Glossary of Terms

Approach — Temperature difference between the leaving fluid and the evaporating refrigerant

ARI Standard Conditions — 54°F. water inlet; 44°F. water out;
35°F. refrigerant; 0.00025 additive fouling factor

Flow Rate or velocity — Speed at which the fluid travels through the evaporator.

Fouling — Dirt and scale build up that impedes heat transfer.

One Ton — 12,000 Btu/hr

Pressure Drop — Difference in pressure between the incoming and leaving fluid pressures.

Range — Temperature difference between the entering warm fluid and the leaving cooled fluid.

Specific Gravity — A measure of the density of a fluid compared to water.

Specific Heat — A measure of a fluid's ability to absorb and transport heat.

Superheat — Extra heat carried by the refrigerant after it has changed from a liquid into a gas.

Thermal Conductivity — A measure of the potential rate of heat transfer.

Viscosity — A measure of the ability of a fluid to flow.
Refrigeration Cycle

Refrigeration is defined as a process of removing heat from an enclosed space or material, and maintaining that space or material at a temperature lower than its surroundings. Cold and hot are relative terms that are not generally used when sizing heat transfer equipment. Objects and space being refrigerated become relatively colder and colder (or less and less hot) as heat is removed.

Removal of heat lowers temperature and may be accomplished by the use of ice, snow, chilled water, or mechanical refrigeration. Mechanical refrigeration can be defined as an arrangement of components in a system for the purpose of transferring heat.

Refrigerant is one of the key components that makes mechanical refrigeration work. A refrigerant is a chemical compound that is alternately compressed and condensed into a liquid, and then permitted to expand into a vapor or gas as it is pumped through the mechanical refrigeration cycle.

This cycle is based on the physical principle that a liquid extracts heat from the surrounding area as it expands ( boils) into a gas.

Refrigerants like Ammonia, R–134A, and R–22, are circulated through the system by a compressor, which increases the pressure and temperature of the vaporous refrigerant and pumps it into the condenser. In the condenser, refrigerant vapor is cooled by air or water until it condenses into a liquid.

The liquid refrigerant then flows to the flow control device, or expansion valve, where flow is metered and the pressure is reduced, resulting in a reduction in temperature. You can understand this concept if you think of carbon dioxide as a natural refrigerant. When CO₂ is released from a high pressure fire extinguisher cylinder to atmosphere, it cools forming ice crystals, just like a halocarbon refrigerant, but less efficient.

After the expansion valve, refrigerant flows into the lower pressure evaporator, where it boils by absorbing heat from the space being cooled, and changes into a vapor.

The cycle is completed when the compressor draws the refrigerant vapor from the evaporator and, once again, compresses the gas so that the cycle can continue.

Chiller Barrels

Most Standard catalog models are direct-expansion. In direct expansion, the refrigerant evaporates inside the tubes as the medium to be cooled flows through a baffled course on the outside of the tube bundles. The baffles assure proper mixing and increase heat transfer. The other common heat exchange barrels are flooded chillers and water-cooled condensers.
There are distinct differences in operation between direct-expansion chiller barrels, flooded chiller barrels, and water-cooled condensers. All are specialized heat exchangers that operate by removing heat from one fluid and transferring it to another. The difference is in the location of the water, and whether the refrigerant is changing state from a liquid to a gas, or from a gas to a liquid.

**DX Chiller**

Direct-expansion chiller barrels are described by the number of refrigerant circuits, refrigerant passes, and their capacity.

A single-circuit chiller has one refrigerant inlet and outlet. A dual-circuit has two refrigerant inlets and two outlets. Each circuit can be used for two separate but similar loads. There’s also a quad-circuit, designed for four separate loads. Direct-expansion chiller barrels are also distinguished by the number of times that refrigerant passes back and forth within the length of the vessel. In a single-pass unit, liquid refrigerant enters at one end, passes straight through and leaves as a vapor in a single pass. In a dual-pass model, the liquid refrigerant must go down and back the length of the chiller before it exits as vapor. Refrigerant enters and exits at the same end of the chiller when the number of passes is even, and at opposite ends when the number of passes is odd.

**Flooded Chiller**

The other commonly found type of chiller barrel is the flooded style. In the flooded chiller, water travels through the tubes and transfers its heat to a boiling refrigerant bath that covers 1/2 to 3/4 of the tube bundle. Flooded chillers, commonly used in low temperature ammonia applications, can be ordered on special request from Standard.
Water-Cooled Condensers

Standard’s other major heat exchanger line, the water-cooled condenser, is arranged in a manner similar to the flooded chiller, except that cool water traveling through an externally finned tube removes heat from condensing refrigerant vapor outside of the tube, producing liquid refrigerant at the bottom of the condenser shell.

Performance Factors

Selecting the right chiller barrel or water-cooled condenser for a particular application depends on the same basic performance factors.

