Ethyl Alcohol
Handbook

EQUISTAR
A Lyondell Company

ETHYL ALCOHOL HANDBOOK 6TH EDITION

Pure Ethyl Alcohol
Specially Denatured Alcohol
Alcohol Solvents
Completely Denatured Alcohol


EQUISTAR

This handbook presents a comprehensive review of the history, authorized uses, specifications, test methods, physical properties, and storage of industrial ethyl alcohol. U.S. government regulations governing the acquisition and use of industrial alcohol are subject to change and are, therefore, presented as a separate booklet, "Government Regulations," which is available from Equistar Chemicals, LP. This booklet is revised and reprinted by Equistar as regulatory changes make it necessary.

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Equistar Chemicals, LP, headquartered in Houston, Texas, is a joint venture between Lyondell Chemical Company (70.5% interest) and Millennium Chemicals Inc. (29.5% interest) and combines their olefins, polymers and oxygenated chemicals businesses. Equistar is one of the world's largest producers of ethylene, propylene and polyethylene and a leading producer of ethylene oxide, ethylene glycol, specialty polymers, wire and cable resins, and polyolefin powders. Equistar was formed in December 1997 and has 16 manufacturing sites located primarily along the U.S. Gulf Coast and in the Midwest.

Lyondell Chemical Company, headquartered in Houston, is a leading producer of propylene oxide (PO), toluene diisocyanate (TDI), propylene glycol (PG), butanediol (BDO) and propylene glycol ether (PGE); styrene monomer and MTBE. Through its 58.75% interest in LYONDELL-CITGO Refining LP, Lyondell is one of the largest refiners in the United States, principally processing extra heavy Venezuelan crude oil to produce gasoline, low sulfur diesel and jet fuel.

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Alcohol: Myths and Realities

Ethyl alcohol has probably been used by human beings as a beverage for at least 300 centuries. Each culture has its own myths about the discovery and significance of this potent liquid. Who discovered it, and how the discovery came about, are lost in antiquity as is the discovery of fire and the invention of the wheel. But, however, and by whom alcohol came into existence, much has happened because of it. Some contend it started the first community life, since several years are required to produce a vineyard. Thus, the pursuit of the fermented product of the juice of grapes may have changed the nomadic pattern of early man to a settled one.

The historical references to alcohol do not appear until 60 or 70 centuries ago in the Hebrew script, on Babylonian tablets, and in ancient Egyptian carvings picturing the manufacture of wine by fermentation. Wine was believed to be made in China before 2000 B.C. The Bible holds wine in high esteem, suggesting that wine is a gift of God, referring to bread and wine as staples of the diet, and including wine as a measure of hospitality and of value as a medicine and an anesthetic.

FROM KUHL TO ALKOHOL

The generally accepted derivation of the word "alcohol" is from the Arabic kuhl, or kohol meaning a very fine powder. Alkohol or "the fine powder" referred usually to a finely powdered antimony sulfide used in cosmetics to darken the eyelids. For example, ferrum alcoholisatum was finely powdered iron. Gradually the word came to mean "essence", and Paracelsus defined it in the 16th century as the most subtle part of anything. It was in this sense, he wrote of ‘alcool vini’, the most subtle part of wine, but never of ‘alcool’ alone. It was not until the 19th century that the term alcohol came to be used generally for wine spirits.

ETHYL ALCOHOL

Probably because of its being the essence of wine and the intoxicating ingredient in many beverages whose production involved a fermentation process, ethyl alcohol must have been one of the earliest organic compounds to be investigated. Despite the Arabic origin of the word alcohol, the separation of ethyl alcohol from wine was apparently unknown to Arabian alchemists. The earliest known description of the concentration of ethyl alcohol by distillation of wine occurs in a Latin manuscript of the 12th century. It is assumed that ethyl alcohol was first separated by distillation around the 11th century in the wine districts of Italy.

Although ethyl alcohol had been known for a considerable time in a crude state in wines and beer, it was not until 1796 that Johann Tobias Lowitz first prepared it free of water. Its composition was determined in 1808 by Théodore de Sassure although Lavoisier had established its qualitative formula even earlier. Its structural formula was established by Sir Edward Frankland later in the 19th century.

In the naming of ethyl alcohol, the limiting term ethyl refers to the fact that this particular alcohol can be converted to ether. The "yl" suffix is derived from the Greek word "hyle" and was employed first by Justus von Liebig and Frederick Wohler in the sense of "stuff" or "material" similar to Paracelsus’ "essence."

ETHYL ALCOHOL TODAY

Ethyl alcohol, one of the oldest organic chemicals known, is a vital industrial material from which other manufacturers make their finished products.

Completely aside from its use in beverages, which is usually our first point of reference when we think about alcohol, ethyl alcohol is one of the most important chemicals available to industry and is involved in the manufacture of many of the significant products of the second half of the 20th century. Its solvent power is particularly useful for the extraction of medicinals from plant and animal tissues and for compounding tonics, syrups, tinctures, liniments and antiseptics. It is used in processing vaccines and is essential to the manufacture of pharmaceuticals such as antibiotics, and numerous over-the-counter preparations.

As an industrial raw material, ethyl alcohol is involved in the manufacture of adhesives, toiletries, detergents, explosives, inks, chemicals, hand creams, plastics, paints, thinners, textiles, vinegar and other products almost too numerous to mention.

While ethyl alcohol has been around since antiquity, scientists today are still discovering new and important uses for it.

Watch the contrail of a jet thread the sky with its wisp of white. Stroke the satin-smoothness of a graceful racing sloop. Fire a rifle. Paint a house. Buy a tire. Take a pill. Set your hair. Treat a cut. Eat a meal. Print a book. Ethyl alcohol is involved.

The Law and Ethyl Alcohol

LIMITING EFFECTS OF TAXATION

While ethyl alcohol has always played a major role in productive communities, its use has been traditionally disciplined by custom and legislation. Until the pressing needs of industry precipitated changes in the law, the principle of taxing and regulating alcoholic beverages was applied to all forms of ethyl alcohol, regardless of its ultimate use. In those countries where no special legislation had permitted the use of tax-free alcohol for industrial purposes, a heavy burden of taxation was placed on every gallon of ethyl alcohol produced. For alcohol, in the view of the law, was a beverage of luxury. Its consumption had, for centuries, provided a rich source of tax income. Until the middle of the 19th century, no government was willing to jeopardize this income by eliminating the tax on pure alcohol which, although destined for industry, might have been diverted, tax-free, into alcoholic beverages.

LIBERATING INFLUENCE OF THE INDUSTRIAL REVOLUTION

England, first to see the smoke and hear the hum of the Industrial Revolution, was also first to recognize the industrial significance of ethyl alcohol. Realizing that this vital commodity had to be made economically viable for use in its emerging industries, England, in 1855, authorized the use of tax-free alcohol for manufacturing purposes. To enjoy this privilege, and to prevent the diversion of industrial alcohol into beverages, manufacturers were directed to add an impure methyl alcohol to the ethyl alcohol they produced. In this way "methylated spirits" became a material of growing significance in the chemistry of manufacturing, and the concept of denaturing was established.

Applications for denatured ethyl alcohol grew as the laws governing its use were liberalized. The Netherlands legalized the use of denatured alcohol in 1865; in 1872, France permitted its use under a special tax; and in 1879, Germany relaxed its regulations. By the turn of the century, most of the countries of Europe had facilitated the use of industrial ethyl alcohol. The United States was just emerging as an industrial power and was, therefore, only beginning to consider the need for tax-free industrial alcohol.

TAX-FREE ALCOHOL IN THE UNITED STATES

In 1897, a joint committee of Congress, investigating the importance of ethyl alcohol, reported its uses in industry as both "legitimate and necessary." The committee acknowledged that "there is scarcely a manufacturer in the country who does not use alcohol in the production of goods to a greater or lesser extent." This was the first of a series of reports and deliberations that led to the enactment of the Tax-free Industrial and Denatured Alcohol Act of 1906.

THE ROLE OF EQUISTAR CHEMICALS

The legacy of Equistar Chemicals, LP, a joint venture of Lyondell Chemical Company, and its predecessor companies in industrial alcohol stretches back to the beginning of the twentieth century via the U.S. Industrial Chemical Company (USI).

When incorporated in 1906 as the U.S. Industrial Alcohol Company, USI was the first company formed to manufacture industrial ethyl alcohol after the passage of the Tax-free Alcohol Act. This law removed the tax on alcohol intended "for use in the arts and industries and for fuel, light and power," provided the alcohol was denatured and rendered unsuitable for use as a beverage.

Pure, undenatured ethyl alcohol was also relieved of the restrictive tax burden if its application to scientific purposes could be guaranteed by the users. In addition, strict controls were imposed upon the distribution of pure industrial alcohol to prevent its illegal use in beverages.

Today in the United States, official regulations governing production, procurement and use of pure ethyl alcohol and denatured alcohol are issued by the Bureau of Alcohol, Tobacco and Firearms (ATF), U.S. Department of Justice. From the time of the passage of the Tax-free Alcohol Act, Equistar and its predecessor companies has been acknowledged as a leader in major constructive developments in this field.

PRODUCTION OF ETHYL ALCOHOL AT TUSCOLA, ILLINOIS

Today at the Tuscola plant, all Equistar industrial alcohol is made from ethylene via direct hydration. Ethylene arrives at the plant from Equistar's Morris, IL facility via a dedicated pipeline.

The ethylene is used at Tuscola for the synthesis of 190 proof and 200 proof ethyl alcohol and purified ethyl ether. The current ethanol production facility was commissioned in 1972, replacing the original plant built on the Tuscola site in 1953. The plant has been subject to multiple improvements over the years, including the 1997 addition of a molecular sieve, which is used to produce anhydrous (200 proof) product.

Services of Equistar Chemicals, LP

Equistar Chemicals, LP operates ethyl alcohol denaturing facilities in the following key industrial centers in the Northeast and Midwest United States. The government assigned identification numbers for these facilities are:

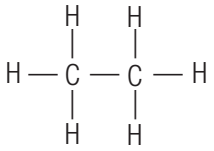
Newark, New Jersey	DSP-NJ-158
Tuscola, Illinois	DSP-IL-95

Lyondell's alcohol facilities are registered with such governmental agencies as the Bureau of Alcohol, Tobacco and Firearms (ATF) and the Food and Drug Administration (FDA). Periodic inspection by authorized representatives of these agencies as well as representatives of such groups as the Kashruth Division, Union of Orthodox Jewish Congregations of America affirm continued compliance to the highest standards and regulations.

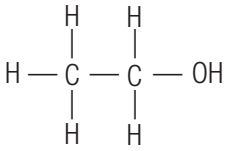
The experience and knowledge of Lyondell trained personnel is available for suggesting proper formulas and for assistance when filing the necessary government regulatory forms. We urge you to call for help with any problems you have relating to industrial ethyl alcohol.

What Is Ethyl Alcohol

Chemically, ethyl alcohol is the common name for the hydroxyl derivative of the hydrocarbon ethane. This relationship is clearly demonstrated by the structural formulas for the two compounds.



ETHANE



ETHYL ALCOHOL

It is also known as alcohol, cologne spirits and ethyl hydrate. The more familiar International Union of Pure and Applied Chemistry name is ethanol. The Chemical Abstract Registry Number (CAS) for pure ethanol is 64-17-5.

Industrial ethyl alcohol is ethyl alcohol produced and sold for other than beverage or fuel purposes.

The Sources of Industrial Ethyl Alcohol

The two principal raw materials from which ethyl alcohol may be produced are agricultural products ("grain") and ethylene derived from natural gas or petroleum.

FERMENTATION OF AGRICULTURAL PRODUCTS

Historically, production techniques have used agricultural materials as the raw material for ethyl alcohol. Such starch-containing food products as corn, rice, wheat and potatoes are converted by enzymes to sugar. This sugar is then typically converted by yeast to alcohol and carbon dioxide. Sugar and sugar-containing materials such as molasses are more directly converted to alcohol by yeast.

Today large quantities of ethyl alcohol are produced by the fermentation process, though most of this material finds its end use as a motor fuel oxygenate or extender. The varied quality of feedstocks and the sharp fluctuations in both the availability and price of these agricultural products, which are used for food and fuel as well as chemicals, have caused some disruption of prices and supply in the fermentation based market.

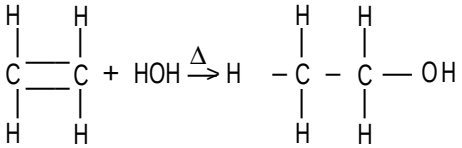
SYNTHESIS FROM NATURAL GAS

Lyondell's ethyl alcohol production plant, located in Tuscola, IL, produces industrial alcohol made from ethylene.

THE EQUISTAR DIRECT HYDRATION PROCESS

Equistar's ethyl alcohol is commercially prepared from ethylene by the direct reaction of extremely pure water with ethylene gas. This process — the direct hydration process — is generally considered to be environmentally and technically the best commercial method for obtaining a consistently high quality alcohol product.

The primary chemical reaction for this process occurs when water vapor and ethylene are combined at elevated pressure and temperature and are passed over the surface of a catalyst support impregnated with phosphoric acid.



Ethylene + Water —> Ethyl Alcohol

High purity ethylene at elevated pressure is mixed with controlled amounts of pure water, heated to reaction temperature and brought into intimate contact with the catalyst. The main reaction yields a dilute crude alcohol. This alcohol is then separated from unreacted ethylene. The unreacted ethylene is recycled and the alcohol is concentrated and purified through a series of distillation towers. In addition to concentrating the alcohol, the rectification of the alcohol provides a means of removing various heavy oils from the alcohol. The alcohol stream is then hydrogenated to convert unsaturated impurities into a form in which they may be more readily removed.

Impurities present at the parts per million levels are removed by an extractive distillation. In this purification step, water and steam are added to the high proof alcohol. The impurities are removed from the distillation tower. The dilute alcohol removed from the bottom of this tower is fed to yet another rectifier, where the alcohol is increased to at least 95 volume percent (190 proof). A final tower distills off the last of any possible remaining foreign odor.

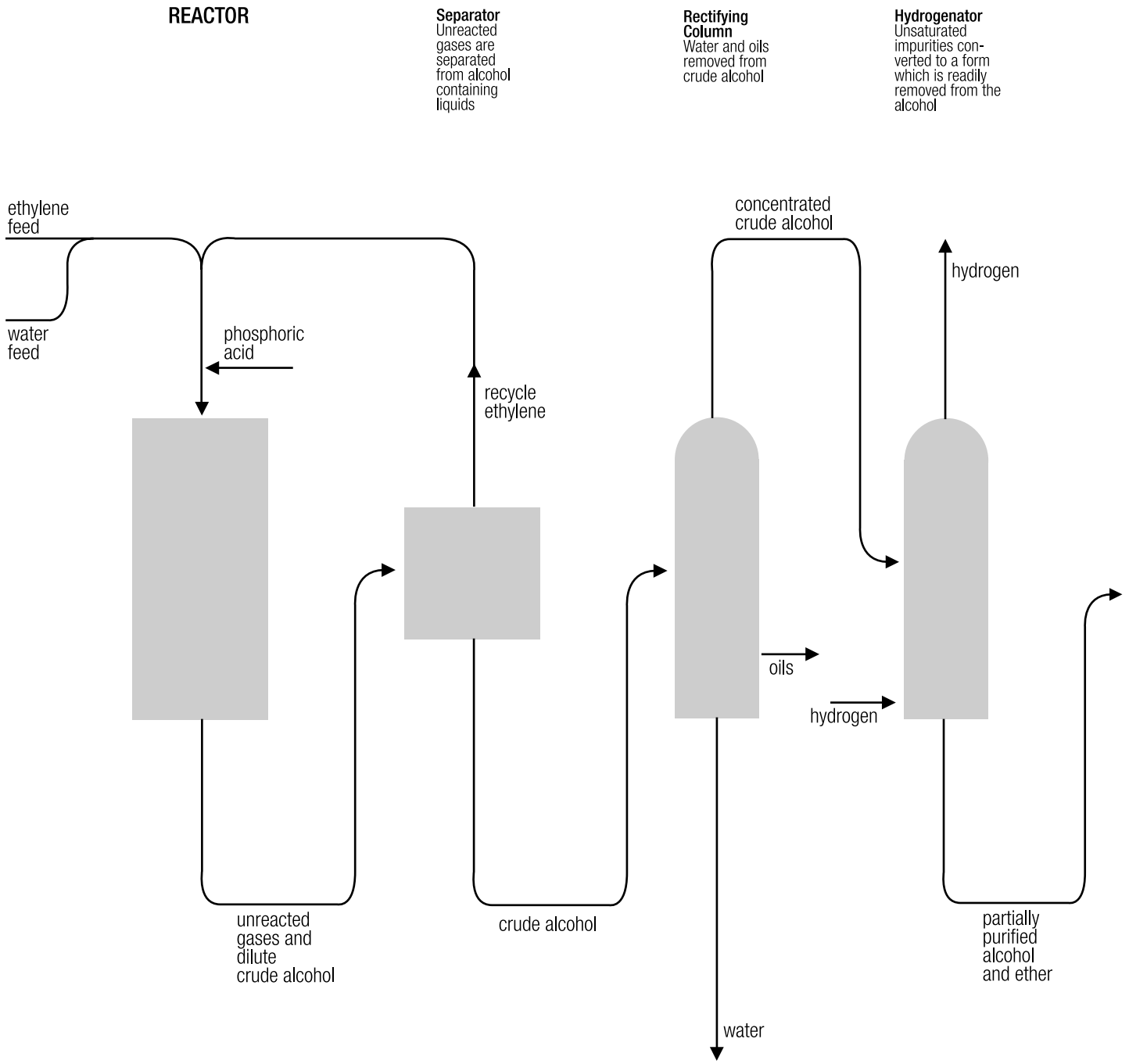
The alcohol obtained from this very thorough purification process is Punctilious ethyl alcohol at 190 proof, which, after various quality checks, is ready for shipping, denaturing, or dehydration to anhydrous (200 proof) ethyl alcohol.

Ethyl ether, a co-product of the ethylene hydration, is removed by distillation and refined further in an adjacent purification facility into the purity grades used for various pharmaceutical, chemical and commercial applications.

ANHYDROUS ALCOHOL BY MOLECULAR SIEVE DISTILLATION

Equistar Chemicals, LP utilizes a Molecular Sieve Dehydration Unit (MSDU) to produce anhydrous alcohol. The purpose of the MSDU is to remove essentially all of the water from the 190 proof alcohol that cannot be separated by rectification. Water is removed by the process of "adsorption." The MSDU performs the adsorption with dual alternating molecular sieve vessels filled with desiccant in combination with strictly controlled pressure and temperature cycles. Water molecules, which are smaller than ethanol molecules, are selectively adsorbed into the desiccant pores as the mixture of ethanol/water vapors passes through the sieve beds. The ethanol molecules are too large to fit into the selectively sized pores, so the purified ethanol passes out the end of the sieve bed, stripped of the water it originally contained. Punctilious anhydrous alcohol is the result, and after various quality checks, is ready for denaturing or shipment.

SYNTHESIS OF ETHYL ALCOHOL FROM ETHYLENE



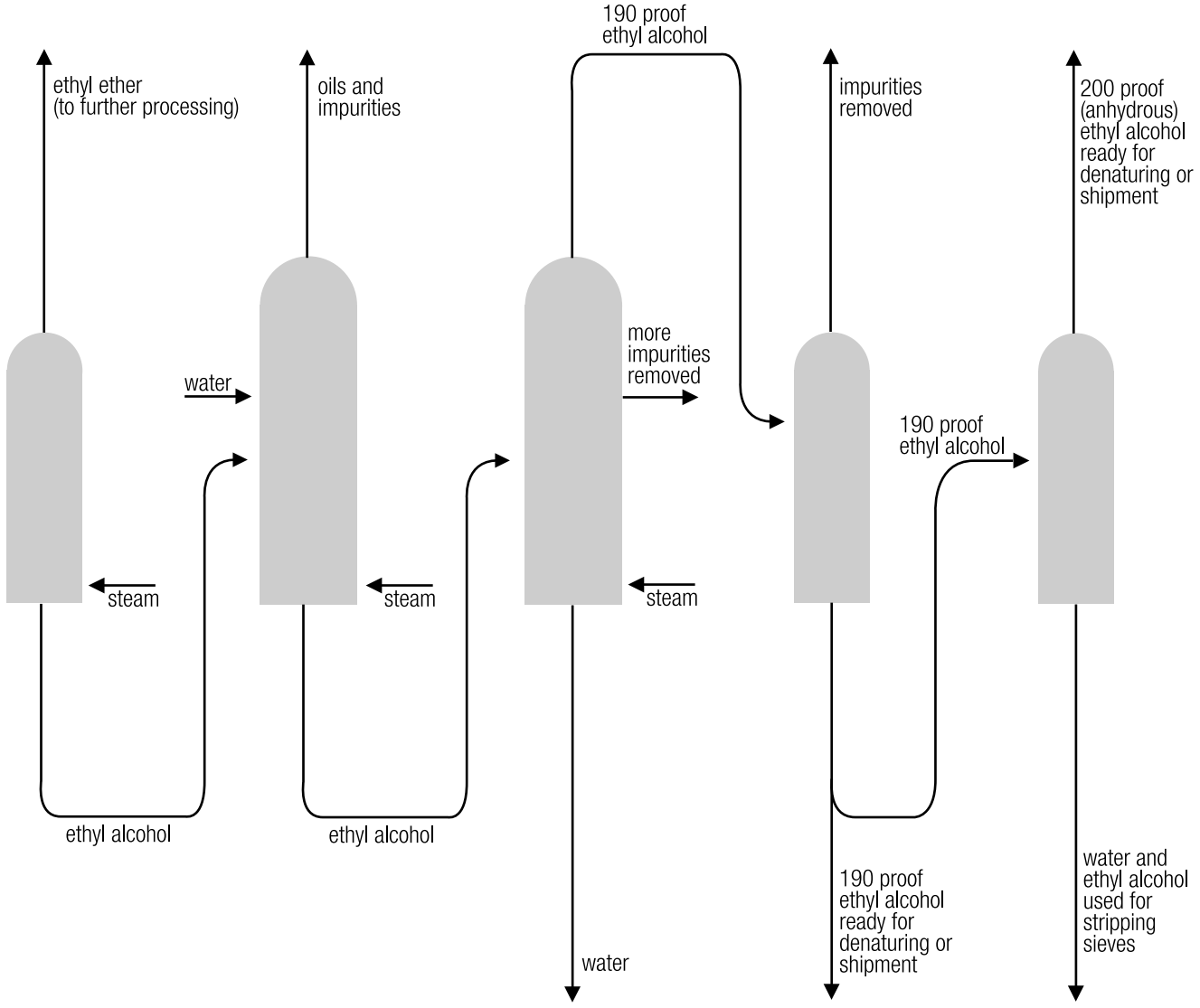
Ether Column
Ethyl ether removed for special processing

Extractive Distillation Column
Impurities removed from dilute ethyl alcohol

Rectifying Column
More impurities removed as ethyl alcohol is concentrated to 190 proof

Heads Stripping Column
Final impurities removed

Molecular Sieve Dehydration Unit
Last 5% of water removed to make absolute alcohol



Punctilious Ethyl Alcohol

Equistar Chemicals, LP prides itself in its ability to produce and supply pure and denatured alcohol meeting the most demanding quality requirements. This is accomplished by a dedicated team of operators, technicians, chemists, engineers and sales representatives, all working together to supply the consistently high quality Punctilious ethyl alcohol our customers have come to expect from us.

The detection and control of foreign substances in alcohol is very important because ethyl alcohol is used in the manufacture of such life sustaining products as pharmaceuticals and food products. The use of alcohol in cosmetics also requires alcohol of the highest quality.

Equistar Chemicals, LP produces pure ethyl alcohol meeting its own high quality standards, as well as the requirements of the U.S. Pharmacopeia, the American Chemical Society, the National Formulary, the Food Chemicals Codex, as well as various other government-recognized specifications.

STRINGENT QUALITY CONTROL CHECKS

Equistar, recognizing the quality requirements of our customers, imposes more stringent quality control checks in areas where experience has shown the need for these controls. Equistar recognizes the occasional need for pure or denatured alcohol to exceed quality requirements, which are defined by standard specifications. Alcohol users with unusual or individual quality requirements are invited and encouraged to submit their specifications to Equistar for consideration.

Industrial Alcohol Available From Equistar Chemicals, LP

Industrial alcohol is available from Equistar with various degrees of governmental control and taxation.

PURE ALCOHOL is available to authorized users in two basic forms: tax-paid alcohol may be obtained by paying a federal tax. When used for the production of various defined products, the user may be entitled to a drawback, or refund for a portion of this tax. Tax-free alcohol is available for various defined academic, medical, scientific and governmental uses. A tax-free permit from the ATF is required.

SPECIALLY DENATURED ALCOHOL (SDA) is a moderately denatured material, which is available in many formulations. Use of SDA is defined by the formula (denaturants) and is available for specifically defined applications to authorized users. The facility receiving the SDA must have an SDA permit from the ATF.

SOLVENTS are highly denatured formulations of ethyl alcohol. They are available in the following basic classes: (No permits are required for the following types.)

Proprietary solvents are highly denatured alcohol formulations. They are available in several authorized formulations and may be sold in bulk quantities or drums quantities to any person.

Special industrial solvents are defined formulations in bulk or drums for authorized industrial users. Filmex is the Equistar trademark name for special industrial solvent.
Special "S" solvents are custom compounded solvents, which have been registered with the ATF for specific customers.

COMPLETELY DENATURED ALCOHOL is a very highly denatured alcohol, which is available with minimum government regulation for sale and use for any lawful purpose in authorized formulations.

Uses of Industrial Alcohol

PURE ETHYL ALCOHOL

Only a very small percentage of all of the ethyl alcohol produced for industrial purposes is sold as pure ethyl alcohol. Nevertheless, pure alcohol makes significant contributions to industry and science. Hospitals and research laboratories depend on its purity and versatility as a reagent and a solvent. Many medicines, food products and flavorings could not be readily produced without it.

Pure alcohol is used for numerous pharmaceutical syrups and elixirs. The flavoring extracts, which are commonly used for many soft drinks are obtained by using pure alcohol, as is the familiar vanilla extract, which is found in virtually any kitchen. Disinfectant properties, solvent power, and purity make pure ethyl alcohol the reagent of choice for numerous clinical and laboratory applications.

DENATURED ALCOHOL

Specially denatured alcohol is the largest, most widely used type of alcohol. Equistar Chemicals, LP is a leading supplier of SDAs to the quality conscious industries who require denatured alcohol of the highest purity for a consistently superior product.

Fragrance Products manufacturers formulate perfumes and colognes from Equistar SDAs.

Personal Care Products include deodorants, hair and scalp preparations, mouthwashes, lotions, creams, soaps and bath preparations and waterless hand washing lotions.

Pharmaceutical Products for external application, such as rubbing alcohol compounds and various antiseptic solutions (e.g. tincture of iodine) are formulated with Equistar SDAs. They are also broadly used as processing solvents in the preparation of antibiotics, hormones, pills, vaccines and vitamins.

Vinegar is extensively produced from specially denatured alcohol. A stable raw material cost and an assured high quality supply offer several advantages to the vinegar producers who use Equistar SDA as their raw material.

Household product applications in which SDAs are used include aerosol insecticides, insect repellants, room deodorants and fungicides. They are also used in the manufacture of numerous personal care items, detergents and soaps.

