Busting Four Myths About Absorption Cooling

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Introduction

Absorption chillers have been around for more than 75 years, with several thousand chillers operating successfully today all over the world. Yet myths about cost, operation and performance surround this technology, particularly in North America. Look beyond the myths and you'll discover absorption cooling technology can be efficient, cost-effective, flexible and reliable.

Myth 1: Absorption chillers are inefficient.

Fact: In the right applications, these chillers can be more cost-effective.

The COP for an electric chiller is typically 6 to 6.5; for an absorption chiller, it can range from 0.7 to 1.4. Some people automatically rule out absorption chillers because of this huge difference—but it's an apples-to-oranges comparison, because:

- **COP is calculated differently for the two chiller types.**
- **An electric chiller is driven by electricity purchased from the grid, while an absorption chiller is driven by available waste heat or low-cost natural gas.**
- **The electric chiller's COP does not account for losses of 60% to 70% in electricity generation, transmission and distribution process.**

In short, COP alone is not a sufficient basis for comparison.

1. Typical Chiller COPs Assumed

Electric Centrifugal Chiller	Direct Natural Gas Fired Absorption Chiller	Double Effect Steam Absorption Chiller	Single Effect Steam Absorption Chiller
6.5	1.2	1.4	0.7

2. Natural Gas $5/MMBTU, Electricity $0.15/kWh, Steam $4 per 1,000 lb (450 Kg)

3. Operational Costs (US Cents/ton-hour)

Electric Centrifugal Chiller	Direct Natural Gas Fired Absorption Chiller	Double Effect Steam Absorption Chiller	Single Effect Steam Absorption Chiller
8.12	5.00	3.43	6.86

Higher COP does not necessarily result in low operational cost

For example, let's use the typical chiller COP values in the table above to calculate operational costs, based on the stated values for electricity, gas and steam. It turns out that the chiller with the highest COP, the electric chiller, does not necessarily yield the lowest operational cost. The direct gas fired absorption chiller and the high pressure, or two stage, steam chiller are more appropriate choices.

Of course, utility costs vary, and in many cases, an electric chiller makes more sense. The point is that it's worth considering absorption chillers, especially if electricity costs are high or rising, demand charges are in effect, and natural gas or waste heat costs are low.

Just a couple applications where an absorption chiller makes sense:

- **A commercial building in New YORK City where the absorption chiller runs from 8 a.m. to 8 p.m., Monday through Friday, April to September.**
- **A hybrid application where the absorption chiller runs during the day and the electric centrifugal chiller runs during the night.**

In the example shown here, the direct fired chiller saves $75,000 in annual operating costs, while the double effect steam saves $100,000. Savings from the single effect chiller aren't as high. While this example by no means represents every application, you can see that the myth of absorption chiller inefficiency is busted.

Example: 1. Average US City, Process Cooling Application, 500 Cooling Tons

2. Electricity $0.15/kWh, Natural Gas $5/MMBTU, Steam $4 per 1,000 lb (450 Kg)

	Electric Centrifugal Chiller	Direct Natural Gas Fired Absorption Chiller	Double Effect Steam Absorption Chiller	Single Effect Steam Absorption Chiller
Chiller COP	6.5	1.2	1.4	0.7
Chiller Cost of Operation (Input Energy)	$ 253,714	$ 169,451	$ 135,181	$ 235,513
Plant Cost of Operation (Chiller + Pumps + Tower)	$ 330,330	$ 256,071	$ 222,152	$ 316,044

Myth 2: Absorption chillers are expensive.

Fact: In the right applications, they can deliver the highest payback.

Let's use the numbers from Myth 1 to calculate simple payback for the different chiller types. As the chart below shows, considering utility costs and the availability of waste heat may reveal that absorption chillers are ultimately the most cost-effective option. Look at these factors as well as initial capital expense and COP—and see that the cost myth is busted.

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Myth 3: Absorption chillers have rigid operating requirements.

Fact: Flexibility has increased dramatically in recent years.

Chances are you've heard that absorption chillers must always operate at the design point, closer to the full load. That you shouldn't mess with flow rates. That chilled water leaving temperature must be above 44°F/7°C, and entering condenser water close to the design temperature, typically 85°F/29.4°C.

