

WHITE PAPER

# GLYCOL ALTERNATIVES

Glycol reduction through alternative freeze-protection technologies.



Written By  
**David Morrison, PE**

---

**ABSTRACT**

While adding glycol to a system has been a default for engineers and designers in cold climates in the past, this paper explores alternatives to adding glycol to a system for freeze protection of the coils inside of an air handler.

**CONTENTS**

---

<b>01</b>	<b>Glycol Properties &amp; Why Coils Freeze</b>	<b>03</b>
	EG vs. PG, the physics of a ruptured coil, and air stratification	
<b>02</b>	<b>Glycol Alternatives</b>	<b>05</b>
	Where systems still freeze, and four freeze-protection strategies compared	
<b>03</b>	<b>Limits to Glycol Alternatives</b>	<b>08</b>
	Where these technologies stop, and what to weigh as a system designer	
<b>04</b>	<b>Calculated Savings</b>	<b>09</b>
	A TMY3 energy model across three climate zones	

---

*"A properly designed system should never freeze." The reality is that there will always be variables that are out of the control of even the best engineered design.*

01 · SECTION

# Glycol Properties & Why Coils Freeze

As long as water has been utilized as a heat transfer medium, the engineers that are tasked with designing the systems have been concerned with freezing of the heat transfer medium. Freezing of the heat transfer medium can occur anywhere the piping in the system is exposed to below freezing air. To avoid freezing, engineers have introduced anti-freeze elements into the heat transfer medium to create a mix of water and ethylene glycol (EG) and propylene glycol (PG) to lower the freezing point of the heat transfer medium and thereby reduce potential for freezing.

While accomplishing the main goal of preventing freezing in piping and coils, there are negative side effects. PG and EG reduce the efficiency of the heat transfer medium and increase the medium's weight which requires additional pumping energy to move the medium through the system.

## Ethylene vs. propylene glycol

Ethylene Glycol (EG) was first utilized as an anti-freeze measure and mixed with water to prevent freezing in automobiles, and HVAC/R equipment. EG was found to be slightly toxic if ingested in high dosages, and therefore has been slowly phased out in many applications in favor of propylene glycol (PG). PG is recognized as "generally safe" to ingest by the Food and Drug Administration (FDA) in food, pharmaceuticals, and cosmetics. PG is less efficient of a heat transfer medium than EG, but the risks of exposure have outweighed in efficiencies in many industries.

Table 1 is a brief summary of the differences between the two types of glycol at different mixtures.

TABLE 1 · PROPYLENE & ETHYLENE GLYCOL COMPARISON						
% By Volume	Freezing Point (°F)		Heat Transfer Eff*		Density**	
	EG	PG	EG	PG	EG	PG
<b>0%</b>	32	32	100%	100%	1000	1000
<b>10%</b>	25.9	26	97%	98%	1018	1012
<b>20%</b>	17.8	18	94%	96%	1036	1022
<b>30%</b>	7.3	7	90%	94%	1054	1031

\*Calculated by comparing specific heat of mixture relative to 100% water at 32°F. \*\*Density of solution (kg/m<sup>3</sup>) at 32°F.

01 · GLYCOL PROPERTIES

# How & Why HVAC Coils Freeze

Hydronic coils in an HVAC system transfer thermal energy from the heat transfer medium, typically water, inside of the coils to the airstream to be distributed to the building. When coils are exposed to freezing air, the water inside of the coil will lower in temperature as heat transfer occurs. If the air is cold enough over a specific section of the coil it can freeze the water inside of the coil and rupture the coil.

The reason that ice ruptures a coil is that as water changes its state from liquid to solid (ice), its volume is increased. Every 100 lbs. of water will fill a volume of 12 gallons (density = 62.4 lb/ft<sup>3</sup>), and every 100 lbs of ice will fill a volume of 13.07 gallons (density = 57.4 lb/ft<sup>3</sup>). That is a difference of over 8% volume. The ice's increased volume does not have space to expand, and therefore creates pressure on the coil. The resultant pressure is strong enough to rupture the coil.

