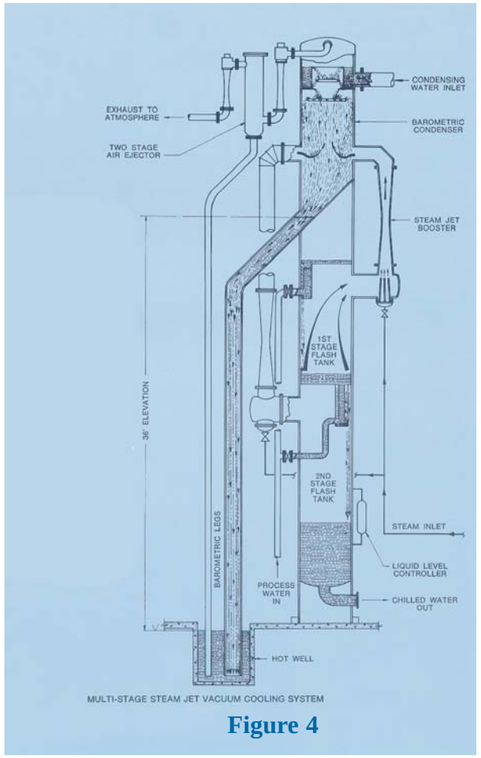

Figure 4

EQUIPMENT ARRANGEMENT

In figure 4 we see the condenser and flash tank arranged in a self supporting tower bolted to a concrete foundation - no supporting steel work is necessary. When a tower can be stayed from another building the construction can be much lighter.

This arrangement is low in first cost for systems of 100 ton or higher.

When a surface condenser is used instead of a barometric the condenser is usually installed at grade and the tower is not as high.

If water is to be chilled through only a small range of temperature a multistage system does not offer much saving and the flash tank can be horizontal and parallel to the condenser.

In units of less than one hundred tons the equipment is smaller and lighter and can be mounted on the roof of a building or inside a building.

MAKE UP WATER

When the chilled water is circulated through a closed loop system, make up water must be added to take the place of the water evaporated.

Steam condensate is preferable as it does not add any solids to the system.

The amount of condensate added can be controlled by a liquid level controller mounted on the flash tank.

steam jet vacuum ejectors steam jet thermo-syphons hydro jet ejectors
vacuum refrigeration venturi desuperheaters fume scrubbers
thermo compressors barometric and surface condensers
process vapor power jets mixing jets draft inducers
hybrid steam jet vacuum systems

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73 Pond Street, Waltham, MA 02451-4594

Since 1934 Artisan experts have led the way, providing integrated solutions to the most challenging separation problems. We combine an innovative approach with an unparalleled depth of knowledge to develop cost effective, practical solutions. Designed and built to exacting standards, our powerful technologies have enabled us to succeed where our competitors have failed. That is why the Artisan name is synonymous with unrivaled product quality and level of service

ARTISAN INDUSTRIES INC.

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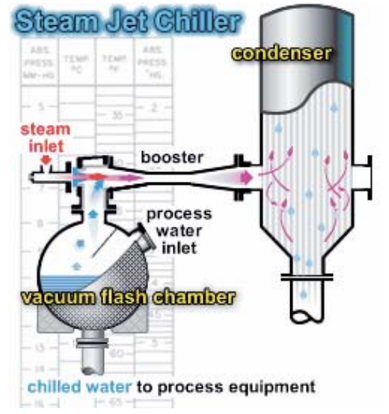
JET-VAC® uum Cooling

One of the simplest, most reliable, and economical ways to chill liquids and solids.



