ETHANOLAMINES

Monoethanolamine

Diethanolamine

Triethanolamine

CONTENTS

ETHANOLAMINES

Dow's versatile family of ethanolamines — including monoethanolamine (MEA), diethanolamine (DEA), and triethanolamine (TEA) — offers a broad spectrum of application opportunities. Triethanolamine is available as TEA, 99% and TEA, Commercial (which contains nominally 15% diethanolamine). Because ethanolamines combine the properties of amines and alcohols, they exhibit the unique capability of undergoing reactions common to both groups. As amines, they are mildly alkaline and react with acids to form salts or soaps. As alcohols, they are hygroscopic and can be esterified. The chemical structures of the ethanolamines are:

Monoethanolamine

Diethanolamine

Triethanolamine

MEA $H_2NCH_2CH_2OH$

DEA $HN(CH_2CH_2OH)_2$

TEA $N(CH_2CH_2OH)_3$

Ethanolamines find uses in such diverse areas as gas sweetening, where they serve as lubricants and scouring agents; detergent and specialty cleaner formulations, in which they are used to form various amine salts and to control pH; and in a host of other applications including concrete admixtures, flexible urethane foam catalysts, pharmaceuticals, personal care products, agricultural chemicals, photographic emulsions, and more.

TECHNOLOGY LEADERSHIP

Ethanolamines from Dow are backed by approximately 80 years of innovative scientific research. Since their introduction in the late 1920s, MEA, DEA, and TEA have undergone extensive commercial development in our laboratories at South Charleston, WV.

WORLD SCALE PRODUCTION CAPACITY

Backed by the world's largest ethylene oxide capacity, Dow's efficient ethanolamines facilities, located at Seadrift, TX, are the world's largest. Designed for flexibility, this plant is capable of producing ethanolamines to meet the most demanding specifications of the marketplace.

Additional worldscale ethanolamines facilities were added in 1997 at Taft, LA, and in 2002, at the Optimal joint venture between Dow and Petronas at Kertih, Malaysia. Additional plants will be added to meet other developing worldwide markets.

Dow's position as the leading producer of basic ethylene oxide and ethanolamines translates into dependability, not only as a source of supply, but in quality of product as well. The purity and consistency of Dow's ethanolamines are unsurpassed.

BROADEST DISTRIBUTION NETWORK

The Dow network of sales personnel, technical service experts, bulk storage terminals, and distributors has been carefully constructed to reach all of Dow's customers worldwide. Problem solving assistance is virtually a phone call away, and Dow's vast distribution system assures fast delivery of tanker, barge, tank truck, tank car, or drum quantities from strategically located bulk terminals and warehouses.

Whatever your needs in ethanolamines — MEA, DEA, or TEA — Dow has the technical, production, and distribution resources to serve you best. This booklet has been designed to provide the answers to most questions about Dow's ethanolamine products. For further information contact your Dow representative.

Ethanolamine Applications

Typical Applications	*MEA*	*DEA*	*TEA, Commercial*	*TEA, 99%*
Adhesives			✗	
Agricultural Chemicals		✗	✗	
Cement Grinding Aids			✗	✗
Concrete Additives				✗
Detergents, Specialty Cleaners Personal Care Products	✗	✗	✗	✗
Gas Treating	✗	✗	✗	✗
Metalworking	✗		✗	✗
Oil Well Chemicals	✗		✗	✗
Packaging & Printing Inks	✗			
Photographic Chemicals		✗		✗
Rubber			✗	
Textile Finishing	✗	✗	✗	✗
Urethane Foams		✗	✗	✗

ETHANOLAMINES FOR GAS SWEETENING

Aqueous solutions of monoethanolamine and diethanolamine react with carbon dioxide and hydrogen sulfide at ambient temperature to form compounds that, when exposed to elevated temperatures, release the acid gas and regenerate the amine for reuse.

Monoethanolamine is commonly used for treating synthesis gas streams formed in ammonia, hydrogen, carbon monoxide, and flue gas facilities. Carbon dioxide is the principal contaminant that is removed.

Diethanolamine is primarily used for treating natural and refinery gas and for liquid streams. Carbon dioxide and hydrogen sulfide are the principal contaminants removed.

Engineering companies can provide individually designed plants or standard packaged units that can be installed wherever it is necessary to remove carbon dioxide and/or hydrogen sulfide from gas streams.

For natural gas systems and refinery-treating systems in sulfur service, diethanolamine solutions have performed satisfactorily for years in units where carbon steel has been the major material of construction. In improperly designed or improperly operated units, however, corrosion will occur in carbon steel exchangers, condensers, and reboiler-type bundles. In special situations, therefore, alloy materials of construction may be required. In addition, improved design and operating criteria may be specified, including activated carbon filtration and good inlet separation.

ETHANOLAMINES FOR DETERGENTS, SPECIALTY CLEANERS, AND PERSONAL CARE PRODUCTS

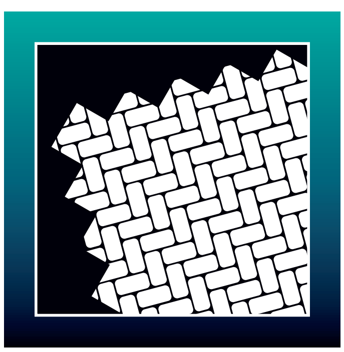
Ethanolamines are used in heavy-duty liquid laundry detergents because they provide a unique combination of beneficial property and performance qualities. These ethanolamines impart a reserve alkalinity to the laundry bath, which is essential to efficient cleaning. They neutralize the fatty acids present in the oily soil components and, through this neutralization, convert them to amine soaps. These soaps, in turn, aid in the overall cleaning process. The effect is readily observed when standard industrial oily soils are used.

These same ethanolamines are also effective soil anti-redeposition agents. They help to keep soil in the laundry bath from redepositing onto the fabric during the cleaning process. The effect is evident in the performance of nonionic, anionic, and mixed nonionic/anionic surfactant-based products on cotton, blended cotton/polyester, and polyester fabrics.

Diethanolamine is used to prepare fatty acid amides, which may be used in various personal care products.

Triethanolamine may be reacted with lauryl sulfate to form the foaming base surfactant used in hair shampoos.

Fatty acids neutralized with ethanolamines, particularly triethanolamine, are excellent emulsifiers for oil-in-water emulsions. Gel-type industrial hand cleaners, aerosol shave creams, and hand and body lotions are only a few of the consumer products commonly formulated with such soaps. Triethanolamine is also used as the base component in the production of certain mild bar soaps.



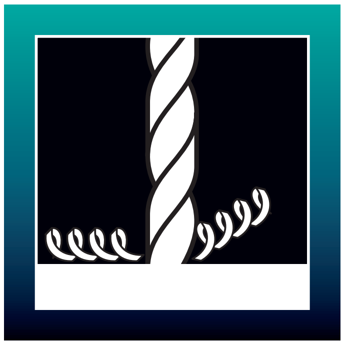
ETHANOLAMINES FOR TEXTILES

Ethanolamines are used in textile processing as reaction intermediates for the preparation of durable press fabric finishes and softeners.

Amine soaps are used as scouring agents for wool and silk because of their low alkalinity.

Ethanolamines are also used as dye auxiliaries. Because of their hygroscopicity, ethanolamines find application in the preparation of vat printing pastes. Diethanolamine and triethanolamine are used in making acetate rayon dyes.

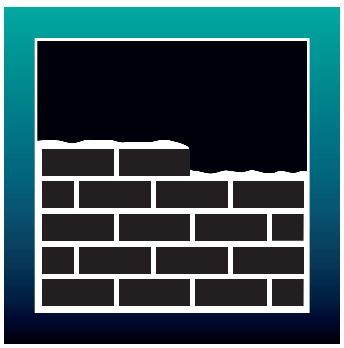
Textile lubricants often incorporate salts of ethanolamines to benefit from their anticorrosion and antistatic properties. Ethanolamine salts of mono- or di-phosphates, sulfonates, and sulfates are typical components of staple finishes.



ETHANOLAMINES FOR METALWORKING

Acidic additives and/or acidic decomposition products are the prime contributors to corrosion of metal surfaces, particularly in the presence of moisture. Ethanolamines are often used as neutralizers of acid components in lubricants and are a time-tested means of preventing corrosion.

In water-soluble cutting and grinding fluids, ethanolamines are used to provide the alkalinity needed to protect against rusting (ferrous metals do not oxidize under alkaline conditions). Ethanolamines are also used as intermediates in the preparation of water-soluble lubricants, emulsifiers, proprietary corrosion inhibitors, and biocides.



OTHER ETHANOLAMINE APPLICATIONS

In addition to supplying ethanolamines for the four major applications already discussed, Dow provides these versatile materials for a variety of other uses (See Applications Chart, page 3).

