



Susterra® the natural choice...  
Purity and Renewable Performance

May 25, 2010

Bob Miller



# DuPont Tate & Lyle Bio Products LLC



*The miracles of science™*

DuPont is a science and technology company that operates in five segments: Agriculture and Nutrition, Coatings and Color Technologies, Electronic and Communication Technologies, Performance Materials and Safety and Protection. 2008 revenues were \$32 B.



Tate and Lyle is a world leader in renewable ingredients providing ingredients, solutions and services to food, beverage and industrial customers. Headquartered in London, Tate and Lyle had sales of \$5 B in 2008.



DuPont Tate & Lyle Bio Products, a joint venture formed in 2004, provides renewably sourced, high quality ingredients that deliver superior functionality and enable our customers to offer renewable, natural and sustainable products. Our initial offerings are Zemea® and Susterra® propanediol from corn sugar, a sustainable & renewable resource.

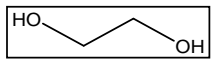
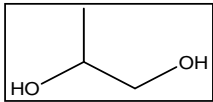

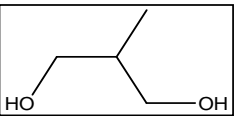
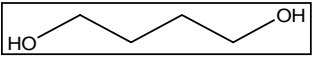
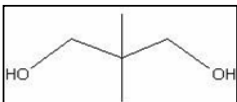
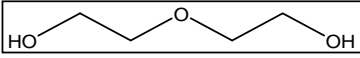
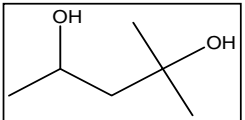
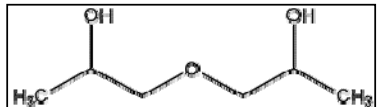


# DuPont Tate & Lyle Bio Products Loudon, Tennessee Plant

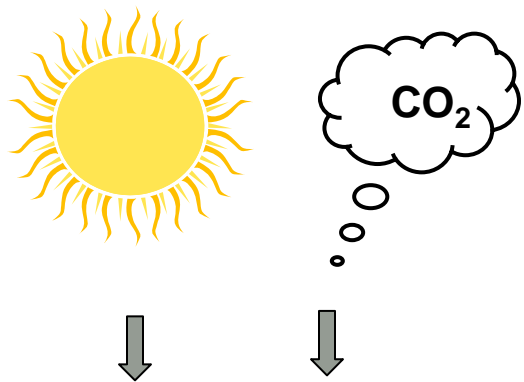
- 12 year R&D effort
- Bio-PDO™ production started in November, 2006
- 100 million pound annual capacity
- \$100 million dollar capital investment



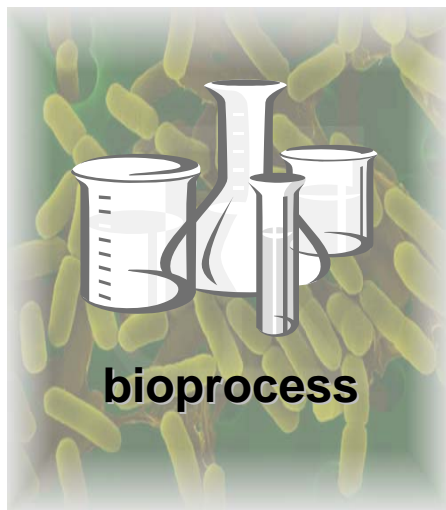
# Susterra® Propanediol (PDO) - a range of potential uses

Common	Ingredient	CAS #	Formula	Structure	Mol. Wt.	Bp, oC	Mp, oC	Density
EG	1,2-Ethandiol	107-21-1	C <sub>2</sub> H <sub>6</sub> O <sub>2</sub>		62.1	197.6	-12.7	1.116
PG	1,2-Propanediol	57-55-6	C <sub>3</sub> H <sub>8</sub> O <sub>2</sub>		76.1	187.3	-60	1.038
<b>Susterra™</b>	<b>1,3-Propanediol</b>	<b>504-63-2</b>	<b>C<sub>3</sub>H<sub>8</sub>O<sub>2</sub></b>		<b>76.1</b>	<b>214</b>	<b>-24</b>	<b>1.053</b>
MPDiol	2-Methyl-1,3-Propanediol	2163-42-0	C <sub>4</sub> H <sub>10</sub> O <sub>2</sub>		90.1	221	-91	1.015
1,4 BDO	1,4-Butanediol	110-63-4	C <sub>4</sub> H <sub>10</sub> O <sub>2</sub>		90.1	230	16	1.017
Neopentyl Glycol	2,2-dimethyl-1,3-Propanediol	126-30-7	C <sub>5</sub> H <sub>12</sub> O <sub>2</sub>		104.1	208	127	~1.05
DEG	Diethylene Glycol	111-46-6	C <sub>4</sub> H <sub>10</sub> O <sub>3</sub>		106.1	245	-10	1.118
Hexylene Glycol	2-Methyl-2,4-Pentanediol	107-41-5	C <sub>6</sub> H <sub>14</sub> O <sub>2</sub>		118.2	197	-40	0.925
DPG	Dipropylene Glycol (several isomers are possible)	25265-71-8	C <sub>6</sub> H <sub>14</sub> O <sub>3</sub>		134.17	231		1.023

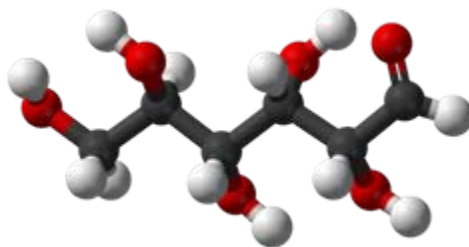
# Process to Susterra<sup>®</sup> Propanediol



**Corn**



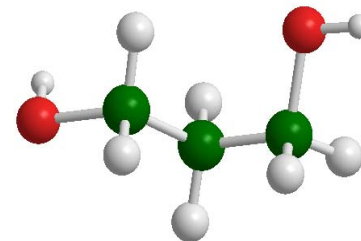
**Fermentation process**



**Glucose**



**Refine to 99.7% Purity**



**Susterra<sup>®</sup>**

(Bio-derived 1,3-Propanediol)

