Heat Transfer Fluid: Risk Mitigation in System Design & Maintenance

Speakers: **Wesley Sherrod / *CORECHEM***
Chloe Pool / *CORECHEM*

DESIGN TRACK • Wednesday • October 23 • 1:45 PM

Presenter Introduction:

Wesley Sherrod
General Manager

Chloe Pool
Marketing Manager

Chloe Pool is an accomplished marketing professional with expertise in industrial chemicals and the water and wastewater sectors. She began her career at CORECHEM as a Strategic Account Manager before transitioning to a role as Communications Manager for First Utility District, one of Tennessee's largest public utilities. In the summer of 2024, Chloe returned to CORECHEM to lead and innovate its marketing initiatives.

Wesley Sherrod is the General Manager of CORECHEM, headquartered in Knoxville, Tennessee. He is the third generation of a family-owned company founded in 1981. For over 40 years, the company has built a reputation on providing personalized service and chemical expertise to their customers. For the last 10 years, this has included heat transfer fluids for the HVACR/Geothermal industries, formulating solutions in an ever-changing climate of green technology.

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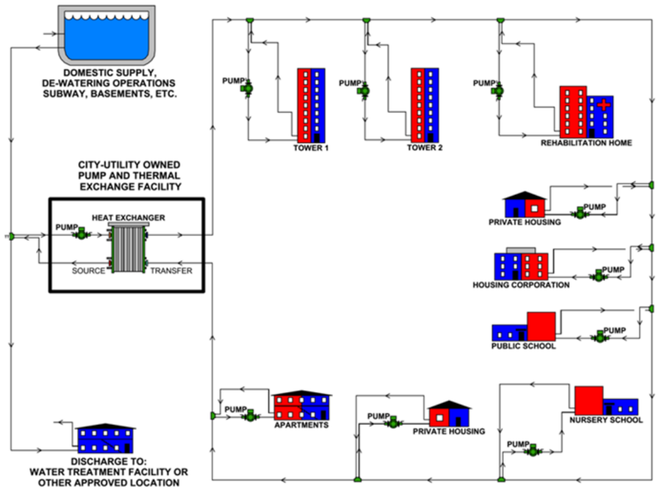
Points Covered In This Webinar:

- System Design
- Proper Fill of the system
- Fluid Selection
- Leak Detection & Remediation
- Fluid Maintenance

System Design



A well-designed geothermal system can last for decades if properly designed, flushed, filled, and maintained. Minimizing the risk of system failure and leakage begins with smart design that looks ahead at potential problems before they arise.

A design focused on optimizing fluid installation and performance should include the following:

- No dead ends and other fluid traps
- Proper flow and pressure testing requirements
- Air removal devices
- Fill inlet specification and location
- Make-up tank design specifications and location
- Make-up fluid concentration and specifications
- Water quality specification
- Recommended fluid & concentration for your specific application.

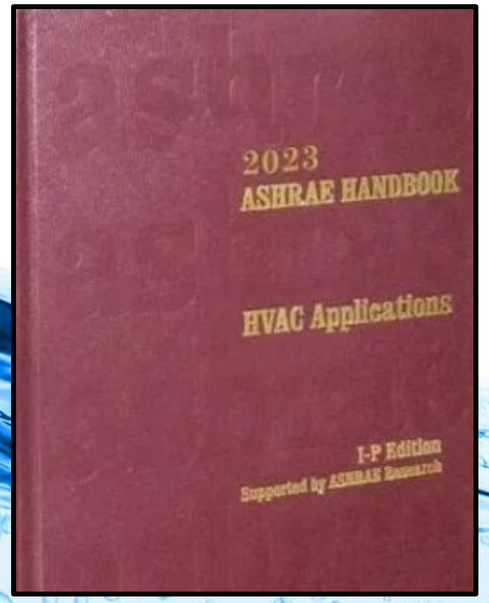
Proper Flow and Pressure Testing

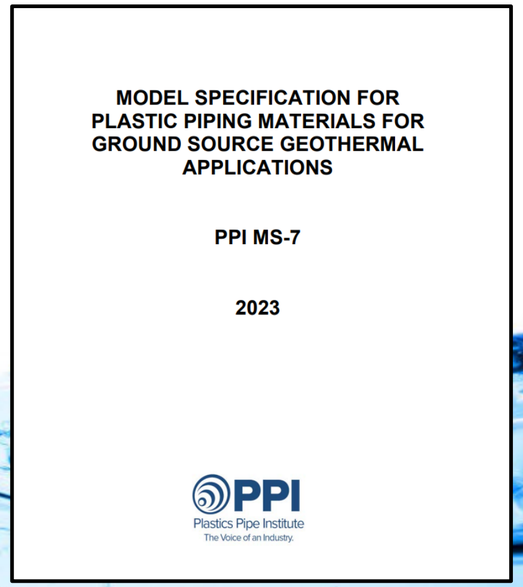
To ensure that the chances of leakage in a thermal energy network or ground heat exchanger distribution system are minimized, flow and pressure testing should be done once the pipes are in the ground and the system is ready to be filled with antifreeze. The Plastic Pipe Institute has standards for geothermal models to aid in this testing.