TYPICAL INDUSTRIAL ALCOHOL APPLICATIONS

Acetic acid • Adhesives and binders • Animal feed supplements • Antibiotics • Antifreeze • Antiseptic solutions • Bath preparations • Bay rum • Brake fluids • Candy glazes • Chemicals • Cleaning solutions • Coatings • Colognes • Cutting oils • Dentifrices • Deodorants • Detergents • Detonators • Disinfectants • Drugs and medicinal chemicals • Duplicating fluids • Dyes • External pharmaceuticals • Fluids • Food products • Fungicides • Hair and scalp preparations • Incense • Inks • Insecticides • Iodine solutions • Laboratory reagents • Lacquer thinners • Liniments • Lotions and skin creams • Mouthwashes • Perfumes • Petroleum products • Photoengraving dyes and solutions • Photographic chemicals • Photographic film and emulsion • Plastics • Polishes • Preserving solutions • Refrigeration • Rotogravure dyes and solutions • Rubber • Rubbing alcohol compounds • Scientific instruments • Shampoo • Shellac • Soaps • Soldering flux • Solvents and thinners • Stains • Sterilizing solutions • Theater sprays • Transparent sheetings • Vaccines • Vinegar • Vitamins • Witch hazel • Wood stains

These are just some of the hundreds of products made with industrial ethyl alcohol.


UTLX 200184
UTLX 200184

PURE ETHYL ALCOHOL

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Pure ethyl alcohol is supplied in both the 190 proof and 200 proof (anhydrous) form. It is available on a tax-paid basis, or for authorized users it may be obtained tax-free. Equistar's pure alcohol meets the requirements of the USP and other industry accepted specifications.

A century of experience in making and selling the highest quality alcohol assures our customers of the benefits of quick delivery, certainty of supply, and experienced assistance with regulatory and technical questions.

Equistar Product Specifications

Formulation Product:Ethyl Alcohol 200 Proof Pure USP Ethyl Alcohol, as 200 Proof	Wt% 100			
	Target	Range Min.	Range Max.	Test Method
Specific Gravity @ 60/60˚ F 68/68˚ F 77/77˚ F	 0.7937 0.7905 0.7871		 0.7942 0.7910 0.7876	STM 101
Water wt%			0.1	STM 155a
Identification A	Pass	Pass		USP
Identification B	Pass	Pass		USP
Acidity			0.9ml of .02N	USP
Non-Volatile Residue			1mg/40ml	USP
Water Insoluble Substances	Pass	Pass		USP
Aldehydes and Foreign Organics	>5 minutes	5 minutes		USP
Amyl Alcohol & Carbonizables Substances	Pass	Pass		USP
Acetone and Isopropyl Alcohol	Pass	Pass		USP
Methanol	Pass	Pass		USP
UV Absorbance	Pass	Pass		USP

Equistar Product Specifications

Formulation Product: Ethyl Alcohol 190 Proof Pure USP Ethyl Alcohol, as 200 Proof Water	Wt% 92.42 7.58			
	Target	Range Min.	Range Max.	Test Method
Specific Gravity @ 60/60˚ F 68/68˚ F 77/77˚ F	 0.8158 0.8126 0.8092	 0.8156 0.8124 0.8090	 0.816 0.8128 0.8094	STM 101
Identification A	Pass	Pass		USP
Identification B	Pass	Pass		USP
Acidity			0.9ml of .02N	USP
Non-Volatile Residue			1mg/40ml	USP
Water Insoluble Substances	Pass	Pass		USP
Aldehydes and Foreign Organics	>5 minutes	5 minutes		USP
Amyl Alcohol & Carbonizables Substances	Pass	Pass		USP
Acetone and Isopropyl Alcohol	Pass	Pass		USP
Methanol	Pass	Pass		USP

Typical Properties

	Units	190 PROOF	200 Proof (Anhydrous)
Boiling Point	°C °F	78.3 172.9	78.3 172.9
Coefficient of Expansion Per °C Per °F		 0.0011 0.00062	 0.0011 0.00062
Flash Point ASTM D-1310 (Tag Open Cup) ASTM D-56 (Tag Closed Cup)	 °C °F °C °F	 21 69 17 62	 18 65 14 57
Weight per gallon at (15.56°C) 60°F, in lbs.		6.794	6.610
Water Solubility	soluble in all proportions		

Shipping Information

CONTAINERS	190 PROOF	200 Proof (Anhydrous)
Tank Cars	30,000 gal.	30,000 gal.
Tank Trucks	varies	varies
Drums	54 gal.	54 gal.
SHIPPING REGULATIONS, D.O.T.	Pure ethyl alcohol is a flammable liquid and must be shipped under item 49 CFR regulation.	


LYONDELL
LYONDELL

SPECIALLY DENATURED ALCOHOL

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Introduction

Specially denatured alcohol (SDA) is alcohol that has been denatured so that it can be used, after obtaining a U.S. Government permit and a bond, in the arts and industries specified for each formula given in this section. The coded uses are those listed by the Bureau of Alcohol, Tobacco and Firearms (ATF), which have been defined in Title 27, Code of Federal Regulations. The code numbers for the given uses must be used when making reports on ATF forms.

Specially denatured alcohol is the most important commercial form of industrial ethyl alcohol. Typically, 90% of all the ethyl alcohol produced for industrial purposes in the United States is denatured.

ATF regulations authorize the use of specific formulas which have very limited commercial use. Equistar Chemicals, LP can, depending upon the availability of the specified denaturants, supply most authorized denatured alcohol formulas. Several defined formulations with limited historical usage are not discussed in detail in this publication. The availability of these formulations can be determined by contacting your Equistar sales representative or our customer service center.

The weight per gallon and resultant volume data of the various specially denatured alcohols given in this book are typically in accordance with information defined in Part 212 of Title 27 Code of Federal Regulations. However, as significant alternate formulations are approved, shipments will be made using the Equistar Chemicals, LP determined properties. As a result, the actual weight per gallon and resultant volume of commercial material sometimes differs slightly from the ATF defined values. These are so indicated where applicable.

Nomenclature

While the basic nomenclature of the various SDA formulations is defined in Part 212 of Title 27 Code of Federal Regulations, users of formulas, which have more than one possible denaturing option, should be careful to specify the denaturants desired. Equistar Chemicals, LP uses a supplemental nomenclature for many individual formulas where more than one denaturant, or combination of denaturants is authorized. SDA products are offered in the 190 proof and anhydrous (200 proof) formulations.

Denaturants

DENATURANT QUALITY

To supply the consistent high quality specially denatured alcohol Equistar customers require and expect takes an extra effort by the Equistar team of purchasing agents, technicians, chemists, production engineers and distribution personnel. While pure Punctilious alcohol is in all of our specially denatured alcohol formulations, denaturants of the highest quality are required to prepare consistently high quality specially denatured alcohol.

The basic quality specifications for all authorized denaturants are defined by the Bureau of Alcohol, Tobacco and Firearms, Part 212 of Title 27 Code of Federal Regulations. In most instances these requirements specify the use of a denaturant meeting the quality standards of the United States Pharmacopeia or the National Formulary. Equistar however, has defined additional quality specifications for numerous denaturants.

Adherence to these rigid denaturant specifications and the continued quality consciousness of our production and distribution personnel help affirm that the shipments will pass the most rigorous quality checks and the user receives specially denatured alcohol of the highest quality.

ALTERNATE DENATURANTS

Substitute and alternate denaturants may be authorized by the ATF director. When an SDA user can show that no presently authorized denaturant or combination of denaturants can be used in the manufacture of a particular product an application may be submitted to the ATF director, requesting permission to use another substance having denaturing properties satisfactory to the director. In such cases the applicant shall furnish the director with specifications, assay methods and duplicate 8-ounce samples of the denaturant for examination.

There are numerous alternate denaturants used mainly for SDA 29 and SDA 38-B, which have been accepted by the ATF.

Under certain circumstances, Equistar will consider using special customer supplied authorized denaturants.

DENATURANT HAZARDS

Denaturants are generally recognized as substances having odorous and/or obnoxious attributes, which prevent the use of the denatured alcohol for beverage purposes, but not for industrial uses. Several authorized denaturants (e.g. methanol, iodine, chloroform, etc.) and denatured alcohol products containing these denaturants, present significant potential health problems if they are improperly handled. Equistar urges extreme care be exercised when handling any potentially hazardous material. Consult the MSDS prior to use.

SDA Samples

Equistar can supply samples of our products to potential customers. A typical sample is 1 pint or quart.

USES OF SPECIALLY DENATURED ALCOHOL*

PRODUCT OR PROCESS	CODE NO.	FORMULAS AUTHORIZED
Acetaldehyde	551	1, 2-B, 29
Acetic acid	512	29, 35-A
Adhesives and binders	036	1,3-A, 3-C, 12-A, 23-A, 30
Aldehydes, miscellaneous	552	1,2-B, 29
Alkaloids (processing)	344	1, 2-B, 2-C, 3-A, 3-C, 12-A, 13-A, 17, 23-A, 30, 32, 35-A
Animal feed supplement	910	35-A
Antibiotics (processing)	343	1, 2-B, 3-A, 3-C, 12-A, 13-A, 23-A, 30, 32, 35-A
Antifreeze, proprietary	760	1
Antiseptic, bathing solution (restricted)	220	46
Antiseptic solutions, U.S.P. or N.F.	244	23-A, 37, 38-B, 38-F
Bath preparations	142	1,3-A, 3-B, 3-C, 23-A, 30, 36, 38-B, 39-B, 39-C, 40, 40-A, 40-B, 40-C
Bay rum	112	23-A, 37, 38-B, 39, 39-B, 39-D, 40, 40-A, 40-B, 40-C
Biocides, miscellaneous	410	1,3-A, 3-B, 3-C, 23-A, 23-H, 27-A, 27-B, 30, 37, 38-B, 39-B, 40, 40-A, 40-B, 40-C
Blood and blood products (processing)	345	1,3-A, 3-C, 12-A, 13-A, 23-A, 30
Brake fluids	720	1,3-A, 3-C
Candy glazes	015	1, 3-A, 23-A, 35, 35-A, 45
Cellulose coatings	011	1, 3-A, 3-C, 23-A, 30
Cellulose compounds (dehydration)	311	1, 2-B, 3-A, 3-C, 32
Cellulose intermediates	034	1,3-A, 3-C, 12-A, 13-A, 19, 23-A, 32
Chemicals (miscellaneous)	579	1, 2-B, 2-C, 3-A, 3-C, 6-B, 12-A, 13-A, 17, 20, 29, 30, 32, 36
Cleaning solutions	450	1,3-A, 3-C, 23-A, 23-H, 30, 36, 39-B, 40, 40A, 40-B, 40-C
Coatings, miscellaneous	016	1, 3-A, 3-C, 23-A
Collodions, industrial	034	1, 3-A, 3-C, 13-A, 19, 23-A, 32
Collodions, U.S.P. or N.E	241	13-A, 19, 32
Colognes	122	38-B, 39, 39-A, 39-B, 39-C, 40, 40-A, 40-B, 40-C
Crude drugs (processing)	341	1,2-B, 3-A, 3-C, 23-A, 30
Cutting oils	730	1,3-A, 3-C
Dehydration products, miscellaneous	315	1, 2-B, 3-A, 3-C
Dentifrices	131	31-A, 37, 38-B, 38-C, 38-D
Deodorants (body)	114	23-A, 38-B, 39-B, 39-C, 40, 40-A, 40-B, 40-C
Detergents, household	450	1,3-A, 3-C, 23-A, 23-H, 30, 36, 39-B, 40, 40-A, 40-B, 40-C
Detergents, industrial	440	1,3-A, 3-C, 23-A, 30
Detonators	574	1, 6-B
Disinfectants	410	1, 3-A, 3-B, 3-C, 23-A, 23-H, 27-A, 27-B, 30, 37, 38-B, 39-B, 40, 40-A, 40-B, 40-C
Drugs and medicinal chemicals	575	1,2-B, 2-C, 3-A, 3-C, 6-B, 12-A, 13-A, 17, 29, 30, 32
Drugs, miscellaneous (processing)	349	1,2-B, 3-A, 3-C, 13-A, 23-A, 30, 35-A, 38-B
Duplicating fluids	485	1,3-A, 3-C, 30
Dyes and intermediates	540	1, 2-B, 2-C, 3-A, 3-C, 12-A, 29, 36
Dyes and intermediates (processing)	351	1, 2-B, 3-A, 3-C, 12-A
Dye solutions, miscellaneous	482	1, 3-A, 3-C, 23-A, 30
Embalming fluids, etc	420	1,3-A, 3-C, 22, 23-A
Esters, ethyl (miscellaneous)	523	1,2-B, 2-C, 6-B, 12-A, 13-A, 17, 29, 32, 35-A
Ether, ethyl	561	1, 2-B, 13-A, 29, 32
Ethers, miscellaneous	562	1,2-B, 13-A, 29, 32
Ethyl acetate	521	1,2-B, 29, 35-A
Ethylamines	530	1,2-B, 2-C, 3-A, 3-C, 12-A, 29, 36
Ethyl chloride	522	1,2-B, 29, 32
Ethylene dibromide	571	1,2-B, 29,32
Ethylene gas	572	1,2-B, 29, 32
Explosives	033	1,2-B, 3-A, 3-C
External pharmaceuticals (not U.S.P. or N.F.)	210	23-A, 23-F, 23-H, 27, 27-A, 27-B, 33, 36, 37, 38-B, 38-F, 39-B, 40, 40- A, 40-B, 40-C
External pharmaceuticals, miscellaneous (U.S.P. or N.F.)	249	23-A, 25, 25-A, 33, 38-B
Fluid uses, miscellaneous	750	1,3-A, 3-C, 23-A, 30
Food products, miscellaneous (processing)	332	1,2-B, 3-A, 3-C, 13-A, 23-A, 30, 32, 35-A
Fuel uses, miscellaneous	630	1,3-A, 3-C, 28-A
Fuels, airplane and supplementary	612	1,3-A, 3-C, 28-A
Fuels, automobile and supplementary	611	1,3-A, 3-C, 28-A
Fuels, proprietary heating	620	1,3-A, 3-C, 28-A
Fuels, rocket and jet	613	1,3-A, 3-C, 28-A
Fungicides	410	1, 3-A, 3-B, 3-C, 23-A, 23-H, 27-A, 27-B, 30, 37, 38-B, 39-B, 40, 40-A, 40-B, 40-C
Glandular products (processing)	342	1,2-B, 3-A, 3-C, 12-A, 13-A, 23-A, 30, 32, 35-A
Hair and scalp preparations	111	3-B, 23-A, 23-F, 23-H, 37, 38-B, 39, 39-A, 39-B, 39-C, 39-D, 40, 40-A, 40-B, 40-C
Hormones (processing)	342	1,2-B, 3-A, 3-C, 12-A, 13-A, 23-A, 30, 32, 35-A

* Other products or processes may be authorized by the Director of the Bureau of Alcohol, Tobacco and Firearms, Washington, D.C.
Uses of Specially Denatured Alcohol — 27 CFR 212.105

PRODUCT OR PROCESS	CODE NO.	FORMULAS AUTHORIZED
Incense	470	3-A, 3-C, 22, 37, 38-B, 39-B, 39-C, 40, 40-A, 40-B, 40-C
Inks	052	1, 3-A, 3-C, 13-A, 23-A, 30, 32, 33
Insecticides	410	1, 3-A, 3-B, 3-C, 23-A, 23-H, 27-A, 27-B, 30, 37, 38-B, 39-B, 40, 40-A, 40-B, 40-C
Iodine solutions (including U.S.P. and N.F. tinctures)	230	25, 25-A
Laboratory reagents (for sale)	811	3-A, 3-C, 30
Laboratory uses (own uses only)	810	3-A, 3-C, 30
Lacquer thinners	042	1, 23-A
Liniments (U.S.P. or N.F.)	243	27, 27-B, 38-B
Lotions and creams (body, face, and hand)	113	23-A, 23-H, 31-A, 37, 38-B, 39, 39-B, 39-C, 40, 40-A, 40-B, 40-C
Medicinal chemicals (processing)	344	1, 2-B, 2-C, 3-A, 3-C, 12-A, 13-A, 17, 23-A, 30, 32, 35-A
Miscellaneous chemicals (processing)	358	1, 2-B, 2-C, 3-A, 3-C, 12-A, 13-A, 17, 23-A, 30, 35-A
Miscellaneous products (processing)	359	1, 2-B, 2-C, 3-A, 3-C, 12-A, 13-A, 17, 23-A, 30, 35-A
Mouthwashes	132	37, 38-B, 38-C, 38-D, 38-F
Organo-silicone products	576	2-B, 3-A, 3-C, 30
Pectin (processing)	331	1, 2-B, 3-A, 3-C, 13-A, 3-C, 23-A, 30, 35-A
Perfume materials (processing)	352	1, 2-B, 3-A, 3-C, 12-A, 13-A, 30
Perfumes and perfume tinctures	121	38-B, 39, 39-B, 39-C, 40, 40-A, 40-B, 40-C
Petroleum products	320	1, 2-B, 3-A, 3-C
Photoengraving dyes and solutions	481	1, 3-A, 3-C, 13-A, 30, 32
Photographic chemicals (processing)	353	1, 2-B, 3-A, 3-C, 13-A, 30
Photographic film and emulsions	031	1, 2-B, 3-A, 3-C, 13-A, 19, 30, 32
Pill and tablet manufacture	349	1, 2-B, 3-A, 3-C, 13-A, 23-A, 30, 35-A, 38-B
Plastics, cellulose	021	1, 2-B, 3-A, 3-C, 12-A, 13-A, 30
Plastics, non-cellulose (including resins)	022	1, 2-B, 3-A, 3-C, 12-A, 13-A, 30
Polishes	051	1, 3-A, 3-C, 30
Preserving solutions	430	1, 3-A, 3-C, 12-A, 13-A, 22, 23-A, 30, 32, 37, 38-B, 42, 44
Product development and pilot plant (own use only)	812	All formulas
Proprietary solvents	041	1, 3-A
Refrigerating uses	740	1,3-A, 3-C, 23-A, 30
Resin coatings, natural	014	1, 23-A
Resin coatings, synthetic	012	1, 3-A, 3-C, 23-A, 30
Resins, synthetic	590	3-A, 3-C, 29, 30, 35-A
Room deodorants	470	3-A, 3-C, 22, 37, 38-B, 39-B, 39-C, 40, 40-A, 40-B, 40-C
Rosin (processing)	354	1, 3-A, 3-C, 12-A
Rotogravure dyes and solutions	481	1, 3-A, 3-C, 13-A, 30, 32
Rubber (latex) (processing)	355	1, 3-A, 3-C
Rubber, synthetic	580	29, 32
Rubbing alcohol	220	23-H
Scientific instruments	710	1, 3-A, 3-C
Shampoos	141	1, 3-A, 3-B, 3-C, 23-A, 27-B, 31-A, 36, 38-B, 39-A, 39-B, 40, 40-A, 40-B, 40-C
Shellac coatings	013	1, 23-A
Soaps, industrial	440	1, 3-A, 3-C, 23-A, 30
Soaps, toilet	142	1, 3-A, 3-C, 23-A, 30, 36, 38-B, 39-B, 39-C, 40, 40-A, 40-B, 40-C
Sodium ethylate, anhydrous (restricted)	524	2-B
Sodium hydrosulfite (dehydration)	312	1, 2-B, 3-A, 3-C
Soldering flux	035	1, 3-A, 3-C, 23-A, 30
Solutions, miscellaneous	485	1, 3-A, 3-C, 23-A, 30, 40-C
Solvents and thinners, miscellaneous	042	1, 23-A, 30
Solvents, special (restricted sale)	043	1, 3-A, 3-C
Stains (wood)	053	1, 3-A, 3-C, 23-A, 30
Sterilizing solutions	430	1, 3-A, 3-C, 12-A, 13-A, 22, 23-A, 30, 32, 37, 38-B, 42, 44
Theater sprays	470	3-A, 3-C, 22, 37, 38-B, 39-B, 39-C, 40, 40-A, 40-B, 40-C
Tobacco sprays and flavors	460	4
Toilet waters	122	38-B, 39, 39-A, 39-B, 39-C, 40, 40-A, 40-B, 40-C
Transparent sheetings	032	1, 2-B, 3-A,13-A, 3-C, 23-A
Unclassified uses	900	1, 3-A, 3-C
Vaccine (processing)	343	1, 2-B, 3-A, 3-C, 12-A, 13-A, 23-A, 30, 32, 35-A
Vinegar	511	18, 29, 35-A
Vitamins (processing)	342	1, 2-B, 3-A, 3-C, 12-A, 13-A, 23-A, 30, 32, 35-A
Xanthates	573	1, 2-B, 29
Yeast (processing)	342	1, 2-B, 3-A, 3-C,12-A, 13-A, 23-A, 30, 32, 35-A

*Other products or processes may be authorized by the Director of the Bureau of Alcohol, Tobacco and Firearms, Washington, D.C.
Uses of Specially Denatured Alcohol—27 CFR 212.105

DENATURANTS AUTHORIZED FOR COMPLETELY DENATURED ALCOHOL (CDA) AND SPECIALLY DENATURED ALCOHOL (SDA)

DENATURANT	USED IN
Acetaldehyde	SDA 29
Acetone, N.F.	SDA 23-A, 23-H
Acetaldol	CDA 18
Almond oil, bitter, N.F. X	SDA 38-B
Ammonia, aqueous	SDA 36
Ammonia solutions, strong, N.F.	SDA 36
Anethole, N.F.	SDA 38-B
Anise oil, N.F.	SDA 38-B
Bay oil (myrcia oil), N.F.	SDA 23-F, 38-B, 39-D
Benzaldehyde, N.F	SDA 38-B
Benzene	SDA 2-B, 2-C, 12-A
Bergamot oil, N.F. XI	SDA 23-F, 38-B
Bone oil (Dipple's oil)	SDA 17
Boric acid, N.F.	SDA 38-F
Brucine alkaloid	SDA 40
Brucine sulfate, N.F. iX	SDA 40
n-Butyl alcohol	SDA 44
tert-Butyl alcohol	SDA 39, 39-A, 39-B, 40, 40-A, 40-B, 40-C
Camphor, U.S.P.	SDA 27, 27-A, 38-B
Caustic soda, liquid	SDA 36
Cedar leaf oil, U.S.P. XIII	SDA 38-B
Chloroform	SDA 20
Chlorothymol, N.F.	SDA 38-B, 38-F
Cinchonidine	SDA 39-A
Cinchonidine sulfate, N.F. IX	SDA 39-A
Cinnamic aldehyde (cinnamaldehyde), N.F. IX	SDA 38-B
Cinnamon oil (cassia oil), U.S.P.	SDA 38-B
Citronella oil, natural	SDA 38-B
Clove oil N.F.	SDA 27-A, 38-B
Coal tar, U.S.P.	SDA 38-B
Denatonium benzoate, N.F.	SDA 1, 40-B
Diethyl phthalate	SDA 39-B, 39-C
Ethyl acetate	SDA 29, 35, 35-A
Ethyl ether	SDA 13-A, 19, 32
Eucalyptol, U.S.P.	SDA 37, 38-B
Eucalyptus oil, N.F. XI	SDA 38-B
Eugenol, U.S.P.	SDA 38-B
Formaldehyde solution, U.S.P.	SDA 22, 38-C, 38-D
Gasoline	CDA 18, 19, SDA 28-A
Gasoline, Unleaded	CDA 18, 19, 20, SDA 28-A
Gentian violet, U.S.P.	SDA 33
Glycerin (Glycerol), U.S.P.	SDA 31-A
Green soap, U.S.P.	SDA 27-B
Guaiacol, N.F. X	SDA 38-B
Heptane	CDA 18, 19, SDA 28-A
Hydrochloric acid, N.F.	SDA 38-F
Iodine, U.S.P.	SDA 25, 25-A
Isopropyl alcohol	SDA 3-C
Kerosene	CDA 18, 19, 20
Kerosene (deodorized)	CDA 18, 19, 20
Lavender oil, U.S.P.	SDA 27-B, 38-B
Menthol, U.S.P.	SDA 37, 38-B, 38-C, 38-D, 38-F
Mercuric iodide, red, N.F. XI	SDA 42
Methyl alcohol	SDA 1, 3-A, 30
Methylene blue, U.S.P.	SDA 4
Methyl isobutyl ketone	CDA 18, 19, SDA 1, 23-H
Methyl normal-butyl ketone	CDA 18, 19, SDA 1
Methyl Salicylate, N.F.	SDA 38-B, 46
Mustard oil, volatile (allyl isothiocyanate), U.S.P. XII	SDA 38-B
Nicotine solution	SDA 4
Nitropropane, mixed isomers of	CDA 18, 19, SDA 1
Peppermint oil, N.F.	SDA 38-B
Phenol, U.S.P.	SDA 38-B, 46
Phenyl mercuric benzoate	SDA 42
Phenyl mercudc chlodde, N.F. IX	SDA 42
Phenyl mercuric nitrate, N.F.	SDA 42
Phenyl salicylate (salol), N.F. XI	SDA 38-B
Pine needle oil, dwarf, N.F.	SDA 38-B
Pine oil, N.F.	SDA 38-B
Pine tar, N.F.	SDA 3-B
Polysorbate 80, N.F.	SDA 38-F
Potassium iodide, U.S.P.	SDA 25, 25-A, 42
Pyridine bases	SDA 6-B
Pyronate	CDA 18
Quassia, fluid extract of, N.F. VII	SDA 39
Quassin	SDA 40
Quinine, N.F.X	SDA 39-A
Quinine bisulfate, N.F. XI	SDA 39-A, 39-D
Quinine dihydrochloride, N.F. XI	SDA 39-A
Quinine sulfate, U.S.P.	SDA 39-D
Resorcin, U.S.P.	SDA 23-F
Rosemary oil, N.F. XII	SDA 27, 38-B
Rubber hydrocarbon solvent	CDA 18, 19, 20, SDA 2-B, 2-C, 28-A
Safrole	SDA 38-B
Salicylic acid, U.S.P.	SDA 23-F, 39
Sassafras oil, N.F. XI	SDA 38-B
Shellac (refined)	SDA 45
Soap, hard, N.F.	SDA 31-A
Sodium iodide, U.S.P,	SDA 25, 25-A
Sodium, metallic	SDA 2-C
Sodium salicylate, U.S.P.	SDA 39, 39-D
Spearmint oil, N.F.	SDA 38-B
Spearmint oil, terpeneless	SDA 38-B
Spike lavender oil, natural	SDA 38-B
Storax, U.S.P.	SDA 38-B
Sucrose octa-acetate	SDA 40-A
Thimerosal, U.S.P.	SDA 42
Thyme oil, N.F. XII	SDA 38-B
Thymol, N.F.	SDA 37, 38-B, 38-F
Tolu balsam, U.S.P.	SDA 38-B
Toluene	SDA 2-B, 2-C, 12-A
Turpentine oil, N.F. XI	SDA 38-B
Vinegar	SDA 18
Zinc chloride, U.S.P.	SDA 38-F

Primary Denaturants Authorized for Denatured Spirits--Title 27 Code of Federal Regulations 212.110

AUTHORIZED COMPOSITION:

	SDA 1-1				SDA 1-2				SDA 2B-2 [1]			
To every 100 gallons of alcohol add:												
Methyl Alcohol, gallons	4				4				—			
Isopropyl Alcohol, gallons	1/8				—				—			
Denatonium Benzoate, N.F. avdp. oz.	—				1				—			
Methyl Isobutyl Ketone, gallons	—				—				0.5			
Rubber Hydrocarbon Solvent, gallons	—				—				—			
Toluene, gallons												
FORMULATION:	190º		Anhydrous		190º		Anhydrous		190º		Anhydrous	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
SPECIFICATIONS:												
Specific Gravity @ 15.56º C/15.56º C (60º F/60º F)	0.8144	0.8156	0.7934	0.7944	0.8142	0.8154	0.7934	0.7944	0.8144	0.8156	0.7926	0.7936
@ 20º C/20º C	0.8113	0.8124	0.7902	0.7912	0.8111	0.8122	0.7902	0.7912	0.8113	0.8124	0.7895	0.7905
@ 25º C/25º C	0.8078	0.8090	0.7868	0.7879	0.8076	0.8088	0.7868	0.7879	0.8078	0.8090	0.7862	0.7871
Acidity, wt/wt% as acetic acid	—	0.0025	—	0.0025	—	0.0025	—	0.0025	—	0.0025	—	0.0025
Non-volatile matter, grams/100 ml	—	0.0025	—	0.0025	—	0.0025	—	0.0025	—	0.0025	—	0.0025
Color, Pt-Co	—	10	—	10	—	10	—	10	—	10	—	10
Water Content, vol./vol. %	—	—	—	0.10	—	—	—	0.10	—	—	—	0.10
Odor	Typical				Typical				Typical			
TYPICAL PROPERTIES:												
Apparent Proof @ 60º F	190.4		199.9		190.5		199.9		190.4		200.2	
Composition, wt/wt %												
Ethyl Alcohol	88.95		96.14		88.12		95.22		92.03		99.56	
Methyl Alcohol	3.76		3.86		3.72		3.82		—		—	
Isopropyl Alcohol	—		—		—		—		—		—	
Denatonium Benzoate	0.001		0.001		—		—		—		—	
Methyl Isobutyl Ketone	—		—		0.94		0.96		—		—	
Rubber Hydrocarbon Solvent	—		—		—		—		0.42		0.44	
Toluene	—		—		—		—		—		—	
Water	7.29		—		7.22		—		7.55		—	
Coefficient of expansion:												
Per 1º C	0.0010		0.0011		0.0010		0.0011		0.0010		0.0010	
Per 1º F	0.0006		0.0006		0.0006		0.0006		0.0006		0.0006	
Flash Point:												
Tag closed cup												
ºC	13		12		14		11		15		13	
ºF	56		53		58		52		59		56	
Tag open cup												
ºC	23		22		18		16		16		13	
ºF	73		71		65		60		60		55	
Pounds per gallon @ 60º F, per 27 CFR 212.115	6.788		6.612		6.788		6.611 [2]		6.788 [2]		6.606 [2]	
Shipping containers												
Tank cars		✓				✓				✓		
Tank trucks		✓				✓				✓		
Drums		✓				✓				✓		

Comments:

1. This formula must be used in a closed end continuous system unless it is shown that it is not practical to do so.
2. Determined by Equistar Chemicals, LP.

