



Ecological and Toxicological Data of DOW Glycol Ethers

Biodegradation of Glycol Ethers

Biodegradation is an important aspect for assessing the ecological performance of chemical substances. Biodegradation of chemicals is a complex process and is influenced by a number of factors, such as:

- chemical structure of the substance
- concentration of the substance
- availability of oxygen
- origin of the microorganisms
- concentration of microorganisms
- type and concentration of nutrients
- "contact time"
- temperature
- pH value.

The OECD has set up a number of standardized test methods for biodegradation, based on various principles.

Dow has performed biodegradation tests according to these OECD test methods, in house or at contract laboratories. Most of the tests were carried out according to GLP (good laboratory practice).

The critical conditions of the OECD test methods used are summarized in tables A, B and C below.

The actual test results obtained with DOW oxygenated solvents are summarized in tables on the next two pages.

Standardized Biodegradation Testing Methods

A. Tests For "Ready" Biodegradability (OECD 301 Series)					
Test	OECD Test Number	Inoculum & Concentration	Concentration of Test Material	Analysis	Pass Level Criteria
DOC Die-Away:	301A	30 mg suspended solids/L	10-40 mg C/L	DOC*	≥70%; ready
CO ₂ Evolution: Modified Sturm	301B	30 mg suspended solids/L	10-20 mg C/L	DOC & CO ₂	≥60% ; ready
Japanese MITI (I)	301C	30 mg suspended solids/L	50-100 mg/l	DOC & DO**	≥60% DO; ≥70% DOC; ready
Closed Bottle	301D	5 mL of effluent/L	5-10 mg ThOD/L	DO	>60%; ready
Modified OECD Screening	301E	0.5 mL of effluent/L	10-40 mg C/L	DOC	>70%; ready
Manometric Respirometry	301F	30 mg suspended solids/L	50-100 mg ThOD/L	DO	>60%; ready

* DOC: Dissolved Organic Carbon**DO: Dissolved Oxygen

- Duration for each test is 28 days

- For all ready biodegradation tests the pass level must be reached within 10 days after the start (10% biodegradation) of the biodegradation process.

B. Tests for Inherent Biodegradability (OECD 302 Series)						
Test	OECD Test Number	Represents	Inoculum & Concentration	Concentration of Test Material	Analysis	Pass Level Criteria
Modified SCAS	302A	Sewage Treatment Plant	Activated sludge dry solids 2.5 g/L	5-20 mg C/L	DOC	≥ 20% inherent ≥ 70% ultimate
Zahn-Wellens/EMPA	302B	Sewage Treatment Plant	Activated sludge dry solids 0.2 – 1.0 g/L	~400 mg C/L	DOC	≥ 20% inherent ≥ 70% ultimate

C. Stimulation Tests						
Test	OECD Test Number	Represents	Inoculum & Concentration	Concentration of Test Material	Analysis	
Aerobic Sewage Treatment: Coupled Units	303A	Continuous completely mixed activated sludge process	Activated sludge dry solids 2.5 g/L	12 mg C/L	DOC	

Biodegradation of DOW Glycol Ethers and PROGLYDE DMM Solvents

		Biodegradation (%)	Test	Biodegradation
DOWANOL*	PM	96	OECD 301E	Ready
	DPM	75	OECD 301F	Ready
	TPM	60	OECD 301F	Ready
	PMA	84	OECD 301F	Ready
	DPMA	58	BOD – 20 days	NA
	PnP	92	OECD 301A	Ready
	DPnP	92	OECD 301A	Ready
	PnB	90	OECD 301E	Ready
	DPnB	91	OECD 301E	Ready
	TPnB	72	OECD 301F	Ready
	PPh	72	OECD 301F	Ready
	Butyl CELLOSOLVE™	72	BOD – 20 days	NA
	Butyl CARBITOL™	50	BOD – 20 days	NA
	Methyl CARBITOL	66	BOD – 20 days	NA
	EPH	80	BOD – 20 days	NA
PROGLYDE*	DMM	25	OECD 302B	Inherent

NA – Not Applicable BPD – Biological Oxygen Demand

Air Quality

Under current legislation, glycol ethers are considered as 100% VOC's in calculations for many types of formulations.

In solvent-borne systems containing no water, VOC calculations can be made directly, with results expressed as pounds solvent per gallon, or grams solvent per liter. Conversions between the two systems of measurement are provided here:

$$1 \text{ pound/gallon} = 119.87 \text{ grams/liter}$$

To convert from pounds per gallon to grams per liter, multiply pounds by 119.87.

