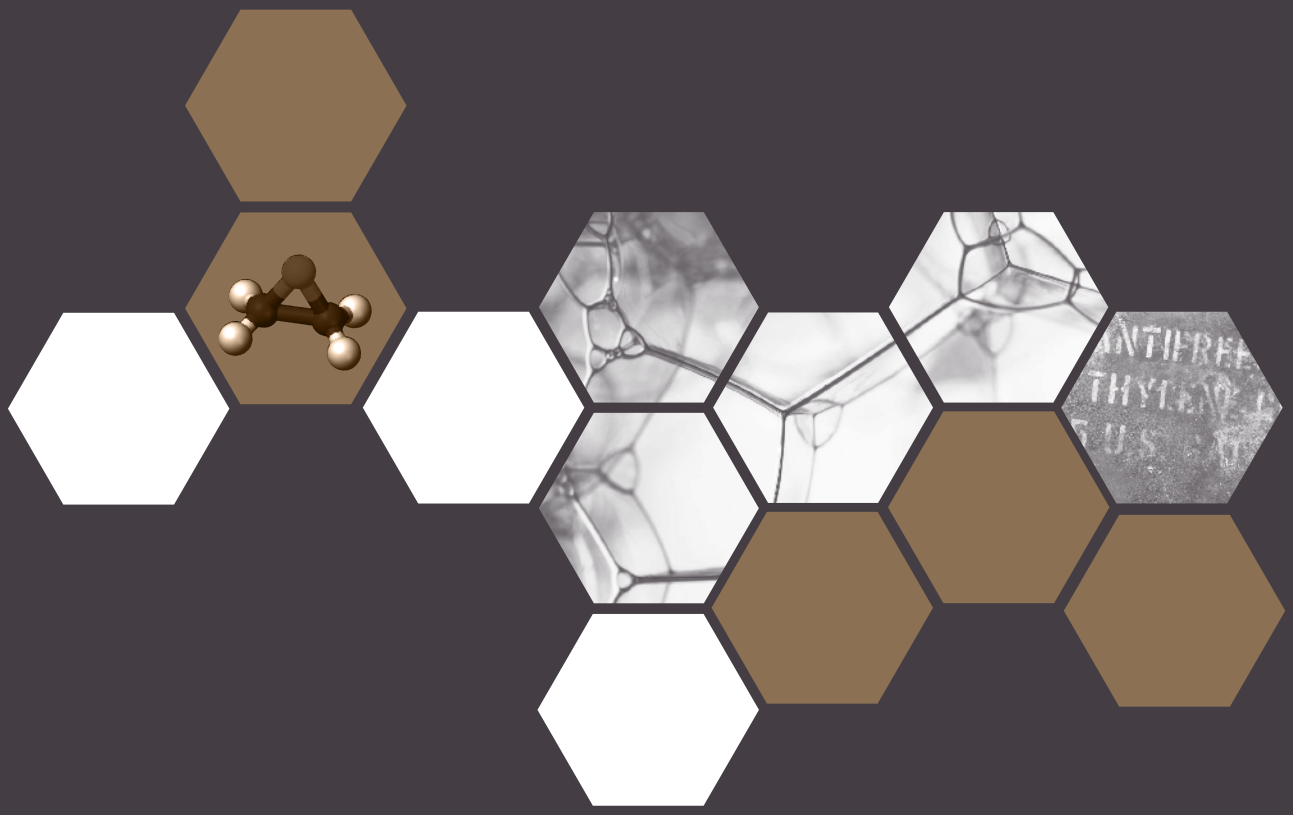
ethyleneoxide

third edition



Legal Notice

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To the Reader

Manual Preparation

As members and affiliated companies of the American Chemistry Council, we support efforts to improve the industry's responsible management of chemicals. To assist in this effort, the American Chemistry Council's Ethylene Oxide/Ethylene Glycols Panel supported the creation and publication of this manual. The Panel is comprised of the following companies:

Balchem Corporation/ARC Specialty Products

BASF Corporation

Bayer Material Science LLC

Celanese Ltd.

Champion Technologies

Croda, Inc.

The Dow Chemical Company

Eastman Chemical Company

Honeywell

Shell Chemical LP

The development of this manual was led by the Panel's Ethylene Oxide Safety Task Group (EOSTG), a group comprised of producers and users of ethylene oxide. The EOSTG functions to generate, collect, evaluate and share information to support product stewardship with regard to ethylene oxide. The EOSTG formed a manual work group, chaired by Keith Vogel of Lyondell Chemical Company, to lead the development of this document. The following work group members provided significant contributions:

Tom Grumbles	Sasol North America
Susan Jackson	BASF Corporation
Robert Lenahan	Bayer MaterialScience LLC
Denis Reeser	The Dow Chemical Company
John Stewart	BASF Corporation
Don Szczepanski	Huntsman Petrochemical Corporation
David Townsend	Celanese Chemicals Ltd.
Randy Viscomi	Balchem Corporation/ARC Specialty Products
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Mike Wagner	Old World Industries
John Wincek	Croda, Inc.
Gerald Wise	Shell Chemical LP

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Karl Loos	Shell Chemical LP
David McCready	The Dow Chemical Company
Kristy Morrison	EO STG Manager, American Chemistry Council
Karyn Schmidt	Assistant General Counsel, American Chemistry Council

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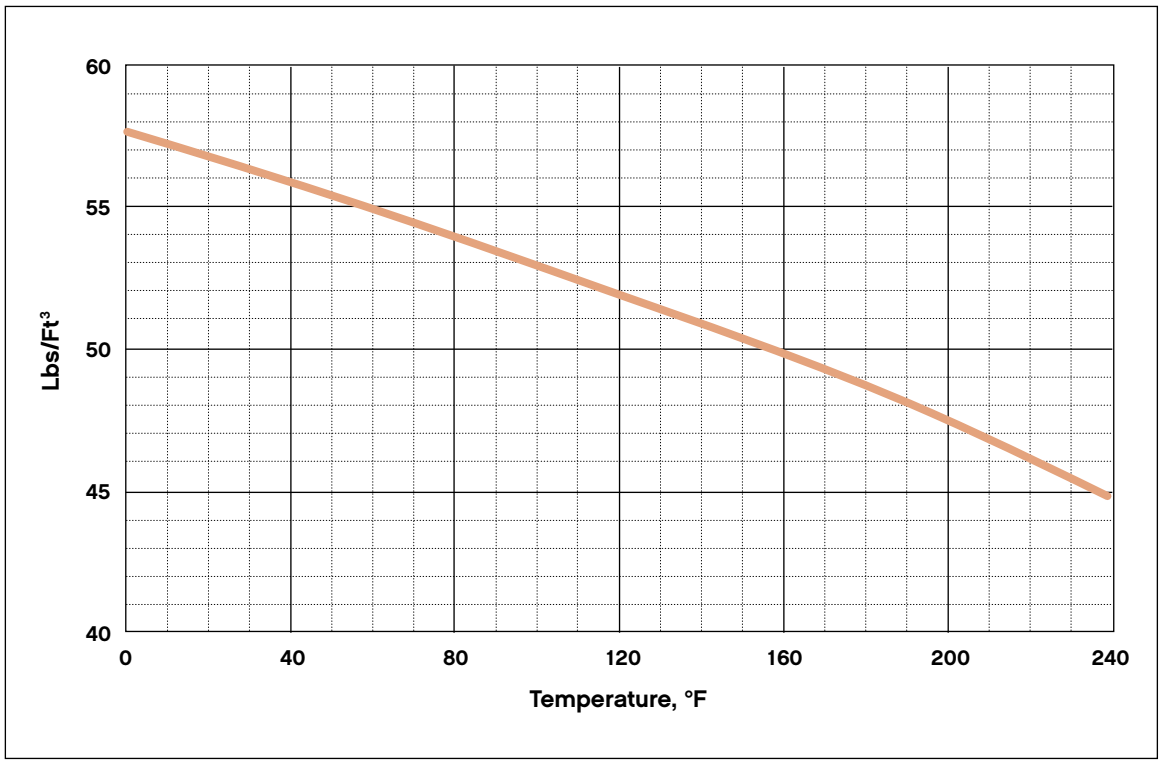