Because of very limited use, there are several approved formulas that are not discussed in this book.
Specific information may be obtained by contacting Equistar Chemicals, LP sales office.

SDA 2B-3 [1]				SDA 3-A				SDA 3-C				Test Method
—				5				—				
—				—				5				
—				—				—				
—				—				—				
0.5				—				—				
190º		Anhydrous		190º		Anhydrous		190º		Anhydrous		
Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	
0.8154	0.8166	0.7936	0.7946	0.8144	0.8156	0.7934	0.7944	0.8140	0.8152	0.7931	0.7942	ASTM D-891
0.8122	0.8134	0.7905	0.7915	0.8113	0.8124	0.7902	0.7912	0.8109	0.8120	0.7900	0.7910	
0.8088	0.8100	0.7871	0.7882	0.8078	0.8090	0.7869	0.7879	0.8074	0.8086	0.7865	0.7876	
—	0.0025	—	0.0025	—	0.0025	—	0.0025	—	0.0025	—	0.0025	ASTM D-1613
—	0.0025	—	0.0025	—	0.0025	—	0.0025	—	0.0025	—	0.0025	ASTM D-1353
—	10	—	10	—	10	—	10	—	10	—	10	ASTM D-1209
—	—	—	0.10	—	—	—	0.10	—	—	—	0.10	ASTM D-1364
Typical				Typical				Typical				Organoleptic
189.9		199.8		190.4		199.9		190.6		200.0		I.R.S. Gauging Manual
91.93		99.45		88.12		95.22		88.15		95.26		
—		—		4.65		4.78		—		—		
—		—		—		—		4.62		4.74		—
—		—		—		—		—		—		
—		—		—		—		—		—		
—		—		—		—		—		—		
0.53		0.55		—		—		—		—		
7.54		—		7.23		—		7.23		—		
0.0010		0.0011		0.0010		0.0011		0.0010		0.0011		
0.0006		0.0006		0.0006		0.0006		0.0006		0.0006		
												ASTM D-56
16		14		16		13		17		13		
61		57		60		55		62		56		ASTM D-1310
21		19		18		16		20		18		
69		66		65		60		68		65		
6.797 [2]		6.613 [2]		6.785		6.609		6.784		6.608		
	✓				✓				✓			
	✓				✓				✓			
	✓				✓				✓			

AUTHORIZED COMPOSITION:

	SDA 12A-3			
To every 100 gallons of alcohol add:				
Toluene, gallons	5			
Ethyl Ether, gallons	—			
FORMULATION:	190º		Anhydrous	
	Min.	Max.	Min.	Max.
SPECIFICATIONS:				
Specific Gravity @ 15.56º C/15.56º C (60º F/60º F)	0.8077	0.8189	0.7972	0.7986
@ 20º C/20º C	0.8146	0.8157	0.7940	0.7955
@ 25º C/25º C	0.8111	0.8123	0.7907	0.7921
Acidity, wt/wt% as acetic acid	—	0.0025	—	0.0025
Non-volatile matter, grams/100 ml	—	0.0025	—	0.0025
Color, Pt-Co	—	10	—	10
Water Content, vol./vol. %	—	—	—	0.10
Odor				
	Typical			
TYPICAL PROPERTIES:				
Apparent Proof @ 60º F	188.7		198.3	
Composition, wt/wt %				
Ethyl Alcohol	87.74		94.80	
Toluene	5.07		5.20	
Ethyl Ether	—		—	
Water	7.19		—	
Coefficient of expansion:				
Per 1º C	0.0011		0.0011	
Per 1º F	0.0006		0.0006	
Flash Point:				
Tag closed cup				
ºC	11		9	
ºF	52		49	
Tag open cup				
ºC	18		16	
ºF	65		60	
Pounds per gallon @ 60º F, per 27 CFR 212.115	6.815[1]		6.644[1]	
Shipping containers				
Tank cars	✓			
Tank trucks	✓			
Drums	✓			

Comments:

1. Determined by Equistar Chemicals, LP.

SDA 13-A				Test Method
—				
10				
190º		Anhydrous		
Min.	Max.	Min.	Max.	
0.8087	0.8100	0.7883	0.7895	ASTM D-891
0.8056	0.8068	0.7851	0.7863	
0.8022	0.8034	0.7816	0.7828	
—	0.0025	—	0.0025	ASTM D-1613
—	0.0025	—	0.0025	ASTM D-1353
—	10	—	10	ASTM D-1209
—	—	—	0.10	ASTM D-1364
Typical				Organoleptic
193.2		>200		I.R.S. Gauging Manual
85.07		91.81		
—				
7.92		8.15		
7.01		—		
0.0011		0.0012		
0.0006		0.0006		
				ASTM D-56
-14		-16		
6		4		
				ASTM D-1310
-12		-12		
10		10		
6.740		6.572		
✓				
✓				
✓				

AUTHORIZED COMPOSITION:

	SDA 20 [1]		SDA 23-A			
To every 100 gallons of alcohol add:						
Chloroform, gallons	5		—			
Acetone, N.F., gallons	—		8			
Methyl Isobutyl Ketone, gallons	—		—			
FORMULATION:	Anhydrous		190º		Anhydrous	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
SPECIFICATIONS:						
Specific Gravity @ 15.56º C/15.56º C (60º F/60º F)	0.8265	0.8282	0.8144	0.8156	0.7939	0.7949
@ 20º C/20º C	0.8233	0.8251	0.8113	0.8124	0.7908	0.7918
@ 25º C/25º C	0.8199	0.8216	0.8078	0.8090	0.7874	0.7884
Acidity, wt/wt% as acetic acid	—	0.0050	—	0.0025	—	0.0025
Non-volatile matter, grams/100 ml	—	0.0025	—	0.0025	—	0.0025
Color, Pt-Co	—	10	—	10	—	10
Water Content, vol./vol. %	—	0.10	—	—	—	0.10
Odor	Typical		Typical			
TYPICAL PROPERTIES:						
Apparent Proof @ 60º F	183.7		190.4		199.7	
Composition, wt/wt %						
Ethyl Alcohol	91.53		85.73		92.57	
Chloroform	8.47		—		—	
Acetone	—		7.24		7.43	
Methyl Isobutyl Ketone	—		—		—	
Water	—		7.03		—	
Coefficient of Expansion:						
Per 1º C	0.0011		0.0011		0.0011	
Per 1º F	0.0006		0.0006		0.0006	
Flash Point:						
Tag closed cup						
ºC	13		6		6	
ºF	56		43		43	
Tag open cup						
ºC	13		10		10	
ºF	55		50		50	
Pounds per gallon @ 60º F, per 27 CFR 212.115	6.886		6.788		6.621	
Shipping containers						
Tank cars	No		✓			
Tank trucks	No		✓			
Drums	✓		✓			

Comments:

1. Available in anhydrous formulation only.

SDA 23-H				Test Method
		—		
		8		
		1.5		
190º		Anhydrous		
Minimum	Maximum	Minimum	Maximum	
0.8140	0.8152	0.7942	0.7952	ASTM D-891
0.8109	0.8120	0.7910	0.7920	
0.8074	0.8086	0.7876	0.7886	
—	0.0025	—	0.0025	ASTM D-1613
—	0.0025	—	0.0025	ASTM D-1353
—	10	—	10	ASTM D-1209
—	—	—	0.10	ASTM D-1364
		Typical		
	190.6		199.6	I.R.S. Gauging Manual
				Organoleptic
	84.58		91.29	
	—		—	
	7.14		7.33	
	1.35		1.38	
	6.93		—	
	0.0011		0.0011	
	0.0006		0.0006	
				ASTM D-56
	6		2	
	43		36	
				ASTM D-1310
	10		2	
	50		35	
	6.785		6.617	
		✓		
		✓		
		✓		

AUTHORIZED COMPOSITION:

	SDA 25-1 [1]		SDA 25-2 [1]	
To every 100 gallons of alcohol add:				
Iodine, U.S.P., pounds	20		20	
Potassium Iodide, U.S.P., pounds	15		—	
Sodium Iodide, U.S.P., pounds	—		15	
Water, pounds	—		—	
FORMULATION:	190º		190º	
	Minimum	Maximum	Minimum	Maximum
SPECIFICATIONS:				
Specific Gravity @ 15.56º C/15.56º C (60º F/60º F)	0.8491	0.8521	0.8494	0.8523
@ 20º C/20º C	0.8460	0.8490	0.8463	0.8492
@ 25º C/25º C	0.8426	0.8456	0.8429	0.8459
Acidity, wt/wt% as acetic acid	—	—	—	—
Non-volatile matter, grams/100 ml	—	—	—	—
Color, Pt-Co	Deep Red-Brown		Deep Red-Brown	
Water Content, vol./vol. %	—	—	—	—
Odor	Typical		Typical	
TYPICAL PROPERTIES:				
Apparent Proof @ 60º F	169.1		168.9	
Composition, wt/wt %				
Ethyl Alcohol	87.90		87.90	
Iodine	2.80		2.80	
Potassium Iodide	2.10		—	
Sodium Iodide	—		2.10	
Water	7.20		7.20	
Coefficient of Expansion:				
Per 1º C	0.0010		0.0010	
Per 1º F	0.0006		0.0006	
Flash Point:				
Tag closed cup				
ºC	16		16	
ºF	60		60	
Tag open cup				
ºC	18		18	
ºF	65		65	
Pounds per gallon @ 60º F, per 27 CFR 212.115	7.084		7.083	
Shipping containers				
Tank cars	No		No	
Tank trucks	No		No	
Drums	50 gallon, polyethylene returnable drums only			

Comments:

1. These SDAs typically supplied only in the 190º formulation.

SDA 25A-1 [1]		SDA 25A-2 [1]	
20		20	
15		—	
—		15	
15		15	
190º		190º	
Minimum	Maximum	Minimum	Maximum
0.8535	0.8564	0.8541	0.8571
0.8504	0.8533	0.8510	0.8539
0.8471	0.8500	0.8476	0.8506
—	—	—	—
—	—	—	—
Deep Red-Brown		Deep Red-Brown	
—	—	—	—
Typical		Typical	
166.1		165.7	
86.09		86.09	
2.74		2.74	
2.06		—	
—		2.06	
9.11		9.11	
0.0010		0.0010	
0.0006		0.0006	
16		16	
60		60	
18		18	
65		65	
7.119		7.117	
No		No	
No		No	
50 gallon, polyethylene returnable drums only			

AUTHORIZED COMPOSITION:

	SDA 28-A [1]	SDA 29-3 [2]		SDA 30	
To every 100 gallons of alcohol add:					
Gasoline, gallons	1	—		—	
Ethyl Acetate, gallons	—	1		—	
Methyl Alcohol, gallons	—	—		10	
Ethyl Ether, gallons	—	—		—	
FORMULATION:	Anhydrous	190º	Anhydrous	190º	
	Minimum Maximum	Minimum Maximum	Minimum Maximum	Minimum	Maximum
SPECIFICATIONS:					
Specific Gravity @ 15.56º C/15.56º C (60º F/60º F)	0.7923 0.7933	0.8160 0.8172	0.7944 0.7954	0.8132	0.8146
@ 20º C/20º C	0.7891 0.7901	0.8128 0.8140	0.7912 0.7922	0.8101	0.8115
@ 25º C/25º C	0.7857 0.7867	0.8094 0.8105	0.7879 0.7889	0.8066	0.8080
Acidity, wt/wt% as acetic acid	— 0.0025	— 0.0025	— 0.0025	—	0.0025
Non-volatile matter, grams/100 ml	— 0.0025	— 0.0025	— 0.0025	—	0.0025
Color, Pt-Co	— 10	— 10	— 10	—	10
Water Content, vol./vol. %	— 20	— —	— 0.10	—	—
Odor	Typical	Typical		Typical	
TYPICAL PROPERTIES:					
Apparent Proof @ 60º F	>200	189.6	199.5	191.0	
Composition, wt/wt %					
Ethyl Alcohol	99.13	91.41	98.87	84.21	
Gasoline	0.87	—	—	—	
Ethyl Acetate	—	1.10	1.13	—	
Methyl Alcohol	—	—	—	8.89	
Ethyl Ether	—	—	—	—	
Water	—	7.49	—	6.90	
Coefficient of Expansion:					
Per 1º C	0.0011	0.0010	0.0011	0.0010	
Per 1º F	0.0006	0.0006	0.0006	0.0006	
Flash Point:					
Tag closed cup					
ºC	7	17	15	16	
ºF	45	62	59	60	
Tag open cup					
ºC	10	16	21	18	
ºF	50	60	69	65	
Pounds per gallon @ 60º F, per 27 CFR 212.115	6.603	6.801[3]	6.621[3]	6.785	
Shipping containers					
Tank cars	✓	✓		✓	
Tank trucks	✓	✓		✓	
Drums	✓	✓		✓	

Comments:

1. This SDA typically supplied only in the anhydrous formulation.
2. This formulation, typically used for vinegar manufacture, is but one of many which is of commercial importance. Other denaturants may be approved by the ATF director, provided the proposed denaturant be not less than 6.8 pounds of solid, or 1 gallon of liquid to 100 gallons alcohol. This formula is restricted to processes in which the alcohol loses its identity by being converted to other chemicals.
3. Determined by Equistar Chemicals, LP.

SDA 30		SDA 32				SDA 35-A				Test Method
—		—				—				
—		—				4.25				
10		—				—				
—		5				—				
Anhydrous		190º		Anhydrous		190º		Anhydrous		
Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	
0.7934	0.7944	0.8122	0.8134	0.7911	0.7921	0.8185	0.8196	0.7974	0.7989	ASTM D-891
0.7902	0.7912	0.8091	0.8103	0.7879	0.7889	0.8153	0.8164	0.7942	0.7957	
0.7868	0.7879	0.8056	0.8068	0.7845	0.7855	0.8119	0.8130	0.7909	0.7923	
—	0.0025	—	0.0025	—	0.0025	—	0.0025	—	0.0025	ASTM D-1613
—	0.0025	—	0.0025	—	0.0025	—	0.0025	—	0.0025	ASTM D-1353
—	10	—	10	—	10	—	10	—	10	ASTM D-1209
—	0.20	—	—	—	0.20	—	—	—	0.10	ASTM D-1364
Typical		Typical				Typical				Organoleptic
199.9		191.5		>200		188.3		198.2		I.R.S. Gauging Manual
90.88		88.59		95.73		88.26		95.38		
						4.50		4.62		
9.12										
		4.13		4.24						
		7.28		0.03		7.24				
0.0011		0.0011		0.0011		0.0011		0.0011		
0.0006		0.0006		0.0006		0.0006		0.0006		
										ASTM D-56
13		-4		-9		14		10		
53		25		15		58		50		
										ASTM D-1310
13		-4		-9		21		17		
55		25		15		70		62		
6.617		6.769		6.593		6.826		6.649		
✓		✓				✓				
✓		✓				✓				
✓		✓				✓				

AUTHORIZED COMPOSITION:

	SDA 36 [1,2]		SDA 37 [1]		TYPICAL SDA 38-B	
To every 100 gallons of alcohol add:						
Ammonia, aqueous, 27 to 30 percent by weight, gallons	3		—			
Eucalyptol, U.S.P., fluid ounces	—		45		Denaturant 10 lbs.	
Thymol N.F. avdp. ounce	—		30			
Menthol, U.S.P., avdp. ounce	—		20			
Boric Acid,[4] U.S.P., pounds			—			
Chlorothymol, N.F., pounds	—		—			
FORMULATION:	190º Minimum	190º Maximum	190º Minimum	190º Maximum	190º	200º
SPECIFICATIONS:						
Specific Gravity @ 15.56º C/15.56º C (60º F/60º F)	0.8189	0.8207	0.8162	0.8174	See page 44.	
@ 20º C/20º C	0.8157	0.8176	0.8130	0.8142		
@ 25º C/25º C	0.8123	0.8142	0.8097	0.8108		
Acidity, wt/wt% as acetic acid	Alkaline		—	0.0030		
Non-volatile matter, grams/100 ml	—	0.0025	N/A			
Color, Pt-Co	—	10	—	20		
Water Content, vol./vol. %	—	—	—	—		
Odor	Typical		Typical			
TYPICAL PROPERTIES:						
Apparent Proof @ 60º F	187.9		189.5		189.4	199.3
Composition, wt/wt %						
Ethyl Alcohol	89.46		91.64		91.08	98.51
Ammonia	0.91					
Eucalyptol			0.40			
Thymol			0.27			
Menthol			0.18			
Boric Acid			—			
Chlorothymol			—		Denaturant 1.45	1.49
Water	9.63		7.51		7.47	
Coefficient of Expansion:						
Per 1º C	0.0011		0.0010		0.0010	0.0010
Per 1º F	0.0006		0.0006		0.0006	0.0006
Flash Point:						
Tag closed cup						
ºC	15		13			
ºF	59		57			
Tag open cup						
ºC	20		21			
ºF	68		70			
Pounds per gallon @ 60º F, per 27 CFR 212.115	6.837		6.794		6.804	6.622
Shipping containers						
Tank cars	✓		✓		✓	
Tank trucks	✓		✓		✓	
Drums	✓		✓		✓ & ✓	

Comments:

1. This SDA typically supplied only in the 190º proof formulation.
2. Alternate denaturants include: 3 gallons of strong ammonia solution, U.S.P.; 17.5 pounds of caustic soda, liquid grade, containing 50 percent sodium hydroxide by weight; or 12.0 pounds of caustic soda, liquid grade containing 73 percent sodium hydroxide by weight to 100 gallons alcohol.
3. 27 CFR 212.51 also authorizes the use of 7 pounds of boric acid U.S.P. and a total of 3 pounds of any two or more denaturing materials listed under Formula No. 38-B.
4. The use of Polysorbate 80 is an authorized replacement for boric acid.

SDA 38-F [1,3]		Test Method
—		
—		
1 1/3 lbs.		
1 1/3 lbs.		
6		
1 1/3		
190º		
Minimum	Maximum	
0.8194	0.8206	ASTM D-891
0.8162	0.8174	
0.8127	0.8140	
N/A		ASTM D-1613
N/A		ASTM D-1353
—	10	ASTM D-1209
—	—	ASTM D-1364
Typical		Organoleptic
187.8		I.R.S. Gauging Manual
91.09		
0.19		
0.19		
0.87		
0.19		
7.47		
0.0010		
0.0006		
16		ASTM D-56
61		
19		ASTM D-1310
66		
6.828		
√ & √X (depending on denaturants)		

√X = resin lined containers

AUTHORIZED COMPOSITION:

	SDA 39-B				SDA 39-C				SDA 40-1			
To every 100 gallons of alcohol add:												
Diethyl Phthalate, gallons	2.5				1				—			
tert-Butyl Alcohol, gallons	1/8				—				1/8			
Brucine Alkaloid, avdp ounces	—				—				1 1/2			
Brucine Sulfate N.F. IX, avdp ozs.	—				—				—			
Sucrose Octaacetate, pounds	—				—				—			
Denatonium Benzoate, N.F., avdp ounces	—				—				—			
FORMULATION:	190º		Anhydrous		190º		Anhydrous		190º		Anhydrous	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
SPECIFICATIONS:												
Specific Gravity												
@ 15.56º C/15.56º C (60º F/60º F)	0.8228	0.8238	0.8028	0.8038	0.8182	0.8192	0.7964	0.7979	0.8154	0.8164	0.7934	0.7944
@ 20º C/20º C	0.8196	0.8207	0.7997	0.8006	0.8149	0.8161	0.7932	0.7948	0.8122	0.8132	0.7902	0.7912
@ 25º C/25º C	0.8162	0.8172	0.7963	0.7972	0.8155	0.8126	0.7899	0.7914	0.8088	0.8098	0.7868	0.7879
Acidity, wt/wt% as acetic acid	—	0.0050	—	0.0050	—	0.0050	—	0.0050	—	0.0025	—	0.0025
Non-volatile matter, grams/100 ml	N/A		N/A		N/A		N/A		—	0.020	—	0.020
Color, Pt-Co	—	20	—	20	—	10	—	10	—	10	—	10
Water Content, vol./vol. %	—	—	—	0.10	—	—	—	0.10	—	—	—	0.10
Odor	Typical				Typical				Typical			
TYPICAL PROPERTIES:												
Apparent Proof @ 60º F	186.0		196.0		188.5		198.6		190.0		199.9	
Composition, wt/wt %												
Ethyl Alcohol	89.25		96.47		91.17		98.61		92.30		99.87	
Diethyl Phthalate	3.32		3.41		1.36		1.39		—		—	
tert-Butyl Alcohol	0.12		0.12		—		—		0.12		0.12	
Brucine Alkaloid	—		—		—		—		0.014		0.014	
Brucine Sulfate	—		—		—		—		—		—	
Sucrose Octaacetate	—		—		—		—		—		—	
Denatonium Benzoate	—		—		—		—		—		—	
Water	7.31		—		7.47		—		7.57		—	
Coefficient of Expansion:												
Per 1º C	0.0010		0.0011		0.0010		0.0011		0.0010		0.0011	
Per 1º F	0.0006		0.0006		0.0006		0.0006		0.0006		0.0006	
Flash Point:												
Tag closed cup												
ºC	14		13		16		13		16		13	
ºF	58		55		60		55		61		56	
Tag open cup												
ºC	18		16		18		16		18		16	
ºF	65		60		65		60		65		60	
Pounds per gallon												
@ 60º F, per 27 CFR 212.115	6.857		6.677		6.819		6.642		6.795		6.611	
Shipping containers												
Tank cars		✓				✓				✓		
Tank trucks		✓				✓				✓		
Drums		✓				✓				✓		

Comments:

1. Determined by Equistar Chemicals, LP.
2. This formula shall be used only in the manufacturers of products which will be packaged in pressurized containers in which the liquid contents are in intimate contact with the propellant and from which the contents are not easily removable in liquid form.

SDA 40-2				SDA 40-A				SDA 40-B				SDA 40-C [2]				Test Method
—				—				—				—				
1/8				1/8				1/8				3				
—				—				—				—				
1 1/2				—				—				—				
—				1				—				—				
—				—				1/16				—				
190º		Anhydrous		190º		Anhydrous		190º		Anhydrous		190º		Anhydrous		
Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	
0.8154	0.8164	0.7934	0.7944	0.8158	0.8170	0.7939	0.7949	0.8152	0.8164	0.7934	0.7944	0.8148	0.8160	0.7829	0.7939	ASTM D-891
0.8122	0.8132	0.7902	0.7912	0.8126	0.8138	0.7908	0.7918	0.8120	0.8132	0.7902	0.7912	0.8116	0.8128	0.7898	0.7908	
0.8088	0.8098	0.7868	0.7879	0.8192	0.8104	0.7874	0.7884	0.8086	0.8098	0.7868	0.7879	0.8082	0.8094	0.7864	0.7874	
—	0.0050	—	0.0050	—	0.0025	—	0.0025	—	0.0025	—	0.0025	—	0.0025	—	0.0025	ASTM D-1613
—	0.020	—	0.020	—	0.16	—	0.16	—	0.0025	—	0.0025	—	0.0025	—	0.0025	ASTM D-1353
—	10	—	10	—	10	—	10	—	10	—	10	—	10	—	10	ASTM D-1209
—	—	—	0.10	—	—	—	0.10	—	—	—	0.10	—	—	—	0.10	ASTM D-1364
Typical				Typical				Typical				Typical				Organoleptic
190.0		199.9		189.7		199.7		190.0		199.9		190.2		200.1		I.R.S. Gauging Manual
92.30		99.87		92.18		99.73		92.31		99.88		89.84		97.13		
—		—		—		—		—		—		—		—		
0.12		0.12		0.12		0.12		0.12		0.12		2.79		2.87		
—		—		—				—		—		—		—		
0.014		0.014		—				—		—		—		—		
—		—		0.15		0.15		—		—		—		—		
—		—		—				0.0006		0.0006		—		—		
7.57		—		7.55		—		7.57		—		7.37		—		
0.0010		0.0010		0.0011		0.0011		0.0010		0.0011		0.0010		0.0011		
0.0006		0.0006		0.0006		0.0006		0.0006		0.0006		0.0006		0.0006		
																ASTM D-56
16		13		16		12		17		13		17		13		
61		56		60		53		62		56		62		55		
																ASTM D-1310
18		16		18		17		18		16		18		16		
65		60		65		62		65		60		65		60		
6.795[1]		6.611[1]		6.798		6.613		6.794		6.610		6.788		6.609		
✓				✓				✓				✓				
✓				✓				✓				✓				
✓				✓				✓				✓				

AUTHORIZED COMPOSITION:

	SDA 45			
To every 100 gallons of alcohol add: Refined Shellac, pounds	300			
FORMULATION:	190º		Anhydrous	
	Minimum	Maximum	Minimum	Maximum
SPECIFICATIONS:				
Specific Gravity @ 15.56º C/15.56º C (60º F/60º F)	0.9036	0.9071	0.8868	0.8905
@ 20º C/20º C	0.9008	0.9043	0.8838	0.8875
@ 25º C/25º C	0.8977	0.9012	0.8806	0.8844
Acidity, as acetic acid	N/A		N/A	
Non-volatile matter, grams/100 ml	N/A		N/A	
Color, Pt-Co	N/A		N/A	
Water Content, vol./vol. %	N/A		N/A	
Odor	Typical			
TYPICAL PROPERTIES:				
Apparent Proof @ 60º F	127.0		141.0	
Composition, wt/wt %				
Ethyl Alcohol	64.11		68.78	
Shellac	30.63		31.22	
Water	5.26		—	
Coefficient of Expansion:				
Per 1º C	0.0009		0.0009	
Per 1º F	0.0005		0.0005	
Flash Point:				
Tag Closed Cup				
ºC	12		11	
ºF	53		52	
Tag Open Cup				
ºC	21		18	
ºF	70		65	
Pounds per gallon, @ 60º F, per 27 CFR 212.115	7.545		7.403	
Shipping containers				
Tank cars	No			
Tank trucks	No			
Drums	50 gallon open head drums			

Test Method
ASTM D-891
ASTM D-1613 ASTM D-1353 ASTM D-1209 ASTM D-1364 Organoleptic
I.R.S. Gauging Manual
ASTM D-56
ASTM D-1310

A Word About SDA 38-B…

The properties of SDA 38-B are as diverse as are the denaturants used in this formula and the products formulated with it.