WHY ICE WINS

**+8%**

volume gain as water freezes  
— with nowhere to expand

**62.4** lb/ft<sup>3</sup>

liquid water · 12 gal / 100 lb

**57.4** lb/ft<sup>3</sup>

ice · 13.07 gal / 100 lb

STRATIFICATION

The airstream entering a coil is typically not isothermal (same temperature throughout), and many times stratification of the air can cause specific portions of the coil to freeze. The stratification is caused by extreme difference in temperature — and therefore air densities — between the outdoor air and return air. The amount of stratification that occurs is primarily a function of the mixing box design.

A coil does not need the entire airstream to be at 32°F to freeze. If a select portion on a coil is consistently exposed to cold temperatures, that portion of the coil can freeze and rupture while the remainder of the coil is exposed to warmer air.

02 · SECTION

# Glycol Alternatives

A common attitude to freeze protection in the engineering industry is "a properly designed system should never freeze." The reality is that there will always be variables that are out of the control of even the best engineered design. Below is a list of applications where the engineered system can encounter a scenario which can freeze a coil despite calculations showing that there should be no freeze concern during normal operation.

## Controls Failure

Outdoor air (OA) dampers are frequently designed for economizer mode to allow 100% OA during swing seasons. However, dampers and springs rust, actuators fail, and controls fail to close the dampers during winter or during startup/shutdown of the unit — resulting in unexpected freezing conditions occurring at a coil and rupturing the coil.

## Central Plant Failures

Steam and hot water plants experience issues that result in not providing the expected heating performance to a coil. These include, but are not limited to, pressure regulator valve (PRV) failure, control valve failure, blockage in piping, and/or central boiler failure that may result in frozen coils in preheat locations and downstream of any preheat coils relied upon to protect downstream cooling coils.

## Power Failure

A significant power outage can result in pumps/AHUs not operating. This in turn will result in the AHU cabinet reaching the same temperature as the outdoors. If this power failure occurs during the winter, the coils inside of the AHU can be one of the first pipes in the building to freeze and burst.

## Human Error

Service technicians and building maintenance personnel frequently change setpoints and operation of equipment. This typically happens to fix an error in one season, which has negative implications in a different season — such as overriding an outdoor air louver to a high percentage in a mild swing season, then forgetting to reset it in winter. This adds additional exposure to harsher conditions on the coil.

The HVAC industry has recognized the negative effects of frozen coils and the energy penalties of utilizing glycol in a system. Every design to mitigate frozen coils has its own benefits and drawbacks. The methods on the following page are not exhaustive — they provide context to understand the difference between each system.

02 · GLYCOL ALTERNATIVES

# Four Freeze-Protection Strategies

1

## Freeze Stat

Typically the first layer of defense. A freezestat is a tube that activates a switch if a specific temperature is reached within the air stream, intended to alert building operators if a freezing condition is occurring. Typically a freezestat will shut off the AHU in the event of a cold condition on the unit. However, each time the AHU is shut down the space it serves experiences downtime. Nuisance trips can result in a headache for maintenance personnel and increase downtime of a facility unnecessarily — occurring if a small portion of the airstream is below freezing, or from malfunction of the freezestat itself.

2

## Recirculation Pump

This strategy utilizes a pump located between the supply/return mains to each coil, activated when the freezestat inside the unit is tripped. The pump keeps a high velocity of the heat transfer medium through the coil to prevent freezing. The challenge is that the pumps infrequently run and service is neglected, so when the pump is needed it does not run as expected. They require routine maintenance to ensure operational condition — an operational expense — and do not provide protection in the event of a power failure unless connected to emergency power.

3

## Rupture Disk

Two to three (2–3) rupture caps are installed in the return header of the coil. When the coil experiences additional pressure the rupture caps open and the coil is protected from freezing. The challenge with rupture caps is that after a freeze event the caps are compromised, and reseating them does not ensure that the header is returned to its previous watertight construction.

4

## Freeze Block® Coil

An expansion relief header is attached to every coil return bend, and a relief valve located at the end of the header releases the pressure of ice expanding inside a coil. The valve has two (2) methods to prevent a coil rupture: pressure and temperature. It looks for a change in pressure resulting from ice expanding in the coil to relieve pressure prior to a rupture, and can also sense if the temperature in the return bend's expansion header approaches freezing. In both instances, the Freeze Block relief valve is designed to release a controlled volume of fluid from the coil. This water is sent to drain, and the coil is prevented from rupturing in almost all cases.