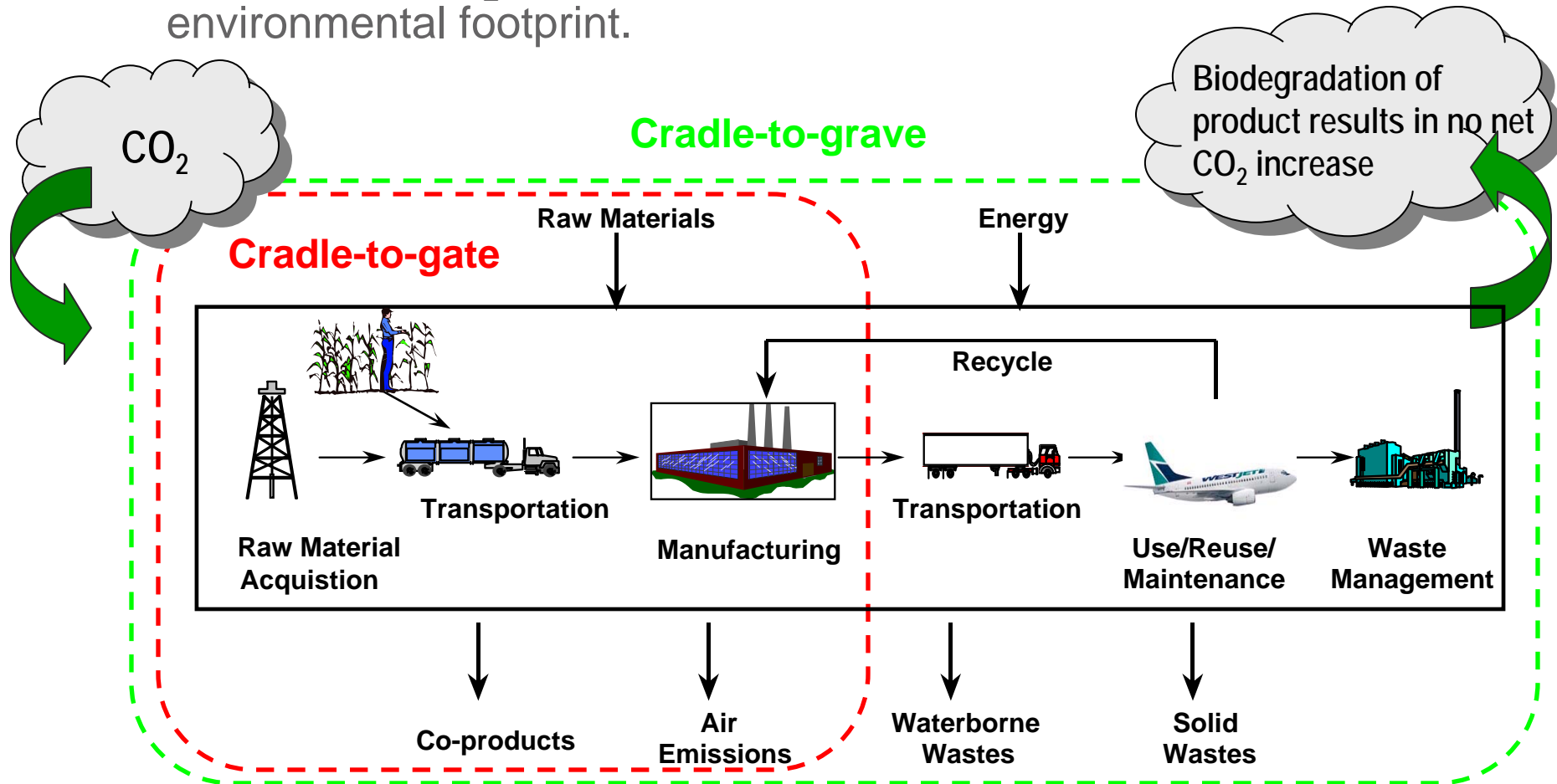
# Susterra® Product Specifications

Release properties (reported on COA)<sup>1</sup>

Property	Units	Limits	
		Min	Max
<b>1,3-Propanediol</b>	GC area%	99.70	100.00
<b>Color</b>	Hazen/APHA	0	15
<b>Water</b>	ppm	0	1000
<b>Appearance Free of Suspended Matter</b>	Visual pass/fail		

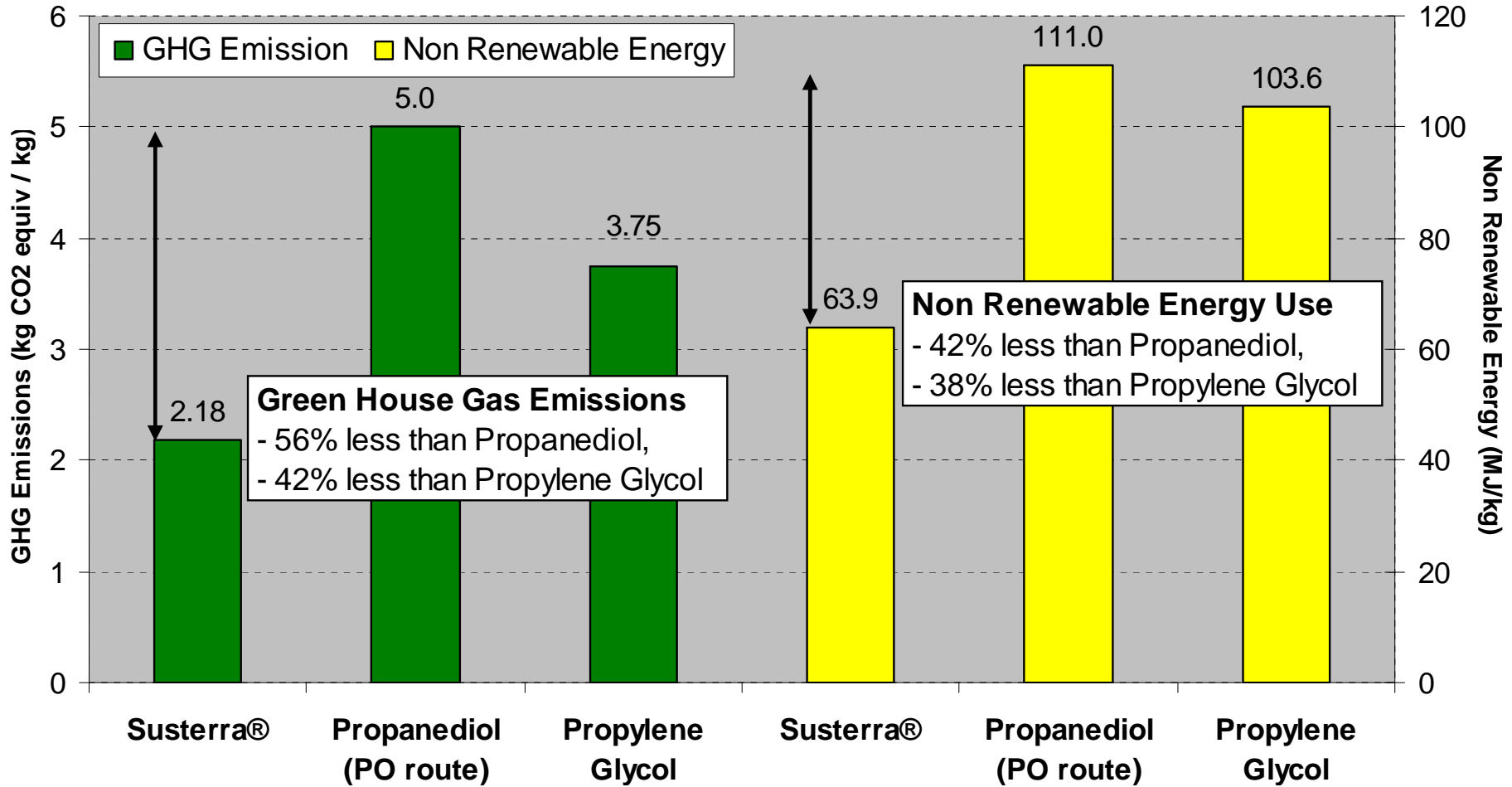
# Life Cycle Analysis Approach

LCA is the only standardized method to evaluate the environmental footprint of a whole supply chain. Energy consumption and Green House Gas (CO<sub>2</sub>) emissions are key factors in determining environmental footprint.



# Susterra® Life Cycle Assessment\* Comparison

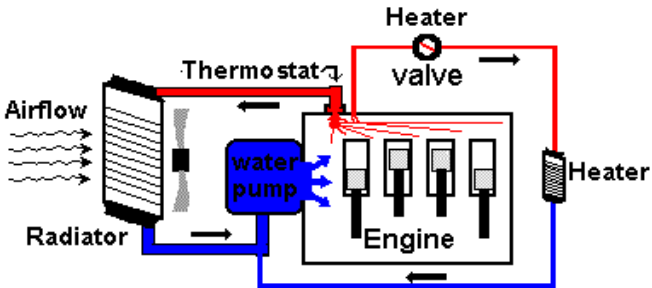
From “cradle-to-gate,” the production of Susterra® consumes 40% less energy and reduces greenhouse gas emissions by more than 40% versus petroleum-based 1,3-propanediol and propylene glycol.



\*Susterra® LCA data based on Loudon process design data; peer reviewed by Five Winds International

# Industrial Fluid Applications with Susterra® Propanediol

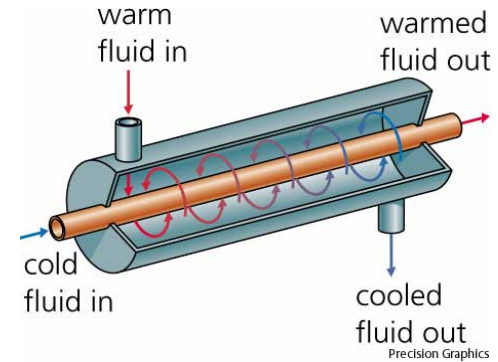
## Antifreeze/Coolants



## Deicing Fluid



## Heat Transfer Fluids



DuPont Tate & Lyle  
Susterra™  
renewably sourced™ propanediol

# Susterra® Propanediol Achieves NSF International Nonfood Compounds Registration

*Ingredient for use in Heat Transfer Fluids with Incidental Food Contact (HTX-1)*

DuPont Tate & Lyle Bio Products is excited to announce that Susterra® propanediol has NSF International Nonfood Compounds Registration. Susterra® is now acceptable as an ingredient for use in heat transfer fluids with incidental food contact (HTX-1) for use in and around food processing areas.

Susterra® propanediol offers formulators and suppliers a renewably sourced glycol base that meets the NSF International Registration Guidelines for Proprietary Substances and Nonfood Compounds.

Formulators using NSF Registered Ingredients need only identify the Susterra® propanediol name, the NSF Registration No. 141749, and concentration of Susterra® in the finished product of their respective application form.