The authorized composition of SDA 38-B requires that 10 pounds of any one, or a total of 10 pounds of two or more, of the oils and substances listed below are to be added to 100 gallons of alcohol. The authorized denaturants include:

Anethole, U.S.P.
Anise oil, U.S.P.
Bay oil (myrcia off), N.F. XI
Benzaldehyde, N.F.
Bergamot oil, N.F.
Bitter almond oil, N.F. X
Camphor, U.S.P.
Cedar leaf oil, U.S.P. XIII
Chlorothymol, N.F. XII
Cinnamic Aldehyde, N.F. IX
Cinnamon oil (Cassia oil), U.S.P.
Citronella oil, natural
Clove oil, U.S.P.
Coal tar, U.S.P.
Eucalyptol, U.S.P., N.F. XII
Eucalyptus oil, N.F.
Eugenol, U.S.P.
Guaiacol, N.F.
Lavender oil, N.F.
Menthol, U.S.P.
Methyl Salicylate, N.F.
Mustard oil, volatile (allyl isothiocyanate), U.S.P. XII
Peppermint oil, U.S.P.
Phenol, U.S.P.
Phenyl salicylate (Salol), N.F. XI
Pine oil, N.F. XII
Pine needle oil, dwarf, N.F.
Rosemary oil, N.F. XII
Safrole
Sassafras oil, N.F. XI
Spearmint oil, N.F.
Spearmint oil, terpeneless
Spike lavender oil, natural
Storax, U.S.P.
Thyme oil, N.F. XII
Thymol, N.F.
Tolu balsam, U.S.P.
Turpentine oil, N.F. XI

Because of the virtually infinite number of authorized denaturants and denaturant combinations, only a typical set of properties for SDA 38-B have been listed on page 38. Equistar will work with prospective users of SDA 38-B to assist in the development of specifications and test methods.

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Introduction

Equistar proprietary solvents, Filmex special industrial solvents, and completely denatured alcohol can be purchased by industrial users without securing an ATF permit, payment of tax, or posting of bond.

The products described in this section are authorized formulations, which have been approved by the ATF for the uses noted under the descriptions of the products. Uses other than those listed in 27 CFR must be approved by the ATF.

Regulations

Detailed regulations pertaining to the use of proprietary solvents and Filmex special industrial solvents can be found in the "Government Regulations" booklet available from your Equistar sales representative.

PROPRIETARY SOLVENTS

Introduction

Proprietary solvents are manufactured in several ATF approved formulations. These are supplied to meet the industrial users' various requirements.

Close quality control of ingredients make Equistar proprietary solvents conform to narrow specification limits. Proprietary solvents are non-corrosive, burn with a clean flame, and have a mild, non-residual odor.

Authorized Composition

The primary component of proprietary solvent is specially denatured alcohol, Formula 1. There are two options for SDA 1.

The following SDA I Formulas are used extensively:

Authorized Composition	-1 (Bitrex Option)	-2 (MIBK Option)
Ethyl Alcohol, gallons	100	100
Methyl Alcohol, gallons	4	4
Denatonium Benzoate, N.F. av. oz.	1/8	—
Methyl Isobutyl Ketone, gallons	—	1

In the formulation of SDA 1, the required denaturants are added to 100 gallons of anhydrous or 190 proof ethyl alcohol. These are used to prepare the anhydrous or 190 proof formulations of proprietary solvent. Equistar manufactures proprietary solvent prepared with SDA 1-1 (Bitrex option), and SDA 1-2 (MIBK option).

PROPRIETARY SOLVENTS:

Equistar offers the following proprietary solvents in both 190 and 200 proof formulations. A redistilled version of some of these formulations is available for solvent applications.

Authorized Composition	Proprietary Solvent
SDA 1-1, gallons	100
Methyl Isobutyl Ketone, gallons	1
Ethyl Acetate, gallons	0.87
Rubber Hydrocarbon Solvent, gallons	1

Uses

Latex coagulants — proprietary solvent is an important raw material in the latex coagulant and rubber goods industry. The low moisture content of the anhydrous formulation, and its relatively high evaporation rate, make it a preferred latex coagulant solvent for latex coagulants.

Shellac — cutting and thinning shellac—because of its solvent power, and its mild, inoffensive odor, proprietary solvent is accepted as the ideal shellac solvent and thinner. The anhydrous formulation has blending features especially adaptable to the manufacture of spirit varnishes.

The usual 4-lb cut of shellac (4 pounds shellac to 1 gallon proprietary solvent or denatured alcohol) should be thinned with additional proprietary solvent to obtain the correct working consistency. Shellac cut with Equistar proprietary solvent gives a smooth film of high gloss and good color; it has good drying qualities and can be used with advantage for a prime coat on floors, cabinetwork, furniture, and other items. The mild odor and superior solvent action of proprietary solvent makes it especially suitable for these purposes.

Chemical manufacture — proprietary solvent is useful in certain purifying and re-crystallizing operations. Anhydrous proprietary solvent is used as a reaction medium for many chemical processes in which the presence of water is detrimental. Proprietary solvent can also be used to furnish the ethyl group in chemical manufacturing where the presence of its denaturants is not objectionable.

Chemical specialties — industrial formulators of chemical specialties have found Equistar's proprietary solvent to be well suited for numerous specialty applications such as:

In window cleaning compounds — proprietary solvent is a valuable aid for removing grease and grime, and gives a clean, brilliant gloss without streaking.

Fuel oil conditioner — water and sludge in the bottom of fuel oil tanks may be removed by pouring a gallon or two of anhydrous proprietary solvent into a nearly empty tank.

Photography — both negatives and paper prints can be dried in a few minutes using proprietary solvent as a final rinse. Proprietary solvent is ideal for cleaning ferrotype plates.

Fuel conditioner — a gallon of anhydrous proprietary solvent for every 20 gallons of gasoline will prevent clogged lines due to freezing as a result of water condensation.

Shipping Information

Deliveries of Equistar proprietary solvent can be made in tank cars of 30,000 gallon and 20,000 gallon capacity, in tank trucks, and in drums.

Proprietary solvent is classified by Department of Transportation (D.O.T.) as a flammable liquid. It must be packaged in D.O.T. approved containers, and when shipped, all other regulations regarding labeling, loading and handling must be followed. Tank trucks and tank cars must bear the D.O.T. flammable liquid placard. Drums and pails must bear the D.O.T. red label for flammable liquids.

SPECIFICATIONS AND TYPICAL PROPERTIES

	PROPRIETARY SOLVENT I-1				PROPRIETARY SOLVENT I-2			
	190 Proof Formulation		Anhydrous Formulation		190 Proof Formulation		Anhydrous Formulation	
SPECIFICATIONS:	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Specific Gravity @ 60° F/60° F	0.8168	0.8179	0.7967	0.7976	0.8166	0.8177	0.7967	0.7976
@ 20° C/20° C	0.8136	0.8148	0.7935	0.7945	0.8133	0.8146	0.7935	0.7945
@ 25° C/25° C	0.8102	0.8113	0.7902	0.7911	0.8100	0.8111	0.7902	0.7911
Acidity, wt./wt. % as acetic acid	—	0.005	—	0.005	—	0.005	—	0.005
Non-volatile Matter, grams/100 ml	—	0.0025	—	0.0025	—	0.0025	—	0.0025
Color, Pt-Co	—	15	—	15	—	15	—	15
Water Content, vol./vol. %	—	—	—	0.20	—	—	—	0.20
Odor	mild, non-residual				mild, non-residual			
TYPICAL PROPERTIES:								
Apparent Proof @ 60° F	189.2		198.6		189.3		198.6	
Composition at 60° F								
Ethyl Alcohol, wt./wt. %	84.25		90.94		83.47		90.06	
Methyl Alcohol, wt./wt. %	3.56		3.65		3.52		3.61	
Methyl Isobutyl Ketone, wt./wt. %	—		—		0.89		0.91	
Rubber Hydrocarbon Solvent, wt./wt. %	0.81		0.83		0.81		0.83	
Ethyl Acetate, wt./wt. %	4.47		4.58		4.47		4.59	
Water, wt./wt. %	6.90		—		6.84		—	
Denatonium Benzoate N.F. wt./wt. %	0.001		0.001		—		—	
Coefficient of Expansion:								
per 1° C	0.0010		0.0010		0.0011		0.0011	
per 1° F	0.0006		0.0006		0.0006		0.0006	
Flash Point:								
Tag Closed Cup								
°C	10		6		9		11	
°F	50		42		48		52	
Tag Open Cup								
°C	12		9		11		16	
°F	53		49		52		60	
Weight per gallon, lbs @ 60° F	6.81		6.64		6.81		6.64	

PROPRIETARY SOLVENT III-1				PROPRIETARY SOLVENT III-2				
190 Proof Formulation		Anhydrous Formulation		190 Proof Formulation		Anhydrous Formulation		
Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Test Method
0.8136	0.8148	0.7932	0.7942	0.8136	0.8148	0.7932	0.7942	ASTM D-891
0.8105	0.8116	0.7900	0.7910	0.8105	0.8116	0.7900	0.7910	
0.8070	0.8182	0.7866	0.7876	0.8070	0.8082	0.7866	0.7276	
—	0.005	—	0.005	—	0.005	—	0.005	ASTM D-1613
—	0.0025	—	0.0025	—	0.0025	—	0.0025	ASTM D-1353
—	15	—	15	—	15	—	15	ASTM D-1209
—	—	—	0.20	—	—	—	0.20	ASTM D-1364
mild, non-residual				mild, non-residual				Organoleptic
190.8		200.0		190.8		200.0		I.R.S. Gauging Manual
86.52 3.66 0.96 0.83 0.94 7.09 0.001		93.46 3.75 0.98 0.85 0.96 — 0.001		85.72 3.62 1.87 0.83 0.94 7.02 —		92.56 3.71 1.91 0.85 0.96 — —		
0.0010 0.0006		0.0011 0.0006		0.0010 0.0006		0.0011 0.0006		
10 50		7 45		10 50		9 48		ASTM D-56
15 59		10 50		14 57		11 51		ASTM D-1310
6.78		6.61		6.78		6.61		

FILMEX® SPECIAL INDUSTRIAL SOLVENTS

Introduction

Filmex is our trade name for special industrial solvent manufactured according to ATF regulations. Each of the six is available in both 190 proof and anhydrous formulations. No permits are required for the use of Filmex solvents.

Authorized Composition

Filmex special industrial solvents are formulated using SDA formula 3-A. This material is prepared by adding 5 gallons of methyl alcohol to 100 gallons of anhydrous or 190 proof ethyl alcohol. Government regulations also permit special industrial solvents to be prepared using SDA 3-C but these formulations are not discussed in this handbook.

Uses

Filmex is used in applications where some of the required denaturants present in proprietary solvents have an adverse effect on the intended use. Filmex, unlike proprietary solvents, will not cloud when diluted with water. Because of the high alcohol content of most formulations and the absence of water-insoluble hydrocarbons, the softening of rubber and various polymers is minimized when these materials are exposed to Filmex.

PRINTING

Filmex is often used in printing operations.
— to clean rubber rollers, plates, and type.
— formulating and thinning inks.
— in the rotogravure process it is especially suitable in producing sharp, distinct etchings.
Filmex is used in other critical arts where the clarity of solvent solution is extremely important.

TEXTILES

In the fabric and textile industry, Filmex is used to promote fabric adhesion, improve dye penetration and acceptance, and to soften various fibers.

CHEMICAL AND DRUG PROCESSING

Filmex has applications where the use of SDA is not required. Its uses include employment as a reaction and extraction solvent.

CHEMICAL SPECIALTIES

Photographic film is rapidly and cleanly dried with Filmex. It is also used as a latex coagulant solvent, in the formulation of lacquers and for numerous other applications where a high quality, special industrial solvent is desired.

Shipping Information

Deliveries of Filmex can be made in tank cars of 30,000-gallon and 20,000-gallon capacity; in tank trucks and drums.

Filmex is classified by the Department of Transportation (D.O.T.) as a flammable liquid. It is considered a denatured alcohol solvent and its D.O.T. nomenclature is alcohol N.O.S. It must be packaged in D.O.T. approved containers, and when shipped, all other regulations regarding labeling, loading and handling must be followed. Tank trucks, tank cars and box trailers (either truckloads or less than truckloads) must bear the D.O.T. flammable liquid placard. Drums must bear the D.O.T. red label for flammable liquids.

SPECIFICATIONS AND TYPICAL PROPERTIES

	FILMEX A-1				FILMEX A-2				FILMEX B			
	190 Proof Formulation		Anhydrous Formulation		190 Proof Formulation		Anhydrous Formulation		190 Proof Formulation		Anhydrous Formulation	
Authorized Formulation (Units are gallons)												
SDA 3-A	100		100		100		100		100		100	
Isopropyl Alcohol	10		10		—		—		5		5	
Methyl Isobutyl Ketone	1		1		1		1		1		1	
Methyl Alcohol	—		—		10		10		5		5	
Ethyl Acetate	—		—		—		—		—		—	
SPECIFICATIONS:	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Specific Gravity @ 60º/60º F	0.8120	0.8132	0.7932	0.7942	0.8126	0.8138	0.7936	0.7946	0.8124	0.8136	0.7934	0.7944
Acidity, as acetic (max. wt. as %)	—	0.0025	—	0.0025	—	0.0025	—	0.0025	—	0.0025	—	0.0025
Non-violatile matter (gm/100 ml, max)	—	0.0025	—	0.0025	—	0.0025	—	0.0025	—	0.0025	—	0.0025
Color (APHA)	—	10	—	10	—	10	—	10	—	10	—	10
Water, vol/vol %	—	—	—	0.20	—	—	—	0.20	—	—	—	0.20
Odor	mild and non-residual				mild and non-residual				mild and non-residual			
TYPICAL PROPERTIES:	% By Weight	% By Volume	% By Weight	% By Volume	% By Weight	% By Volume	% By Weight	% By Volume	% By Weight	% By Volume	% By Weight	% By Volume
Composition at 60º F												
—Ethyl Alcohol, absolute basis	79.62	81.52	85.81	85.80	79.56	81.58	85.75	85.80	79.59	81.54	85.78	85.81
—Methyl Alcohol	4.20	4.29	4.31	4.29	13.02	13.30	13.34	13.30	8.61	8.79	8.83	8.79
—Isopropyl Alcohol	8.76	9.01	8.97	9.01	—	—	—	—	4.38	4.51	4.48	4.50
—Methyl Isobutyl Ketone	0.89	0.90	0.91	0.90	0.89	0.90	0.91	0.90	0.89	0.90	0.91	0.90
—Ethyl Acetate	—	—	—	—	—	—	—	—	—	—	—	—
—Water	6.53	5.30	—	—	6.53	5.30	—	—	6.53	5.30	—	—
Apparent proof @ 60º F	191.6		200.0		191.3		199.8		191.4		199.9	
Coefficient of expansion—per 1º C	0.0011		0.0011		0.0011		0.0011		0.0011		0.0011	
per 1º F	0.0006		0.0006		0.0006		0.0006		0.0006		0.0006	
Flash Point:												
Tag Closed Cup, ºC	17		14		16		12		17		14	
ºF	61		57		60		54		61		57	
Tag Open Cup, ºC	19		18		19		17		19		18	
ºF	66		65		66		61		66		65	
Weight per gallon @ 60º F (lbs)	6.77		6.61		6.77		6.61		6.77		6.61	
Water Solubility	infinite				infinite				infinite			

FILMEX C				FILMEX D-1				FILMEX D-2				
190 Proof Formulation		Anhydrous Formulation		190 Proof Formulation		Anhydrous Formulation		190 Proof Formulation		Anhydrous Formulation		
100 — 1 — 4.25		100 — 1 — 4.25		100 15 1 — —		100 15 1 — —		100 — 1 15 —		100 — 1 15 —		
Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Test Method
0.8175	0.8187	0.7979	0.7989	0.8112	0.8124	0.7929	0.7939	0.8120	0.8132	0.7936	0.7946	ASTM D-891
—	0.0025	—	0.0025	—	0.0025	—	0.0025	—	0.0025	—	0.0025	ASTM D-1613
—	0.0025	—	0.0025	—	0.0025	—	0.0025	—	0.0025	—	0.0025	ASTM D-1353
—	10	—	10	—	10	—	10	—	10	—	10	ASTM D-1209
—	—	—	0.20	—	—	—	0.20	—	—	—	0.20	ASTM D-1364
mild and non-residual				mild and non-residual				mild and non-residual				Organoleptic
% By Weight	% By Volume	% By Weight	% By Volume	% By Weight	% By Volume	% By Weight	% By Volume	% By Weight	% By Volume	% By Weight	% By Volume	
83.36 4.40 —	85.95 4.52 —	89.95 4.52 —	90.49 4.52 —	76.28 4.03 12.58	78.02 4.11 12.93	82.13 4.12 12.88	82.10 4.11 12.93	76.21 16.69 —	78.02 17.04 —	82.05 17.08 —	82.10 17.04 —	
0.93 4.47 6.84	0.95 4.04 5.59	0.95 4.58 —	0.95 4.04 —	0.85 — 6.26	0.86 — 5.08	0.87 — —	0.86 — —	0.85 — 6.25	0.86 — 5.08	0.87 — —	0.86 — —	
188.8		198.1		192.0		200.1		191.6		199.8		I.R.S. Gauging Manual
0.0011 0.0006		0.0011 0.0006		0.0011 0.0006		0.0011 0.0006		0.0010 0.0006		0.0011 0.0006		
13 56 18 65		11 52 15 59		17 61 21 70		14 58 18 65		16 60 21 70		13 56 17 63		ASTM D-56 ASTM D-1310
6.81		6.65		6.76		6.61		6.77		6.61		
infinite				infinite				infinite				

S-SOLVENTS

Introduction

Equistar can provide government-approved, special solvent blends for specific authorized uses. These blends are prepared from various government approved formulas with other defined solvents. The resultant articles, such as printing inks, duplicating and printing fluids, contain specially denatured alcohol and may not be sold for other solvent use or be reprocessed into products for sales. Duplicating and printing fluids containing 1 percent or more of a glycol ether and 10 percent or more, by weight, of methyl alcohol may, however, be reprocessed into printing ink for sale, provided proper application and formula approval is obtained by the reprocessor from the ATF director.

Equistar invites you to discuss your special solvent requirements with a representative from the Equistar sales office nearest you.

COMPLETELY DENATURED ALCOHOL

Introduction

Completely denatured alcohol (CDA) is ethyl alcohol to which certain denaturants prescribed by the Bureau of Alcohol, Tobacco and Firearms, have been added to render it entirely unfit for human consumption. Because of this, CDA can be marketed and used with a minimum number of restrictions.

Regulations

Completely denatured alcohol may be handled, for legitimate purposes, by manufacturers, dealers, and the general public without filing a bond, obtaining a permit or payment of tax.

Uses

CDA is used in fuels, the manufacture of cleaning fluids, detergents, proprietary antifreeze solutions, thinners, lacquers, and brake fluids.

Since CDA is denatured with crude or partially refined products, it is not as suitable as a proprietary solvent for many manufacturing processes. CDA should not be used where odor may be a critical consideration. Of the three CDA formulas authorized, we recommend and supply CDA 19, denatured with the gasoline option, as the one more suitable for the majority of uses.

Authorized Composition

	CDA 19
Ethyl Alcohol, gallon	100
Methyl Isobutyl Ketone, gallon	4
Gasoline, Kerosene, or Deodorized Kerosene, gallon	1

CDA 19 Specifications

	190 PROOF FORMULATION		ANYDROUS FORMULATION		
	Minimum	Maximum	Minimum	Maximum	TEST METHOD
Specific Gravity @60ºF/60ºF @20ºC/20ºC @25ºC/25ºC	 0.8126 0.8094 0.8059	 0.8156 0.8124 0.8089	 0.7917 0.7885 0.7851	 0.7947 0.7915 0.7881	ASTM D-851
Acidity, wt/wt % as Acetic Acid	—	0.005	—	0.005	ASTM D-1613
Color: Pt-Co	—	15	—	15	ASTM D-1209
Non-volatile matter: grams/100 ml	—	0.005	—	0.005	ASTM D-1353
Water Content: Vol./Vol. %	—	—	—	0.20	ASTM D-1364
Odor	Typical, Characteristic		Typical, Characteristic		Organoleptic

Typical Properties

	190 PROOF	ANHYDROUS	TEST METHOD
Apparent Proof @ 60º F	190.9	200.2	I.R.S. Gauging Manual
Ethyl Alcohol Content, vol./vol.% Absolute basis	 90.5	 95.3	
Coefficient of Expansion: per 1º C per 1º F	 0.0011 0.0006	 0.0011 0.0006	
Flash Point Tag Closed Cup ºC ºF Tag Open Cup ºC ºF	 12 54 19 67	 12 53 17 62	 ASTM D-1310 ASTM D-56
Weight per gallon, lbs. @ 60º F	6.78	6.71	

Equistar supplies industrial users of CDA in tank cars, (20,000 gallon minimum) tank trucks, and drums.

Shipping Information

CDA is classified by the Department of Transportation (D.O.T.) as a flammable liquid. It must be packaged in D.O.T. approved containers, and when shipped, all other regulations regarding labeling, loading and handling must be followed. Tank trucks and tank cars must bear the D.O.T. flammable liquid placard. Drums must bear the D.O.T. red label for flammable liquids.


DL18

ETHYL ALCOHOL PROPERTIES

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PHYSICAL AND THERMODYNAMIC PROPERTIES

Units				REFERENCE
Molecular Weight		46.07		1
CAS Registry No.		000064175		
Autoignition Temperature	°C °F	423 793		3 3
Boiling Point at 760 mm Hg	°C °F	78.29 172.92		2 2
Bulk Modulus of Elasticity @ 68°F	$K_m$psi	15-7,350 psi 7,350-14,700 psi 14,700-22,050 psi 22,050-29,400 psi 29,400-36,750 psi	1.75×10^5 2.36×10^5 3.00×10^5 3.52×10^5 4.16×10^5	7
Coefficient of Expansion per °C per °F		 0.0011 0.0006		 5 5
Critical Density	gm/cm^3	0.276		1
Critical Pressure	atmospheres psia	63.1 927.3		4 4
Critical Temperature	°C °F	243.1 469.6		1 1
Density @15°C @20°C @25°C	 gm/cm^3 gm/cm^3 gm/cm^3	 0.79360 0.78937 0.78509		 1 2 2
Density @60°F	lb/ft^3	49.3		7
Dielectric Constant @25°C		 24.55		 1
Dipole Moment, Liquid @20°C	$\mu \times 10^{18}$esu	1.66		1
Electrical Conductivity @ 25°C	$ohm^{-1}\,cm^{-1}$	1.35×10^{-9}		1
Explosive Limits in Air Lower Upper	 volume % volume %	 3.3 19.0		3
Flame Temperature, Ethanol-Air	°C °F	1575 2870		8 8
Flash Point Tag Open Cup Tag Closed Cup	 °C °F °C °F	 18 65 14 57		 5 5 5 5

	Units		REFERENCE
Free Energy of Formation, ΔF^o @ 25	Kcal/mole	-40.2	4
Freezing Point	°C °F	-114.1 -173.4	2 2
Heat Capacity (Liquid) @ 78.29°C	cal/ °C /mole	33.10	2
Heat of Combustion	Kcal/mole	326.86	2
Heat of Formation, Liquid ΔH @ 25°C	Kcal/mole	-64.7	4
Heat of Fusion @ Freezing Point	cal/gm	24.9	4
Heat of Vaporization @ Boiling Point	cal/gm	204.3	4
Magneto-optic Rotation @ 20°C and 589.3 nμ	Verdet's Constant (r)	+0.0107	7
Refractive Index @ 760 mm and 20°C 25°C 30°C	n_D n_D n_D	1.3614 1.3594 1.3575	2 2 2
Solubility in Water	miscible in all proportions		
Specific Gravity @ 60°F/60°F		0.7937	4
Specific Heat @ 0°C	cal/gm	0.548	7
Surface Tension	20°C dynes/cm 30°C dynes/cm	22.32 21.48	1 1
Thermal Conductivity @ 20°C	BTU/(hr)(sq.ft.)(°F/ft.)	0.105	4
Threshold Limit Value	volume of vapor/million volumes, contaminated air @ 25°C and 760 mm Hg	1000	6
Vapor Density	Air = 1	1.59	3
Viscosity @25°C @30°C	 centipoises centipoises	 1.078 0.991	 1 1

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1. Riddick, John A. and Bunger, William B., *Organic Solvents*, 3rd Edition, Wiley-Interscience (1970)
2. Wilhoit, R.C. and Zwolinski, B.J., "Physical and Thermodynamic Properties of Aliphatic Alcohols," American Chemical Society and American Institute of Physics (1973)
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4. Mellan, Ibert, *Industrial Solvents Handbook*, 2nd Edition, Noyes Data Corporation (1977)
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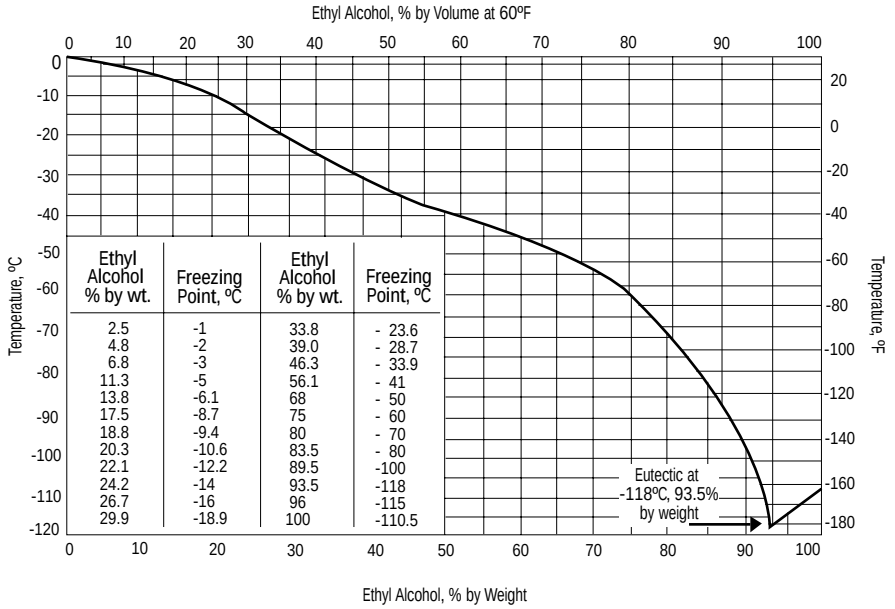
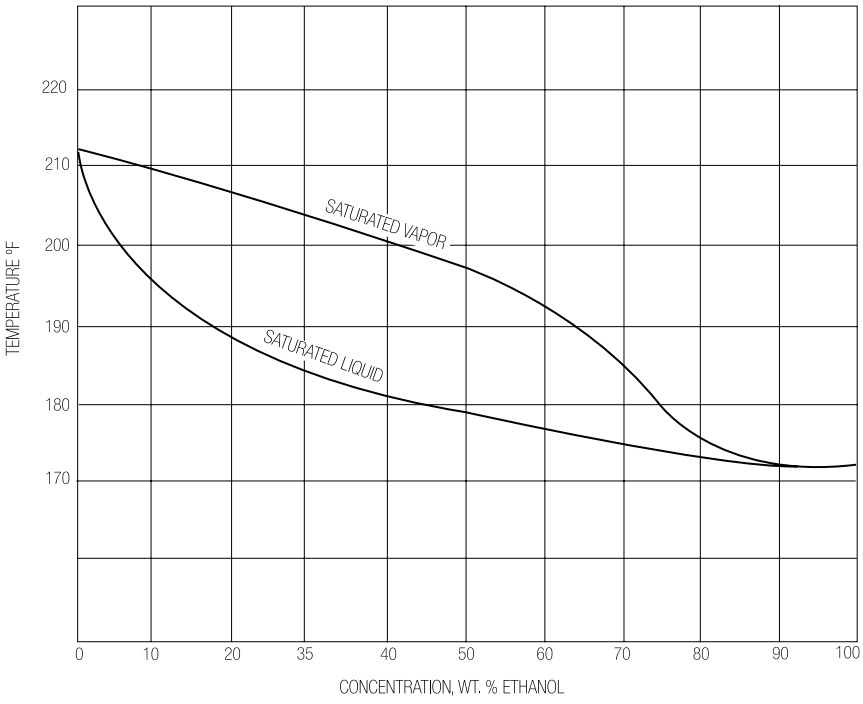
FREEZING POINTS OF ETHYL ALCOHOL-WATER MIXTURES



