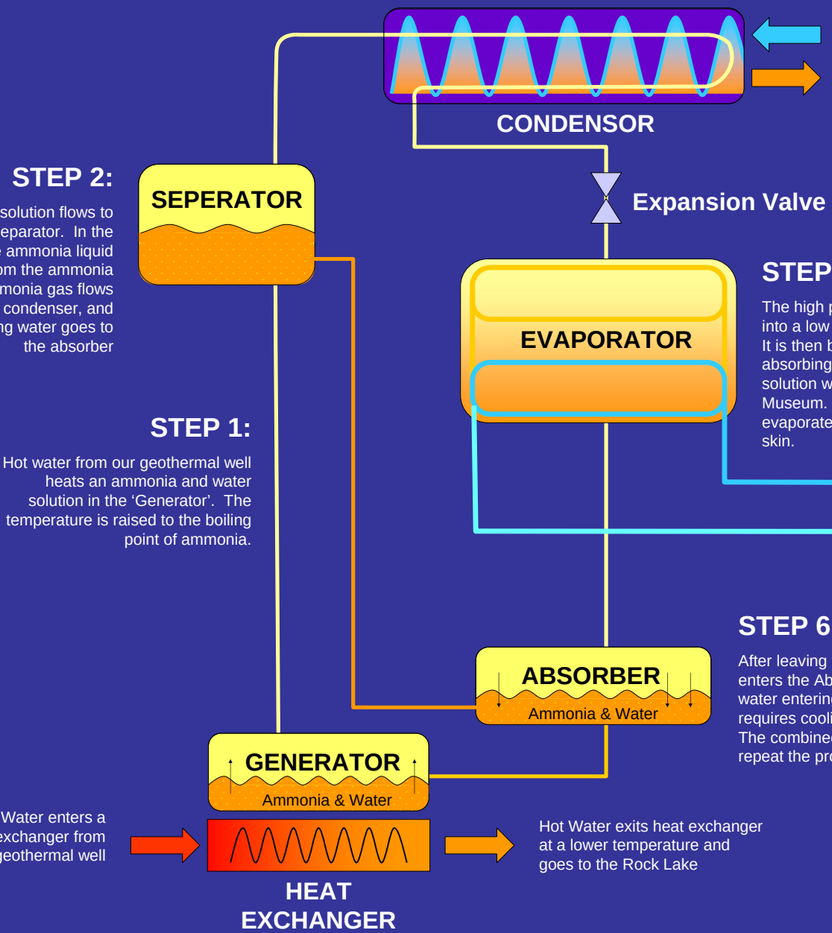
Using Geothermal Water to Cool the Ice Museum

Chena Hot Springs Absorption Refrigeration System

A major consideration when deciding whether to make the Aurora Ice Museum a year-round facility was figuring out how to cool it in a cost effective manner during our warm summer months. Because of our remote location, electric power is very expensive at Chena Hot Springs. We generate our own power onsite at cost of 30¢ per kilowatt-hour. This meant using a traditional compression refrigeration system (like the one you probably use in your home) was out of the question, as the fuel cost alone for the system would be about $500/day. Instead, we looked into alternatives and teamed up with Energy Concepts to design a two stage ammonia absorption refrigeration system to meet our needs – the first absorption refrigeration system using geothermal heat as the generating heat source in the world.

The system designed by Energy Concepts Co. uses cold water from Monument Creek (which runs behind the Ice Museum) and hot water at 165ºF from our geothermal well to provide an average of 10 tons of refrigeration to the Ice Museum. This system is enough to keep the Ice Museum 'on ice' all summer, even during 90ºF days. The entire Absorption Refrigeration System fits into a 4ft x 4ft x 8ft space. Below is a simplified explanation of how the system works:



STEP 3:

Cooling water from Monument Creek enters the Condenser and causes the ammonia vapor to condense back into a liquid at high pressure.

STEP 2:

The boiling solution flows to the separator. In the separator, the ammonia liquid separates from the ammonia gas. The ammonia gas flows upward to the condenser, and the remaining water goes to the absorber

STEP 4:

The high pressure ammonia liquid is expanded back into a low pressure liquid through an expansion valve. It is then boiled at low temperature in the Evaporator, absorbing heat from the Ice Museum via a brine solution which circulates to air handlers behind the Museum. A similar process occurs when liquid water evaporates off your skin and cools the surface of your skin.

