ABSORPTION CHILLERS

Timothy C. Wray P.E. 1995

The most common type of absorption chiller found in the commercial world today is a Lithium Bromide and Water machine. Lithium Bromide is used as the absorbent and Water is used as the refrigerant.

Principle Absorption Refrigeration Cycle

NOTE: The entire cycle is preformed in a vacuum.

1. Weak solution of lithium bromide and water is heated to approximatly 220°F for separation and concentration. Water is separated when boiled off thus concentrating the lithium bromide solution.

2. The separated concentrated solution and water vapor are then cooled.

3. The water is then sprayed as a fine mist over the concentrated solution.

4. The water droplets are absorbed into the lithium bromide solution at such a rate it creates a vacuum.

5. The water boils under a the vacuum created by the absorption process. The chilled water is cooled due to the heat transfer in the latent heat of the boiling water.

6. Once the water is absorbed into the lithium bromide the solution is weaken and the process has to start again.

Types of Absorption Chillers

1. Single Stage, Single Effect
   a. Low Pressure steam
      Pressure required - up to 15 PSIG
      Steam Consumption - 17 #/ton to 20 #/ton
      Condenser water @18 #/ton (30,000 btuh)
      12 85°F to 97°F - 5 gpm/ton
      15 85°F to 100°F - 4 gpm/ton

   b. High Temperature Hot Water
      Temperature rating - up to 250°F
      Flow rate - 18,500 btuh, 1.85 gpm/ton @ 20
      Condenser water 18,500/ton (30,500 btuh)
      12 85°F to 97°F - 5 gpm/ton
      15 85°F to 100°F - 4 gpm/ton

2. Two Stage, Double Effect
   a. High Pressure steam
      Pressure required - up to 115 PSIG
      Steam Consumption - 9.7 #/ton to 12 #/ton
      Condenser water @10 #/ton (22,000 btuh)
         12 85°F to 97°F - 3.7 gpm/ton
         15 85°F to 100°F - 3 gpm/ton

3. Direct Fired Two Stage, Double Effect
   a. Gas or #2 fuel oil.
      Fuel Consumption - 11700 btuh/ton
      Condenser water @ 22,000 btuh
         12 85°F to 97°F- 3.7 gpm/ton
         15 85°F to 100°F- 3 gpm/ton