ADVANTAGES

- Very reliable, NO MOVING PARTS
- No electricity required
- Very low maintenance, especially with a barometric condenser
- Low operating cost - uses waste or low cost steam
- No chemical refrigerants
- Low noise
- Few spare parts needed in inventory

Operation

- A steam jet ejector creates a vacuum in a chamber
- Process water flows into this vacuum chamber where it boils at the temperature determined by the vacuum level
- Approximately 1060 Btu of liquid cooling occurs for each lb. of water evaporated
- The steam jet ejector compresses the water vapor to an absolute pressure where it can be condensed by the available cooling water

Figure 1

ABS. PRESS. MM-HG	TEMP. °C	TEMP. °F	ABS. PRESS. "HG.
5		35	.2
6	5	40	.25
7		45	.3
8			
9	10	50	.35
10			.4
11		55	.45
12			
13	15	60	.5
14			
15		65	.6
16			
17	20	70	.7
18			
19		75	.8
20			.9
25	25	80	1.0
			1.1
30	30	85	1.2
			1.3
35		90	1.4
			1.5
40	35	95	1.6
			1.7
45			1.8
		100	1.9

JET-VACuum Cooling

One of the simplest, most reliable, and economical ways to chill liquids and solids.

Many plants do not have the abundant natural supply of cool water required for their processes, particularly during hot seasons. In such instances a JET-VACuum cooling system can produce the required quantity of cool water needed for the most efficient operation of a specific process at temperatures from ambient to freezing. JET-VAC cooling - all done by vacuum - has a wide variety of industrial applications, when processing liquids solids, and even heat sensitive materials.

For example, at high temperatures food products would burn and chemicals would decompose. That's why milk is evaporated at about 140°F and orange juice at about 60°F, and chemicals are processed at temperatures determined by the nature of the solvent used.

Many materials may be processed by JET-VACuum cooling. Sugar solutions can be cooled and concentrated at the same time. Leafy vegetables, fruits, corn mash, cottage cheese, can all be cooled by evaporation of part of the moisture inherent in the product.

In principle, any product having surface moisture can be cooled by evaporation. But by far, the majority of installed systems are used for cooling water.

Figure 1 shows the relation between boiling temperatures and corresponding absolute pressures for water.

A JET-VACuum cooling system has all the simplicity and reliability of a steam jet ejector. It is low in first cost and inexpensive to operate. It has no moving parts and requires almost no maintenance.

CONTINUOUS VACUUM COOLING SYSTEM

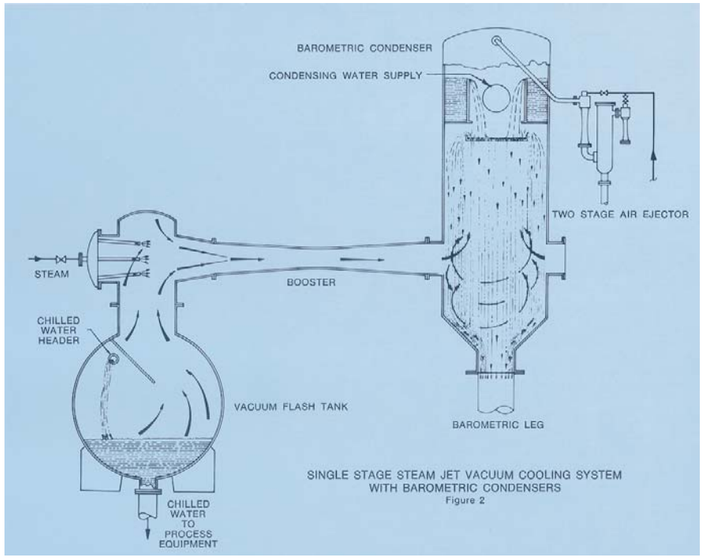
Figures 2 and 3 show simple single stage cooling systems. An absolute pressure corresponding to the desired chilled water temperature is maintained in the flash tank.

Water to be chilled enters the flash tank continuously and a small portion is evaporated. It takes about 1060 BTU/lb to evaporate water and the removal of this much heat with the vapor cools the liquid until its temperature comes to equilibrium with the absolute pressure (Figure 1).