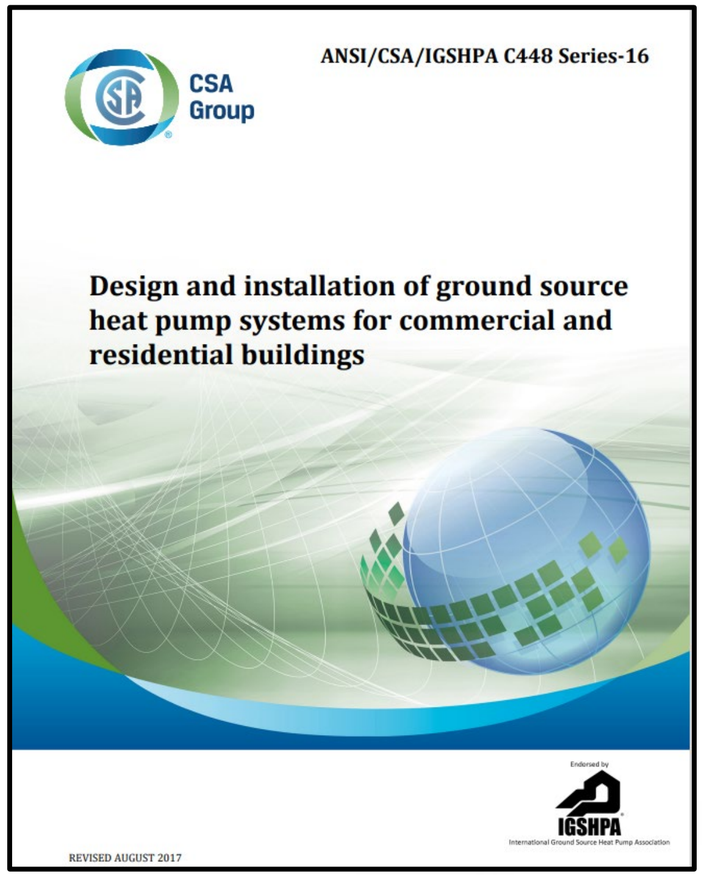
Proper Fill of the System

The initial fill of a system sets the tone for a successful start up. Avoid a wasteful and costly repeat filling due to construction debris or water that is out of spec. It is important to make sure the system is clean , and the water used for dilution is contaminant free, extending the life of your heat transfer fluid, and thereby the life of the system. A healthy system minimizes the risk of failure that can lead to ruptures and leaks.

Excellent resources for flushing/purging of a system, flow and pressure testing, water quality specifications, and both chemical and mechanical fluid treatments.







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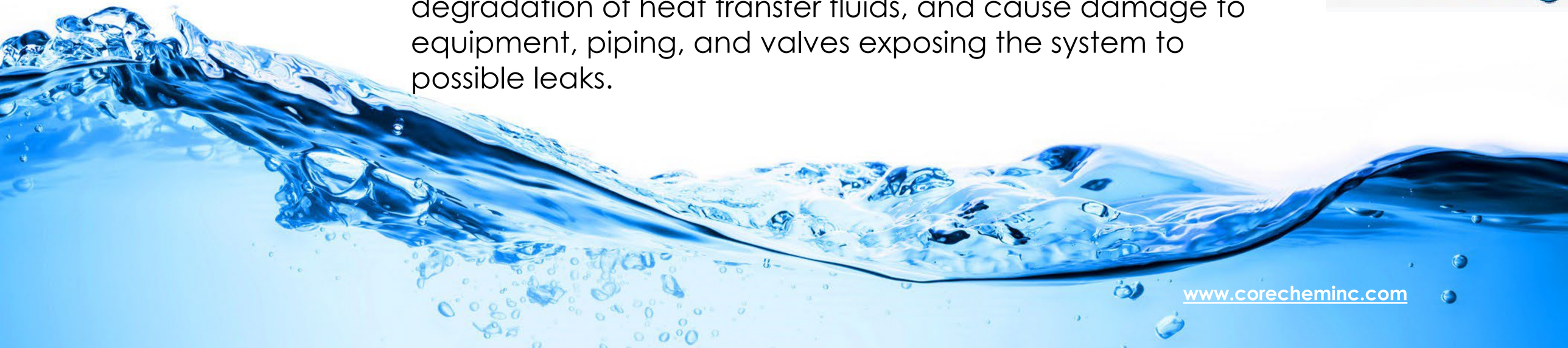
Water Quality - Why it Matters?

The quality of water used can have an enormous impact on system performance. Marginal quality water can lead to the development of:

- Scale
- Sediment deposits
- Creation of a sludge in the heat exchanger

This will reduce heat transfer efficiency, premature degradation of heat transfer fluids, and cause damage to equipment, piping, and valves exposing the system to possible leaks.



Water Quality Specification

Water quality should always meet equipment or component manufacturers' specifications. If no specification is provided, use the recommended water quality specifications per **ASHRAE Application Handbook Table 21.** This addresses limits for:

Check with local county or city water departments to determine the chemical properties of the water that will be used. If dilution water will be drawn from a well (typically hard water) or the local water authority cannot provide an accurate profile, we recommend having the water tested.

- **pH**
- **Total Dissolved Solids**
- **Iron**
- **Total M Alkalinity**
- **Calcium**
- **CO3/HCO3**
- **Hardness**
- **Chlorides**
- **Mn**
- **Oxygen**
- **H2S**
- **CO2**

As well as information on the:

- **Stability Index (Ryznar Index)**
- **Saturation Index (Langlier Index)**
- **BART (Bacteriological Activity Reaction Test)**

Poor quality water can damage the system by depleting the corrosion inhibitor and promoting a number of corrosions including general and acidic attack corrosion.

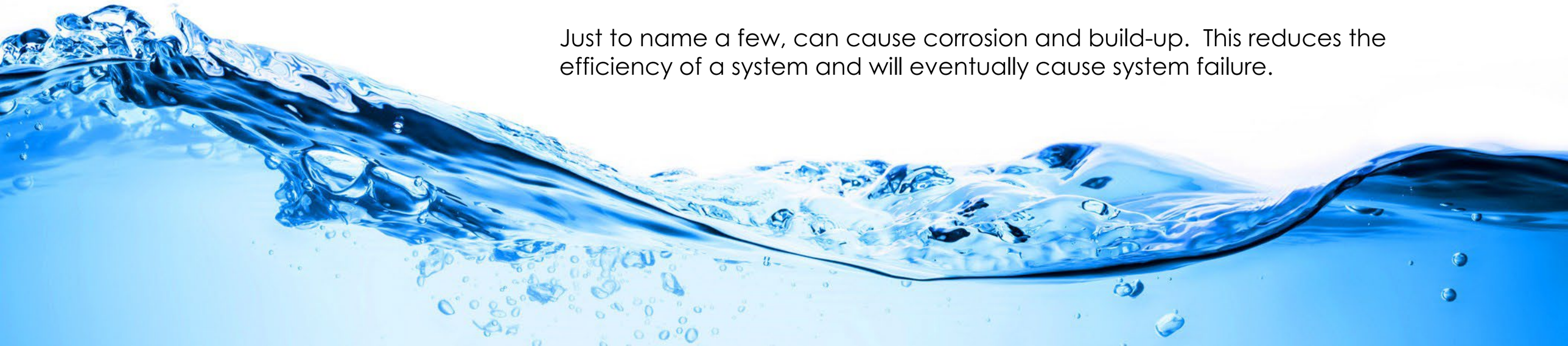
Potable Water Myth:

If I can drink it, then it is good enough for my Hydronic System.

