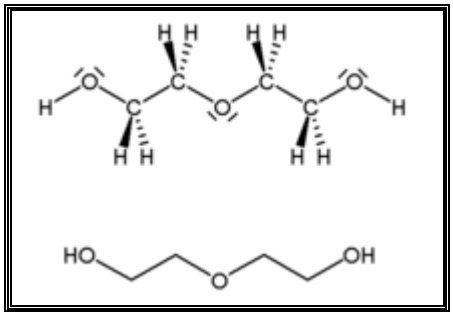
THE BASIC CHEMISTRY
OF
DIETHYLENE GLYCOL HYDRAULIC FLUIDS

All diethylene glycol hydraulic fluids are formulated from four basic components; diethylene glycol polyalkylene glycol thickeners, high purity de-ionized water, and amine additives. The proportions of the basic components differ from one fluid to another and from one manufacturer to another. Each component provides separate functions, which when blended, create a fluid capable of performing as a superior hydraulic lubricant. The true difference in the fluids comes from the additive amine package. These additive packages are kept proprietary from one manufacturer to the next. This document has not been drafted to deal with the specifics of the diethylene glycol fluids that MRL Hydraulics LLC provides, but has been drafted for general information only.

DIETHYLENE GLYCOL

Diethylene glycol is used in the hydraulic fluid blend to provide viscosity and to broaden the physical characteristics of the fluid. It lowers the freezing point and increases the boiling point. The glycol, depending on the fluid and manufacturer represents 35% to 55% of the fluid blend. Polyalkylene glycol (PAG) another polymer is added to thicken the diethylene glycol.

Diethylene glycol (DEG) is an organic compound described by the structural formula HO-CH_2-CH_2-O-CH_2-CH_2-OH. It is a clear, hygroscopic, odorless liquid. It is miscible with water and polar organic solvents such as alcohols and ethers.
IUPAC name: (2-hydroxyethoxy) ethan-2-ol Other names diethylene glycol; ethylene diglycol; diglycol; 2,2'-oxybisethanol; 3-oxa-1,5-pentanediol; dihydroxy diethyl ether Identifiers
CAS number 111-46-6
PubChem 8117 Smiles OCCOCCO



Properties:
Molecular formula $C_4H_{10}O_3$
Molar Mass 106.12 g/mol
Appearance Colorless liquid
Density 1.118 g/mL
Melting point -10.45 °C
Boiling point 244-245 °C
Solubility in water miscible

Except where noted otherwise, data are given for materials in their (at 25° C 100 kPa)

Diols and polyols

Diethylene glycol is one of several diols (hydrocarbon containing two alcohol groups). They are derived from ethylene oxide and are described with the formula HO-CH_2-CH_2(-O-CH_2-CH_2)$_n$-OH:

- **n = 0 ethylene glycol ("antifreeze")**
- **n = 1 DEG**
- **n = 2 triethylene glycol, TEG, or triglycol is also a colorless odourless viscous liquid. It is used as a plasticizer for vinyl. It is also used in Air-Sanitizer products, like "Oust" or "Clean and Pure." When aerosolized, it acts as a disinfectant. Glycols are also used as liquid desiccants for natural gas and in air conditioning systems. It is an additive for hydraulic fluids and. brake fluids.**
- **n = 3 tetraethylene glycol**

- **n = 4 pentaethylene glycol**
- **Higher numbers for *n* describe a non-toxic polymer called polyethylene glycol**

Toxicity

Diethylene glycol is toxic to humans and animals and death can occur by renal failure. The LD50 for small mammals has been tested at between 2 and 25 g/kg - much less toxic than its relative ethylene glycol, but still inappropriate for even minor consumption. Several poisonings have occurred when DEG is substituted for the non-toxic naturally-occurring "triol" glycerine ($HOCH_2CH(OH)CH_2OH$, also called glycerol) in foodstuffs and pharmaceuticals. Glycerine, which is higher melting (18 vs. -10.45 °C) and more viscous than DEG, costs about three times the price of DEG.

Uses

Like ethylene glycol, a solution of diethylene glycol and water is used as a coolant. It both lowers the freezing point of the solution and elevates its boiling point making it more suitable for hot climates. DEG is also a building block in organic synthesis e.g. of morpholine and 1,4 dioxane. It is a solvent for nitrocellulose, resins, dyes, oils, and other organic compounds. It is a humectant for tobacco, cork, printing ink, and glue. It can be also found in some hydraulic fluids and brake fluids.

In personal care products (e.g. skin cream and lotions, deodorants) DEG is often replaced by the much less toxic diethylene glycol ethers.

Diethylene glycol is also illegally used as counterfeit glycerin in some nations and sold internationally as a component of cough syrup and toothpaste.

References

- *Merck Index*, 12th Edition, **3168**.