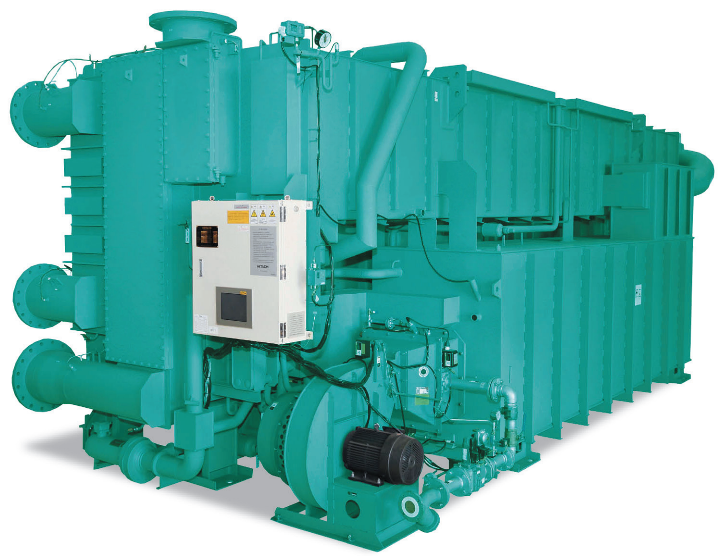
Things have improved a lot in the last 25 years. Here's the reality:

- **Water flow rate can be changed at 5% per minute.**
- **Units can be designed with varying flow rates, in a wide range.**
- **There's no issue with turndown from 100% to 10% cooling load.**
- **Entering condenser water temperatures can be as low as 68°F/20°C.**

It's true that absorption chillers have slower response times due to the inertia of the lithium bromide solution. And the temperature of entering condenser water must be 68°F/20°C or higher, no matter who makes the absorption chiller, while electric chillers can handle temperatures down to 55°F. Electric centrifugal chillers certainly respond better to fluctuating loads and faster to issues such as power loss, making them a sound choice for mission-critical applications such as data centers.

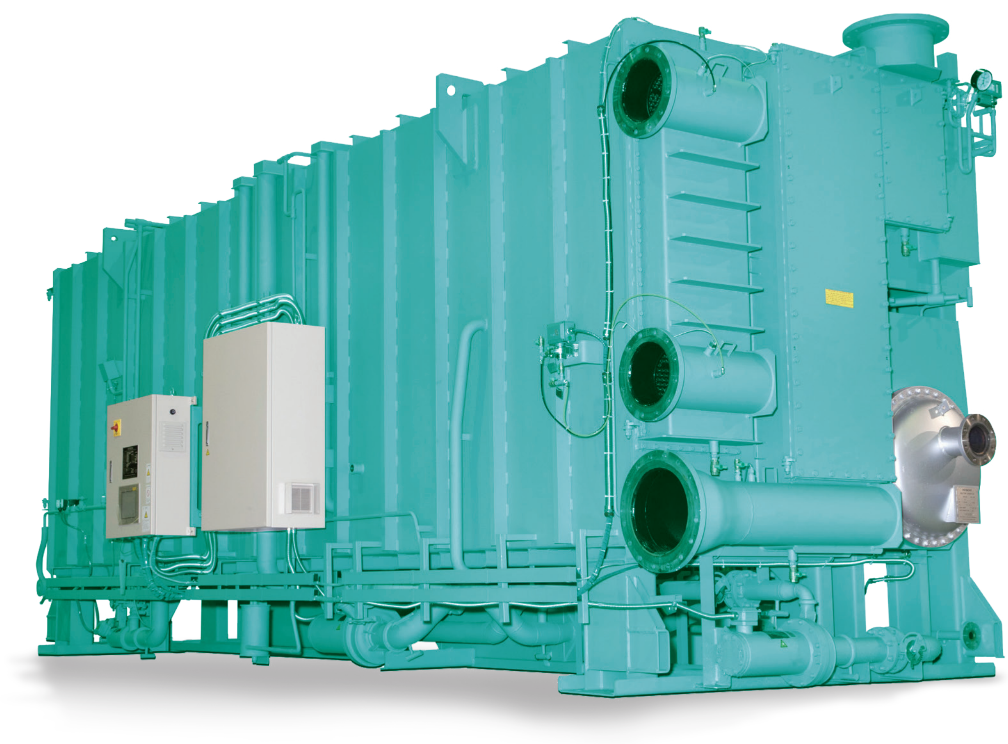
Even so, operating flexibility for absorption chillers has dramatically improved over the last several years. Lithium bromide water-based cycles can now achieve low leaving evaporative temperatures from 34°F/1°C down to 23°F/-5°C—which is perfect for dairy and brewery applications.