STEP 1:

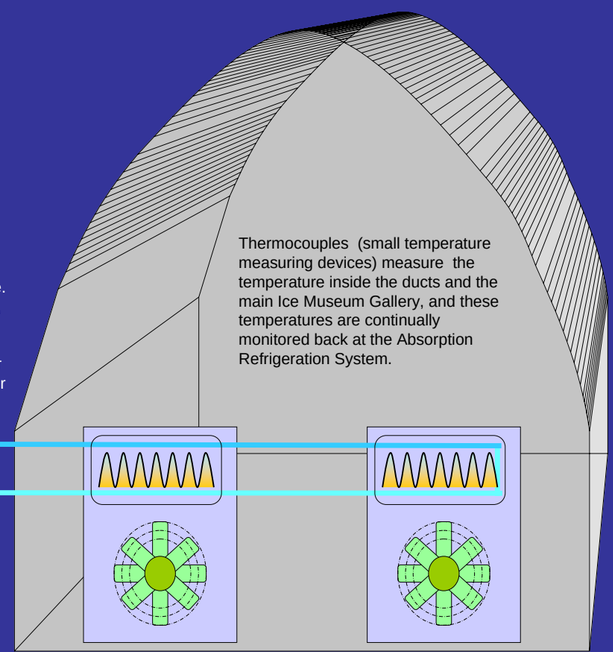
Hot water from our geothermal well heats an ammonia and water solution in the 'Generator'. The temperature is raised to the boiling point of ammonia.

STEP 6:

After leaving the evaporator, the ammonia vapor enters the Absorber where it is re-absorbed by water entering from the Separator. This step also requires cooling water from Monument Creek. The combined fluid returns to the Generator to repeat the process.

Hot Water enters a heat exchanger from our geothermal well

Hot Water exits heat exchanger at a lower temperature and goes to the Rock Lake



Thermocouples (small temperature measuring devices) measure the temperature inside the ducts and the main Ice Museum Gallery, and these temperatures are continually monitored back at the Absorption Refrigeration System.

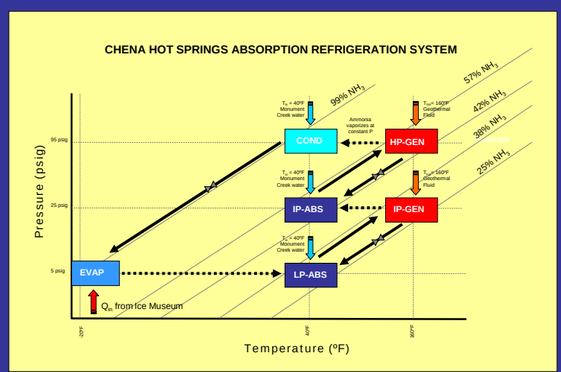
STEP 5:

Calcium Chloride ($CaCl_2$) brine is used as a heat exchange fluid to run through two air handlers, located behind the Ice Museum, which blow cooled air into duct spaces between the inner and outer walls of the Ice Museum.

An Engineering Approach to Understanding the Absorption Refrigeration Cycle:

The schematic on the left represents a simplified version of the operation of the Absorption Refrigeration System. It shows only one Absorber, Separator and Condenser, while in the actual system there are two of each of these components. The cycle you see to the left is actually repeated a second time at a lower pressure to get the brine temperature even colder. This is why this system is called a 'two-stage ammonia absorption system'.

Engineers often use a VLE diagram, like the one shown below, to give a visual interpretation of a thermodynamic process which uses a gas as the working substance. The Second Law of Thermodynamic states that heat will not flow from a cold reservoir to a hot reservoir unless we input work. In this case, we are using ammonia to collect energy from a cold area (the Ice Museum) and exhaust it to a higher temperature area. This work is only done when the volume of the ammonia changes, as it does in the Evaporator. This work is performed by the temperature difference between our water from our geothermal well, and the cooling water from Monument Creek.



Created by Gwen Holdmann for Chena Hot Springs Resort