2016 ACEC Awards of Excellence in Consulting Engineering

Whale Cove Arena - Sustainable Ice Plant Design & Implementation

Government of Nunavut

Accutech Engineering Inc.

Whale Cove, Nunavut

Project Attribute Description for:

Whale Cove Arena Ice System

Whale Cove, Nunavut

Project by: Accutech Engineering Inc.

Client: Government of Nunavut

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General Project Description

Accutech Engineering was retained by the Government of Nunavut for the provision of Project management and complete engineering design to implement a proprietary design for an “energy-free” refrigeration system in Whale Cove, Nunavut. Whale Cove is a Hamlet of approximately 400 people located approximately 1,400 km north of Winnipeg in Canada’s high arctic. The community required additional activities for their youth, and a zero impact on their operating budget.

The project involves the renovation of an existing arena. Accutech has developed a proprietary design to provide “zero-energy” refrigeration systems to arenas within Nunavut. The Whale Cove Arena Project is beautiful in its elegant simplicity, and the not-so-obvious solution implemented in an extreme location. The success of the project is a function of the sum of its parts, and not each individual part. Each of the main components has been considered and designed with the end-user constantly in mind. The three main components are:

1. Concrete floor for the Arena – provides year round use of the space, thermal storage for the refrigeration system, and prevents rink-flood water from seeping into the permafrost and potentially thawing the permafrost or damaging the building foundation through ice formation around the footings.
2. Thermosyphons – provide energy free refrigeration for the ice surface. These are passive devices that transfer heat from beneath the arena floor to the cooler ambient conditions. Thermosyphons are maintenance free and have no moving parts.
3. Ventilation system – the ventilation system installed provides dehumidification, cooling and general building ventilation. The control system is multi-faceted to facilitate all aspects of the design, yet provides a simple user interface.

All components are conscious of the extreme energy cost in Whale Cove, unique construction constraints and are virtually maintenance free.

This is a proven design that will extend the operating season by approximately four months for virtually zero operating cost increase.

Cultural Background

Nunavut, Canada’s newest territory, was established in 1999. The Hamlet of Whale Cove is a principally Inuit community, with 96% of the population being Inuit. The Inuit culture and traditions place heavy emphasis on being together as a community in all aspects.

Sports have a long-standing place within the Inuit culture. The Inuit have many traditional sporting events. There is strong competition between the communities for regional/territorial events and strong collaboration between communities for events outside of Nunavut.

Within the Inuit culture, it is traditional to host community feasts. Traditionally, a community feast in Whale Cove would consist of locally available “country foods” such as seal, walrus, caribou, and berries. In recent

years, these feasts were hosted in the gymnasium of the school; the only single room large enough to accommodate the entire community. In the warmer weather, the feast may be outdoors. It is difficult to find suitable outdoor venues in Whale Cove due to a lack of seating, variability of weather, mosquito population, and dust created by vehicles.

Hockey in Whale Cove

In recent years, hockey is of primary importance to all 26 communities in Nunavut. Hockey has tremendous popularity within the community and across the Territory and is continuing to gain momentum with the success of local players like Jordan Tootoo and territorial programs such as the Nunavut Stars hockey camp. Currently Whale Cove boasts several youth, men's, and women's hockey teams. The enthusiasm of hockey in Whale Cove is highlighted by *Hockey: Home and Really Far Away*, a Sportsnet™ feature about a Whale Cove youth hockey team crowd sourcing expenses and travelling 7,200 kilometers round trip to participate in a hockey tournament in Geraldton, Ontario.

Due to a smaller base population and reduced available ice time, hockey players in Whale Cove are at a competitive disadvantage when compared to the larger communities in Nunavut that have artificial ice plants. An extended hockey season would be particularly beneficial to youth in the community as they have the opportunity to represent Nunavut in various regional, territorial, and international hockey tournaments such as the Arctic Winter Games.

Community Gathering

Community Feasts are a traditional way of life for the Inuit. The community feasts are gatherings, typically held two or three times per year.

In modern times, the community feasts have been held in the school's gymnasium. The gym was the largest single space within the community. As the population within the communities grow, the gymnasium is quickly becoming too small.

