



Heat Transfer Fluids

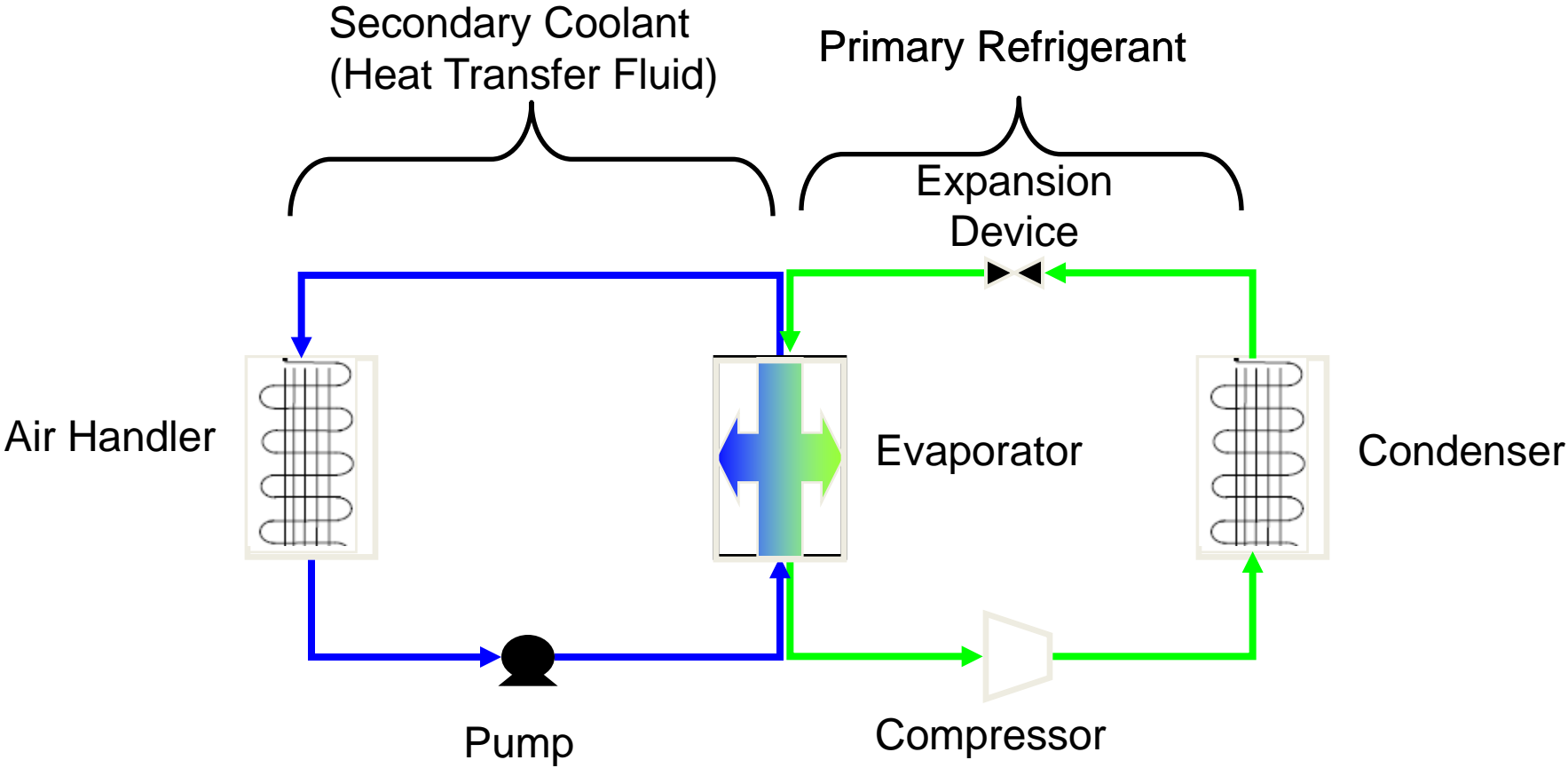
Dispelling the Myths of Heat Transfer Fluids

Kevin Connor – The Dow Chemical Company

Solutions for life.