Ethyl Alcohol % by wt.	Freezing Point, ºC	Ethyl Alcohol % by wt.	Freezing Point, ºC
2.5	-1	33.8	- 23.6
4.8	-2	39.0	- 28.7
6.8	-3	46.3	- 33.9
11.3	-5	56.1	- 41
13.8	-6.1	68	- 50
17.5	-8.7	75	- 60
18.8	-9.4	80	- 70
20.3	-10.6	83.5	- 80
22.1	-12.2	89.5	-100
24.2	-14	93.5	-118
26.7	-16	96	-115
29.9	-18.9	100	-110.5

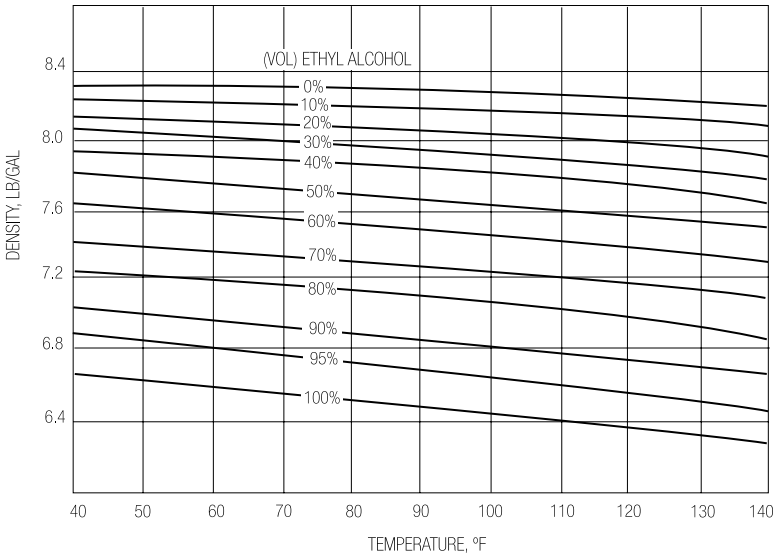
J.C. Chu et al., 'Vapor-Liquid Equilibrium Data,' J.W. Edwards, Ann Arbor, Michigan (1956)

BOILING POINT OF ETHYL ALCOHOL-WATER MIXTURES



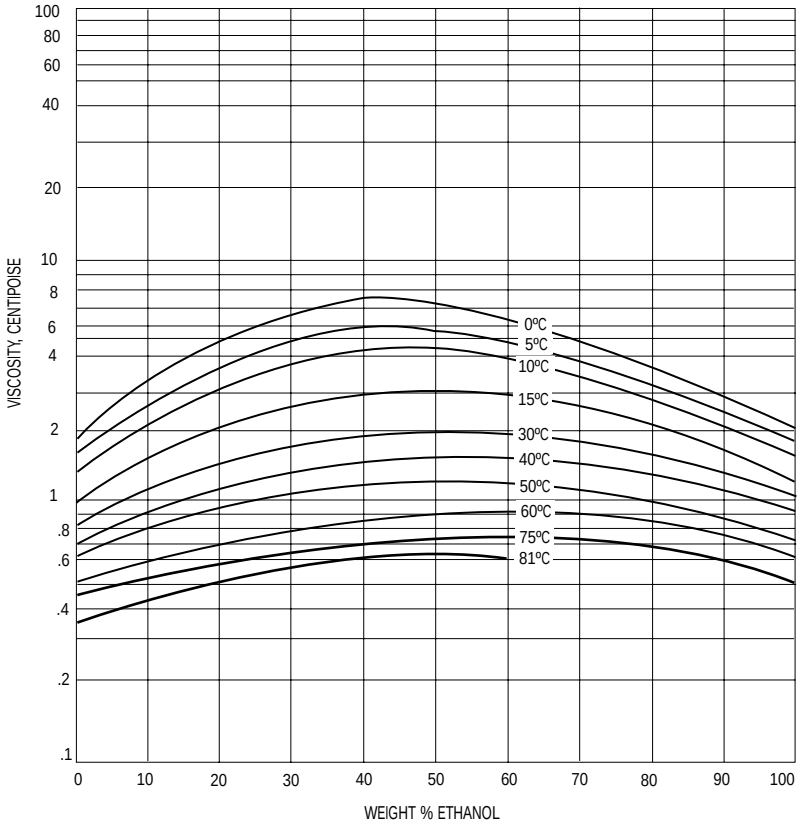
E.W. Washburn et al., International Critical Tables of Numerical Data, Physics, Chemistry and Technology. McGraw Hill, New York (1933)

DENSITY OF ETHYL ALCOHOL-WATER MIXTURES



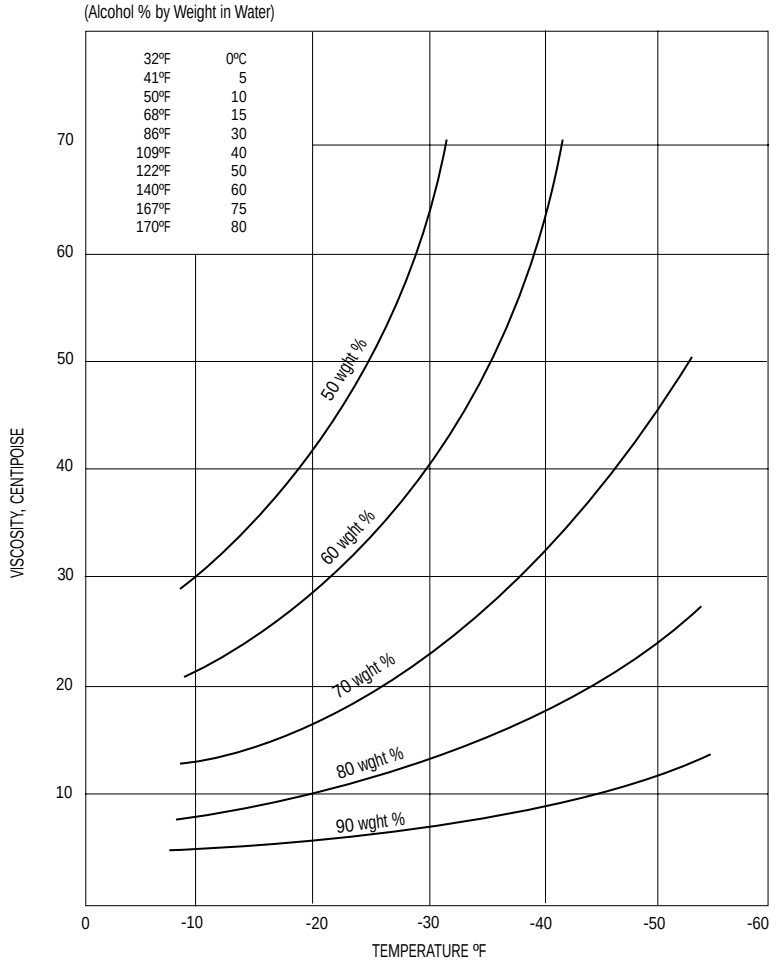
National Bureau of Standards Bulletin, 14 (1918), 59.
Equistar Chemicals, LP, Tuscola, Illinois.

VISCOSITY OF ETHYL ALCOHOL-WATER MIXTURES



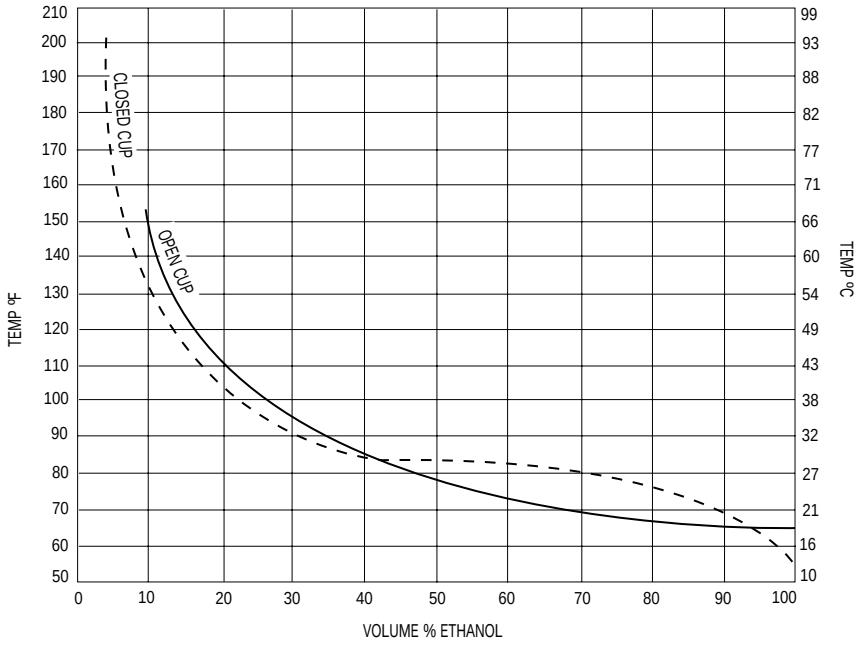
VISCOSITY OF ETHYL ALCOHOL–WATER MIXTURES

(Alcohol % by Weight in Water)



FLASH POINT OF AQUEOUS ETHYL ALCOHOL SOLUTIONS

ºC and ºF VS VOL. % ETHANOL



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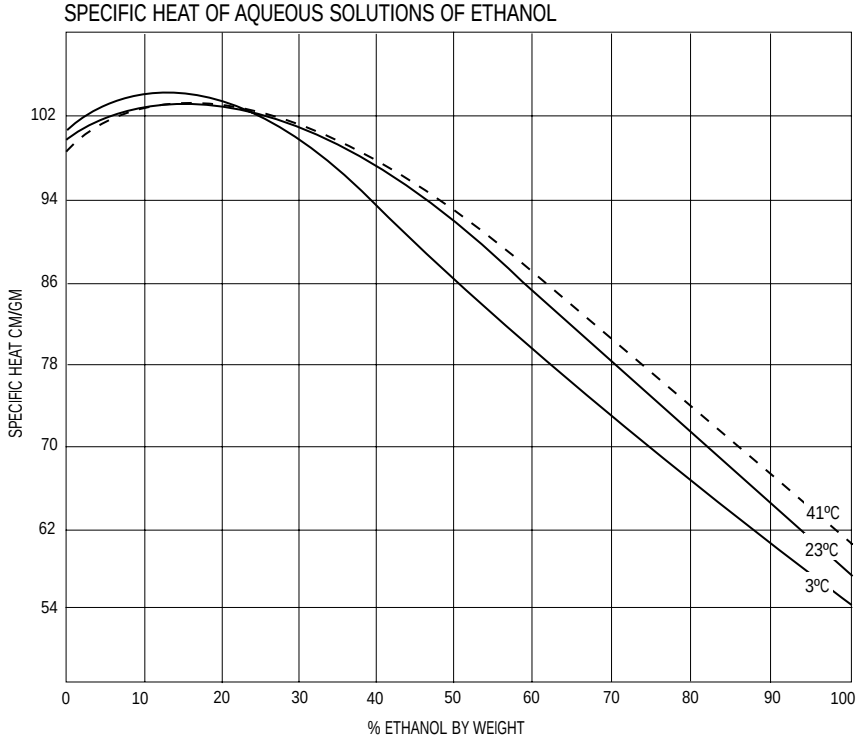
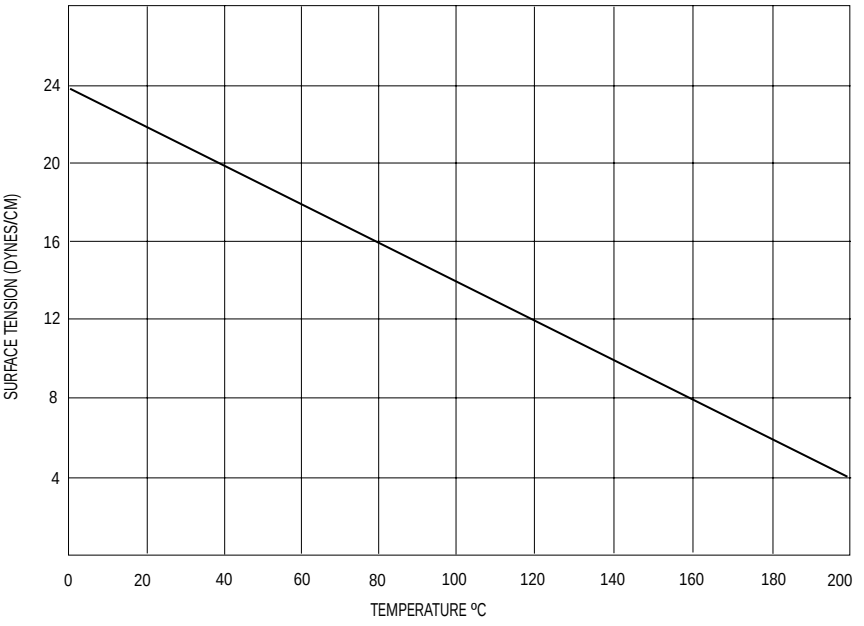
SPECIFIC HEAT OF AQUEOUS SOLUTIONS OF ETHANOL



Ibert Mellan, 'Industrial Solvents,' 2nd Edition, Reinhold Publishing Corp. (1950)

SURFACE TENSION OF PURE ETHANOL AT VARIOUS TEMPERATURES



Ibert Mellan, "Industrial Solvents Handbook"
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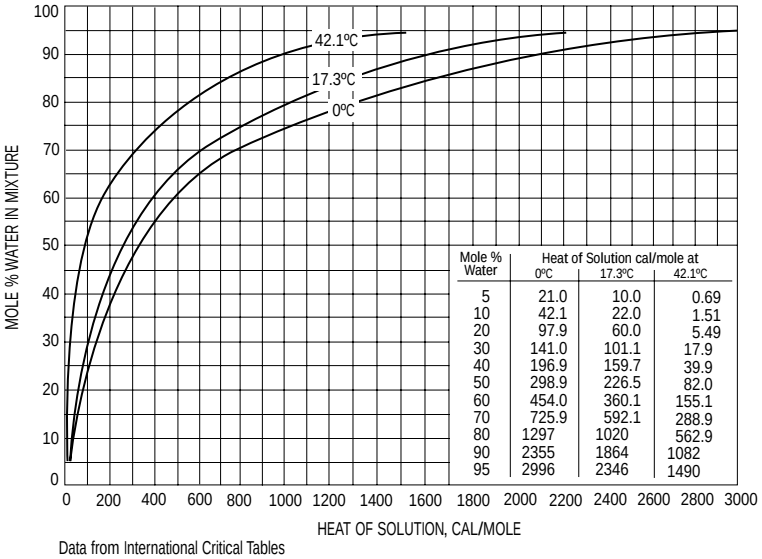
HEAT OF SOLUTION OF ETHYL ALCOHOL IN WATER

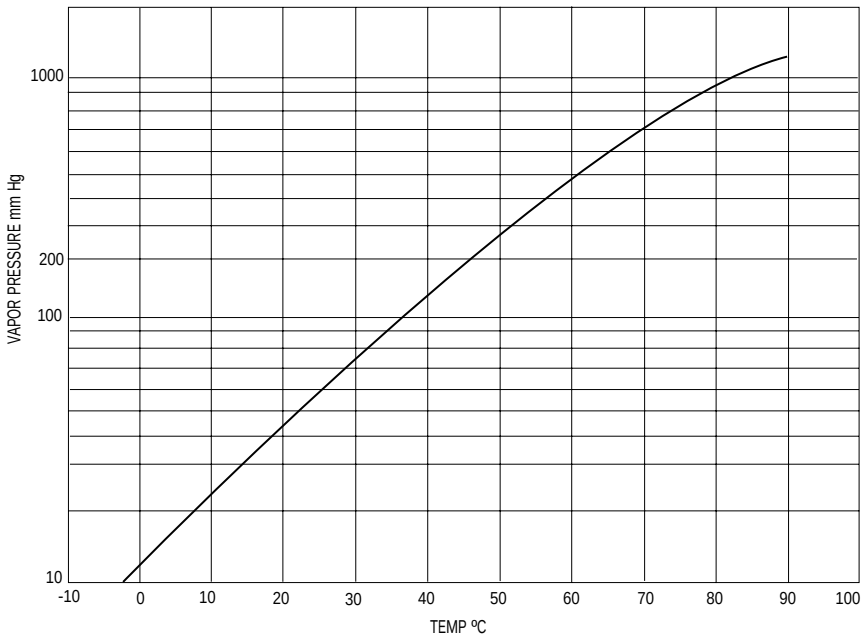


Mole % Water	Heat of Solution cal/mole at 0ºC	17.3ºC	42.1ºC
5	21.0	10.0	0.69
10	42.1	22.0	1.51
20	97.9	60.0	5.49
30	141.0	101.1	17.9
40	196.9	159.7	39.9
50	298.9	226.5	82.0
60	454.0	360.1	155.1
70	725.9	592.1	288.9
80	1297	1020	562.9
90	2355	1864	1082
95	2996	2346	1490

Data from International Critical Tables
BTU/lb mole = 1.8 cal/g mole

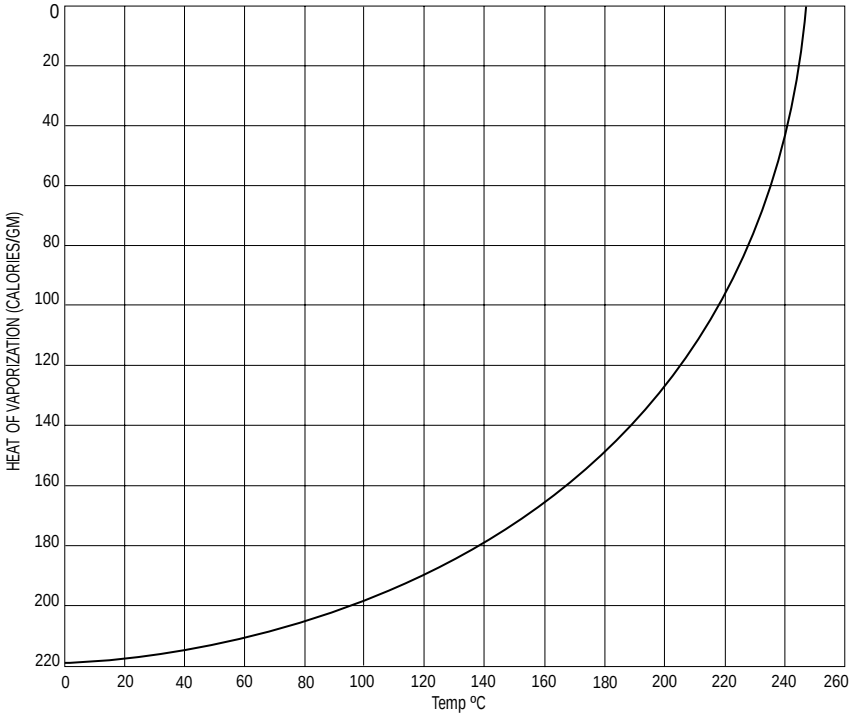
R.C. Wilhoit & B.J. Zwolinski, 'Physical and Thermodynamic Properties of Aliphatic Alcohols,'
American Chemical Society and American Institute of Physics (1973)

VAPOR PRESSURE OF ETHYL ALCOHOL



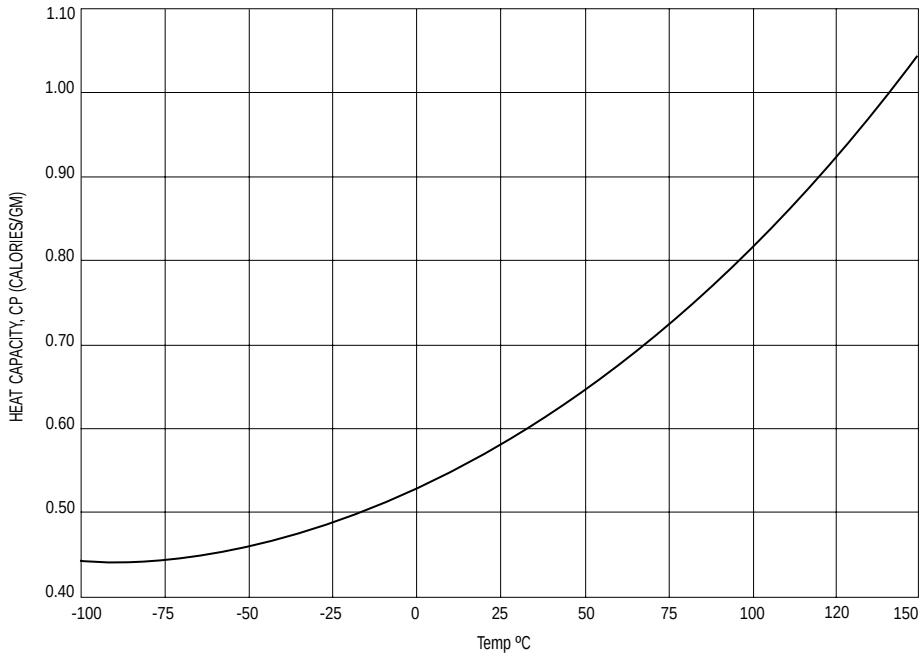
R.C. Wilhoit & B.J. Zwolinski, 'Physical and Thermodynamic Properties of Aliphatic Alcohols,' American Chemical Society and American Institute of Physics (1973)

LATENT HEAT OF VAPORIZATION OF ETHYL ALCOHOL



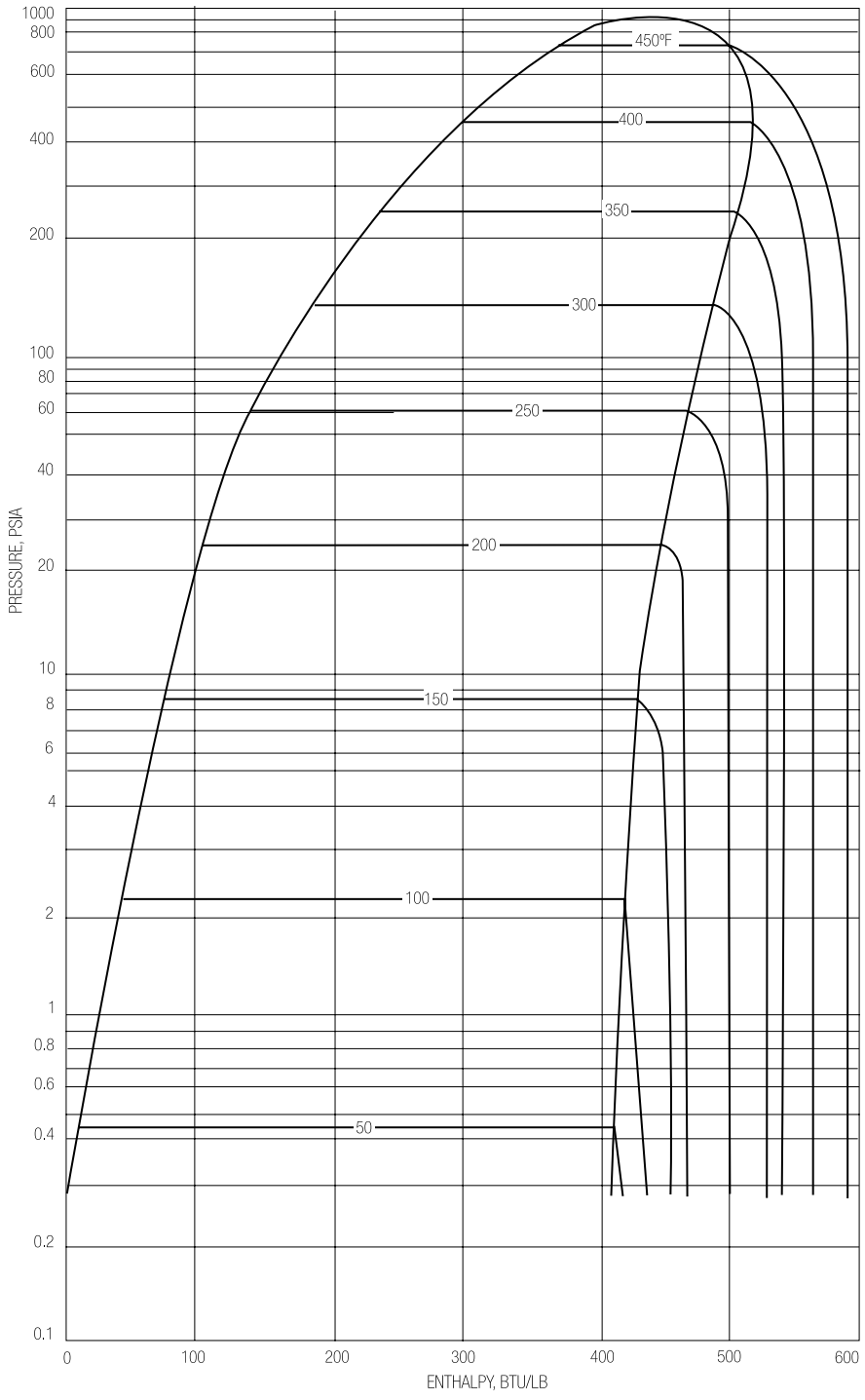
Data from International Critical Tables

HEAT CAPACITY OF ETHYL ALCOHOL AT VARIOUS TEMPERATURES



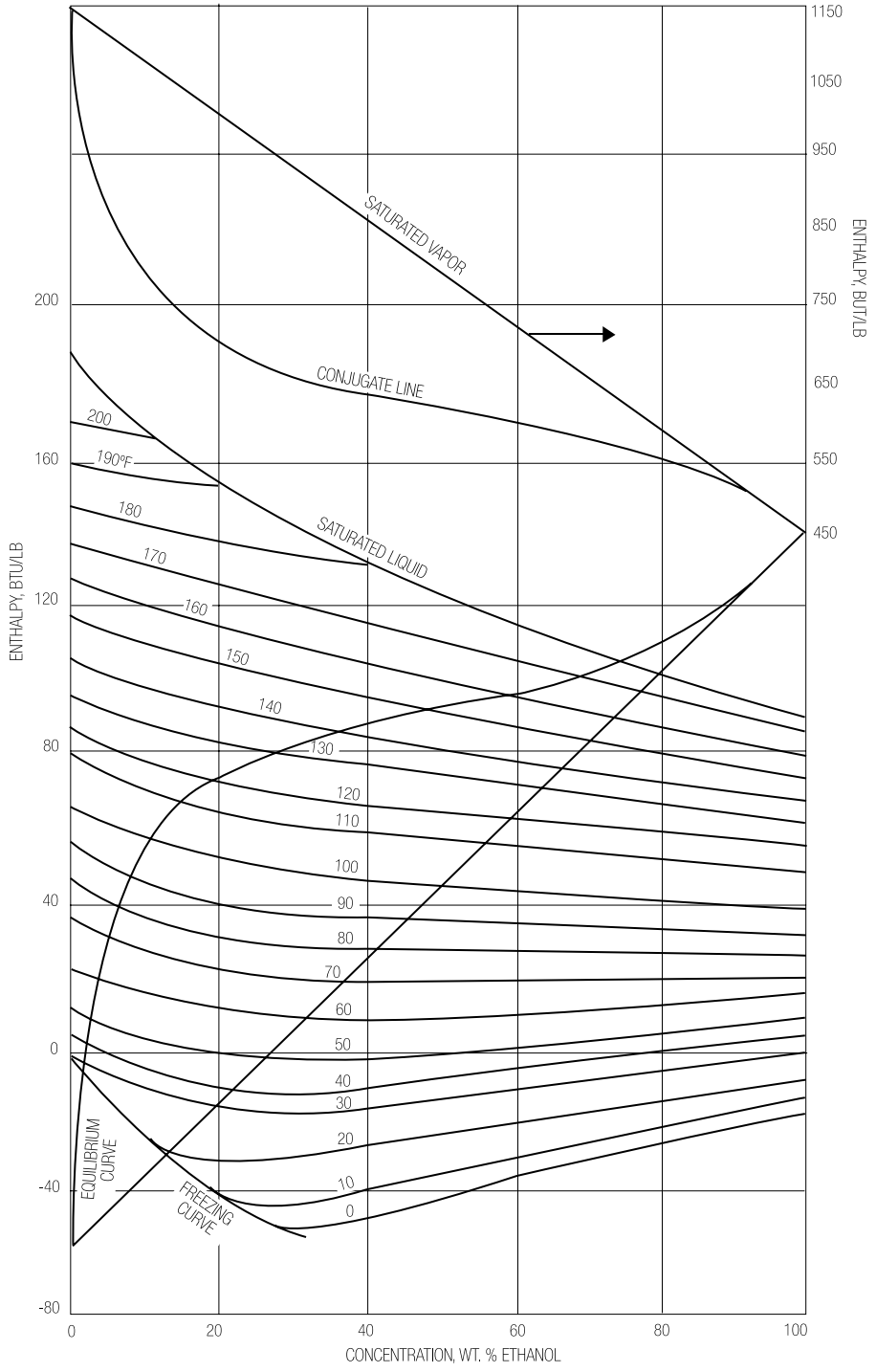
ENTHALPY OF ETHYL ALCOHOL

Reference: Chem. Eng. Prog., 47, 417 (1951)