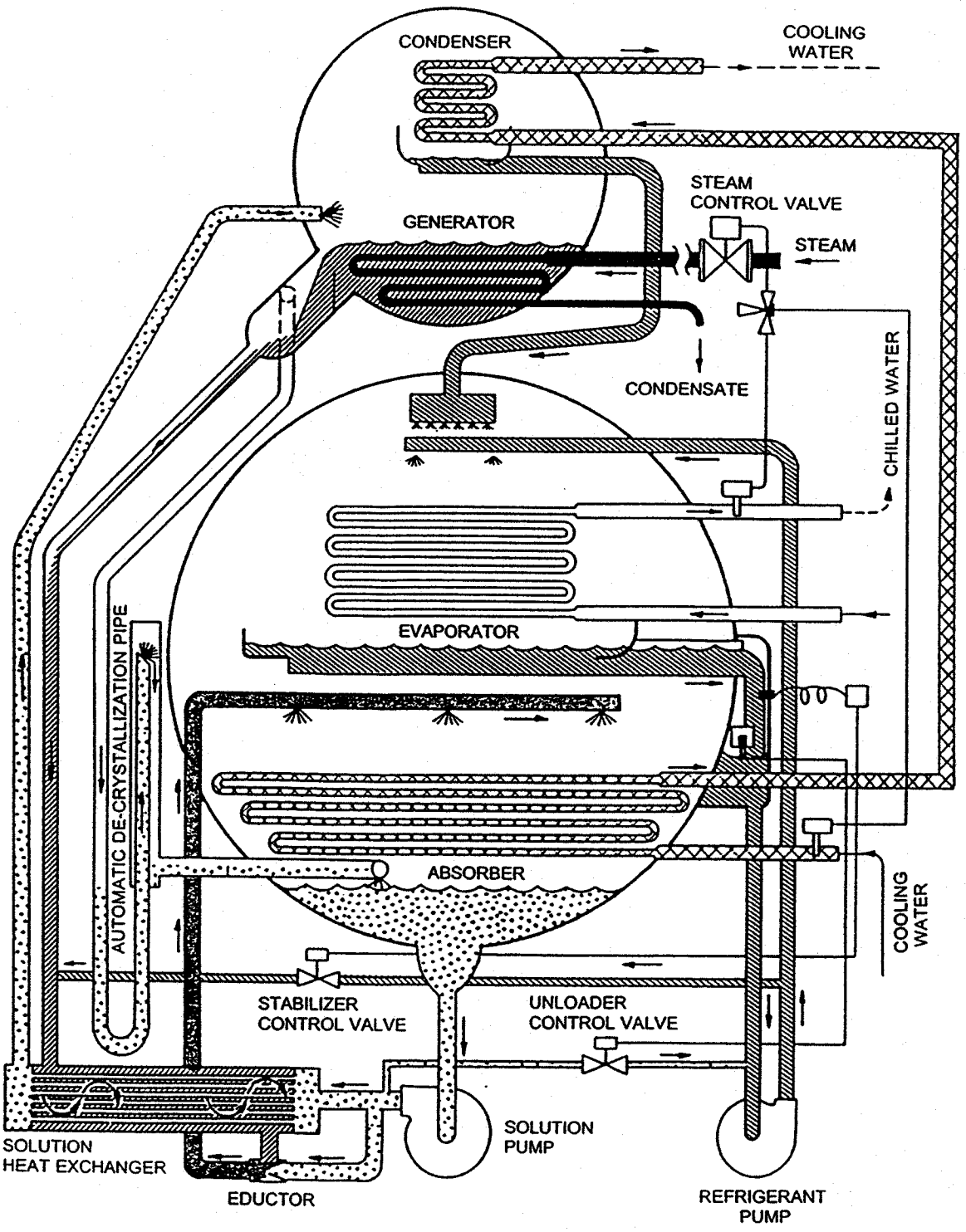
Advantages of Absorption Chillers
1. Fuel cost savings, gas is relatively inexpensive when compared to electricity in high demand charge areas.
2. Can produce chilled water from waste heat.
3. Advanced microprocessors make machine easy to start, operate, and modulate.

Disadvantages of Absorption Chillers
1. Initial capital cost for machine and installation.
2. Increased maintenance cost, plus fewer people know how to work on them.
   Approx 20$/ton/yr for two stage vs 15 $/ton/yr for elect.
3. Increased condenser water pump sizes.
4. Increased cooling tower sizes.
5. Minimum chilled water supply temperature is 42°F
   Water is used as the refrigerant.
6. Increased mechanical room footprint required.

Design Considerations
With machine size set
1. Decrease in steam pressure will decrease cooling capacity.
2. Decrease in condenser water temperature will increase cooling capacity.
3. Decrease in leaving chilled water temperature will decrease cooling capacity.

SINGLE STAGE, SINGLE EFFECT

STANDARD STEAM CYCLE DIAGRAM

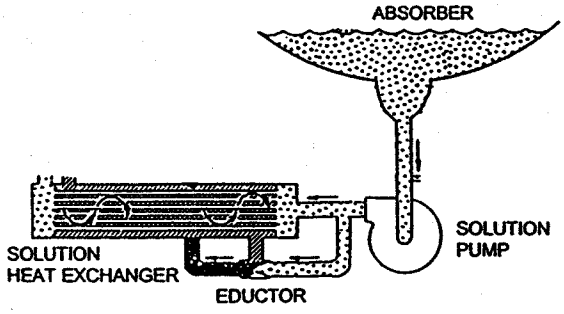


CHILLED WATER
CONDENSER WATER
CONCENTRATED SOLUTION (LI. BR.)
INTERMEDIATE SOLUTION (LI. BR.)
DILUTE SOLUTION (LI.BR.)
STEAM OR HOT WATER
REFRIGERANT WATER