Diethanolamine and triethanolamine are used as catalysts that promote stability during the reaction process in the manufacture of flexible and rigid urethane foams. In the photographic chemical industry, these ethanolamines find application in complex modern developing systems. Diethanolamine and triethanolamine are used in the agricultural chemical field as intermediates in a number of applications, most notably the manufacture of herbicides.

Triethanolamine finds use as an intermediate for additives that control the rate at which water evaporates from drying concrete. In another application, triethanolamine is used as a component in the formulation of cement grinding media during the manufacture of cement. In still another important use, triethanolamine is utilized “down hole” in oil wells to prevent corrosion of drilling equipment.

Triethanolamine also functions as an intermediate for adhesive and rubber chemicals. Monoethanolamine is used as a pH control agent in the formulation of packaging and printing inks.

Triethanolamine (Trolamine 99% NF Grade) meets the requirements of the applicable National Formulary monograph.

Typical Physical Properties

The properties of Dow's family of ethanolamines enable these versatile materials to be utilized in a broad range of applications. Typical properties of the ethanolamines are shown in the table below and in Figures 1-23.

Table 1 • Typical Properties of DOW Ethanolamines

	Monoethanolamine	*Diethanolamine*	*Triethanolamine*
Formula	$H_2NCH_2CH_2OH$	$HN(CH_2CH_2OH)_2$	$N(CH_2CH_2OH)_3$
Molecular Weight	61.08	105.14	149.19
Apparent Sp. Gr. at 20/20°C	1.017	1.092[a]	1.126[f]
ΔSp. Gr./Δt at 10 to 80°C	0.00080	0.00065[b]	0.00059
Boiling Point at 760 mm Hg, °C	170.4	268[c]	335[c]
at 50mm Hg, °C	101	182	245[c]
at 10mm Hg, °C	71	150	205
Vapor Pressure at 20°C, mm Hg	<1	<0.01	<0.001
Freezing Point, °C(°F)	10.5 (50.9)	28.0 (82.4)	21.6 (70.9)[e]
Absolute Viscosity at 20°C, cP	24.1	—	921[f]
at 30°C, cP	16.2	380	404
Solubility at 20°C, % by wt			
In Water	Complete	Complete[f]	Complete[f]
Water In	Complete	—	Complete[f]
Solubility in Organic Liquids at 25°C, % by wt			
Acetone	Complete	Complete[f]	Complete
Benzene	0.6	0.03	2
Carbon Tetrachloride	0.1	0.01	Complete
Ethyl Ether	0.7	0.5	2
Heptane	0.1	0.03	<0.03
Methanol	Complete	Complete[f]	Complete
Surface Tension, dynes/cm	48.3[d]	48.5[g]	48.9[d]
Refractive Index, n_D^{20}	1.4539	1.4747[g]	1.4852[f]
$\Delta N_D/\Delta t$ at 20 to 40°C per °C	0.00034	0.00027[b]	0.00020
Flash Point, °C (°F)	96 (205)[h]	191 (375)[h]	208 (407)[h]

(a) At 30/20°C
(b) At 35 to 65°C
(c) Extrapolated (decomposes)
(d) At 25°C
(e) Supercools easily
(f) Supercooled liquid
(g) At 30°C
(h) Determined by ASTM Method D 93, using the Pensky-Martens Closed Cup

NOTE

This table sets forth typical properties of Monoethanolamine, Diethanolamine, and Triethanolamine based upon analysis(ses) of commercial product or purified sample, etc.; however, Dow does not analyze each shipment of product for all of these properties. Dow warrants only that, at the time of delivery, product will conform to Dow's standard specifications as then in effect.

Figure 1

Vapor Pressure of Ethanolamines

Note: Ethanolamines begin decomposing at temperatures above about 200°C and can undergo self-sustained decomposition at temperatures above 250°C.

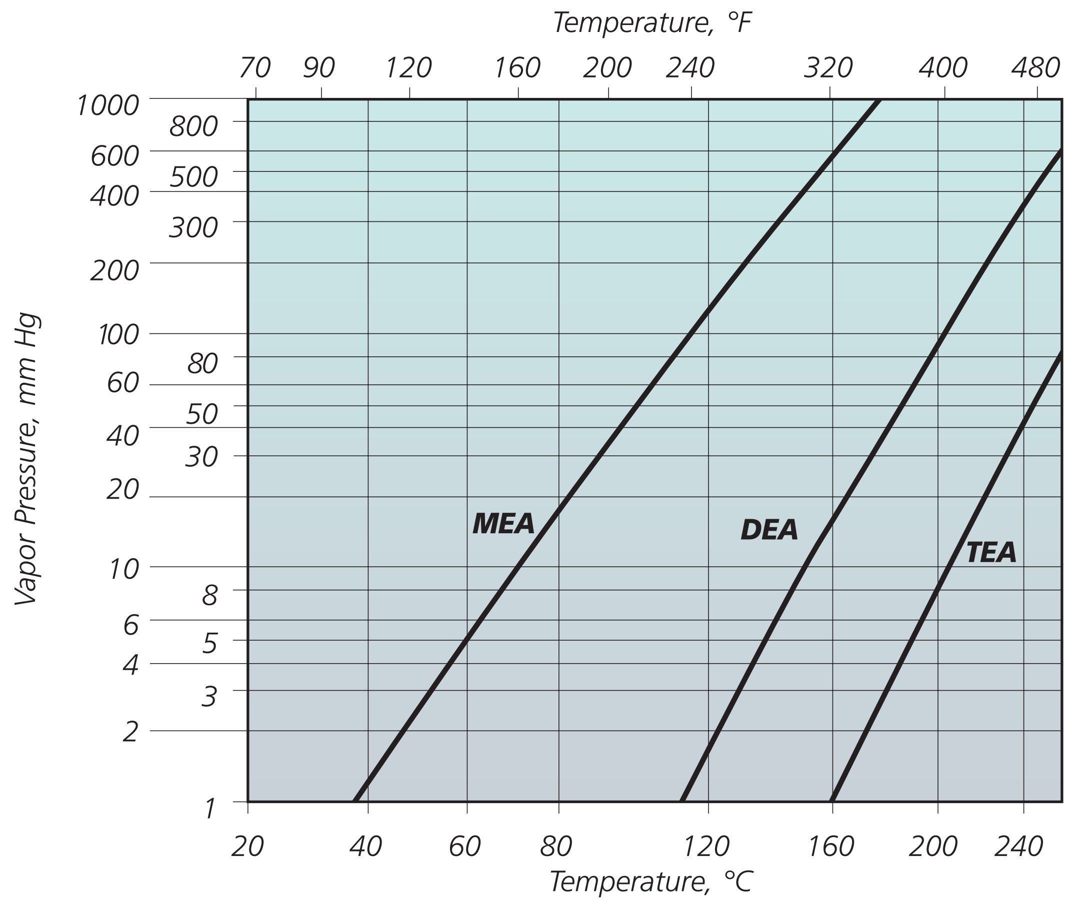
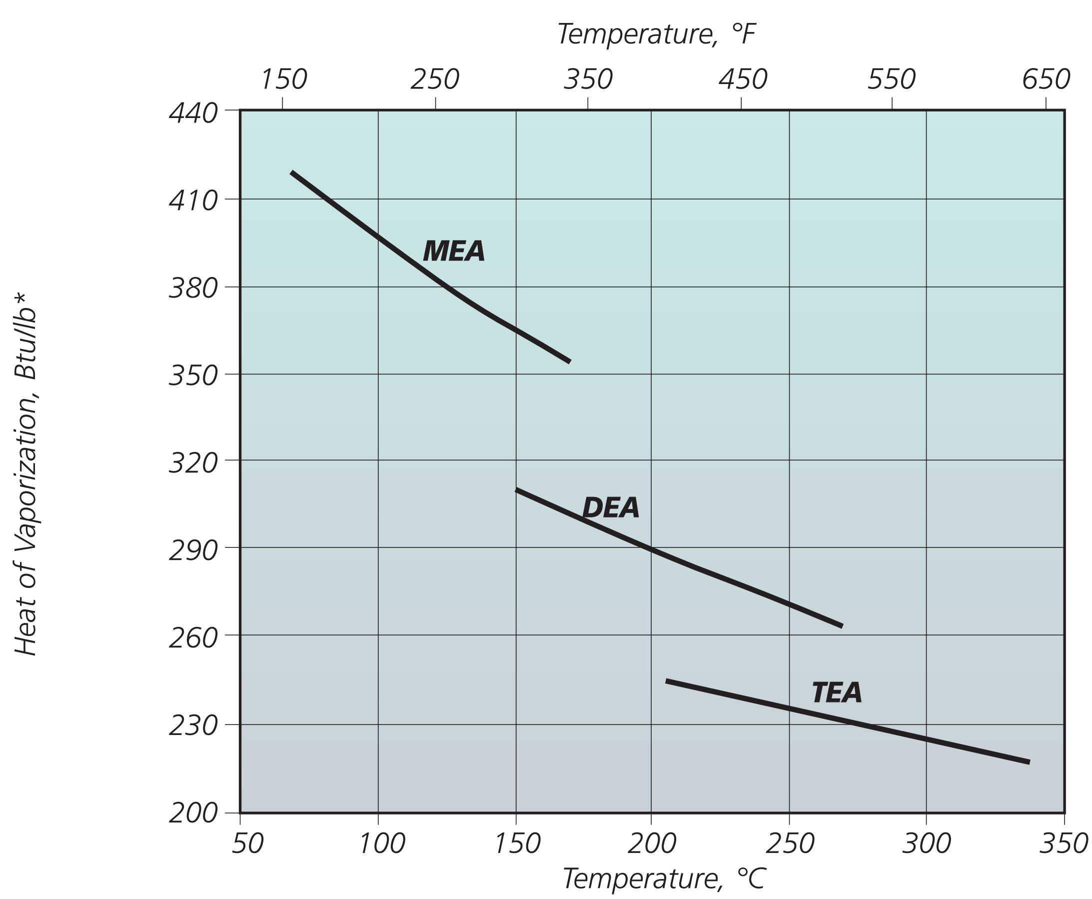