ENTHALPY OF ETHANOL–WATER MIXTURES

Reference: Pet. Refiner, 24, 297 (1945)



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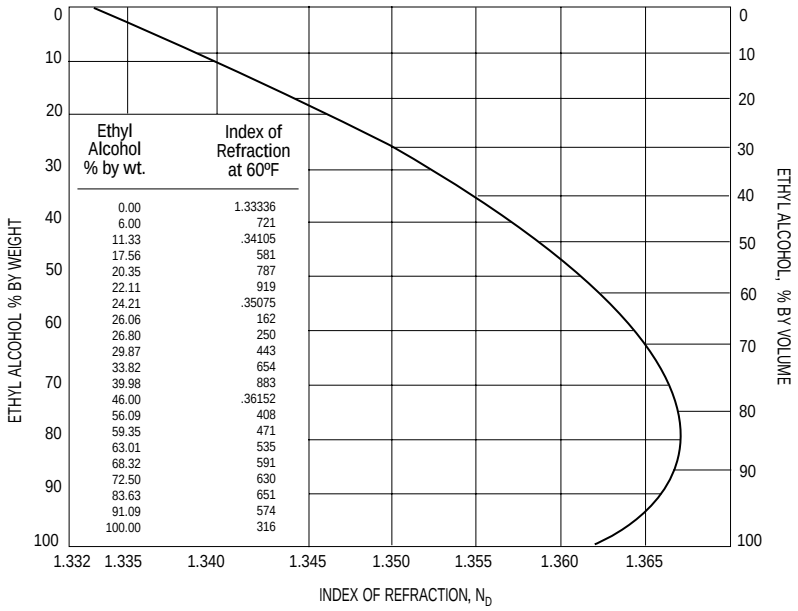
INDEX OF REFRACTION OF ETHYL ALCOHOL-WATER MIXTURES AT 60ºF



Ethyl Alcohol % by wt.	Index of Refraction at 60ºF
0.00	1.33336
6.00	721
11.33	.34105
17.56	581
20.35	787
22.11	919
24.21	.35075
26.06	162
26.80	250
29.87	443
33.82	654
39.98	883
46.00	.36152
56.09	408
59.35	471
63.01	535
68.32	591
72.50	630
83.63	651
91.09	574
100.00	316

Data from International Critical Tables

CONVERSION TABLE: WEIGHT AND VOLUME PERCENT OF ETHYL ALCOHOL IN ETHYL ALCOHOL-WATER MIXTURES

% Alcohol By Volume at 60ºF	% to be Converted	% Alcohol By Weight	% Alcohol By Volume at 60ºF	% to be Converted	% Alcohol By Weight	% Alcohol By Volume at 60ºF	% to be Converted	% Alcohol By Weight	% Alcohol By Volume at 60ºF	% to be Converted	% Alcohol By Weight
1.257	1	0.795	31.555	26	21.285	58.844	51	43.428	82.121	76	68.982
2.510	2	1.593	32.719	27	22.127	59.852	52	44.374	82.967	77	70.102
3.758	3	2.392	33.879	28	22.973	60.854	53	45.326	83.805	78	71.234
5.002	4	3.194	35.033	29	23.820	61.850	54	46.283	84.636	79	72.375
6.243	5	3.998	36.181	30	24.670	62.837	55	47.245	85.459	80	73.526
7.479	6	4.804	37.323	31	25.524	63.820	56	48.214	86.275	81	74.686
8.712	7	5.612	38.459	32	26.382	64.798	57	49.187	87.083	82	75.858
9.943	8	6.422	39.590	33	27.242	65.768	58	50.167	87.885	83	77.039
11.169	9	7.234	40.716	34	28.104	66.732	59	51.154	88.678	84	78.233
12.393	10	8.047	41.832	35	28.971	67.690	60	52.147	89.464	85	79.441
13.613	11	8.862	42.944	36	29.842	68.641	61	53.146	90.240	86	80.662
14.832	12	9.679	44.050	37	30.717	69.586	62	54.152	91.008	87	81.897
16.047	13	10.497	45.149	38	31.596	70.523	63	55.165	91.766	88	83.144
17.259	14	11.317	46.242	39	32.478	71.455	64	56.184	92.517	89	84.408
18.469	15	12.138	47.328	40	33.364	72.380	65	57.208	93.254	90	85.689
19.676	16	12.961	48.407	41	34.254	73.299	66	58.241	93.982	91	86.989
20.880	17	13.786	49.480	42	35.150	74.211	67	59.279	94.700	92	88.310
22.081	18	14.612	50.545	43	36.050	75.117	68	60.325	95.407	93	89.652
23.278	19	15.440	51.605	44	36.955	76.016	69	61.379	96.103	94	91.025
24.472	20	16.269	52.658	45	37.865	76.909	70	62.441	96.787	95	92.423
25.662	21	17.100	53.705	46	38.778	77.794	71	63.511	97.459	96	93.851
26.849	22	17.933	54.746	47	39.697	78.672	72	64.588	98.117	97	95.315
28.032	23	18.768	55.780	48	40.622	79.544	73	65.674	98.759	98	96.820
29.210	24	19.604	56.808	49	41.551	80.410	74	66.768	99.386	99	98.381
30.388	25	20.443	57.830	50	42.487	81.269	75	67.870	100.000	100	100.000

Values from Tables 5 and 6, Bureau of Standards Circular No. 19

VOLUMETRIC EQUIVALENTS

The following table will be helpful in the preparation of reports showing disposition of 190 proof and anhydrous (200 proof) tax-free and specially denatured alcohol.

Fluid Ounces	Milliliters	Wine Gallons	Proof Gallons	
			190 Proof	200 Proof
1	30.	0.008	0.015	0.016
2	59.	.016	.030	.031
3	89.	.023	.045	.047
4	118.	.031	.059	.062
5	148.	.039	.074	.078
6	177.	.047	.088	.094
7	207.	.055	.103	.109
8	237.	.063	.119	.125
9	266.	.070	.134	.140
10	296.	.078	.149	.156
11	325.	.086	.164	.172
12	355.	.094	.179	.187
13	385.	.102	.194	.203
14	414.	.109	.209	.218
15	444.	.117	.224	.234
16 (1 pint)	473.	.125	.238	.250
32 (1 quart)	946.	.250	.475	.500
64 (2 quarts)	1892	.500	.950	1.000
96	2839	.750	1.425	1.500
128 (1 U.S. gallon)	3785	1.000	1.900	2.000
		5.000	9.500	10.000
		30.000	57.000	60.000
		54.000	102.600	108.000
		55.000	104.500	110.000

ETHYL–ALCOHOL WATER MIXTURES

Corresponding values for proof, parts by volume of water and alcohol, weight % alcohol and specific gravity in air.

U.S. PROOF degrees at 60ºF	PARTS BY VOLUME* OF		WEIGHT % ETHYL ALCOHOL	SPECIFIC GRAVITY		
	WATER	ETHYL ALCOHOL		at 60º/60ºF (15.56º/15.56ºC)	at 68º/68ºF (20º/20ºC)	at 77º/77ºF (25º/25ºC)
0	100.00	0.0	0.00	1.0000	1.0000	1.0000
1	99.53	0.5	0.40	.9992	.9992	.9992
2	99.06	1.0	0.80	.9985	.9985	.9985
3	98.58	1.5	1.19	.9978	.9978	.9978
4	98.12	2.0	1.59	.9970	.9970	.9970
5	97.65	2.5	1.99	.9963	.9963	.9963

*The parts by volume of water and the parts by volume of ethyl alcohol do not add to unity (100) at any one proof reading because of the shrinkage in volume which occurs when ethyl alcohol and water are mixed. The *parts* by *volume* of ethyl alcohol are the same as *percent* by *volume* of ethyl alcohol used to determine proof for tax purposes. Ethyl alcohol proof, by legal definition, is twice the percent by volume.

U.S. PROOF degrees at 60ºF	PARTS BY VOLUME* OF		WEIGHT % ETHYL ALCOHOL	SPECIFIC GRAVITY		
	WATER	ETHYL ALCOHOL		at 60º/60ºF (15.56º/15.56ºC)	at 68º/68ºF (20º/20ºC)	at 77º/77ºF (25º/25ºC)
6	97.18	3.0	2.39	.9956	.9956	.9956
7	96.71	3.5	2.79	.9949	.9949	.9948
8	96.24	4.0	3.19	.9942	.9942	.9941
9	95.78	4.5	3.60	.9935	.9935	.9934
10	95.31	5.0	4.00	.9928	.9928	.9927
11	94.85	5.5	4.40	.9921	.9921	.9921
12	94.39	6.0	4.80	.9915	.9914	.9914
13	93.93	6.5	5.21	.9908	.9908	.9907
14	93.46	7.0	5.61	.9902	.9902	.9901
15	93.01	7.5	6.02	.9896	.9895	.9894
16	92.55	8.0	6.42	.9890	.9889	.9888
17	92.09	8.5	6.83	.9884	.9983	.9882
18	91.63	9.0	7.23	.9878	.9876	.9875
19	91.18	9.5	7.64	.9872	.9870	.9869
20	90.72	10.0	8.05	.9866	.9864	.9863
21	90.27	10.5	8.46	.9860	.9858	.9856
22	89.81	11.0	8.86	.9854	.9852	.9850
23	89.36	11.5	9.27	.9848	.9846	.9844
24	88.90	12.0	9.68	.9843	.9840	.9838
25	88.45	12.5	10.09	.9837	.9835	.9832
26	88.00	13.0	10.50	.9832	.9829	.9826
27	87.55	13.5	10.91	.9826	.9823	.9820
28	87.10	14.0	11.32	.9821	.9817	.9814
29	86.65	14.5	11.73	.9816	.9812	.9808
30	86.20	15.0	12.14	.9810	.9806	.9802
31	85.75	15.5	12.55	.9805	.9801	.9796
32	85.30	16.0	12.96	.9800	.9797	.9790
33	84.85	16.5	13.37	.9794	.9790	.9784
34	84.40	17.0	13.79	.9789	.9784	.9778
35	83.95	17.5	14.20	.9784	.9779	.9773
36	83.50	18.0	14.61	.9779	.9773	.9767
37	83.06	18.5	15.03	.9774	.9768	.9761
38	82.61	19.0	15.44	.9769	.9763	.9756
39	82.16	19.5	15.85	.9764	.9757	.9750
40	81.72	20.0	16.27	.9759	.9752	.9744
41	81.27	20.5	16.68	.9754	.9747	.9739
42	80.82	21.0	17.10	.9749	.9741	.9733
43	80.38	21.5	17.52	.9744	.9736	.9727
44	79.93	22.0	17.93	.9739	.9731	.9721

* The parts by volume of water and the parts by volume of ethyl alcohol do not add to unity (100) at any one proof reading because of the shrinkage in volume which occurs when ethyl alcohol and water are mixed. The *parts by volume* of ethyl alcohol are the same as *percent by volume* of ethyl alcohol used to determine proof for tax purposes. Ethyl alcohol proof, by legal definition, is twice the percent by volume.

U.S. PROOF degrees at 60ºF	PARTS BY VOLUME* OF		WEIGHT % ETHYL ALCOHOL	SPECIFIC GRAVITY		
	WATER	ETHYL ALCOHOL		at 60º/60ºF (15.56º/15.56ºC)	at 68º/68ºF (20º/20ºC)	at 77º/77ºF (25º/25ºC)
45	79.48	22.5	18.35	.9734	.9725	.9715
46	79.03	23.0	18.77	.9729	.9720	.9710
47	78.58	23.5	19.19	.9724	.9714	.9704
48	78.14	24.0	19.60	.9718	.9708	.9698
49	77.69	24.5	20.02	.9713	.9703	.9692
50	77.24	25.0	20.44	.9708	.9697	.9686
51	76.79	25.5	20.86	.9703	.9691	.9679
52	76.34	26.0	21.28	.9697	.9686	.9673
53	75.89	26.5	21.71	.9692	.9680	.9667
54	75.44	27.0	22.13	.9687	.9674	.9661
55	74.98	27.5	22.55	.9681	.9668	.9654
56	74.53	28.0	22.97	.9676	.9662	.9648
57	74.08	28.5	23.40	.9670	.9656	.9642
58	73.62	29.0	23.82	.9664	.9650	.9635
59	73.17	29.5	24.24	.9659	.9644	.9629
60	72.72	30.0	24.67	.9653	.9638	.9622
61	72.26	30.5	25.10	.9647	.9632	.9616
62	71.81	31.0	25.52	.9641	.9626	.9609
63	71.35	31.5	25.95	.9635	.9619	.9602
64	70.89	32.0	26.38	.9629	.9613	.9595
65	70.13	32.5	26.81	.9623	.9606	.9588
66	66.97	33.0	27.24	.9616	.9599	.9581
67	69.51	33.5	27.67	.9610	.9593	.9574
68	69.05	34.0	28.10	.9604	.9586	.9567
69	68.59	34.5	28.54	.9597	.9579	.9559
70	68.12	35.0	28.97	.9590	.9572	.9552
71	67.66	35.5	29.41	.9584	.9565	.9544
72	67.19	36.0	29.84	.9576	.9557	.9537
73	66.72	36.5	30.28	.9570	.9550	.9529
74	66.25	37.0	30.72	.9562	.9542	.9521
75	65.78	37.5	31.16	.9555	.9535	.9513
76	65.31	38.0	31.60	.9548	.9527	.9505
77	64.84	38.5	32.04	.9540	.9519	.9497
78	64.37	39.0	32.48	.9533	.9512	.9489
79	63.90	39.5	32.92	.9525	.9504	.9481
80	63.42	40.0	33.36	.9517	.9496	.9473
81	62.95	40.5	33.81	.9509	.9488	.9464
82	62.47	41.0	34.25	.9501	.9479	.9456
83	61.99	41.5	34.70	.9493	.9471	.9447

The parts by volume of water and the parts by volume of ethyl alcohol do not add to unity (100) at any one proof reading because of the shrinkage in volume which occurs when ethyl alcohol and water are mixed. The *parts by volume* of ethyl alcohol are the same as *percent by volume* of ethyl alcohol used to determine proof for tax purposes. Ethyl alcohol proof, by legal definition, is twice the percent by volume.

U.S. PROOF degrees at 60ºF	PARTS BY VOLUME* OF		WEIGHT % ETHYL ALCOHOL	SPECIFIC GRAVITY		
	WATER	ETHYL ALCOHOL		at 60º/60ºF (15.56º/15.56ºC)	at 68º/68ºF (20º/20ºC)	at 77º/77ºF (25º/25ºC)
84	61.52	42.0	35.15	.9485	.9463	.9439
85	61.04	42.5	35.60	.9477	.9454	.9430
86	60.56	43.0	36.05	.9469	.9446	.9421
87	60.08	43.5	36.50	.9460	.9437	.9412
88	59.59	44.0	36.96	.9452	.9428	.9403
89	59.11	44.5	37.41	.9443	.9419	.9394
90	58.63	45.0	37.86	.9434	.9410	.9385
91	58.14	45.5	38.32	.9426	.9402	.9376
92	57.66	46.0	38.78	.9417	.9292	.9366
93	57.17	46.5	39.24	.9408	.9383	.9357
94	56.68	47.0	39.70	.9399	.9374	.9348
95	56.19	47.5	40.16	.9389	.9364	.9338
96	55.70	48.0	40.62	.9380	.9355	.9328
97	55.21	48.5	41.09	.9371	.9345	.9319
98	54.72	49.0	41.55	.9361	.9336	.9309
99	54.22	49.5	42.02	.9352	.9326	.9299
100	53.73	50.0	42.49	.9342	.9316	.9289
101	53.24	50.5	42.96	.9332	.9306	.9279
102	52.74	51.0	43.43	.9322	.9296	.9269
103	52.25	51.5	43.90	.9312	.9286	.9258
104	51.75	52.0	44.37	.9302	.9276	.9248
105	51.25	52.5	44.85	.9292	.9266	.9238
106	50.75	53.0	45.33	.9282	.9256	.9228
107	50.26	53.5	45.80	.9272	.9245	.9217
108	49.76	54.0	46.28	.9262	.9235	.9207
109	49.26	54.5	46.76	.9252	.9225	.9196
110	48.76	55.0	47.24	.9241	.9214	.9185
111	48.25	55.5	47.73	.9230	.9204	.9175
112	47.75	56.0	48.21	.9220	.9193	.9164
113	47.25	56.5	48.70	.9210	.9182	.9153
114	46.75	57.0	49.19	.9199	.9171	.9142
115	46.24	57.5	49.68	.9188	.9161	.9131
116	45.74	58.0	50.17	.9177	.9150	.9120
117	45.23	58.5	50.66	.9166	.9139	.9109
118	44.72	59.0	51.15	.9156	.9128	.9098
119	44.22	59.5	51.65	.9144	.9116	.9087
120	43.71	60.0	52.15	.9133	.9105	.9076
121	43.20	60.5	52.65	.9122	.9094	.9064
122	42.69	61.0	53.15	.9111	.9083	.9053

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U.S. PROOF degrees at 60ºF	PARTS BY VOLUME* OF		WEIGHT % ETHYL ALCOHOL	SPECIFIC GRAVITY		
	WATER	ETHYL ALCOHOL		at 60º/60ºF (15.56º/15.56ºC)	at 68º/68ºF (20º/20ºC)	at 77º/77ºF (25º/25ºC)
123	42.18	61.5	53.65	.9100	.9071	.9041
124	41.67	62.0	54.15	.9088	.9060	.9030
125	41.16	62.5	54.66	.9077	.9048	.9018
126	40.65	63.0	55.16	.9065	.9037	.9006
127	40.14	63.5	55.67	.9054	.9025	.8995
128	39.62	64.0	56.18	.9042	.9014	.8983
129	39.11	64.5	56.70	.9031	.9002	.8971
130	38.60	65.0	57.21	.9019	.8990	.8959
131	38.08	65.5	57.72	.9007	.8978	.8948
132	37.57	66.0	58.24	.8996	.8966	.8936
133	37.05	66.5	58.76	.8984	.8954	.8924
134	36.54	67.0	59.28	.8972	.8942	.8912
135	36.02	67.5	59.80	.8960	.8930	.8899
136	35.50	68.0	60.32	.8948	.8918	.8887
137	34.99	68.5	60.85	.8936	.8906	.8875
138	34.47	69.0	61.38	.8923	.8894	.8862
139	33.95	69.5	61.91	.8911	.8882	.8850
140	33.43	70.0	62.44	.8899	.8869	.8838
141	32.91	70.5	62.98	.8886	.8856	.8825
142	32.38	71.0	63.51	.8874	.8844	.8812
143	31.86	71.5	64.05	.8861	.8831	.8800
144	31.34	72.0	64.59	.8848	.8819	.8787
145	30.82	72.5	65.13	.8836	.8806	.8774
146	30.29	73.0	65.67	.8823	.8793	.8761
147	29.76	73.5	66.22	.8810	.8780	.8748
148	29.24	74.0	66.77	.8797	.8767	.8735
149	28.71	74.5	67.32	.8784	.8754	.8722
150	28.19	75.0	67.87	.8771	.8741	.8709
151	27.66	75.5	68.43	.8758	.8728	.8696
152	27.13	76.0	68.98	.8745	.8715	.8682
153	26.60	76.5	69.54	.8732	.8702	.8669
154	26.07	77.0	70.10	.8718	.8688	.8655
155	25.54	77.5	70.67	.8705	.8674	.8642
156	25.01	78.0	71.23	.8691	.8661	.8628
157	24.47	78.5	71.80	.8678	.8647	.8614
158	23.94	79.0	72.38	.8664	.8633	.8600
159	23.40	79.5	72.95	.8650	.8620	.8586
160	22.87	80.0	73.53	.8636	.8606	.8572
161	22.33	80.5	74.11	.8622	.8592	.8558

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U.S. PROOF degrees at 60ºF	PARTS BY VOLUME* OF		WEIGHT % ETHYL ALCOHOL	SPECIFIC GRAVITY		
	WATER	ETHYL ALCOHOL		at 60º/60ºF (15.56º/15.56ºC)	at 68º/68ºF (20º/20ºC)	at 77º/77ºF (25º/25ºC)
162	21.80	81.0	74.69	.8608	.8577	.8544
163	21.26	81.5	75.27	.8594	.8563	.8530
164	20.72	82.0	75.86	.8580	.8549	.8516
165	20.18	82.5	76.45	.8566	.8535	.8501
166	19.64	83.0	77.04	.8552	.8520	.8487
167	19.10	83.5	77.64	.8537	.8506	.8472
168	18.55	84.0	78.23	.8522	.8491	.8458
169	18.01	84.5	78.84	.8508	.8476	.8443
170	17.46	85.0	79.44	.8493	.8461	.8428
171	16.92	85.5	80.05	.8478	.8446	.8413
172	16.37	86.0	80.66	.8462	.8431	.8398
173	15.82	86.5	81.28	.8447	.8416	.8382
174	15.27	87.0	81.90	.8432	.8400	.8367
175	14.72	87.5	82.52	.8416	.8385	.8351
176	14.16	88.0	83.14	.8401	.8369	.8335
177	13.61	88.5	83.78	.8385	.8353	.8319
178	13.05	89.0	84.41	.8369	.8337	.8303
179	12.49	89.5	85.05	.8353	.8321	.8287
180	11.93	90.0	85.69	.8336	.8305	.8271
181	11.37	90.5	86.34	.8320	.8288	.8254
182	10.80	91.0	86.99	.8303	.8271	.8237
183	10.24	91.5	87.65	.8286	.8254	.8220
184	9.67	92.0	88.31	.8268	.8237	.8203
185	9.09	92.5	88.98	.8251	.8219	.8185
186	8.52	93.0	89.65	.8233	.8201	.8167
187	7.94	93.5	90.34	.8215	.8183	.8149
188	7.36	94.0	91.02	.8196	.8164	.8130
189	6.77	94.5	91.72	.8178	.8146	.8111
190	6.18	95.0	92.42	.8158	.8126	.8092
191	5.59	95.5	93.14	.8138	.8107	.8072
192	4.99	96.0	93.85	.8118	.8087	.8052
193	4.39	96.5	94.58	.8098	.8066	.8032
194	3.78	97.0	95.32	.8077	.8045	.8011
195	3.17	97.5	96.07	.8056	.8024	.7990
196	2.55	98.0	96.82	.8033	.8002	.7968
197	1.93	98.5	97.60	.8010	.7978	.7944
198	1.29	99.0	98.38	.7987	.7955	.7921
199	.65	99.5	99.19	.7962	.7930	.7896
200	.00	100.0	100.00	.7936	.7905	.7871

U.S. Department of Commerce, STANDARD DENSITY AND VOLUMETRIC TABLES, CIRCULAR OF THE BUREAU OF STANDARDS NO. 19 (Washington: U.S. Government Printing Office, 1924) pp. 8, 9, & 18.

U.S. Treasury Department, GAUGING MANUAL EMBRACING INSTRUCTIONS AND TABLES FOR DETERMINING THE QUANTITY OF DISTILLED SPIRITS BY PROOF AND WEIGHT (Washington: U.S. Government Printing Office, 1970).

Specific Gravity at 20º/20ºC and 25º/25ºC from Table 52.003, OFFICIAL METHODS OF ANALYSIS OF THE ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS, Twelfth Edition, 1975.

* The parts by volume of water and the parts by volume of ethyl alcohol do not add to unity (100) at any one proof reading because of the shrinkage in volume which occurs when ethyl alcohol and water are mixed. The parts *by volume* of ethyl alcohol are the same as *percent by volume* of ethyl alcohol used to determine proof for tax purposes. Ethyl alcohol proof, by legal definition, is twice the percent by volume.

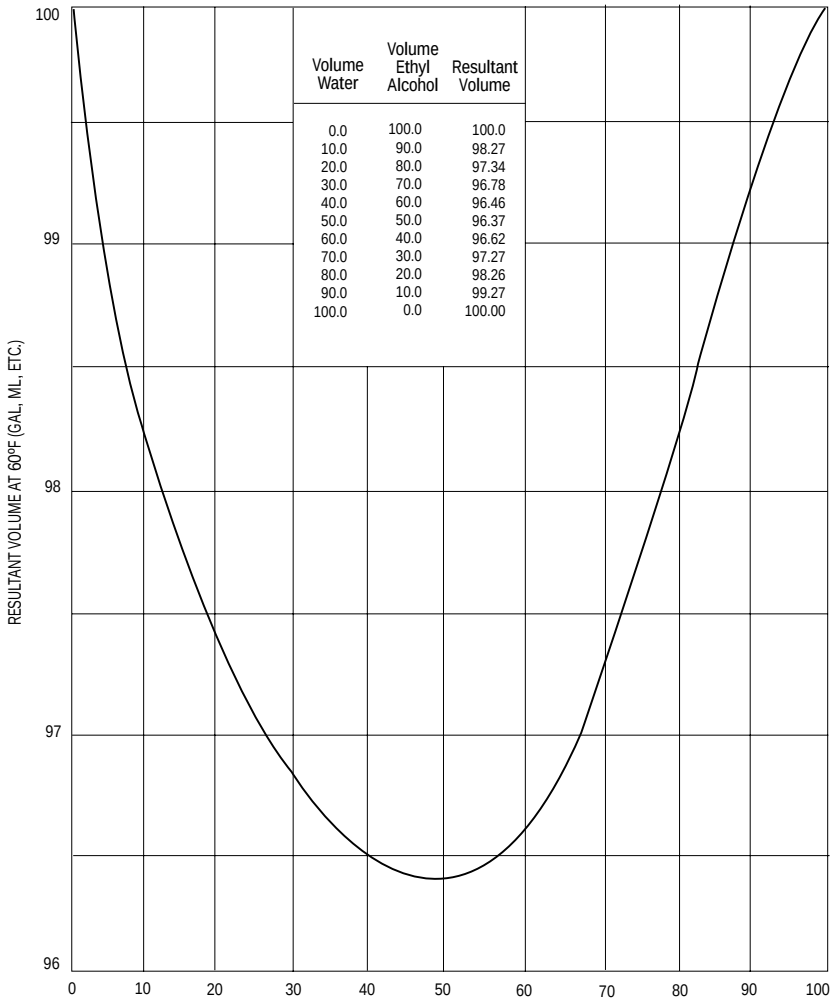
CALCULATING THE AMOUNT OF WATER REQUIRED TO REDUCE ALCOHOL PROOF

A volume of alcohol at a defined temperature, when mixed with an equal volume of water at the same temperature, will produce a resultant mixture with a total volume less than the sum of the component parts if measured at the same temperature. When making aqueous volumetric blends of alcohol this "shrinkage" of resultant volume must be considered.