The use of absorption chillers on passenger vessels further illustrates the technology's evolution. Absorption chillers successfully overcome the vessel's rolling, pitching and tilting, demonstrating true operating flexibility. If it can be done on the ocean, it can be done on land!



The example below shows a 1000-ton unit with varied condenser water flow rates. As we move from 4 gpm to 2 gpm per ton, the unit maintains a COP of 1.4 with no change in the model number. Check whether your manufacturer provides this capability.

Condenser Flow	4 gpm/ton (0.9 m3/hr/ton)	3 gpm/ton (0.68 m3/hr/ton)	2 gpm/ton (0.45 m3/hr/ton)
Capacity (tons)	1000	1000	1000
Chilled Water Inlet/Outlet	12.2/6.7°C 54/44°F	12.2/6.7°C 54/44°F	12.2/6.7°C 54/44°F
Condenser Water Inlet	29.4°C 85°F	29.4°C 85°F	29.4°C 85°F
Condenser Water Outlet	35.1°C 95.1°F	37.1°C 98.8°F	41.1°C 106°F
Pressure Drop	58 kPa 19.4 ft wc	42 kPa 14 ft wc	20 kPa 6.7 ft wc
COP*	1.42	1.40	1.36



Myth 4: Absorption chillers are not reliable.

Fact: Properly designed units prevent crystallization.

People considering absorption chillers are especially concerned about the crystallization of lithium bromide, a salt similar to table salt. When lithium bromide is fully dissolved in water, overheating or overcooling can cause it to crystallize. While chiller controls can prevent overheating/overcooling, **crystallization is most commonly caused by low-temperature entering condenser water.**

Suppose a chiller is working at full load and has non-condensable gases, perhaps due to low inhibitor levels. The cooling tower temperature control is lost, and the unit moves toward the crystallization zone.

The table below shows how salt solution concentration values relate to crystallization temperature. (A 57% solution has 57% salt and 43% water. A 60% solution has 60% salt and 40% water.)

If the solution temperature drops below the values shown, the solution crystallizes. Just a three percent difference in salt content has a huge impact on the temperature at which crystallization occurs. Even a change of .5% to 1% makes a big difference.

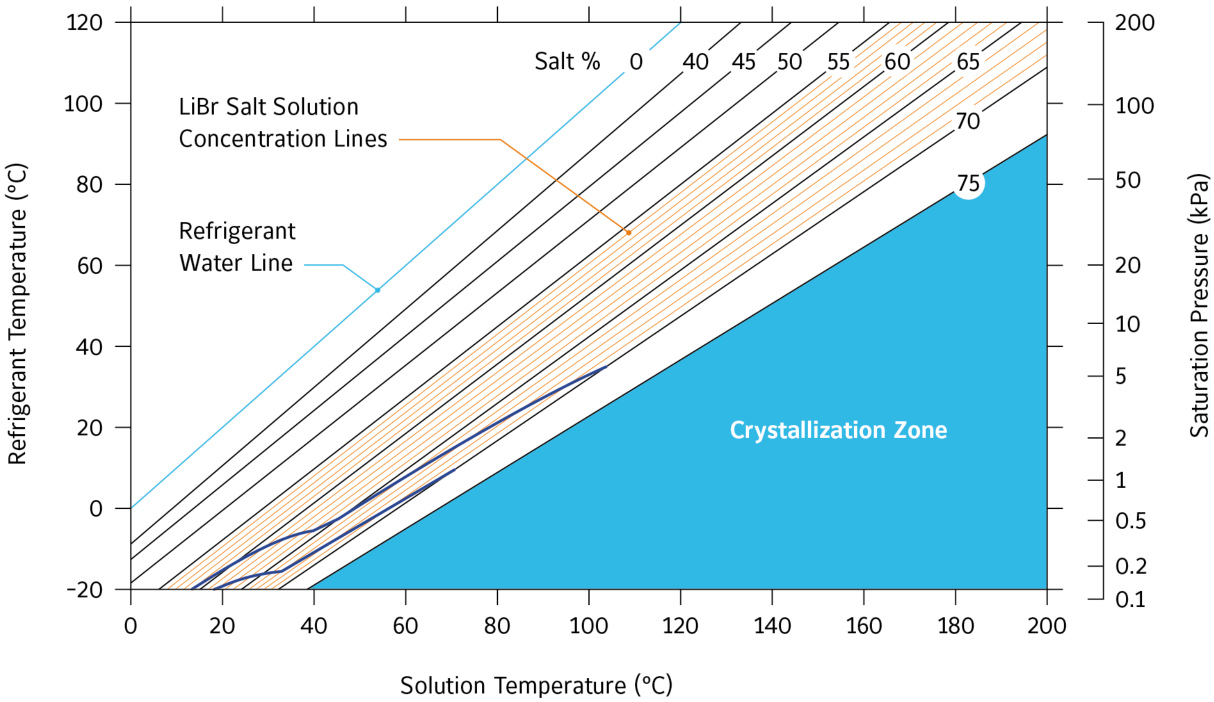
The risk of crystallization is always high at full or near-full load, and significantly reduced at part load. **The lower the salt percentage, the better—because that means the crystallization temperature is lower.**

