

Propylene Glycol: Dusting off an Old Study for a New Generation

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Belforts and Geonors also use antifreeze



Why Antifreeze?

- Solution needed to keep contents from freezing, and for falling snow to be melted
- Specific gravity (SG) is the key – solution must be LESS DENSE than water (< 1.0) so it is “self-mixing”
- 40:60 Glycometh solution used for years – NWS
- Ethylene glycol is poisonous – CNS damage to mammals, concerns about onsite disposal
- Study done in 1992, change to propylene glycol, a non-poisonous “sugar” in common use, but what ratio?

Attributes of PG and Ethanol

- SG of PG is 1.04 – water falling into a gauge would melt but not mix, and a disk of ice would form on top
- SG of ethanol is ~0.82 – perfect for melting snow and mixing with PG, but evaporates easily
- PGE mixture is non-toxic, degrades easily in soil, and readily available –evap control is needed
- SG of Mineral (baby) Oil is 0.80, does not evaporate, and is a perfect “cap” to prevent ethanol evaporation
- What ratio of PG to E?

1992 WSC report

Table 1

VOLUMES OF PROPYLENE GLYCOL (PG) AND
ETHANOL FOR EACH SET OF DILUTIONS

Ratio (%) PG : Ethanol	Volume (ml) PG	Ethanol
20 : 80	135	540
30 : 70	203	472
40 : 60	270	405
50 : 50	338	338
60 : 40	405	270

Dilutions in Water

Table 2

VOLUMES OF EACH RATIO OF PROPYLENE GLYCOL AND ETHANOL SOLUTION (PGE) MIXED WITH WATER TO ACHIEVE TEN DILUTIONS SIMULATING MIXING WITH PRECIPITATION

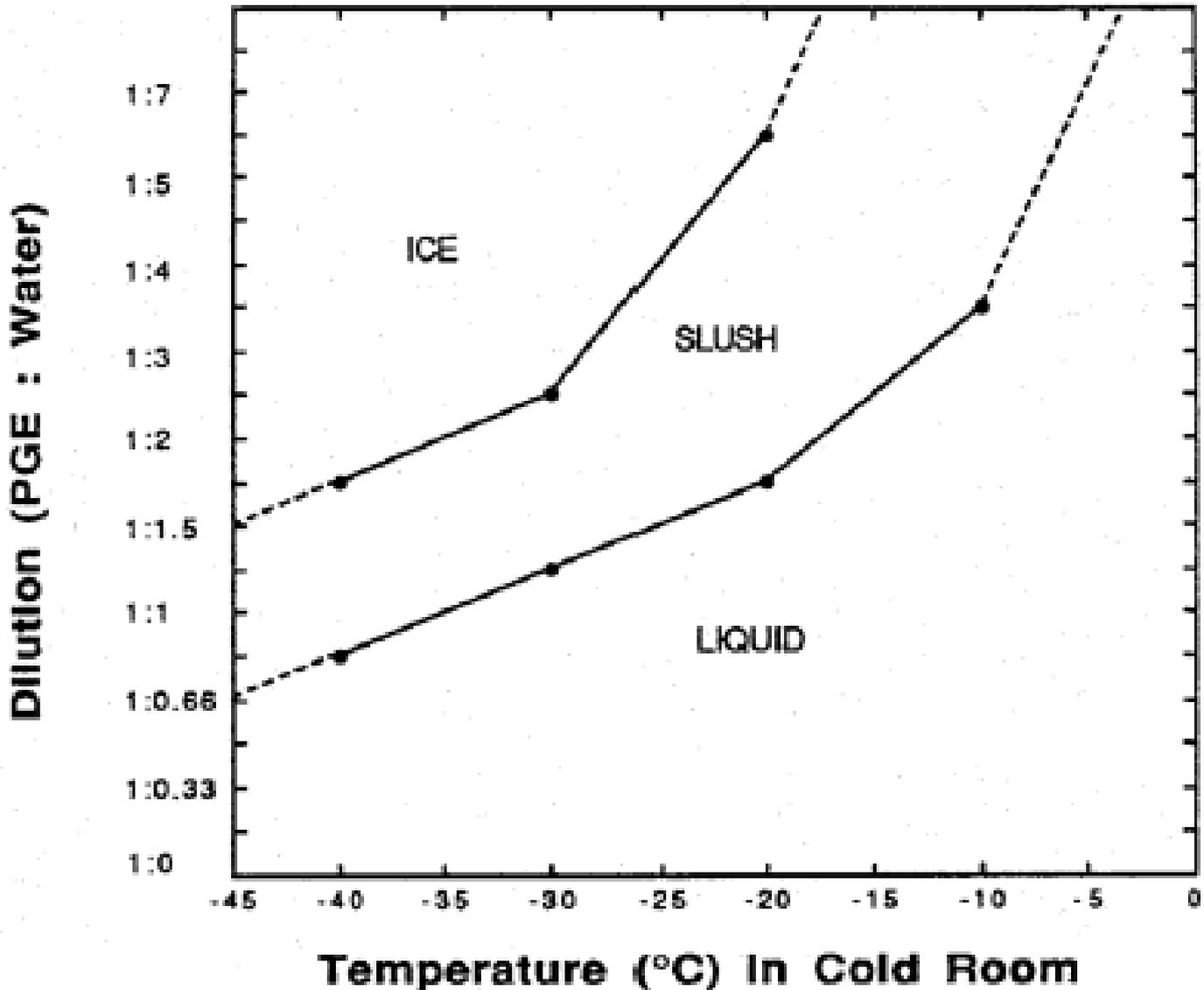
<u>Dilution</u> PGE:Water	Volume (ml)	
	PGE	Water
1 : 0	150	0
1 : 0.33	113	37
1 : 0.66	90	60
1 : 1	75	75
1 : 1.5	60	90
1 : 2	50	100
1 : 3	38	112
1 : 4	30	125
1 : 5	25	125
1 : 7	19	131