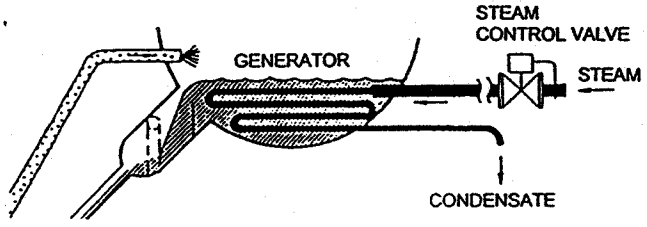
How It Works SINGLE STAGE, SINGLE EFFECT

The IsoFlow single effect absorption cycle uses ordinary water as the refrigerant and lithium bromide as the absorbent. It is the strong affinity that these two substances have for one another that makes the cycle work. The entire process occurs in almost a complete vacuum.

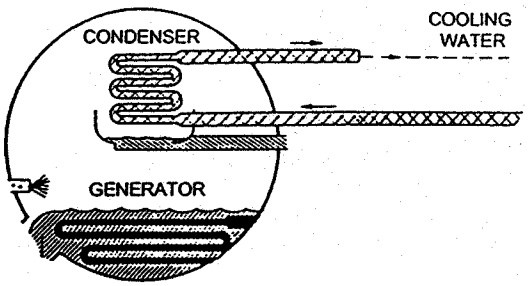
1. Solution Pump – A dilute solution (58.5%) of lithium bromide solution is collected in the bottom of the absorber shell. From here, a hermetic solution pump moves the solution through a shell and tube heat exchanger for preheating.



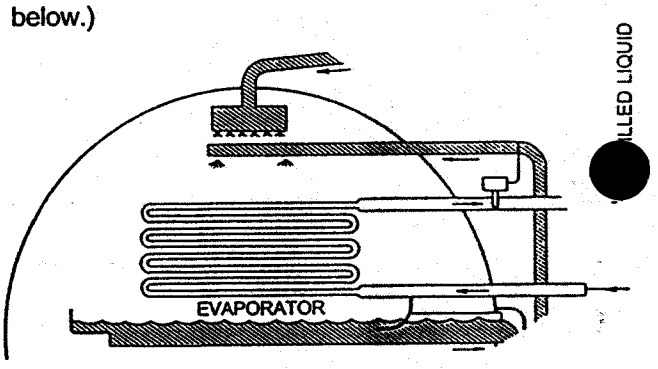
2. Generator – After exiting the heat exchanger, the dilute solution moves into the upper shell. The solution surrounds a bundle of tubes which carries either customer provided steam or hot water. The steam or hot water transfers heat into the pool of dilute lithium bromide surrounding the tube bundle. The solution begins to boil, sending refrigerant vapor upward into the condenser and leaving behind concentrated lithium bromide (about 65%). The concentrated lithium bromide solution moves down to the heat exchanger, where it is cooled by the weak solution.



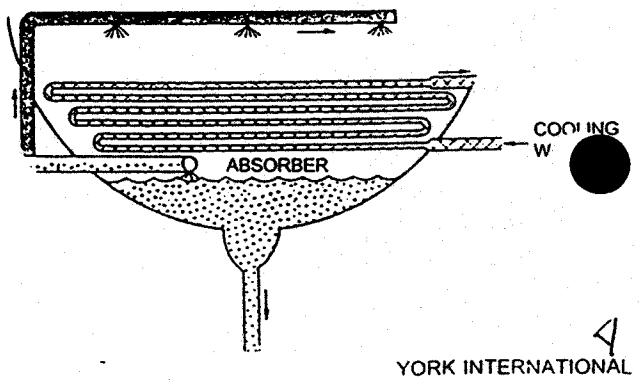
3. Condenser – The refrigerant vapor rises through vapor eliminators and strikes the condenser tube bundle. The refrigerant vapor condenses on the tubes, and the heat is removed by the customer provided tower water which moves through the inside of the tubes. As the refrigerant water condenses, it collects inside trough at the bottom of the condenser.



