized two sets of the second service conductors. After some controls work, and an inspection of boiler no. 1, we energized the boiler.

Due to limitations on the main 800 amp circuit breaker to the 800 amp switchboard (it is an standard 80% rated circuit breaker), approx. 120 KW of boiler no. 2 is disabled. Due to broken wiring and worn contactors in boiler no. 1 as well as 500 amp fuses, approx. 160 KW of the boiler is disabled. This week, we will return to Petersburg to replace the 800 amp main circuit breaker with a 100% rated breaker and with 600 amp fuses. This will allow boiler no. 1 to operate at 100% capacity and boiler no. 2 to operate with only 80 KW disabled. Both boilers have damaged parts that need to be replaced. They also have life limited parts that need to be replaced. They are being operated in a temporary configuration and require more work to be returned to normal service. This will also allow the sauna to be returned to service.

The fire alarm panel will be replaced this week thus enabling the fire alarm system to be re-tested and certified for normal operation.

The elevator will require a visit from the state elevator inspector to be returned to service as it's safeties need to be checked, including electrical shunt trip and other safety features. This will be planned as part of the permanent repairs.

It is important to remember that this facility has been restored to operational status in a temporary configuration. Temporary wiring has been used. Temporary circuit protection has been used. Controls have been placed in local or manual mode to obtain sufficient operation of the systems for the facility to be used. Permanent repairs to the building should be completed as soon as practical.

**WHAT IS NEXT**

As has been discussed above and outlined in greater detail in Alaska Energy Engineering's report, there is more work needed in this building than repairing the damage due to the electrical fire and associated voltage fluctuations throughout the building. This work can be broken out in the following categories:

1. Repairs from fire, water, and electrical fault damage
2. Code Compliance Items
3. Deferred Maintenance Items/Repairs
4. Operational Improvements
5. Energy Efficiency Measures

Some of this work should be covered by the building insurance and some by the Petersburg Borough. Some of this work is mandatory and some is elective. In order for decisions to be made about what work should be done and who should pay for it, a scope of work document needs to be developed for each of the work elements with an associated construction cost estimate. In order to determine potential cost savings due to energy savings from re-configured mechanical systems, an energy audit and analysis is needed.

We recommend the Petersburg Borough enter into a design build contract with Anderson Brothers Electric to take the project from this point to completion of the permanent repairs and any other additional work that is requested to be done.

Here is a proposed sequence of steps and estimated time to perform the work:

1. Petersburg Borough authorization to complete scope of work document describing work in each of the five categories; Fire Repairs, Code Items, Deferred Maintenance, Operational Improvements, and Energy Efficiency Measures. This work would be performed on a Time and Expense basis not to exceed $50,000. Jan 15
2. Anderson Brothers delivers the scope of work document to Petersburg Borough. Jan 15
3. Meeting between Petersburg Borough and Anderson Brothers to discuss the scope of work items, costs, and any applicable operational cost savings. Jan 22
4. Petersburg Borough Discussions and subsequent agreement with their insurer(s) as to which scope of work items are to be covered. Feb 5
5. Petersburg Borough Determination of which scope of work items are to be performed. Feb 19
6. Petersburg Borough authorization to Anderson Brothers Electric to perform the selected scope of work items on a time and expense basis with a not to exceed amount. The not to exceed amount to be adjusted when unanticipated items are discovered during design or construction and, upon authorization by the Petersburg Borough, are added to the scope of work. Feb 26
7. Anderson Brothers authorizes their team to perform the design of the selected work. March 5
8. Anderson Brothers provides the design documents to the Petersburg Borough for review and approval. April 30
9. Design Review Meeting with Petersburg Borough and Anderson Brothers Electric. May 7
10. Petersburg Borough approves the design for construction with comments. May 21

11. Anderson Brothers Elec and their subcontractors perform the work with their team engineers reviewing submittals, working out construction issues with the contractors and inspecting the work for compliance with the design and applicable codes. Sep 30, 2021.

The schedule is very preliminary as we don't know the scope of work or the lead times on major equipment that may be included in the work.

Some of the work smaller work items that do not need design such as replacing life limited components and damaged components in the boilers will be done on an expedited basis along with replacing starters in the HRVs if reconfiguration work on these units is not done.