Figure 2

Heat of Vaporization of Ethanolamines



*1 Btu/lb = 0.56 cal/g

Figure 3

Specific Heat of Ethanolamines

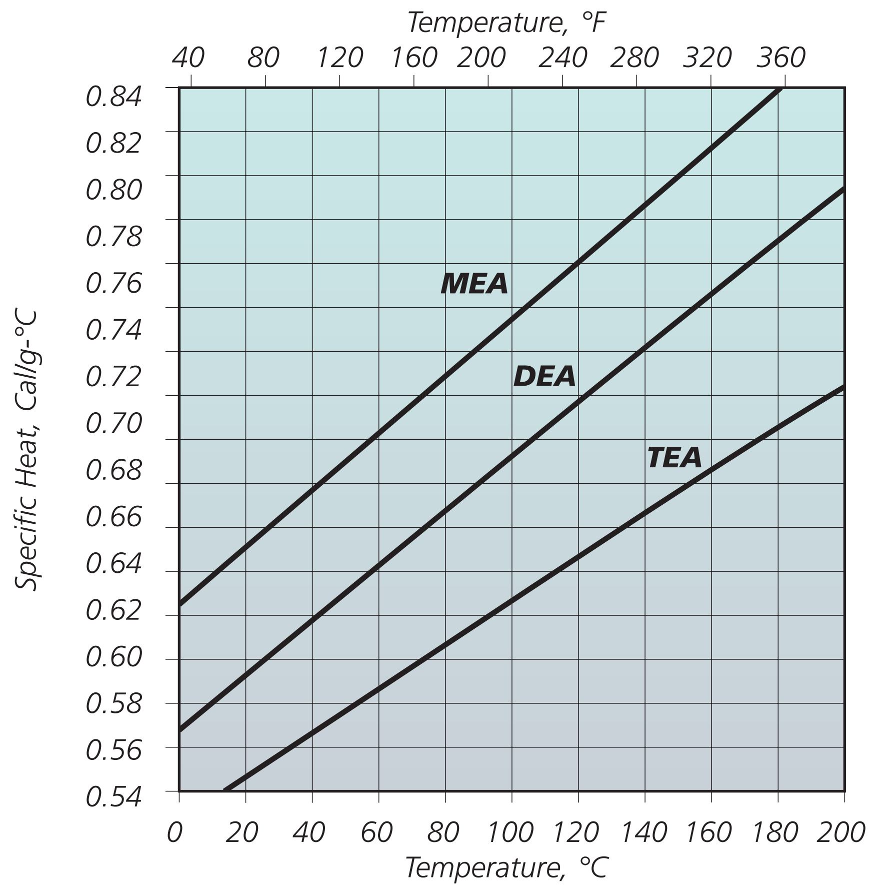


Figure 4

Comparative Hygroscopicities of Diethanolamine and Triethanolamine from 75° to 80°F