Hard water may have all the minerals a human body can process, but to a hydronic system they can be devastating.

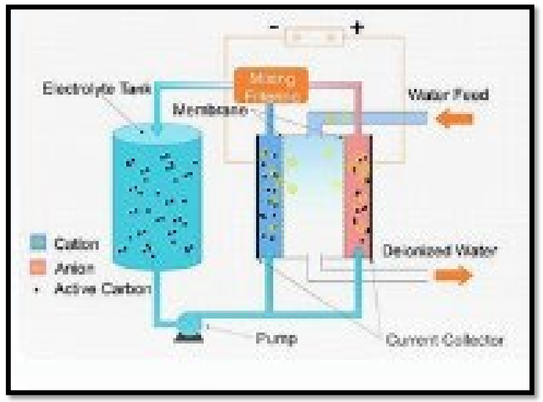
- Calcium
- Magnesium
- Iron
- Chlorides
- Sulphates

Just to name a few, can cause corrosion and build-up. This reduces the efficiency of a system and will eventually cause system failure.



In those cases where tap water does not meet the standards for quality, deionized water or water that has been processed through reverse osmosis to remove unwanted minerals is recommended.

A suitable corrosion inhibitor must be used with DI or RO water even when the treated water is pH neutral.



Prepping a Closed Loop System to Prevent Biofouling:

In addition to corrosion, biofouling plugs up critical components of a system, leading to ruptures and leaks.

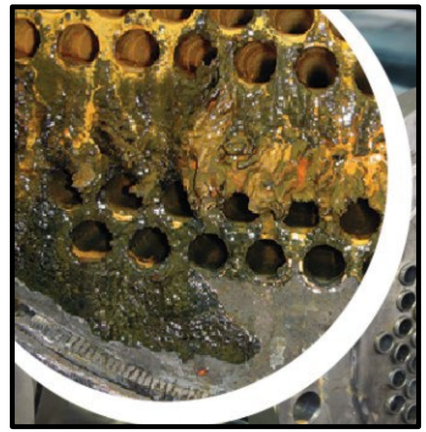
<u>You can treat and prevent organic growth one of two ways:</u>

1. **After the initial flush of the system, administer a Sodium Hypochlorite flush**

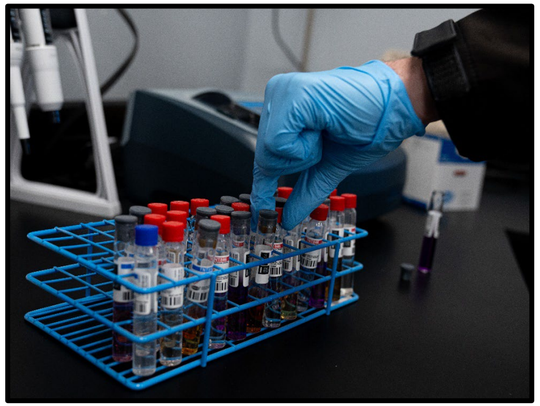
2. **Introduce a Biocide per manufacturer's instructions.**

A fully formulated HTF generally has adequate protection against biofouling at a concentration greater than 25%.

For systems designed for a concentration of 25% or less, additional measures should be taken to protect against biological growth.



Did You Know?

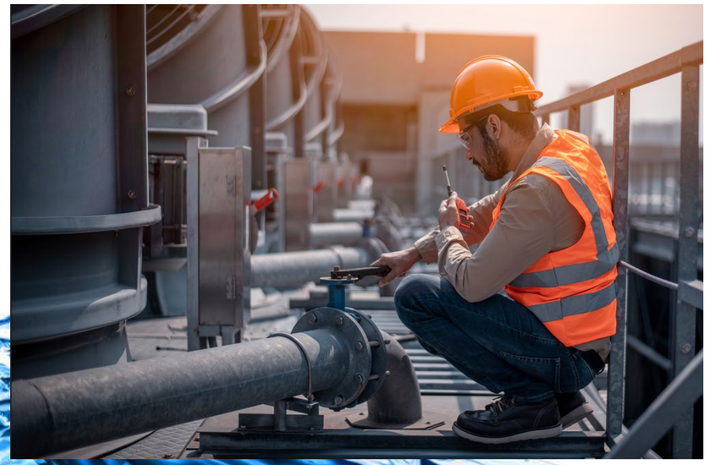


Eligibility of some rebate programs can depend upon proof of testing and flushing/purging procedures.

Check with your local programs for eligibility requirements before you begin to make sure you don't miss out on valuable savings!

Importance of System Freeze Protection:

Whether through environmental conditions, equipment malfunction, or reduced turbidity, exposing fluid in the system to freezing temperatures will cause fluid expansion and possible rupture and leakage.