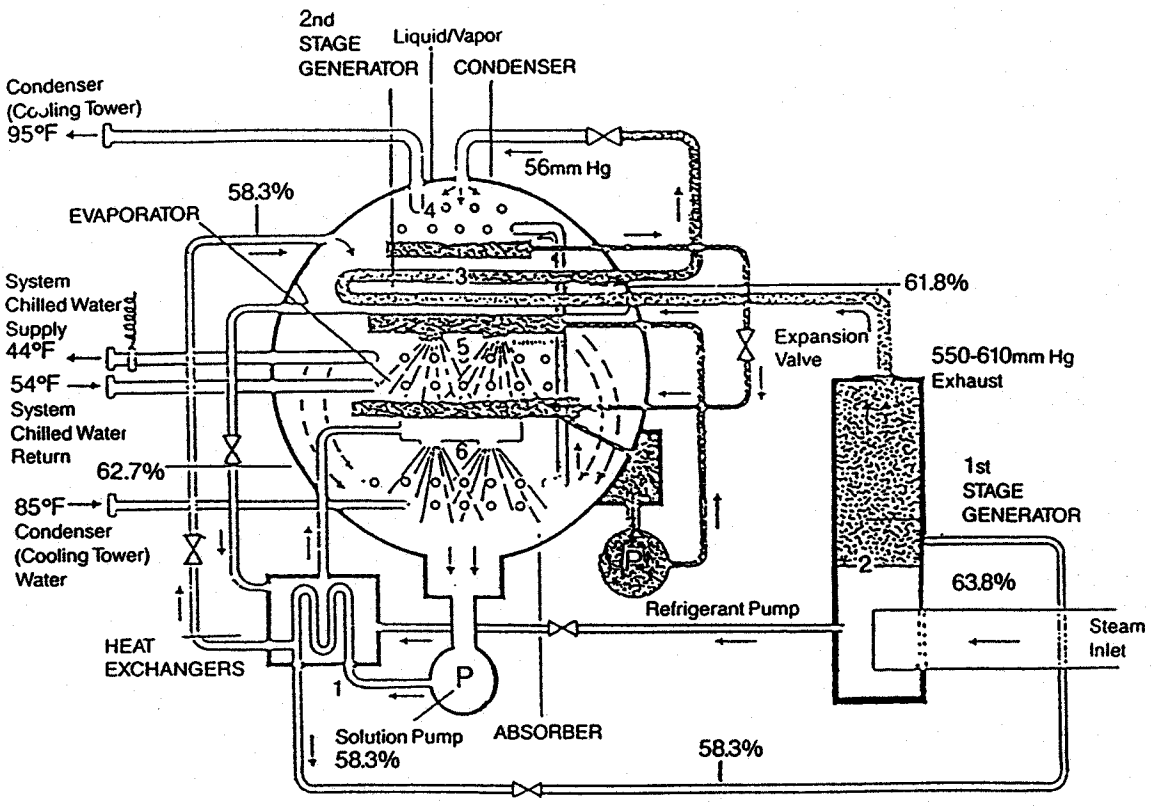
4. Evaporator – The refrigerant water moves from the condenser in the upper shell down to the evaporator in the lower shell. Due to the extreme vacuum in the evaporator (6 mm Hg absolute pressure), the refrigerant water which strikes the evaporator tube bundle boils at 39°F, creating the refrigerant effect. (This deep vacuum is created by hygroscopic action in the Absorber directly below.)



5. Absorber – As the refrigerant vapor descends to the Absorber from the Evaporator, the strong lithium bromide solution from the generator is sprayed over the top of the Absorber tube bundle. The strong lithium bromide solution actually pulls the water vapor into solution. This creates the deep vacuum in the Evaporator, and it also generates heat which is removed by customer provided tower water. A dilute solution of lithium bromide collects in the bottom of the absorber, and the process begins once again.



How It Works TWO STAGE, DOUBLE EFFECT



Steam Machines

ParaFlow's remarkably efficient two stage absorption refrigeration cycle uses water as the refrigerant and lithium bromide as the absorbent. It is the strong affinity these two substances have for each other that makes the cycle work. The entire process occurs in hermetic vessels in an almost complete vacuum.