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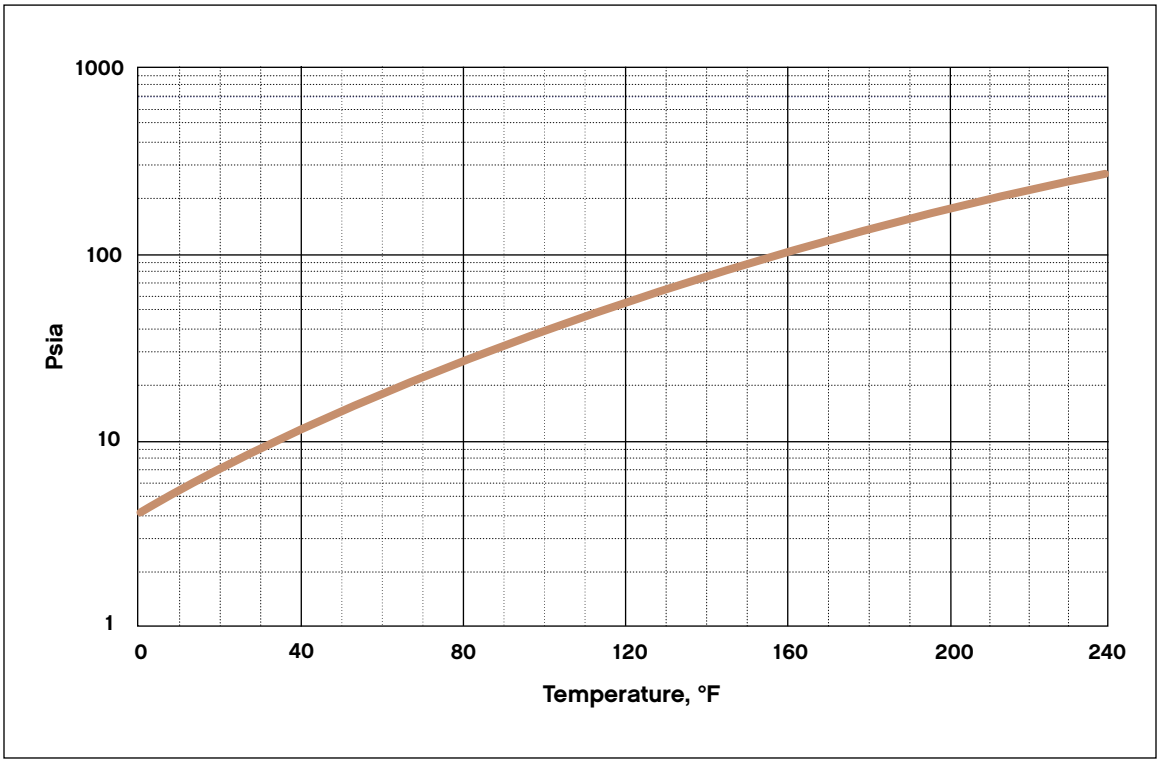

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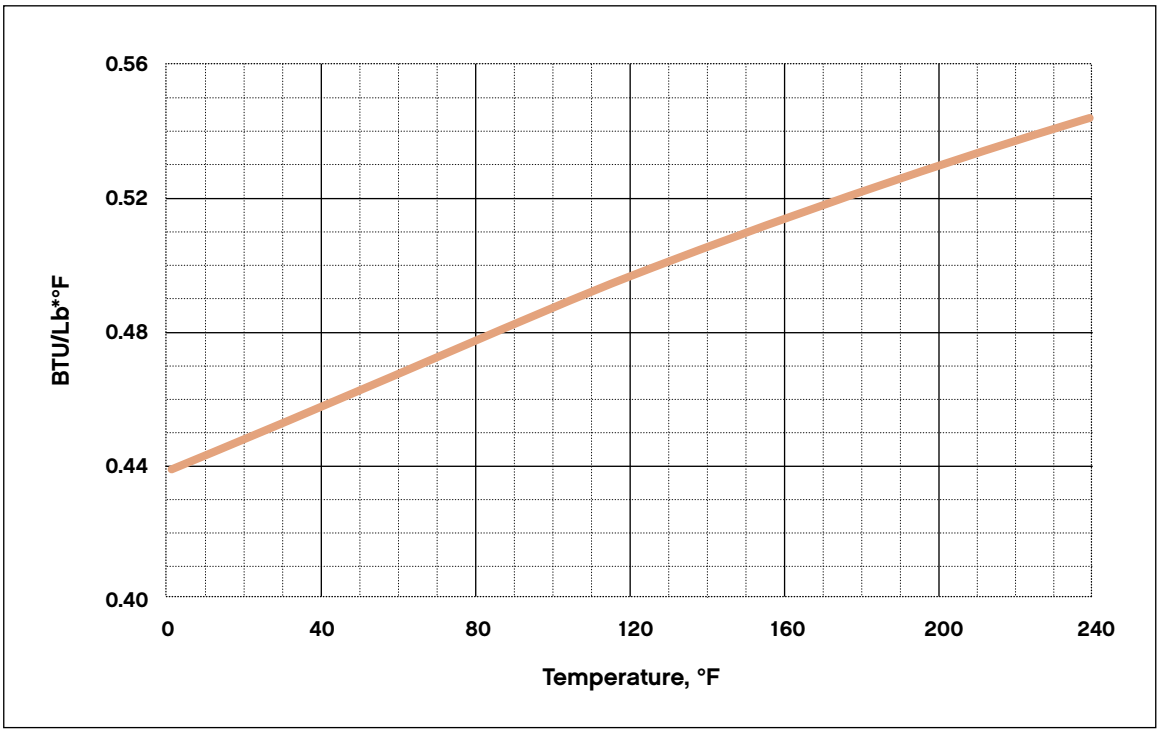

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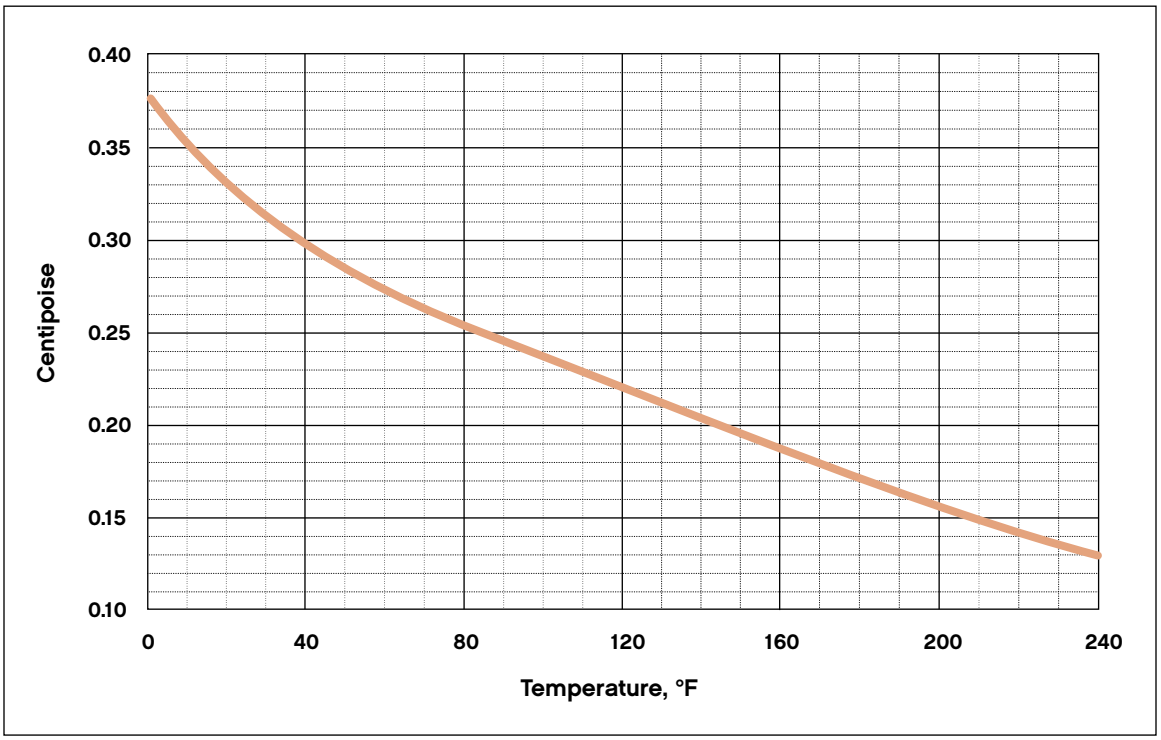

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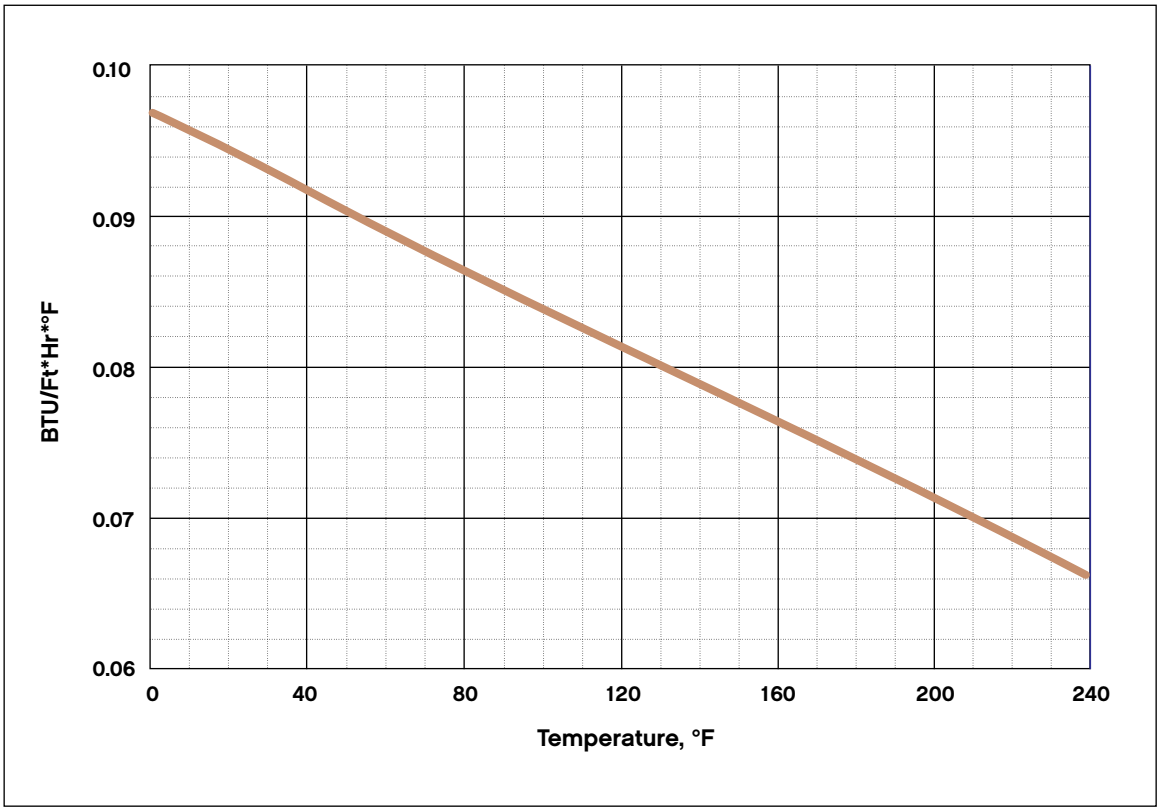