To convert from grams per liter to pounds per gallon, divide grams by 119.87.

For systems containing water, the water must be subtracted from the system before VOC content is calculated. A formula frequently used for this purpose by the U.S. Environmental Protection Agency is:

$$\text{(volume fraction organic solvent) X (organic solvent density)}$$

VOC content =

1- volume fraction water

Following is a sample calculation using the above formula for a model system containing 20% DOWANOL PnB glycol ether by volume, 30% water by volume, and 50% other ingredients by volume. The density of DOWANOL PnB glycol ether is 7.31 pounds per gallon.

$$0.2 \times 7.31 \text{ lb/gal} = 2.09 \text{ lb/gal}$$

VOC content =

1 - 0.3

DOW Glycol Ethers : Ecological Data

Dow Glycol Ether	Fish LC ₅₀ (¹)	Daphnia Magna LC ₅₀ (¹)		Henry's Law Constant, H
	mg / L	mg / L	Log Pow(²)	atm * m ³ /mol
DOWANOL PM	4600-10000 G; 20800 F	23300	-0.437	2.80E-06
DOWANOL DPM	> 10000 F; > 150 E	1919	-0.064	1.60E - 07
DOWANOL TPM	11600 F	> 10000	0.309	1.14E - 08
DOWANOL PMA	161 F; 100-180 R	> 400	0.430	4.22E - 06
DOWANOL DPMA	151 F	1090	0.803	2.03E - 07
DOWANOL PnP	> 100 R; > 1000 F	> 100	0.621	6.87E - 07
DOWANOL DPnP	> 100 R	> 100	0.994	2.01 E - 07
DOWANOL PnB	560-1000 G	> 1000	1.150	3.86E - 06
DOWANOL DPnB	841 G	> 1000	1.523	3.78E - 07
DOWANOL TPnB	564 G	> 1000	1.896	4.05E - 08
DOWANOL PPH	280 F	370	1.497	4.47E - 07
Butyl CELLOSOLVE	983 G; > 1000 R	835 - 1720	0.83	2.08E - 07
Butyl CARBITOL	1150 G; > 500 E	2850	0.56	1.52E - 09
Methyl CARBITOL	5741 F; > 500 E	1192	-0.682	1.65E - 11
DOWANOL EPH	347 F	460	1.16	2.0E - 07
PROGLYDE DMM	> 1000 G	> 1000	0.42	1.25E - 08

R= Rainbow Trout F= Fathead Minnow E= Emerald Shiner G= Guppy

(1) LC₅₀= Concentration of test material resulting in 50% mortality

(2) Estimated Octanol/ Water Partition Coefficient

Exposure Guidelines

Adequate ventilation should be provided when working with glycol ethers and acetates. Table 2 lists the acceptable exposure limits for the DOW glycol ethers and acetates supplied by Dow. Since these values may be subject to change, customers are urged to consult the most recent Material Safety Data Sheet for the current guidelines.

Table – 2 Exposure Guidelines for DOW Glycol Ethers and Acetates¹

DOWANOL	Chemical Name	OSHA ² Exposure Limit PEL ^{2a}	ACGIH ³ TLV ⁴ Effects	Dow Internal Industrial Hygiene Guide
P-Series				
DOWANOL PM	Propylene glycol methyl ether	100 ppm ⁵ (STEL ⁶ 150 ppm)	100 ppm (STEL ⁶ 150 ppm)	NE
DOWANOL DPM	Dipropylene glycol methyl ether	100 ppm ⁵ (skin) ⁷ (STEL ⁶ 150 ppm)	100 ppm (STEL ⁶ 150 ppm)	NE
DOWANOL TPM	Tripropylene glycol monomethyl ether	NE ⁸	NE	NE
DOWANOL PMA	Propylene glycol methyl ether acetate	NE	NE	NE
DOWANOL DPMA	Dipropylene glycol monomethyl ether acetate	NE	NE	NE
DOWANOL PnP	Propylene glycol n-propyl ether	NE	NE	NE

DOWANOL DPnP	Dipropylene glycol n-propyl ether	NE	NE	NE
DOWANOL PnB	Propylene glycol n-butyl ether	NE	NE	NE
DOWANOL DPnB	Dipropylene glycol n-butyl ether	NE	NE	NE
DOWANOL TPnB	Tripropylene glycol n-butyl ether	NE	NE	NE
DOWANOL PPh	Propylene glycol monophenyl ether	NE	NE	NE
E-Series				
Butyl CELLOSOLVE	Ethylene glycol n-butyl ether	25 ppm ⁵ (skin) ⁷	25 ppm ⁵ (skin) ⁷	NE
Butyl CARBITOL	Diethylene glycol n-butyl ether	NE	NE	35 ppm
Methyl CARITOL	Diethylene glycol methyl ether	NE	NE	30 ppm
DOWANOL EPh	Ethylene glycol phenyl ether	NE	NE	25 ppm (skin) ⁷

¹Accurate as of August 1992

²Occupational Safety and Health Administration.