Cold Room Freeze Tests



- Cold room located – Saskatoon
- Tests: Room at 0, -10 (14 F), -20 (-4 F), -30 (-22 F), & -40 (-40 F) deg. C
- Three states recognized: liquid, slush, & solid
- Slush identified by visible crystals
- Solid identified by inability to insert thermometer
- Thermometers liquid in glass, precision 0.1 deg. C
- Solutions in 250 ml Nalgene bottles in mesh racks, two 5x10 matrices

Results – Temp. vs. Dilution



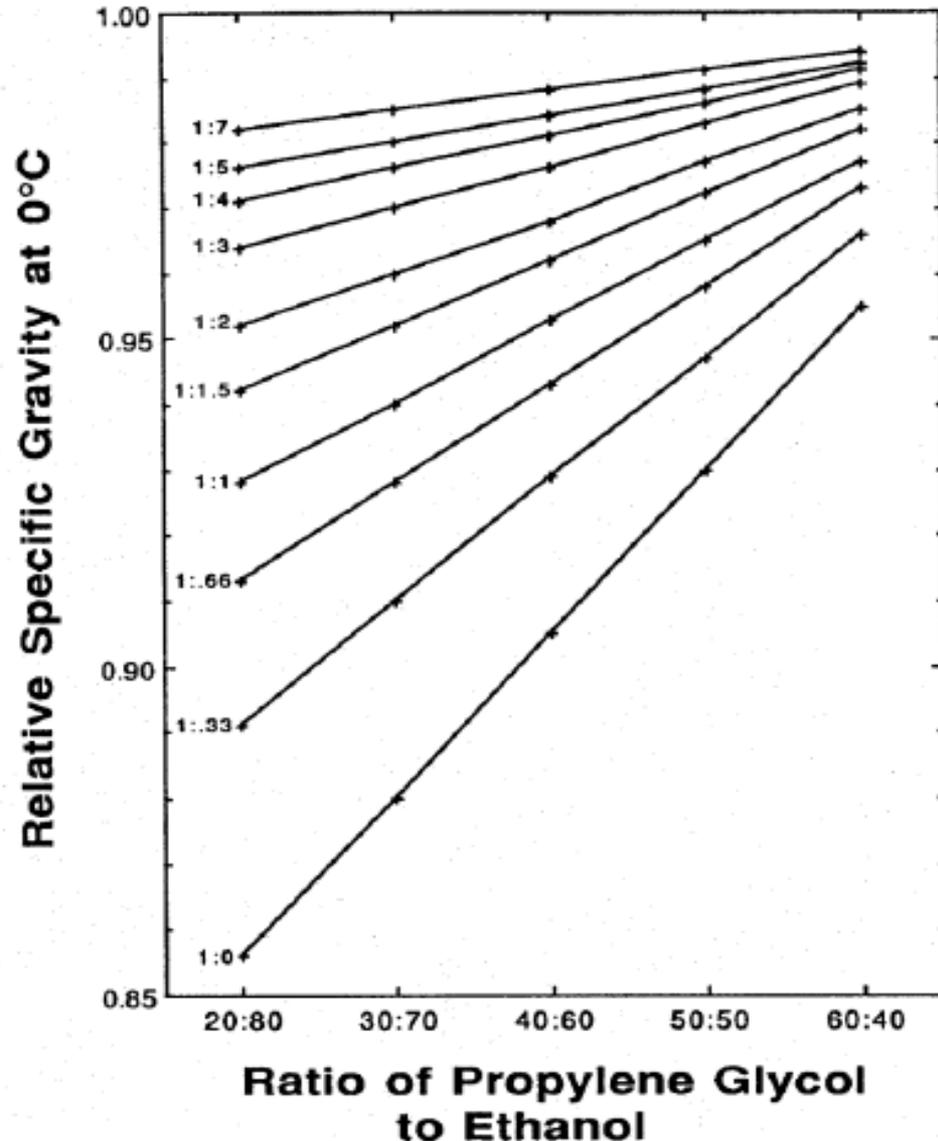
Results – Dilution & Ratio

- No evidence that PG:E ratio had effect on freezing temperature
- Dilution ratio (PGE:water) dominated freezing temp
- Selection of optimal ratio of PG:E dependent on desired range of SG – initial SG, Jan. 1 SG, and season-end SG
- Volume of initial charge of PGE dependent on expected minimum temperatures and seasonal precip accumulation (storage gages)



PG:E ratio selection

- SG of water & PGE solution rises as season progresses
- Mixing equation from NRCS (1982) used to calculate dilution due to Jan. 1 % of seasonal total precip
- Solution must be more dense than oil cap (0.8)
- 20:80 and 30:70 ratios rejected, SG's below 0.9
- **50:50 optimal**



Mixing table – Storage gauge

MINIMUM OCTOBER 1 RECHARGE VOLUMES OF A 50:50 MIXTURE OF PROPYLENE GLYCOL AND DENATURED ETHANOL FOR PRECIPITATION GAUGES, IN LITERS (U.S. GALLONS)

Minimum January 1 Temp. °C °F		Maximum Jan. 1 Water %	Average Annual Precipitation: cm (inches)										
			51 (20)	76 (30)	102 (40)	127 (50)	152 (60)	178 (70)	203 (80)	229 (90)	254 (100)	305 (120)	530 (140)
-10	14	78	5.1 (1.3)	7.1 (2.0)	10@ (2.6)	12 (3.3)	15 (3.9)	17 (4.6)	20 (5.2)	22 (5.9)	25 (6.5)	30 (7.8)	35 (9.2)
-20	-4	64	12 (3.3)	17 (4.5)	22 (5.8)	27 (7.1)	32 (8.4)	37 (9.7)	42 (11.0)	47 (12.3)	52 (13.6)	62 (16.2)	72 (19.0)
-30	-22	56	18 (4.8)	25 (6.6)	32 (8.4)	39 (10.2)	46 (12.0)	52 (13.8)	59 (15.6)	66 (17.4)	73 (19.2)	87 (22.8)	101 (27)