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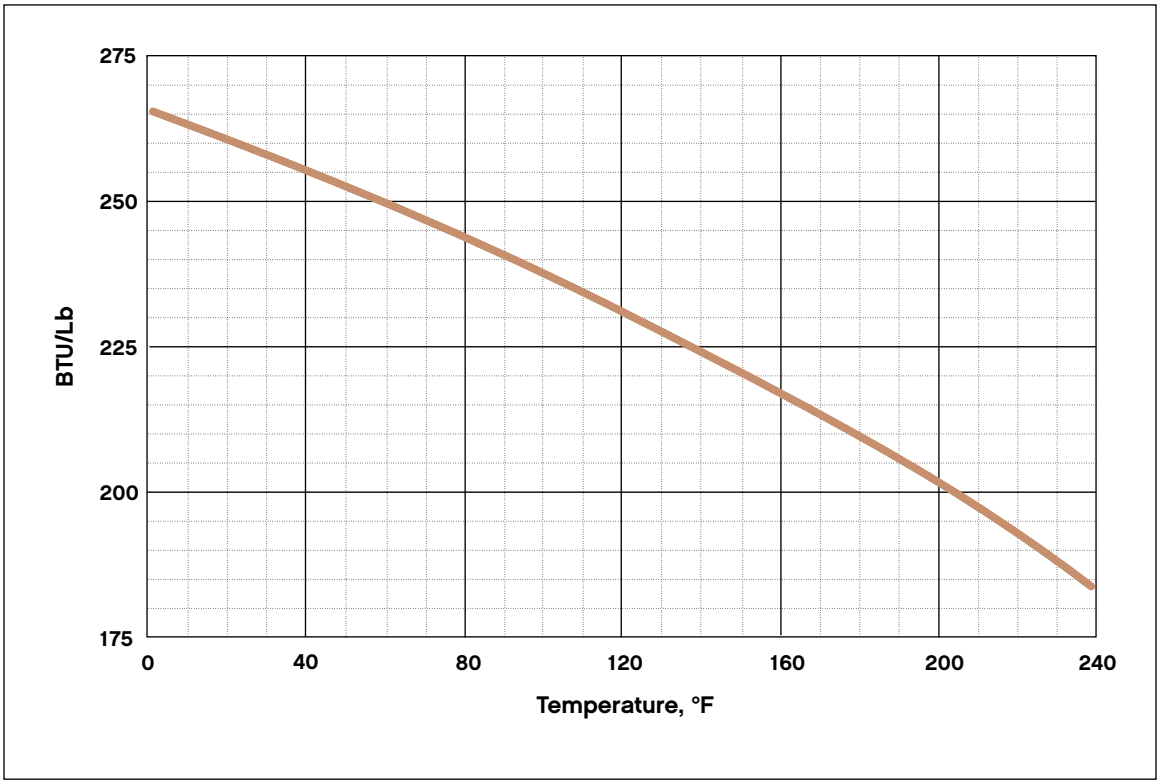

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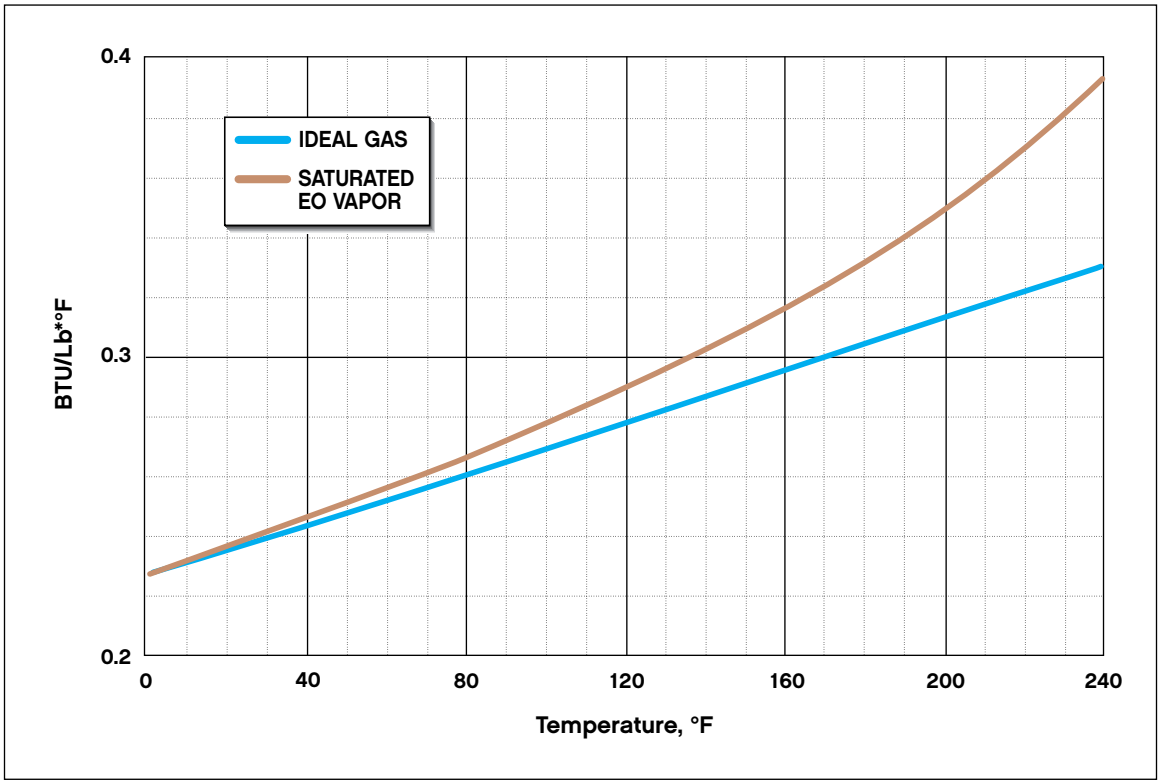

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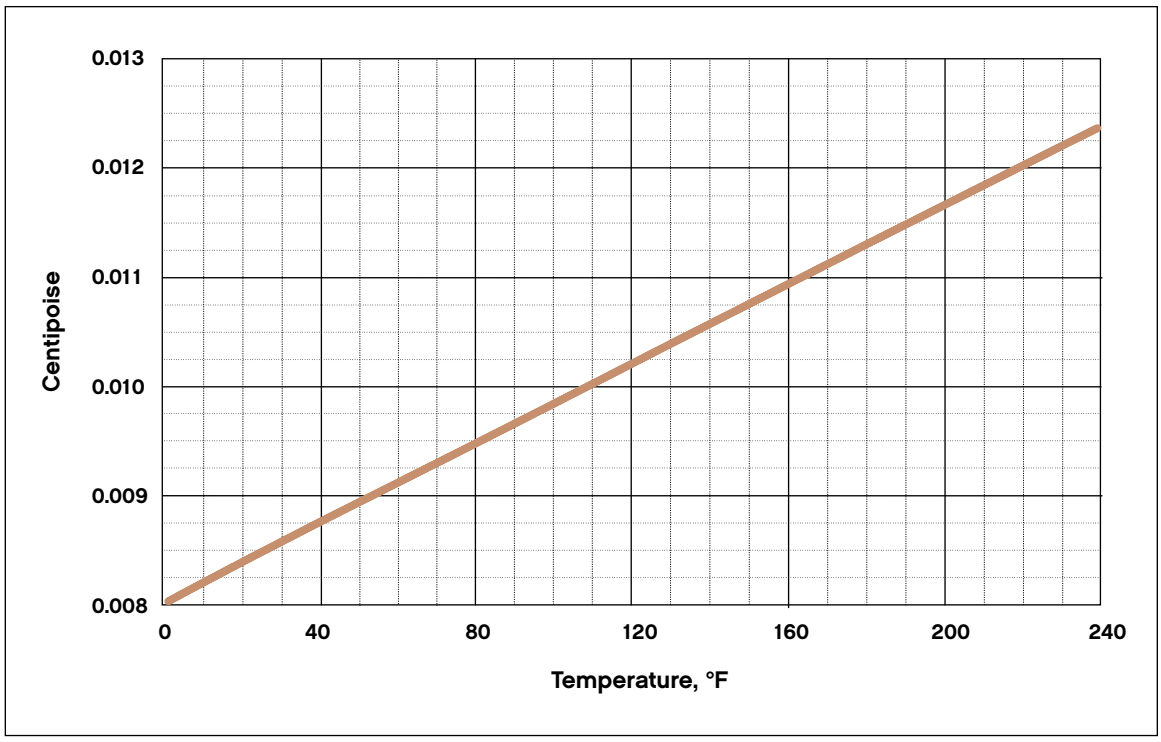