^{2a}Permissible Exposure Limit

³American Conference of Governmental Industrial Hygienists

⁴Threshold Limit Value, the time-weighted average (TWA) to which it is believed most workers may be repeatedly exposed 8 hours per day, 40 hours per week without adverse health effect.

⁵PELS are in accord with those recommended by OSHA, as in 1989 revision of PELs.

⁶STEL= Short Term Exposure Limit, a fifteen minute time-weighted average exposure which should not be exceeded at any time during a work day, even if the 8-hour time-weighted average is within the Threshold Limit Value.

⁷Listed substances followed by the designation "skin" refer to the potential contribution to the overall exposure by the cutaneous route including mucous membranes and eye, either by airborne, or more particularly, by direct contact with the substance.

Substances having a skin notation and a low TLV may present a problem at high airborne concentrations, particularly if a significant area of the skin is exposed for a long period of time.

This attention-calling designation is intended to suggest appropriate measures for the prevention of cutaneous absorption so that the threshold limit is not invalidated.

⁸None established

Note: For definitions of the terminology used here, please consult the current issue of Threshold Limit Values and Biological Exposure Indices from ACGIH.

Toxicology of DOW Glycol Ethers

The body of toxicological information on DOW glycol ethers and their acetates is constantly growing. In addition to the data in this brochure, we constantly update our customer information regarding the toxicity, storage, handling, and use of the glycol ethers and acetates we sell.

To obtain updated Material Safety Data Sheets or additional information on toxicology and handling, visit our website at <http://www.dow.com>.

The Properties of Each DOW Glycol Ether Product are Unique

Although DOW glycol ethers all have some fundamental similarities in chemical structure, there are significant differences among them. Not only are DOW glycol ether products divided broadly into ethylene-based (E-Series) and propylene-based (P-Series) families, but no two products in either family has the same toxicologic properties.

Broadly, toxicity studies have established that there are very significant differences between E-Series and P-Series glycol ethers. For example, the comparative metabolism and disposition in rats differs markedly for ethylene glycol methyl ether (EM)¹ and the predominant isomer of propylene glycol ether (PM). As shown in Figure 1 (on page 6), the major metabolite of ethylene glycol methyl ether was found to be methoxyacetic acid, while that of propylene glycol methyl ether was found to be propylene glycol, which a multitude of studies indicate is a substance with minimal toxicity. These differences in routes of metabolism and types of metabolites appear to be the basis for the remarkably different toxicological properties of the two major types of glycol ether products.

A careful review of the data in Table 1 will underscore the importance of treating each DOW glycol ether as unique. While toxicological studies such as the preceding example have shown unfavorable results for some individual E-series glycol ethers, no study has yet shown an unfavorable pattern of toxicity for the entire E-Series family.

In addition, species differences may influence the degree of toxicity observed. For instance, ethylene glycol butyl ether (EGBE) exposure has been found to produce red blood cell damage (hemolysis) in rats due to the metabolite butoxyacetic acid (BAA). Recent studies, including a complex computer model which shows how EGBE and BAA are absorbed, distributed and eliminated from the body, show that humans are not only less susceptible to the hemolytic effects of BAA, but are less capable of producing BAA in the first place.

¹ This product is not sold by The Dow Chemical Company

Figure 1 – Comparative Metabolism and Disposition of Ethylene Glycol Methyl Ether and DOWANOL PM Propylene Glycol Methyl Ether