02 · GLYCOL ALTERNATIVES

# Comparing the Alternatives

A side-by-side view of how each strategy behaves across the attributes that matter most during a freeze event.

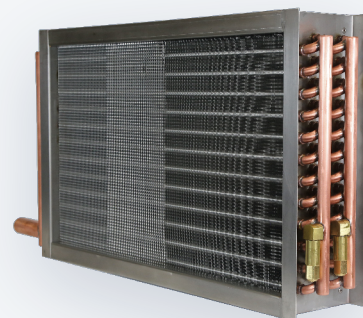
**TABLE 2 · COMPARISON OF GLYCOL ALTERNATIVES**

Capability	Freezestat	Recirc. Pump	Rupture Disk	Freeze Block® + Detection Kit
Requires periodic maintenance		●		
Ability to shut down AHU	●			●
Notification of frozen coil	●			●
Relief device to prevent coil damage			●	●
Reset needed after frozen coil	●		●	●

● Capability present    ● Operational consideration

### DUAL-SENSING RELIEF

The Freeze Block valve responds to both pressure and temperature, releasing a controlled volume of fluid to drain before ice can rupture the coil — protection that holds even through a power failure, with no pump to maintain and no header to reset.



03 · SECTION

# Limits to Glycol Alternatives

The technologies described here are focused on preventing freezing at the coil in the AHU. There are other places in an HVAC system that can freeze. Piping exposed to the outdoors can freeze if the flow of the water is reduced for long periods or if the heat tracing for the piping fails. Loss of flow and heat trace failures can both happen if an extended power outage occurs.

There are also applications where the design of the system requires sub-freezing temperatures, such as in a cold storage area or cold production area. In this case utilizing water as a heat transfer medium would not be appropriate, and there are also temperature ranges in which glycol is no longer effective — an alternative heat transfer medium such as Syltherm should be considered.

The design engineer should focus on the entire system and understand what situations can lead to exposure of the heat transfer medium to below-freezing temperatures for prolonged periods of time. Once the locations of exposure are known, the engineer can then consider what risks each scenario poses and what mitigation measures can be put in place. If it is solely a frozen coil due to human error, then one of the technologies mentioned above would be an appropriate mitigation strategy — and adding glycol to the system may be creating unintended energy penalties.