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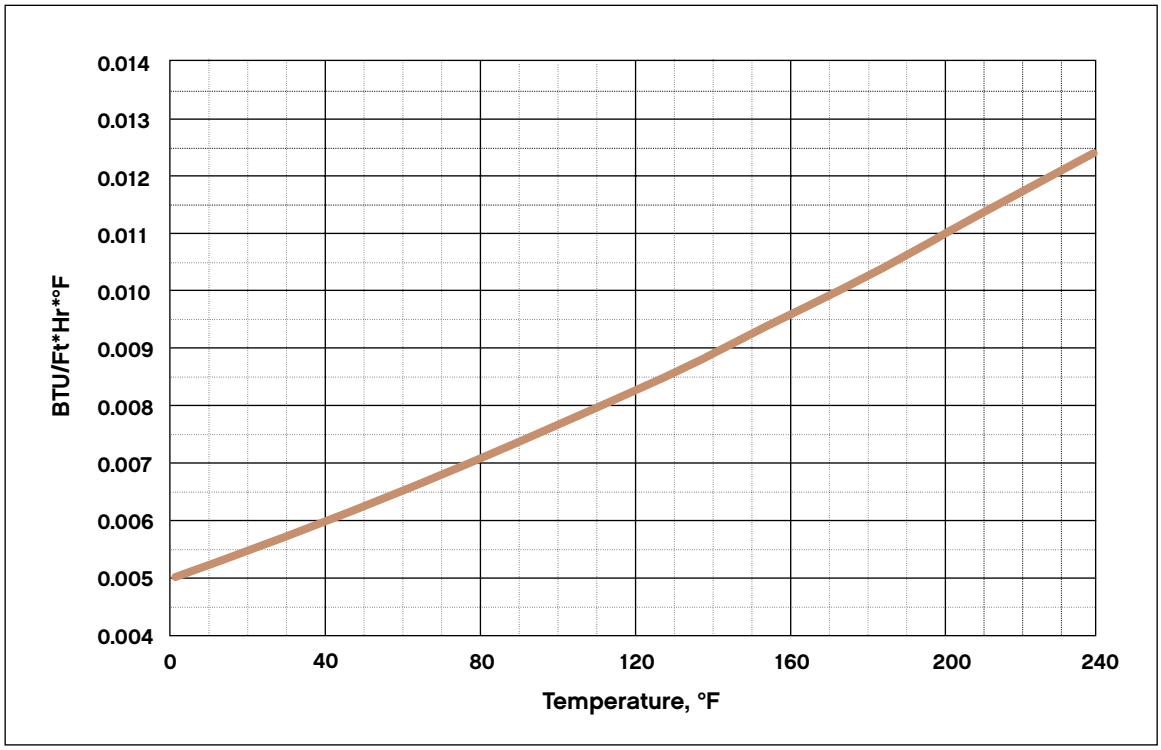

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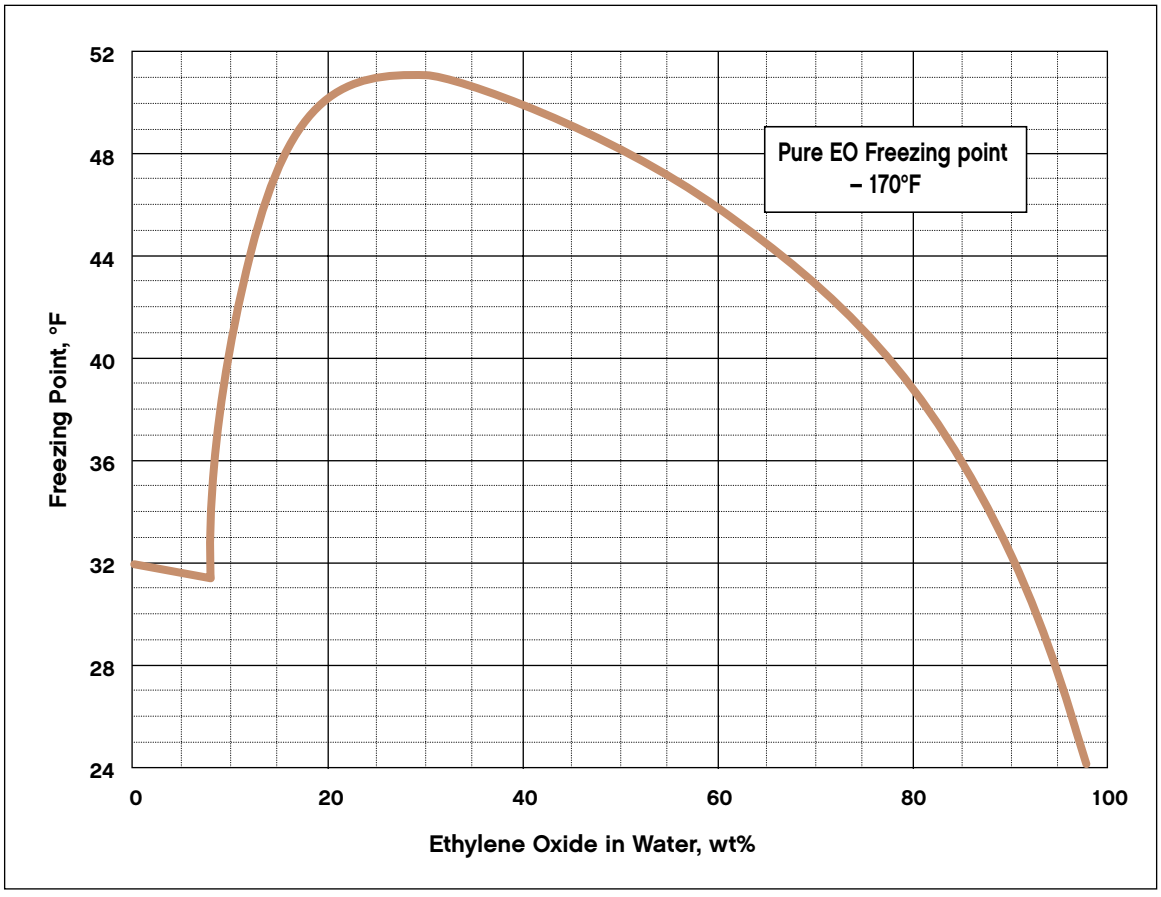

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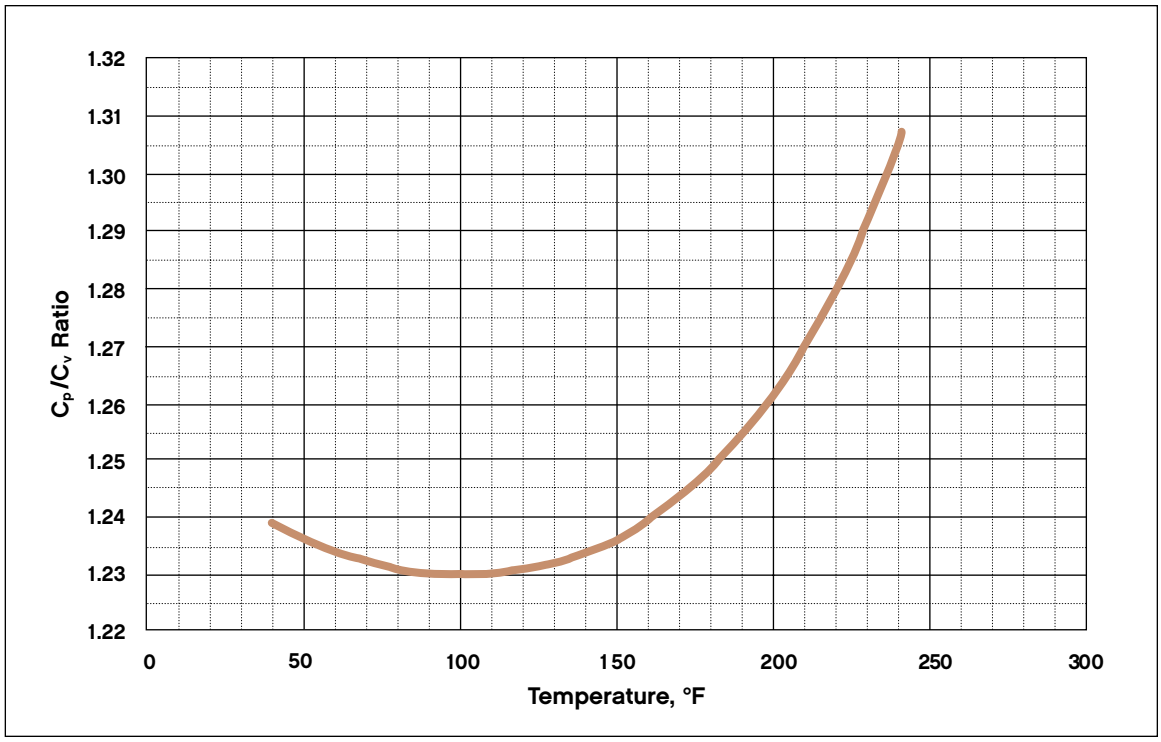