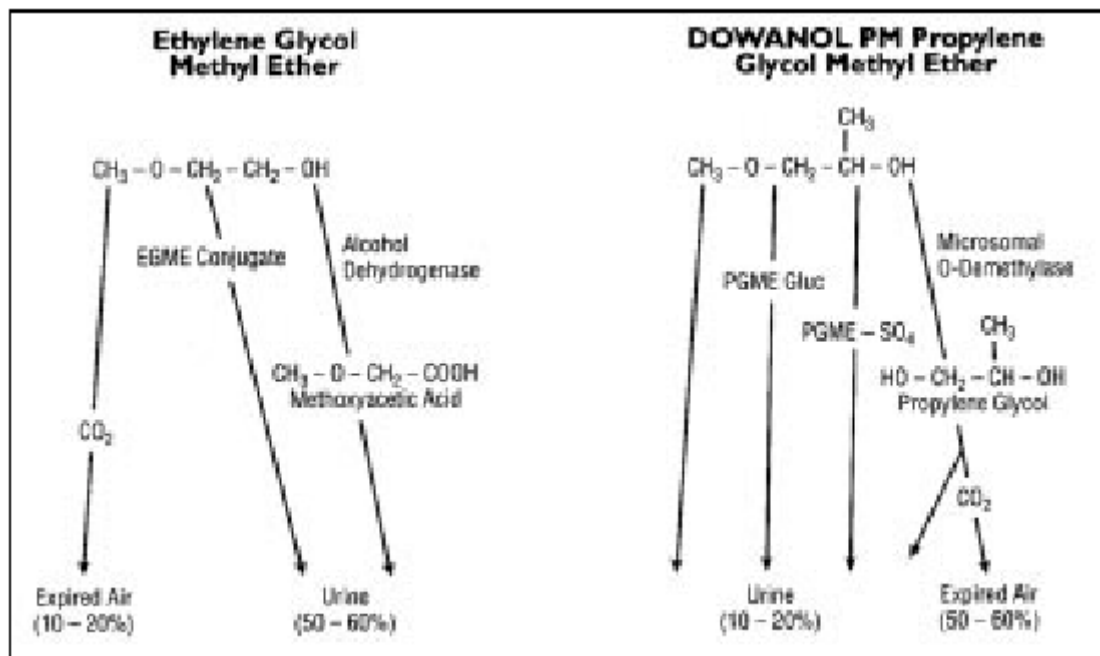


Table 1 – Toxicity Summary for DOW Glycol Ethers

Glycol Ether Toxicity: Summary of Key Studies

Type of Study	Species	Exposure Level	Effects
Propylene Glycol Monomethyl Ether (PM)			
90-day Subchronic Inhalation Study	Rats	3000 ppm	Sedation early in study; adaptive liver weight increase; male rat specific kidney effects.
		1000 ppm	NOEL in first of two studies
		300 ppm	NOEL in second study except for very slight male rat specific kidney effects, irrelevant for humans.
	Rabbits	3000 ppm	Sedation early in study. Adaptive liver weight increase (female mice).
	Mice	1000 ppm	NOEL
Generation Inhalation Reproduction Study	Rats	3000 ppm	Sedation and decreased parental body weights; any effects on reproductive parameters result from high dose general toxicity to the mothers.
		1000 ppm	NOEL for reproductive effects.
Inhalation teratology study	Rats	3000 ppm	Maternal toxicity (Sedation early in study and decreased food consumption); slight fetotoxicity.
		1500 ppm	NOEL
	Rabbits	3000 ppm	Maternal toxicity (sedation early in study and decreased food consumption).
		1500 ppm	NOEL