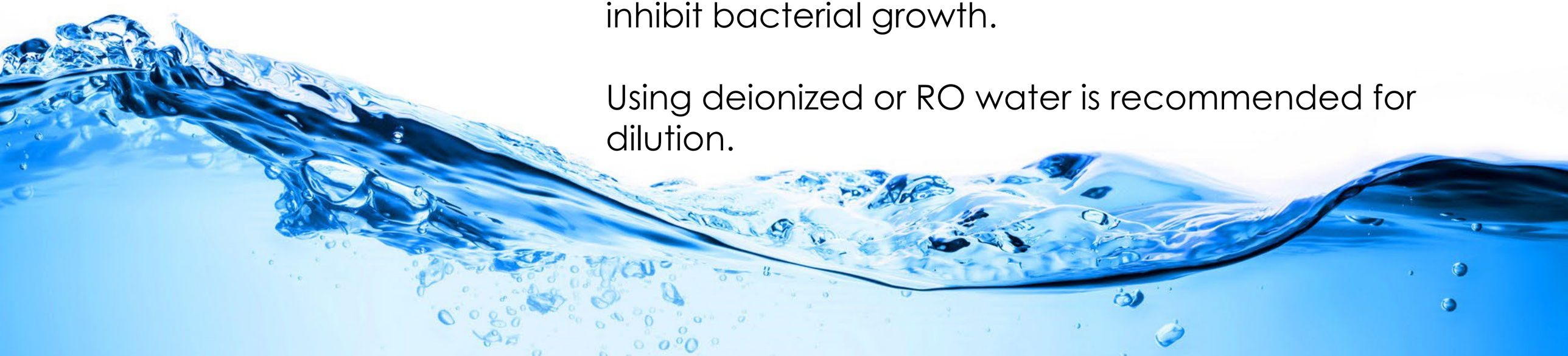
Using a fully formulated antifreeze solution with inhibitors greatly increases protection for your system for both corrosion and lower temperatures than water alone. It is a valuable **“insurance policy”** for your hydronic system.

Proper Concentration of the Heat Transfer Fluid of Choice.

To obtain adequate freeze protection, select a concentration with a freeze point at least 9°F below the lowest anticipated ambient temperature. (ANSI/CSA/IGSHPA C448.3-16 section 7.4.4.2)

Any dilution below 25% will require additional corrosion inhibitors to ensure adequate corrosion protection as well as additional protocols to inhibit bacterial growth.

Using deionized or RO water is recommended for dilution.



Heat Transfer Fluids… Which One Do I Need?

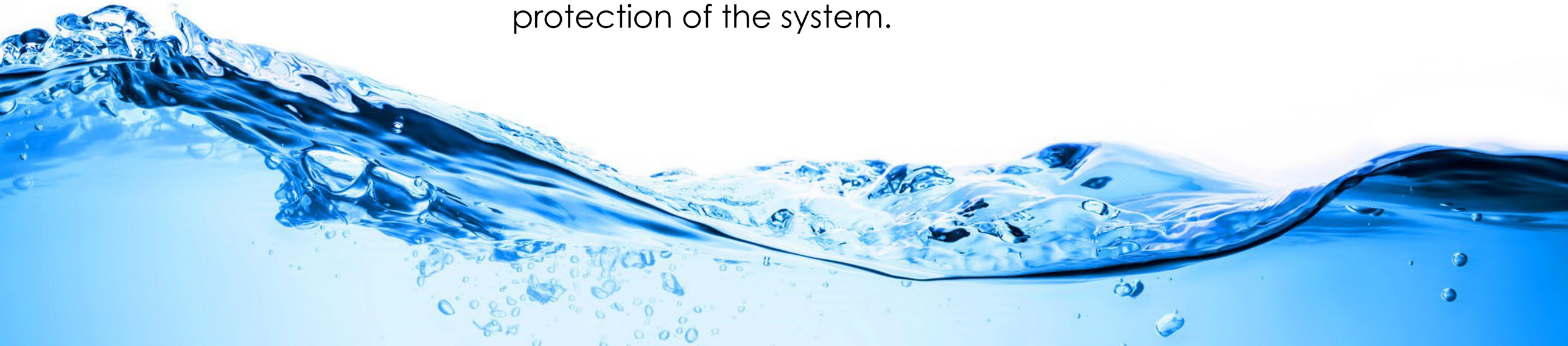
Choosing the right antifreeze solution for your system depends upon a variety of factors in addition to the system itself.

- State/local building codes and environmental standards
- Toxicity of the fluid – use & handling protocol
- Biodegradability in case of spill
- Viscosity within the system
- ASTM D8039 and ASTM D1384 Corrosion/Freeze Standards
- Specific heat and thermal conductivity

Heat Transfer Fluid Standards

To ensure that any heat transfer fluid protects your hydronic system from corrosion and freezing, a set of standards have been developed by the ASTM to test their effectiveness.

Make sure any HTF you choose meets or exceeds these standards for optimal performance and protection of the system.



ASTM D1384-05 – Corrosion Test for Engine Coolants in Glassware

This test method covers a simple beaker-type procedure for evaluating the effects of engine coolants on metal specimens under controlled laboratory conditions.

The results of this test method cannot stand alone as evidence of satisfactory corrosion inhibition (per ASTM D1384-05 section 4.1).

ASTM D8039-16 – Heat Transfer Fluids (HTF) for Heating and Air Conditioning (HVAC) Systems

This specification covers the requirements for ethylene glycol, propylene glycol, 1,3 propanediol as well as glycerin base heat transfer fluids (HTF) used in heating and air conditioning (HVAC) systems. When prediluted heat transfer fluids (30% by weight minimum) are used without further dilution, they will function effectively to provide protection against freezing and corrosion.

Heat transfer fluids meeting this specification shall be tested and fully comply with requirements (per ASTM D8039 -16 section 1.4).

Heat Transfer Fluids Pros

HTF	Freeze Protection	Low Viscosity	Good Heat Transfer	Available in Biobased	Use in Food Processing
Ethylene Glycol	x	x	x	o	o
Methanol	x	x	x	o	o
Ethanol	x	x	x	x	o
Propylene Glycol	x	o	o	x	x
New Technologies	x	Unknown	Unknown	Unknown	Unknown

Propylene Glycol is typically considered the 'chemistry of choice' for geothermal systems

Heat Transfer Fluids Cons

HTF	Toxic	Hazardous	Use in Geothermal	Restricted Use	DOT Regulated
Ethylene Glycol	x	x	o	x	x
Methanol	x	x	x	x	x
Ethanol	x	x	x	x	x
Propylene Glycol	*o*	*o*	x	o	o
New Technologies	Unknown	Unknown	unknown	Unknown	Unknown

Standard automotive antifreeze is typically Ethylene Glycol based.