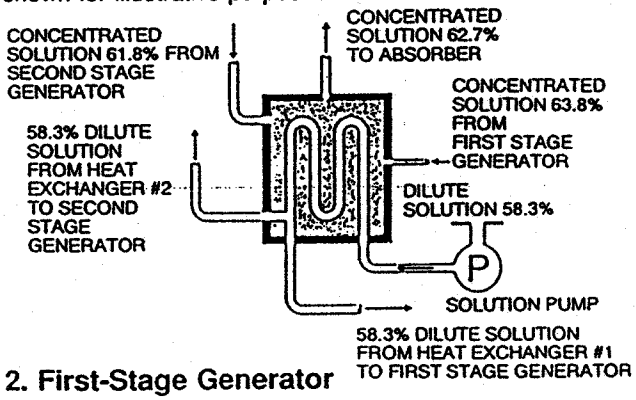
The large diagram above indicates the complete chilling cycle. The six steps are detailed below, with corresponding numbers in the diagram to show where each step takes place. ParaFlow's two stage absorption chilling cycle is continuous; however, for the sake of clarity and simplicity, it is divided into six steps.

1. Solution Pump/Heat Exchangers

A dilute solution (58.3%) of lithium bromide and water descends from the Absorber to the Solution Pump. This flow of dilute solution is split into two streams and pumped through heat exchangers to the First-Stage Generator and to the Second-Stage Generator.

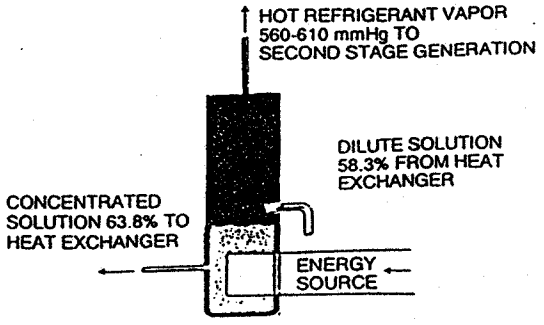
ParaFlow's exclusive two-way split of solution flow virtually eliminates the possibility of crystallization (solidification) by allowing the unit to operate at much lower solution concentration and temperatures than series flow systems.

Note: There are three heat exchangers, but only one is shown for illustrative purposes.



2. First-Stage Generator

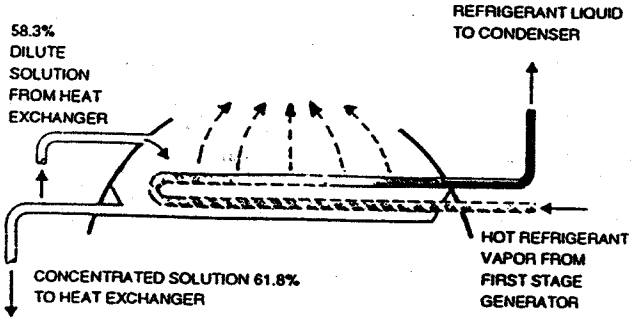
An outside steam source heats dilute lithium bromide (58.3%) coming from the Solution Pump/Heat Exchangers. This produces hot refrigerant vapor which is sent to the Second-Stage Generator, leaving a concentrated solution (63.8%) that is returned to the Heat Exchangers.



3. Second Stage Generator

The energy source for the production of refrigerant vapor in the Second Stage Generator is the hot refrigerant vapor produced by the First Stage Generator.

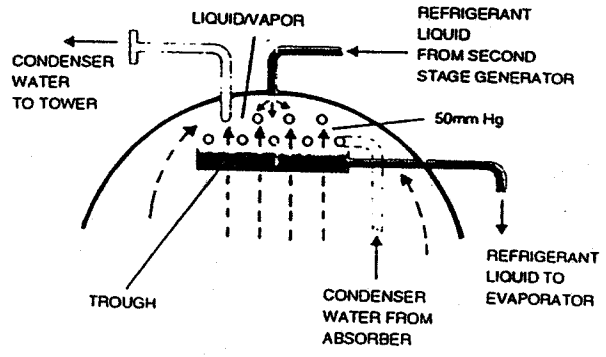
This is the heart of YORK's remarkably efficient two-stage absorption effect. The refrigerant vapor produced in the First Stage Generator is increased by 40% - at no additional expense of fuel. The result is much higher efficiency than in conventional systems.