## THE ENGINEER'S CHECKLIST

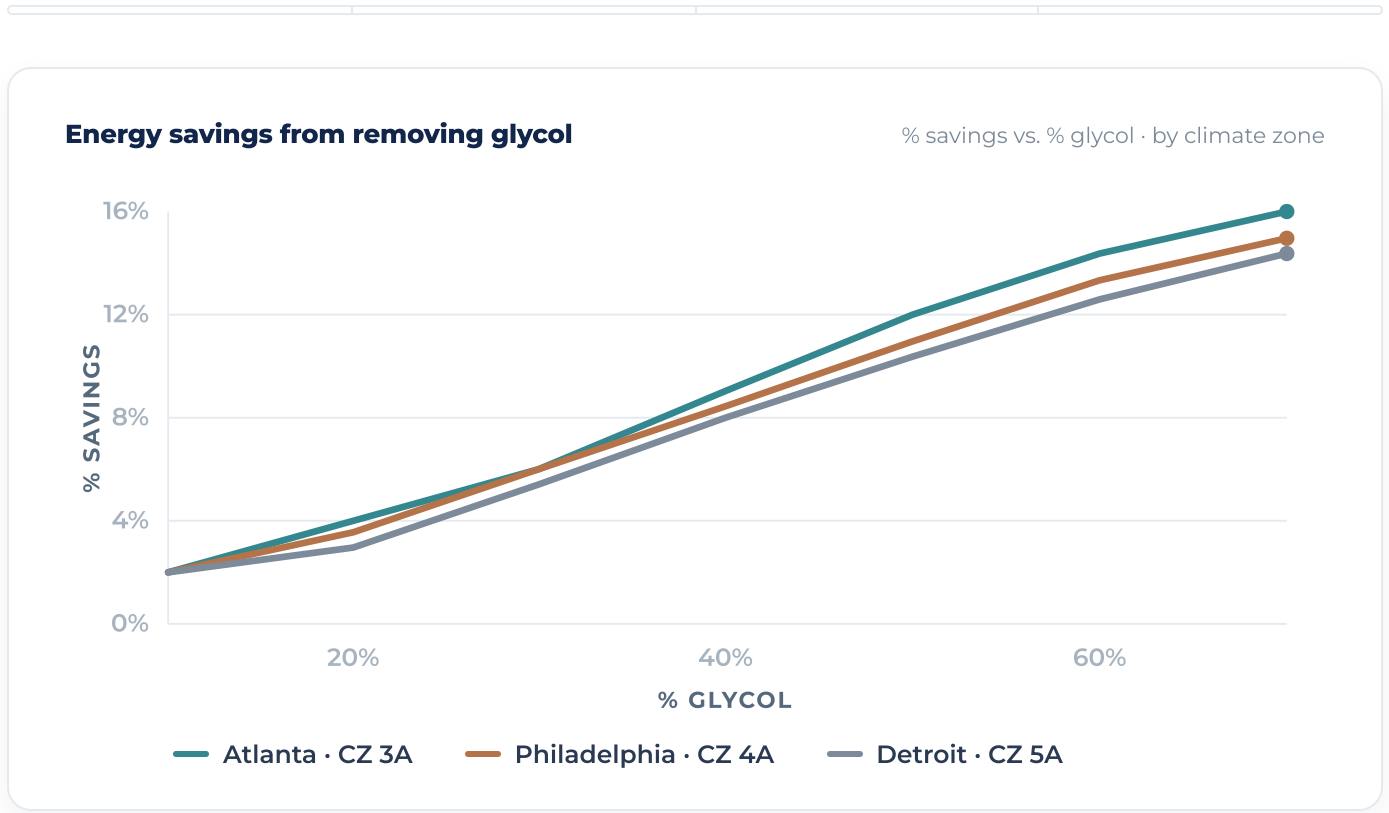
- Map every location where the heat transfer medium can sit below freezing for a prolonged period — coils, exposed piping, and dead legs alike.
- Weigh the risk and consequence of each scenario before defaulting to a system-wide glycol charge.
- Reserve glycol for genuine sub-freezing process loads; protect coils against human error with a relief technology instead.

04 · SECTION

# Calculated Savings

There are many variables that affect the energy costs of having glycol in a system. To show a comparison, a traditional chilled water system with a 100% outside air handler was modeled utilizing TMY3 (Typical Meteorological Year) weather data while the % of propylene glycol (PG) was varied. The energy usage of the pumps and chiller were then compared to a baseline with no glycol in the system.

The AHU was modeled at 20,000 CFM with a 3 inWC static pressure supply fan. The chilled water system is modeled with a 12°F ΔT loop, and chilled water pumps have a baseline of 75 ft of head which increases with % of glycol to account for the increased viscosity of the mixture. The chiller is sized to match the AHU and has an assumed average efficiency of 0.78 kW/Ton.



The model was run in three locations: Atlanta (Climate Zone 3A), Philadelphia (Climate Zone 4A), and Detroit (Climate Zone 5A). The climate zones demonstrate that a zone where an engineer is most likely to utilize glycol (Detroit) takes a lesser penalty than a hotter climate like Atlanta, due to the shorter cooling season. However, the energy penalty is still substantial and reaches up to 8% savings at the higher glycol concentrations.



## IN CLOSING

Glycol is the right call for some systems and the wrong one for others. The hard part is knowing which.

Cooney Technologies helps building and HVAC professionals weigh the options, whether that means dialing in the right glycol concentration, evaluating a switch, or looking at alternatives that protect your equipment without the efficiency tradeoff. We bring field expertise and engineering review to the question, so you can make the call with real numbers in front of you.

When you are ready to talk it through, you have a direct line to the people who work this every day.

---

**Engineered for what happens next.**

---

### OFFICE

20130 Valley Forge Cir  
King of Prussia, PA 19406

### GET IN TOUCH

[sales@cooneytechnologies.com](mailto:sales@cooneytechnologies.com)  
[cooneytechnologies.com](http://cooneytechnologies.com)  
(610) 783-1136