Heat Transfer – Chill Water Loop



The Need for “Antifreeze”

- Water is almost a perfect fluid...
 - Excellent heat transfer
 - Excellent health & safety
 - Low cost
- *BUT* water freezes at 0°C / 32°F
- Antifreeze protects system piping and components from damage caused by freezing
 - Volume expansion due to ice crystals generates pressure which ruptures pipes and can destroy equipment

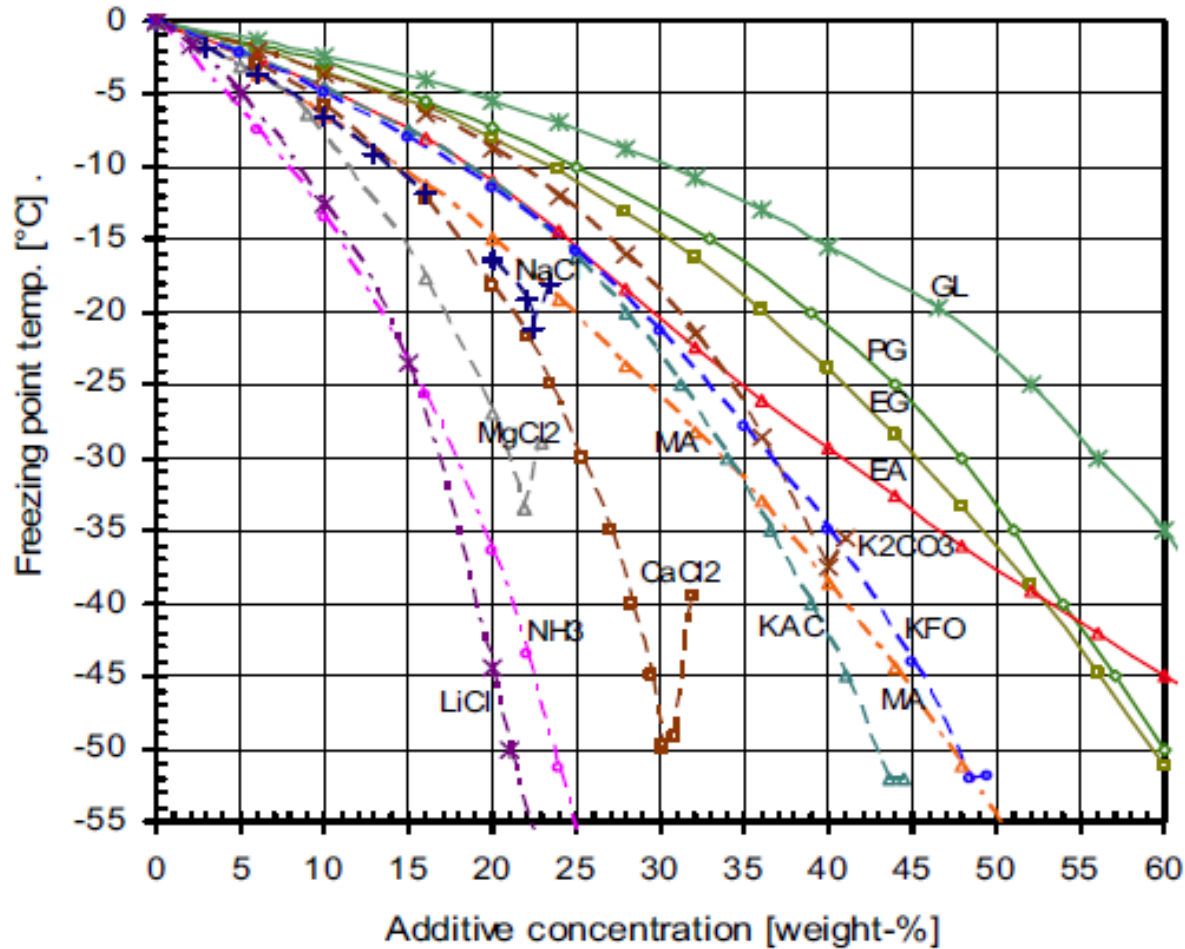
Heat Transfer Fluid “Wish List”

- Effective freeze protection
 - Freezing point below -40°C / -40°F
- Efficient heat transfer over broad temperature range
 - -15°C to 125°C / 0°F to 250°F
- No harmful effects (health, safety, environment)
 - Non-toxic, non-flammable, environmentally benign
- Non-corrosive / non-destructive to materials
 - 20+ year fluid life
- Low cost
 - Low power consumption, low capital cost, and low maintenance

Choice of Heat Transfer Fluids

- Salt based (brines)
 - Lithium bromide
 - Calcium chloride
 - Magnesium chloride
 - Sodium chloride
 - Potassium acetate
 - Potassium formate
 - Potassium carbonate
 - Betaine
- Alcohols & Glycols
 - Methanol
 - Ethanol
 - Ethylene glycol
 - Propylene glycol
 - 1,3-propanediol
 - Glycerin
- Non-aqueous Fluids
 - Mineral oils
 - Synthetics

Impact on Freezing Point



Data from Melinder 2007
 "Thermophysical Properties of
 Aqueous Solutions Used as
 Secondary Working Fluids "