Ibert Mellan, 'Industrial Solvents Handbook,' 2nd Edition, Noyes Data Corporation (1977)

RESULTANT VOLUME WHEN ETHYL ALCOHOL AND WATER ARE MIXED

Volume Water	Volume Ethyl Alcohol	Resultant Volume
0.0	100.0	100.0
10.0	90.0	98.27
20.0	80.0	97.34
30.0	70.0	96.78
40.0	60.0	96.46
50.0	50.0	96.37
60.0	40.0	96.62
70.0	30.0	97.27
80.0	20.0	98.26
90.0	10.0	99.27
100.0	0.0	100.00



A calculation of the water required to reduce proof is demonstrated by the following typical example.

Example. How much water must be added to 50 gal of 190 proof ethyl alcohol to make it 180 proof?

Alcohol at 190 proof. It can be seen from the table on p. 77 that 190 proof alcohol contains 95 parts by volume of pure alcohol and 6.18 parts by volume of water. Every 100 gal of 190 proof alcohol, therefore, contains 95 gal of pure alcohol and 6.18 gal of water.

Alcohol at 180 proof. Using the same table, it can be determined that 180 proof alcohol contains 90 parts pure alcohol and 11.93 parts water.

Put the 190 proof alcohol on the same basis as 180 proof alcohol. The ratio of alcohol to water at the finish of dilution (180 proof) is: $\frac{90}{11.93}$

Before 100 gal of 190 proof alcohol is diluted, it contains 95 gal of pure alcohol; so it must be adjusted into a 90/11.93 ratio to make it 180 proof. To do this the amount of water at the finish of dilution, called *c*, must be determined, so:

$$\frac{90}{11.93} = \frac{95}{c}$$

Solving for c

$90c = (95)\,(11.93) = 1133.35$

$c = 1133.35 / 90$

$c =$ 12.59 gal of water in the 180 proof alcohol after dilution.

–6.18 gal of water in the 190 proof alcohol before dilution.

6.41 gal of water to add to 100 gal of 190 proof alcohol to make it 180 proof.

Answer. Put the 6.41 gal on the basis of a 50-gal batch instead of 100 gal.

$6.41 \times \frac{50}{100}$ = 3.2 gal of water to add to 50 gal 190 proof alcohol to make it 180 proof.

TEMPERATURE CONVERSION

$^oF = (^oC \times 9/5) + 32 = (^oC + 40) \times 9/5 - 40$

$^oC = (^oF - 32) \times 5/9 = (^oF + 40) \times 5/9 - 40$

$^oR = {}^oF + 459.69$

$^oK = {}^oC + 273.16$

INTERPOLATION DIFFERENCES

°C	Temp	°F	°C	Temp	°F
0.5556	1	1.8	3.3334	6	10.8
1.1111	2	3.6	3.8889	7	12.6
1.6667	3	5.4	4.4445	8	14.4
2.2222	4	7.2	5.0000	9	16.2
2.7778	5	9.0	5.5556	10	18.0

°C	Temp	°F	°C	Temp	°F	°C	Temp	°F
-206.67	-340		-95.56	-140	-220	-14.44	6	42.8
-201.11	-330		-90.00	-130	-202	-13.89	7	44.6
-195.56	-320		-84.44	-120	-184	-13.33	8	46.4
-190.00	-310		-78.89	-110	-166	-12.78	9	48.2
-184.44	-300		-73.33	-100	-148	-12.22	10	50.0
-178.89	-290		-67.78	-90	-130	-11.67	11	51.8
-173.33	-280		-62.22	-80	-121	-11.11	12	53.6
-167.78	-270	-454	-56.67	-70	-94	-10.56	13	55.4
-162.22	-260	-436	-51.11	-60	-76	-10.00	14	57.2
-156.67	-250	-418	-45.56	-50	-58	-9.44	15	59.0
-151.11	-240	-400	-40.00	-40	-40	-8.89	16	60.8
-145.56	-230	-382	-34.44	-30	-22	-8.33	17	62.6
-140.00	-220	-364	-28.89	-20	-4	-7.78	18	64.4
-134.44	-210	-346	-23.35	-10	14	-7.22	19	66.2
-128.89	-200	-328	-17.78	0	32	-6.67	20	68.0
123.33	-190	-310	-17.22	1	33.8	-6.11	21	69.8
-117.78	-180	-292	-16.67	2	35.6	-5.56	22	71.6
-112.22	-170	-274	-16.11	3	37.4	-5.00	23	73.4
-106.67	-160	-256	-15.56	4	39.2	-4.44	24	75.2
-101.11	-150	-238	-15.00	5	41.0	-3.89	25	77.0

O.W. Eshbach & M. Soudens, 'Handbook of Engineering Fundamentals,' 3rd Edition, John Wiley and Sons (1975)

ºC	Temp	ºF	ºC	Temp	ºF	ºC	Temp	ºF
-3.33	26	78.8	24.44	76	168.8	182.22	360	680
-2.78	27	80.6	25.00	77	170.6	187.78	370	698
-2.22	28	82.4	25.56	78	172.4	193.33	380	716
-1.67	29	84.2	26.11	79	174.2	198.89	390	734
-1.11	30	86.0	26.67	80	176.0	204.44	400	752
-0.56	31	87.8	27.22	81	177.8	210.00	410	770
0	32	89.6	27.78	82	179.6	215.55	420	788
0.56	33	91.4	28.33	83	181.4	221.11	430	806
1.11	34	93.2	28.89	84	183.2	226.66	440	824
1.67	35	95.0	29.44	85	185.0	232.22	450	842
2.22	36	96.8	30.00	86	186.8	237.77	460	860
2.78	37	98.6	30.56	87	188.6	243.33	470	878
3.33	38	100.4	31.11	88	190.4	248.88	480	896
3.89	39	102.2	31.67	89	192.2	254.44	490	914
4.44	40	104.0	32.22	90	194.0	260.00	500	932
5.00	41	105.8	32.78	91	195.8	315.6	600	1112
5.56	42	107.6	33.33	92	197.6	371.1	700	1292
6.11	43	109.4	33.89	93	199.4	426.7	800	1472
6.67	44	111.2	34.44	94	201.2	482.2	900	1652
7.22	45	113.0	35.00	95	203.0	537.8	1000	1832
7.78	46	114.8	35.56	96	204.8	593.3	1100	2012
8.33	47	116.6	36.11	97	206.6	648.9	1200	2192
8.89	48	118.4	36.67	98	208.4	704.4	1300	2372
9.44	49	120.2	37.22	99	210.2	760.0	1400	2552
10.00	50	122.0	37.78	100	212.0	815.6	1500	2732
10.56	51	123.8	43.33	110	230	871.1	1600	2912
11.11	52	125.6	48.89	120	248	926.7	1700	3092
11.67	53	127.4	54.44	130	266	982.2	1800	3272
12.22	54	129.2	60.00	140	284	1038	1900	3452
12.78	55	131.0	65.56	150	302	1093	2000	3632
13.33	56	132.8	71.11	160	320	1149	2100	3812
13.89	57	134.6	76.67	170	338	1204	2200	3992
14.44	58	136.4	82.22	180	356	1260	2300	4172
15.00	59	138.2	87.78	190	374	1316	2400	4352
15.56	60	140.0	93.33	200	392	1371	2500	4532
16.11	61	141.8	100.00	212	413.6	1427	2600	4712
16.67	62	143.6	104.44	220	428	1482	2700	4892
17.22	63	145.4	110.00	230	446	1538	2800	5072
17.78	64	147.2	115.56	240	464	1593	2900	5252
18.33	65	149.0	121.11	250	482	1649	3000	5432
18.89	66	150.8	126.67	260	500	1704	3100	5612
19.44	67	152.6	132.22	270	518	1760	3200	5792
20.00	68	154.4	137.78	280	536	1816	3300	5972
20.56	69	156.2	143.33	290	554	1871	3400	6152
21.11	70	158.0	148.89	300	572	1927	3500	6332
21.67	71	159.8	154.44	310	590	1982	3600	6512
22.22	72	161.6	160.00	320	608	2038	3700	6692
22.78	73	163.4	165.56	330	626	2093	3800	6872
23.33	74	165.2	171.11	340	644	2149	3900	7052
23.89	75	167.0	176.67	350	662	2205	4000	7232

O.W. Eshbach & M. Soudens, 'Handbook of Engineering Fundamentals,' 3rd Edition, John Wiley and Sons (1975)

ANALYTICAL TEST METHODS

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*The use of portions of the text of USP 26-NF 21 is by permission of the USP Convention, the Convention is not responsible for any inaccuracy of quotation or for any false or misleading implication that may arise from separation of excerpts from the original context or by obsolescence resulting from publication of superseding editions and their supplements.

Introduction

The primary analytical test procedures for the quality evaluation of ethyl alcohol are defined by the specifications under which the alcohol is sold. The test procedures used to evaluate 190 proof U.S.P. and dehydrated alcohol are found in the current edition of the Pharmacopeia of the United States.

Various other industry recognized specifications such as the Food Chemical Codex, the American Chemical Society 'Reagent Chemicals' and U.S. government specifications may also be used to define the quality of Equistar pure Punctilious alcohol.

Equistar defines specifications for specially denatured alcohol, proprietary solvents and completely denatured alcohol. Standard, industry recognized, test procedures are used for quality definition.

Pure Alcohol Specifications

Our pure ethanol meets the requirements of the current US Pharmacopeia. The individual requirements of these specifications are listed below:

*United States Pharmacopeia**
U.S.P. Alcohol (Ethanol, Ethyl Alcohol)
Alcohol contains not less than 92.3 percent and not more than 93.8 percent by weight corresponding to not less than 94.9 percent and not more than 96.0 percent by volume, at 15.56ºC, of C_2H_5OH.

*The United States Pharmacopeia, United States Pharmacopeia Convention, Inc., 1260 Twinbrook Parkway, Rockville, MD 20852

Packaging and Storage—Preserve in tight containers, remote from fire.

Identification—
A: Mix 5 drops in a small beaker with 1 ml of potassium permanganate solution (1 in 100) and 5 drops of 2 N sulfuric acid, and cover the beaker immediately with a filter paper moistened with a solution recently prepared by dissolving 0.1 g of sodium nitroferricyanide and 0.25 g of piperazine in 5 ml of water: an intense blue color is produced on the filter paper, the color becoming paler after a few minutes.
B: To 5 ml of a solution (1 in 10) add 1 ml of 1.0 N sodium hydroxide, then slowly (over a period of 3 minutes) add 2 ml of 0.1 N iodine; the odor of iodoform develops, and a yellow precipitate is formed within 30 minutes.

Specific Gravity—Between 0.812 and 0.816 at 15.56ºC, indicating between 92.3% and 93.8% by weight, or between 94.9% and 96.0% by volume, of C_2H_5OH.

Acidity—To 50 ml, in a glass-stoppered flask, add 50 ml of recently boiled water. Add phenolphthalein test solution, and titrate with 0.020 N sodium hydroxide to a pink color that persists for 30 seconds: not more than 0.90 ml of 0.020 N sodium hydroxide is required for neutralization.

Nonvolatile Residue—Evaporate 40 ml in a tared dish on a water bath, and dry at 105ºC for 1 hour: the weight of the residue does not exceed 1 mg.

Water-Insoluble Substances—Dilute the sample with an equal volume of water: the mixture is clear and remains clear for 30 minutes after cooling to 10ºC.

Aldehydes and Other Foreign Organic Substances—Place 20 ml in a glass-stoppered cylinder that has been thoroughly cleaned with hydrochloric acid, then rinsed with water and finally with the alcohol to be tested. Cool the contents to approximately 15ºC and

add, by means of a carefully cleaned pipet, 0.10 ml of 0.10 N potassium permanganate, noting the exact time of addition. Mix at once by inverting the stoppered cylinder, and allow it to stand at 15ºC for 5 minutes: The pink color does not entirely disappear.

Amyl Alcohol and Nonvolatile, Carbonizable Substances, etc.—Allow 25 ml to evaporate spontaneously from a porcelain dish, carefully protected from dust, until the surface of the dish is barely moist: no red or brown color is produced immediately upon the addition of a few drops of sulfuric acid.

Acetone and Isopropyl Alcohol—To 1.0 ml add 1.0 ml of water, 1.0 ml of a saturated solution of sodium phosphate, and 3.0 ml of a saturated solution of potassium permanganate. Warm the mixture to 45º to 50ºC and allow to stand until the permanganate color is discharged. Add 3.0 ml of 2.5 N sodium hydroxide, and filter, without washing, through a sintered-glass filter. Prepare a control by mixing 1.0 ml of the saturated solution of sodium phosphate, 3.0 ml of 2.5 N sodium hydroxide, 80 µg of acetone and 5.0 ml of water. To each solution add 1 ml of furfural solution (1 in 100), allow to stand for 10 minutes, then to 1.0 ml of each solution add 3 ml of hydrochloric acid: any pink color produced in the test solution is not more intense than that in the control.

Methanol—To 1 drop add 1 drop of water, 1 drop of dilute phosphoric acid (1 in 20), and 1 drop of potassium permanganate solution (1 in 20). Mix, allow to stand for 1 minute, and add sodium metabisulfite solution (1 in 20), dropwise, until the permanganate color is discharged. If a brown color remains, add 1 drop of the dilute phosphoric acid. To the colorless solution add 5 ml of freshly prepared chromotropic acid test solution, and heat on a water bath at 60ºC for 10 minutes; any violet color should not exceed that produced by .04 mg of methanol in 1 ml of water, treated in the same way as the sample.

U.S.P. Dehydrated Alcohol (Ethanol, Ethyl Alcohol)
Dehydrated Alcohol contains not less than 99.2 percent, by weight, corresponding to not less than 99.5 percent, by volume, at 15.56º, of C_2H_5OH.

Packaging and Storage—Preserve in tight containers, remote from fire.

Identitication—
A: Mix 5 drops in a small beaker with 1 ml of potassium permanganate solution (1 in 100) and 5 drops of 2 *N* sulfuric acid, and cover the beaker immediately with a filter paper moistened with a solution recently prepared by dissolving 0.1 g of sodium nitroferrieyanide and 0.25 g of piperazine in 5 ml of water: an intense blue color is produced on the filter paper, the color becoming paler after a few minutes.
B: To 5 ml of a solution (1 in 200) add 1 ml of 1.0 *N* sodium hydroxide, then slowly (over a period of 3 minutes) add 2 ml of 0.1 *N* iodine: the odor of iodoform develops, and a yellow precipitate is formed within 30 minutes.

Specific Gravity <841>: not more than 0.7962 at 15.56º, indicating not less than 99.2% of C_2H_5OH by weight.

Acidity—To 50 ml, in a glass-stoppered flask, add 50 ml of recently boiled water. Add phenolphthalein TS, and titrate with 0.020 N sodium hydroxide to a pink color that persists for 30 seconds: not more than 0.90 ml of 0.020 N sodium hydroxide is required for neutralization.

Nonvolatile Residue—Evaporate 40 ml in a tared dish on a water bath, and dry at 105º for 1 hour: the weight of the residue does not exceed 1 mg.

Water-insoluble Substances—Dilute it with an equal volume of water: the mixture is clear and remains clear for 30 minutes after cooling to 10º.

Aldehydes and Other Foreign Organic Substances—Place 20 ml in a glass-stoppered cylinder that has been thoroughly cleaned with hydrochloric acid, then rinsed with water and finally with the dehydrated alcohol to be tested. Cool the contents to approximately 15º, and add, by means of a carefully cleaned pipet, 0.10 ml of 0.10 *N* potassium permanganate, noting accurately the time of addition. Mix at once by inverting the stoppered cylinder, and allow it to stand at 15º for 5 minutes: the pink color does not entirely disappear.

Amyl Alcohol and Nonvolatile, Carbonizable Substances—Allow 25 ml to evaporate spontaneously from a porcelain dish, carefully protected from dust, until the surface of the dish is barely moist: no red or brown color is produced immediately upon the addition of a few drops of sulfuric acid.

Ultraviolet Absorbance—Record the ultraviolet absorption spectrum between 340 nm and 235 nm in a 1 cm cell, with water in a matched cell in the reference beam. The absorbance is not more than 0.08 at 240 nm, and 0.02 between 270 nm and 340 nm, and the curve drawn through these points is smooth.

Acetone and Isopropyl Alcohol—To 1.0 ml add 1 ml of water, 1 ml of a saturated solution of sodium phosphate, and 3 ml of a saturated solution of potassium permanganate. Warm the mixture to 45º to 50º, and allow to stand until the permanganate color is discharged. Add 3 ml of 2.5 *N* sodium hydroxide, and filter, without washing, through a sintered-glass filter. Prepare a control containing 1 ml of the saturated solution of sodium phosphate, 3 ml of 2.5 *N* sodium hydroxide, and 80 µg of acetone in 9 ml. To each solution add 1 ml of furfural solution (1 in 100), and allow to stand for 10 minutes, then to 1.0 ml of each solution add 3 ml of hydrochloric acid: any pink color produced in the test solution is not more intense than that in the control.

Methanol—To 1 drop add 1 drop of water, 1 drop of dilute phosphoric acid (1 in 20), and 1 drop of potassium permanganate solution (1 in 20). Mix, allow to stand for 1 minute, and add sodium metabisulfite solution (1 in 20), dropwise, until the permanganate color is discharged. If a brown color remains, add 1 drop of the same dilute phosphoric acid. To the colorless solution add 5 ml of freshly prepared chromotropic acid TS, and heat on a water bath at 60º for 10 minutes: no violet color appears.

In addition to the above specifications, we will supply alcohol meeting the following specifications, upon request:

AMERICAN CHEMICAL SOCIETY

(ACS) Ethyl Alcohol (Ethanol)
(ACS) Ethyl Alcohol, Absolute (Ethanol, Absolute)

FOOD CHEMICALS CODEX*

**Food Chemicals Codex, National Academy of Science, Washington, D.C.*
F.C.C. Ethyl Alcohol (Alcohol; Ethanol)

FEDERAL AND MILITARY SPECIFICATIONS

Federal contractors and various governmental agencies often specify industrial alcohol by defining a federal or military specification. The more common of these specifications are listed in terms of the generally recognized industry standard.

Federal Specification 0-E-00760 C

GRADES AND CLASSES		EQUISTAR PRODUCT
Grade I Class A Class B	—ACS Grade —Absolute —190º	Pure Ethyl Alcohol 200º (ACS) 190º (ACS)
Grade II Class A Class B	—Pharmaceutical Grade —Dehydrated, N.F. —USP 190º	Pure Ethyl Alcohol 200º (NF) 190º (USP)
Grade III	—Denatured	Any Specially Denatured Alcohol
Grade IV	—Proprietary Solvents	Proprietary Solvents
Grade V	—Special Industrial Solvents	Filmex Formulas

Military Specifications MIL-E-463B

CLASSIFICATION	EQUISTAR PRODUCT
Grade 1	Pure 190º
Grade 2	SDA-2B, 190º
Grade 3	SDA-2B, 200º
Grade 4	SDA-40, 190º
Grade 5	SDA-3A, 200º
Grade 6	Filmex C, 200º


Tuscola Plant
Punctilious®
Ethyl Alcohol

STORAGE AND MAINTENANCE OF QUALITY

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Introduction

Pure ethyl alcohol, special industrial solvents, proprietary solvents, completely denatured alcohol and specially denatured alcohol formulations are flammable liquids. Most of these formulations can be stored in mild steel tanks and handled in equipment having iron or brass parts.

Some of the major exceptions are SDA formulations containing alkaline denaturants, corrosive halogens, highly acidic denaturants or certain essential oils. These require special handling and storage. Representative of these formulas is SDA 36, which contains aqueous ammonia or caustic soda, and is reactive to brass and other copper containing metals. SDA 25 and SDA 25-A contain iodine and sodium or potassium iodide. A container lining, such as polyethylene is typically used to prevent container corrosion for formulations containing this type of denaturant. Some of the formulations prepared with "essential oils," and other commonly used SDA 38-B denaturants (e.g. cinnamic aldehyde, cassia oil and sodium salicylate), are traditionally packaged in resin-coated containers.

Corrosion and stability studies are recommended if there is any doubt regarding the suitability of the material of construction for an alcohol handling and storage system. The following guide may be useful in selection of the proper construction material.

Materials of Construction

Character of Denaturant	Typical Denturants	Typical Container
Acidic	Cassia oil Cinnamic aldehyde Methyl salicylate Phenol Phenyl salicylate Sodium salicylate	Resin coated steel is generally adequate. Stainless steel (300 series) has also been used.
Alkaline	Aqueous ammonia Caustic soda	Copper and copper alloys should be avoided. Steel is adequate for most purposes, however stainless steel and resin coated steel have been used for specific applications.
Halogen	Iodine Mercuric iodide Potassium iodide Sodium iodide	Polyethylene-lined steel containers are typically used. The formulations using these denaturants are traditionally supplied in drum quantities.
Organic Solvents	Alcohols Ethers Aliphatic Hydrocarbons Aromatic Hydrocarbons Ketones Esters	Mild steel is adequate for most applications.

Regulatory Concerns

An industrial user of alcohol should consider the following points before installation of any bulk storage.

Comply with the requirements of the ATF.

Comply with the requirements of the insurance carrier.

Comply with the applicable requirements of federal, state, local and municipal laws, regulations, and fire codes.

TANKS

Alcohol storage tank size is determined by mode of delivery (tank truck or tank car) and by the expected weekly or monthly alcohol requirements. A good practice is to have capacity at least 50 percent greater than the delivering unit. Mild steel, as previously indicated, is adequate for most applications.

There are numerous suppliers of prefabricated and custom-built tanks. Local inquiry will generally find a suitable supplier who can be helpful with specific requirements.

Ideally, the tank should be located as near as possible to the incoming tank car or tank truck approach and should also be as close as practical to the alcohol use facility. Alcohol is flammable, therefore, local fire and electrical code enforcement agencies, codes (e.g. NFPA 30) and insurance representatives should be consulted to determine the acceptable safe distance and specific tank location.

Location

Above ground tanks—Insurance carriers and fire codes at most locations require that tanks be separated from buildings by a defined distance. This distance is dependent upon such factors as type of tank, capacity and maximum anticipated internal tank pressure. This distance should be established when tank installation is considered.

It is common practice to build a dike around alcohol storage tanks. This dike typically should contain about 150% of the capacity of the largest enclosed tank. Concrete dikes seem most desirable, since they look neat, afford the necessary protection, and require least space and upkeep. An alternative is a mounded dirt dike. Whichever is used, the tank should be built on a firm foundation to assure structural stability.

Access—for aboveground tanks, a platform with stairs or a ladder from the ground should be provided to the top of the tank.

Access to the top of the tank is required in order to measure the liquid volume if no other liquid level indicator is used. This is necessary to comply with various good manufacturing practices and ATF requirements.

A sidewall manway should also be provided near the bottom of the tank, for tank entry, to facilitate inspection and cleaning.

Cleaning—tank washing is typically required only if a new material is to be stored in the tank. A bottom outlet expedites this occasional cleaning.

Grounding—all alcohol storage tanks should be electrically bonded and grounded to prevent accumulation of static electricity.

Painting—the outside of the storage tank is commonly covered with a light-colored paint to reflect the sun's heat and to maintain the lowest possible tank shell temperature. It should be noted that each storage tank of SDA must be marked to show its serial number, capacity and use. ATF regulations permit the marks for underground tanks to be placed at a convenient and suitable location.

Stand Pipe—a stand pipe discharge line placed several inches above the opening of the inlet should be considered.

Fill Line—Tanks should use submerged fill lines to minimize emissions. All tanks should avoid splash filling due to the potential build-up of static electricity.

Vent and Flame Arrestor—a properly designed air vent is necessary on all alcohol storage tanks to allow for normal breathing with temperature changes, and to handle surges of air during unloading. Tank vents and openings must be designed to exclude rain and snow. For alcohol storage, a flame arrestor is required. For long term above ground storage, a desiccant containing drier, mounted in the vent, could be considered to prevent absorption of atmospheric moisture into anhydrous alcohol.

PIPING

Schedule 40 is typically used for most bulk alcohol grades and formulations. The pipe size should be consistent with good engineering practice and should be dictated by pipe length, pump capacity and manufacturing requirements.

Welding and flanged piping connections are recommended. Teflon®* envelope type gaskets are preferred gasket material.

Transfer lines should be bonded and electrically grounded. Particular attention should be given to any gasketed flanges in the pipeline. Copper wire should be used to jump around these flanges to maintain the integrity of the grounding system.

PUMPS

The type of pump selected for alcohol transfer depends upon several factors. Alcohol being a flammable liquid requires that all motors and controls should meet the National Electrical Code requirements for Class 1, Group D locations.

Where the available head pressure is sufficient, centrifugal pumps with mechanical seals are commonly used. If insufficient net positive suction head is present, self-priming centrifugal pumps or positive displacement pumps should be used. If, however, a positive displacement pump is used, a relief valve or by-pass should be used to relieve possible excessive line pressure which would develop by inadvertent closure of a discharge valve.

VALVES

In general, any standard type of valve is satisfactory for most alcohol use. While block valves with steel or modular iron and metal internal parts are generally used adjacent to above ground storage tanks, for protection in the event of fire, brass gate valves with metal to metal seats or iron or bronze ball valves with Teflon® seats are often used in other locations.

HOSES

Transfer hoses fabricated from polypropylene are suitable for handling alcohol. Any hose used for alcohol should contain an internal bond to assure a completely grounded transfer system.

*Teflon® is a registered trademark of E.I. duPont de Nemours & Co., Inc.

Tank Aperture Requirements

To accommodate the listed aperture requirements, tank openings of the indicated size have proven satisfactory:

	Typical Tank Opening Size in Inches
VENT, VAPOR CONSERVATION VENT OR FLAME ARRESTOR A vent is necessary for any tank. A vapor conservation type vent should be considered, if dictated by local conditions. Vent lines of all flammable liquid storage tanks should be equipped with approved flame arrestors.	3
GAUGING WELL, SAMPLING PORT, ETC. The sampling, gauging, inspection opening is merely a 6-inch nipple welded onto the top of the tank. It is equipped with flanges that can be bolted tight. The opening provides a means of obtaining samples, accurately setting the tank gauge and for inspection of the tank. One of the most common type of tank gauge is the float-steel tape type affixed to the tank. Gauges of this type have been used to meet the ATF tank gauge requirements.	6
ACCESS MANWAY Installation of an 18-inch manhole is suggested in the side of the tank, with the bottom of this access port about 3 feet above the bottom of the tank. Another position for the manhole is on top of the tank.	18
THERMOMETER WELL A 2-inch flanged nipple should be installed in the side of the tank just above the manual gauge counter. This is to be used for obtaining the average temperature of the alcohol in the tank. The temperature will be used to determine the alcohol volume, corrected to 60°F, as required by ATF regulations.	2
TANK INLET AND SUCTION OPENINGS A number of variations can be made on the inlet and suction openings to the tank. If desired, an inlet can be placed in the dome of the tank with a vented (small part at the top end) down pipe which extends to within several inches of the bottom of the tank. If the pump is to be used for both tank filling and transfer, only one opening in the tank would be needed. This could be located at the bottom of the tank and would be identical to a 3-inch suction line, which should be present in either case. The suction line can be tied-in several different ways. The tank, however, should be designed to allow for total tank drainage.	3

TANK CALIBRATION

It is essential that the alcohol storage tank be properly calibrated so that periodic inventory measurements, which are required by ATF regulations etc., may be obtained. The tank supplier generally will have measurement charts, which can be used for this purpose. However, the ATF requires that tanks must be accurately calibrated and certified by a reputable engineering concern.