# Chemical and Physical Properties

Glycol Comparison

Freeze Point

Boiling Point

Viscosity

Specific Heat

Thermal Conductivity

Specific Gravity

Thermal Expansion

Refractive Index

Density

Material Compatibility

Degradation

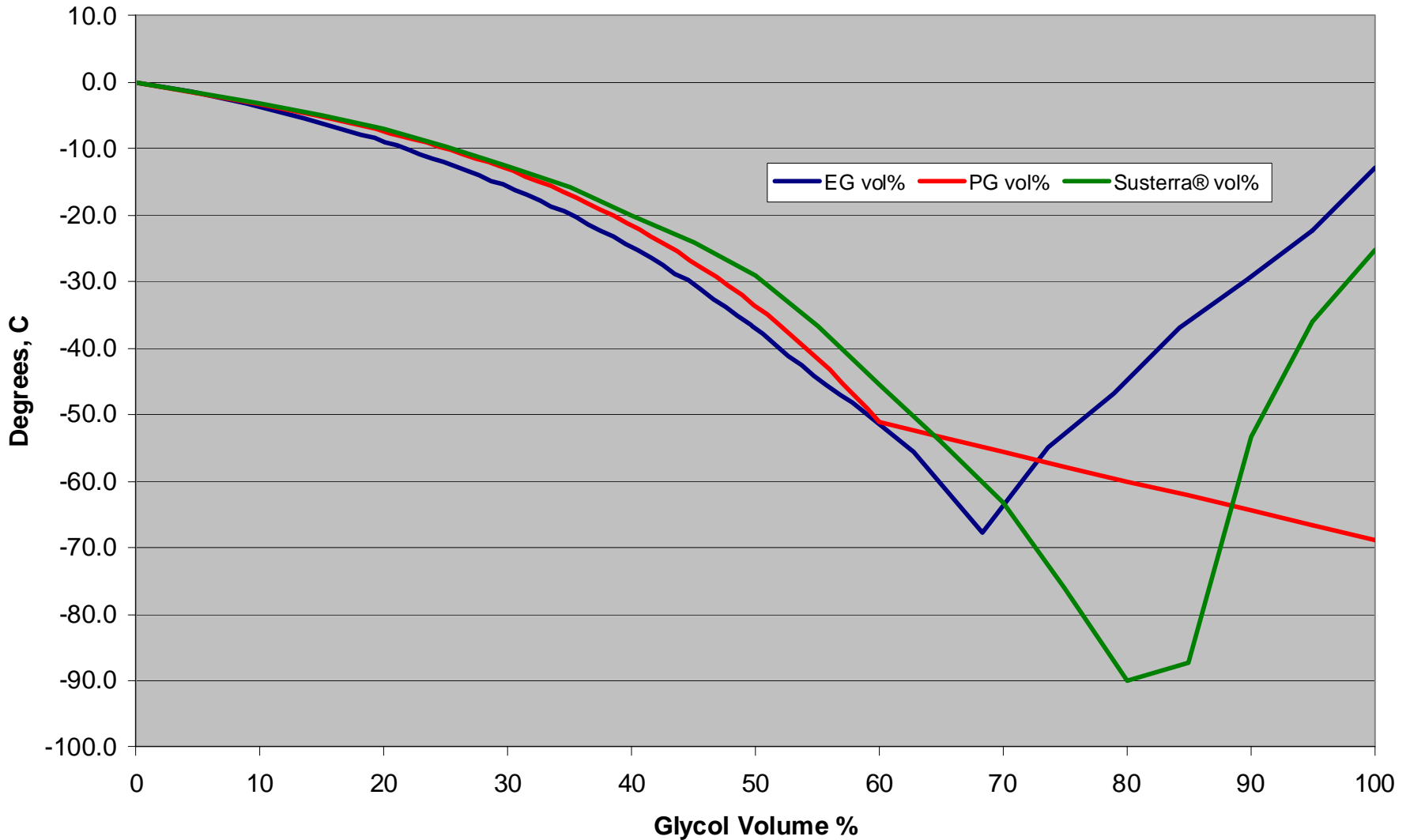
Pumping Data

Engineering Data - Glycol Comparison

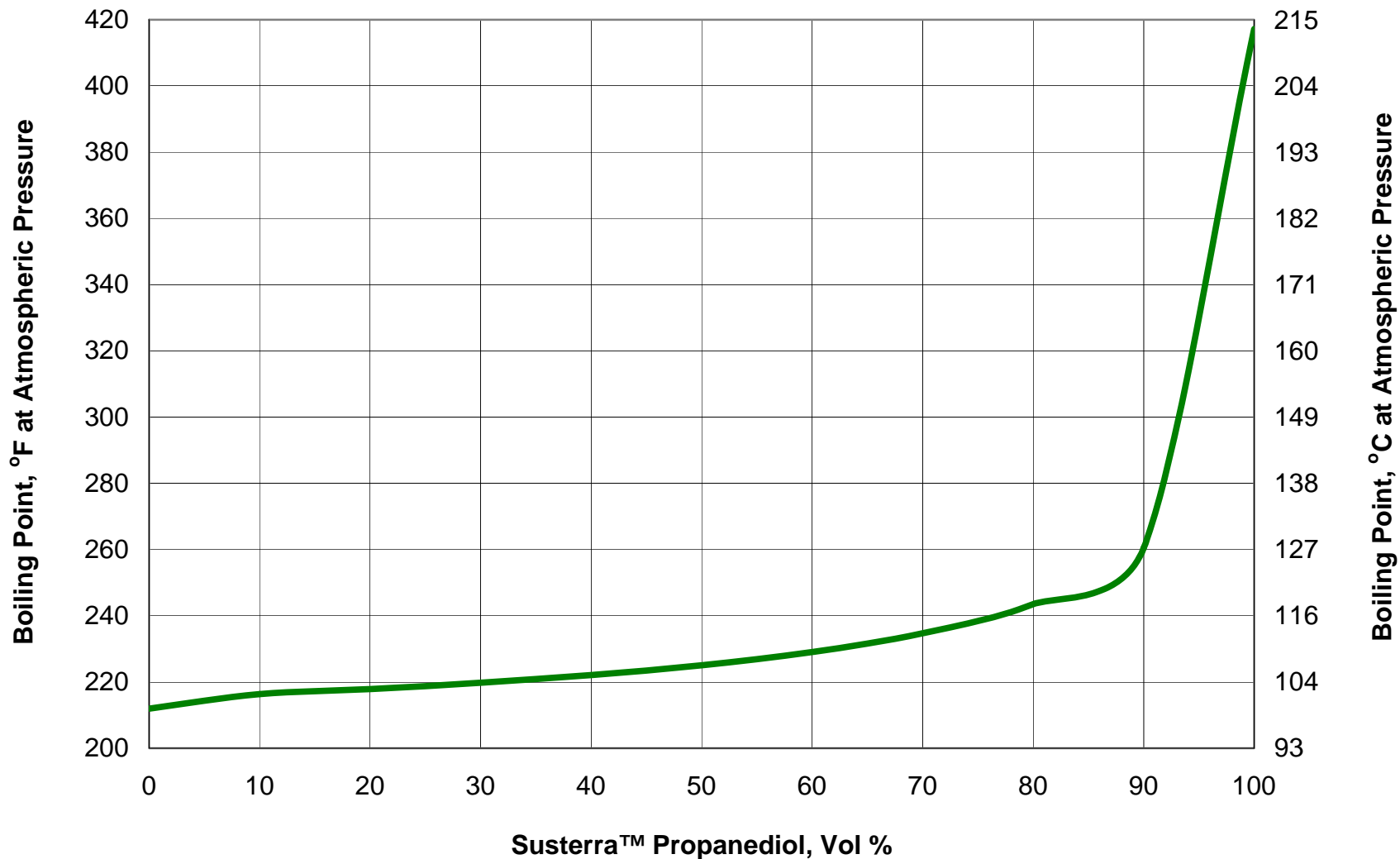
# Glycol Comparisons

Parameters	EG	PG	Susterra®
Chemical Formula	C <sub>2</sub> H <sub>6</sub> O <sub>2</sub>	C <sub>3</sub> H <sub>8</sub> O <sub>2</sub>	C <sub>3</sub> H <sub>8</sub> O <sub>2</sub>
CAS #	107-21-1	57-55-6	504-63-2
HMIS Rating: Health	2	0	0
Fire	1	1	1
Reactivity	0	0	0
Molecular Weight	62.07	76.1	76.1
Specific Gravity (20/20°C)	1.115	1.038	1.055
Weight/gal (US) lbs/20°C	9.28	8.64	8.78
Refractive Index (20°C)	1.432	1.433	1.439