Impact on Corrosion



15% Methanol

15% Propylene
Glycol

Water

Corrosion

- All salts are very corrosive
 - Long term protection is impossible even with corrosion inhibitors
- Glycols or alcohols (without corrosion inhibitors) are corrosive to most metals
 - Oxidize to form acids → low pH → acidic pH is corrosive
 - Must use correct type of corrosion inhibitor technology
- Corrosion damage can occur in less than 2 years
 - Worse for high temperatures and high exposure to air or dissolved O₂

Corrosion Control

- Corrosion can be limited by control of key environmental variables
 - Design & Operation
 - Materials
 - Temperature & exposure to O₂
 - Fluid Chemistry
 - Corrosion inhibitors & pH
 - Fluid purity
- Maintain metal in passive rather than active state
 - Corrosion rate 1000 times lower



Impact on System Efficiency

* Data from Melinder 2007
 "Thermophysical Properties of
 Aqueous Solutions Used as
 Secondary Working Fluids "

Physical Properties @ 10°C/ 50°F

Fluid Description	Freezing Point (°C)	Thermal Conductivity (W / m.K)	Volumetric Heat Capacity (kJ / L.K)	Viscosity (cP)
water	0	0.582	4.18	1.3
Methanol * 12 wt%	- 7.5	0.525	3.86	1.3
Ethanol * 15 wt%	- 7.5	0.500	3.83	2.7
Ethylene Glycol * 19 wt%	-7.5	0.501	3.94	2.0
Propylene Glycol * 20wt%	-7.5	0.484	3.86	2.8
Glycerol * 26wt%	-7.5	0.481	3.97	3.1
Mineral Oil (VG2)	-15 (pour pt.)	~0.16	~1.6	~28

System Performance

- Adding antifreeze to water negatively impacts system performance
 - Must trade performance for freeze protection
- Reduced heat transfer efficiency
 - Antifreeze decreases thermal conductivity & specific heat
 - How much will system performance be reduced?
 - Regrettably there is no “one size fits all” answer
- Increased power consumption
 - Antifreeze increases viscosity → affects pump horsepower and fluid flow