Type of Study	Species	Exposure Level	Effects
Dipropylene Glycol Monomethyl Ether (DPM)			
90-day subchronic inhalation study	Rats	200 ppm	No treatment- related effects at any level.
	Rabbits	50 ppm, 15 ppm	
Inhalation teratology study	Rats	300 ppm	No treatment- related effects at any level.
	Rabbits	150 ppm, 50 ppm	
4-week dermal study	Rats	1000 mg/kg, 100 mg/kg	No treatment- related effects.
Tripropylene Glycol Monomethyl Ether (TPM)			
Dermal 90-day subchronic study	Rabbits	10 ml/kg 5 ml/kg 3 ml/kg 1 ml/kg	Mortality at high dose; narcosis at lower doses; mild skin irritation.
Inhalation teratology study	Rats	Aerosols of 1.0 mg/L 0.3 mg/L 0.1 mg/L	Maternal toxicity at high dose; no embryo/ fetotoxicity and teratogenicity. NOEL for developmental toxicity = 1.0 mg/L.
Propylene Glycol Monomethyl Ether Acetate (PMA)			
Inhalation	Rats	3000 ppm	Mild, high-dose liver effects similar to those seen with DOWANOL PM;
9-day subacute study	Mice	1000 ppm, 300 ppm	evidence of upper respiratory tract irritation in all exposures in mice and high exposure in rats.
Inhalation teratology study	Rats	4000 ppm 400 ppm	No embryo/ fetotoxicity & teratogenicity. NOEL= 4000 ppm. Slight maternal toxicity.
Dipropylene Glycol Monomethyl Ether Acetate (DPMA)			
No subchronic, teratogenicity, or reproductive studies have been conducted. However, this compound is likely to rapidly and completely convert to dipropylene glycol monomethyl ether after absorption into the body. Thus, its systemic toxicity would be expected to be similar to dipropylene glycol monomethyl ether.			
Propylene Glycol n-Butyl Ether (PnB)			
13-week subchronic dermal study	Rabbits	2 ml/kg/day of 57% soln. 5.7% soln. 0.57% soln.	Skin effects at all levels; no systemic effects at any level.
13-week subchronic dermal study	Rats	1 ml/kg/day (880 mg/kg/day) 0.3 ml/kg/day 0.1 ml/kg/day	Minor skin effects at all levels; no systemic effects at any level.
13-week subchronic oral study	Rats	1000 mg/kg 350 mg/kg 100 mg/kg	Increased liver and kidney weights at 1000 mg/kg. NOEL = 350 mg/kg
Dermal teratology study	Rats	1 ml/kg/day 0.3 ml/kg/day	No embryo/fetotoxicity or teratogenicity at any level.
	Rabbits	100 mg/kg/day 40 mg/kg/day at any level. 10 mg/kg/day	No embryo/fetotoxicity or teratogenicity
Dipropylene Glycol n-Butyl Ether (DPnB)			
13-week subchronic diet study	Rats	1000 mg/kg/day 450 mg/kg/day 200 mg/kg/day	Slight effects to body weights, clinical chemistries, and liver weights. Capacity changes; not considered toxic effects. NOEL
13-week subchronic dermal study	Rats	1 ml/kg/day 0.3 ml/kg/day 0.1 ml/kg/day	Skin effects; effects to body weights, food consumption, and liver weights Effects to body weights and food consumption. NOEL for systemic effects.
Dermal teratology study	Rats	1 ml/kg/day 0.3 ml/kg/day	Minor maternal skin effects at all levels; no embryo/fetotoxicity or teratogenicity at any level.
Tripropylene Glycol n-Butyl Ether (TPnB)			
90-day subchronic rat drinking water study with 4-week recovery		1000 mg/kg/day	Decreased water and food consumption; Decreased body weight (reversible); Adaptive liver weight increase (reversible); Increased kidney weight; slight tubular effects (reversible)
		350 mg/kg/day	Slightly decreased water consumption; Adaptive liver weight increase (reversible); Increased female kidney weight (reversible); No observed adverse effect level
		100 mg/kg/day	Slightly decreased water consumption NOEL

Type of Study	Species	Exposure Level	Effects
Propylene Glycol Monophenyl Ether (PPh)			
28-day subchronic dermal study	Rats	1000mg/kg 300 mg/kg 100 mg/kg	No evidence of systemic toxicity. (NOEL= 1000 mg/kg); mild, transient dermal irritation at all doses.
Ethylene Glycol Monobutyl Ether (BuCs)			
90-day subchronic inhalation study	Rats	77 ppm 25 ppm	Blood effects NOEL
90-day subchronic dermal study	Rabbits	150 mg/kg 50 mg/kg 10 mg/kg	No treatment-related effects at any level.
Inhalation teratology study	Rats	200 ppm 100 ppm 50 ppm	Maternal toxicity, embryo toxicity, fetotoxicity. NOEL
	Rabbits	200 ppm 100 ppm	Maternal toxicity, embryo toxicity. NOEL
Diethylene Glycol Mono-n-Butyl Ether (BuCb)			
90-day subchronic dermal study	Rats	2000 mg/kg 666 mg/kg 200 mg/kg	Slight hemoglobinuria NOEL
90-day subchronic dermal	Rats	2000 mg/kg 666 mg/kg 200 mg/kg	No reproductive effects at any level.
Dermal teratology study	Rabbits	1000 mg/kg	NOEL for embryo toxicity and fetotoxicity.
90-day subchronic dermal neurotoxicity study	Rats	2000 mg/kg	NOEL for neurotoxicity.
Diethylene Glycol Monomethyl Ether (MeCb)			
90-day subchronic inhalation study	Rats	216 ppm 100 ppm 30 ppm	No treatment-related effects at any level.
90-day subchronic dermal study	Guinea Pig	1000 mg/kg 200 mg/kg 40 mg/kg	Decreased spleen weights at higher doses; Mild fatty liver changes, all cases, of questionable toxicologic significance.
Oral teratology study	Rats	2165 mg/kg 729 mg/kg	Decreased maternal body weight (high dose); malformations at both doses.
Dermal teratology study	Rabbits	750 mg/kg 250 mg/kg 50 mg/kg	Maternal toxicity; slight embryotoxic and fetotoxic. Slightly fetotoxic. NOEL