The ATF also requires that each stationary tank, used for the storage of specially denatured or tax-free alcohol, be equipped for locking in such a manner as to control unauthorized access to the alcohol.

Maintenance of Quality

The maintenance of alcohol quality involves three general efforts, which should be an integral part of any alcohol user's good manufacturing practices:

Incoming shipments of ethyl alcohol should be accurately gauged and sampled to verify volume and quality.

All storage vessels, containers and equipment should be kept in repair and scrupulously cleaned before receiving a new material.

Accurate and detailed records conforming to present guidelines for good manufacturing practice and ATF requirements should be kept. Each step should be recorded from receipt and quality control examination to final use of the alcohol.

SAMPLING AND GAUGING

Sampling, while basically a simple procedure, is one in which it is very easy to introduce error. Recognizing that an analysis can be only as good as the sample upon which the analysis is performed, it is essential, as in all laboratory-oriented procedures, that strict attention to detail and cleanliness be observed.

Before sampling, the area around the sampling point should be cleaned of any dust, dirt, rust and other contaminants. Then an "all-level" representative sample may be taken through the top opening of the vessel. If desired, a second sample may be obtained from the vessel's bottom discharge line, but not before making a minimum purge of the line.

Sample containers should not be re-used. Using a fresh container eliminates the possibility of contaminating the sample with the residue of something else. A good practice is to rinse even a new container with a small quantity of the material to be sampled, to remove dust, lint, etc.

The sample container should have a proper cap with a liner compatible with the material to be sampled. For alcohol, aluminum foil is recommended. Polyethylene, polyvinyl chloride, wax or soft resin-coated caps should not be used, as they are often attacked by alcoholic products. The container should be properly labeled as soon as the sample is drawn.

Sampling of drums and bottles of alcohol is best done with either a metal thief or a glass tube. The sampling equipment should first be rinsed with a small quantity of the material to be sampled.

Some tanks have sampling cocks, which greatly simplify the procedure. Sample cocks should be flushed before the sample is taken. Where the tank has a top manway, the sample should be taken from all levels to assure homogeneity. This is easily accomplished with a weighted bottle which fills slowly as it descends.

Gauging of alcohol will vary depending on the type of shipping container. Standard dimension drums are conveniently gauged with a clean steel tape. Gauging of trucks and tank cars is more complicated, since their greater volumes vary more widely due to temperature effects.

TANK TRUCKS

Our Equistar facilities, Tuscola and Newark DSPs, load trucks of material with the bill of ladings reflecting NET weight of the material in the trailer. The pure alcohol, special denatured alcohol, Filmex, ethers and proprietary solvents all have particular weights per gallon of liquid. The trailer may be loaded by metering into it and denaturants metered into the container. At other times the trailer may be loaded from a mix tank directly using an outage as described below. All the trailers are then weighed on certified scales thus providing a check with our meters and the volume that ultimately is in the trailer. We welcome any questions that pertain to our loading and weighing of our products.

If scales are unavailable the option below may be utilized for gauging the contents of a tank truck.

Instructions for gauging contents of tank trucks.

While the quantity of material received in a tank truck may be measured either by weight or by volume, we have found that the volume of liquid in a tank truck can be determined with a high degree of accuracy. As the weight of a tank truck is influenced by varying quantities of ice, snow, mud, and the gasoline load it is carrying, the quantity of material in a tank truck should be determined by volumetric measurements.

Every tank truck is calibrated by a competent independent company whose business is the calibration of tanks. Each truck carries certified calibration charts showing the capacity of each compartment at various liquid levels. To get an accurate gauge, the truck must be stationary and located on level ground.

Measuring volume—The following data must be obtained to measure the volume of liquid in a tank truck:

(1) Determine the liquid level in the compartment by measuring above or below the "full marker," then calculate the volume from the calibration chart. This is the apparent volume.

(2) Determine the average temperature of the liquid in the compartment. It is a good practice to determine the temperature at approximately the top, middle and bottom of the tank by the use of a cup thermometer, or a thermometer which is enclosed in a container, and then take the average of the three readings.

(3) It is necessary to know the coefficient of expansion of the contained material. This coefficient can be found under the typical property section of this book for the specific product being gauged.

Temperature correction—The apparent volume in gallons must now be corrected to the standard 60ºF temperature obtained from the measurement and the referenced calibration chart used for ethyl alcohol and denatured alcohol formulas. Multiply the number of degrees above or below the standard temperature by the coefficient of expansion and then multiply this product by the apparent volume. For temperatures below the standard (volume contracted), add the result obtained to the apparent volume. For temperature above the standard (volume expanded), subtract the result from the apparent volume. The apparent volume plus (or minus) the temperature correction (in gallons) gives the net gallons at the standard temperature. If the weight is desired, it may be determined by multiplying the corrected gallons by the weight per gallon of the truck contents at the standard temperature.

Example Using SDA 3-A

Apparent Volume
(determined by measurement and truck calibration chart) .....6500 gal
Average Temperature 80ºF
SDA 3-A Coefficient of Expansion.....0.0006 per ºF
Calculation.....6500 x (80º – 60º) x 0.0006 = 78 gal
Corrected Volume at 60°F .....6500 – 78 = 6422 gal
Weight – (corrected volume)
(wt per gal* at 60°F) = 6422 x 6.785 = 43,573 lb

*The pounds per gallon of SDA 3-A is given on page 29 and defined in Part 212.115, Code of Federal Regulations.

TANK CARS

Instructions for gauging contents of tank cars

As with tank trucks, alcohol received in tank cars is measured by volume. A loaded tank car cannot be weighed with an accuracy better than plus or minus 500 pounds on railroad track scales. Various other elements, rain water or snow deposited on the car, possible in-transit changes of running gear, etc. contribute to this lack of accuracy. Equistar Chemicals, LP uses and recommends the following gauging method.

Determine:

1. The capacity of the car as stenciled on the shell. Note: this is the number of gallons the car will hold with the shell exactly full and no liquid in the dome at standard temperature.
2. The coefficient of expansion of the contained liquid. This value may be found in the typical property section of this book for the product to be gauged.
3. Apparent volume.
4. Temperature of liquid.

The first two are known factors, while the last two must be determined by actual measurement.

Measuring Volume—Before measuring the apparent volume of the tank car, it should be located on a level track. Determine the distance in inches of the liquid surface below or above the tank shell, making the measurement in either case from the top of the tank car—lower side of metal—to the surface of the liquid. Obtain from "tank outage" tables the gallons corresponding to this measurement. (Note: tables for tank cars will be supplied, on request, by Equistar Chemicals, LP). If the liquid is up in the dome, add the gallonage to the "stenciled capacity." If the liquid is below the shell, subtract gallonage from the "stenciled capacity." The result will be the "apparent volume" which must be corrected to standard temperature.

Temperature Correction—The standard temperature for ethyl alcohol is 60ºF. Since the temperatures of the alcohol at different levels in the tank car often vary more than 10º, care must be exercised to determine, properly, the true temperature. The recommended method is to use a cup thermometer and take temperature readings of samples obtained at approximately every thousand-gallon level throughout the depth of the car. The average of the readings may be considered the true temperature.

Using this temperature, calculate the correction, multiplying the number of degrees above or below the standard temperature by the coefficient of expansion, and this product by the apparent volume originally determined. For temperatures below the standard volume contracted, add the result obtained to the apparent gallon, while for temperature above the standard volume expanded, subtract from the apparent volume.

The "apparent volume" plus (or minus) the temperature correction (in gallons) gives the net gallons at the standard temperature. The weight can be determined by multiplying the gallons by the unit weight per gallon.

Example Using SDA 40 Anhydrous in GATX 98244

Tank car stenciled capacity .....20829 gallons
Gauge measurement .....8 3/4" outage
Outage .....763 gallons
Average temperature 43ºF
SDA 40 Anhydrous coefficient of expansion .....0.0006 per ºF
Calculation (20829 – 763) x (60º – 43º) x 0.0006 = 205 gal
Corrected volume at 60ºF 20066 + 205 = ...20,271 gal
Weight = (corrected volume) x (wt. per gal.* at 60ºF) =
20271 x 6.611 = ...134,012 lb

*The pounds per gallon of SDA 40 anhydrous is given on page 40 and defined in Part 212.115, Code of Federal Regulations

EQUIPMENT CLEANLINESS

Maintenance of a high quality alcohol requires that a properly maintained transfer and storage system be thoroughly cleaned before putting it into service. Do not shift from one formulation to another without a thorough cleaning.

Emptying and cleaning is not necessary if the tank already contains the same alcohol formula as the new shipment. New tanks, and those that have held other formulations or products, must be scrupulously cleaned.

Cleaning Procedure
The following procedure is suggested:

Drain the tank and introduce nitrogen at a point to force all remaining liquid from the tank and associated line. Nitrogen is recommended to minimize the potential safety hazard imposed by flammable mixtures of alcohol vapors and air.

Rinse the tank with water through the top manway and drain through the bottom outlet. Steam clean through the top manway. Steaming should last at least a half-hour, though longer periods may be required for large tanks.

Purge with either nitrogen or air until dry. Personal entry into any tank must never be made until the absence of explosive vapors and the presence of an adequate air supply is assured.

Records

Users of industrial alcohol are required to maintain specific records for examination by ATF inspectors and to periodically submit a User's Report of Denatured Alcohol to the ATF. The user must certify the receipt of SDA shipments and must account, to the ATF, for inventory gains or losses. The details of these requirements are beyond the scope of this book. However, additional information may be obtained from Equistar or your ATF Regional Regulatory Administrator.

In addition to the ATF records mentioned above, and depending on the business of the user, records should be maintained for compliance with good manufacturing practice, and for such internal business controls and other purposes deemed necessary.

Helpful Storage Hints

Some helpful hints for the efficient storage of alcohol.

1. Obtain approval for the use of ethyl alcohol products from the Bureau of Alcohol, Tobacco and Firearms.

2. When ordering alcohol, be sure:
   a) Proper formulation (denaturants) and proof are specified.
   b) Always verify the formulation and proof with the CSR (Customer Service Rep).
   c) Proper container is ordered, truck, railcar, or drum etc.
   d) Quantity ordered is within your storage capacity and ATF permit requirements.
   e) Adequate time is given to Equistar to assure on-time delivery.
   f) Clean, proper hose and fittings are available at receiving point.
   g) Any customer requirements should be explained to the CSR so that the delivery is made with the right equipment needed in the offloading process, rear, or center unloading trailer, compartment trailer, or extra hoses, fittings, time of day or night that deliveries are expected etc.

3. Upon receipt of load:
   a) Compare bill of lading with the purchase order for correct amount and formulation of product.
   b) Take a sample and gauge contents of the container (if applicable) otherwise scale the trailer for weight on a certified scale.

4. After it is determined that the material is as ordered, direct the carrier to correct receiving location.
   a) Check that it is the correct unloading point, validate with the carrier the proper unloading hose/tank to be used.
   b) Proper labeling of the lines and tank are assets in seeing that the unloading is safe and not contaminated.

5. Exercise continuous safety precautions during unloading operations.
   a) Remember these are flammable liquid products, reduce any ignition sources, open flames, exposed electrical wiring etc, NO SMOKING during offloading or transferring of products.
   b) The trailer should be positioned as close to unloading as possible, ensure grounding of the trailer to unloading line or equipment. Use proper PPE (gloves, safety glasses, tools, and possibly goggles or air masks) check MSDS.

c) Check again for proper hookup to correct lines. Is a feed/bleed system being utilized when necessary to protect tank? Make sure operator/or unloader KNOWS how to shutdown transfer in case of an emergency.

d) Check the gauge on the receiving tank to verify that it will hold the volume in the trailer.

e) Once transferring has been initiated, check all hoses and fittings for leaks.

f) When transfer is complete, verify that the trailer is empty, close all valves before disconnecting and remove ground strap from trailer. Check volume in the tank to confirm the amount unloaded with the bill of lading.

g) Check trailer valves are closed, manway closed, placards in place, weigh the empty trailer if necessary to verify the net weight of the product delivered.

HEALTH AND SAFETY INFORMATION

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First Aid

If swallowed and patient is conscious, induce vomiting and repeat until vomit is clear. Never give anything by mouth to an unconscious person.

If inhaled, remove victim to fresh air immediately. If not breathing, or if breathing is difficult, give mouth-to-mouth artificial respiration. Oxygen may be administered by trained personnel only.

In case of contact with eyes or skin, immediately flush affected area with plenty of water for at least 15 minutes. Remove and wash clothing before re-use. Call a physician.

FOR SPECIFIC INFORMATION REFER TO THE EMERGENCY OVERVIEW IN SECTION 3 OF THE MSDS FOR THE SPECIFIC PRODUCT IN QUESTION.

Inhalation: If symptoms are experienced, move victim to fresh air. Seek medical attention if discomfort persists.

Eye: Thoroughly flush the eyes with large amounts of clean low-pressure water for at least 15 minutes, occasionally lifting the upper and lower eyelids. If irritation persists, seek medical attention.

Skin: Immediately flush affected area with plenty of water while removing contaminated clothing. Wash contaminated clothing before reuse. If irritation persists, get medical attention.

Ingestion: If victim is conscious and able to swallow, have victim drink water to dilute. Never give anything by mouth if victim is unconscious or having convulsions. Induce vomiting only if advised by a physician or Poison Control Center. CALL A PHYSICIAN OR POISON CONTROL CENTER IMMEDIATELY (800-222-1222).

Safety Considerations

FLAMMABLE NATURE

Ethyl alcohol is an OSHA/NFPA Class 1B flammable liquid., as defined by the National Fire Protection Association's Flammable and Combustible Liquids Code (NFPA 30).[1] Ethyl alcohol has a Tag Closed Cup flash-point of approximately 55ºF (13ºC). At atmospheric pressure (14.7 psia), ethyl alcohol has a boiling point of 173ºF (78ºC), an auto-ignition temperature of 793ºF (423ºC), and lower and upper flammability limits of 3.3% and 19%, respectively, by volume in air.[2]

STORAGE AND HANDLING

Because ethyl alcohol is flammable, special care must be used when working with it to insure that all sources of ignition such as heat, sparks and flames have been eliminated from the workplace. Specific guidelines governing the storage and handling of ethyl alcohol are contained in NFPA 30.

Unless they are specifically exempted, all operations in which ethyl alcohol is used should conform to these standards. In particular, all electrical wiring and electrical equipment potentially in contact with flammable vapor mixtures of ethyl alcohol must be suitable for Class 1 operations, as defined by Article 501 of the National Electric Code (and NFPA 30). Additionally, wherever the possibility of the accumulation of flammable vapor mixtures of ethyl alcohol exists, adequate exhaust ventilation should be provided.

Properly constructed and marked safety containers should be used when transporting or storing small quantities of ethyl alcohol. Drums and other containers used for dispensing ethyl alcohol should be equipped with self-closing valves. When ethyl alcohol is being transferred between electrically conductive containers, the containers should be grounded and electrically bonded. The inlet fill pipe on ethyl alcohol storage tanks should discharge near the bottom of the tank and should be designed to minimize liquid turbulence and the creation of flammable vapor within the tank. Special care must be taken to insure that no possible ignition sources exist in the vapor space of an ethyl alcohol storage tank.

LOCAL FIRE CODES SHOULD ALWAYS BE CONSULTED FOR ADDITIONAL STORAGE REGULATIONS, QUANTITY LIMITS OR OTHER REQUIREMENTS.

TANK ENTRY

BEFORE ENTERING ANY EMPTY TANK REVIEW THE REQUIREMENTS OF OSHA 1910.146 CONFINED SPACES AND 1910.147 LOCK OUT TAG OUT / ISOLATION OF ENERGY SOURCES. The tank should be isolated to prevent materials from accidentally entering the tank. A qualified safety specialist should determine that the atmosphere in the tank is non-toxic, non-flammable, and contains sufficient oxygen to maintain life. In the case of an empty tank that previously had contained ethyl alcohol, it is recommended that the tank be purged with steam or water. Purging the tank with air may result in the formation of a flammable gas mixture within the tank during the purging operation. Purging the tank with an inert gas may result in the atmosphere in the tank being oxygen deficient subsequent to purging.

The OSHA standard for worker exposure to ethyl alcohol is 1,000 ppm (See Health Considerations, Workplace Exposure). Precautions should be taken to ensure that workers entering tanks previously containing ethyl alcohol are not overexposed.

A tank or any other confined space in which the oxygen content of the atmosphere is or could be immediately hazardous to life or health should not be entered unless the individual is wearing either (1) a NIOSH-approved positive pressure self-contained respirator, or (2) a NIOSH-approved combination supplied-air respirator, pressure-demand type, with an auxiliary pressure-demand self-contained air supply. Before any work is to be performed within a confined space that previously contained ethyl alcohol, care should be taken to insure that a flammable vapor mixture does not exist.

SPILL CLEANUP

In the event of an ethyl alcohol spill, the affected area should be evacuated as soon as possible. All ignition sources within the area should be eliminated. The spill should be contained. Use water spray or alcohol resistant foams to reduce and control vapors, if possible pump into a closed container. Any spill material which cannot be collected in this manner should be absorbed using an appropriate absorbent or flushed with water to a suitable containment basin (prevent entry into sewer systems, basements or other confined areas) and treated in accordance with applicable local, state and federal wastewater regulations. If absorbent is used, it should be collected in liquid-tight containers and disposed of in accordance with applicable waste disposal regulations. All personnel participating in the cleanup operations should be provided adequate personal protective equipment, including impervious suits, gloves, boots and respirators. Eye protective devices, such as chemical safety goggles, should be used when necessary. Federal, State and Local authorities may need to be notified in accordance with applicable regulations and amounts of material involved in the spill.

FIRE-FIGHTING

Ethanol vapor is heavier than air and may travel considerable distances to a source of ignition and flashback. Alcohols burn with a pale blue flame that is often hard to see in normal lighting conditions, always fight alcohol fires from the maximum possible distance and/or with unmanned monitors, nozzles or water curtains.

Ethyl alcohol fires should be extinguished by using dry chemical, "alcohol" foam or carbon dioxide extinguishers (these are suitable for small fires, but have a tendency to spread large spill fires, and should not be used with them). For large fires, large amounts of water can be effective as an extinguishing agent when fighting ethyl alcohol fires. It can be applied in the form of a spray to absorb the heat of the fire and to keep fire-exposed material and containers in the area adjacent to the fire cool. When following this procedure, care should be taken to ensure that the fire is not spread by the inadvertent overflowing of vessels containing ethyl alcohol.[3]

Health Considerations

WORKPLACE EXPOSURE

Many individuals work with ethyl alcohol in industrial settings, where they may be exposed to it by breathing the vapors, or they may experience direct skin contact.

The inhalation of excessive quantities of ethyl alcohol vapors can lead to health problems. Because of this fact, the federal government, through the Occupational Safety and Health Administration (OSHA), has established a limit on the amount of ethyl alcohol vapors to which an individual may be exposed over a workshift. The OSHA standard for ethyl alcohol is 1,000 ppm. This means that over an eight-hour workday, the average air concentration to which an employee can be exposed should not exceed 1,000 parts of ethyl alcohol vapor per million parts of air (ppm). Short-term worker exposure may exceed 1,000 ppm, provided this exposure is compensated by an equivalent level below 1,000 ppm. The average concentration to which a worker is exposed during the same workday must be 1,000 ppm or less.

Although individual susceptibilities may cause a small percentage of individuals to experience discomfort when exposed to ethyl alcohol concentrations at or below 1,000 ppm, all available evidence indicates that most workers can be repeatedly exposed to this level without adverse health effects.[4] Under most circumstances the human body can eliminate ethyl alcohol at the same rate that it is absorbed.[5]

EXPOSURE MEASUREMENTS

The actual concentration of ethyl alcohol to which an individual is exposed can be determined by measuring the alcohol concentration in the ambient air that the individual breathes. Tests of this nature are generally conducted by professional industrial hygienists, who are trained in the recognition, evaluation and control of occupational health hazards.

ODOR THRESHOLD

The vapors of ethyl alcohol can be detected at concentrations significantly less than the OSHA standard. Ethyl alcohol's odor threshold is reportedly in the range of 10 ppm[6] to 350 ppm[7]. At 6,000 ppm to 9,000 ppm, the odor is reportedly very intense. However, due to olfactory fatigue, continued exposure to alcohol vapor is characterized by loss of odor perception at these concentrations.

TOXIC EFFECTS

Acute Inhalation

Human Experience—The effects of short-term inhalation exposures to ethyl alcohol on the health of individuals have been studied extensively. In one such study,[5] human volunteers were exposed to ethyl alcohol vapor concentrations of between approximately 5,000 ppm and 10,000 ppm for periods of up to six hours. The individuals involved reported that the alcohol exposure caused coughing and irritation of the eyes and nose. Once the individuals were removed from the ethyl alcohol environment, the symptoms were reported to have disappeared within a few minutes. Volunteers could not tolerate being exposed to vapor concentrations of approximately 20,000 ppm for even a short period.

In evaluating the results of their study, the investigators calculated that the breathing rate required for a 150-pound man exposed to an ethyl alcohol vapor concentration of 1,000 ppm to become overexposed to the alcohol vapors would have to be much higher than the breathing rate normally required for hard physical labor.

Other studies involving human inhalation exposures to ethyl alcohol are referenced for the interested reader.[7,8] It should be noted that at least one case of fatal intoxication following ethyl alcohol vapor inhalation has been reported.[9]

Animal Testing—Several studies[10] using laboratory animals to determine lethal vapor concentrations have been reported. The results of these studies are summarized in the following table.

LETHAL CONCENTRATION VALUES FOR ETHYL ALCOHOL

Species	Concentration	Time Until Death
Mice	30,000 ppm	Not Specified
Rats	10,000-12,500 ppm	21 hours
Rats	45,000 ppm	4.5 hours
Guinea Pigs	45,000 ppm	10.75 hours

Chronic Inhalation

Human Experience—There appear to be very few published reports[7,10,11,12] addressing the effects of long-term human inhalation exposure to ethyl alcohol vapors. It has been reported that an individual can develop a tolerance to repeated exposures to ethyl alcohol vapor. This tolerance is demonstrated by a slight decrease in severity and a delayed onset of overt symptoms such as headache and drowsiness.[7] Asthma patients inhaling an ethanol mist reportedly do not show ethyl alcohol toxicity.[11]

Animal Studies—Limited animal testing has been conducted to determine subchronic and chronic inhalation health effects.[7, 13]

Dermal

Acute Effects—Short-term, non-repeated contact with ethyl alcohol may cause eye irritation and mild skin irritation. Ethyl alcohol also dehydrates the skin.[9] Acute ethyl alcohol intoxication by dermal exposure is unusual, but it has been reported.[10,14]

Chronic Effects—Allergic contact dermatitis has been reported in some individuals repeatedly exposed to ethyl alcohol.[15] As with other contact allergens, there is an initial sensitization period, after which further skin contact may result in redness or blistering.

CONTROL OF OCCUPATIONAL EXPOSURES

There are several methods which can be used to reduce industrial exposures to ethyl alcohol. In general, these methods include engineering controls, work practice controls and respiratory protection.

Engineering Controls—Wherever possible, industrial processes should be designed to prevent the release of ethyl alcohol vapors into the workplace. Where this is not possible, mechanical ventilation should be used to control and to remove the ethyl alcohol vapors from the work environment. If possible, local exhaust ventilation should be used to collect and exhaust the ethyl alcohol vapors at the point of contaminant generation. If the process or operation prohibits the use of local exhaust, then it may be necessary to ventilate the entire workplace.

Work Practice Controls—Workers can prevent unnecessary exposures to ethyl alcohol by following good work practices. These include the regular use of protective clothing (gloves, aprons, coveralls, etc.) to prevent skin contact. They may also be used when storing and transferring ethyl alcohol in closed containers, and the operation of all process equipment in such a manner as to avoid accidental or unnecessary releases of ethyl alcohol vapors into the workplace.

Respiratory Protection—If the airborne concentrations of ethyl alcohol which exist in the workplace cannot be reduced to acceptable levels, workers should be protected through the use of respiratory equipment. Care must be taken in choosing and using a respirator. All aspects of any respiratory protection program should be thoroughly reviewed and approved by a competent safety or health professional.

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GLOSSARY

Anhydrous Formulas—Formulas with this designation are made with pure ethyl alcohol 200 proof (100% ethanol) anhydrous.

Apparent Proof—the equivalent of proof for ethyl alcohol solutions containing ingredients other than water.

Completely Denatured Alcohol (CDA)—Ethyl alcohol which has been denatured according to completely denatured alcohol formulas prescribed by federal (BATF) regulations.

Dehydrated Alcohol—Ethyl alcohol of the highest proof obtainable (200º proof).

Denaturant—An ATF approved material added to ethyl alcohol to make it non-potable.

Drawback—A tax refund given when tax-paid alcohol is used to produce approved products unfit for beverage purposes.

Ethyl Alcohol—The common name for the hydroxyl derivative of the hydrocarbon ethane which is also known as ethanol, grain alcohol, fermentation alcohol, cologne spirits and spirits of wine.

Industrial Alcohol—Ethyl alcohol produced and sold for other than beverage purposes. It is sold by Equistar Chemicals, LP in the form of pure ethyl alcohol, completely denatured alcohol, specially denatured alcohol and as proprietary solvent blends.

Punctilious Ethyl Alcohol—High quality alcohol produced by Equistar Chemicals, LP which has received extra attention during manufacturing, testing, storage, and shipment.

Proof—The ethyl alcohol content of a liquid at 60º F stated as twice the percent of ethyl alcohol by volume.

Proof Gallons—One proof gallon is a gallon that contains 50 percent by volume of ethyl alcohol having a specific gravity of 0.7939 at 60º F as unity, or the alcoholic equivalent thereof. Proof gallons are calculated by multiplying the wine (standard liquid) gallons of ethyl alcohol by its proof and dividing it by 100. One wine gallon of 190 proof ethyl alcohol is equal to 1.9 proof gallons.

Proprietary Solvent—A solvent, adapted for specific uses, which contains more than 25 per cent ethyl alcohol by volume and which is manufactured from specially denatured alcohol according to a formula approved by the Director of the Bureau of Alcohol, Tobacco, and Firearms.

Specially Denatured Alcohol (SDA)—Ethyl alcohol in which the denaturants allow its use in a great number of applications. It is sold free of federal tax; but its use is regulated closely and the denaturing formulas are specified by law.

Tax-free Alcohol—Pure ethyl alcohol withdrawn free of tax for government, for science or for humanitarian reasons. It cannot be used in foods or beverages. All purchasers outside of the government must obtain permits, post bonds and exert controls upon storage and use of tax-free alcohol.

Tax-paid Alcohol—Pure ethyl alcohol that has been released from federal bond by payment of the federal excise tax at $13.50 per proof gallon.

Wine Gallon—A United States gallon of liquid measure equivalent to the volume of 231 cubic inches.

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More detailed safety and disposal information on our products is contained in the Material Safety Data Sheet (MSDS). All users of our products are urged to retain and use the MSDS. An MSDS is automatically distributed upon purchase/order execution. You may request an advance or replacement copy by calling our MSDS Hotline at (800) 700 - 0946.

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