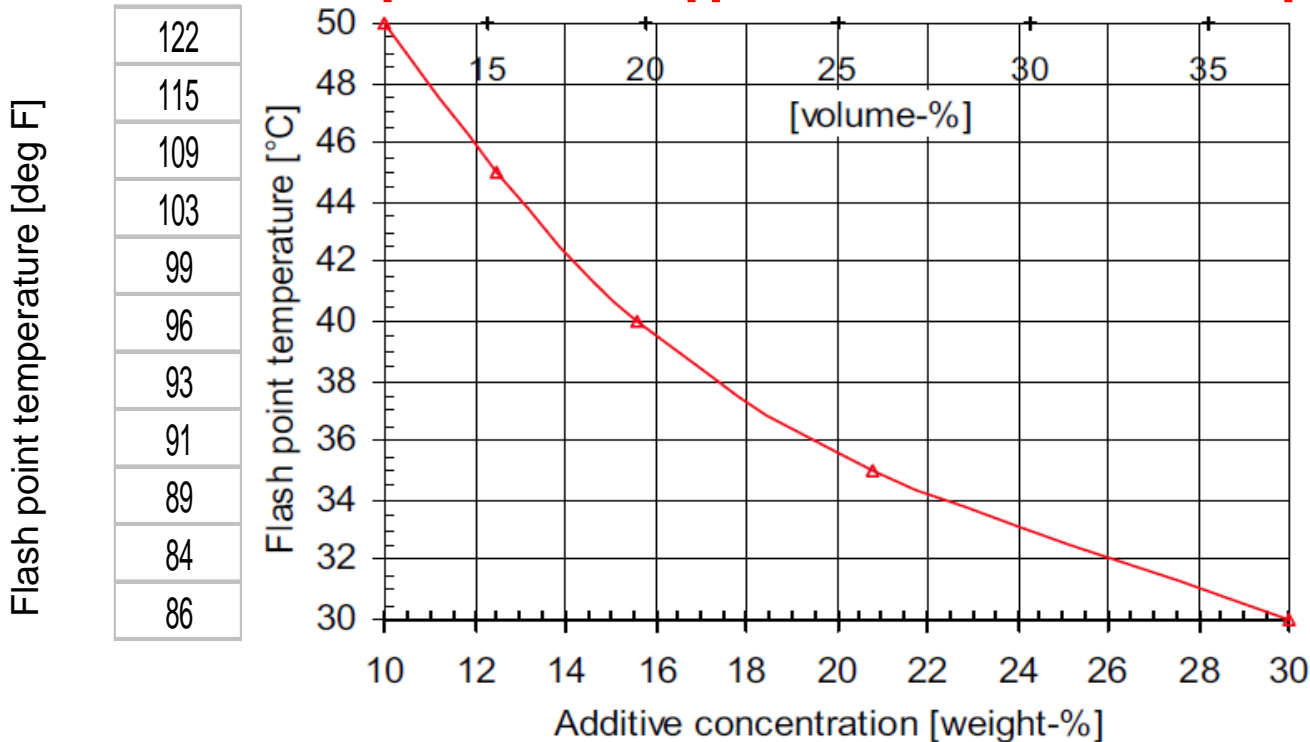
Impact on Health & Safety

- Methanol and ethylene glycol are classified as moderately toxic
 - About 125 mLs is lethal dose for typical sized adult
- Industrial ethanol (not for consumption) is denatured
 - Can contain methanol, pyridine or other (toxic) denaturants
- Only propylene glycol is formally approved by FDA
 - Direct food additive – essentially non-toxic
 - Generally Regarded As Safe (GRAS)
- Alcohols are low boiling fluids with low flash points
 - Flammability and fire safety concerns

Fire Safety

RCRA hazardous waste (ignitable)

OSHA hazardous material (flammable)



LFL "pure" ethanol = 4%
Flash pt = 13°C / 55°F

Advantages of Using Glycol

- ☑ Effective Freeze Protection
- ☑ Non-corrosive (if properly formulated)
- ☑ Relatively Efficient Heat Transfer
- ☑ No Adverse HS&E Effects
 - ☑ Health – Low toxicity (PG fluids)
 - ☑ Safety – Non-flammable
 - ☑ Environment – Readily Biodegradable
- ☑ Relatively Low Cost

Advantages of Choosing Dow

- Dow heat transfer fluids are properly formulated with corrosion inhibitors and pH buffers which
 - Passivate metal surfaces → prevent corrosion
 - Neutralize degradation compounds → prevent pH drop
 - Thermoxidatively stable → provide long term protection
- Avoid cooling tower inhibitor packages
 - Designed for water --- not glycol
- Avoid automotive coolant inhibitors
 - Designed for relatively short fluid lifetimes

DOWTHERM™ SR-1 Fluid

- Ethylene glycol-based fluid (95%)
- Fluorescent pink
- Efficient heat transfer
 - -28° to 120° C
- Provides freeze / burst protection
 - -51° C / -60° C (depending on concentration)
- Dow is the oldest back-integrated supplier of glycol based heat transfer fluids:
 - DOWTHERM™ SR-1 originated in the late 1940's



DOWFROST™ Fluid

- Propylene glycol-based fluid (96%)
- Water white
- Low toxicity – fully complies with FDA & NSF regulations
 - Made with DOW PuraGuard™ Propylene Glycol USP/EP
- Efficient heat transfer
 - -18° to 120° C
- Provides freeze / burst protection
 - -51° C / -60° C (depending on concentration)



Advantages of DOW PuraGuard™

- DOWFROST™ is the only inhibited glycol made with DOW PuraGuard™ Propylene Glycol USP/EP, a pharmaceutical grade of monopropylene glycol with a specified purity of 99.8% or greater
- Competitive products are made with lower quality PG
 - Fluid lifetime & safety are compromised
- Industrial grade PG or bio-derived PG can have:
 - High aldehydes & dioxolanes → odor forming compounds
 - High ethylene glycol & diethylene glycol → toxic compounds

DOWFROST™ HD Fluid

- Propylene glycol-based fluid (94%)
- Fluorescent yellow
- Fortified inhibitor package versus regular DOWFROST™
 - Does not have same FDA / NSF approval
- Efficient heat transfer
 - -18° to 135° C
- Provides freeze / burst protection
 - -51° C / -60° C (depending on concentration)
- Available as concentrate or premixed solution
 - Customer blends available from Dow distributors



DOWFROST™ GEO 20

- Propylene glycol-based fluid (20 vol%)
 - Fluorescent yellow
- Designed for Geothermal Heat Pumps
 - Lower concentration means lower pumping cost & higher heat transfer efficiency
 - Excellent corrosion protection
 - Bio-static concentration (will not support bio-degradation / bio-fouling unless diluted)
- Operating range:
 - 23° to 212° F with 18.5° F freeze point
- Drum & smaller packages available from Dow distributors



Which Product Do I Choose?