Viscosity, cP (20°C)	21	56	52
Flash Point, °C(°F)	118(244)	103(217)	129(264)
Boiling Point, °C(°F)	198(387)	187(369)	214(417)
Freezing Point, °C(°F)	-13(8.6)	-60(-76)	-24(-11.2)
Vapor Density (air = 1)	2.1	2.62	2.5
Explosive Limits: Lower (%)	3.2	2.6	2.6
Upper (%)	15.3	12.5	16.6
Autoignition Temp, °C(°F)	399(752)	415(779)	405(761)
Vapor Pressure, mmHg (20°C)	0.06	<0.1	0.08
Surface Tension, dyne/cm (20°C)	48.4	40.1	46.2
Specific Heat, cal/g°C (20°C)	0.56	0.59	0.53
Coeff of Expansion, per °C (10° - 40°C)	0.00062	0.00069	0.00061
Heat of Formation (kJ/mol)			-480.8
Heat of Vaporization (kJ/mol)			57.9
Heat of Fusion (kJ/mol)			7.1
Critical Temp (°C)			445
Critical Pressure (mPa)			6.55

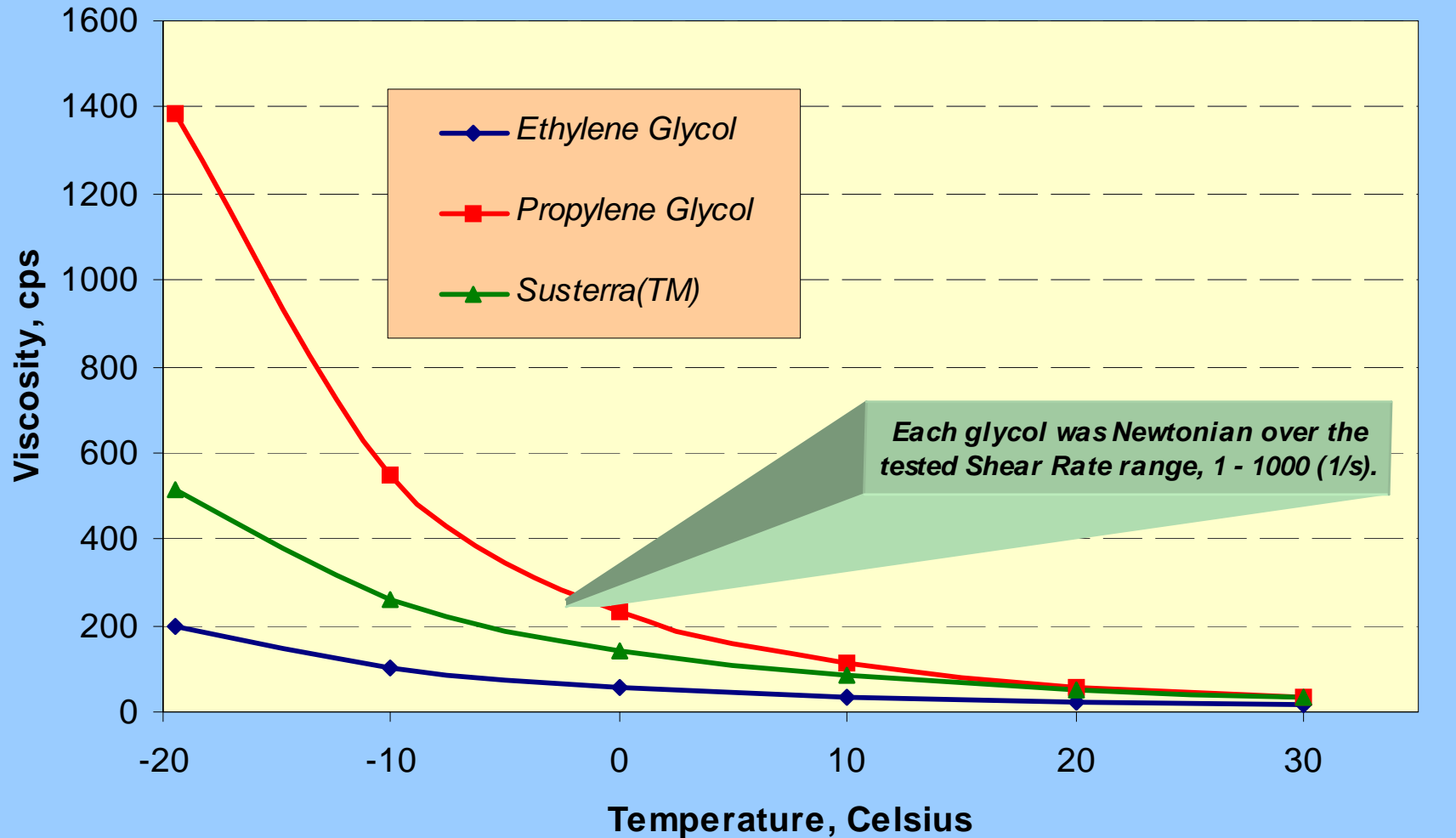
## Freeze Points of Aqueous Glycol Solutions

