Chilling Maple Sap

Adam Wild, 2025

Benefits of Chilling Maple Sap

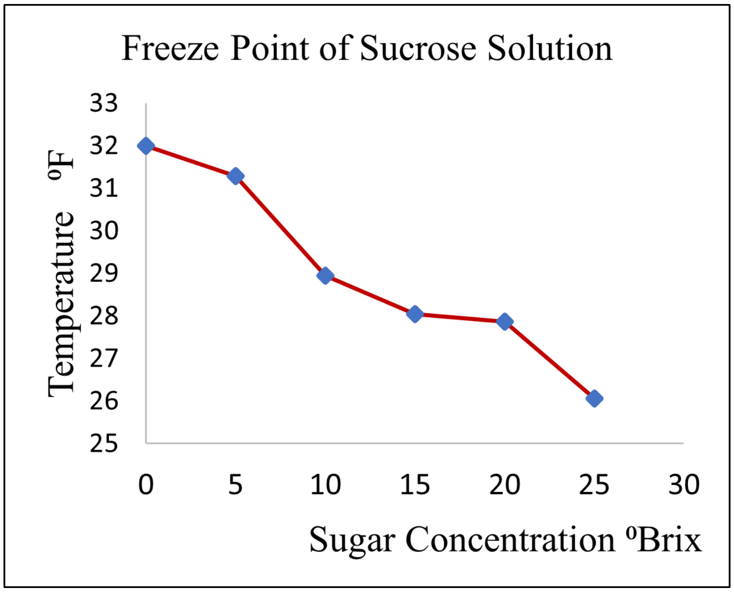

Figure 1. Freezing point of sucrose water solutions at different concentrations. Note that this is pure water and sucrose without minerals or other compounds. Data from Jayawardena et al., 2017.

As spring temperatures rise, microbial growth increases rapidly in sap collection systems. This growth degrades sap quality and can lead to spoilage. Poor-quality sap yields poor-quality syrup or sometimes must be discarded. Poor-quality sap complicates syrup production by clogging filters, plugging reverse osmosis (RO) membranes, and increasing foaming in the evaporator. Chilling sap helps preserve quality, enabling producers to store sap longer and process it when convenient. This flexibility is especially helpful for part-time producers and those managing large operations. Chilling also enables longer, more efficient boils. To make the most efficient use of storage space, it is recommended to chill concentrated sap which is more prone to spoilage than unprocessed sap due to its higher sugar content.

Concentrated sap chilled to just above the freezing point can been stored for over a week and still produce maple syrup with no quality degradation. There is limited information on how long chilled sap can be stored, but observational data has found no quality degradation for concentrated sap (20 °Brix) stored just above the freezing point for 10 days (Aaron Wightman, personal communication). It is best to store maple sap near, but not below, the freezing point. Concentrated maple sap has a lower freezing point than unprocessed sap. For example, the freezing point of maple sap concentrated to 25 °Brix is approximately 26 °F (Figure 1; Jayawardena et al., 2017). Concentrated maple sap stored in a chilling tank with agitation will often start to form a slush before it fully freezes.

Methods for Chilling Maple Sap

Refrigeration

Refrigerated milk tanks, used for keeping milk cool on a dairy farm, have seen limited installation in maple operations, but producers are increasingly considering their

Figure 2. Refrigerated milk tank

application. Refrigerated tanks utilize a compressor and condensing unit to pump chilled refrigerant through the chilling plates of a double-walled insulted tank. These tanks, if operational and sized correctly, can be effective for chilling maple sap or concentrate. Agitators are necessary to keep the solution mixed and prevent freezing along chilling plates. Dairy tanks are designed to chill milk from 101 °F (the body temperature of a cow) down to 40 °F and to maintain this temperature even on the hottest days of the year. Maple sap is not nearly as warm as fresh cow's milk, and the ambient temperature is cooler during the maple season. Because of the use they were designed for, refrigerated milk tanks are more than effective for chilling maple sap and maintaining it at low temperatures, even below 40 °F. It may be necessary to adjust the thermostat to run at a lower temperature (33 °F or lower) than would be used for a dairy operation.