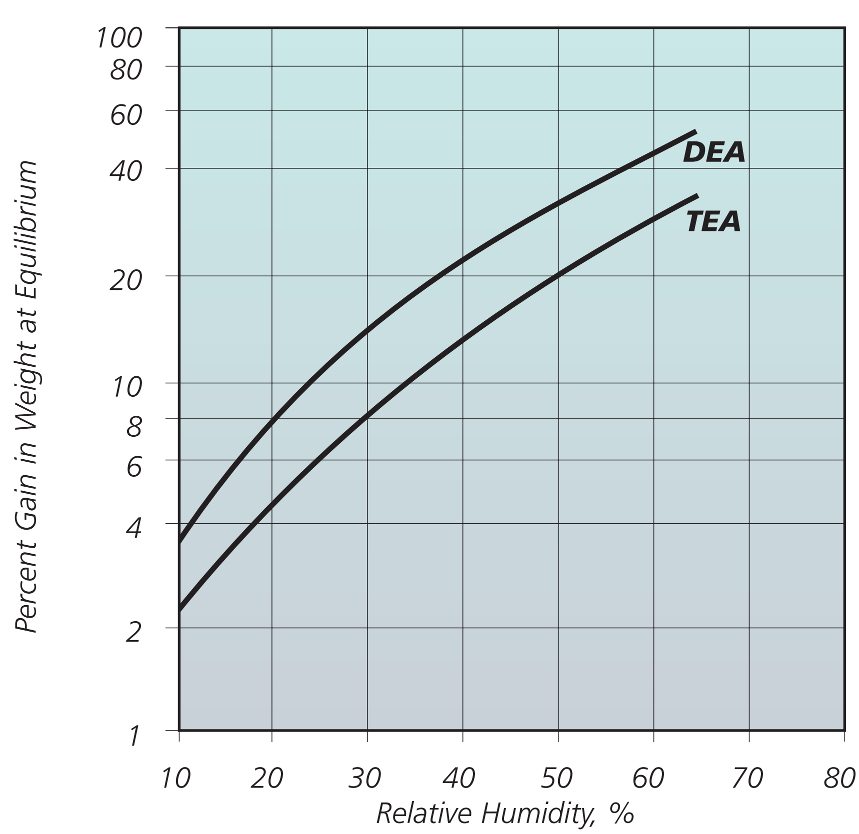


Figure 5

Weight Percent Ethanolamine in Aqueous Solutions vs Normality of Solution

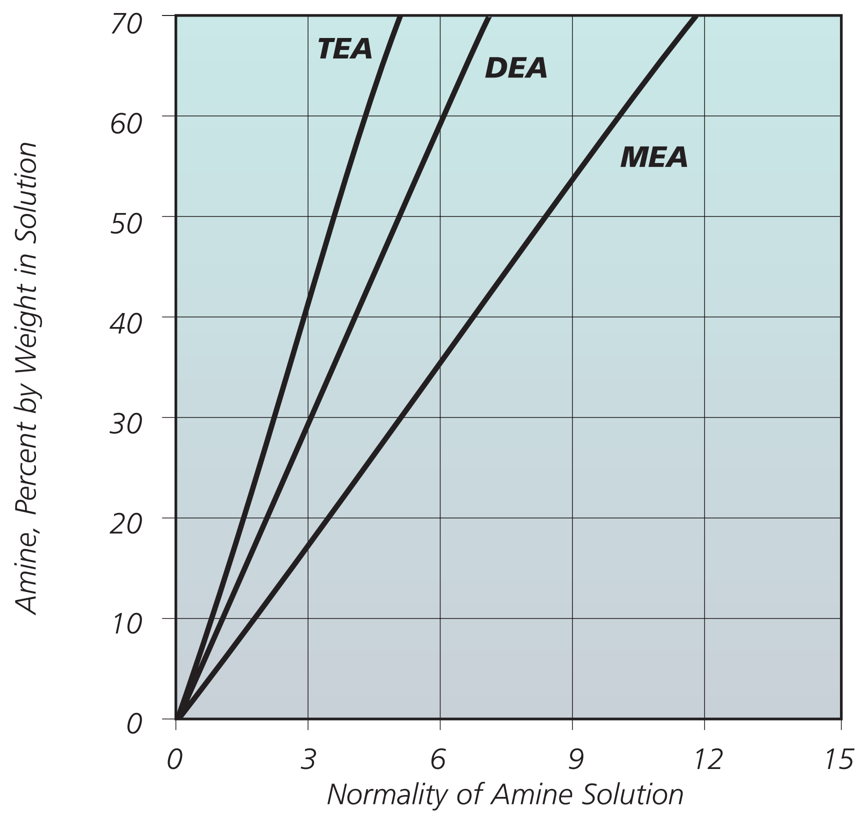


Figure 6

pH of Ethanolamine Solutions

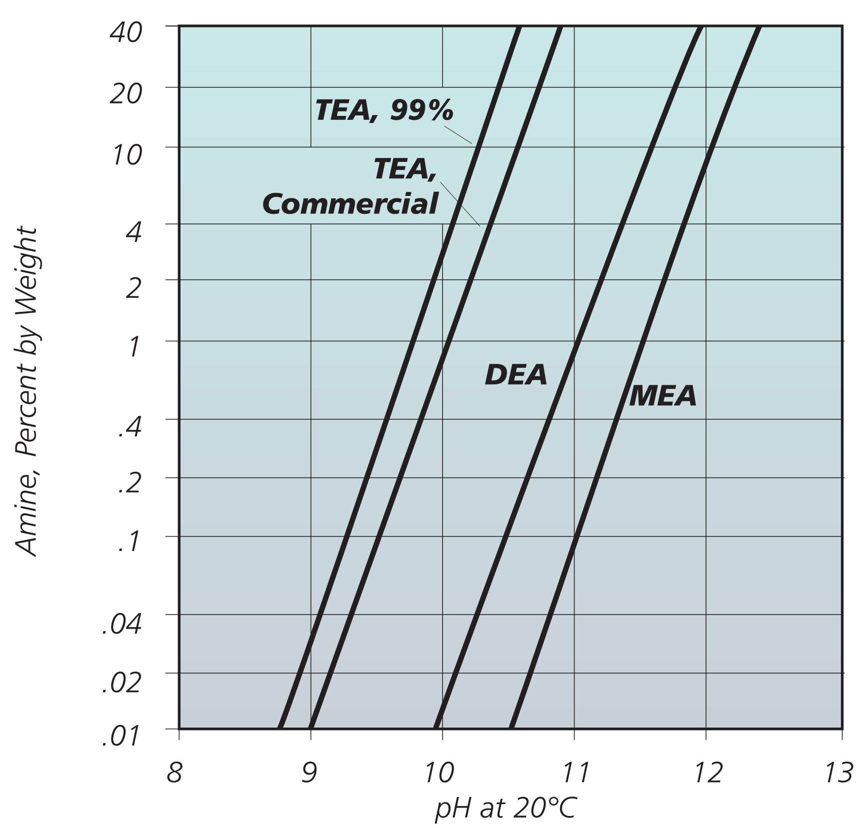


Figure 7

Partial Pressure of Monoethanolamine in Aqueous Solutions at Various Temperatures

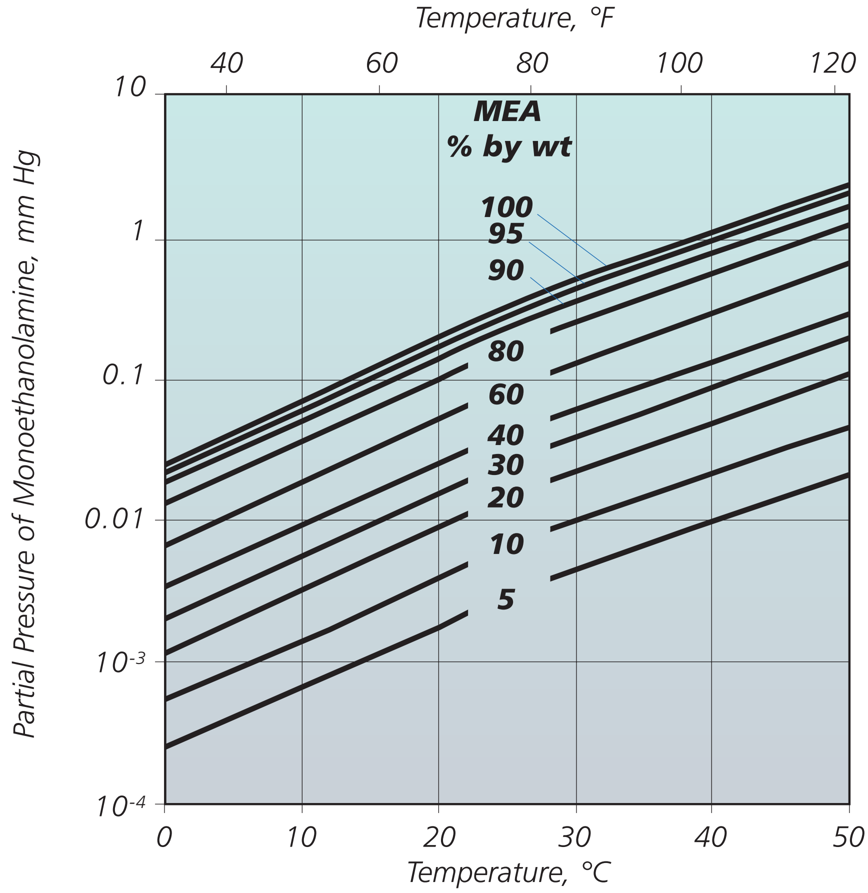


Figure 8

Vapor-Liquid Equilibria (T-x-y) of Aqueous Monoethanolamine Solutions at 760 mm Hg Absolute