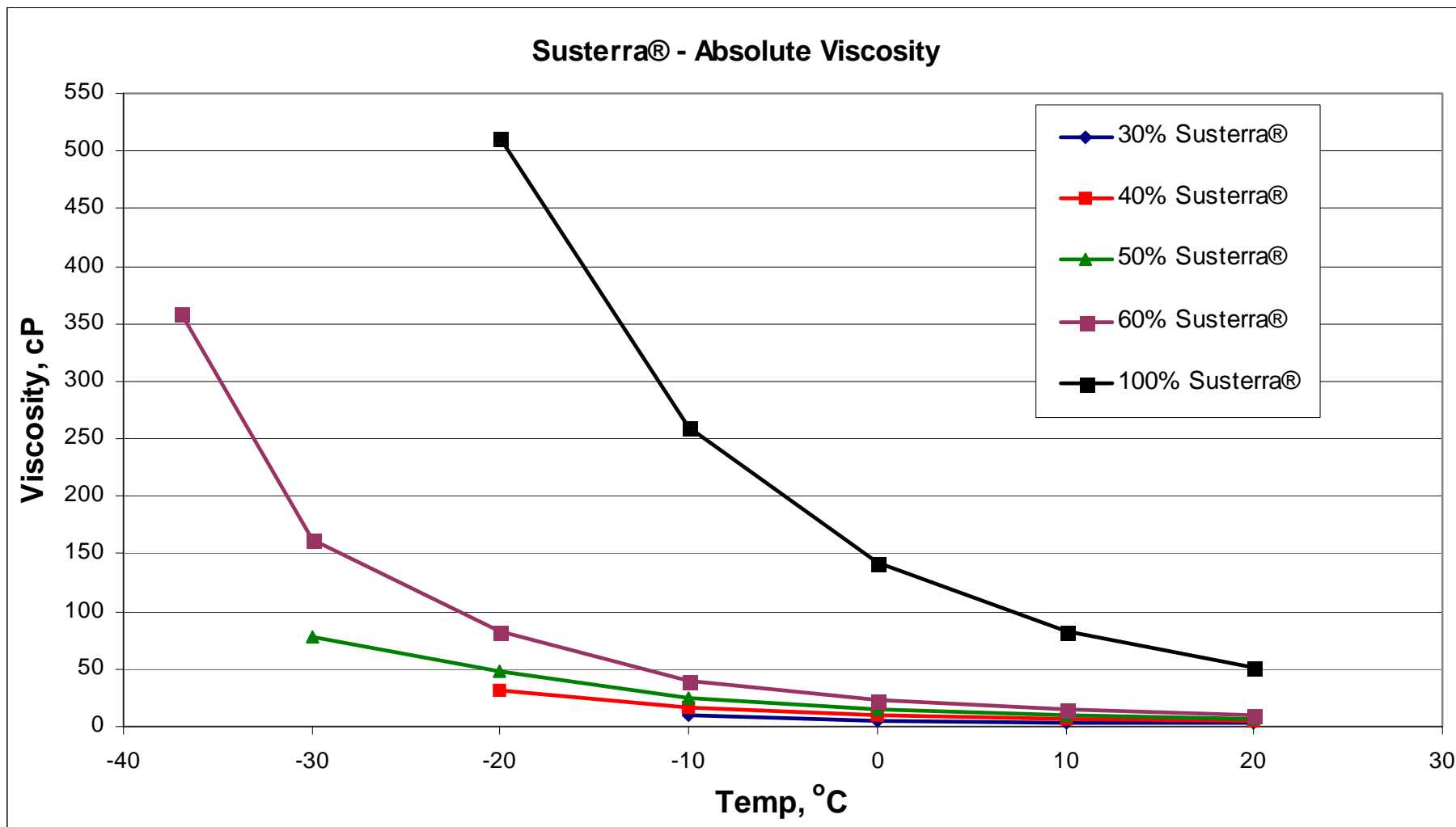


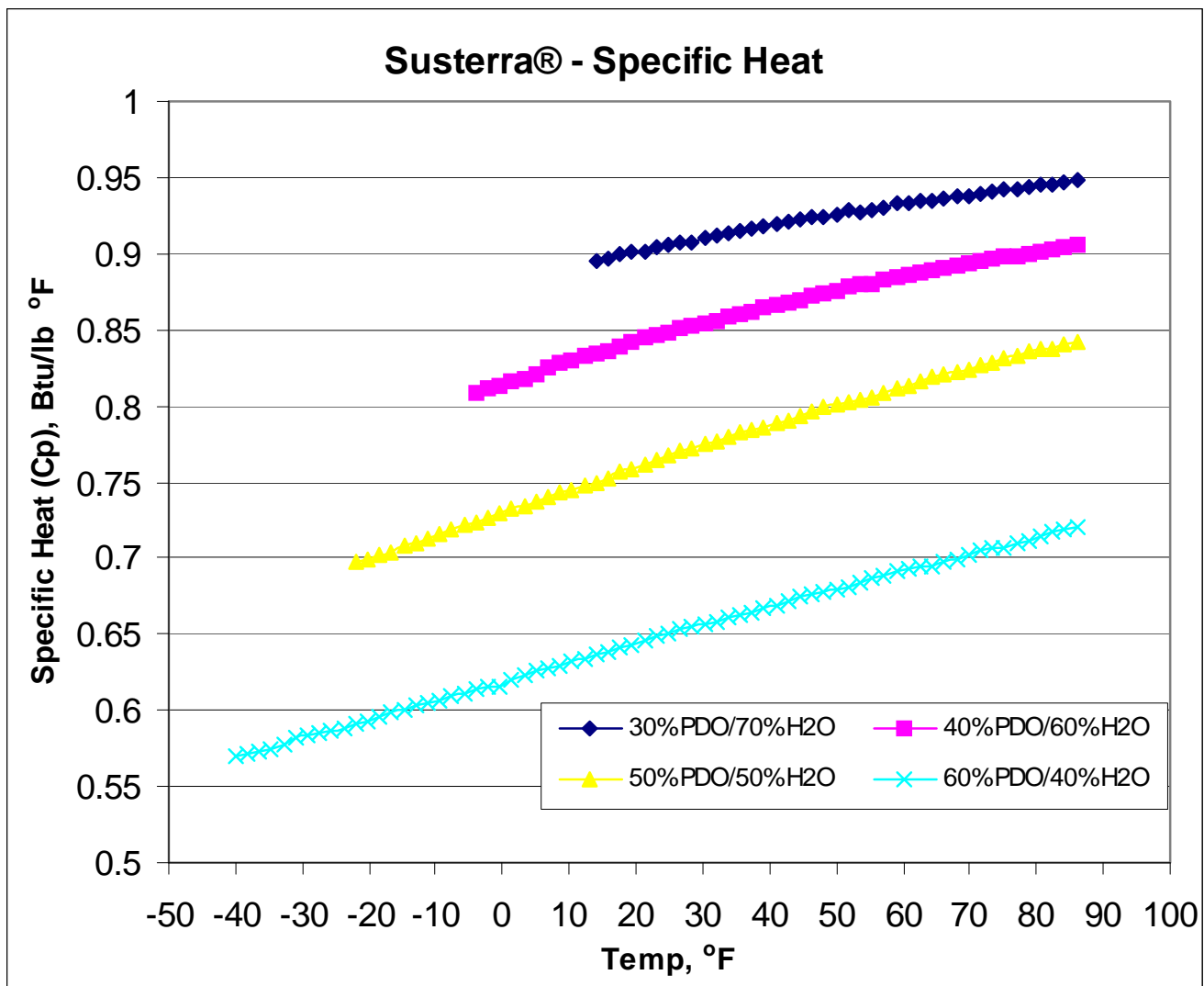
## Boiling Points of Aqueous Susterra™ Propanediol