Although effective, the purchase of a new refrigerated milk tank is cost prohibitive for most maple producers. A new 1,000-gallon tank with a compressor can cost $80,000 without delivery and installation fees.

Figure 3. Compressor unit with condenser used for chilling and pumping refrigerant into the chilling tank in Figure 2

Note: Take extreme caution when considering purchasing and installing a used refrigerated milk tank. It is recommended to either purchase from a dairy supply company or to have an expert inspect the tank and compressor unit before purchase. A tank without a compressor unit connected may not be usable for refrigerant if it was not professionally decommissioned. When the lines are disconnected, they need to be completely capped (brazed shut) to prevent any moisture from entering the refrigerant lines. Tape will not suffice. If the lines have taken on any moisture, you may not be able to reconnect the tank for refrigeration. This is just one of many reasons to have a professional inspect and disconnect the unit. Some additional aspects to consider include:

- If a compressor unit is included, make sure it is functional and refrigerant is not leaking.

- Look for signs of leaking oil around fittings on the unit and on the tank. Tanks can have small leaks that periodically need recharging and servicing by a specialist.
- Know what type of refrigerant the condensing unit utilizes. Older units require older types of refrigerants that are no longer manufactured as they release more harmful ozone-depleting hydrofluorocarbons to the environment. Older refrigerants can sometimes be purchased used, but, if available, are often more expensive due to limited supply. Some refrigerants have newer refrigerant replacements, but a valve and other components may need to be swapped out to accommodate the change in refrigerant.

A license is typically needed to purchase refrigerant. One could spend thousands of dollars to purchase older refrigerants to get a system up and running. If properly decommissioned, the refrigerant may be salvaged and reused. Additionally, all this work needs to be performed by a specialist with the tools and knowledge to properly disconnect and connect the compressor unit to the tank. Refrigerant lines are typically vacuumed out and pressure tested with nitrogen before filling with refrigerant.

In certain areas, especially areas without dairy farms, finding a specialist can be difficult. One could pay from $2,000 to $10,000 or more for refrigeration tank installation alone.

If your system has a small refrigeration leak, just having the unit recharged can be $700. That cost may be necessary annually, at the start of each season. Used milk tanks that no longer have a working condensing unit or were disconnected incorrectly are often more affordable and can be considered for use as tanks for other chilling methods such as with glycol solutions.

Glycol Chilling

Glycol chillers are commonly used in many industries from manufacturing and food production to the brewing industry. Glycol chillers utilize a refrigerant system and a chilling coil to cool down a solution of glycol that can be pumped in a loop to a heat exchanger or chilling plate and back to the chiller. As the chilled glycol passes through a chilling plate or heat exchanger, it removes heat from the solution in which the chilling plate is immersed (e.g., concentrated sap). Glycol chillers do utilize refrigerant and a compressor, but these components are completely contained within the unit and do not require a specialist to connect. Pumping chilled glycol from the chiller to a chilling plate or heat exchanger requires only minimal plumbing skills. Although slightly less efficient at chilling than a direct refrigeration system, glycol chillers are a more cost-effective way to chill maple sap due to a combination of lower upfront costs and easier set-up and long-term maintenance.

Glycol chilling also provides flexibility in that it allows for adaptation of existing sap tanks into chilling tanks or for in-line sap chilling. The following list covers a few applications for utilizing glycol chillers in a maple operation for chilling sap:

Figure 4. Insulated chilling tank

Stainless Steel Chilling Tank: Maple producers commonly use milk tanks sourced from the dairy industry, but brewery tanks and other food manufacturing tanks can be utilized. These tanks are usually double-walled, insulated tanks that have a chilling plate attached to the inner tank wall. The chilling plate has a series of channels running back and forth that a cold substrate moves through to chill the inside surface of the tank and the solution stored within (Figure 5). Some chilling tanks have stainless steel rings or coils off-set from the wall inside of the tank instead of a chilling plate. An agitator inside of the tank is recommended for mixing the sap to ensure even chilling.