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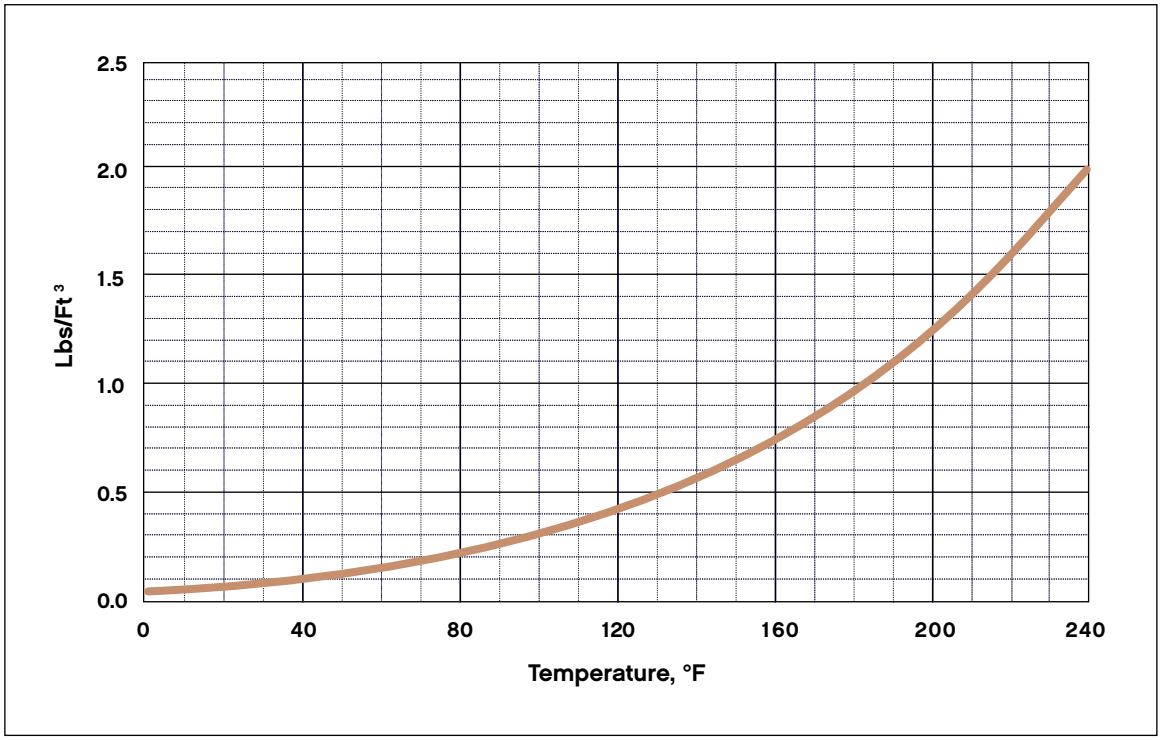

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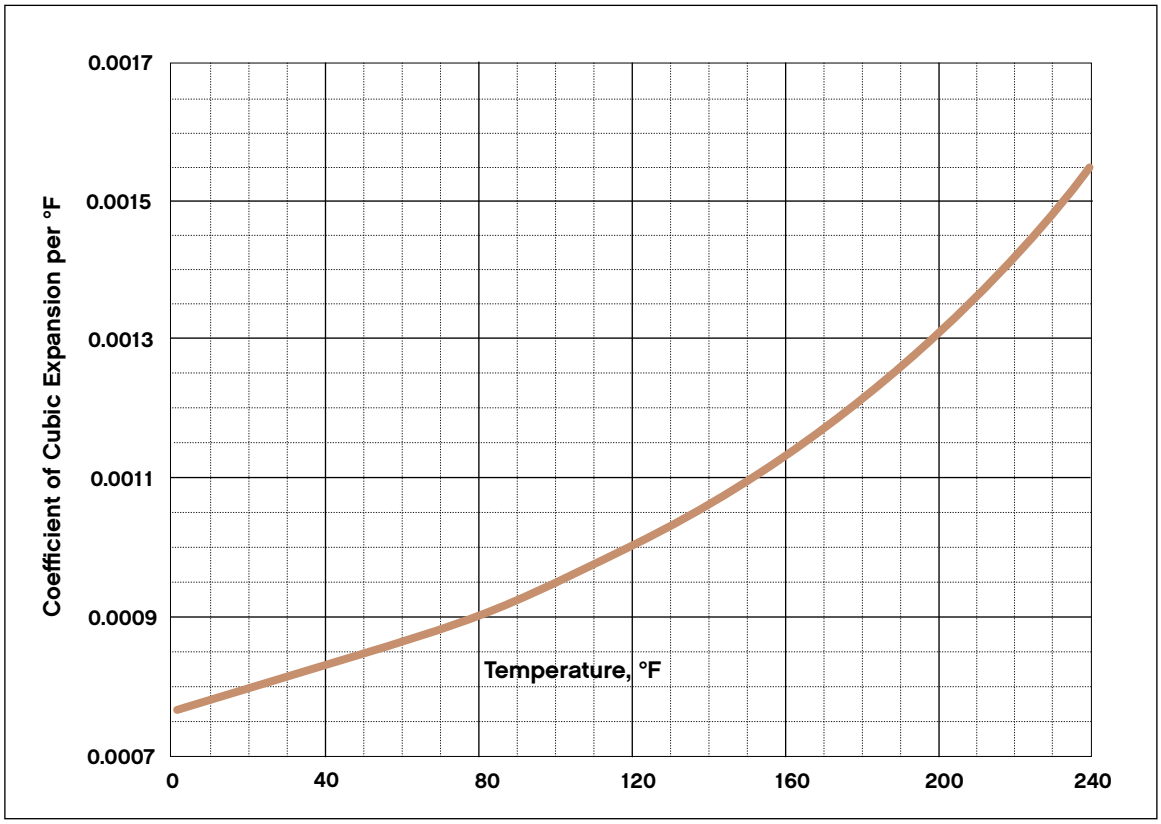

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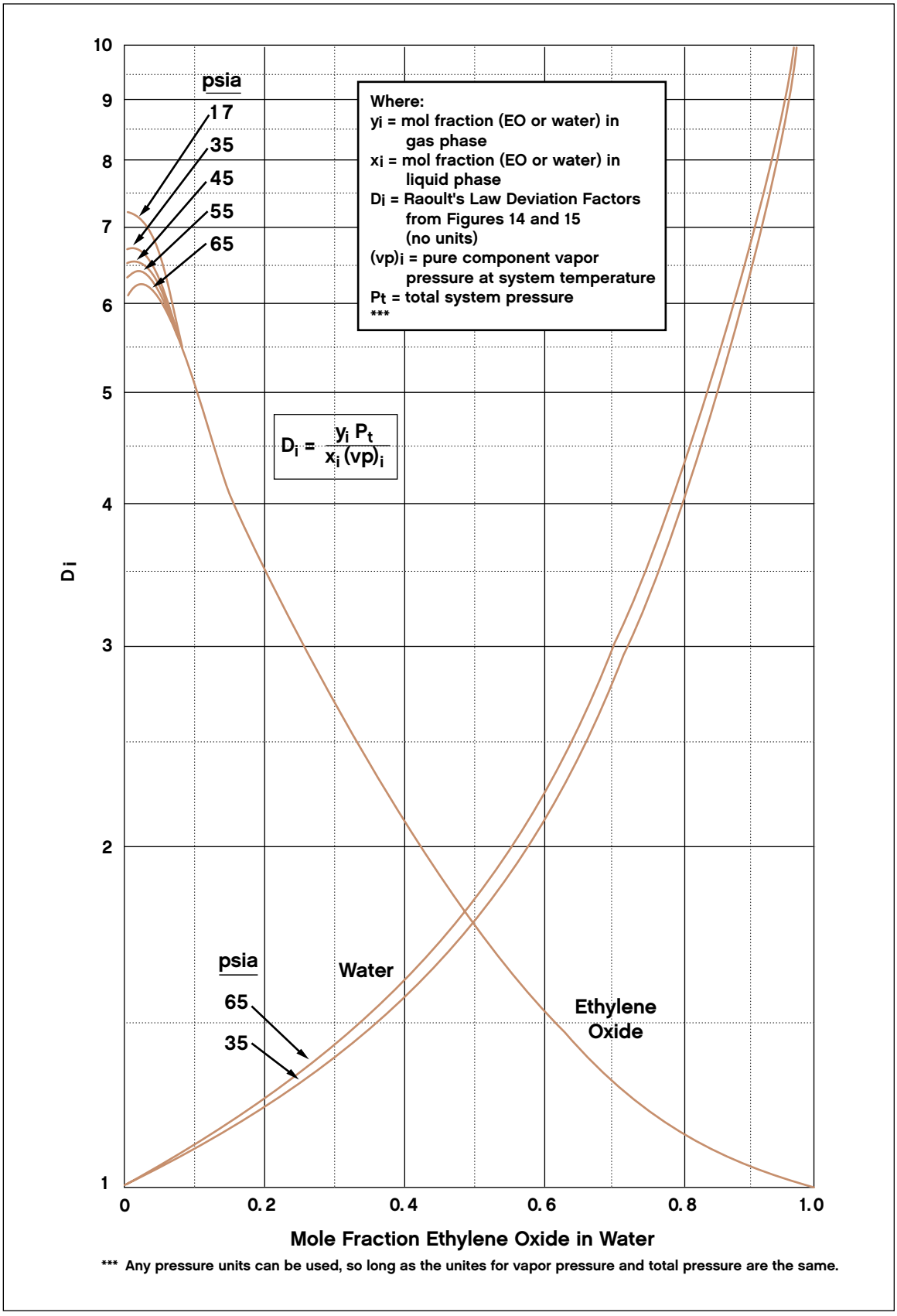