Again, lower-temperature entering condenser water is what causes a lower solution temperature—and that principle directly affects chiller design. For example, a 57% solution has a crystallization temperature of 26.6°F/-3°C. That's not possible in real life, because water entering from the cooling tower cannot drop to such low temperatures. However, if the same unit is designed with a high absorber entering concentration, such as 63.5%, the table shows a crystallization temperature of 78.8°F/26°C. This temperature is entirely possible in day-to-day operation, particularly if the temperature of condenser water entering from the cooling tower into the absorber section is poorly controlled.

Salt % in Solution	54%	57%	58%	60%	61.5%	63.5%
Crystallization Temperature	-16.1°C (3.02°F)	-3°C (26.6°F)	0.9°C (33.6°F)	10.5°C (50.9°F)	18°C (64.4°F)	26°C (78.8°F)

In the PTX diagram below—the Duhring Diagram, named after the German scientist who invented it—the X and Y axes and slanting lines represent a combination of pressure, temperature and concentration.

Duhring Diagram - Pressure Temperature Concentration



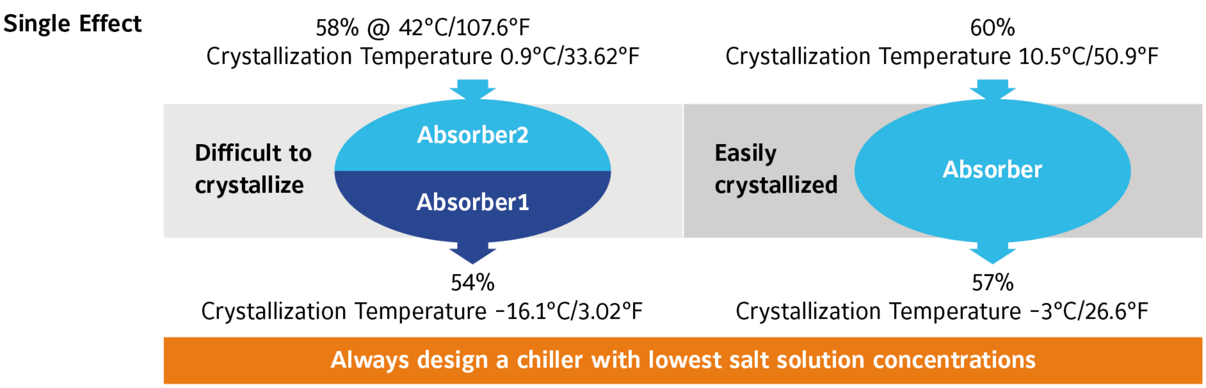
The lithium bromide solution entering the absorber is the line most prone to crystallization. This is referred to as the absorber spray line. To the right is the crystallization zone. The farther the distance from the crystallization zone, the better.

To achieve maximum distance from the crystallization zone, the unit should be designed to minimize the solution concentration. Less salt, more water. That makes the solution easier to boil; we don't need to heat it to a very high temperature. Lower temperature also means lower corrosion, increasing reliability and extending equipment life.

So, low pressure, low temperature and low concentration provide excellent protection against crystallization and corrosion. Don't count on sophisticated controls to keep you out of the danger zone. The unit should be intrinsically designed so that even if the controls aren't working, the solution won't crystallize.