By using a design build team on a time and expense basis, we believe we can work with the Petersburg Borough to perform work in a manner that least disturbs the operation of the pool as well as to repair the building as quickly as possible with the work that can be done sooner and only allowing the long lead items and portions of the work that need a full design to be constructed next summer. This will require multiple contractor visits to the site but will reduce the "temporary nature" of the systems as the equipment repairs/replacement are performed as soon as they are designed/procured.

Sincerely,

Mark Morris, P.E.
President

MORRIS ENGINEERING GROUP INC.

Inspection of Petersburg Aquatic Center Electrical Fire

On October 28-29, I visited the Petersburg Aquatic Center and inspected the switchboard which had a fire on October 16, 2020 at approx. 19:41 according to data provided from Petersburg Municipal Power and Light.

The building is fed by two electrical services; one to each of two Square D QED style switchboards. The switchboards are located in the back of the mechanical room which appears to be CMU block construction with a concrete ceiling. The switchboards are located side by side. The left switchboard is rated 277/480V, three phase, 1,600 amp is fed with four sets of underground service entrance lateral conductors approx. 500 mcm. The switchboard has two sections; the left section has the service entrance conductor terminations in the bottom half and a utility bar type CT compartment in the upper half with a remote mounted meter on the outside of the exterior wall. The bar type CTs are bolted to buss work that is routed horizontally into the right section of the switboard. The buss work then transitions vertically and then turns 90 degrees to feed a Square D I Line style vertical buss. The vertical buss then feeds two 800 amp circuit breakers according to the facility design drawings. An 800 amp sticker was still visible on one circuit breaker. Each breaker feeds one Precision Electric Boiler rated at 480 KW.

The right switchboard is rated at 277/480v, three phase, 800 amps and is fed with (3) sets of 300 mcm conductors. The switchboard has a back fed main circuit breaker rated at 800 amps which feeds a Square D I Line style vertical buss. The buss feeds a 400 amp three phase breaker which feeds a 400 amp Square D NF panel in the same room. There are a 250 amp, 90 amp, and 100 amp breakers that feed other panels and an elevator in other parts of the building. There are two spare 225 amp circuit breakers.

The left switchboard had the fault and subsequent fire. The load side of the upper 800 amp circuit breaker where the transition occurs from the breaker to the buss is completely missing. The dead front cover is bent out at this location. If a fault occurred here, the resulting blast and vaporized metal may have caused a fault at the bus bar connection directly below the breaker where the switchboard buss is connected to the I-line style buss. The top of the lower 800 amp breaker has damage along with the top portion of the transition section between the lower breaker at the I-Line style buss. Fires occurs on the right side of the switchboard melting the empty breaker space covers, burning through the metal divider to the back of the switchboard that breakers are mounted to, melting the insulation off of the feeder conductors routed through the top of the switchboard into conduit. Another fire occurred in the bottom of the switchboard, maybe from melted parts dropping to the bottom of the switchboard. The fires melted holes in the switchboard steel covers. Morris Engineering Group, Inc. does not claim to know how the faults were started or how the fires were started. These are just field observations. The feeder conductors do not appear to be melted or faulted where they are terminated on the circuit breakers or where they are routed up the left side of the switchboard. Their insulation becomes significantly damaged as they transition into the upper section of the switchboard reserved for routing conductors. Where the conductors leave the switchboard, they pass through bushings. There is no appearance of a fault at this location, i.e., the visible strands of the wire have no appearance of arcing, missing portions of wire, nor do the bushings appear to be damaged. I didn't move anything around as I assumed someone trained in determining causes of these faults may investigate the switchboard and would not want anything disturbed. The left and right side covers were off the distribution sections of both switchboards when I arrived. I took off the right hand end cover of the right switchboard to compare the buss work arrangement with the left switchboard.

The right switchboard had soot damage in the top, otherwise it appeared undamaged by faults or a fire. The public utility Petersburg Municipal Power and Light (PMPL) was called to the sceen (see attached email) and disconnected power to the transformer by pulling one primary phase elbow at a time. The transformer was still providing power at the time. The fire was extinguished by this time and the PMPL lineman went into the room with the fire department and turned off the main circuit breaker on the right switchboard which was de-energized when the transformer elbows were disconnected. However, the right switchboard remained energized through the faults and fire in the left switchboard and while the phases were disconnected one at a time from the transformer. This probably resulted in very significant voltage changes to all energized equipment in the building. After the building is re-energized, many more damaged equipment may be discovered when it is put back into use.