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Emerging Technologies
Proprietary Fluid Blends

PROS

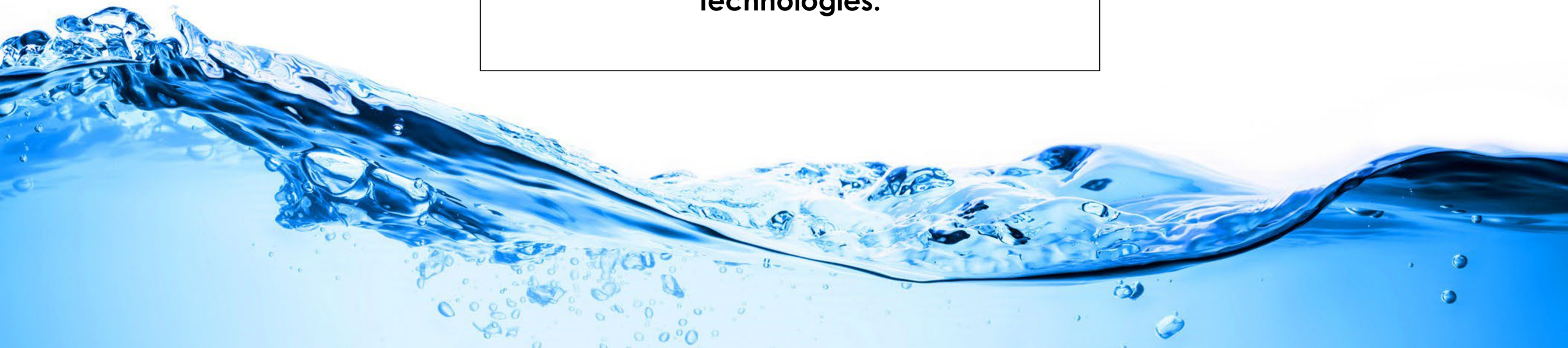
Emerging technologies are placing more emphasis on lower viscosities, and even nano-technology in order to get more life and more cost reduction over the life of the fluid.

Consult an Engineer to research performance and environmental impact.

3rd party verification of freeze protection and viscosity/thermal dynamics is always recommended with developing technologies.

CONS

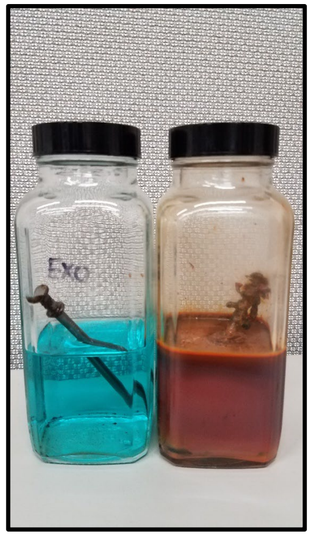
These new Proprietary blends are still largely untested in environmental impacts, and long-term cost savings.

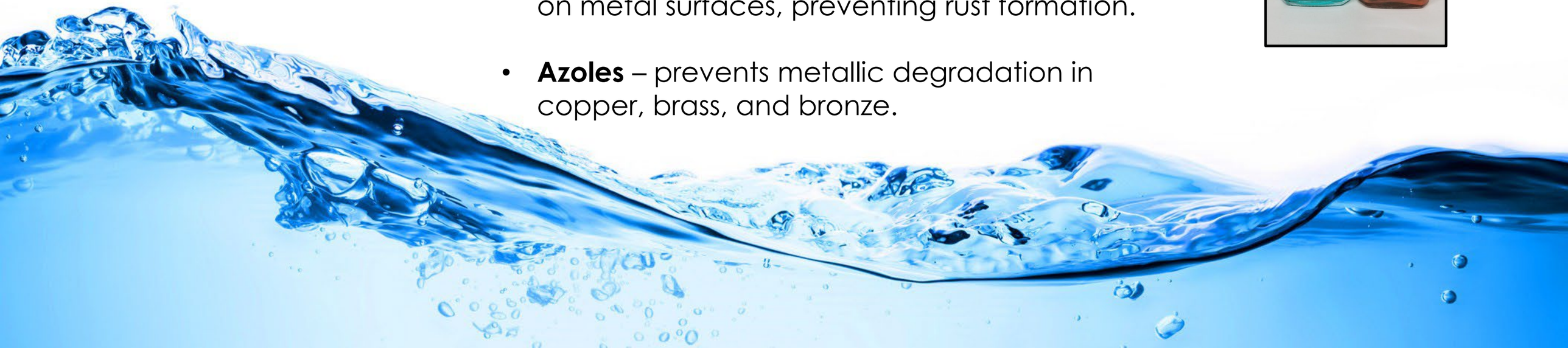


Inhibitors

Common inhibitors used in fully formulated HTF products:

- **Phosphate Based** – Acts as an electronic buffer to reduce the corrosion of metals and alloys.
- **Nitrite Based** – recommended where water quality is a concern. Not recommended for open systems due to oxidation.
- **Molybdate Based** – forms a protective layer on metal surfaces, preventing rust formation.
- **Azoles** – prevents metallic degradation in copper, brass, and bronze.





Do you think your state prohibits the use of inhibitors in HTF for geo-exchange systems?

Check with your state department of natural resources.

For Example: Minnesota requires an HTF that meets ANSI 60 or NSF HT1 standards. A product that meets these standards can be purchased as fully formulated with inhibitors.

Nonfood Compounds
Program Listed HT1
(148445)

Environmental Concerns?

As a non-toxic antifreeze, propylene glycol is used in breweries and dairy establishments and as an inhibitor of fermentation and mold growth.

In veterinary medicine, propylene glycol is used in oral medications and as a solvent for various drugs.

Propylene glycol has even been used in vapor form as an air sterilizer in hospitals and public buildings.

It is not listed as a toxic substance under Section 313 of the Emergency Planning and Community Right-To-Know Act.