This additional refrigerant vapor (dotted arrows) is produced when dilute solution from the Heat Exchanger is heated by refrigerant vapor from the First Stage Generator. The additional concentrated solution (light grey) that results is returned to the Heat Exchanger. The refrigerant vapor from the First Stage Generator condenses into liquid (dark grey) giving up its heat, and continues to the Condenser.

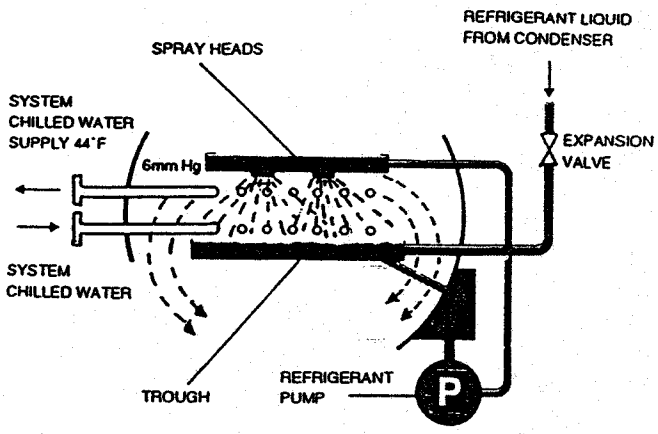
4. Condenser

Refrigerant from two sources - (1) liquid (dark grey) resulting from the condensing of vapor produced in the First Stage Generator and (2) vapor (dotted arrows) produced by the Second Stage Generator - enters the Condenser. The refrigerant vapor is condensed into liquid and the refrigerant liquid is cooled. The refrigerant liquids are combined and cooled by condenser water. The liquid then flows down to the Evaporator.



5. Evaporator

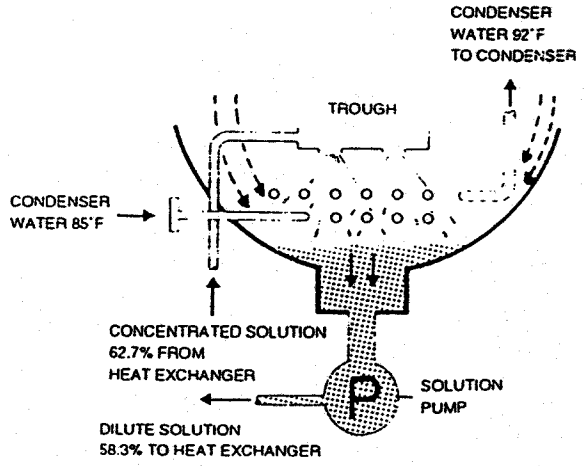
Refrigerant liquid from the Condenser passes through a metering valve and flows down to the Refrigerant Pump, where it is pumped up to the top of the Evaporator. Here the liquid is sprayed out as a fine mist over the Evaporator tubes. Due to the extreme vacuum (6mm Hg) in the Evaporator, some of the refrigerant liquid vaporizes, creating the refrigerant effect (This vacuum is created by hygroscopic action - the strong affinity lithium bromide has for water - in the Absorber directly below.)



The refrigerant effect cools returning system chilled water in the Evaporator tubes. The refrigerant liquid/vapor picks up the heat of the returning chilled water, cooling it from 54°F to 44°F. The chilled water is then supplied back to the system.

