Alaska Energy Engineering LLC
25200 Amalga Harbor
Juneau, Alaska 99801
Phone: 907-789-1226
jim@alaskaenergy.us

Technical Memorandum
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To: **Rusty Shivers, Project Manager**

Subject: **HVAC and DDC Controls Assessment Report - Draft**

Project: **Dimond Park Aquatic Center**

INTRODUCTION

The Dimond Park Aquatic Center (DPAC) has been in operation since 2012. The facility is experiencing significant issues with the ventilation and the direct digital control (DDC) systems. This report provides a condition assessment and recommendations for restoring proper operation.

Background

A natatorium is a challenging indoor environment. It is essential that the ventilation and control systems are in good working order to maintain a healthy indoor environment, protect the building from the corrosive, salt and chlorine-laden air and minimize energy consumption. The ventilation and control systems must operate dynamically to maintain pressure relationships, humidity levels, temperature setpoints, and indoor air quality in a dynamic indoor environment that is influenced by variations in use and outside temperatures.

Our investigation revealed that the ventilation and DDC control systems are not operating optimally and are experiencing numerous issues.

ASSESSMENT

Natatorium Air Handling Unit AHU-1

Description

The natatorium environment is controlled by AHU-1, which provides critical ventilation, dehumidification, pressure control and heating functions. Its major components are supply and return fans, an air-to-air heat exchanger that recovers heat from the exhaust air to preheat ventilation air, mixing dampers that modulate outdoor and return airflows, and a heating coil. A DDC control system operates the AHU components to ventilate the natatorium, maintain humidity at a desired level, keep the natatorium at a negative pressure to preclude the migration of corrosive air into the structure, and supply heat.

Air Leakage

AHU-1 experienced air leakage soon after it was initially commissioned. The leakage occurs between the supply and exhaust airstreams because the various compartments are at different pressures and are not adequately sealed which causes air and water to flow between the compartments. The leakage affects the humidity and pressure control that is essential in a natatorium system. The leakage also exposes hidden areas within the AHU to the corrosive airstream. Several attempts have been made to seal the seams between the compartments but leakage issues continue to plague the AHU.

The AHU materials are deteriorating due to the corrosive air streams. The following repairs have been enacted to extend the life of the system. These include:

- Sealing of compartment walls and seams
- Installation of drain pans and pumps to remove standing water
- Installation of coatings on the interior surfaces to reduce corrosion
- Replacement of failing fan and motor bearings
- Sealing of light fixtures and conduits inside the unit to preclude the drawing of water vapor into the conduits and accumulating water

Water is currently leaking from the unit onto the fan room floor. The leak is occurring under the unit and cannot be determined and repaired without dismantling the unit, a process that is likely to do more harm than good.

Heat Exchanger

The AHU has an air-to-air heat exchanger that transfers heat from the exhaust air to the outside air stream. The heat exchanger is an essential part of the energy performance of the system and is the interface between the humid air leaving the facility and outside air that provides dehumidification. The heat exchanger is experiencing the following issues:

- Ice formation on the exhaust air surfaces of the heat exchanger during cold weather
- Air and water leakage between the air streams

Construction

The long-standing issues with the AHU indicate that its construction is incapable of withstanding the differential pressure relationships between the cabinets and the corrosive properties of the natatorium airstream. Its failures have resulted in a disproportionate demand on resources to repair and maintain it. The corrosion issues that have been present from early in its life are an indication that the unit construction has not been sufficiently resistant to the corrosive natatorium environment. Yet, despite the many issues, there is no clear indication of the remaining life of the system. Natatorium air is highly corrosive and persistent leakage makes it highly likely that enclosed surfaces and components of the AHU are corroding.

Failure Risk

The largest failure risk is that internal corrosion leads to a structural failure that renders the AHU inoperable. This would result in a shutdown of the building and draining of the pools to minimize humidity and corrosive air. The resulting disruption could vary from a quick repair to restore operation until a permanent fix can be procured to a long unplanned shutdown to replace the AHU. Either way, considerable resources will be expended to drain the pools, keep the natatorium heated and manage humidity levels.

Natatorium air handlers have an expected service life of 20-years. Given the AHUs deteriorating condition and corrosion history, it is likely that its service life will be shorter. The AHU is 10-years old and likely has 5-years of remaining life. It is recommended that a planned replacement within 5-years occur to mitigate the risk of AHU failure.

Locker/Common Air Handling Unit AHU-2

Description

AHU-2 supplies ventilation air to the locker rooms and common areas. Its major components are supply and return fans, an air-to-air heat exchanger that recovers heat from exhaust air to preheat ventilation air, and a heating coil. The components are controlled by the DDC control system to provide ventilation to the spaces.

Assessment

The AHU is in good condition. It has an estimated 25-year service life and appears to be capable of operating another 15 years. The only reported issue is that moisture in the outside airstream, which travels a relatively long and circuitous path, occasionally wets the filters.

A systemic issue with the system is that it supplies the same temperature air to both the common areas and the locker rooms. The supply air temperature is controlled to keep the common areas from overheating, which causes the locker rooms to be underheated. This issue can be resolved by adding a heating coil to the locker supply air duct so the lockers can be controlled to a higher temperature.

DDC Control System

Description

The DPAC mechanical systems are controlled by a Siemens direct digital control (DDC) system. The system provides control and monitoring and alarm functions and has been in operation since 2012.