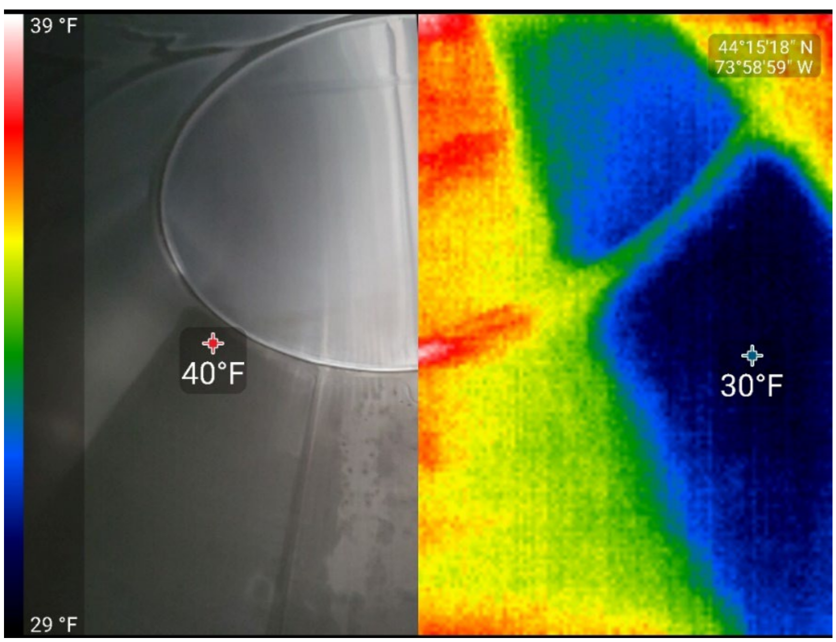

Figure 5. Photo of the inside of a dairy tank with chilling plates. The image is split with the left side showing the normal camera image and the right side showing a thermal image. In the thermal image, you can see where the chilling plate runs along the back wall and bottom right of the tank. There is another chilling plate on the bottom of the tank that was not connected, so the reading was 40 °F. A third chilling plate is on the left side of the tank directly opposite the one pictured, but it is not visible without the thermal camera.

Plate Heat Exchangers: These devices cool sap quickly by passing it through sealed channels adjacent to channels filled with cold water or glycol. The large surface area in the exchanger allows for rapid cooling. Cold water from a stream or spring can reduce the temperature of the maple sap, but stream water temperature, especially later in the season, will most likely not be cold enough to chill sap for longer-term storage. The size and number of plates along with flow rate will determine the cooling capacity. Shell-and-tube heat exchangers can be considered but are less efficient.

Figure 6. Plate Heat Exchanger connected to RO and glycol chiller

There are several ways to utilize heat exchangers for chilling maple sap, and they can be used in combination with other methods such as a chilling tank. Sap can be pumped from one tank to another through a heat exchanger or pumped through a heat exchanger and back into the same tank in a loop until the desired temperature is reached. A great place for a heat exchanger is on the outfeed of an RO where the pump from the RO can be utilized to push concentrated sap through the heat exchanger.

In our test of a heat exchanger, we connected a DIY 5,000 BTU/h AC unit chiller (Figure 9) to pump chilled glycol through the heat exchanger. We then connected the concentrate outlet from an RO to push water (sap was not available because the experiment was run during the off season) through the heat exchanger. Water was passed through the heat exchanger at a rate of 1.0 gallon per minute. After passing through the heat exchanger, the temperature of the water from the RO was lowered from a starting temperature of 40.8 °F to 33.7 °F, a reduction of 7.1 °F. Dropping the temperature much further would have iced up the water. Further testing is needed to see if the temperature differential before and after the heat exchanger can be increased with different starting temperatures, different glycol temperatures, and different glycol flow rates.