There were two sprinkler heads in front of the switchboards which activated according to the building staff present at the inspection (Cody, Colin, and Stephannie). The sprinkler heads sprayed down both switchboards, and the adjacent fire alarm panel, two 208V panels, a step down transformer, a 480V panel, and a lighting control panel. Presumably the water turned to steam when it hit the switchboard on fire thus subjecting the entire room to steam damage. We took covers off the 480 and 208V panels are saw soot inside the panels.

The local utility has hired an electrical consultant to evaluate what happened and how the utility system responded. The lineman that disconnected the power, Kevin, shared with me some fault information from two faults that the system saw as well as a time line of the faults. It appears that the utility power was disconnected twice automatically several minutes apart and when reconnected the second time, the fault had cleared. We measured the impedance between each phase and neutral as well as between phases and did not find any measurements below 3,000 ohm. The neutral was bonded to ground.

I had multiple conversations with Don Foster at Square D, an engineer that has provided technical assistance to me on Square D equipment for my entire consulting career of 29 years. Don told me that Square D has a group of folks that look at these type events and Mike Scott with Square D will be organizing a trip to the site for a Field Service Representative. I shared many pictures with Don and he said that he has never seen anything like this in his 35 year career. Neither have I. However, I did discuss this with another electrical engineer who used to own a consulting engineering firm in Juneau who told me a similar event happened at Harborview Elementary School in Juneau in approx. 1990. It was a similar design with one switchboard that fed electric boilers. The take away here is that the determination of what happened, if there is enough evidence left to conclusively do so, should be left to the folks who do this for a living. The National Fire Protection Association, NFPA, may have investigators who can assist in determining a cause.

Below are pictures with captions to show what is described above:

AlaskaEnergy
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**Technical Memorandum**
December 1, 2020

| | |
|---|---|
| To: | **Peter Anderson, Project Manager**<br>**Anderson Brothers Electric LLC** |
| Subject: | **Mechanical Systems Assessment Report** |
| Project: | **Petersburg Aquatic Center Emergency Repairs** |

## SUMMARY OF FINDINGS

The project team visited the Petersburg Aquatic Center to return the building to operation after an electrical fire. The mechanical systems were assessed to determine if the associated electrical surge had caused damage. During the course of the investigation, unrelated issues were discovered, operational deficiencies were identified and opportunities to improve the operation and energy efficiency of the systems were revealed. This report presents our findings.

### Fire Damage

The mechanical systems suffered a few failures that resulted from the electrical fire. These include:

- The boiler B-2 low water safety board was damaged. It is an essential, code-required safety that must be replaced.
- The hot water heater automatic valves were damaged. They must be replaced to restore proper operation.
- The heat recovery ventilator (HRV) motor starters were damaged. They should be replaced with VFDs to minimize load impacts to the electrical system.

### Repairs

The following equipment requires immediate repairs due to failure or near the end of its service life.

- Boiler B-1 Temperature Controller: The controller failed previously on Boiler B-1 and was replaced. It is likely the B-2 controller will also fail. Upgrade the temperature controller to the same controller that is installed on Boiler B-2.
- Boiler Wiring: Both boilers have issues with burned wiring, faulty connectors and blown fuses. These issues were partially repaired and should be completed.
- The domestic hot water thermostatic mixing valve is not functioning properly. It is designed to protect against scalding but is supplying hot water at a dangerously high temperature. The piping to the valve must be reconfigured and the valve tested to ensure it provides constant temperature output over normal flow ranges.
- The hot water recirculation pump is too small to maintain the temperature in the hot water distribution piping. Replace the pump with a properly sized pump.

