The Absorption Cycle (simplified)

The absorption cycle uses a heat-driven concentration difference to move refrigerant vapors (usually water) from the evaporator to the condenser. The high concentration side of the cycle absorbs refrigerant vapors (which, of course, dilutes that material). Heat is then used to drive off these refrigerant vapors thereby increasing the concentration again. Lithium bromide is the most common absorbent used in commercial cooling equipment, with water used as the refrigerant. Smaller absorption chillers sometimes use water as the absorbent and ammonia as the refrigerant. As you can probably guess, the absorption chiller must operate at very low pressures (about 1/100th of normal atmospheric pressure) for the water to vaporize at a cold enough temperature (e.g., at ~ 4.4°C) to produce 6.6°C chilled water.

The simplified diagram here illustrates the overall flow path. Starting with the evaporator, water at about 4.4°C is evaporating off the chilled water tubes, thereby bringing the temperature down from the 12.2°C being returned from the air handlers to the required 6.6°C chilled water supply temperature. One ton of cooling evaporates about 4.5 kg of water per hour in this step.

This water vapor is absorbed by the concentrated lithium bromide solution due to its hygroscopic characteristics. The heat of vaporization and the heat of solution are removed using cooling water at this step. The solution is then pumped to the concentrator at a higher pressure where heat is applied (using steam or hot water) to drive off the water and thereby re-concentrate the lithium bromide.
The water driven off by the heat input step is then condensed (using cooling tower water), collected, and then flashed to the required low temperature (4.4°C in our illustration) to complete the cycle. Since water is moving the heat from the evaporator to the condenser, it serves as the refrigerant in this cycle. There are also absorption chillers in use (e.g. in motor homes) that use ammonia as the refrigerant in the same cycle.

The absorbent is the material that is used to maintain the concentration difference in the machine. Most commercial absorption chillers use lithium bromide. Lithium bromide has a very high affinity for water, is relatively inexpensive and non-toxic. However, it can be highly corrosive and disposal is closely controlled. Water of course is extremely low cost and safety simply isn't an issue.

**Absorption Chillers**

Absorption chillers are available in two types:

1. Single Effect (Stage) Units using low pressure (20 psig or less) as the driving force. These units typically have a COP of 0.7 and require about 18pph per ton of 9 psig steam at the generator flange (after control valve) at A.R.I. standard rating conditions.

2. Double Effect (2-Stage) Units are available as gas-fired (either direct gas firing, or hot exhaust gas from a gas-turbine or engine) or steam-driven with high pressure steam (40 to 140 psig). These units typically have a COP of 1.0 to 1.2. Steam driven units require about 9 to 10pph per ton of 114 psig input steam at A.R.I. standard rating conditions. Gas-fired units require an input of about 10,000 to 12,000 BtuH HHV per ton of cooling at A.R.I. standard rating conditions. To achieve this improved performance they have a second generator in the cycle and require a higher temperature energy source.