Compared to other heat transfer fluids, propylene glycol has a proven track record as an antifreeze when leakage might lead to contact with the environment.

The Food and Drug Administration (FDA) has classified propylene glycol as an additive that is “generally recognized as safe” for use in food.

Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry (ATSDR) Public Health Statement Propylene Glycol CAS# 57-55-6

U.S. Department of Health and Human Services, Public Health Service, ATSDR, Toxicological Profile For Propylene Glycol, Sept. 1997.

Soil Contamination

The high solubility of propylene glycol in water ensures at least partial removal of the compound will occur by wet deposition.

Biodegradation by a variety of microorganisms under both aerobic and anaerobic conditions is the most important transformation process for propylene glycol in soils.

Propylene glycol can be used by microbes as a preferred and highly accessible carbon source.

Generally, the rate of propylene glycol biodegradation is faster in soils with low glycol concentrations, high organic carbon content, and higher ambient soil temperatures.

Bioconcentration and biomagnification are also not likely to occur.

Canadian Council of Ministers of the Environment, 2006 Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health – Propylene Glycol

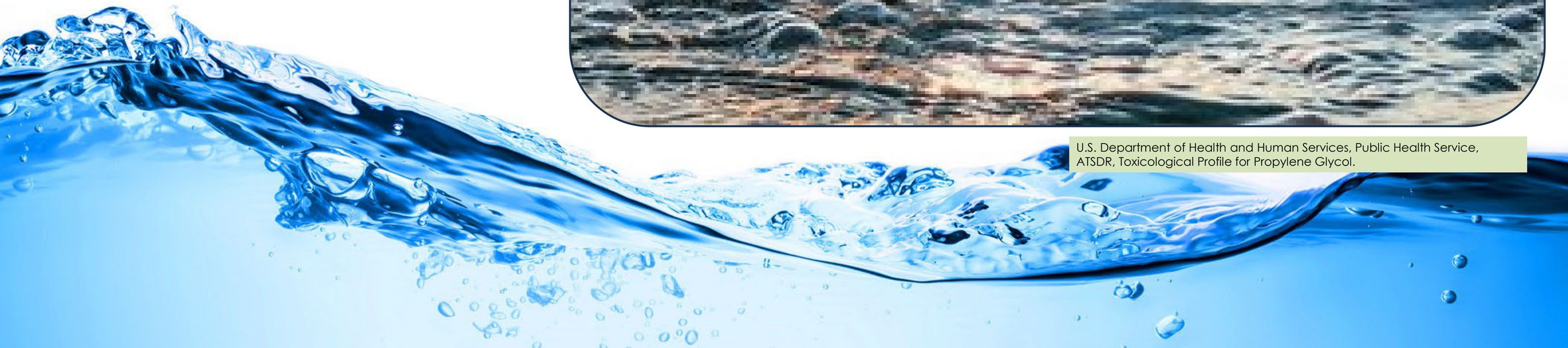
U.S. Department of Health and Human Services, Public Health Service, ATSDR, Toxicological Profile for Propylene Glycol.

Groundwater Contamination:

Propylene glycol is expected to be highly mobile in moist soils and may leach into groundwater upon release to surface soils. However, rapid biodegradation is expected to limit the extent of the leaching.

Propylene glycol is rapidly degraded in all environmental media. The half life of propylene glycol in water is estimated to be 1-4 days under aerobic and 3-5 days under anaerobic conditions.

In soil, the half life is expected to be equal to or less than that for water.



U.S. Department of Health and Human Services, Public Health Service, ATSDR, Toxicological Profile for Propylene Glycol.

Surface Water Contamination:

Although the direct toxicity of propylene glycol is low, there are indirect effects on aquatic life.

Glycols require oxygen to biodegrade, increasing the anaerobic conditions, especially during warmer weather.

It should be noted that propylene glycol diluted with water exerts a lower biological oxygen demand than pure glycol.

Propylene glycol is not expected to bioconcentrate or become biomagnified in aquatic food chains due to the rapid degradation rate in aquatic systems.

Canadian Council of Ministers of the Environment, 2006 Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health – Propylene Glycol

U.S. Department of Health and Human Services, Public Health Service, ATSDR, Toxicological Profile for Propylene Glycol.

Signs of a Leak

Being able to quickly identify a leak in the system can avoid any environmental impacts or damage to your system. Look for:

- Loss of pressure
- Drop in make-up tank levels
- Puddling near the system or in the ground loop area
- Sounds of crackles/bubbles/hissing
- Warm spots

Leak Detection Process

1. Is There a Leak? – A hydrostatic pressure test can reveal if there is a leak and how quickly the system is losing water.

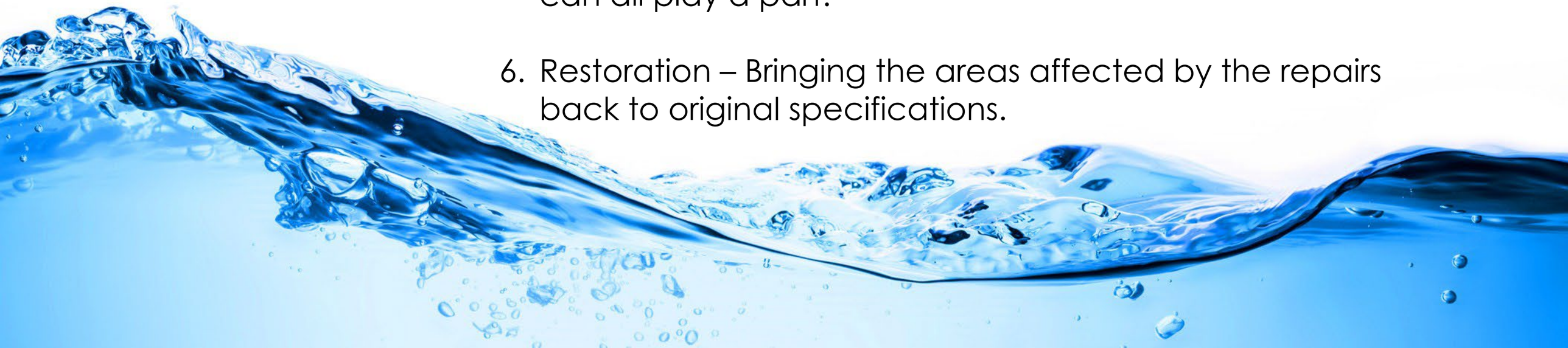
2. Isolation – If loops/manifolds are valved on the supply and return, you can begin the process of elimination.