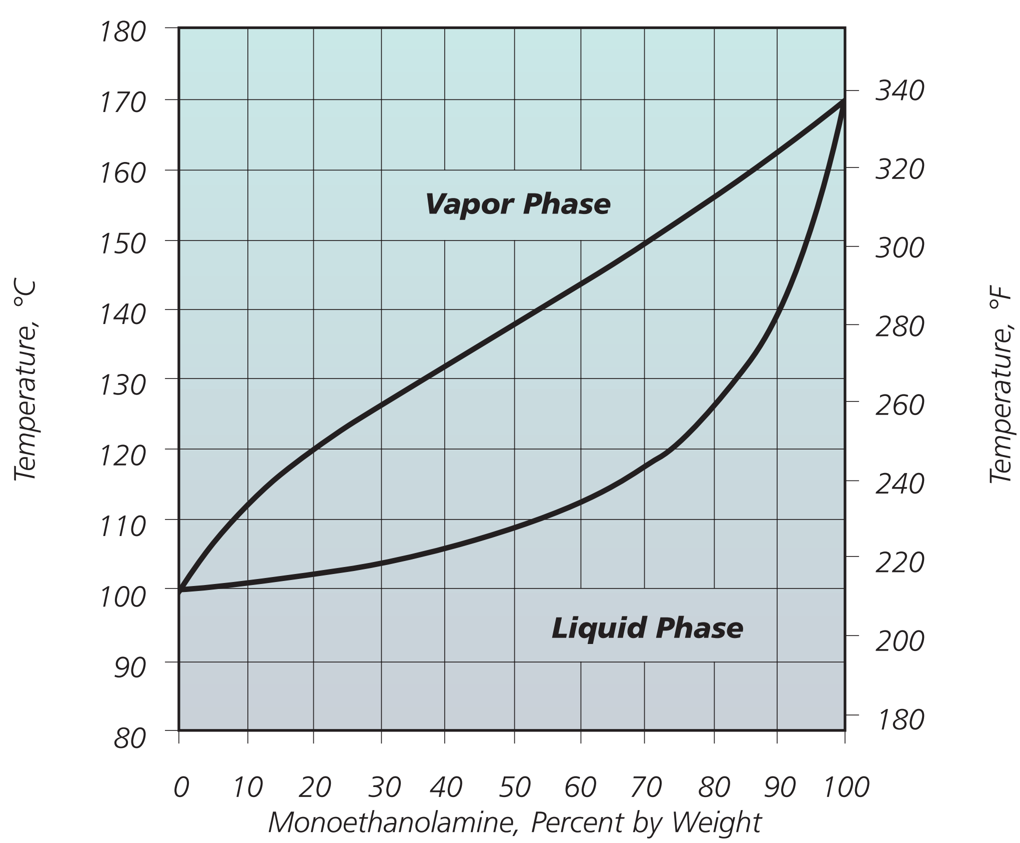


Figure 9

Partial Pressure of Diethanolamine in Aqueous Solutions at Various Temperatures

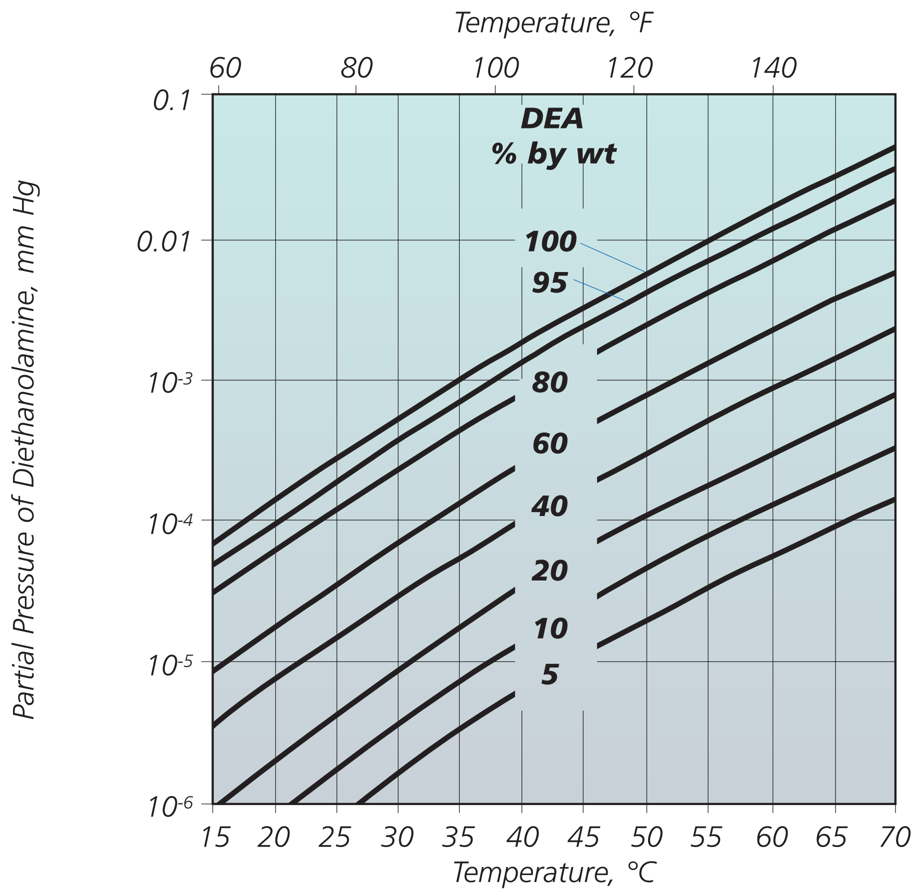
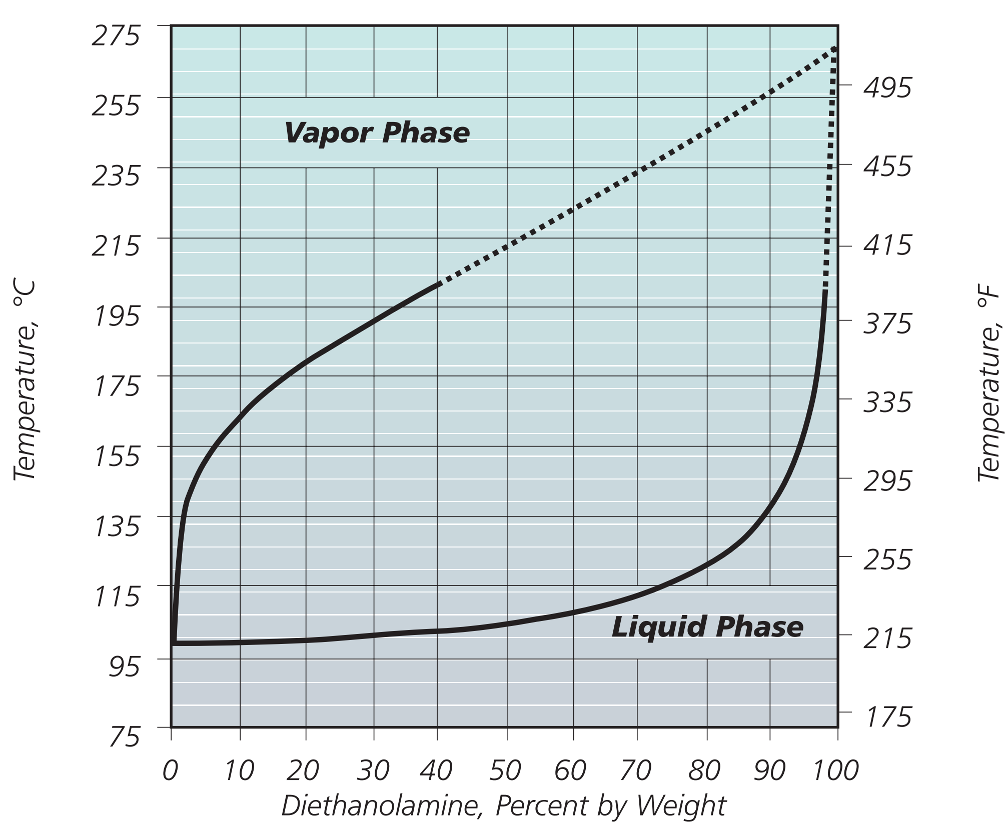


Figure 10

Vapor-Liquid Equilibria (T-x-y) of Aqueous Diethanolamine Solutions at 760 mm Hg Absolute



Note: Ethanolamines can undergo decomposition at temperatures above approximately 200°C

Figure 11

Partial Pressure of Triethanolamine in Aqueous Solutions at Various Temperatures

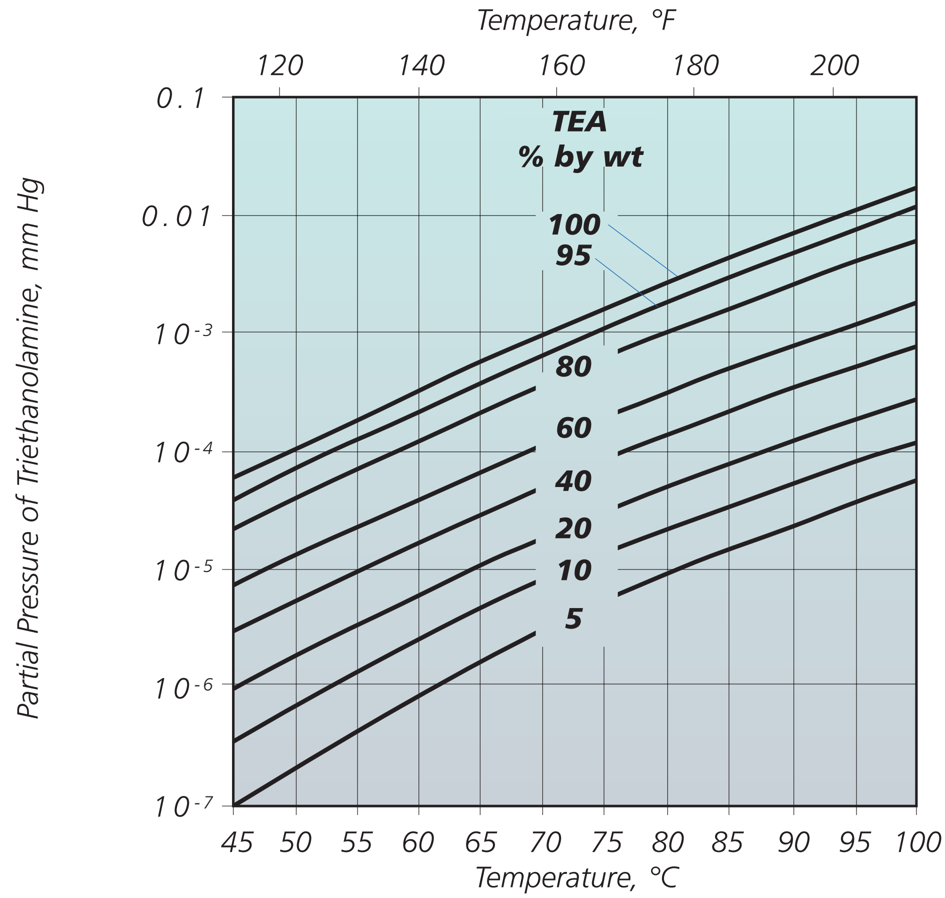
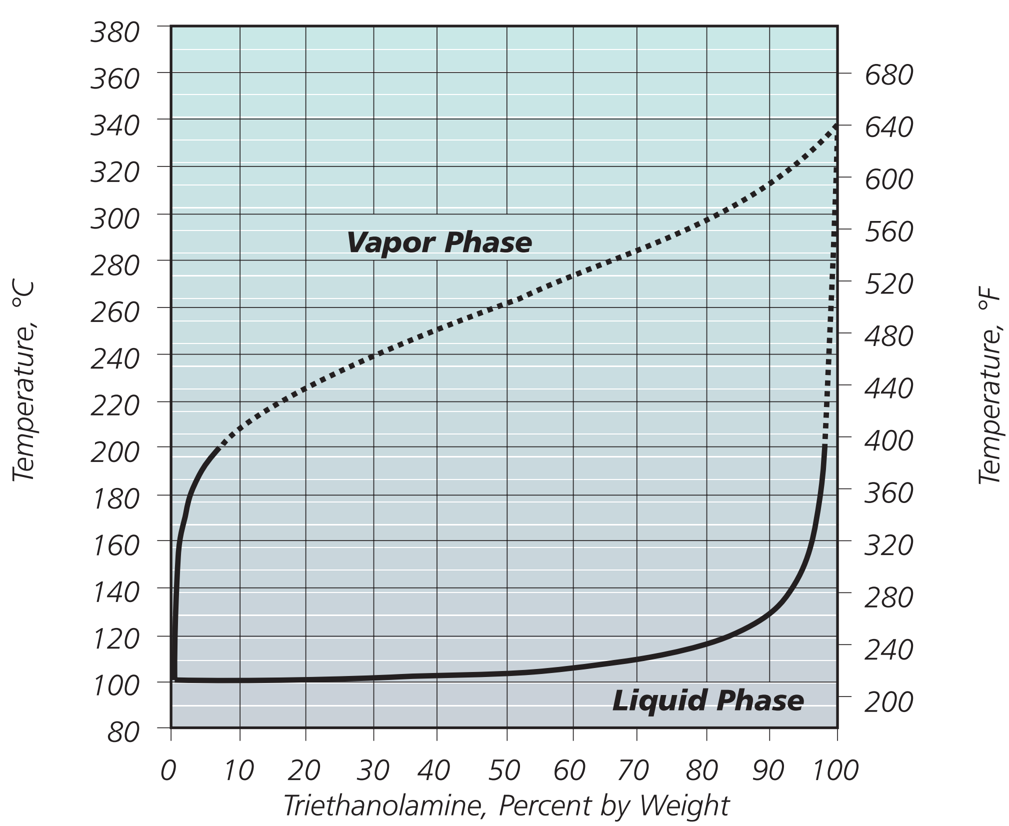