Assessment

The DDC system was commissioned and fully operational when it was installed. The programming has been altered over time to improve operation and to accommodate equipment changes. In 2019, a power event damaged some of the control equipment, causing a loss of programming. The effort to restore the system included controller replacements and restoring the programming from a backup. This work resulted in a loss of essential control functions.

Issues that were observed include:

- Inconsistency between actual and expected values
- Operators having trouble navigating and making changes to the graphic screens
- Loss of AHU-1 return fan control
- Loss of communication with the ground source and water source heat pumps
- Loss of radiant floor control
- Slow response to setpoint changes
- Airflow monitoring stations that are not reporting or are inaccurate
- Natatorium pressure control is not working

The lack of optimal control function is a serious issue that renders the natatorium system incapable of the dynamic response that is essential to control indoor air quality, maintain natatorium pressure and humidity and operate the facility at peak energy efficiency. It is essential that full control be restored.

Bret Burnett of Inside Passage Integrated Control Systems performed an assessment of the DDC system and observed the following:

- Inconsistent data values persist in the DDC system.
- The graphic screens are not properly displaying the data.
- The reason for the loss of return fan control remains unknown.
- The reason for the loss of radiant floor control remains unknown.
- The reason for the slow response to setpoint changes remains unknown.
- A defrost cycle would be useful to preclude frosting of the heat recovery cell.

John Roscovius of Siemens, was hired to investigate why the DDC system is failing to perform properly. He determined the following:

- The stand-alone control modules are functioning properly and are not experiencing failures. System tests were performed to observe control system responses and no issues were observed.
- Control devices are working but there is some concern that pressure and flow transducers are not calibrated.
- There is a polling issue with interfaced equipment which is causing data from the heat pumps (BACnet points) to be dropped/missed and the displayed values are not very useful to an operator trying to investigate the heat pumps.
- The host or main operator interface is basically a read only device and cannot be used to troubleshoot beyond looking at values.

These finding are encouraging because they indicate that the DDC control system can be restored to full functionality. The following steps are recommended to restore DDC control function:

- Perform a point-to-point checkout of the sensors, transducers and control devices such as actuators for dampers and valves.
- Calibrate all devices
- Troubleshoot the communications with the systems that are integrated via BACnet protocols.

CBJ maintenance has recently reinstalled Siemens Insight, a DDC front-end software with a more user-friendly interface to the DDC system. This will make it easier for CBJ staff to interface with the DDC system.

The Siemens system uses code programming that is proprietary and is not as user-friendly as other manufacturer's products. This has hindered CBJ staff in troubleshooting and correcting control issues. The control system would benefit from a more user-friendly front end that uses block programming technics that are familiar to CBJ staff.

RECOMMENDATIONS

HVAC Systems

Initial Repairs

The following are recommended to improve the performance of the existing HVAC systems.

- Natatorium AHU-1: The return air damper blades should be repaired so the damper operates properly.
- Lockers/Public Spaces AHU-2: Install heating coils in the supply air ducts to the locker rooms to improve thermal comfort.

AHU-1 Replacement

A budget and schedule should be developed for initiating a planned replacement of AHU-1. Replacing the AHU in its current location will be a complex project which will require demolishing the fan room walls and potentially the roof to replace the AHU. The contractor will require road access to the end of the building that is furthest from roads and parking areas to bring in equipment and materials to construct the work. The project costs should include construction access.

The schedule should seek to minimize the disruption that will occur during AHU replacement. Our preliminary estimate is 4-6 months of downtime.

The cost estimate will first require a conceptual design of the new AHU so that its size and installation requirements can be determined since they directly affect the extent of demolition and access that will be required. A conceptual design will also afford an opportunity to configure the system to correct several issues with the existing AHU including:

- Protecting the heat exchanger from frost formation
- Minimizing pressure differences between cabinets to preclude leakage
- Using materials that are resistant to chlorine corrosion
- Decoupling and simplifying ventilation, humidity, and pressure controls
- Increasing energy efficiency
- Shipping the unit in sections that ease installation and minimize risk of leakage

The conceptual design will allow for development of a comprehensive cost estimate for removing and replacing the AHU.

DDC System Repairs

Phase I

It is imperative that proper control be reestablished in a timely manner to protect occupant health and the building. This will require a Siemens control technician to perform point-to-point and calibration tests. Concurrent with the repairs should be modifications to the sequence of control to improve performance and enact solutions for devices that are not functioning well, such as airflow monitoring stations. The updated sequence would include:

- Natatorium pressure control sequence that does not rely on the air flow monitoring stations
- Stabilizing the humidity control
- Implementing a heat recovery core defrost cycle that precludes frosting of the heat exchanger

The DDC system also lacks a modern web-based interface with block programming for remote control and monitoring of the systems. A cost estimate for converting from code language to block programming should be obtained to weigh the cost/benefit of switching to block programming.

Upon completion of the repairs and establishing proper control, the operation should be verified through a commissioning process.

Phase II

The DDC control system will likely be 15 years old when AHU-1 is replaced. By then, the DDC system will have only a 25% of its remaining expected service life. Replacing the DDC system at the same time will lead to a more successful result than adding new AHU-1 controls to an aging DDC system.

It is recommended that the DDC system be upgraded when the AHU is replaced. This work can be performed while the natatorium is shut down so that it does not disrupt facility use. A cost estimate for DDC system replacement should be developed along with the AHU-1 replacement estimate.

by: ______________________

Jim Rehfeldt, P.E.