3. As-Built Records – Can narrow a search area down.

4. Various Detection Methods – Detail on next slide.

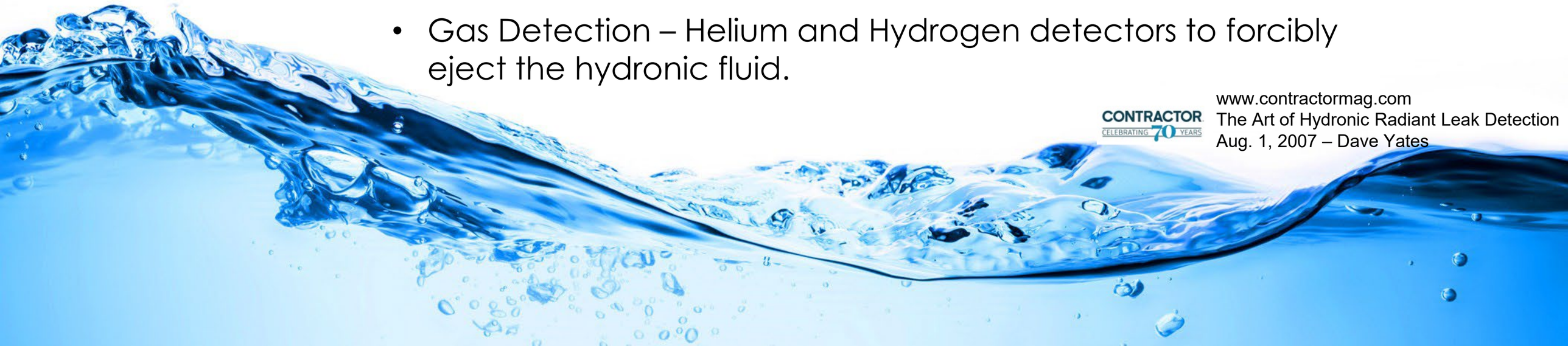
5. Repair – Demolition, potential interference, age of system can all play a part.

6. Restoration – Bringing the areas affected by the repairs back to original specifications.



Detection Methods

- Stop, Look, and Listen – areas of excessive condensation or puddling. Wet, moldy areas. Sounds of hissing or roiling boil.
- Infrared Thermometer – will note areas that are warmer. Can find air-bound loops that aren't circulating.
- Ultrasonic Leak Detection – escaping fluid crackles as air bubbles pass from high to low pressure in the system.
- Infrared Thermal Imaging Cameras – Show temperature variations by color.
- Gas Detection – Helium and Hydrogen detectors to forcibly eject the hydronic fluid.



www.contractormag.com
The Art of Hydronic Radiant Leak Detection
Aug. 1, 2007 – Dave Yates

Deceptive “Leaks”

There are some situations that will mimic a leak but are not actual leaks.

- Thermal Expansion and Contractions
- Condensation (white paper towel test)
- Trapped air can impact system pressure.

Use of Dyes in Leak Detection

UV dyes that are added to heat transfer fluids have gained some popularity in leak detection. Underground leaks present a challenge to find. UV dyes can make it easier to find the general area, preventing excessive digging or demolition.

It should be noted that as indicated in the previous set of slides, Propylene Glycol breaks down very quickly in the environment. The dye itself will remain detectable long after the antifreeze is biodegraded. The dye may indicate a contaminant, where no contaminant exists.

Remediation Technologies Study

The Air Force Research Laboratory did a study on Deicing/Propylene Glycol Microbial Remediation Technology. The Air Force uses significant amounts of PG based aircraft deicing fluids. Their Air National Guard base in Bangor, Maine uses approximately 40,000 gallons a season of 40:60 PG to water mixture.

They identified 10 technologies consisting of Bioremediation, Standard Mechanical Filtration, and Evaporative Processes. They chose bioremediation because it is less capital intensive, requires less maintenance, and requires less oversight.

They tested 3 microbial solutions and found that the PG concentration was reduced to a non-detectable level after 96 hours.

https://apps.dtic.mil/sti/tr/pdf/ADA564124.pdf (Deicing/Propylene Glycol (PG) Microbial Remediation Technology) David J. Dougherty, Elizabeth Berman.

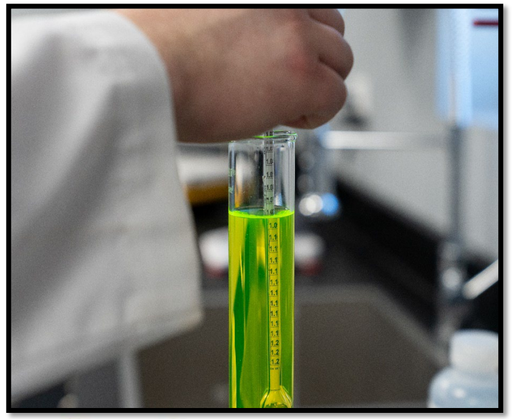
The National Library of Medicine's National Center for Biotechnology Information published a paper on natural and enhanced biodegradation of propylene glycol in airport soil.

They found that with the addition of a microbial nutrient, the PG is degraded even at low temperatures (4 degrees C) that occurs at the high season of snowmelt in aerobic conditions. In anaerobic conditions, it allows for full mineralization of PG without by products (propionic acid, reduced Fe and Mn, methane).