Care must be taken when using chilled glycol in a heat exchanger to prevent ice blockages and leaks. Sap can freeze in the exchanger especially if sap flow is slowed or paused. Additionally, while uncommon, it is possible for leaks to occur in heat exchangers due to corrosion over time. This is especially true if the wrong type of glycol is used or if the glycol solution is not made with distilled water (see "Glycol Selection" below for more information). Maintaining higher pressure in the sap solution than the glycol can help prevent sap contamination with glycol in the case of a leak. Periodic pressure testing of the heat exchanger to ensure there are no leaks is an important step in the maintenance routine.

Immersion Chilling Plates or Coils: A stainless-steel chilling plate is a large, thin, rectangular plate with a snaking channel. A cold liquid, typically glycol, is slowly pumped through the channel in the chilling plate. The chilling plate is submerged into a tank of sap and acts like a block of ice. The snaking channel creates additional surface area for the chilled glycol to pass through and remove heat from the sap. This works much like a chilling tank except that the plate is submerged inside of the tank and any tank can be used. Chilling plates can be purchased from winery and brewery supply companies. Due to their small size, they are most effective for smaller maple operations that want to utilize an existing tank. An agitator or bubbler is recommended to mix the sap within the tank to ensure more even and faster cooling. A spiral coil of stainless steel, such as a wort chiller for homebrewing, immersed within the tank can also be used.

Figure 7. Cooling plate connected to glycol chiller submerged in tank of sap

DIY Chilling Tank: An existing sap tank can be turned into a chilling tank by wrapping the outside of the tank with flexible copper lines and then insulating the outside of the tank. Chilled glycol can then be pumped through the copper lines to chill the walls of the tank and the sap stored inside. If you have an open top tank, consider using an insulated lid for efficiency. Adding agitation is helpful for even chilling.

Glycol Selection

Not all glycols are the same. There are two main types of glycols: ethylene glycol and propylene glycol. Ethylene glycol has strong antifreeze ability and is slightly more efficient in chilling systems, such as in car radiators, but ethylene glycol is toxic and should not be used in a maple sap chilling system. Propylene glycol is recommended for use in food production operations, including maple operations. Propylene glycol is considered GRAS (Generally Recognized As Safe) by the US Food and Drug Administration (FDA). It is considered safe at its current typical usage levels – very low doses when used as a food additive. This is why you will see it listed as an ingredient in some maple defoamer products. However, a leak in a chilling operation would introduce propylene glycol into sap and syrup at much higher levels than is considered safe, and also at levels that would render the finished syrup "adulterated". So for this reason, despite its food-grade and GRAS status, care must be taken to prevent contamination of the sap with glycol in a chilling system.

Propylene glycol can be formulated with or without “corrosion inhibitors”, chemical compounds that protect metals from corrosion. Although propylene glycol is not extremely corrosive, it can cause corrosion of pumps, fittings, etc., over time. This is especially true if the glycol solution is mixed with hard water. Utilizing purified water from the RO to mix with food-grade inhibited propylene glycol is a good practice.

Glycol Efficiency

To prevent spoilage, it is important to lower the temperature of maple sap to as cold as possible without freezing. Sap and concentrate have a lower freezing point than pure water, so it is necessary to use a solution with a lower freezing point than water to reach the desired temperatures in the sap. This is why a glycol-water solution is used for chilling; it has a lower freezing point than pure water alone. While glycol is an effective chilling solution, it is not as efficient at transferring heat as pure water. Therefore, the higher the concentration of glycol in the solution, the less efficient at chilling the solution will be. It is important to balance the efficiency of the solution with the freezing point of the solution (Table 1).

The ratio of glycol to water will depend upon how cold the solution has the potential of reaching. For chilling maple sap, the coldest the glycol solution will need to reach is 20 °F which would only require a 20% glycol solution (Table 1). However, if there is a chance that the glycol solution will be exposed to very cold temperatures because it is stored outside all winter in the jacket wall of a tank or inside an unheated building, a 35-50% glycol solution will be required (Table 1).

The freezing point in Table 1 refers to the lowest temperature at which propylene glycol can still be pumped and transfer heat without any slush formation. “Burst Protection” in Table 1 refers to the temperature at which full freezing and expansion can occur and cause damage. The “Burst Protection” temperature is what needs to be considered for the coldest day of the year in the location of glycol solution. A 35% glycol / 65% water formulation should provide enough freeze protection in most maple producing regions without sacrificing too much efficiency.