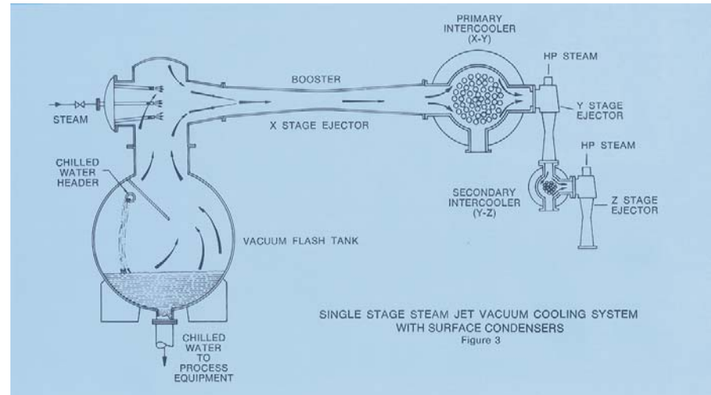
The vapor is compressed by the steam jet booster to an absolute pressure where steam and vapor can be condensed with the available condensing water supply.

A two stage ejector then compresses the air leakage saturated with water vapor, up to atmospheric pressure. The amount of steam used by the air ejector is very small compared to the amount of steam used by the booster.

The chilled water is pumped from the flash tank and circulated to the process, in either a closed or open system.



SINGLE STAGE STEAM JET VACUUM COOLING SYSTEM WITH BAROMETRIC CONDENSERS
Figure 2



SINGLE STAGE STEAM JET VACUUM COOLING SYSTEM WITH SURFACE CONDENSERS
Figure 3

BATCH VACUUM COOLING

Figures 2 and 3 may also be used as examples of batch vacuum cooling. The flash tank is partially filled with liquid to be cooled.

The liquid is in equilibrium with the vapor at all temperatures. Thus a large part of the heat is being taken out at the higher temperature instead of all of it being taken out at the lowest temperature.

For good equilibrium the flash tank needs to be furnished with an agitator of some sort to keep the liquid turning over, otherwise the cooling is not as efficient.

MULTISTAGE CONTINUOUS CONDENSER

When water is cooled through a large range of temperature such as 80° to 40°F it is possible to effect a considerable utility saving by using a multistage flash tank. Fig. 4 shows a 2-stage system where two flash tank compartments are stacked one above the other in the same shell as the barometric condenser.

The water to be chilled flows from one compartment to the other by gravity and is cooled in successive stages. Instead of all the heat being removed at 40° a portion is removed at 56°, the intermediate temperature. This reduces the size of the flash tank and economizes on steam.

BAROMETRIC VS. SURFACE COOLING

In the direct contact barometric condenser the vapor to be condensed comes in direct contact with water under vacuum.

The absolute pressure that can be maintained will correspond to a temperature of 3° to 5° F warmer than the condensing water outlet temperature. This terminal difference depends on the temperature rise of the condensing water and the amount of non-condensable present. The lower the absolute pressure in the condenser the less the amount of steam required to operate the steam jet booster. When a barometric condenser is mounted 36' in the air, the water will drain down the barometric leg into a hot well and no pump is necessary.

A system of this sort is virtually fool proof. It has no moving parts and can be run for years with very little attention.

Units of small tonnage are easily mounted on the roof of a building. Large units can be made self-supporting (Front Page photos).

A barometric condenser can be mounted at low level provided the condensing water is pumped out of the condenser.

With a surface condenser the steam is usually condensed outside of the tubes and the cooling water circulated through the tubes (Figure 3).

This is more expensive initially than a barometric condenser but it is easily mounted at ground level using condensate removal pumps. The steam condensate is easily recovered and fed back to the boiler if the flashed vapor is not a contaminant. The surface condenser is not as efficient as the barometric and will not maintain as low an absolute pressure.

PARTIAL LOAD OPERATION

The capacity of each steam jet booster is fixed and cannot be changed by throttling the steam. The boosters can simply be turned on and off. Thus, in Figure 4, the upper booster can be shut off and the water to be chilled enters the lower compartment instead of the upper compartment.