- The fan belt is broken on Exhaust Fan EF-5 and must be replaced.
- The turn vanes in the HRV-2 supply duct are broken and should be repaired to ensure uniform airflow down the duct.
- The HRV-2 gravity exhaust air damper no longer operates and should be replaced with an automatic damper.
- The exhaust fan gravity dampers no longer operate and should be replaced with automatic dampers.
- The HRV condensate drain pans are rusting and will fail unless they are recoated with an epoxy-type paint.
- The HRV heating coils have frozen and broke in the past due to lack of low temperature safety controls. Install safety controls and implement control sequences that protect the heating coils during freezing weather.
- The HRV humidity sensors have failed which has defeated the HRV humidity control of the natatorium. Replace the humidity sensors.
- The belts on the HRV-2 supply fan are loose and should be replaced.

**Operational Improvements**

The following are recommended to improve the operation and monitoring of the systems.

- Accurate temperature thermometers and sensors are needed to monitor the operation of the mechanical systems. Install digital thermometers and DDC temperature sensors to allow monitoring of the heating system.
- Replace the hot water heaters which are nearing the end of their service life with stainless steel models that have a temperature controller with temperature setpoints.
- Install digital thermometers and sensors on each hot water heater so their operation can be monitored.
- Modify HRV-2 so it supplies higher temperature air to the natatorium room containing both pools and cooler air to the offices and public spaces.
- Rebalance the ventilations systems to provide sufficient positive pressure in the Lobby to create air flow from the lobby and public spaces to the natatorium.

**Energy Efficiency Measures (EEMs)**

The following EEMs are likely to be worthy investments in long-term energy savings. An energy and life cycle cost analysis is recommended to evaluate their economic potential.

- Boiler Lead/Standby Control: Program the DDC system to provide lead/standby control of the boilers.
- Replace the oversized and failing pumps P-1A and P-1B with smaller pumps installed on each boiler.
- Convert to variable speed pumping by replacing pumps P-3A, P-3B, P-4A, P-4B and P-5 with two variable speed pumps operating in a lead/standby arrangement and converting the piping system to a primary/secondary system.

- Replace the diverting valve in the pool circulation system with an injection pump that circulates pool water through the pool heat exchangers.
- Install a return air damper in HRV-2 (similar to the damper in HRV-1) so ventilation airflow can be modulated based on occupancy and humidity levels.
- Modify the control sequences for optimal control of the HRVs during occupied and unoccupied periods to maintain adequate indoor air quality, control humidity and minimize energy consumption.

### Retro-Commissioning

A retro-commissioning process is recommended to verify that the building systems are optimally operating to maintain adequate air quality, thermal comfort and energy efficiency.

## HEATING SYSTEM

### System Description

Heating Plant

Two electric boilers operate in a lead/standby arrangement to heat the building. Heating pumps P-1A and P-1B operate in a lead/standby arrangement to circulate heating water through the boilers and a primary heating loop in the mechanical room.

Secondary Heating Loops

The following secondary heating loops are supplied from the primary loop:

- Radiant Heating: Pump P-2A circulates heating water between the primary loop and two radiant heating manifolds. A 4-way mixing valve maintains the radiant loop temperature setpoint. Radiant heat is supplied to the offices, lobby and locker rooms.
- Heat Recovery Ventilator HRV-1 supplies heated air to the natatorium. Pump P-3A circulates heating water between the primary loop and the HRV-1 heating coil.
- Heat Recovery Ventilator HRV-2 supplies heated air to the natatorium, offices and public areas. Pump P-3B circulates heating water between the primary loop and the HRV-2 heating coil.
- Domestic Hot Water Heating: Pumps P-4A and P-4B supply heating water to two indirect hot water heaters. See Domestic Hot Water section for additional information.
- Pool Heating: Pump P-5 supplies heating water to heat exchangers HX-1 which serves the lap pool and HX-2 which serves the therapy pool. Heating water circulates through the hot side of each heat exchanger transferring heat to pool water circulating in the cold side of the heat exchanger. An automatic valve controls the heating water to each heat exchanger to maintain the pool setpoint.