For efficiency, it is best to maintain the glycol solution at 10 °F below the goal temperature of the sap. If the goal temperature of the sap is 35 °F, then the chiller should be set to maintain the glycol solution at 20-30 °F . A temperature regulator for the chilled sap tank should be used to make sure that the sap does not freeze within the tank. If a temperature regulator is not used in the sap tank, then it is best to set the glycol chiller to maintain the glycol at the same temperature as the goal temperature of the sap. This will allow the two solutions to equalize in temperature with less active management.

Table 1: Freezing point and cooling efficiency of propylene glycol solutions.

Propylene Glycol Concentration	Freezing Point[1]	Burst Protection[2]	Specific Heat (BTU/lb°F)[3]
20%	18.7 °F	10.2 °F	0.937
25%	14.0 °F	0 °F	0.921
30%	8.4 °F	-10.2 °F	0.904
35%	1.5 °F	-30.2 °F	0.885
40%	-6.7 °F	-60 °F or lower	0.866
45%	-16.8 °F	-60 °F or lower	0.845
50%	-28.6 °F	-60 °F or lower	0.823

[1]Freezing point refers to the coldest operating temperature at which the solution is no longer functional for pumping and cooling. Damage does not occur at this point.

[2]Burst protection refers to the temperature at which freezing and expansion can cause damage.

[3]Specific heat is the amount of energy required to raise a unit of a substance (in this case, 1 lb of the specified propylene glycol solution) by a degree (in this case 1 °F). Water has a specific heat of 1.0. The higher the solution's specific heat, the more heat it is able to absorb and transfer. Specific heat values in this table are based on the glycol solution at 25 °F. Colder solutions are less efficient.

Data sourced from Dow for their product, DOWFROST™. Calculator available on Dow website. Glycol formulations can have different properties depending on the manufacturer's formula, so it is best to source technical data from the manufacturer.

Sap Chilling Experiments at Cornell University

Effectiveness of chilling concentrated maple sap with glycol was tested at the Cornell University Uihlein Maple Research Forest during the 2025 maple season. A 16,000 BTU/h (rated at 28 °F) glycol chiller was connected to a used 1,500-gallon milk tank previously chilled using refrigeration. PEX lines were connected to the copper refrigeration lines on the milk tank. Chilled glycol was pumped in a loop through the chilling plates of the milk tank and back to the glycol chilling unit. The thermostat on the chilling unit was set to maintain the glycol at 25 °F. A thermostat controller (INKBIRD ITC 308) turned the glycol pump on and off to reach and maintain the goal temperature of the concentrated maple sap in the milk tank.

Maple sap was concentrated to 22 °Brix and set to chill to 29 °F. At this temperature, a small amount of slush started to form. Most days, around 500-800 gallons of concentrate needed to be chilled. We found that the glycol chiller performed at 12,000-16,000 BTU/h and was able to chill the concentrate rather effectively within 8-12 hours depending on the temperature of the concentrate leaving the RO and the ambient temperature outside the tank (our chiller tank was located outside).

The glycol circulation began as soon as the RO started filling the tank or an hour before in order to chill the tank ahead of time. Chilling the tank beforehand was found to be more effective. The glycol chiller was also able to maintain the temperature of the concentrate in the tank for 5 or more days. After the next sap run, more concentrate would be added which would warm up the liquid in the tank, but the chiller would then bring down the temperature on the full tank of concentrate within the same 8-12 hours of time.