- Ethylene glycol (EG) is moderately toxic
 - ~½ cup is lethal to an average size adult
- Propylene glycol (PG) is essentially non-toxic
 - Approved by FDA as direct food additive
- Use DOWFROST™ for low toxicity needs
 - Food processing (DOWFROST™ only)
 - Schools or hospitals (DOWFROST™HD)
- Use DOWTHERM™SR-1 for other applications
 - EG provides better performance (heat transfer & pumping power) → lower cost option

Avoid Poorly Formulated Products

Metal	Test Data	ASTM Limit
Copper	1.6	10
Solder	9.2	30
Brass	3.7	10
Steel	199	10
Cast Iron	297	10
Aluminum	88	30



Tips for Proper Operation

- Use purified water (distilled, de-ionized) for dilution
- Install and maintain “correct” glycol concentration
 - Over-dilution → causes corrosion & bio-fouling
 - Too concentrated → causes poor heat transfer
- Operate within recommended temperature ranges
 - Over-heating → compromises fluid life
- Test your fluid regularly
 - Good fluid maintenance helps prolong the life of your system

Water Quality

- Salts cause corrosion
- Hardness causes scales & sludge
- Requirements for dilution water
 - Chlorides <25 ppm
 - Sulfates <25 ppm
 - Total hardness (as CaCO_3) <100 ppm



Over-Dilution

- Over-dilution causes corrosion and bio-fouling
 - Glycol degradation
 - Unpleasant odors
- Minimum concentration
 - 20% - 25%
- Maximum concentration
 - 60% - 65%



Bio-fouling - customer sample with 11% propylene glycol

Over-Heating

- Fluid degradation and corrosion increase as temperature increase
 - Fluid life compromised
- Temperature limits
 - Max bulk: 250 F to 350 F
 - Max film: 300 F to 400 F



→
Increased time / temperature, exposure to O₂ / air

Dow Analytical Service

- Free service if system contains more than 250 gallons of DOWTHERM™ SR-1 / DOWFROST™
- Sample analysis kits are available from Dow
 - “2 PAK’s” and “6 PAK’s”
- Send samples to Dow laboratory and receive comprehensive analysis & report within 2 weeks
- Detailed analysis:
 - Glycol concentration & freeze point
 - Corrosion inhibitors, pH, various contaminants
 - System maintenance recommendations

Sample Kits



Solutions for life.



Heat Transfer Fluids

Example Report

The DOW CHEMICAL COMPANY

DOWFROST* *Heat Transfer Fluids* **DOWFROST***

Sample Analysis Report

██████████
 TEXAS OPERATIONS, 2301 BRAZOSPORT
 FREEPORT, TX
 979-238-9427

This is a copy of the report for:
 ██████████
 ██████████
 ██████████
 Sparks, NV 89431

Sample Label Description: Lasko

Sample Received: 01/04/2002
 Sample Number: 2002-001-0036
 Login Number: 110-2002-0007
 Report Date: 01/24/2002

Distributor:
 Not Available

	New Data	Acceptable
Appearance:		
Color	fluorescent yellow	---
Clarity	clear	clear
Sediment	none	none
Concentration & Freeze Point:		
Propylene Glycol	35	25-60
Freeze Point	10 °F (-13 °C)	---
Corrosion Inhibitors:		
Iron inhibitor (phosphate)	acceptable	---
Copper inhibitor (azole)	acceptable	---
Fluid pH	8.8	8-10.5
Reserve Alkalinity	17.2	>8
Corrosives & Scale Promoters:		
Chloride	30	≤100
Sulfate	0	≤250
Total Hardness	13	≤100
Ferrous metal corrosion rate	≤0.05	≤0.5
Copper corrosion rate	0.06	≤0.5
Contaminants & Other Glycols:		
Nitric	ppm NO2	0
Nitrate	ppm NO3	≤100
MBT	ppm MBT	0
Ethylene Glycol	vol% EG	≤1
Diethylene Glycol	vol% DEG	≤1
Triethylene Glycol	vol% TEG	≤1

FLUID MAINTENANCE RECOMMENDATIONS:
 This fluid is in good condition and is suitable for continued use. No adjustments or inhibitors are needed at this time.

* denotes a registered trademark of the Dow Chemical Company

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 For technical assistance regarding this report please contact Kevin Connor at 989-636-8690
 For sales and general information about our products please contact Dow Customer Service: 1-800-447-4369

The Bottom Line

- Glycol based fluids provide excellent overall protection
- Understand the impact that glycol has on water
 - Trade off between performance versus freeze protection
- Select and use a properly formulated glycol based fluid
 - Specifically designed for HVAC applications
- Correctly installed and maintained DOWTHERM™ and DOWFROST™ inhibited glycol heat transfer fluids can help protect your system for 20+ years

www.dowfrost.com

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