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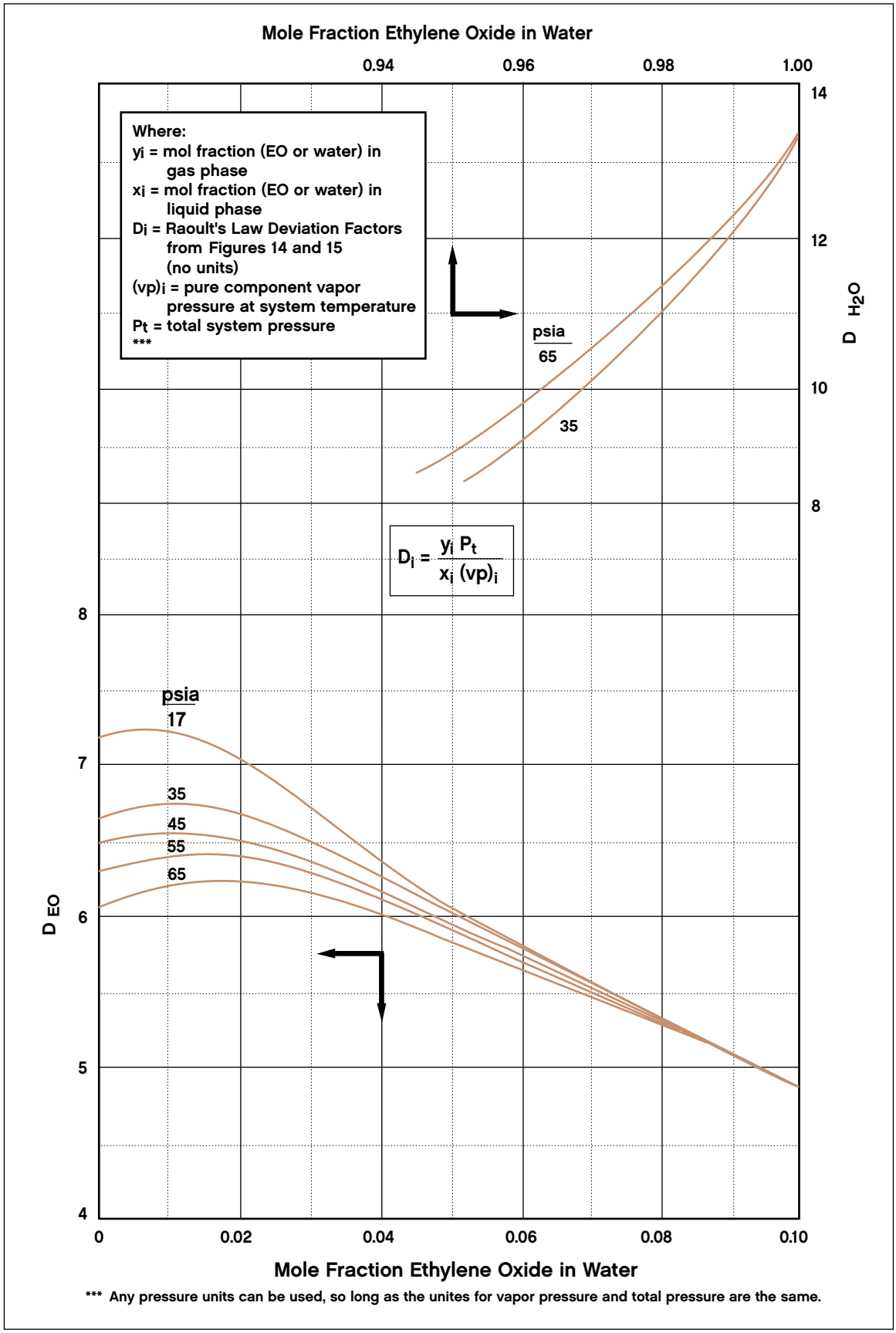

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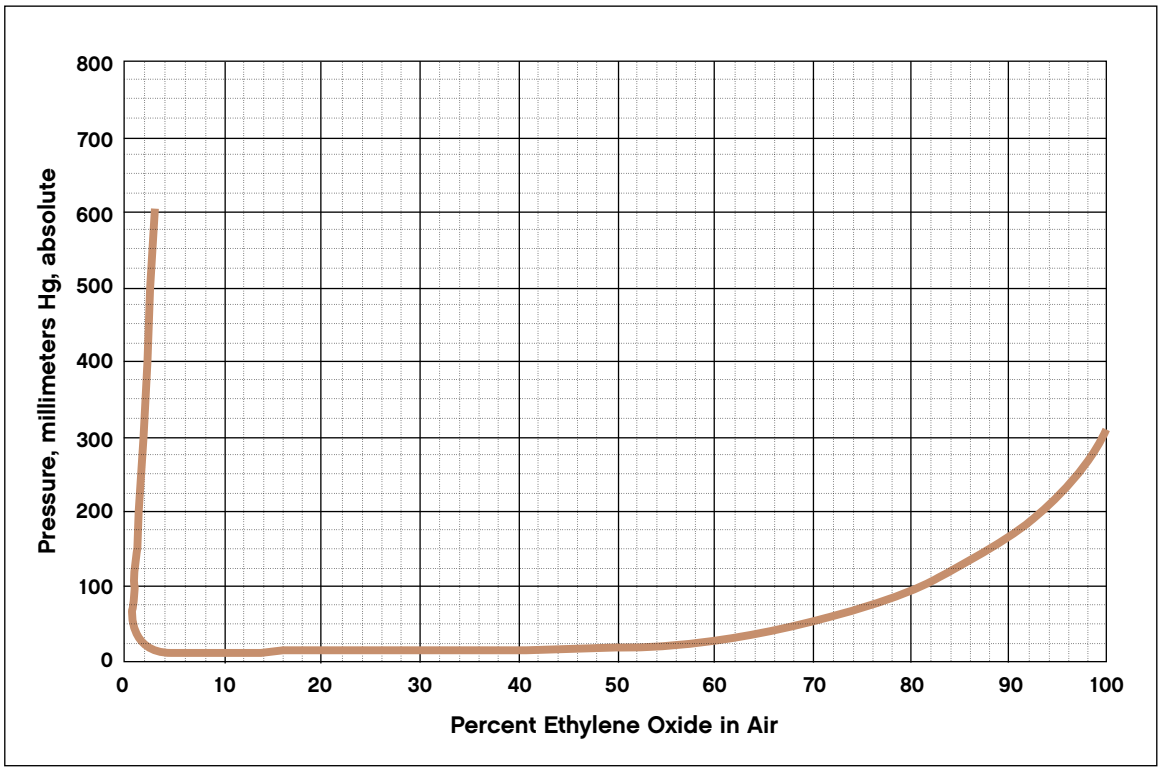

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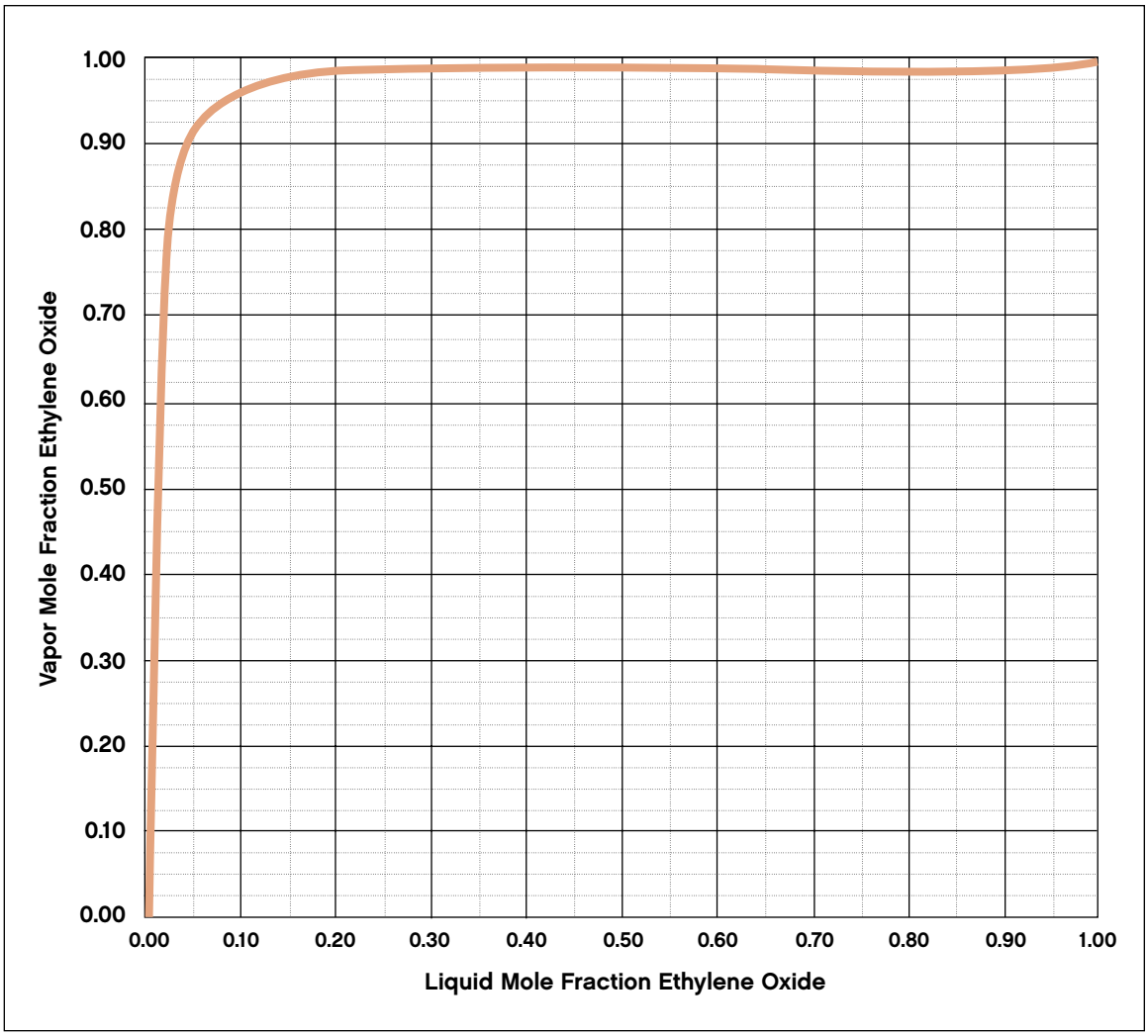