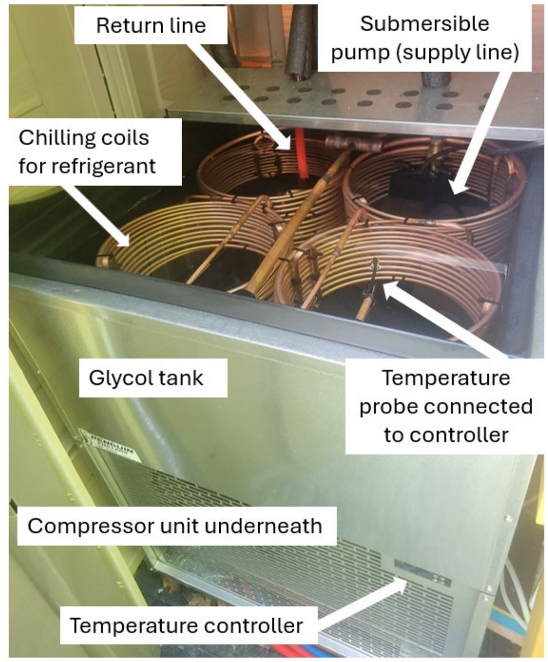

Figure 8. Commercial glycol chiller

Overall, we were thrilled with the effectiveness of chilling maple sap with a glycol chiller and use of a do it yourself glycol chiller (mentioned in a separate document), and we plan to continue use for future production seasons at the Cornell University Uihlein Maple Research Forest. Having the ability to chill and hold onto concentrated sap reduced the number of boils by 40% from our previous average. At an average time of 2-man hours for setting up and cleaning after boiling, this saved 24 hours of time during the 2025 maple season. Two other maple producers who have implemented glycol chilling both reported it to be effective for chilling maple sap.

Sizing a Chiller: Calculating BTUs

Understanding BTUs, British Thermal Units, is important for designing a sap chilling system. BTUs are used to measure the amount of heat energy that must be transferred to warm or cool a substance. One BTU equals the amount of heat needed to raise the temperature of one pound of water by 1 °F. For chilling applications, BTUs describe the amount of heat that must be removed from the substance. Most chillers have a BTU per hour (BTU/h) rating that can be used to calculate the chilling capacity. However, not all BTU ratings are equivalent across different substrates. Air, water, and glycol all have different specific heat capacities that will react differently in heat transfer.

Calculating the BTU/h rating needed for your operation can be performed following the steps below. When using this formula for chilling maple sap, the weight of the sap will be slightly heavier and the weight from Table 2 should be utilized instead.

1. Calculate the weight of sap typically chilled within a tank.

Weight of sap = Gallons of sap × Density of sap in lb/gal (see Table 2)

Example: If on average you want to chill 500 gallons of 10 °Brix sap:

Weight of sap = 500 gallons of sap × 8.66 lb/gal = 4,330 lb of sap.

Note that if 1 BTU is equal to lowering 1 lb of water 1 °F, then 4,330 BTUs would be needed lower the 500 gallons of sap 1 °F.

Table 2. Weight of sucrose-water solution at varying °Brix levels Data from USDA AMS, 2025.

°Brix	Density (lb/gal) at 68 °F
0	8.34
2	8.39
5	8.49
10	8.66
15	8.83
20	9.01
25	9.20
30	9.40
35	9.60

2. Determine how many degrees Fahrenheit you will need to lower the temperature of your sap. It is best to plan for the worst-case scenario to make sure the chiller is at capacity. Typically, this will be with warmer sap later in the season.

   Change in sap temperature =
   Starting temperature – Goal temperature

Example: Let's say that maple sap can reach 55 °F in the collection system later in the season, and that you will want to chill it to 35 °F at the sugarhouse.

Change in sap temperature = 55 °F – 35 °F = 20 °F

In this case, you will want to lower the 500 gallons of sap by 20 °F.

3. Multiply the total pounds of sap by the degrees F needed to lower the sap to determine the total BTU.

   Total BTU = Pounds of maple sap × Change in sap temperature (°F)

Example:

Total BTU = 4,330 lb sap × 20 °F = 86,600 BTUs

In this case, 86,600 BTUs are necessary to drop the temperature of 500 gallons of maple sap from 55 °F to 35 °F.

4. Chillers (and air conditioners) are assigned a rating of BTU per hour. It is not necessary to completely chill all the sap within one hour, and in most maple applications, sap is filled into the tank over time. Therefore, when determining the necessary rating for a chilling unit, the BTU needs over time should be estimated.