-40	-40	45	29 (7.7)	40 (10.6)	51 (13.4)	61 (16.2)	72 (19.0)	83 (21.8)	94 (24.7)	104 (27.5)	115 (30.3)	136 (36.0)	157 (41)
-50	-58	35*	46 (12.1)	62 (16.3)	78 (20.6)	94 (25.0)	111 (29.2)	127 (33.5)	143 (37.8)	159 (42)	176 (46)	208 (55)	242 (64)

* : Estimated

@ : Volumes greater than 10 liters (40 gallons) rounded to nearest unit

Recommendations

- 1:3 is best recipe for colder sites to reduce slush periods
- Can go to 1:4 as season warms (March or April on)
- For 12" weighing gauge, that means 3" of PGE per charge, plus approx. quarter-cup of oil on top
- Sierra Chem (W. Sacto) sells Sierra Blend 50-50, SG is 0.91 at 70 deg F - perfect
- Sierra Blend 83-17) (PG:E) has an SG of 1.03 – DENSER than water! Not SELF-MIXING, water would stay on top and freeze.

Substitute veg oil for mineral oil

- SG is 0.85, only slightly greater than mineral oil
- Salt water SG is 1.03, and will not self mix

That natural and vegetable oils are biodegradable is not in doubt. “Vegetable oils and synthetic esters have a much better biodegradation capacity than mineral oil under aerobic as well as anaerobic conditions” (Broekhuizen et al, 2003). Tests carried out severally indicate that vegetable oils undergo about 70-100% biodegradation in a period of 28 days.

Environmental issues

- PGE is non-toxic. However, methanol may
- be included at a 5% ratio in the alcohol – mildly toxic to mammals
- PG is a sugar solution, used as RV antifreeze and de-icer, routinely flushed to the ground, digested.
- Ethanol evaporates or infiltrates into soil and is digested by soil organisms
- Avoid discharge into streams/water bodies but aquatic toxicity is low
- **NO NEED** to remove diluted mixture, but agency policies vary and often ignore the **SCIENCE**



Hundreds attend global warming protest