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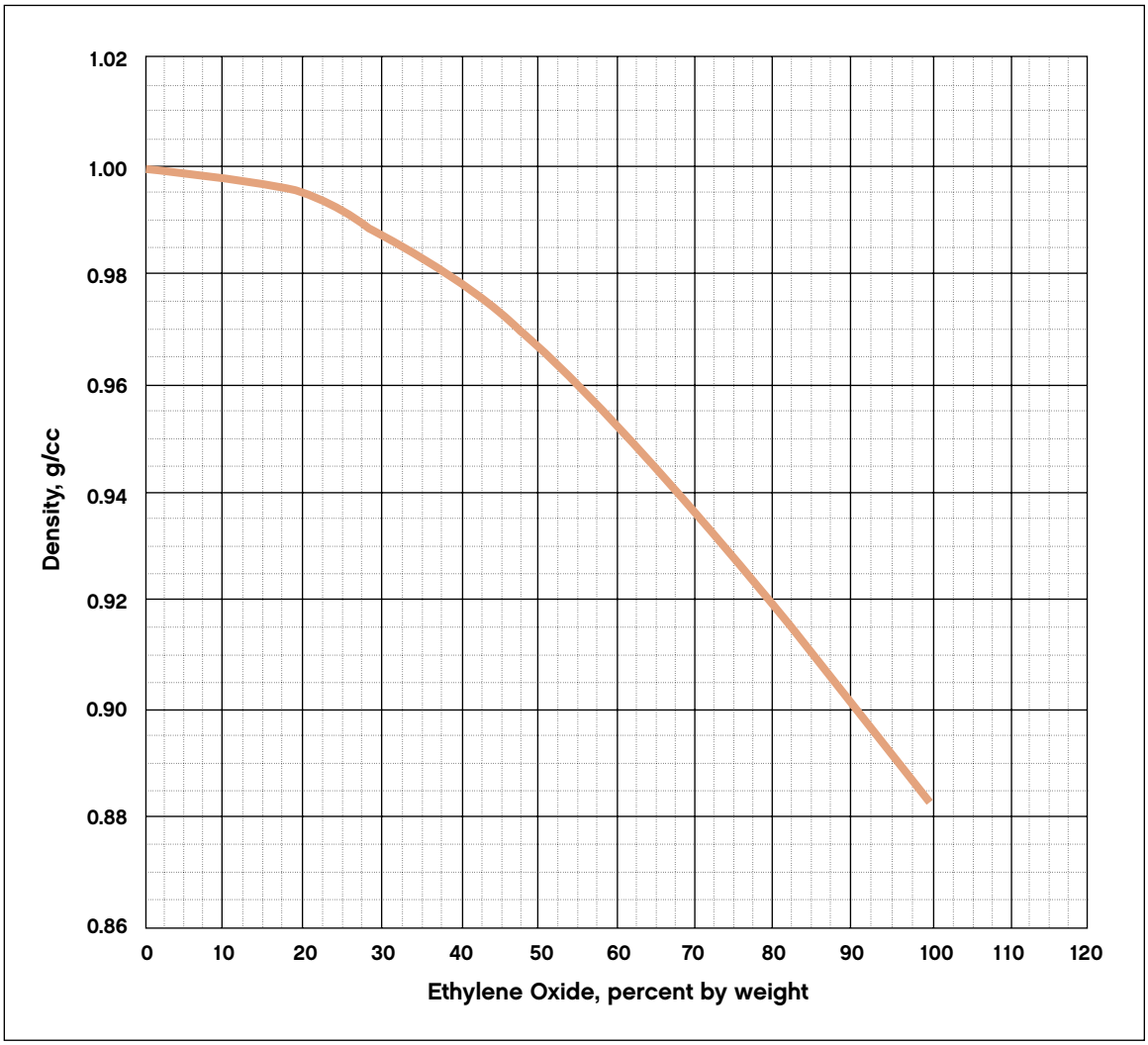

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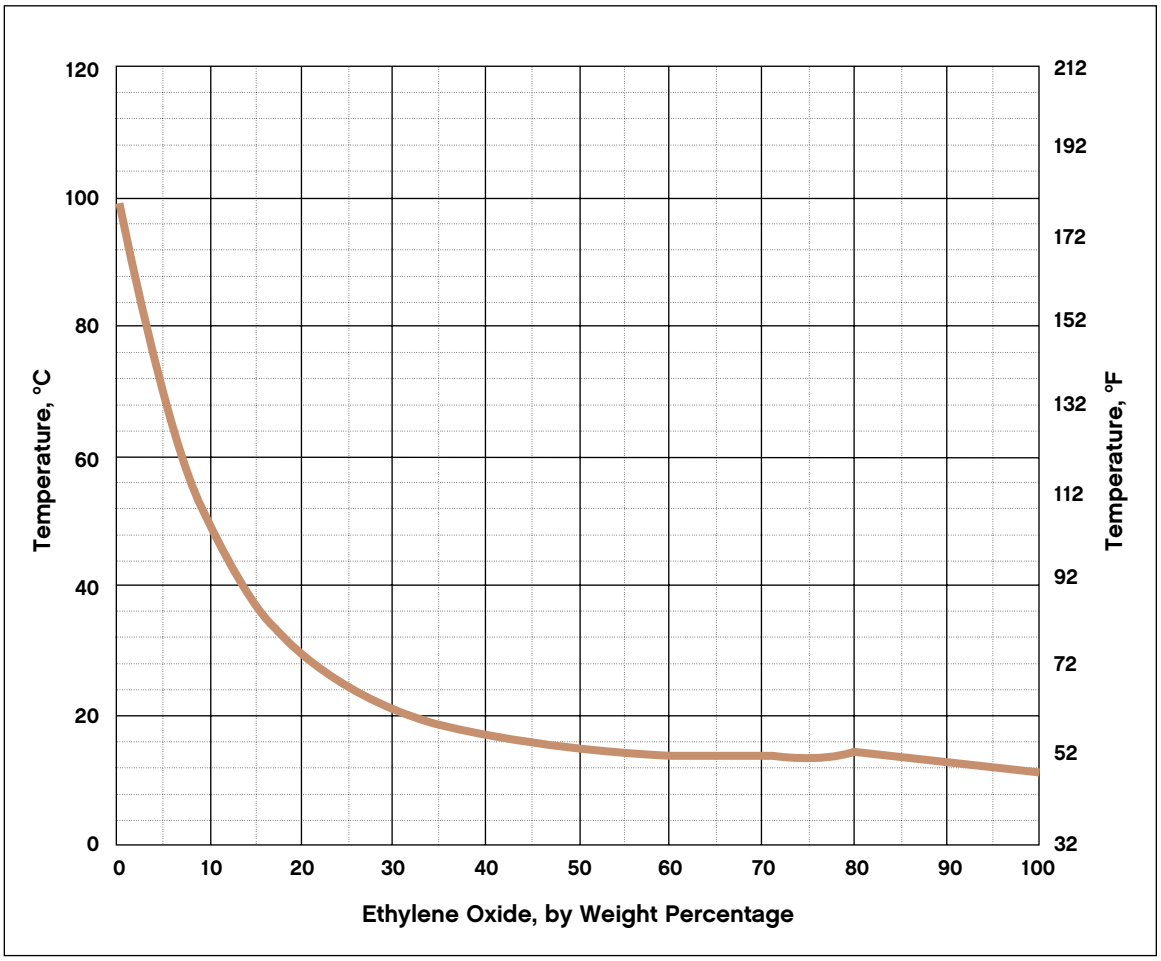

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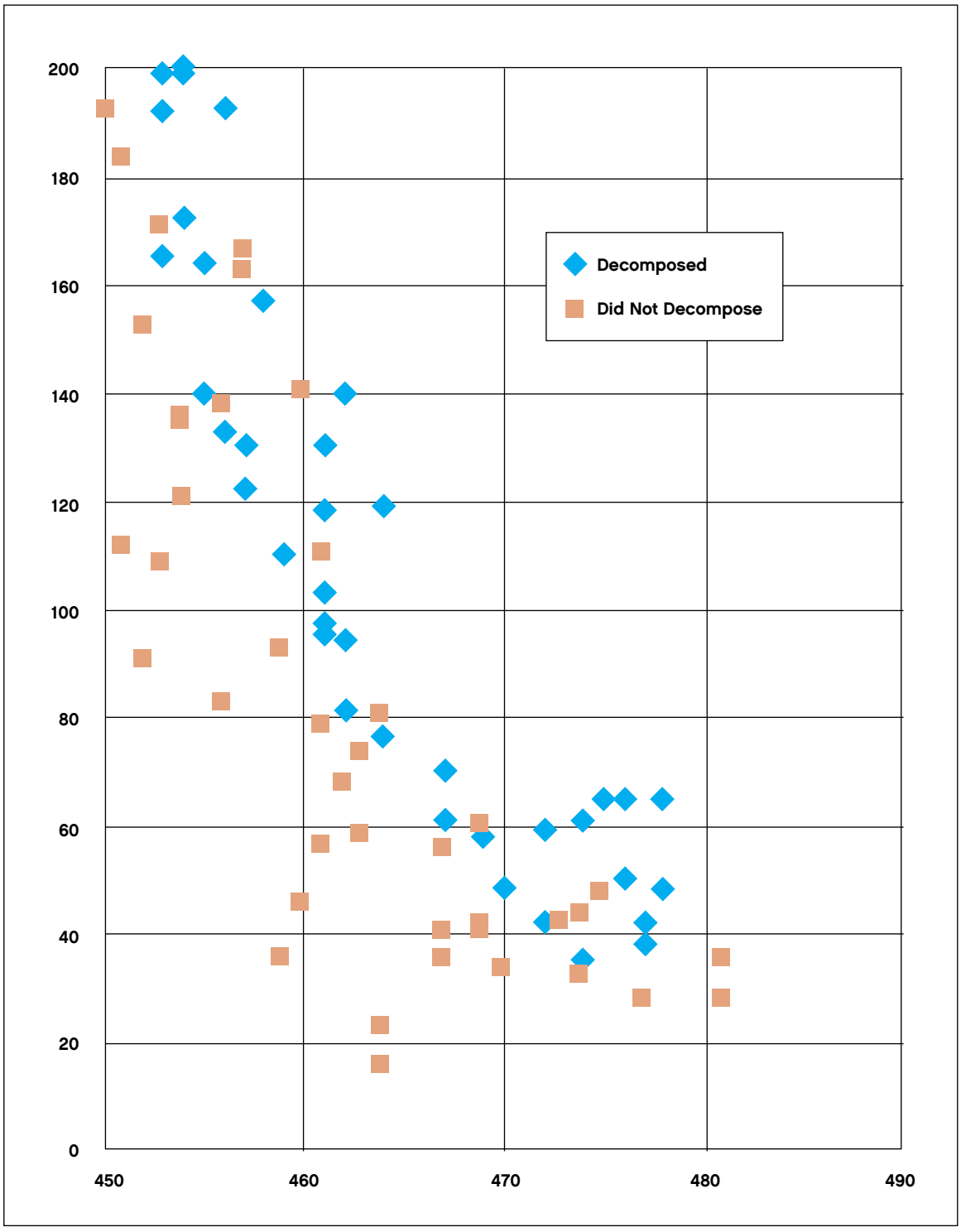