NIH National Library of Medicine
National Center for Biotechnology Information

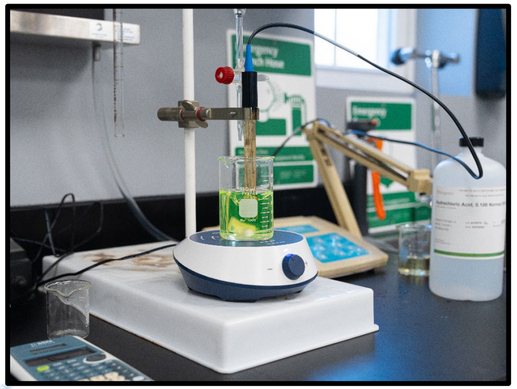
https://pubmed.ncbi.nih.gov/23828729/
National Library of Medicine – National Center for Biotechnology Information.
Natural and enhanced biodegradation of propylene glycol in airport soil.
Giuseppe Toscano, M Letizia Colarieti, Attila Anton, Guido Greco, Borbala Biro.

Maintenance of your hydronic system is just as important as the design, water quality, and initial fill. Monitoring your antifreeze will indicate any issues with corrosion and biofouling, as well as indicate signs of system damage or leakage. Addressing any issues as early as possible will aid in mitigating the risks of damage and/or contamination.



- A Heat Transfer Fluid analysis test should be conducted 90 days after system start-up.
- Any adjustments to the fluid should be made based upon the test results.
- At a minimum, annual inspections will need to take place to ensure the longevity of the HTF and the system.

HTF Fluid Testing – What Should it Screen For?



- Visual analysis of fluid to include color, sediment, and particulate matter
- Base fluid concentration can be tested with a hydrometer or refractometer (digital or analog)
- pH level of the fluid – ensure fluid remains within specification
- Reserve Alkalinity (RA) value – typically done in a lab
- Level of corrosion inhibitors – can deplete over time
- Fluid degradation – due to excessive heat
- Acids – form during degradation causing system corrosion
- Corrosive ions – chlorides/sulfates in poor water quality
- Degradation products – presence of copper or iron indicating corrosion
- Monitor for presence of biological/organic growth

Make-Up Fluid

Make-up system should not be supplied by a municipal water system. We recommend that the product in the make-up tank is the same antifreeze concentration as the system itself.

A Makeup tank is necessary to control the level and dilution of the HTF in the system. An automatic system for topping up the antifreeze should be provided, complete with a pressure-actuated control that sets off an alarm when a leak is detected.

Monitoring levels in the tank can detect a spike in usage, indicating a leak in the system and necessitating a fluid test to assure dilution and corrosion inhibitors are at optimal levels.

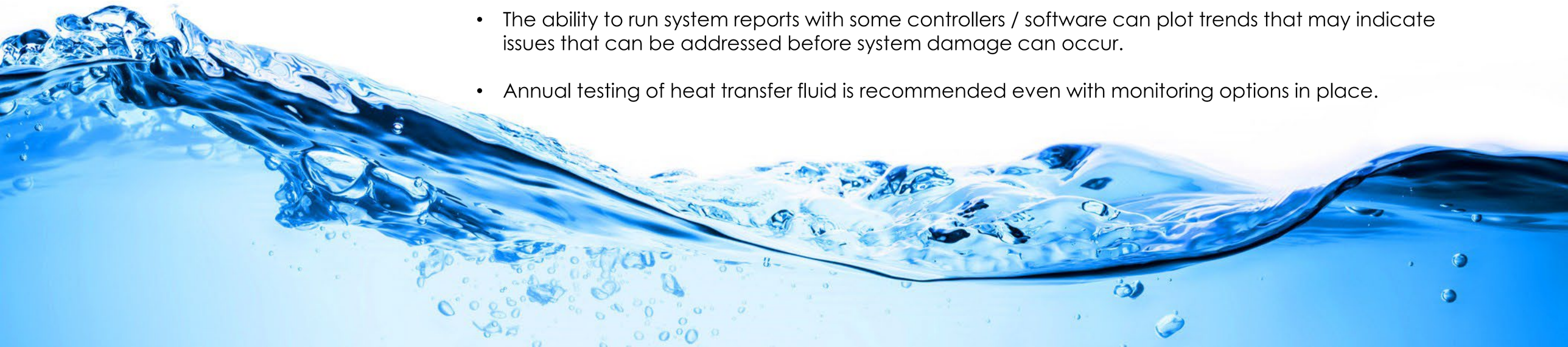
(see ANSI/CSA/IGSHPA C448.1 section 7.1.4.5)or
(IAPMO/ANSI H1001.1-2021 section 4.7)

Remote Monitoring:

Monitoring tank levels, corrosion, and biofouling remotely may be an option to consider.

Remote Monitoring equipment can be designed into the hydronic system itself, to alert facilities of indicators that can damage equipment both long term and short term.

- The ability for simultaneous monitoring of fluid temperature, pH, and total dissolved solids keeps your finger on the pulse of your hydronic system.
- Tank level monitors can track heat transfer fluid usage and can indicate a spike in use or when additional top off fluid is required.
- The ability to run system reports with some controllers / software can plot trends that may indicate issues that can be addressed before system damage can occur.
- Annual testing of heat transfer fluid is recommended even with monitoring options in place.



Questions?

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Review Questions:

Water Quality – “If it’s good enough to drink, it’s good enough to fill your system.” **False, poor water quality will reduce heat transfer efficiency**

“To prevent biofouling, a fully formulated heat transfer fluid needs a concentration greater than what percentage?” **25%**

“Which ASTM specification covers the requirement for ethylene glycol, propylene glycol, and other heat transfer fluids.” **ASTM d8039**

There is widespread disagreement about the ability of corrosion inhibitors to increase the life of a system.” **False.**

Review Questions:

“Which of the following are leak detection processes? A) A hydrostatic pressure test, B) Isolation through valving loops and/or manifolds, C)Infrared thermometer, or D) All of the above?” **4, all of the above.**

“At minimum, inspections of the system must happen every two years to ensure the longevity of the heat transfer fluid and the system.” **False, annually**

“Makeup heat transfer fluid should be supplied by a municipality.” **False, makeup fluid should match the original fluid**