6. Absorber

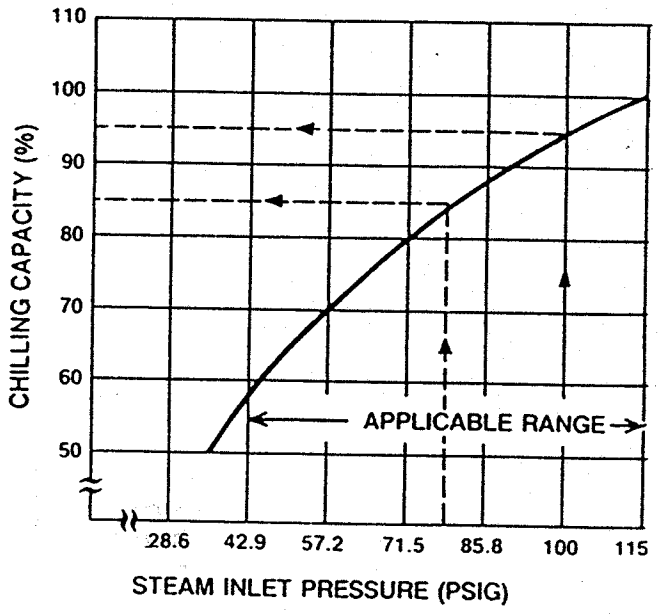
As refrigerant liquid/vapor descends to the Absorber from the Evaporator, concentrated solution (62.7%) coming from the Heat Exchanger is sprayed out into the flow of descending refrigerant. The hygroscopic action between lithium bromide and water - and the related changes in concentration and temperature - result in the creation of an extreme vacuum in the Evaporator directly above. The dissolving of the lithium bromide in water gives off heat, which is removed by condenser water entering from the Cooling tower at 85°F and leaving for the Condenser at 92°F (black dotted lines). The resultant dilute lithium bromide solution collects in the bottom of the Absorber, where it flows down to the Solution Pump.

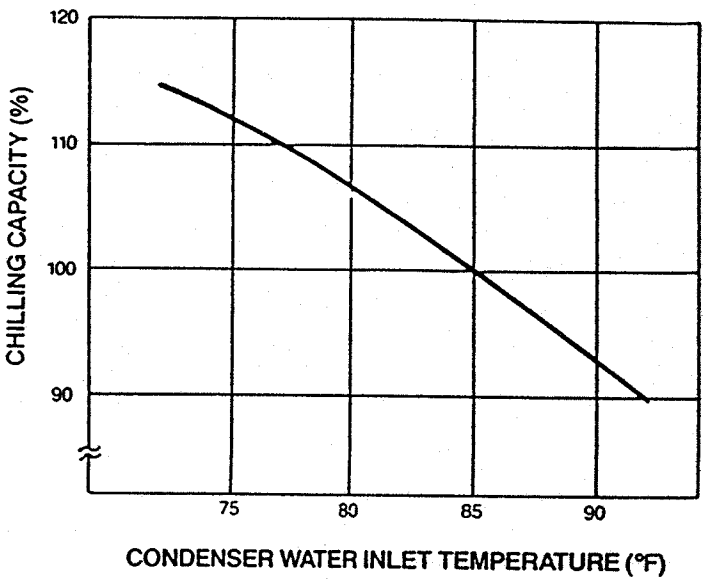


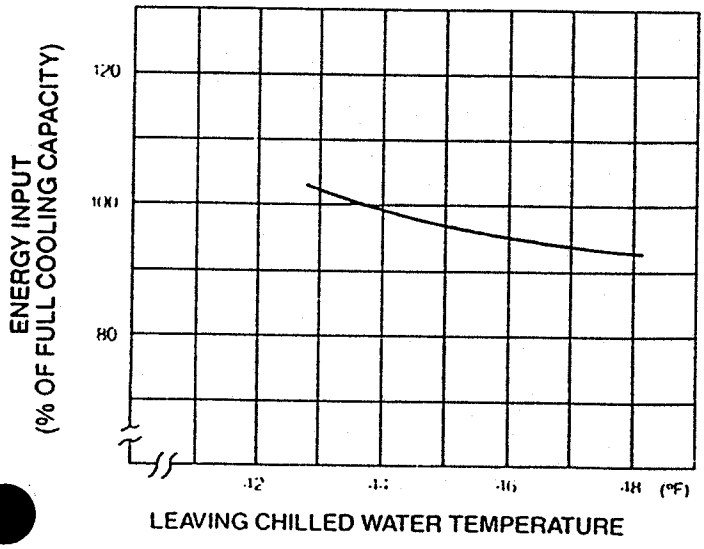
The chilling cycle is now completed and begins again at Step 1.