The factors are: flow rates or velocity, pressure drop, fouling, types of fluids (refrigerants, as well as cooling fluids), and temperature differential or TD.

There are also some terms to know which refer to special temperature differentials. They are: range, approach, and superheat.

New Terms

Range
Approach
Superheat

Range

Range is the difference between incoming and outgoing water or fluid temperature. It is the temperature difference across the chiller.

Approach

Approach is the temperature difference between the leaving water or fluid and the evaporating refrigerant temperature.
Standard measures evaporating temperature as the saturated equivalent temperature to the refrigerant outlet pressure, a method that takes into account pressure drop in the barrel. This is a conservative method of ensuring the capacity claimed.

Performance is governed by both range and approach, especially when sizing at other than nominal or American Refrigeration Institute conditions.

Here's an example of the dramatic influence of approach temperature on sizing. A Standard TX-10 at a 10°F range has 9.5 tons capacity at a 8.7°F approach, but can handle 13.4 tons when the approach is increased to 12°F. That is a 30% performance increase.

As a general rule, every one-degree change in Approach is approximately equivalent to a 13% difference in chiller barrel capacity.

In spite of the dramatic increase in capacity, there are good reasons to limit approach. For one, high approaches can risk costly freeze-up damage. Evaporating temperatures below freezing can destroy a chiller barrel, unless it is protected by a freezestat, flow switch, low pressure cut-off, or special fluids like glycols and brines.

Secondly, as the suction temperature and evaporating temperature are lowered, the capacity of the compressor is reduced, lowering the amount of refrigeration available in the system.

**Superheat**

Superheat is the extra heat that is carried by a gas after it has changed from a liquid into a gas. Steam at a temperature greater than 212°F Fahrenheit is a good example of a super-heated gas. Super-heating occurs in a refrigeration system when refrigerant gas in the evaporator tubes and suction line continues to absorb heat after it has undergone its change of state from liquid to vapor. The presence of some superheat is beneficial, since it is proof that the refrigerant has completely evaporated and that no liquid refrigerant is left in the line to slug back to the compressor.

Standard Refrigeration sizes chillers to meet the ARI standard of a minimum 7°F superheat. Some other manufacturers use virtually zero degrees of superheat to boost the apparent rated capacity of their units. Higher superheat ratings reduce the overall rated performance of a chiller, since tubing that could carry efficient heat absorbing liquid refrigerant is now dedicated to less efficient refrigerant vapor.

Manufacturers that reduce superheat ratings below the ARI standard of 7°F gain chiller barrel economy, but increase the danger of liquid slugging. Low superheat ratings increase the need for a suction line accumulator or a suction line heat exchanger to protect the compressor from severe damage.

Let's review the other five factors that affect performance, flow rates or velocity, pressure drop, fouling, types of fluids, and temperature differential or TD.

### Performance Factors

- Flow Rates or Velocity
- Pressure Drop
- Fouling
- Types of Fluids
- Temperature Differential
Flow Rates
Water flow rates (velocity) in a chiller barrel must be held to 4\(\frac{1}{2}\) feet per second to avoid impingement corrosion damage. All Standard selection recommendations in our literature are under 4\(\frac{1}{2}\) feet per second.

Pressure Drop
Pressure drop is the difference between the entering and leaving water pressure. The pump capacity must be great enough to overcome the combined pressure drop across the chiller barrel and piping. Choose another model unless you’re sure that your pump has the capacity.

Fouling
Fouling is scale or foreign material build-up that reduces heat transfer. Most packaged chillers for air-conditioning have sealed loop systems. There is little opportunity for fouling within the chiller barrel, because the cooling fluid is sealed from external environmental factors. Process chillers in plastics molding and other industrial applications often have open chilled water tanks or open processes where the water can foul badly and added capacity must be available to compensate for the fouling.

Standard rates its chiller barrels with an additive fouling factor of 0.00025 (0.0005 total).

Types of Fluids
Fluid types and refrigerants can vary, depending on the application. The most common fluids are water, ethylene glycol, propylene glycol, and brine solutions.

Fluids are the gasses or liquids that exchange heat in heat transfer. Fluids other than water can be considerably less efficient and have a substantial effect on the sizing of a chiller. Special chiller designs may be required if glycols are used to prevent freeze damage in low temperature applications.

The refrigerant itself must be taken into consideration. Standard’s cataloged capacity data is based on R-22. However, information for other refrigerants, including R-502 and ammonia, are readily available from the factory or sales representative.

The major fluid characteristics that affect chiller performance are Specific Heat, Specific Gravity, Viscosity, and Thermal Conductivity.

Fluid Characteristics

- **Specific Heat**
- **Specific Gravity**
- **Viscosity**
- **Thermal Conductivity**

**Specific Heat**
Specific Heat is a measure of the ability of a fluid to absorb and transport heat. The specific heat value of water is 1.0. Glycols and brines used in many low temperature process cooling applications have lower specific heat values than water and are less efficient. The greater the percentage, the lower the specific heat.