Figure 12

Vapor-Liquid Equilibria (T-x-y) of Aqueous Triethanolamine Solutions at 760 mm Hg Absolute



Note: Ethanolamines can undergo decomposition at temperatures above approximately 200°C

Figure 13

Absolute Viscosity of Aqueous Monoethanolamine Solutions

1 30°C (86°F)
2 50°C (122°F)
3 75°C (167°F)
4 100°C (212°F)

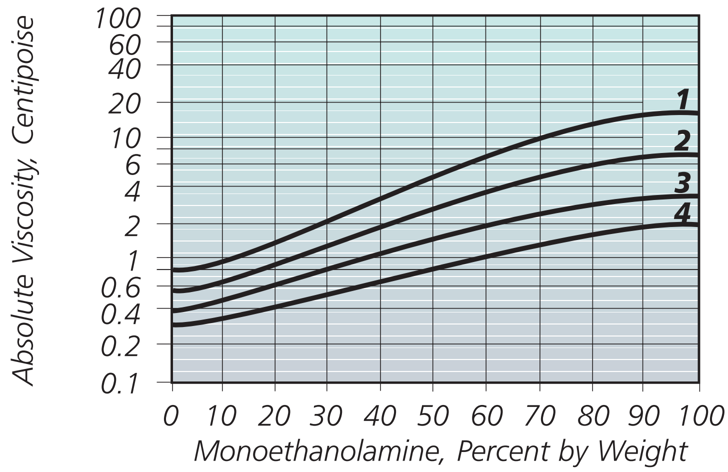


Figure 14

Absolute Viscosity of Aqueous Diethanolamine Solutions

1 30°C (86°F)
2 50°C (122°F)
3 75°C (167°F)
4 100°C (212°F)

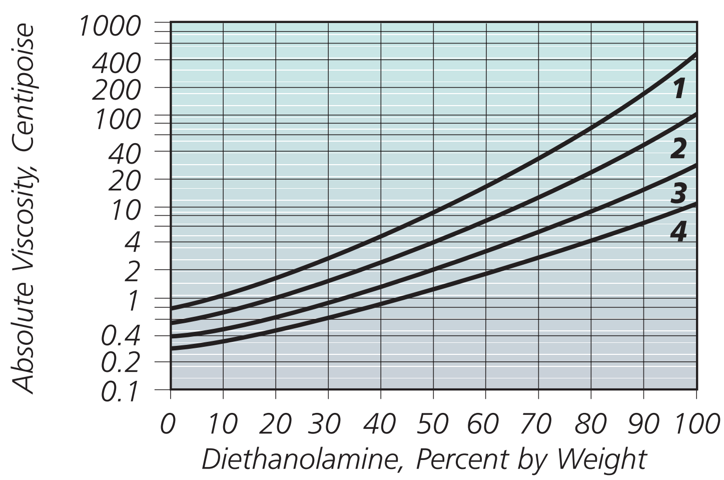


Figure 15

Absolute Viscosity of Aqueous Triethanolamine Solutions

1 30°C (86°F)
2 50°C (122°F)
3 75°C (167°F)
4 100°C (212°F)

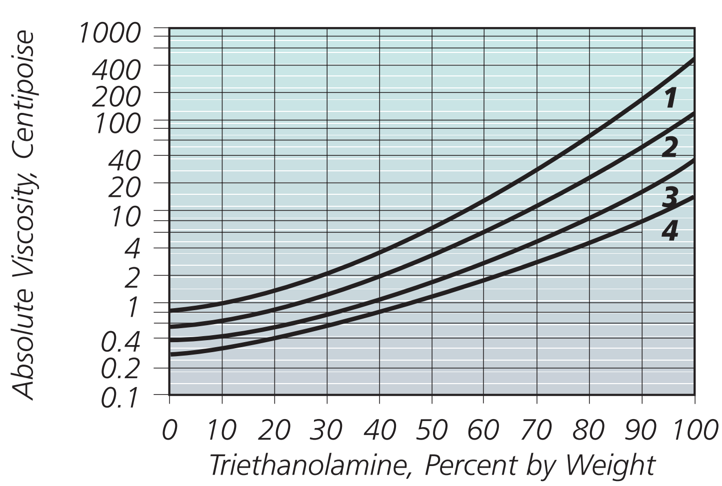
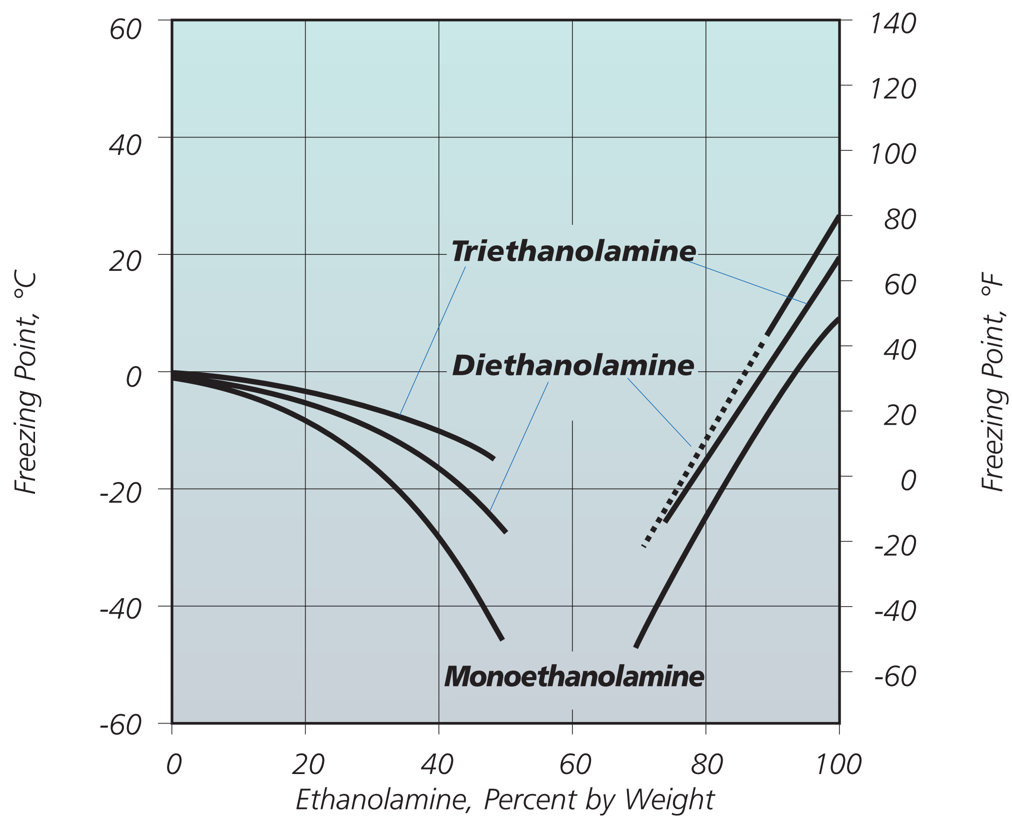