DEIONIZED/DE-IONIZED WATER

In general deionized water is water that has been stripped of all ions rendering it ultra pure for use in chemical blending. Water as it's used in water glycol hydraulic fluids is utilized as a way of controlling the viscosity of the fluid and renders the fluid fire resistant. For the fluid to burn all of the water must be boiled off before it will sustain combustion. Water constitutes from 35% to 60% of the fluid.

Deionized water (**DI water or de-ionized water**; **also spelled deionised water**, **is water that lacks ions, such as cations from sodium, calcium, iron, copper and anions such as chloride and bromide. This means it has been purified from all other ions except H_3O^+ and OH^-, but it may still contain other non-ionic types of impurities such as organic compounds. This type of water is produced using an ion exchange process. Deionized water is similar to distilled water, in that it is useful for scientific experiments where the presence of impurities may be undesirable.**

Properties

The lack of ions causes the water's resistivity to increase. Ultra-pure deionized water can have a theoretical maximum resistivity up to 18.31 MΩ·cm, compared to around 15 kΩ·cm for common tap water. Deionized water's high resistivity allows it, in some very highly specialized instances, to be used as a coolant in direct contact with high-voltage electrical equipment. Because of its high

relative dielectic constant (~80), it is also used (for short durations) as a high voltage dielectric in many pulsed power applications, such as Sandia's Z Machine.

pH values

The pH is a logarithmic measurement of proton presence; the true pH of deionized water is 7.0, because the ionization constant of water (K_w) ~ 10^{-14}, so p[K_w] = 14, and pH + pOH = p[K_w]

In practice, the indication from chemical indicators can give a value of usually between pH 5.0 and pH 9.0 depending on the indicator used (the indication being the ions introduced by the indicator itself, its solvent and its impurities). Electronic pH meters will output an unpredictable value since the absence of ions in the liquid means that the two parts of the electrode are insulated from each other and thus would generate no EMF. In practice since absolutely pure water is an unattainable goal, the liquid will contain a very small amount of ions, but the current this would allow the probe to generate will be far smaller than that required to operate the metering circuit.

Electrodes of a pH meter should not be immersed in deionised water for prolonged periods as the lack of any ions 'sucks' them out of the electrode degrading its performance. Deionised water should be used for cleaning only rarely as the effect is cumulative. Electrodes should be cleaned using proper cleaning solution (usually very acidic), and rinsed between samples; ideally it should be rinsed using an extract from the next sample to be tested, but failing that, a pH neutral liquid such as tap water or pH 7.0 buffer solution is suitable.

Deionized water will quickly acquire a pH when exposed to air. Carbon dioxide, present in the atmosphere, will dissolve in the water, introducing ions and giving an acidic pH of around 5.0. The limited buffering capacity of DI water will not inhibit the formation of carbonic acid H_2CO_3. Boiling the water will remove the carbon dioxide to restore the pH to 7.0.

Ultrapure deionized water

The uses of ultrapure deionized water are many and varied, often having applications in scientific experimentation such as when very pure chemical reagent solutions are needed in a chemical reaction or when a biological growth medium needs to be sterile and very pure. Laboratory grade ultra pure water cannot be stored in glass or plastic containers because such materials leach contaminants at very low concentrations into the water. Storage vessels made of silica are used for less demanding applications but for highest purity uses, containers made from ultra pure Tin are used.

Deionization

Process utilizing specially-manufactured ion exchange resins which remove ionized salts from water can theoretically remove 100% of salts. Deionization typically does not remove organics, virus or bacteria, except through "accidental" trapping in the resin and specially made strong base anion resins which will remove gram-negative bacteria.

AMINE ADDITIVES

Amines are organic compounds and a type of functional group that contain nitrogen as the key atom. In structure, amines resemble ammonia, wherein one or more hydrogen atoms are replaced by organic substiuents such as alkyl and aryl groups. An important exception to this rule is that compounds of the type $RC(O)NR_2$, where the C(O) refers to a carbonyl group, are called amides rather than amines. Amides and amines have different structures and properties, so the distinction is chemically important. Somewhat confusing is the fact that amines in which an N-H group has

been replaced by an N-M group (M = metal) are also called amides. Thus $(CH_3)_2NLi$ is lithium dimethylamide.

Amines are central in organic chemistry. All known life processes depend on amino acids each of which contains an amine group.

Amines in the fluid blend are used to control lubricity and are base pH from 8.0 to 10.0. The amine additives range from 5% to 10% of the fluid. The additive package provides not only lubricity, but also anti-wear agents, anti-oxidation agents, anticorrosion agents and anti-foaming agents. The package is proprietary to the manufacturer and controlling the pH of the fluid is used to control the boundary layer lubrication film between the mating surfaces.

ADDITIONAL ADDITIVES

Different dyes may be added to the fluid to colorize it. These dyes do not affect the fluid or the fluid's performance. Some companies add additional additives to assist in maintenance leak detection. Again these do not alter the fluid in any way.