Community gatherings and feasts are difficult to hold outdoors. Winter is harsh and the summer is dusty, windy with extremely large and aggressive mosquito and black-fly populations. The ideal location for these events is inside an enclosed building with adequate space, seating and lighting.

The existing gravel floor in the arena and the lack of proper ventilation did not provide a suitable venue for hosting summer events.

Energy Resources

All electricity in Whale Cove, and Nunavut, is generated through diesel generator sets. An entire year's supply of diesel fuel is shipped to the Hamlet in the fall on an annual re-supply barge. The fuel is stored within each community at a central tank farm. Fuel is trucked to each building on a regular basis.

The operation and maintenance of the electricity distribution and generation system is the responsibility of Qulliq Energy Corporation, a corporation of the Government of Nunavut. As of May 2014, the electricity rate

in Whale Cove for Government owned commercial building is 122.71 cents/kW-hr. As a comparison, in Winnipeg, the same unit of energy will cost approximately 5.5 cents/kW-hr.

The energy cost is Whale Cove is approximately 22 times more expensive than in Winnipeg.

The current power generating, fuel storage, and other required infrastructure could not facilitate the high energy use traditional ice plant. Frankly, it doesn't make sense to install a traditional ice plant in the high arctic.

Undertaking a traditional artificial ice plant in Whale Cove is not sustainable design and not affordable to build or operate. To provide the programs for the community, Accutech had to come up with alternate solutions. Working in the high arctic requires creative and "out-of-the-box" thinking. Solutions must consider all requirements.

Water Resources

With the high energy costs, the cost to produce clean water is also high. Hamlets will have a central water treatment plant; the treated water is stored in tanks and all water is trucked to the individual buildings; there is no central water distribution system. The design must conserve water.

Project Requirements

The Government of Nunavut specifically requested a design for a low operating cost refrigeration system for the hockey rink. The citizens of Whale Cove needed a longer hockey season and more activities for their youth. The community needed a viable long-term solution. The project needed to meet the following User Requirements:

Renovation of the Existing Building and Improving Operations

- The existing building is a pre-engineered steel building, with a heated office, dressing rooms and mechanical room, dasher boards around the ice, and a porous gravel floor for the ice surface.
- In the late fall, when ambient freezing temperatures are continually present, the rink operator would flood the arena with water. The gravel rink floor was porous and the water would leak through the gravel.
- Typically, the ice surface would be playable starting in late December or early January. The ice would become unusable in approximately April due to frost build-up at the underside of the roof.

Refrigeration Requirements

- Extend the hockey season at each end. Ideally, the hockey season would start in October or November and end in April or May. Extending the season will provide additional activities for all ages
- The design or establishment of an ice surface could not impact the foundation of the building or cause any damage to the fragile permafrost during construction or during operation.
- The system had to be designed for the anticipated climate change.

- The design had to minimize water consumption. A thicker water layer also requires longer times to freeze and more refrigeration.

Dehumidification Requirements

- While extending the hockey season and maintaining ice is a good thing, warmer spring temperatures and constant use of the rink through the winter can result in excess moisture build-up within the space. In Nunavut, it was reported that snow and ice were typically found at the underside of the roof structure during the late winter and early spring months. The potential for large snow pieces to fall and hurt a player would often cause an early end to hockey season.
- The design had to consider eliminating the moisture; and the ice and snow build-up within the space.

Specific Operational Requirements

- Low operating costs, and very low energy consumption is a requirement. Without this, the arena would be shut down due to insufficient operating budget.
- Very low maintenance requirements. Using a traditional artificial ice plant requires highly specialized maintenance and technical skills. It is not economically feasible to employee a full-time artificial ice plant operator in a small Hamlet like Whale Cove thus requiring flying a service person to the community from Winnipeg. The estimated costs for a simple service call start at minimum $5,000.
- High degree of reliability. Breakdowns within the system will shut down the arena. Any systems used had to be reliable and simple to maintain.
- Maintenance Training was needed for several employees of the hamlet who worked at the Arena. The arena workers may or may not have any technical training to draw on. The systems had to be simple, reliable and repeatable.