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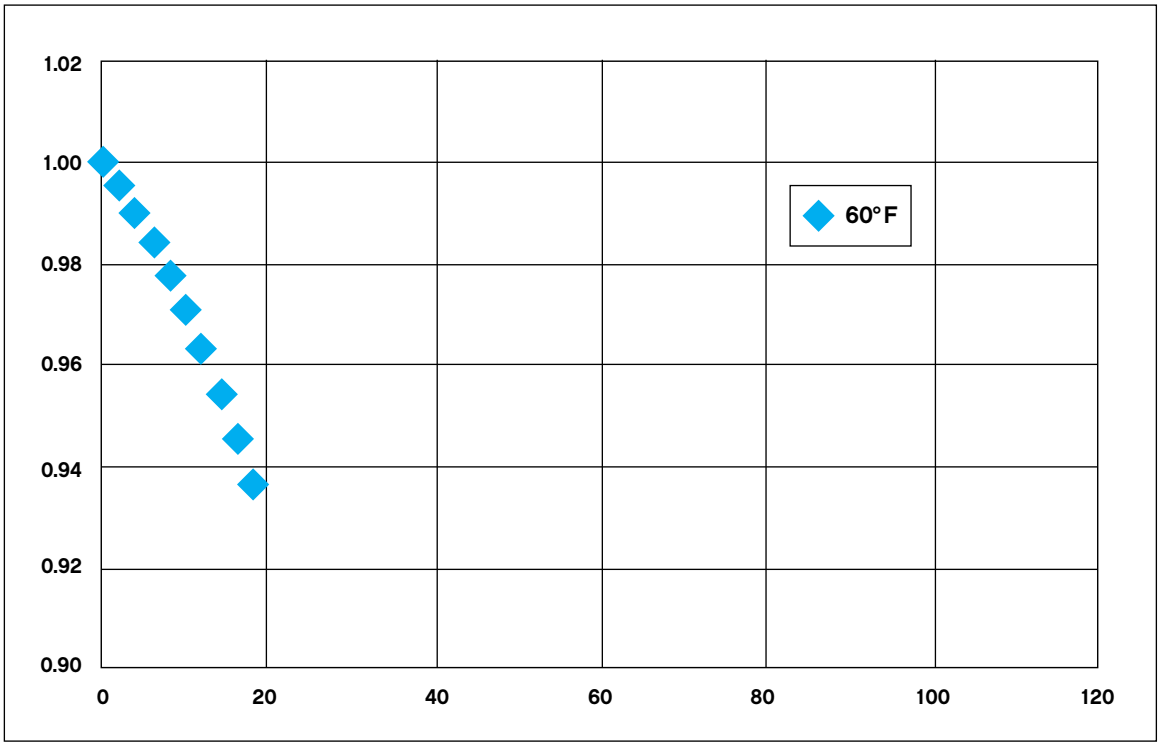

Table A1 Physical Property Equations

EQUATION COEFFICIENTS (ALL PROPERTIES IN SI UNITS)					
PROPERTY	UNITS	A	B	C	D
Solid Density	KgMOL/M^3	2.75E+01			
Liquid Density	KgMOL/M^3	1.8360E+00	2.6024E-01	4.6915E+02	2.6960E-01
Coeff of Expansion	per°K		2.6024E-01	4.6915E+02	2.6960E-01
Vapor Density	KgMOL/M^3	3.3904E+00	-5.0556E-02	2.9019E-04	-7.6743E-07
Vapor Pressure	Pa	9.1944E+01	-5.2934E+03	-1.1682E+01	1.4902E-02
Heat of Vaporization	J/KgMOL	3.6652E+07	3.7878E-01		
Solid Heat Capacity	J/KgMOL*°K	-2.1143E+04	1.4903E+03	-1.1881E+01	3.8745E-02
Liquid Heat Capacity	J/KgMOL*°K	1.4471E+05	-7.5887E+02	2.8261E+00	-3.0640E-03
Ideal Gas Heat Capacity	J/KgMOL*°K	3.3460E+04	1.2116E+05	1.6084E+03	8.2410E+04
Second Virial Coefficient	M^3 KgMOL	6.0016E-02	-5.2057E+01	-1.8056E+07	6.9368E+19
Liquid Viscosity	Kg/M*S	-8.5210E+00	6.3502E+02	-3.3140E-01	
Vapor Viscosity	Kg/M*S	2.9540E-06	4.7120E-01	7.874E0+02	-2.3580E+04
Liquid Thermal Conductivity	W/M*°K	2.6957E-01	-3.9840E-04		
Vapor Thermal Conductivity	W/M*°K	-3.7880E+04	1.1150E+00	-5.6410E+03	
Surface Tension	N/M	7.4730E-02	1.1410E+00		

*Note: The symbol * denotes multiplication. The symbol ^ denotes exponentiation.*
T is temperature, deg Kelvin. Tr is reduced temperature, T/T critical

Table A2 Conversion Factors

To Convert From	To	Multiply By	Notes
KgMOL/M^3	Lb/Gal	0.3676	1
Pascals	Lb$_f$/sq in	.445E-04	
J/KgMOL	BTU/Lb	9.785E-06	1
J/KgMOL*°K	BTU/Lb*°F	5.422E-06	1
KgM*S	Centipoise	1E+03	
W/M*°K	BTU/Ft*Hr*°F	0.578	
N/M	Lb$_f$/ft	6.852E-02	

Notes: 1. Only valid for Ethylene Oxide

	E	USABLE RANGE		EQUATIONS
		MIN°K	MAX°K	
			161	Y = A + (B*T) +(C*T^2) + (D*T^3) + (E*T^4)
		161	469	Y = A/(B^(1+(1-T/C)^D))
		161	469	Y= (-D/C)*LN(B)*((1-T/C)^ (D-1))
	7.9840E-10	233	383	Y= A + (B*T) + (C*T^2) + (D*T^3) + (E*T^4)
	1.0000E+00	161	469	Y = exp (A + (B/T) +(C*lnT) + (D*T^E))
		161	469	Y = A*((1-Tr)^(B + (C*Tr) + (D*Tr^2) + (E*Tr^3)))
		25	161	Y= A + (B*T) + (C*T^2) + (D*T^3) + (E*T^4)
		161	284	Y= A + (B*T) + (C*T^2) + (D*T^3) + (E*T^4)
	7.3730E+02	50	1500	Y = A + B*((C/T)/SINH (C/T)) ^2 + D*((E/T)/COSH(E/T))^2
	-1.7212E+00	235	1500	Y = A +(B/T) + (C/T^3) +(D/T^8) +(E/T^9)
		161	284	Y = exp (A + (B/T) +(C*lnT) + (D*T^E))
		161	1000	Y = (A*T^B) / (1 + (C/T) + (D/T^2))
		161	284	Y= A + (B*T) + (C*T^2) + (D*T^3) + (E*T^4)
		273	1000	Y = (A*T^B) / (1 + (C/T) + (D/T^2))
		161	469	Y = A*((1-Tr)^(B + (C*Tr) + (D*Tr^2) + (E*Tr^3)))

Table A3 Henry's Law Constants (Atm/mole fraction)

T (°C)	Nitrogen	Argon	Methane	Ethane
32	2800	1671	613	84.3
77	2180	1420	614	109
122	1820	1270	595	129

Table A4 Henry's Law Constants (MPa/mole fraction)

T (°C)	Nitrogen	Argon	Methane	Ethane
0	284	169	62.1	8.5
25	221	144	62.2	11.0
50	184	129	60.3	13.1

Henry's Law Constants can be used with the following equation to determine solubility of these gases:

$$X_i = \frac{Y_i P_t}{H_i}$$

Where:
Xi = mol fraction of gas (N2, Ar, Methane, or Ethane) in liquid EO
Yi = mol fraction of gas in vapor space above liquid EO
Pt = total pressure, Atm
Hi = Henry's Law Constants for gas, Atm

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