   BTU/h = Total BTU / Time to chill

Example: If you are okay with chilling the sap over 10 hours, you divide the total BTUs by the desired hours of chilling:

BTU/h = 86,600 BTU / 10 hours = 8,660 BTU/h

In this example, a chiller would need to be rated for at least 8,660 BTU/h to lower 500 gallons of sap 20 °F over ten hours.

Additional considerations:

- Not all BTUs will be applied to heat transfer within the maple sap. Some will be lost through pumps, plumbing, tank walls, etc. It is better to add a margin for this loss when calculating necessary BTUs.
- Ambient temperature will impact chilling capacity.
- Larger chillers and refrigeration systems are rated in tons. One ton of BTU per hour capacity is equal to 12,000 BTUs per hour.

The following table provides a quick reference for the BTU/h rating needed for chilling different volumes of concentrated sap.

Table 3. Approximate chiller rating (BTU/h) needed per volume of sap.

Gallons of sap[1]	**BTU/h[2]**
100	2,100
250	5,300
500	10,500
750	15,800
1,000	21,000
1,250	26,300
1,500	31,500

[1]Assumes the sap has a sugar content of 2 °Brix and a density of 8.39 lb/gal (Table 2).

[2]Calculated using a change in sap temperature of 30 °F over 12 hours. Chiller rating is rounded up to the nearest 100 BTU/h.

Purchasing a Chiller: Other Considerations

- With commercial chillers, look for the temperature of the solution at which the BTUs are rated. Glycol chiller ratings are typically based off a colder temperature and will provide a more accurate rating.
- Glycol chillers typically come with a tank from which the chilled glycol solution is pumped.
- Some glycol chillers come with circulation pumps while others require separate purchase of a pump.
- Some chillers are sold as glycol chillers and others as water chillers.

- Despite the name, water chillers can be utilized for chilling down a glycol solution but are typically rated for chilling down with pure water maintained at 50 °F. The colder a solution, the less efficient it will be at transferring BTUs (Table 1). As a result, a water chiller will not provide the same BTU/h capacity when utilized for maintaining a glycol solution at 25 °F. If utilizing a water chiller, a good rule of thumb is to expect the chiller to provide only 50% of the BTU/h rating when adapted to operate with a glycol solution.
- Water chillers are typically designed for the chilling solution to pass over a chilling coil or plate within a loop and do not have a tank to immerse the chilling coils within. In this case, purchase of a separate tank to hold the glycol solution will be required.

Figure 9. DIY glycol chilling unit made from a window AC unit and a plastic cooler. The chilling coil from the front of the AC unit is immersed in glycol solution held inside of the cooler. A new thermostat is installed within the aluminum box. The chiller unit sits on a wooden base with castor wheels for easy transport.

- The most important parts of a chiller are the compressor and the condensing unit. Once these parts fail, the whole chiller will most likely need to be replaced.

DIY: Making Your Own Glycol Chiller

Through research trials at the Cornell University Uihlein Maple Research Forest we successfully produced a cost-effective way to build a do-it-yourself (DIY) glycol chiller by modifying a window air conditioning (AC) unit in combination with a picnic cooler (Figure 9). By utilizing used window AC units and parts around the sugarhouse, we were able to build a chiller for $35. Purchasing a new window AC and cooler increased the cost to $520. A commercial glycol chilling unit of equivalent chilling capacity cost $3,500 or more.

To make your own DIY glycol chiller, check out the Cornell Maple Program extension bulletin titled, "How To Build a Maple Sap Chiller" at www.cornellmaple.com.

Conclusion

Glycol chillers are an effective way to cool maple sap to maintain freshness of sap without spoilage. The use of glycol chillers provides simplicity, cost-effectiveness, and flexibility in comparison to the use of refrigerant systems. Glycol chillers allow for more options for chilling sap, such as applying in-line heat exchangers or adding submersible chilling plates to existing tanks. By chilling maple sap, producers can preserve the quality of their sap for extended periods and schedule boiling for when is convenient. This ability provides the flexibility needed to accommodate other priorities in the maple operation or to improve work-life balance.

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Cornell Maple Program

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