## Glycol Viscosity Comparison

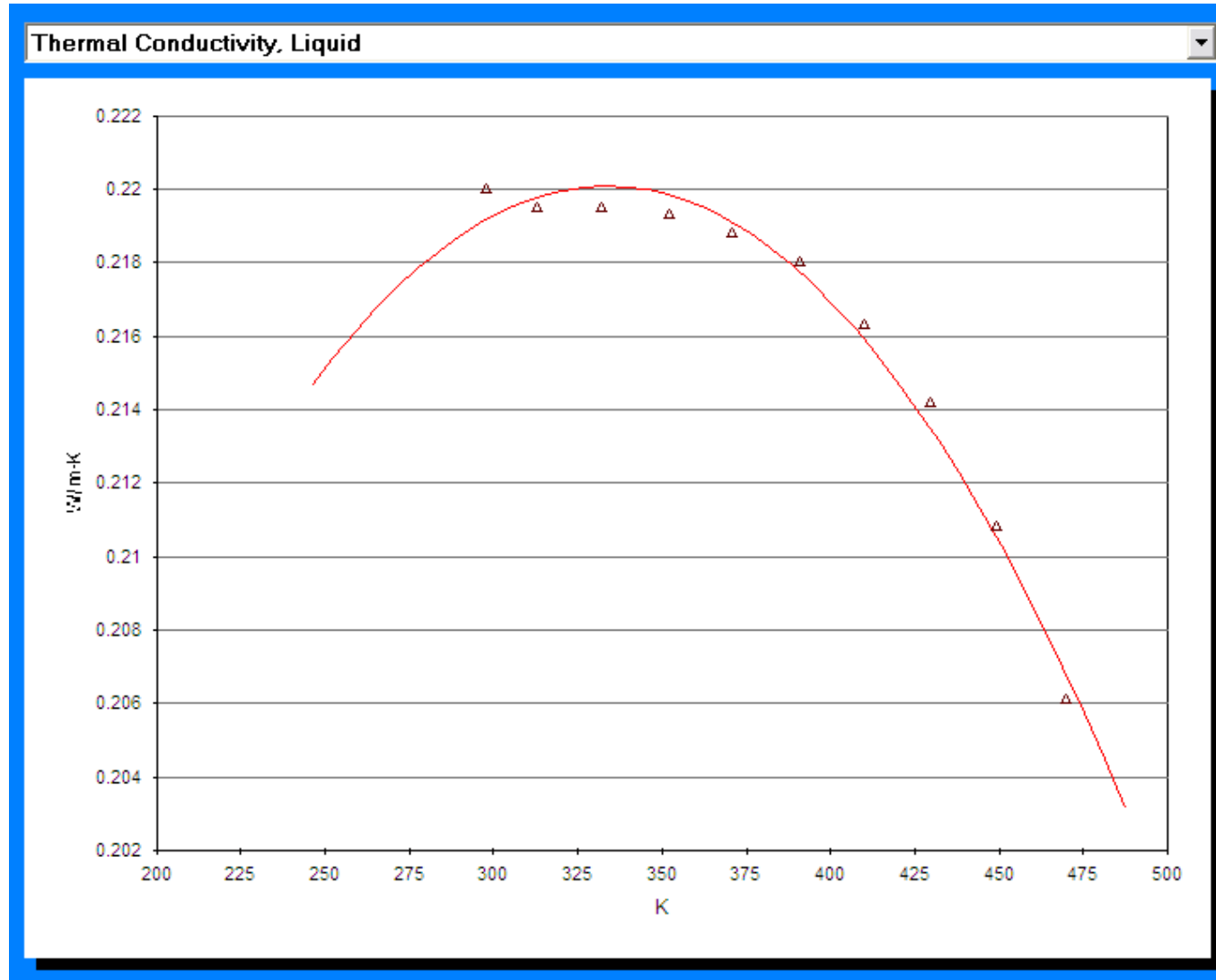


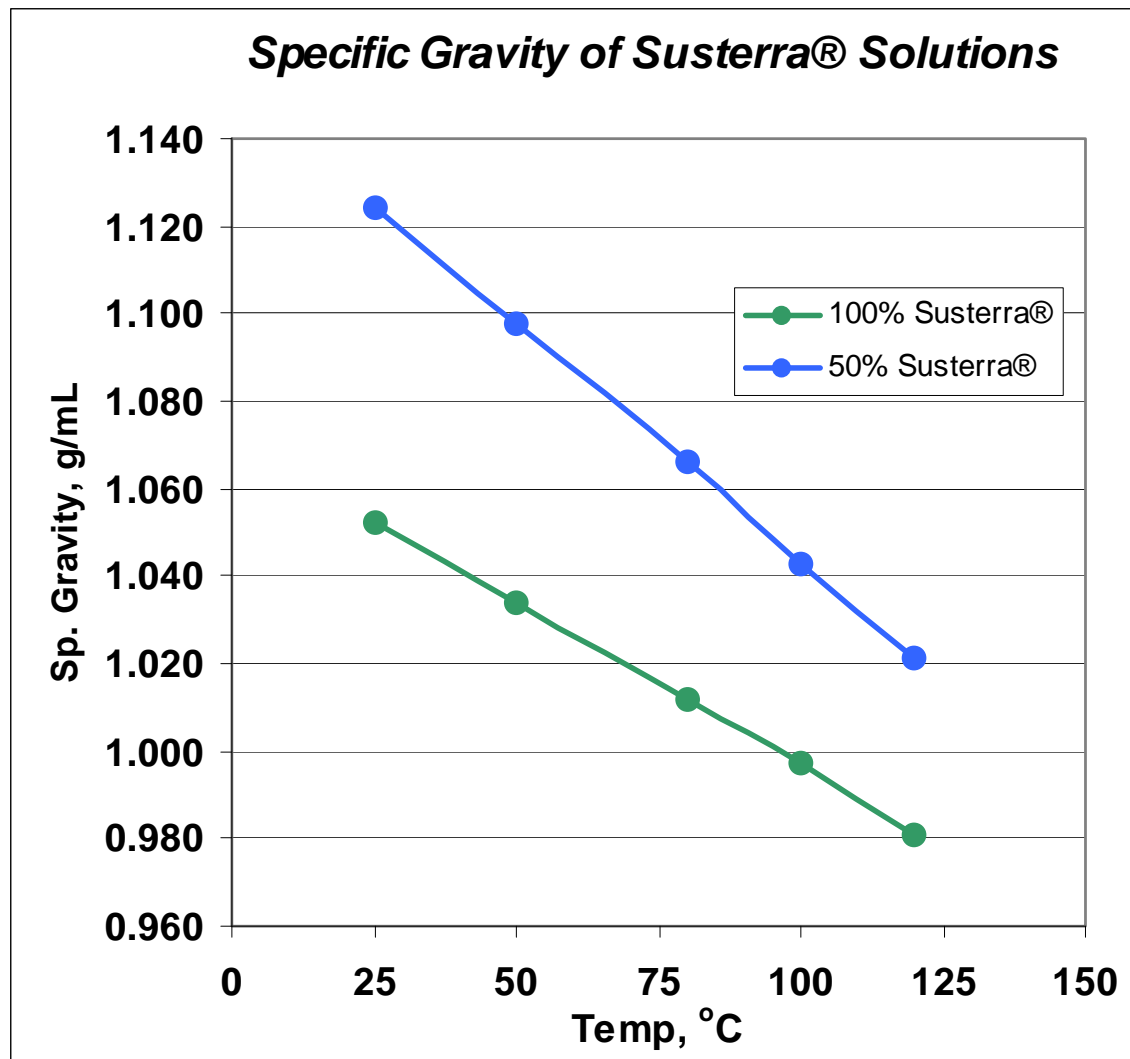


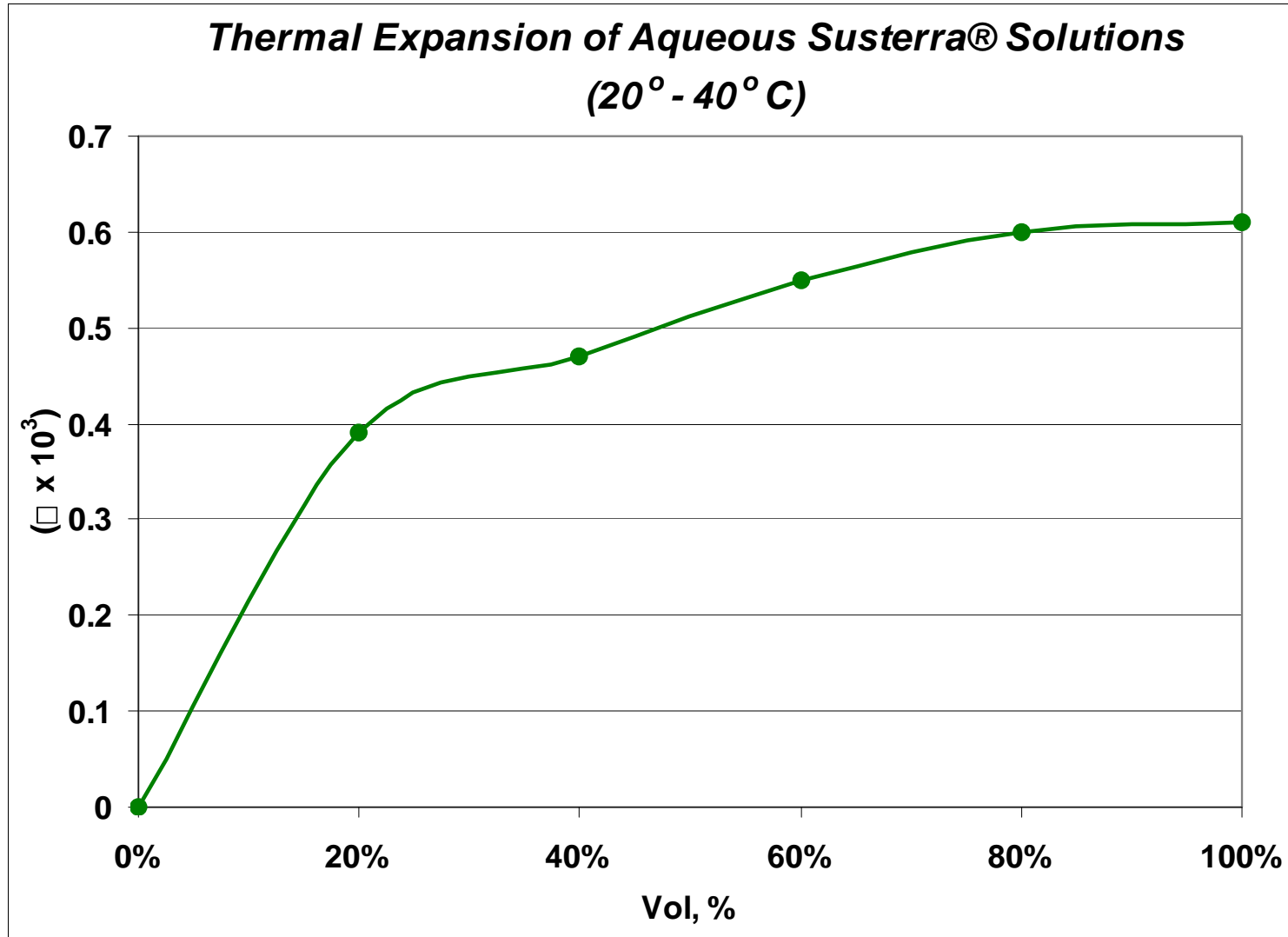


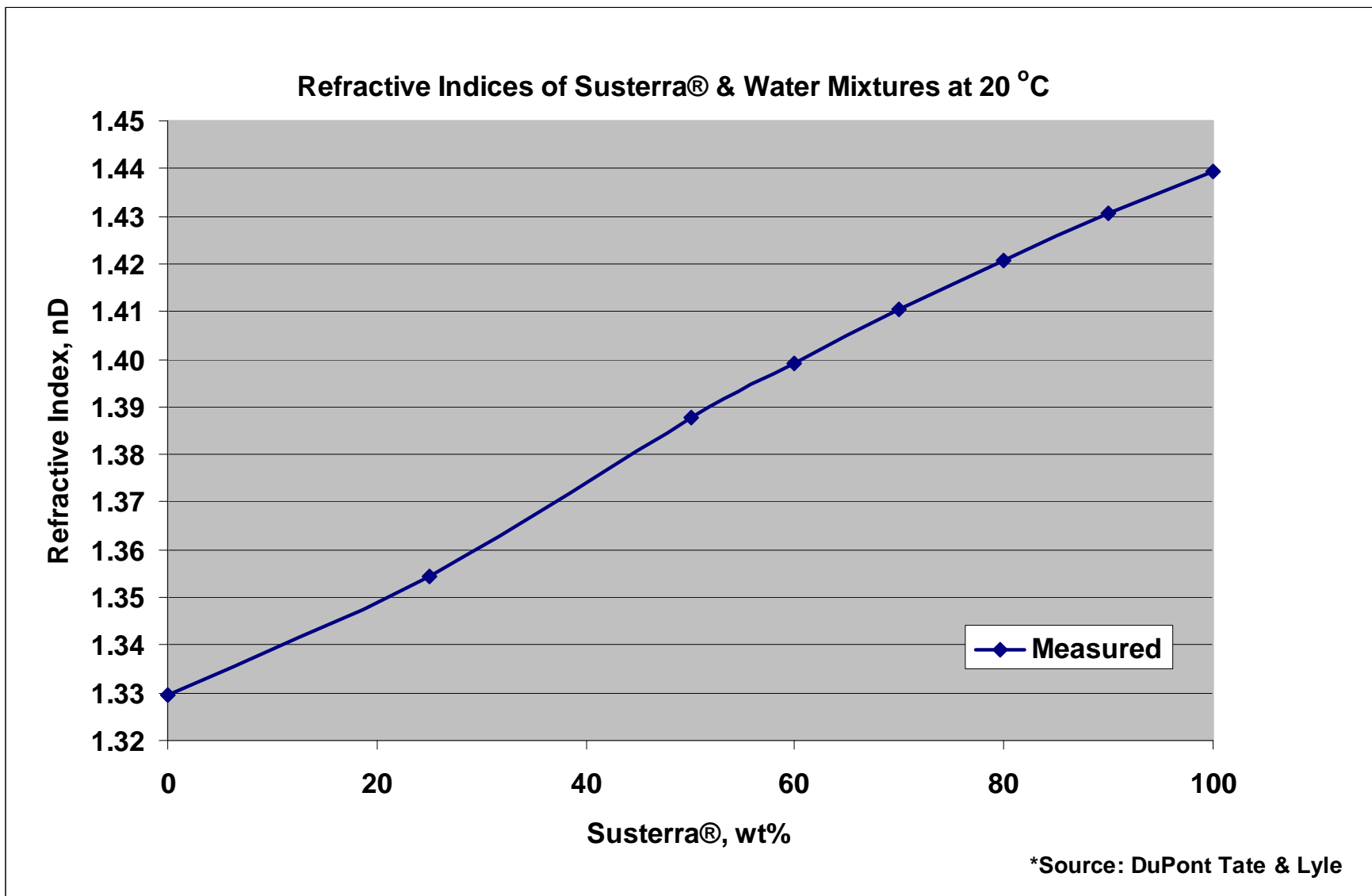
Data ref: Bleazard, J.G., Sun, T.F., Johnson, R.D., DiGuilio, R.M., Teja, A.S., "The Transport