Multi-use Requirements

- To provide added value to the community, the project was to consider ways to use the space throughout the year. This included summer recreation, youth programs and community gatherings. Skateboarding, indoor soccer, roller blading, lacrosse and other activities are becoming popular in the community. Having the year-round use of the building will provide significant social benefits.

Accutech Solution

The solution implemented by Accutech met and exceeded all of the Owner's specified criteria. The overall key to the project was that it was simple, extremely low operating costs, and easy to maintain.

The design features included:

Ice Making and Refrigeration

- A passive refrigeration system was implemented. This design used thermosyphons to transfer the cold from outside to below the ice surface floor. The thermosyphons replaced the traditional brine system for cooling the ice surface.
- The thermosyphons have no moving parts and consume zero energy.
- A thermosyphon is a passive heat transfer device. Refrigerant is transferred between the evaporator and the condenser through the differences in density between the liquid and the vapour.
- Having no moving parts means that there is no maintenance required.
- The thermosyphons were installed with satellite communication for monitoring performance. Throughout the initial freeze-back of the sub-base, the temperature profile of each thermosyphon is being monitored on a regular basis.
- The data collection and monitoring system was solar powered; again zero energy consumption.
- The gravel floor presented many challenges to making ice and using the facility throughout the year. In the past, the ice-maker would flood the rink and the water would soak through the gravel. The high water consumption was not only expensive but potentially damaging the permafrost and the building foundations below.

Accutech implemented a concrete floor on top of the excavated gravel. By preventing seepage, the concrete floor reduces overall water consumption for the arena and maintains the integrity of the permafrost. This helps the ice-makers build-up the hockey ice faster, reducing operating costs and material usage.

Dehumidification

- Accutech implemented a simple dehumidification system to replace the humid air within the building with the drier outdoor air. The design used direct drive fans and high-performance dampers to seal out the cold during the extreme weather.
- To increase reliability of the system, the design provided 100% redundancy by providing two fully operational ventilation systems.
- The direct drive fans required minimal maintenance and would not be subject to belt/drive losses. Having no drive belts also reduced maintenance requirements.
- The system was arranged similar to a displacement style. The humid air that typically collects at the top of the structure was exhausted while the drier air from outside was brought in at the floor level.
- The ventilation system was controlled by a simple programmable controller with manual override switches on the exterior of a locked cabinet. This controller monitored indoor temperature, outdoor temperature, indoor humidity, and outdoor humidity to provide real-time adjustments to the indoor

humidity level. Upon sensing high carbon monoxide levels, the ventilation systems and controls would alarm and energize to prevent an unsafe build-up of exhaust gases from the Zamboni.

- The dehumidification/ventilation system was used to supplement the thermosyphons during the initial ice-making period at the beginning of the season and during the cooler nights near the end of the season. This helped to extend the hockey season.
- All components used were heavy industrial design, well suited for use in remote locations and subject to extreme environments.

Training

Accutech Engineering completed a "one-page" maintenance task list for the facility. Training was provided to all staff within the Arena. The maintenance tasks can be completed by staff with minimal mechanical background or training. In addition, a full colour poster board showing all maintenance tasks was provided along with the training.

Year-Round Use Facility

Having the concrete floor and the ventilation system allowed the community to use the hockey rink to host many community events including skateboarding and soccer in the summer and community feasts in the spring, summer and fall. The social benefits to be realized will be significant.

Nunavut Design Specific Requirements

The project design and construction had to consider many of the features of the climate, maintaining the integrity of the permafrost foundation, shipping season and hockey season.

The design of the granular sub-base, thermosyphon evaporator layer, insulation and excavation had to consider the depth of permafrost and not damaging it during construction yet allowing the contractor to excavate the required amount of fill. The construction and operation of the arena did not and will not degrade the permafrost or the Arena foundation.

The construction scheduling had to consider placing the concrete and charging the thermosyphons. Once the thermosyphons are charged, they start operating immediately. The thermosyphons were installed and the floor assembly was built up. After the concrete had adequate time to cure, the thermosyphons were charged and immediately started to chill the concrete floor.

Accutech was on site at key times during the excavation of the floor, placing of the thermosyphons, and compaction. Accutech was on site full time during the pouring of the concrete floor to provide a quality oversight.

