Healthy Lake Aeration System

The Healthy Lake Aeration System (HLAS) has been developed as a hybrid system designed to deal with the specific adversities created in shallow, eutrophic prairie lakes, with heavy recreational traffic in the summer and prolonged winters with inconsistent power supply.

The HLAS has been developed and installed entirely by volunteers for improvement of local watersheds and recreation fisheries. Any information in this document should be considered open source.

Compressor/Power Building

- The area where the power is supplied and the compressors and VFDs are housed is critical for the life and maintenance of the system.
- HLAS use a minimum of a 12’x12’ insulated lined shed.
- The HLAS utilizes galvanized air hoods with 20”x20” filters to supply dry filtered air to the compressors; this extends the life of the internal filters and provides fresh air for cooling.

- Cooling is extremely important; the waste product of compressing air is heat. We have found for our 170cfm 20hp compressors a minimum of 1000cfm of fresh air flow is required. We use 1350cfm powered roof vents with temperature sensors to achieve this.
- The sheds are insulated to provide sound protection to neighbours and keep the space warm in the event of a power failure in the winter months. A 1500-watt electric heater is installed as a back up to prevent a hard freeze if the compressor should shut down for an extended period in the winter.

- The sheds are lined with plywood to allow for easy mounting of equipment.
- Early on we used a small booth to house the compressors. This caused heat and humidity problems and premature equipment failures.

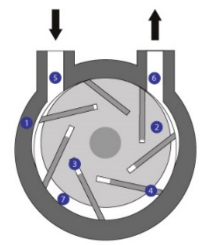
Power/VFDs

- HLAS uses Hitachi inverting variable frequency drives (VFDs)
- The VFDs allow for the use of single-phase power and inverts it into more efficient and flexible three-phase power.
- Single-phase power is readily available and significantly cheaper to install than three-phase power.
- The VFDs allow us to increase and decrease the speed and air volume of the compressor. This allows the system to be better adjusted to changing lake conditions.
- Generally, a 10% decrease in the frequency of the VFD output results in a 27% savings in power consumption. For this reason, HLAS will generally oversize the compressor by 10%-25%, then

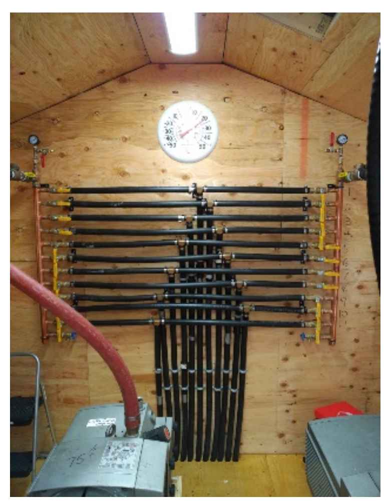
run the system at a lower frequency. This saves power and extends the service life of the compressor.

- The manufacturers do not recommend running the motors at more than a 20% power reduction or 48htz.
- The VFDs also allow for a slow or soft start which prevents sudden large power draws on the grid and sudden pressure surges in distribution system. We usually use a 60 second ramp up to the target frequency.
- The VFDs will also initiate an automatic restart in the event of a power failure.

Compressors



- HLAS utilizes Becker or equivalent rotary vane compressors.
- These compressors have a sealed three-phase totally enclosed electric motor. We have had the motors run with over 20 years on them.
- The rotary vane compressor uses carbon fiber vanes in an offset housing to generate air flow.
- Because the carbon fiber vanes are the only part in the air flow that is wearing the only waste product is a black carbon dust which is captured in the exhaust filter. This means there is no possible contamination with oil or other products into the water column.
- The vanes last between 12 and 18 months and the compressors need lubrication and service every 1-2months.
- These are high-volume low-pressure compressors with a max pressure of 26psi. If the system is run above 20psi vane life is significantly reduced. Therefore, it would unrealistic to use this type of compressor in depths greater than 40’. HLAS are currently running at depths between 8’ and 21’.
- HLAS has a minimum of two compressors in every system. This provides redundancy if one compressor should fail and allows for the system to be overdriven in the event of poor lake conditions.
- The compressors are usually of different sizes to provide more flexibility in air volume supplied to the system. i.e. if a 98cfm 10 hp compressor is paired with a 173cfm 20hp compressor the range of air flow in the system could range form 78cfm to 271cfm.



Air Distribution

- HLAS moves the air from the compressors though a double manifold system.
- The double manifold allows for maximum flexibility in choosing and balancing the system.
- Each compressor supplies one of the manifolds and valves allow for line supply choice.
- HLAS installed to date have ranged in size from 8 to 12 main supply lines; each main line is a 1” schedule 11 pipe HDPE (high density

polyethylene) geothermal pipe with a 5500psi break strength and is thermally stable to 220c. Average cost $0.65 per foot.

- The main supply lines are line bored from the shed to middle of the distribution field.
- Line boring under the lake protects the air supply from damage by ice movement, recreational boaters and prevents line freeze up in the winter.
- Line freeze can occur if the power shuts down and water comes back up the lines to the frost level or if the line is cooled to freezing point and moisture in the line freezes out. HLAS avoids this by dropping the lines below the frost level as quickly as possible and bundling the lines together so the hot air coming from the compressor keeps the ground around it warm. A 10hp compressor can produce as much as 10,000 btu of heating in the lines. We found when using smaller diameter pipe like 1/2", cooling could occur too quickly, and lines would freeze.
- Once the 1" pipe is protruding from the bottom of the lake we switch to ¾" HDPE pipe and bubbler heads are installed every 50' to 100' feet. The farther apart the better.
- 3/4" pipe is used because a 10mm length of steel rebar will sink it; 1" remains buoyant.
- 10mm rebar runs approximately $0.30 per foot
- The aeration field is typically laid out in a fan shape to maximize separation between the individual heads.
- The number of heads on a line is kept between 6 and 8; anymore and there is insufficient air flow in the line to balance properly. Less than 6 is inefficient and drives installation costs up unnecessarily.