Properties of Seven Alkanediols, " Fluid Phase Equilibria, 117, 386 (1996)

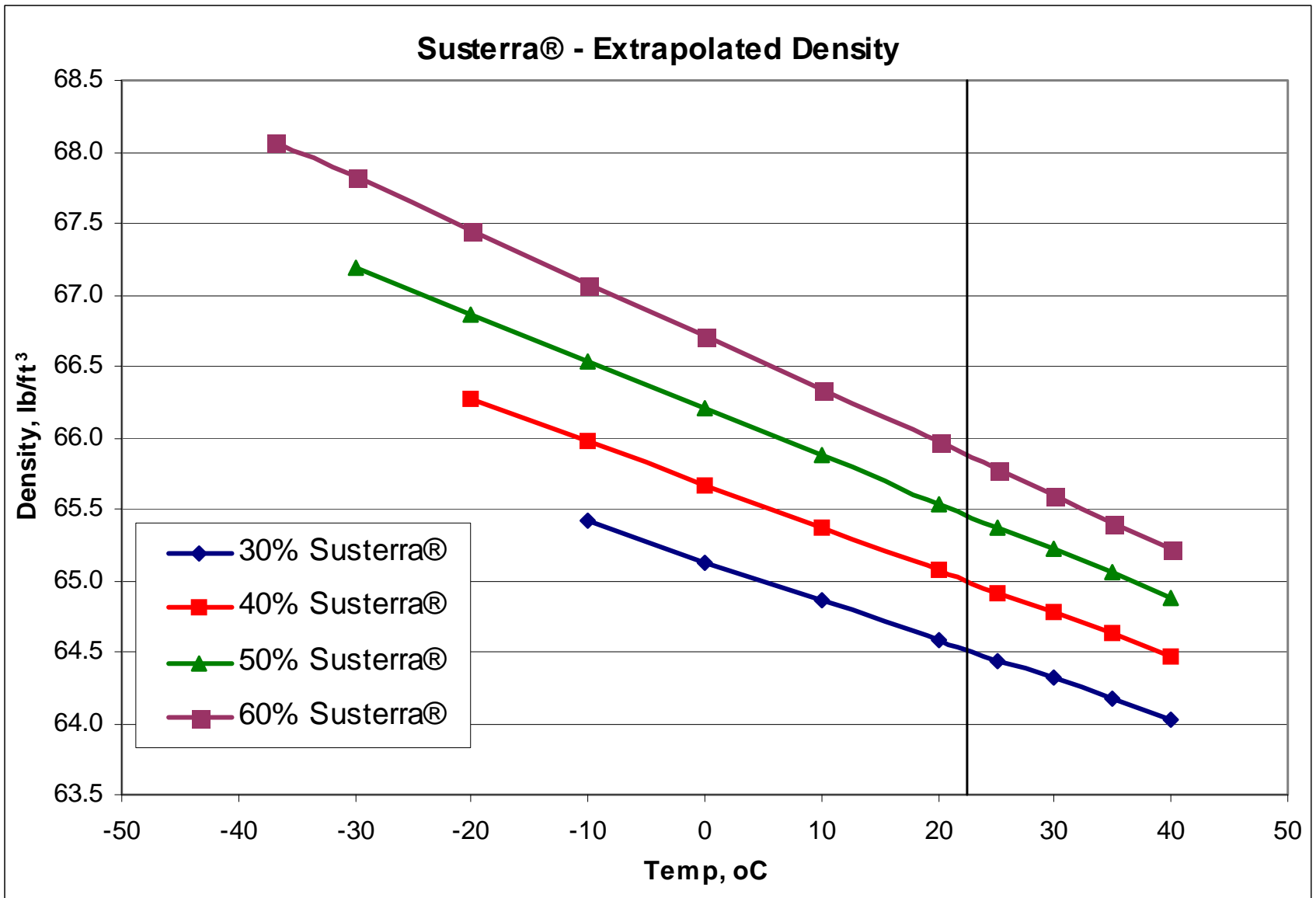
<u>T, (K)</u>	<u>W/m·K</u>
297.60	0.22
312.60	0.2195
332.20	0.2195
352.30	0.2193
370.90	0.2188
390.90	0.218
409.80	0.2163
429.60	0.2142
449.30	0.2108
469.70	0.2061