Construction Requirements

The construction materials arrive by barge on the annual re-supply. The project was tendered in the spring of 2014 with construction due to start in the fall 2014, just before hockey season. The contractor successfully completed the tasks competently in November 2015 and without delay or problems.

Hockey season started on time in late fall 2014. After Accutech's final inspection and certification of the system, the building was turned over to an enthusiastic community. Even with the construction taking place, the community was playing hockey one month earlier than normal.

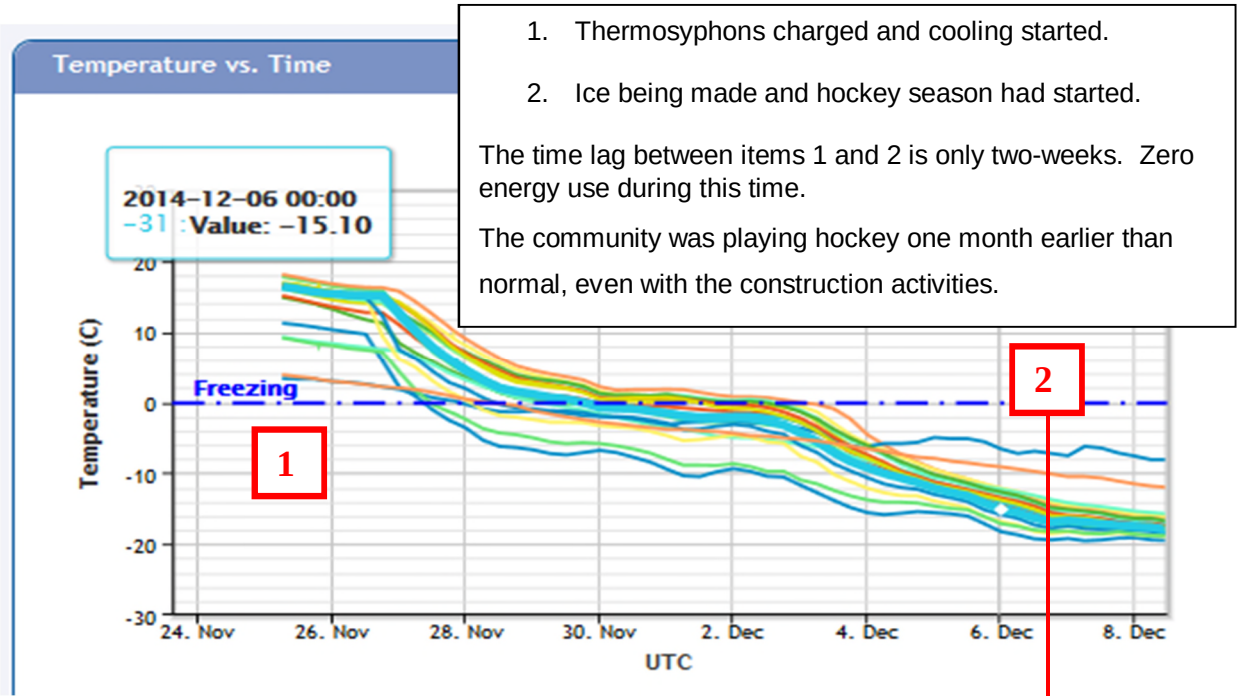
Meeting Long-Term Sustainable Design

The Whale Cove Arena retrofit met and exceeded all of the client's requirements.

Performance

The system performance is being monitored through the first year of operation. The temperature profile of the ice surface is shown below.

The thermosyphons were charged on November 25, 2014, and the ice was ready for flooding two weeks later. The hockey season had started. Based upon Environment Canada climate data for Whale Cove, it is estimated that the refrigeration system will allow for the hockey season to be extended until the end of May 2015 or potentially early June 2015. In the future, it is predicted that the hockey season in Whale Cove could commence as early as the month of October and continue through to the end of May, resulting in approximately eight months of skating.



1. Thermosyphons charged and cooling started.
2. Ice being made and hockey season had started.

The time lag between items 1 and 2 is only two-weeks. Zero energy use during this time.