**Specific Gravity**
Specific gravity is a measure of the density of a fluid as compared to water. As the specific gravity increases, the ability of a fluid to absorb and hold heat also increases. The specific gravity of water is 1.0. Most glycols and brines have specific gravities greater than one.

**Viscosity**
Viscosity is a measure of the ability of a fluid to flow. It is measured in a unit called centipoise. The viscosity of water at 67° Fahrenheit is 1.0 centipoise, and varies only slightly with temperature. Other fluids, like glycols, may have much higher viscosities that change considerably with temperature. This can result in unacceptable pressure drops at low temperatures and reduction in capacity.
Thermal Conductivity

Thermal Conductivity is the fourth fluid factor that can affect performance. It is related to the potential rate of heat transfer across a temperature differential for a fluid. The thermal conductivity of pure water at 44° Fahrenheit is 0.338, while a 30% solution of ethylene glycol at the same temperature is 0.256.

It is always best to consult with your Standard sales representative for fluids other than water. Standard has complete data on ethylene and propylene glycols, as well as sodium and calcium brines. If you are dealing with a more exotic fluid, try to have the specific heat, specific gravity, viscosity, and thermal conductivity ready when you call Standard for help with your selection.

Materials

Remember that most stock chiller barrels contain copper tubes; therefore, ammonia refrigerant or chloride brines cannot be used. Cupronickel construction should be specified for chloride brines. Carbon or stainless steel should be specified for ammonia applications. Be sure to consult the factory for a special selection if you have any questions.

Sizing

Sizing by Nominal Tons

There are three basic selection methods you can use to size a chiller. The first and easiest is to size by nominal systems tons. The second method is to use compressor capacity. The third and recommended method is sizing by range, flow and approach.

Sizing by nominal tons is done according to ARI standards. Chillers can be selected on a nominal system tons basis, as shown in the catalog, or reflected in the model name. For example, an TX–50–2 is a nominal 50 ton dual-circuit barrel.

Nominal ton ratings are based on the conditions of ARI Standard 480 utilizing R–22, which are:

- 54°F water in
- 44°F water out
- 35°F refrigerant temperature
- 7° superheat
- 0.00025 additive fouling factor (0.0005 total)
- 100°F liquid refrigerant entering the flow control

This method is reasonably accurate for sizing air-conditioning systems. However, it is not recommended for evaporating temperature below 34°F, or when the fluids used are other than water and R-22.
Sizing by Compressor Capacity

You may also size by compressor capacity. Compressor manufacturer performance curves of compressor Btu per hour data can be used to select chiller barrels for a given system. By reading the performance curve for the compressor at the conditions that you require, you can determine the maximum capacity of the chiller barrel you will need.

Sizing by Range and Flow

The most precise way to size a chiller barrel when water is used is by range and flow, as seen in this formula.

\[
 \text{Btu/hr capacity} = \text{Range} \times \text{gpm} \times 500
\]

To obtain the Btu per hour capacity, just multiply the Range or Temperature Drop by gpm flow, and convert to pounds of water per hour by multiplying by 500. The Btus can then be divided by 12,000 to yield the tons of load.

For example—

With an incoming water temperature of 55°F, outgoing water temperature of 45°F, and a 479 gpm water flow. Btu capacity can be calculated like this:

\[
(55° - 45°) \times 479 \text{ gpm} \times 500 = 2,395,000 \text{ Btu/hr}
\]

\[
2,395,000 \text{ Btu/hr} \div 12,000 \text{ Btu/ton} = 199.5 \text{ tons}
\]

Standard’s sales catalog is designed to make your selection job easy after you have determined the cooling load. Once fluid range has been determined, locate the table for that range. If no table exists, use the next lowest range.

Next, locate an acceptable approach at the top of the table and read down the tons column to the capacity that is adequate for the job.

The water pressure drop in psi is listed to the right. To determine gpm multiply tons by the gpm factor at the bottom of each range chart.

In this case, an FSX–150 will provide the duty at a 10° range and 11° approach with a 34° suction.

In cases where the fluid being cooled is other than water, capacity can be determined by adding the specific heat and specific gravity into the equation:

\[
\text{Btu/hr} = \text{Range} \times \text{gpm} \times 500 \times \text{Sp Heat} \times \text{Sp Gravity}
\]

This equation will give you the capacity required, but chiller selection should be made by your factory representative since the fluid is not water.

All of Standard’s rating data is based on ARI standards, a suction temperature of thirty-five degrees, using water as the fluid. Contact your local Standard representative for special fluid conditions.

All heat exchangers have capacity limits. Careless sizing of chiller barrels leads to needless performance problems.

Undersizing can lead to insufficient cooling and inefficient compressor operation.

Oversizing can lead to control valve hunting, poor performance, oil logging, and refrigerant slugging.