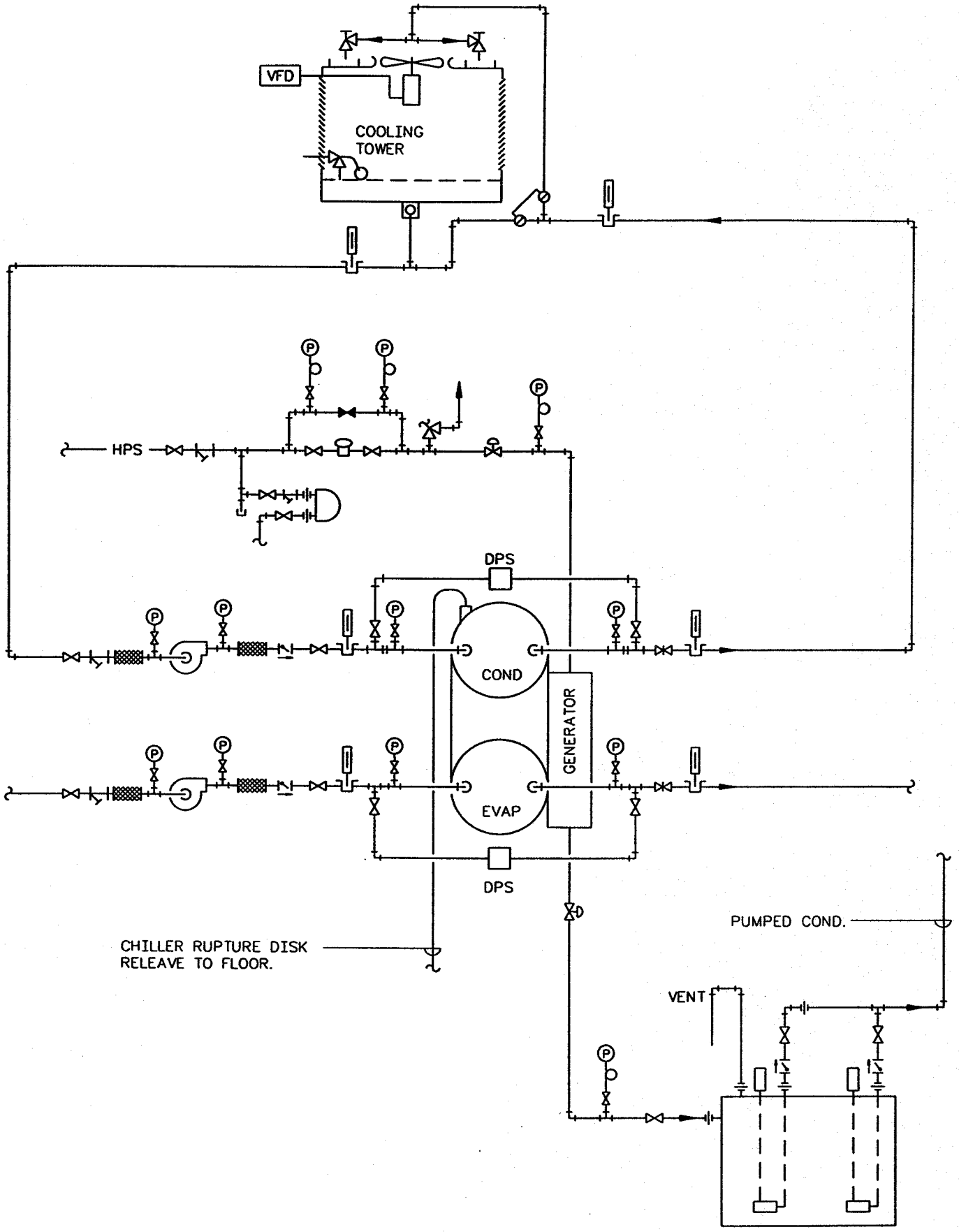
KJWW ENGINEERING CONSULTANTS

PROJECT	DATE	BY	PROJECT NO.
ABSORPTION CHILLER CHARACTERISTICS	4-95		









ABSORPTION CHILLER FLOW DIAGRAM

NO SCALE: