Modern Absorption in 2018 What has changed?

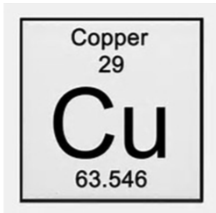
- **Corrosion** & degradation of performance was an issue with Absorbers in the past.
- **Old Absorption technology** requires operators to periodically run a vacuum pump to insure operation & to maintain chilled water set point.
- **Oxygen** is the source of corrosion inside an Absorber. If proper vacuum can be maintained for the absorbers life ***there is no opportunity*** to have corrosion form inside the Absorber.

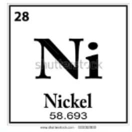
“Big 10”, “State”, “Ivy League” and Universities all across North America & Canada are using “Modern Absorption” to lower the cost of proving chilled water on campus.

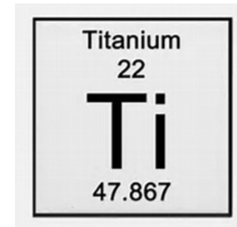
INTERNATIONAL DISTRICT ENERGY ASSOCIATION • SINCE 1909 •

Absorber Factory Testing is now a “New Normal” and the only way to truly guarantee AHRI 560 performance standards.

Absorption tube material selection is a critical success factor for long life & low life cycle costs







Commercial Production 1960 - 1970 - 1980 - 1990 – 2000 - 2010 - 2020

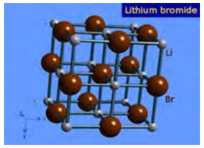
Time line of Absorption Manufacturing

What should be is inside an absorber besides a vacuum?

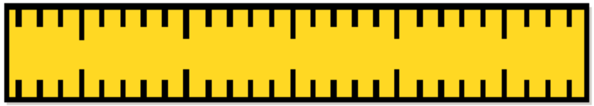
Distilled Water

R718

Lithium Bromide (LiBr)



Lithium Bromide Solution

48%  56%

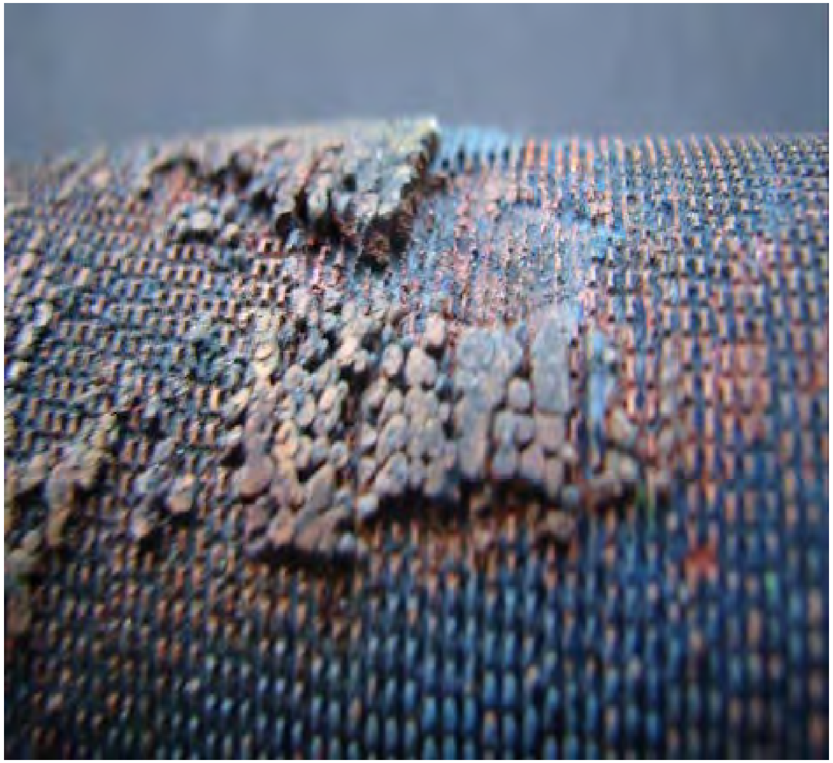
Diluted Solution **Concentrated Solution**

<u>Lithium Bromide(LiBr) Solution</u>

1) LiBr Boiling point is much higher when compared to water 100℃ (212℉) at Atm Pressure

2) Very strong affinity towards water vapor

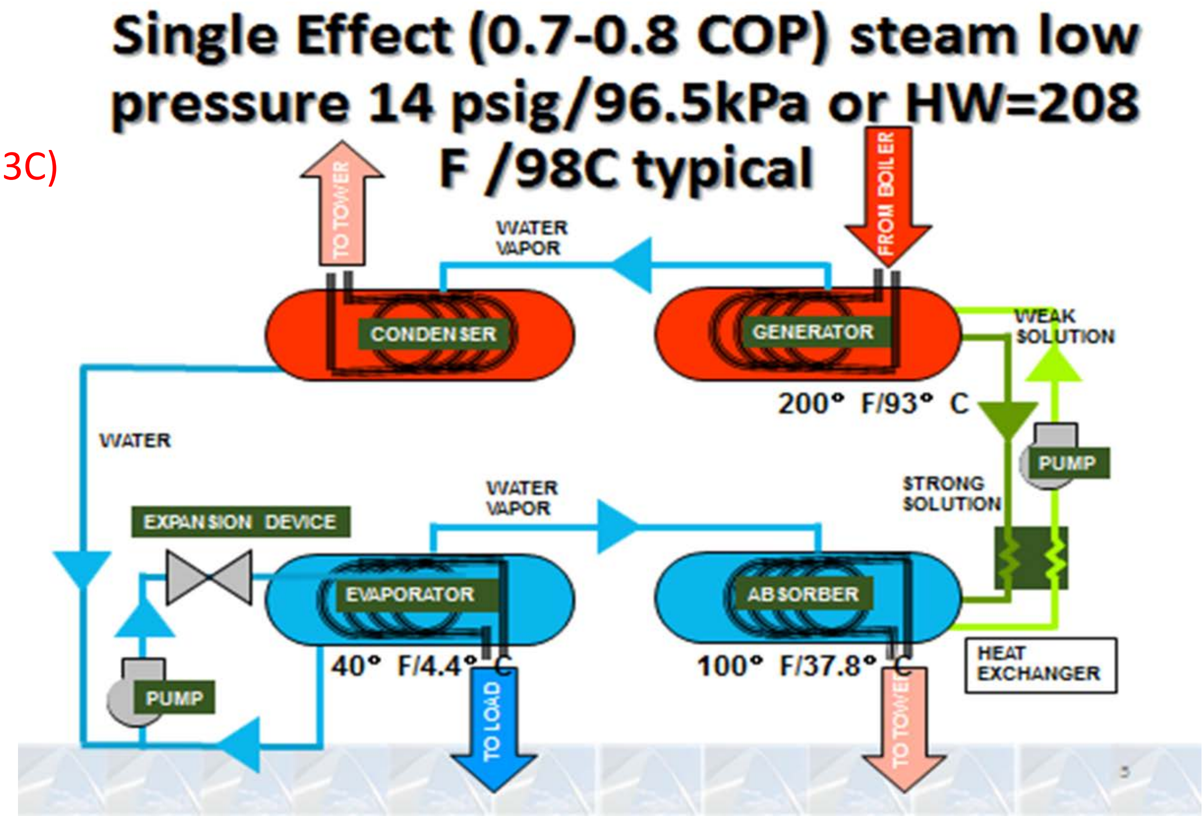
At high temperature, ***Copper*** can react chemically with LiBr solution, leading to electrochemical corrosion.



Challenge = Eliminate the potential for corrosion

Absorbers are made up of multiple shell & tube heat exchangers with ***different*** application environments

- Single Stage Absorbers have 4 main shell & tube heat exchangers:



- Generator (200F / 93C)
- Condenser
- Evaporator
- Absorber

Two Stage Absorbers have 5 or more shell & tube heat exchangers:

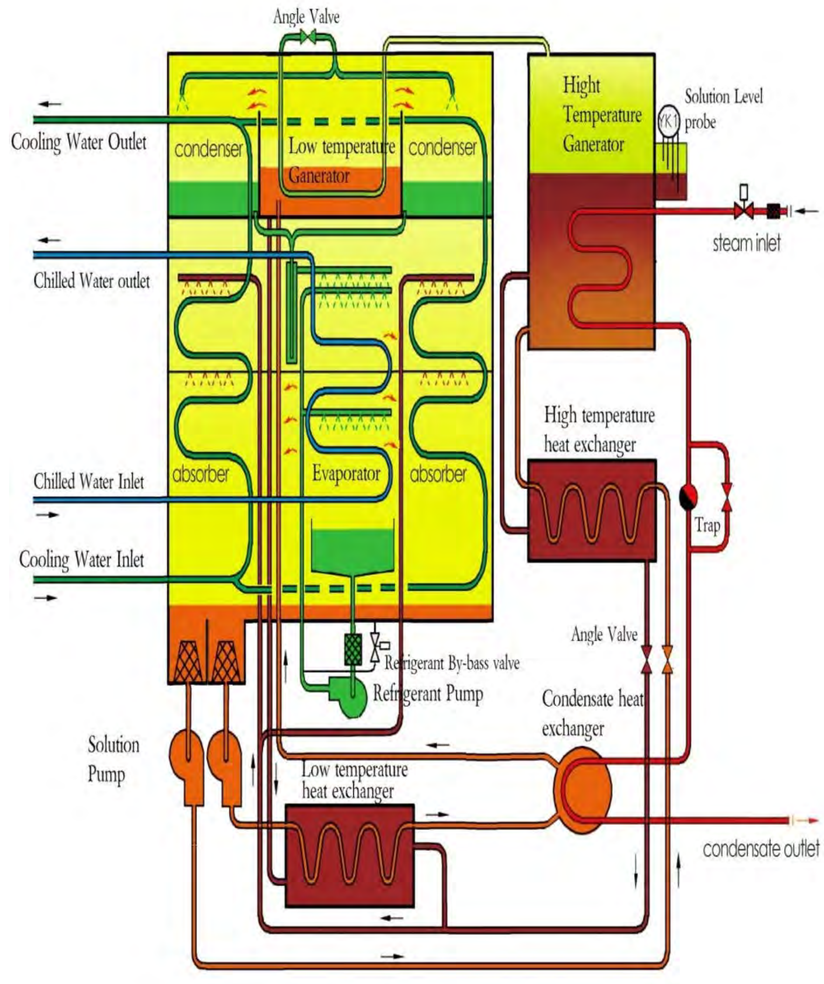
- Generator "HTG" (300 F /148 C)

"high temperature generator"

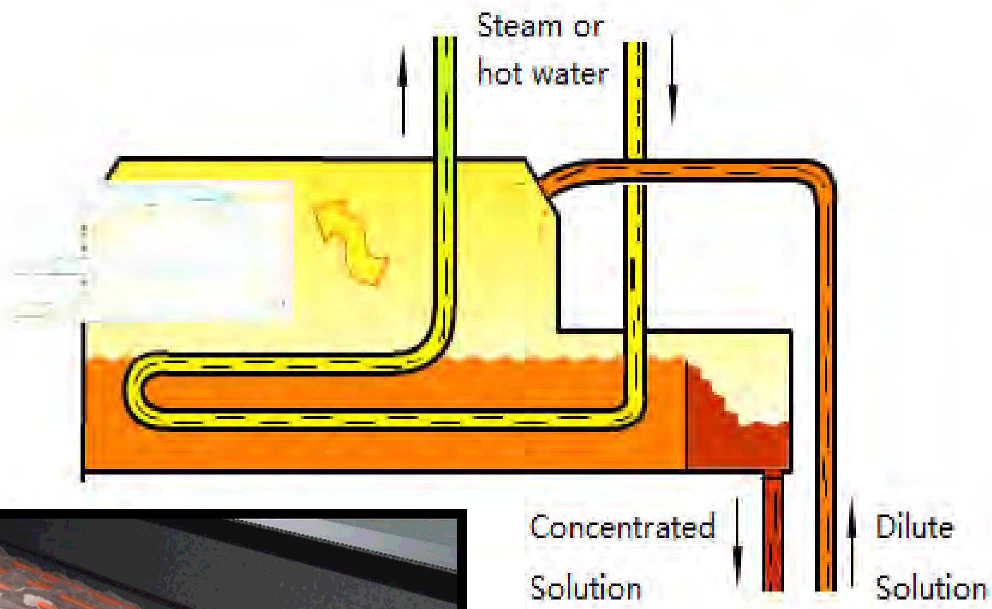
- Generator "LTG"

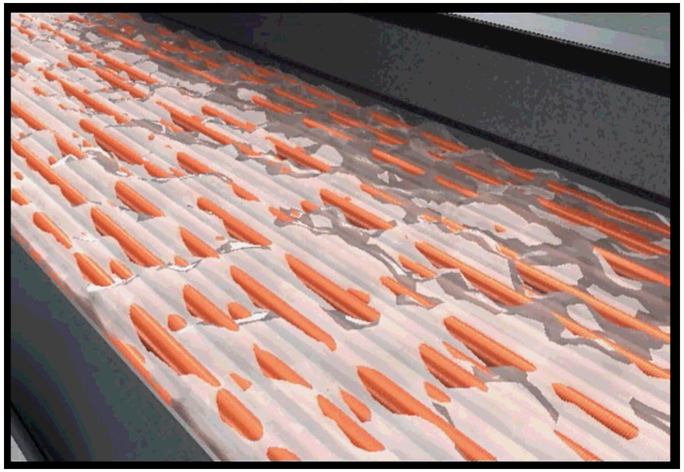
"low temperature generator"

- Condenser
- Evaporator
- Absorber



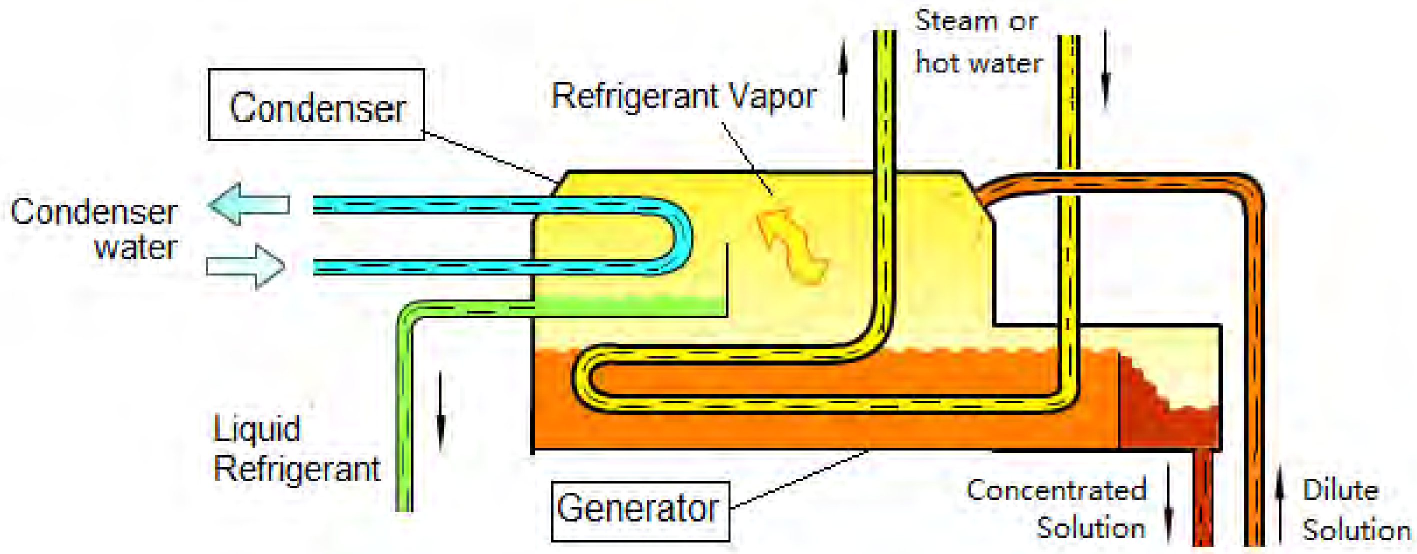
Generator tubes are immersed in Li Br solution at the Highest Temperature



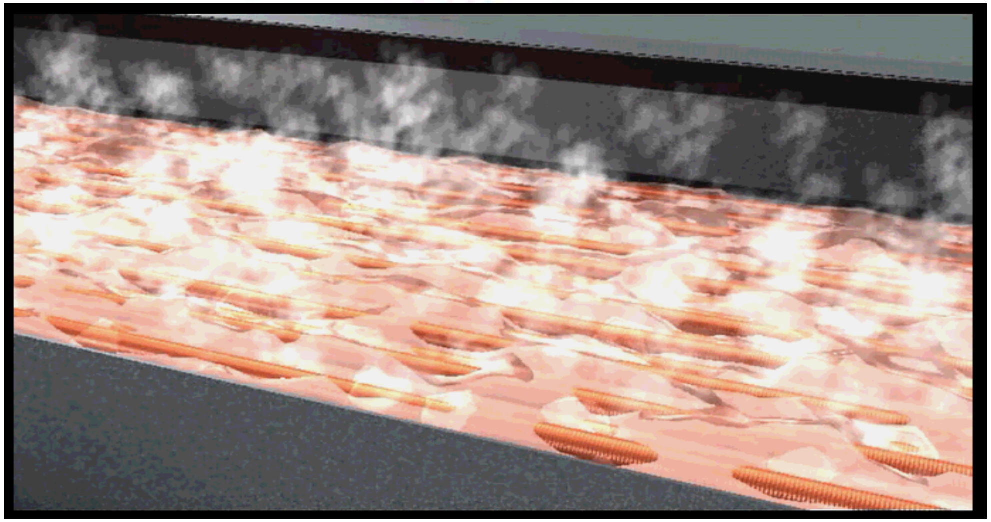


The LiBr solution absorbs heat causing the refrigerant H2O to boil . As the refrigerant is boiled away, or “generated,” the LiBr solution becomes more concentrated.

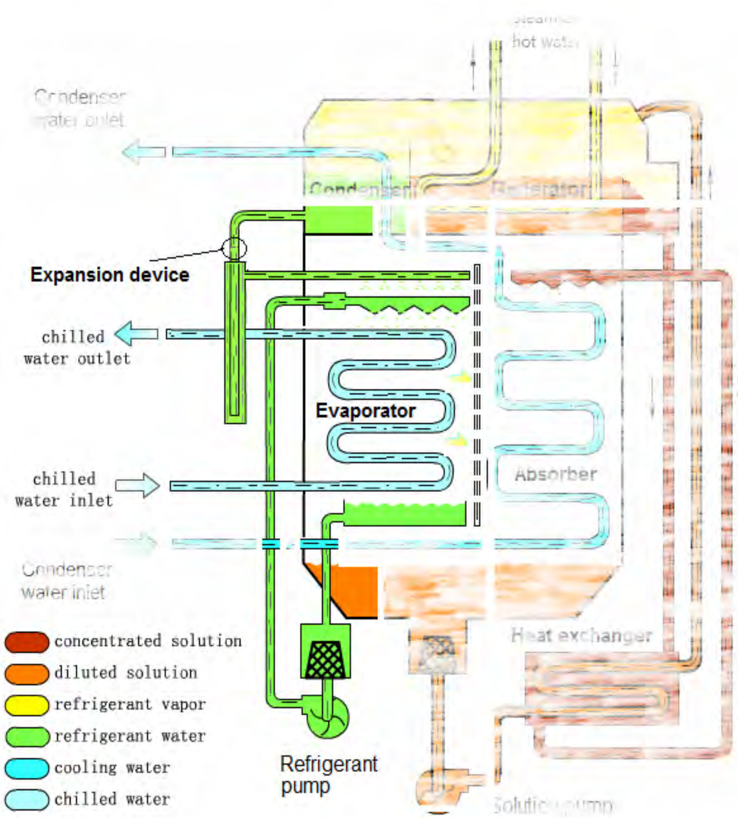
Condenser tubes theoretically only see H2O inside the absorber.
The cooling tower water inside the tubes are often the source of corrosion as it is an "open loop" & local water treatment service can vary greatly.



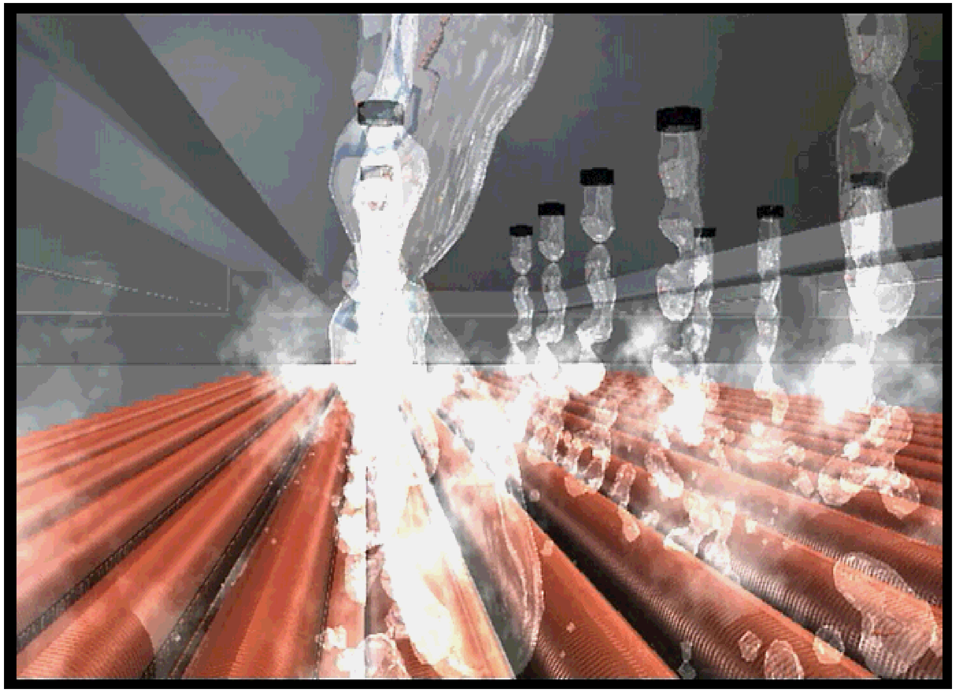
Heat transfers from the refrigerant vapor to the tower water, inside the tubes the refrigerant H20 condenses on the tube surfaces and collects in the bottom of the condenser.



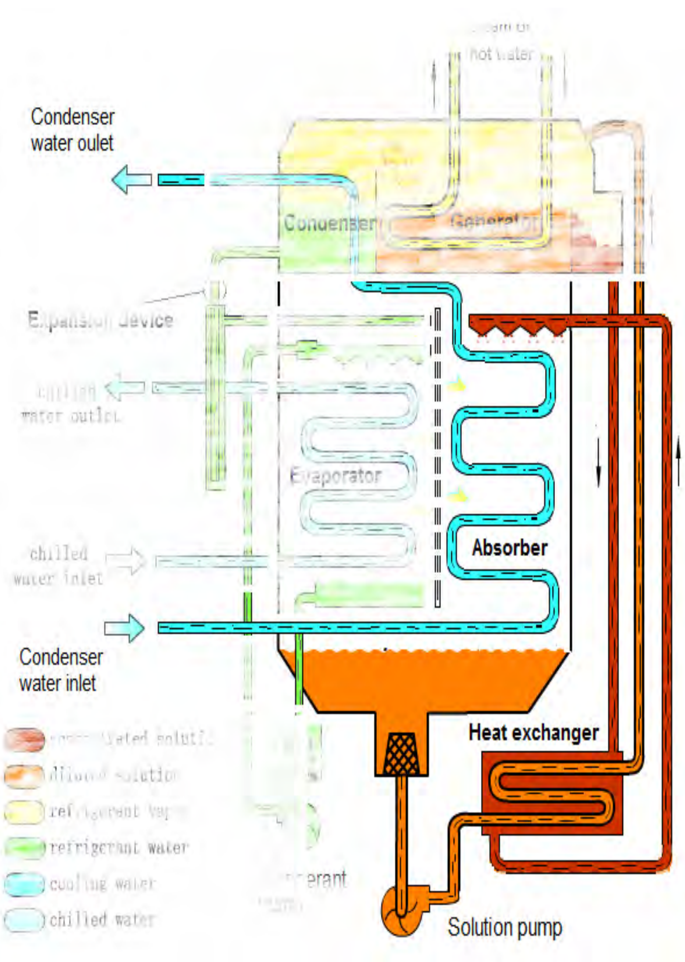
Evaporator theoretically does not see LiBr solution only R718= H2O



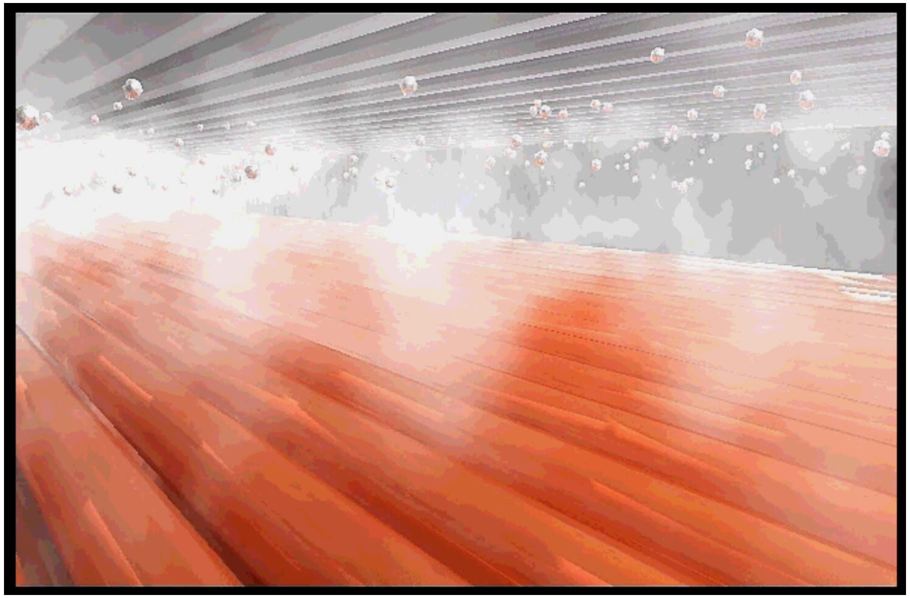
Chilled water through the tubes, liquid refrigerant is sprayed over the tube surfaces. As heat transfers from the chilled water to the cooler liquid refrigerant, the refrigerant boils (vaporizes) change of state.



Absorber tubes are immersed in LiBr solution & typically connected to a open cooling tower.

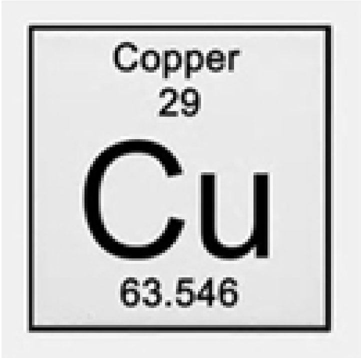


Refrigerant vapor is absorbed by the LiBr solution. As the refrigerant vapor is absorbed, it condenses from a vapor to a liquid, releasing heat. This heat, is rejected to the cooling tower water



The Historical Most Common TUBE materials used in Absorbers

- Copper is characterized by high ductility, and electrical and thermal conductivity.
- The softness of copper explains its **high thermal conductivity**. Pure copper is orange-red and acquires a reddish tarnish when exposed to air. As with other metals, if copper is put in contact with another metal, galvanic corrosion will occur.



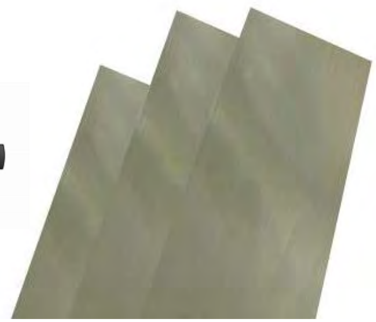
Another historical common TUBE materials used in Absorbers such as the generator.

- **Cupronickel** (aka **copper-nickel**) is an alloy of copper that contains nickel and strengthening elements, such as iron and manganese. Despite its high copper content, cupronickel is silver in color.
- Cupronickel is highly resistant to corrosion in seawater. For this reason, it is used for piping, heat exchangers and condensers in seawater systems, marine hardware.

Common Tube materials used in Absorbers and other heat exchangers.

- **Stainless Steel** is a steel alloy with a minimum of 10.5% chromium content by mass.
- Stainless steels are notable for their corrosion resistance, which increases with increasing chromium content. Molybdenum additions increase corrosion resistance in reducing acids and against pitting attack in chloride solutions. Stainless steel differs from carbon steel due to the presence of chromium. Unprotected carbon steel rusts readily when exposed to the combination of air and moisture. In comparison, stainless steels contain sufficient chromium to undergo passivation, spontaneously forming a microscopically thin inert surface film of chromium oxide by reaction with the oxygen in air and even the small amount of dissolved oxygen in water.[1]. Stainless steels are used where both the strength of steel and corrosion resistance are required.

Typical Materials in 2018
Stainless Steel economizers – heat exchangers



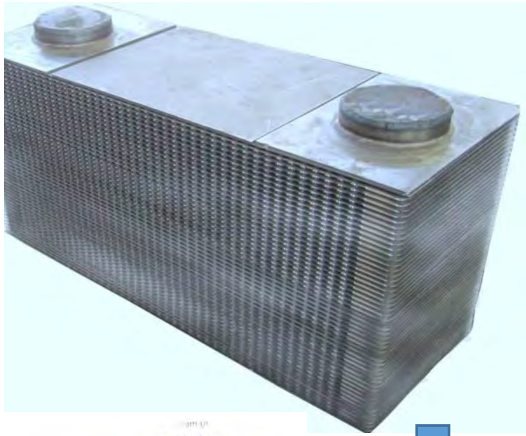
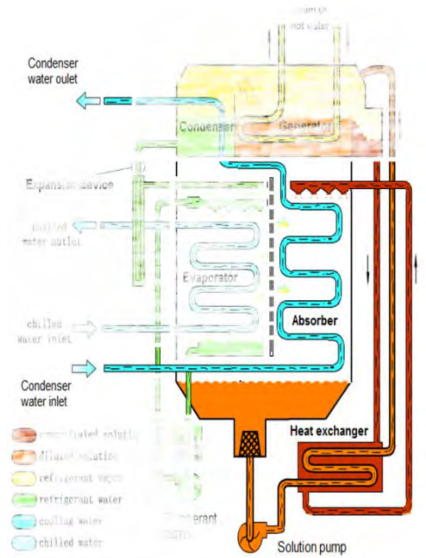


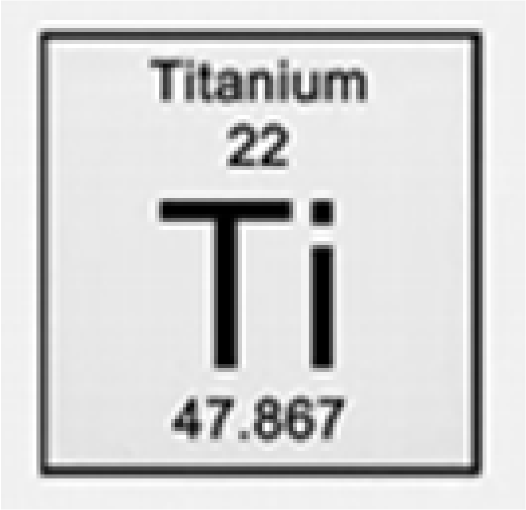
Plate Heat Exchanger for economizers
316L Plates, Nickel alloy is solder.

- No copper in plate heat exchanger, no corrosion.

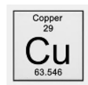
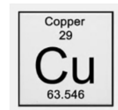
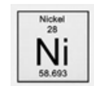
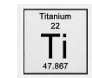


TUBE materials used in Absorbers

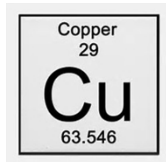
- Titanium: **Titanium** is a chemical element with a silver color, low density, light weight and high strength. Titanium is resistant to corrosion in sea water, aqua regia, acids and chlorine.

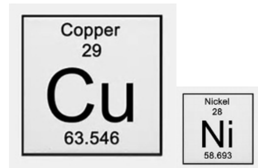


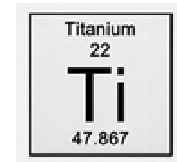
Comparison on Material Corrosion Resistance and Velocity

	Pure Copper	Copper-Nickel	Stainless Steel	Titanium
		 		
Clorine	Resist corrosion under low temp& low concentration	Resist corrosion under low and medium temperature	Resist corrosion differs by types of stainless steel	No corrosion
salt water (speed)	1.2 m/s 3.9 Ft/sec	3.6 m/s 11.7 ft/s	5-7m/s 16.2 -22.7 ft/s	No limitation
Ammonia	Serious corrosion	Corrosion	No corrosion	No corrosion
Polluted air & water	Corrosion	Slight corrosion	No corrosion	No corrosion

Comparison on Material Strength





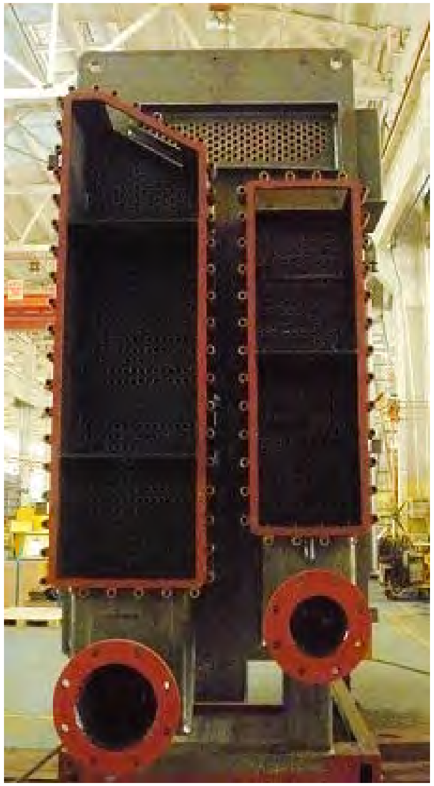


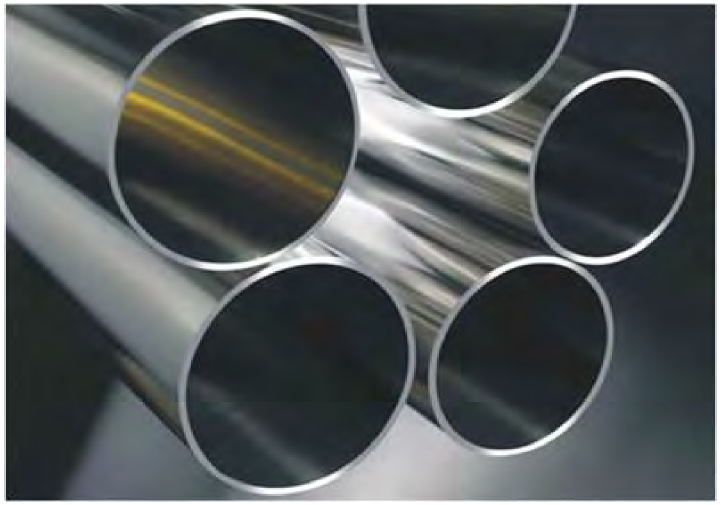
	Pure copper	Copper Nickel	Stainless Steel	Titanium
Tensile Strength(Mpa) PSI	250-270 36250 39150	320-380 46400-55100	480-520 69600-75400	420-480 60900-69600
Yield Strength(Mpa) PSI	150-160 21750-23200	190-230 27550-33350	290-320 42050-46400	320-380 46400-55100

The importance of Tube Material Strength in sections that see large temperature swings frequently (thermal stresses) such as generator(s) room temperature to well above 300F / 148 C is often a large design consideration.

Typical Materials in 2018 by location

Evaporator
Tube Bundles





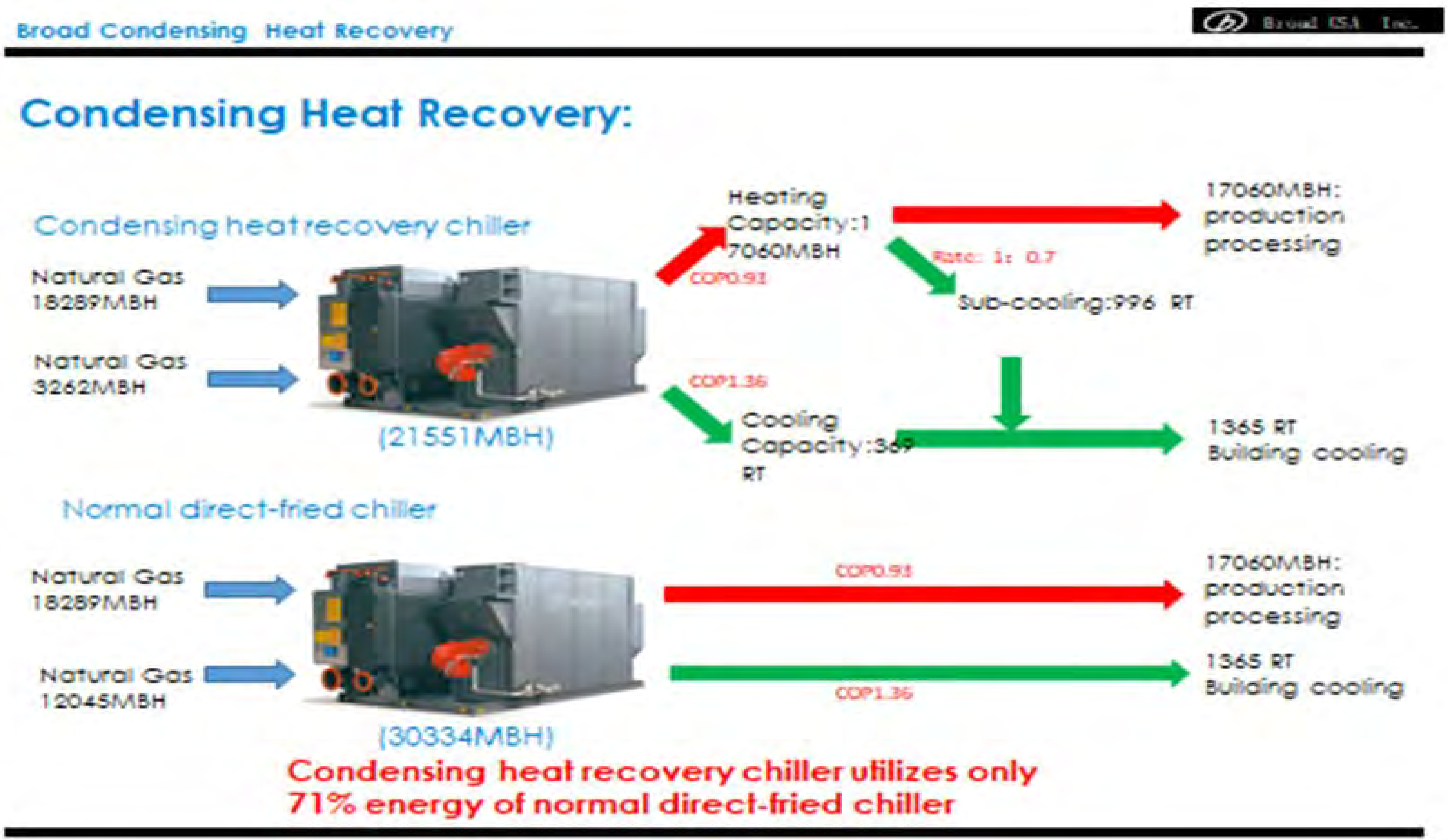
Condenser Absorber Generator
Tube Bundles

Economics & life cycle factors tube material selection has an impact.

In Conclusion

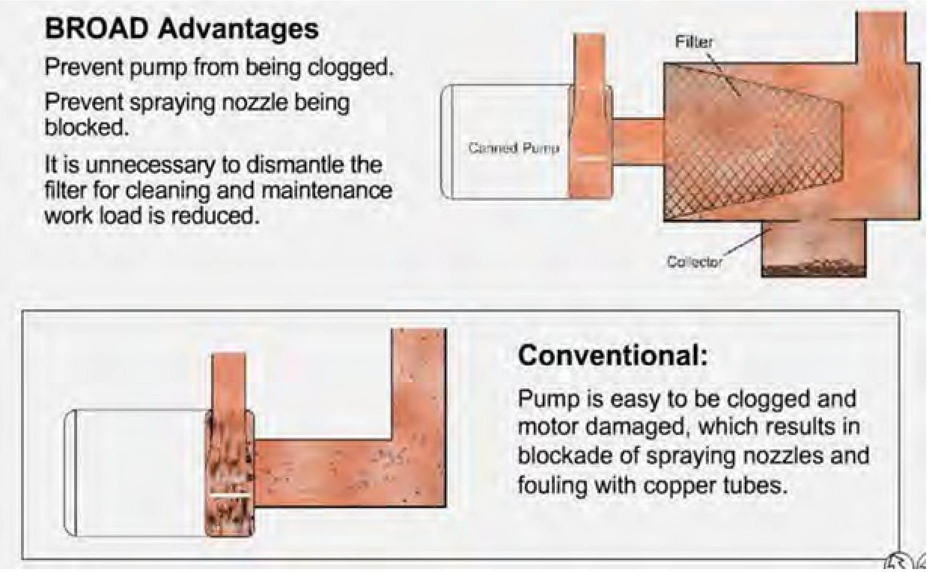
- Tube selection can be a significant factor to and Absorbers life cycle & should be a considered with each application for use based on project goals and specifics.
- As tubes become stronger and less resistant to deterioration wall thickness can be reduced to gain or overcome thermal efficiency differences between material choices.
- Less weight can reduce installation costs.
- Materials that are stronger and resistant to corrosion will reduce life cycle cost
- Economics of materials and tubes technology changes such as enhancements, cross hatching-rifleling allow for numerous choices for tube selection to improve life cycle costs and the efficiency of the chiller.

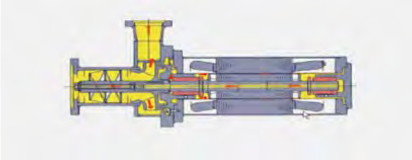
Condensing Direct Fired Absorption ?

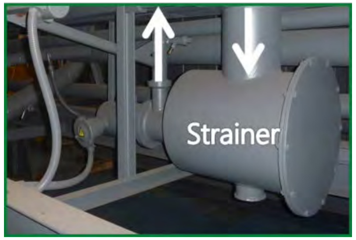


New Normal magnetic & other filters extend the lifecycle

High density magnetic field filters trap and hold ferrous fines, fragments, and small metal objects.
Maintains LiBr solution purity
Maintains COP
Maintain low operating cost







Titanium Tubes the "New Normal of Modern Absorption Units"

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BROAD U.S.A. INC.

INTERNATIONAL DISTRICT ENERGY ASSOCIATION
MEMBER