The community was playing hockey one month earlier than normal, even with the construction activities.

As of February, the trending showed good ice surface temperatures for the hockey rink.

For information, a traditional ice rink will operate at an ice temperature of approximately -7°C; as of February 2015 the rink is operating at approximately -15°C.

Power Consumption

The only power consumption for the facility is the lighting and two 3-HP ventilation fans that operate a fraction of the time. As a comparison, Accutech reviewed the anticipated operating cost of the Whale Cove Arena with a traditional ice plant versus the Accutech Design.

Based on our estimated power consumption for a hockey rink in Whale Cove, it would cost in excess of $300,000 annually to provide ice. This cost is prohibitive; as are modifications to the infrastructure to support such a power demand.

The requirement for low power consumption was met. By meeting this requirement, there were no requirements to upgrade the power generating facilities or the fuel storage facilities within the community.

Environmentally Friendly

By minimizing the power consumption, the production of greenhouse gases has been minimized through burning fuel oil in the generators. Accutech Engineering has estimated that power for a traditional ice plant in Whale Cove would have produced approximately 330-Metric Tonnes of greenhouse gases per season of operation. Over a 20-year operating life, that translates into 6,600-Metric Tonnes of greenhouse gases that were avoided over the life of the building.

The design as implemented is estimated to produce less than 0.5% of that noted for the traditional ice plant. The Owner's performance requirements have been met with a minuscule carbon footprint. Due to the small electrical load, there were no requirements to upgrade the fuel oil storage tanks, or power generation capacity in the Hamlet.

Meeting Long-Term Sustainable Design, Maintenance Costs

The design of the system has minimal moving parts. Thus maintenance of the system is virtually eliminated.

The only components requiring maintenance are:

- Two direct drive propeller fans. The fans used are heavy-duty industrial designs that should last in excess of 20-years in a harsh environment. Minimal maintenance is required.
- Fresh air damper and damper motors. High performance dampers and damper motors were provided. The dampers are located at ground level for easy access and service work. These components are visible to the operators and easily adjusted and maintained. It is estimated that maintenance will be required once at the beginning of the hockey season and again at the end of the season. Maintenance can be completed with minimal training.
- Spare parts were provided as part of the contract.
- All sensors and control devices were adequately protected from stray pucks.

Accutech provided training to all Arena staff. A single full-colour poster board was provided that illustrates all maintenance activities required.

The requirement for low maintenance systems was met.

Conclusion

The Arena retro-fit project met and exceeded the Owner's requirements. Although the list of project requirements was extensive, the design and engineering services provided by Accutech was instrumental in the success of the project.

Extended hockey season - Ice was ready within two weeks of charging system. Hockey season is expected to be extended by four months in total. Even with construction activities, the hockey season started approximately one month earlier than normal.

No foundation damage due to degradation of permafrost or build-up of ice - Monitoring shows permafrost is strong and established. Construction activities did not damage permafrost. No damage was done to the existing building foundation.

Dehumidification - The building has not gone through a spring and removal of the hockey ice. Similar designs have proven highly effective and meeting the Owner's requirements.

Low Operating Cost - The only two motors in the design are 3-HP each. The traditional ice plant would have in excess of 100-HP for a similar size rink. Water Consumption was minimized by using the concrete floor.

Low Maintenance Requirements AND Easily Maintained - The only maintenance requirements are to review the damper motors every few months and the exhaust fans annually. This work can be completed by people with minimal training. The refrigeration system is maintenance free. All components are heavy industrial design and vandal resistant. Spare parts were provided as part of the project. The systems can be maintained by people with minimal background in mechanical maintenance. Training was provided to all Arena staff by Accutech Engineering. A "one-page" maintenance task list was provided to the operations staff. The system operation can be monitored remotely

Multi-use Requirement - The concrete floor and ventilation system provide the perfect venue for community feasts and gatherings during the spring, summer and fall. Skateboarding, roller blading, soccer and lacrosse are all possible when the ice is taken out. Having the additional recreation space and youth programs will have a significant positive impact on the community over the life of the facility.

Accutech Engineering delivered a simple, elegant, sustainable solution that helps the people of Whale Cove for virtually zero operating cost increase.