With a horizontal flash tank the boosters operate in parallel instead of series and can be turned on and off as more or less refrigeration is required.

VERSATILITY OF JET-VACUUM COOLING

JET-VAC has pioneered in the manufacture of ejectors that run on fluids other than steam.

LOW PRESSURE EXHAUST STEAM

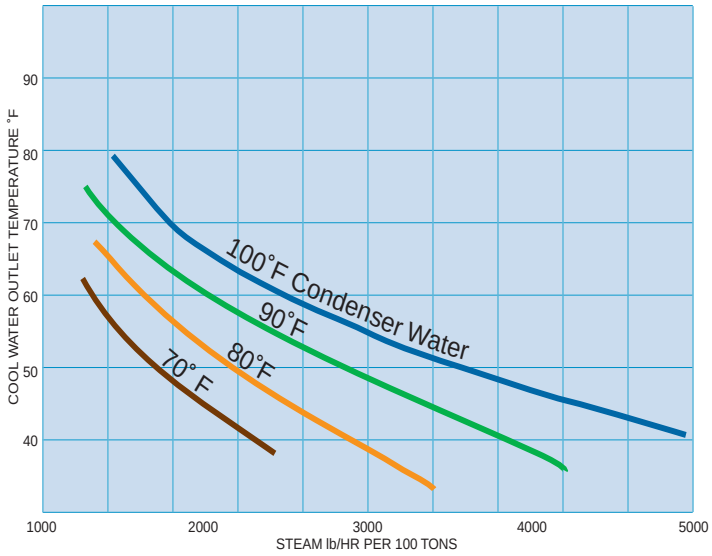
The boosters of a vacuum cooling system do not need to be operated on high pressure steam. Low pressure exhaust steam from a turbine or other source may be used. Boosters have been made to operate at 0 psig.

Of course, in this event a great deal more steam is required and also more water to condense the steam. The equipment must also be larger and more expensive. However, the low cost of the steam may offset these disadvantages.