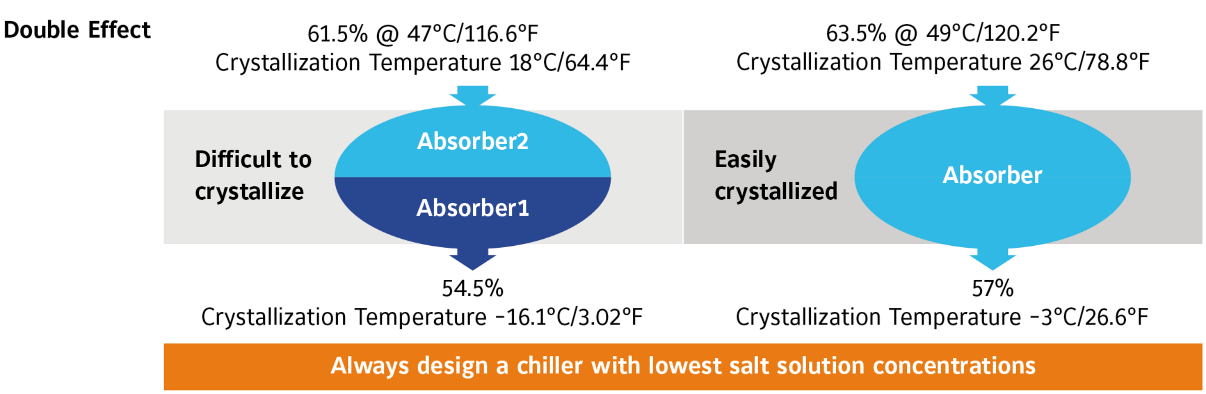
Example: Single Effect Absorption Chiller

The modern unit on the left is designed with a lower-concentration salt solution entering and leaving the absorber (note: values are drawn from actual use). The conventional unit on the right is designed with relatively high lithium bromide concentrations. The crystallization temperatures make it clear that the unit on the left is far less likely to crystallize than the unit on the right. Less salt, more water!



Example: Double Effect Absorption Chiller

A double effect chiller typically operates with higher pressure, temperature and concentrations than a single effect, or single state, chiller. As in the previous example, the unit on the left is designed with lower-concentration salt solutions, providing the best protection against crystallization. The "small" half percent or 1% difference in salt solution makes a big difference for the conventionally designed unit on the right. Controls are important—but design makes the difference.



Benefits of Absorption Technology

Absorption cooling technology offers significant advantages:

- **It's truly sustainable, driven by waste heat or low-cost heat, with eco-friendly water as a refrigerant.**
- **Maintenance is relatively minimal, primarily requiring qualified service representatives to analyze vacuum water quality on the condenser water side and the lithium bromide solution once or twice a year, depending on hours in operation.**
- **This technology is proven across a full range of applications: small, medium and very large; commercial, industrial and district cooling.**

It's true that absorption chillers tend to have a larger footprint and higher heat rejection to the cooling tower. The latter is especially important if an electric chiller is being replaced by absorption, or an absorption chiller is being added to the plant room. Equally important, ensure any service personnel working on the unit are qualified in absorption chillers. Troubleshooting differs from that for an electric chiller or boiler. Knowledgeable staff can speed the process.

Absorption chillers are common in Europe and the Asia Pacific and being seriously considered in the Middle East and Latin America. As the U.S. and Canada see lower natural gas costs and a greater focus on sustainability, absorption chiller use is likely to grow.

Key Advantages

1 Water as the refrigerant (zero ODP/GWP)

2 Driven by waste heat or low-cost natural gas

3 Operates under vacuum; quiet, with few moving parts

4 Negligible electric consumption; not reliant on the grid

5 Helps reduce emissions as well as electric and water costs

6 Well-established over 75 years

7 Thousands of commercial, industrial and marine applications

Conclusion

It's time to dispel the myths surrounding absorption chiller technology and reveal the facts. These chillers are reliable, flexible and sustainable. They offer a quick economic payback where electric costs are high. The key is to look beyond academic COP and initial costs. Weigh all the factors discussed above, and you may well discover that the most efficient, cost-effective choice is indeed an absorption chiller.

Visit **www.YORK.com/absorption-chillers** to learn more about our absorption chillers, features and benefits.