**Assessment**

Boilers

The boilers have reportedly experienced numerous control and operational issues. Our investigation revealed the following:

- Boiler B-2 Temperature Controller: The temperature controller was recently replaced but was not properly programmed. The control is supposed to send a variable signal to the staging controller so it can stage the heating elements. Instead, the controller was sending a constant full capacity signal. This caused the boiler to unacceptably cycle from full output to off, numerous times per hour. The controller was reprogrammed and is now properly staging the heating elements.
- Boiler B-2 Low Water Alarm: The boiler displays a low water alarm even when the boiler is full of water. Troubleshooting revealed that the low water control board is likely faulty and should be replaced.
- Boiler Control Panel: A boiler control panel is installed to provide lead/lag operation of the boilers. The panel adds unnecessary complexity to the boiler operation and is contributing to control issues with the boilers. The boiler control panel was bypassed to simplify the controls. The preferred boiler control is:
    - Local Control: When the control switch on each boiler is in the Local position, the boiler is enabled and operated by its integral controller. The boilers are currently operating under Local control.
    - Remote Control: When the control switch on each boiler is in the Remote position, the DDC system enables the boilers in a lead/standby manner. This is the preferred operating condition because only one boiler will be enabled and the other will operate only if it fails or cannot meet the load. This will reduce the operating time of each boiler and reduce heat loss because only one boiler will be hot at any time.
- Boiler Staging Controls: The staging controller in each boiler is set with a short time delay between stages. This is causing the stages to cycle on and off repeatedly. The time delay was increased to 5 minutes to reduce the cycling of the stages.
- Boiler Wiring: The internal power and control wiring was damaged in numerous locations, terminal connections were loose, and fuses were blown. Many of these issues were repaired but lack of parts will necessitate a return visit to complete the repairs.
- Thermometers and Temperature Sensors: The thermometers in the heating supply and return piping to each boiler are improperly installed and are not accurate. Recommend replacing them with properly installed digital thermometers. The DDC system has temperature sensors in the combined heating supply and return piping form the boilers. Recommend installing sensors in each boiler supply and return piping so their operation can be readily monitored.

Pumps P-1A and P-1B

The pumps are oversized and consume more energy than necessary. In addition, they are sized for the operation of both boilers and are not capable of modulating the majority of the time when only one boiler is operating.

Pump P-1A is making noises that indicate a pending bearing failure.

The DDC control is switching the lead pump daily. This occurs without first disabling the boilers, causing them to shut down on a low flow alarm. Recommend switching lead pumps monthly and enabling the lag pump prior to disabling the lead pump.

Pumping energy will be reduced if the pumps are replaced with smaller pumps serving each boiler. This will require a reconfiguring of the primary piping loop in the boiler room.

Heating Pumps P-3A, P-3B, P-4A, P-4B and P-5

The pumps are nearing the end of their service life. Some are leaking which indicates that seals are failing.

The heating piping arrangement places the secondary loops in series. This is a poor arrangement because downstream loops are supplied lower temperature water.

Pumping energy will be saved by replacing the secondary pumps with two variable pumps operating in a lead/standby arrangement and reconfiguring the piping so each heating loop receives full temperature water.

Locker Rooms

The locker rooms are heated by radiant heating loops. The thermostats are located in the hallway outside of the room. Recommend relocating them to the other side of the wall so they are in the respective locker room.

The radiant heating supply and return thermometers are improperly installed and are not accurate. Recommend replacing them with properly installed digital thermometers.

Pool Heating

The pool circulation water is heated by diverting some of the pool recirculation flow through the pool heat exchangers. There is a diversion valve that creates flow through the heat exchanger but it was not properly set to ensure adequate flow (and heating) through the heat exchanger. The diverting valve was adjusted to increase heat exchanger flow which increased the pool heating capacity.

The pool heating thermometers are improperly installed and are not accurate. Recommend replacing them with properly installed digital thermometers. The heat exchanger outlet temperature is not being monitored by the DDC system. Temperature sensors are recommended so heat exchanger operation can be monitored.

The use of a diverting valve to create flow to the heat exchanger adds pressure drop and pumping energy. Less pumping energy will be required if an injection pump was added to the heat exchanger loop rather than throttling the main pool flow.

**Recommendations**

The following summarizes the recommended repairs and operational improvements that will improve the heating system. An energy and life cycle cost analysis can be provided to estimate the cost and determine if they are a worthy investment.

Repairs

- Boiler B-1 Temperature Controller: Upgrade the temperature controller to the same controller that is installed on Boiler B-2.
- Boiler B-2 Low Water Control Board: Replace the faulty low water control board.
- Boiler B-1 Wiring: Repair wiring and connectors.

Operational Improvements

- Install digital thermometers and DDC temperature sensors to allow monitoring of the heating system:
  - Heating supply and return piping to each boiler
  - Heating supply and return piping to each pool heat exchanger
  - Heating supply and return piping to the radiant heating system
  - Heating supply and return piping to each HRV

Energy Efficiency Measures (EEMs)

The following EEMs are recommended for additional energy and life cycle cost analysis:

- Boiler Lead/Standby Control: Program the DDC system to provide lead/standby control of the boilers.
- Replace Primary Pumps P-1A and P-1B: Replace Pumps P-1A and P-1B with smaller pumps installed on each boiler.
- Convert to Variable Speed Pumping: Replace pumps P-3A, P-3B, P-4A, P-4B and P-5 with two variable speed pumps operating in a lead/standby arrangement. Convert the piping system to a primary/secondary system. Replace 3-way control valves with 2-way valves to reduce pumping energy.
- Install injection pumps for the pool heating systems.

## HOT WATER SYSTEM

**System Description**

Two indirect hot water heaters are heated by the boilers and supply domestic hot water to the building. A thermostatic mixing valve provides scald protection and hot water recirculation pump maintains the temperature of the water in the distribution piping.

**Assessment**

The hot water heaters are nearing their expected service life of 15 years. The tanks have a temperature control that does not allow for setting a specific tank temperature. This is a poor control method for a hot water heater.

The automatic valves that control the heating water flow to the hot water heaters are faulty. This is causing overheating which is a safety and code violation. The automatic valves must be replaced.

Thermometers are not installed on each hot water heater to verify the temperature setpoint and monitor its operation. Thermometers are essential to ensure safe operation of the hot water system.

The thermostatic mixing valve is not maintaining a constant temperature hot water supply to the building. Recommend reconfiguring it in accordance with the manufacturer's recommendations and verifying its operation.

The hot water recirculation pump is undersized and is not keeping the water in the piping at distribution temperature. Recommend replacing it with a larger pump.

**Recommendations**

Repairs

- Replace the automatic valves on each hot water heater.
- Reconfigure the thermostatic mixing valve piping arrangement and test the valve for constant temperature output over normal flow ranges.
- Replace the hot water recirculation pump with a properly sized pump.

Operational Improvements

- Replace the hot water heaters with stainless steel models that have a temperature controller with temperature setpoints.
- Install digital thermometers on each hot water heater so their operation can be visually monitored.

## VENTILATION SYSTEMS

**System Description**

Two heat recovery ventilators (HRVs) provide air circulation and ventilation. HRV-1 supplies the north end of the natatorium and HRV-2 supplies the south end of the natatorium, offices and public spaces. Each HRV draws in outside air, preheats it with a heat exchanger that recovers heat from the exhaust air, adds additional heat and supplies it to the building. Return air is drawn back to the HRV from the lockers, toilet rooms and natatorium. HRV-1 recirculates the air to the building while HRV-2 fully exhausts the return air.

Exhaust fans are installed in equipment spaces to remove contaminants from pool equipment rooms and heat from the boiler room.

**Assessment**

Deficiencies

Exhaust fan EF-5 has experienced a belt failure.

The HRV-2 supply duct has broken turn vanes that are essential to creating smooth distribution air flow.

HRV-2 has a gravity exhaust air damper that was found to be inoperable. The damper was bolted open so the exhaust air path is open. Replacement with an automatic damper is recommended.

The exhaust fans have gravity backdraft dampers that are failing to open or are stuck open. Recommend replacing the dampers with automatic dampers that are powered open when the fan operates.

The drain pans in each HRV capture condensate from the chlorine-laden exhaust air. The drain pans are rusting. They should be refinished with epoxy-type paint.

The HRVs have experienced freezing of the heating coils that resulted in breakage. The systems do not have low temperature safety controls to protect the coils. In addition, the control sequences do not maintain heating flow in the coils during freezing weather to protect the coils from freezing. These measures are recommended.

HRV-1 has the ability to modulate outside air to maintain humidity levels. The humidity sensors are inaccurate and the control has failed. Humidity control is essential to a natatorium and repairs are recommended.

The belts are loose on the HRV-2 supply fan.

Operational Issues

The HRVs are not being operated during unoccupied periods. This can cause high humidity levels that can degrade the building assemblies. It also causes high chlorine levels that in addition to being unhealthy can degrade the structure and subject it to failure. It is critical that the HRVs operate continuously.

The airflow design does not create sufficient positive pressure in the Lobby to create air flow from the lobby to the natatorium. This is essential to contain the pool air within the natatorium. Recommend adjusting the airflows and rebalancing the systems to achieve the appropriate pressure relationships within the building.

Systemic Issues

The two HRVs supply about 23,000 cfm of outside air to the natatorium. The code requires about 5,000 cfm. This added ventilation air greatly increases energy costs. Optimally, the HRVs would supply code ventilation air during occupied periods and supply additional ventilation as needed to control humidity when large numbers of people are swimming. During unoccupied periods, the system would reduce air flow and ventilation air to maintain humidity and maintain indoor air quality. This strategy will be very effective at reducing energy costs because staff deploys pool covers to minimize evaporation when the pool is not in use. The following modifications are recommended to minimize ventilation air while ensuring indoor air quality:

- Replace motor starters with variable frequency drives so fan speeds can modulate.
- Install a return air damper in HRV-2 so it can recirculate air and reduce ventilation airflow to what is required by code or for dehumidification.
- Replace the humidity sensors.
- Modify the control sequences for optimal control of the HRVs to maintain adequate indoor air quality, control humidity and minimize energy consumption.

HRV-2 ventilates and heats the south end of the natatorium in addition to the offices and public spaces. These two areas are preferably maintained at different temperatures but the system does not provide this functionality. The system has a thermostat in the lobby that maintains the supply air temperature at about 72°F. This effectively cools the south end of the natatorium, which is the therapy end and should be equally warm. Recommend modifying HRV-2 so it can supply air to both areas at the optimal temperature.

**Recommendations**

Repairs

- Replace the belt on EF-5.
- Repair the HRV-2 supply duct turn vanes.
- Replace the HRV-2 gravity exhaust air damper with an automatic damper.
- Replace the exhaust fan gravity dampers with automatic dampers.
- Recoat the drain pans in each HRV.
- Install low temperature safety controls and implement control sequences that protect the heating coils during freezing weather.
- Replace the humidity sensors.
- Tighten the belts on the HRV-2 supply fan.

Operational Improvements

- Replace the motor starters with VFDs to minimize load impacts to the electrical system and allow for fan modulation.
- Modify HRV-2 so it supplies warm air to the natatorium and cooler air to offices and public spaces.
- Rebalance the ventilations systems to provide sufficient positive pressure in the Lobby to create air flow from the lobby and public spaces to the natatorium.

Energy Efficiency Measures

The following EEMs are recommended for additional energy and life cycle cost analysis:

- Install a return air damper in HRV-2 (similar to the damper in HRV-1) to reduce ventilation airflow and allow ventilation airflow modulation in response to humidity levels.
- Modify the control sequences for optimal control of the HRVs to maintain adequate indoor air quality, control humidity and minimize energy consumption.

## RETRO-COMMISSIONING

**Description**

Our assessment of the systems and their operation indicates that the building was not properly commissioned. Commissioning is regularly performed at the end of a construction project to verify the operation of the building systems. It is essential that a complex, energy intensive building like a natatorium is properly commissioned.

**Recommendations**

A retro-commissioning process is recommended to verify that the building systems are optimally operating to maintain adequate air quality, thermal comfort and energy efficiency. The following steps are recommended:

- Construct repairs, operational improvements and energy efficiency measures.
- Develop optimal control sequences for the building and design control modifications to achieve the control intent.
- Modify and upgrade the control system as needed.
- Perform functional performance tests to ensure the building is operating optimally. Include facilities staff during the testing so they are familiarized with system operation and the controls.
- Train operations staff on the equipment and building operation.
- Develop a systems manual that describes the HVAC system, their operation and identifies parameters to monitor to ensure proper operation and maximize efficiency.
- Develop a preventative maintenance manual for use by maintenance staff.

by: [signature]

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