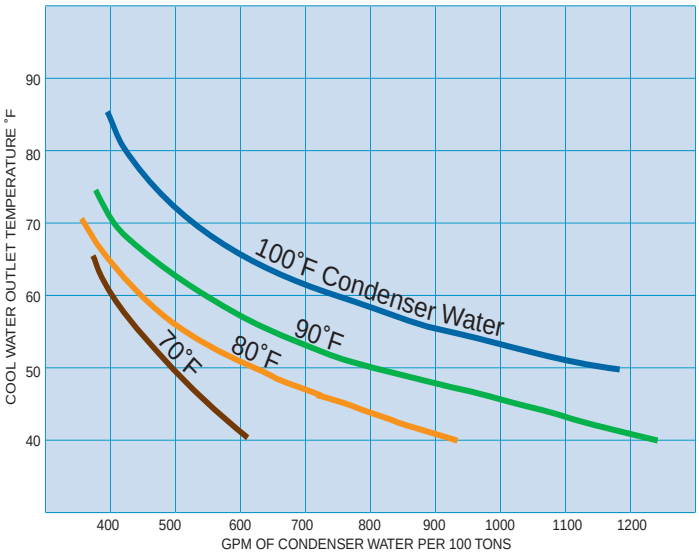
UTILITIES FOR ONE, TWO AND THREE STAGE COOLING WITH BAROMETRIC CONDENSERS*

2-stage ejector air pump steam consumption is included

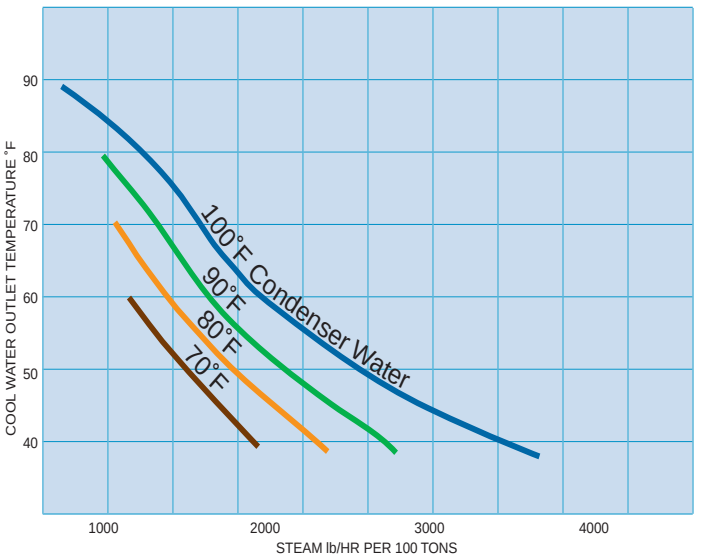
SINGLE STAGE VACUUM COOLING SYSTEM —100 PSIG STEAM



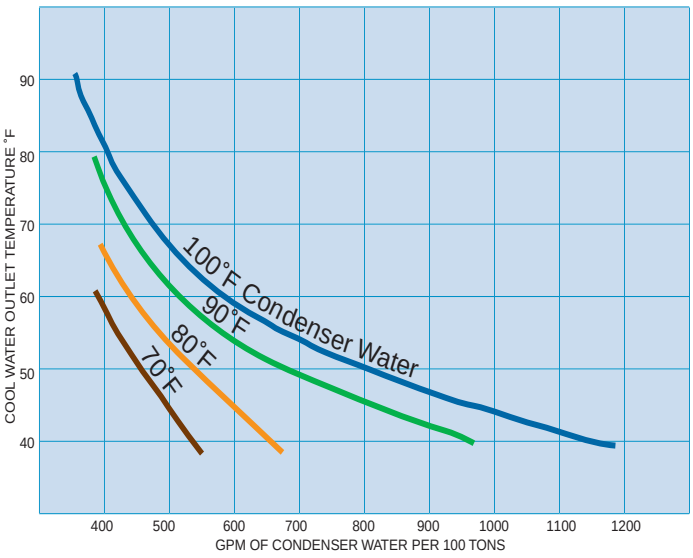
SINGLE STAGE VACUUM COOLING SYSTEM —100 PSIG STEAM



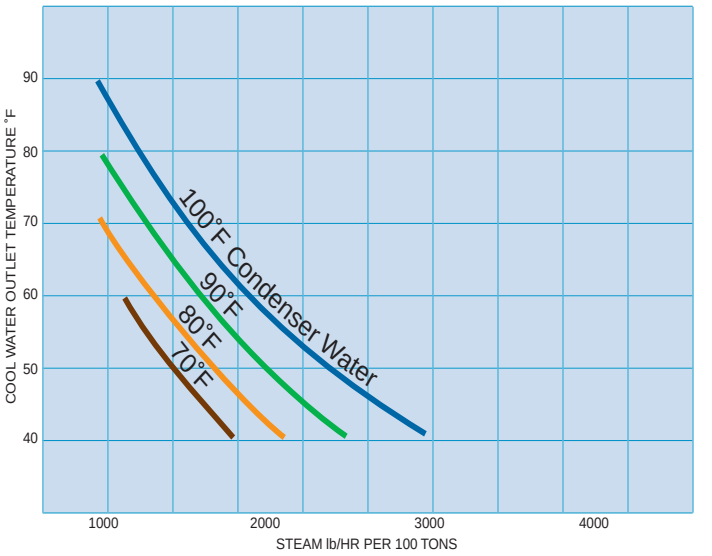
TWO STAGE VACUUM COOLING SYSTEM —100 PSIG STEAM



TWO STAGE VACUUM COOLING SYSTEM —100 PSIG STEAM



THREE STAGE VACUUM COOLING SYSTEM —100 PSIG STEAM



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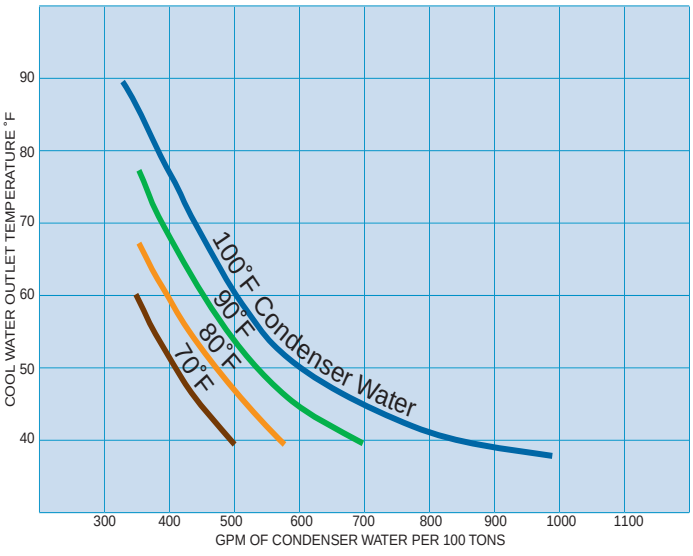
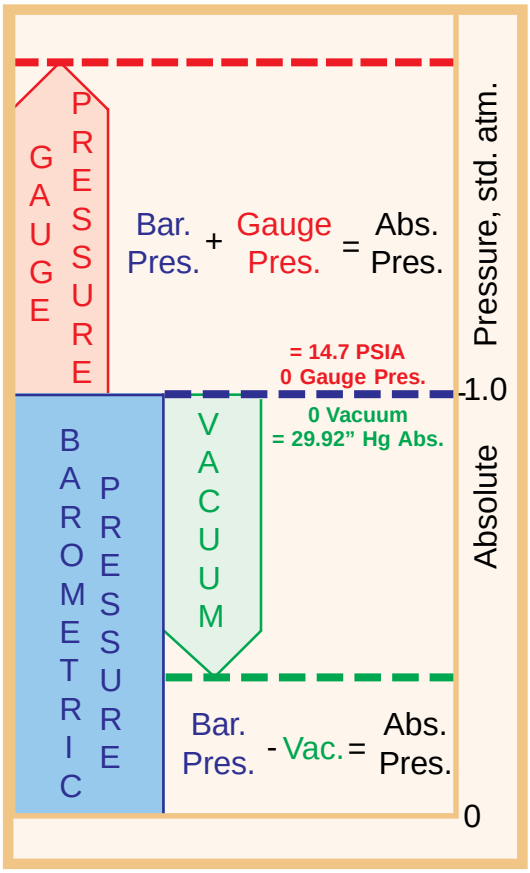


A ton of refrigeration is the amount of heat that must be removed from a ton of water to make a ton of ice in a 24 hr. day. 1 ton = 12,000 BTU/hr. As ther is about 1060 BTU/lb. removed from water to evaporate it, one ton equals about 11.3 lb/hr of evaporation.

*Steam consumption for surface condensers will be higher. Utilities shown are liberal. Call us for more exact figures.

Jet-Vac®

Practical Engineering Information



1.0 Standard Atmosphere (Std. Atm.) is equivalent to
14.7 psi
or 33.9 ft of H_20
or 29.921 in of Hg
or 760 mm of Hg
or 1.0332 kg/cm^2
or 101.325 Kilopascals (Kpa)
or 1.01325 Bars

Example Conversion

Convert 7.0 psi to Bars:

$$7.0\ \text{psi} \times \frac{1.01325\ \text{Bars}}{14.7\ \text{psi}} = 0.48\ \text{Bars}$$

# of Stages	Operating Suction Press. (Hg Abs.)	Closed Test Suction Press. (Hg Abs.)
1	3" and up	1½"-2"
2	10 mm - 4"	5 mm
3	2 -15 mm	1 mm
4	0.25 - 3 mm	50 - 100 microns
5	0.3 mm and less	5 - 10 microns

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