Figure 16

Freezing Points of Aqueous Ethanolamine Solutions



Note: Freezing point data for 70% to 90% Diethanolamine in water are extrapolated

Figure 17

Specific Gravity of Aqueous Ethanolamine Solutions at 20/20°C

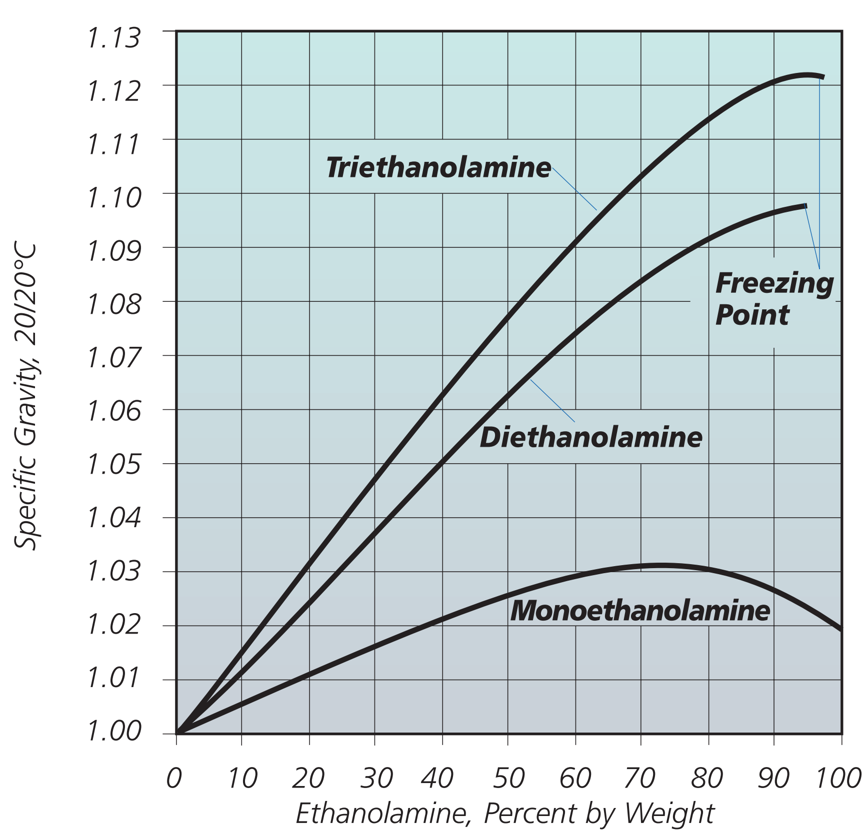


Figure 18

Weight per Gallon of Aqueous Monoethanolamine Solutions at Various Temperatures

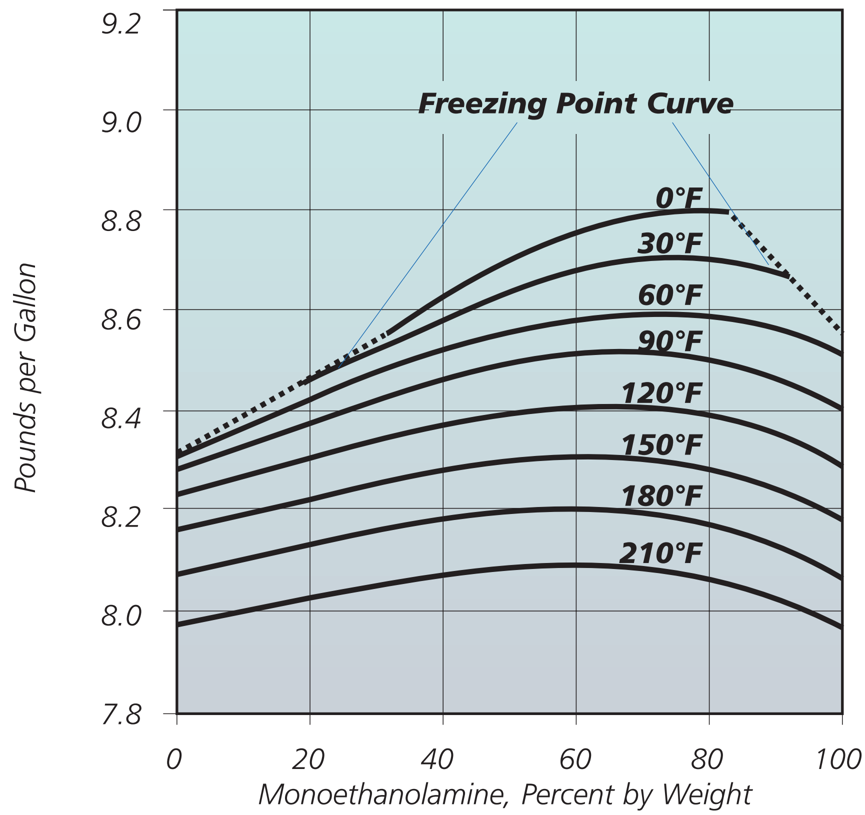


Figure 19

Weight per Gallon of Aqueous Diethanolamine Solutions at Various Temperatures

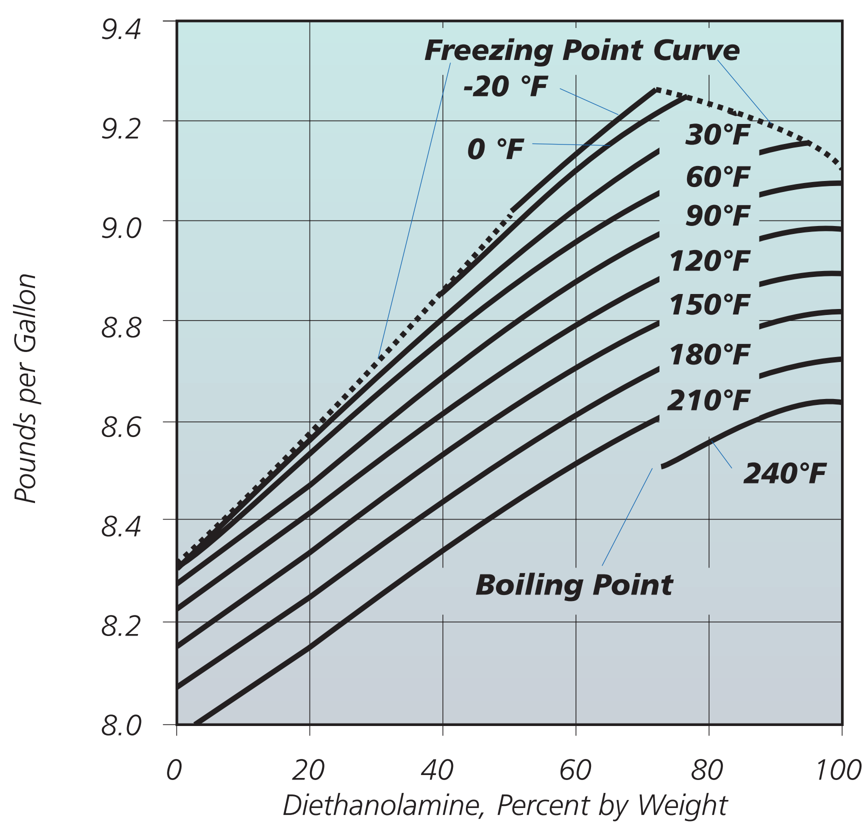


Figure 20

Weight per Gallon of Aqueous Triethanolamine Solutions at Various Temperatures

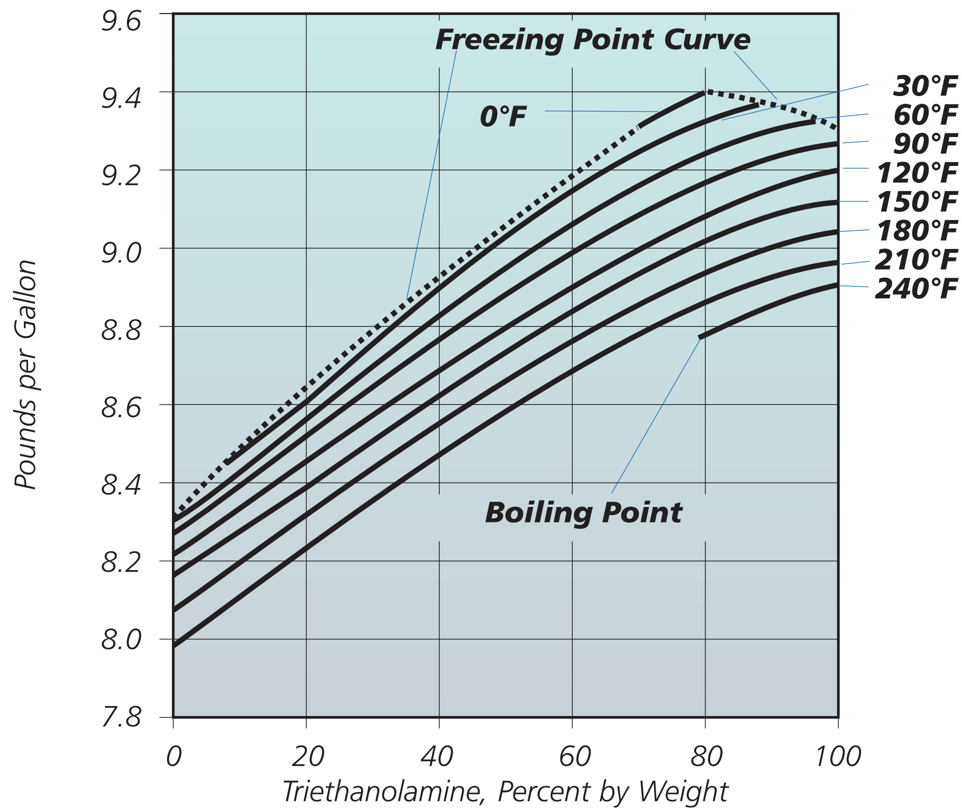


Figure 21

Specific Heats of Aqueous Monoethanolamine Solutions

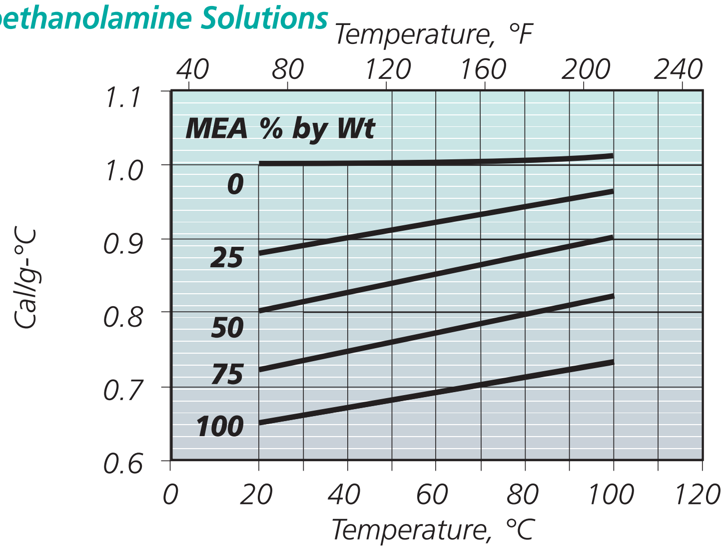


Figure 22

Specific Heats of Aqueous Diethanolamine Solutions

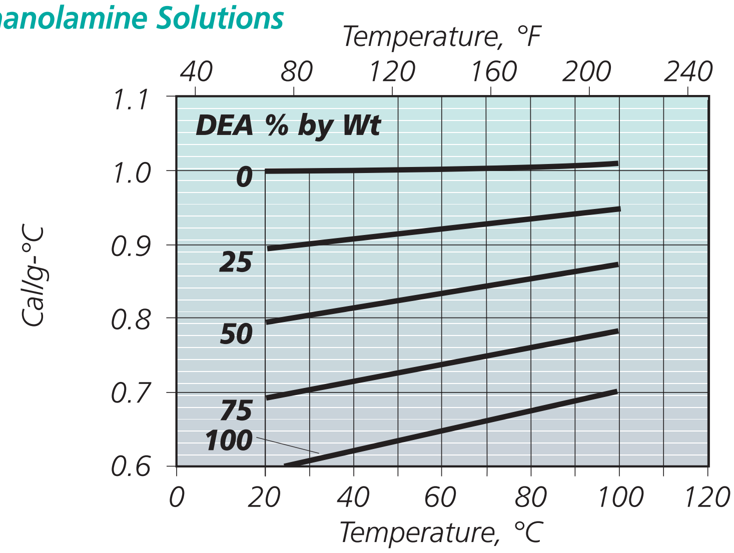
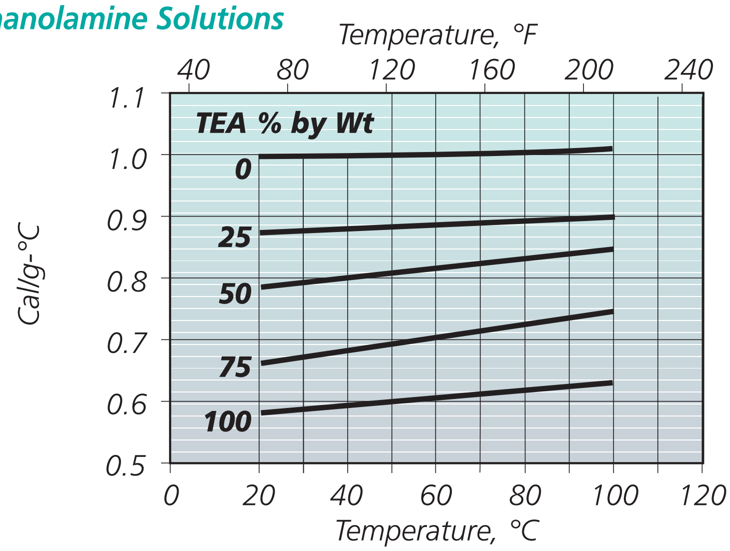


Figure 23

Specific Heats of Aqueous Triethanolamine Solutions



Storage and Handling

Proper storage and handling will help maintain the quality of ethanolamine products. Under normal conditions ethanolamines are considered to be thermally stable molecules and are not corrosive to the proper containers. However, they are sufficiently reactive that upon exposure to adventitious carbon dioxide, nitrogen oxides, and oxygen, trace levels of byproducts can form and increased color often results.

For storage and handling information contact your Dow representative.

SAFETY NOTE — MONOETHANOLAMINE

Monoethanolamine in contact with iron can form a crystalline complex called tris(ethanolamino)-iron. This compound can ignite when heated to 130-160°F (54-71°C) in the presence of air. A fire is known to have occurred in a storage tank equipped with a carbon steel heating coil using 150 psig steam. For internal steam applications, stainless steel heating coils should be used; low-pressure steam is preferred for safety and product quality.

STORAGE TEMPERATURES

Ethanolamines require heated and insulated storage and transfer facilities. Ethanolamines darken, however, at temperatures above 140°F (60°C).

Table 2 • Storage Temperatures for Ethanolamines

	Freezing Point, °C (°F)	*Storage Temperature, °F*	*Approximate Viscosity, cP, 30°C (86°F)*
Monoethanolamine	10.5 (50.9)	65-95	15
Diethanolamine	28.0 (82.4)	95-120	380