Bubbler Head Design

- HLAS uses a micro bubbler system manufactured with Swan colorite tubing. The white paper on this tubing shows that air flow of .4 cfm per lineal foot of tubing is the most efficient for oxygen transfer and water movement.
- The Swan product assumes that the average course bubble is 2 cm diameter and a micro bubble from their product would be 0.3 cm diameter. This would mean with the micro bubbles, for the 4.19 cm^3 of 2 cm course bubble we would get 300 micro bubbles with a total surface area of 83.8 cm^2 or 6.6 times the total surface area of the course bubble of the same volume.

- http://www.coloriteaerationtubing.com
- The HLAS bubbler head is not necessarily more efficient than other micro-bubbler systems, but rather is designed to be tough and inexpensive. The average cost per head was around $35.00 and it can be bent, hit, crushed and will keep working. Early in the project we purchased 20 commercially manufactured micro-bubbler heads at a cost of $250.00 each; these heads worked fine however one was damaged during installation and another was destroyed by an anchor strike.

- The HLAS bubbler head is a 6' figure eight design that stands between 6"-8" off the bottom. The holes in the figure eight increase water flow though the head and thus create more water movement for the same volume of air supplied. Each head is designed and tuned to use 2.4 cfm of air. A ball valve installed on the base allows a diver to tune the air flow to the heads.
- Our assumption is a course bubbler system would transfer about 10% of the oxygen in the bubble whereas the micro bubble would transfer about 30% based on colorite white papers. As well, we assume we will move 6 times the volume of water for the same air flow based on the higher surface area of the bubbles interacting with the water.

Installation

- The HLAS is installed by creating the assembly on shore and towing it out to a waiting pontoon boat set up to finish the assembly, attach the weights (10mm rebar) using cable ties, and sink the line with the heads to the bottom. A diver will follow later to check the installation and tune the heads.
- The assembly is typically 8 sections of 100' ¾ HDPE pipe joined with ¾" to 1/2" tees. A bubbler head will be placed on the tee on the assembly boat along with the rebar.
- Once the 3/4" line is in place it is joined to the 1" pipe and air is pushed through the line to clear any debris and keep the pipe floating.

- A boat will go to the end of the line and hold it in position allowing the assembly boat to work its way along the pipe.
- On busy lakes it is critical to have chase boats available to prevent boat traffic from hitting the floating assembly pipe.

- Once the line is on the bottom we push aproxemtly 19.2 cfm though the line (8 x 2.4 cfm per head). a diver will then start at the first head on the line and tune the line so all heads are receiving equial air. The diver will also make sure the pipe and heads are properly positiond on the bottom.

Operation

- Operation of the HLAS can be separated into summer and winter modes.
- Winter mode is about maintaining good oxygen levels and helping off-gas any toxic gases like ammonia and hydrogen sulfide.
- In a normal year the system would be set to run at about 75% of its full capacity and dissolved oxygen testing would guide us from there. Most of our systems can be overdriven to 150% of their design flow.
- In years of low water or poor water quality the system would be set to 100% at freeze up.
- Summer operation is for destratification and oxygenation of the anaerobic mud layer at the bottom of the lake. As well, during cyanobacteria blooms the mixing of the cyanobacteria into the water column helps prevent the clumping at the surface.
- Typical summer operation would be at 50% of design flow and in the event of a bloom it would be turned up above 100%.

Overview

- Any aeration system must pump air; this comes at a cost. The HLAS is designed to produce the most air at the lowest cost possible per cfm and create the maximum effect possible per cfm of air supplied. One way to express this is by looking at the amount of open water in relationship to the amount of air supplied.
- At the Marina Terrace system, the average power consumption was $700/ winter month in 2017 and we were pumping 150 cfm. Or $4.66 per cfm per month.
- The Marina Terrace system operates in 11’-15’ of water with a winter average of 1.5 cfm per head. The picture #11 was taken February 4, 2017 with an air temperature of -20 Celsius. Each head is producing a circle of open water approximately 50’ in diameter or approximately 2000 sq feet. Or 1333 per cfm.

- This means it costs $3.49 per month to create 1000 square feet of open water or $0.12 per day.

Picture 11

- The deeper the water the larger the open water; the Killarney system operates in 20’ of water and has an average circle of open water approximately 75’ in diameter at 2 cfm per head.
- Environmental pressures change this daily; picture #12 was taken on March 3, 2016. The size of the open water is approximately 2600’ by 1100’ or 2,860,000 sq. ft. or 65 acres. This would be $0.27 per month for a 1000 sq feet of open water. Or 1 cent per day.
- The other cost to factor in is maintenance; currently we are showing this to be around $1.00 per cfm per month.
- Total operational costs at Marina Terrace would be $4.49/1000 sq feet per month.

Picture 12

Observations

- Pelican Lake is a 7000-acre lake with an average depth of approx. 9’-10’. Historically the lake would experience winter kills every 5 to 7 years.
- The 2 HLAS installed on pelican have 152 aeration heads and aerate approximately 60 acres of the lake (less than 1%) and yet the systems have been able to constantly hold the lake above 4ppm DO thought the worst winters. In favorable winters the aeration fields will open to several hundred acres and DO will test constantly above 8ppm.
- Since the both HLAS have gone into operation in 2015 we have seen no winter kill.

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