# Corrosion data for common metals

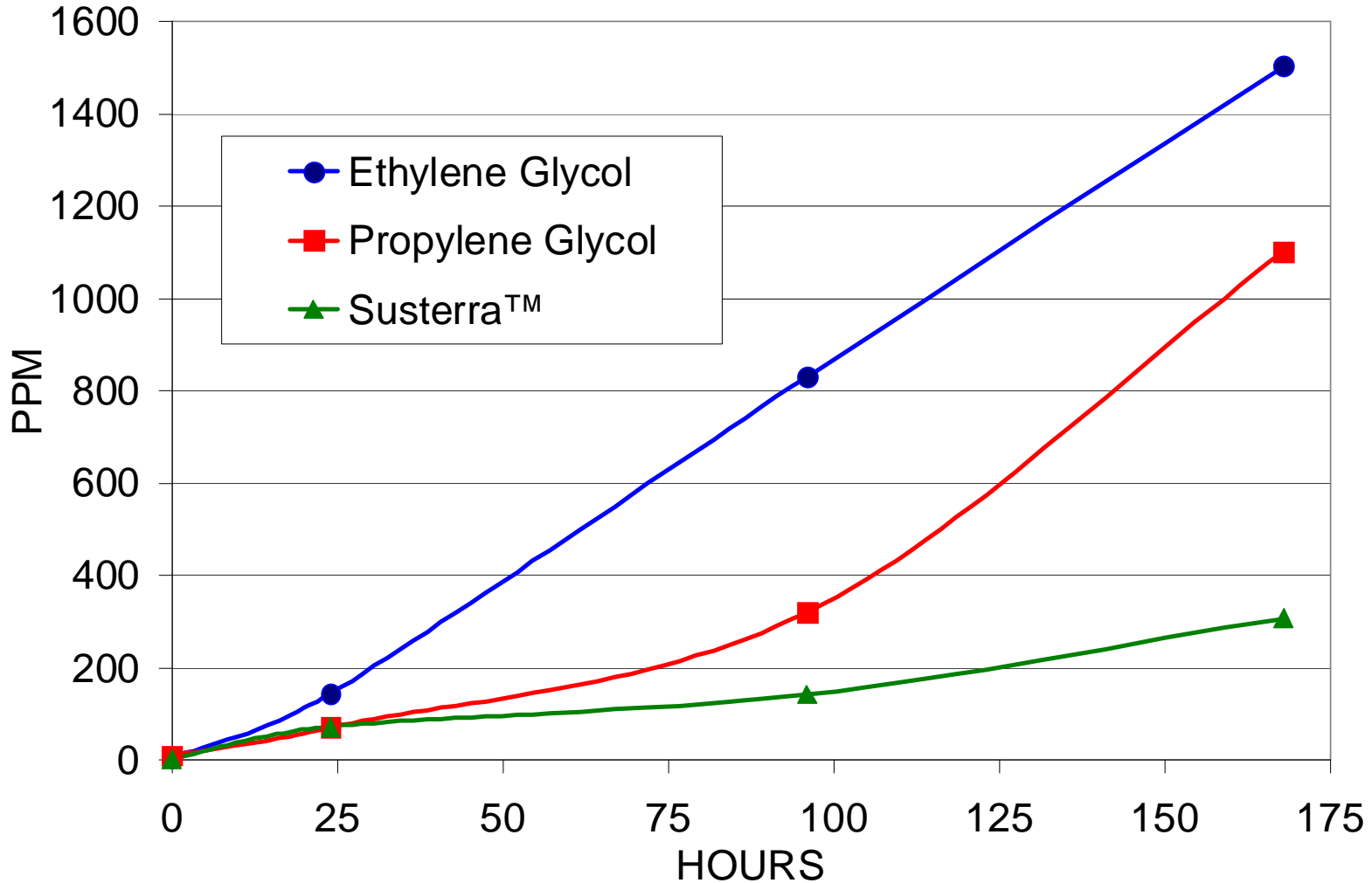
Coupon Data*						
Alloy (UNS #)	Alloy Name	Coupon Condition	Corrosion Rate (mpy)			
			PDO 18°C	PG 18°C	PDO 50°C	PG 50°C
A96063	6063 Aluminum	120 Grit	0.4	0.5	0.2	0.1
A96063	6063 Aluminum	120 Grit	0.5	0.5	0.3	0.6
C12200	DHP Copper	120 Grit	0.1	0.3	0.1	0.1
C12200	DHP Copper	120 Grit	0.3	0.3	0.1	0
C44300	Admiralty Brass	120 Grit	0.2	0.2	0	0.1
C44300	Admiralty Brass	120 Grit	0.1	0.2	0.1	0
F33100	65-45-12 Ductile Iron	120 Grit	0.2	0.2	0.5	0.8
F33100	65-45-12 Ductile Iron	120 Grit	0.2	0.3	0.4	0.7
G10180	1018 CS	120 Grit	0.1	0.2	0.4	0.4
G10180	1018 CS	120 Grit	0.2	0.1	0.3	0.2
R50400	Titanium Gr 2	120 Grit	0.1	0.1	0	0
R50400	Titanium Gr 2	120 Grit	0.1	0.1	0	0
S30403	304L SST	120 Grit	0	0	0	0
S30403	304L SST	120 Grit	0	0	0	0

\*Tested and Supplied by DuPont Tate & Lyle

# General Compatibility - Literature

<b>Material</b>	<b>EG [107-21-1]</b>	<b>PG [57-55-6]</b>	<b>PDO [504-63-2]</b>
<b>Aluminum T356 (Al/Si)</b>	A	A	A
<b>Cast Iron (Fe/&gt;2%C)</b>	A	A	A
<b>Hastelloy (Ni alloy)</b>	A	A	A
<b>Stainless Steel 304 (Fe/Cu/Ni)</b>	B	B	A
<b>Stainless Steel 316 (Fe/Cu/Ni/Mo)</b>	B	B	A
<b>Buna N - NBR</b>	A	A	A
<b>EPDM</b>	A	A	A
<b>Nitrile (TS)</b>	A	A	A
<b>PTFE</b>	A	A	A
<b>Viton</b>	A	A	A
<b>Teflon</b>	A	A	A

## Degradation of 50 wt% Aqueous Glycol Solutions Acid Concentration vs. Time 150°C, 28psi, 168hrs



# Comparison of Pumping Pressure – PDO vs. PG

At -10 C, a 40% PG/ 60% water solution requires 2.4 X's the pumping energy as a 40% PDO/60% water solution.

<i>Thermophysical Properties at -10 C</i>	40.5 wt % (~14 mol %) 1,2-propanediol	40 wt % (13.6 mol %) 1,3-propanediol
Absolute Viscosity (cP)	24.48 <sup>1</sup>	16.5 <sup>2</sup>
Density (g/ml)	1.05 <sup>1</sup>	1.06 <sup>3</sup>
Specific Heat (kJKg <sup>-1</sup> K <sup>-1</sup> )	3.602 <sup>1</sup>	3.495 <sup>4</sup>
Thermal Conductivity (Wm <sup>-1</sup> K <sup>-1</sup> )	.374 <sup>1</sup>	0.39 <sup>5</sup>
Kinematic Viscosity (cSt) <sup>6</sup>	23.3	15.5
Fp (C)	-20 <sup>1</sup>	-20 <sup>7</sup>

$$PPR_{12} = (v_1 / v_2)^{1.95} (\rho_1 / \rho_2)^{-0.05} (k_1 / k_2)^{-2.3} (C_{p1} / C_{p2})^{-1.05}$$

PPR<sub>12</sub> at -10 C, using the thermophysical properties from above, describes the amount of energy needed to pump fluid 1 relative to fluid 2 in order to get the same heat transfer performance.

Fluid 1 = 1,2-propanediol

Fluid 2 = 1,3-propanediol

$$PPR_{12} \text{ at } -10 \text{ C} = 2.4$$

This PPR<sub>12</sub> equation comes from substituting appropriate values in equation 9 of the following paper: Sherwood, G, "Secondary Heat Transfer Systems and the Application of a New Hydrofluoroether," Alternatives the 1995 International CFC and Halon Conference.

## Engineering Data - Glycol Comparisons

Operating Temp °C (°F)	Glycol	Solution, wt%	Density, lb/ft <sup>3</sup>	Specific Heat (Cp), Btu/lb °F	Viscosity, cP	Freezing Point	
						°C	°F
-1.1 (+30)	EG	25	64.7	0.905	3.8	-10.6	12.9
	PG	30	64.5	0.932	7.5	-13.3	8
	<b>Susterra®</b>	<b>30</b>	<b>65.1</b>	<b>0.91</b>	<b>5.7</b>	<b>-12.6</b>	<b>9.4</b>
-9.4 (+15)	EG	35	65.9	0.84	6.8	-16.7	2
	PG	40	65.3	0.89	23.5	-21.7	-7
	<b>Susterra®</b>	<b>40</b>	<b>65.9</b>	<b>0.84</b>	<b>16.5</b>	<b>-20.1</b>	<b>-4.1</b>
-20.6 (-5)	EG	45	67.4	0.755	17.2	-26.1	-15
	PG	50	66.2	0.833	51	-33.3	-28
	<b>Susterra®</b>	<b>50</b>	<b>66.9</b>	<b>0.723</b>	<b>47.7</b>	<b>-29.2</b>	<b>-20.5</b>
-34.4 (-30)	EG	55	68.6	0.67	75	-41.7	-43
	PG	60	67	0.772	700	-50	-58
	<b>Susterra®</b>	<b>60</b>	<b>68.1</b>	<b>0.583</b>	<b>162</b> (-30 °C)	<b>-40</b>	<b>-40</b>
					<b>359</b> (-37 °C)		