Triethanolamine, Commercial	15.8 (60.4)	75-110	400
Triethanolamine, 99%	21.6 (70.9)[(a)]	85-110	400

(a) Supercools easily

Shipping Information

For your convenience in ordering, Dow markets ethanolamines both direct and through an effective network of distributors. Less than full tank car or tank truck quantities can be delivered most rapidly through a Dow distributor. Consult your Dow representative for the name of the distributor nearest you.

For delivery of large volume orders, ethanolamines are stocked in terminals throughout the world.

Table 3 • Shipping Data for Ethanolamines

	Monoethanolamine	*Diethanolamine*	*Triethanolamine, Commercial*	*Triethanolamine, 99%*
Pounds per Gallon at 20°C Kilograms per liter at 20°C	8.47 1.015	9.10 (30°C) 1.088 (30°C)	9.37 1.123	9.38 1.124
Coefficient of Expansion at 55°C, per °C	0.00081	0.00060	0.00049	0.00053
Flash Point, °C (°F)[(a)]	96 (205)	191 (375)	194 (382)	208 (407)

(a) Determined by ASTM Method D 93, using the Pensky-Martens Closed Cup

Specifications

Specifications for DOW Ethanolamines are available on request from your Dow sales representative.

Product Safety

When considering the use of any Dow products in a particular application, you should review Dow's latest Material Safety Data Sheets and ensure that the use you intend can be accomplished safely. For Material Safety Data Sheets and other product safety information, please contact us using the numbers on the back cover of this brochure. Before handling any other products mentioned in the text, you should obtain available product safety information and take necessary steps to ensure safety of use.

No chemical should be used as or in a food, drug, medical device, or cosmetic, until the user has determined the suitability and legality of the use. Since government regulations and use conditions are subject to change, it is the user's responsibility to determine that this information is appropriate and suitable under current, applicable laws and regulations.

Dow requests that the customer read, understand, and comply with the information contained in this publication and the current Material Safety Data Sheet(s). The customer should furnish the information in this publication to its employees, contractors, and customers, or any other users of the product(s), and request that they do the same.

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