Type of Study	Species	Exposure Level	Effects
Ethylene Glycol Monophenyl Ether (EPh)			
90-day subchronic dermal study	Rabbits	500 mg/kg 150 mg/kg 50 mg/kg	Minor skin effects; no evidence of systemic toxicity at any level.
90-day subchronic oral study	Rats	2000 mg/kg 400 mg/kg 80 mg/kg	Some lethality, body and organ weight effects at 2000 mg/kg; kidney effects (males) at 400 mg/kg; NOEL 400 mg/kg (females), NOEL 80 mg/kg (males)
Dermal teratology study	Rabbits	1000 mg/kg 600 mg/kg 300 mg/kg	Some maternal deaths and hemolysis at two highest doses. No maternal effects at 300 mg/kg; no embryo/fetotoxicity or teratogenicity at any level.
Dietary Continuous Breeding	Mice	4000 mg/kg 2000 mg/kg 400 mg/kg	Male reproductive NOEL Female and neonatal effects at top and middle doses secondary to general toxicity. Female and neonatal NOEL
Dipropylene Glycol Dimethyl Ether (DMM)			
28-day rat drinking water toxicity study		1000 mg/kg/day 500 mg/kg/day	Slightly decreased water consumption; Increased liver weight Slightly decreased water consumption NOEL
13-week subchronic rat inhalation study		700 ppm 100 ppm 50 ppm	Adaptive liver weight increase; Slight adrenal cortical vacuolation (males) Male rat specific kidney effects Adaptive liver weight increase Male rat specific kidney effects NOEL
Rabbit oral teratology study		250 mg/kg 100 mg/kg	Maternal sedation Slight possible fetotoxicity secondary to maternal sedation. No malformations. Slight maternal sedation. Fetal NOEL.
Rat inhalation teratology study		700 ppm 225 ppm	Slight decreased food consumption and maternal weight gain. Increased maternal liver weight. Slight fetotoxicity secondary to maternal effects. No malformations. Maternal, embryo and fetal NOEL.
2-Generation rat drinking water study		1000 mg/kg/day 250 mg/kg/day 50 mg/kg/day	Adults: Decreased water, feed consumption and body weight. Increased liver weight with very slight liver toxicity. Slight kidney toxicity. Neonatal toxicity: Decreased pup body weight and survival. NOEL for reproductive indices. Adults: Decreased water, feed consumption and body weight. Increased liver weight. Slight kidney toxicity. NOEL for neonatal toxicity. Parental NOEL

NOEL: No Observed Effect Level

NOAEL: No Observed Adverse Effect Level

Acute Oral LD50 Values for DOW Glycol Ethers

	Acute Oral LD50 (Rats)
DOWANOL PM	6100 mg/kg
DOWANOL PMA	≥8532 mg/kg
DOWANOL DPM	≥5180 mg/kg
DOWANOL DPMA	> 5000 mg/kg
DOWANOL TPM	3200 mg/kg
DOWANOL PnB	≥3300 mg/kg
DOWANOL DPnB	≥3700 mg/kg
DOWANOL TPnB	≥2600 mg/kg
DOWANOL PnP	≥2000 mg/kg
DOWANOL DPnP	> 1500 mg/kg
DOWANOL PPh	≥2830 mg/kg
Butyl CELLOSOLVE	470 mg/kg**
Butyl CARBITOL	≥5080 mg/kg
Methyl CARBITOL	≥5500 mg/kg
DOWANOL EPh	≥1300 mg/kg**
PROGLYDE DMM	3300 mg/kg

** The cause of death is due to a massive intravascular hemolysis; however rates are unusually sensitive to this toxicity, and human red blood cells are known to be significantly more resistant to the hemolytic effect. Thus, the acute lethality of Butyl CELLOSOLVE and DOWANOL EPH is likely significantly less in humans compared to rats. Other than these two glycol ethers, the remaining ethers in the series have a low acute oral toxicity, i.e., the LD50 values are greater than or equal to 2,000 mg/kg.

DOW Glycol Ethers and the Environment

Disposal

DO NOT DUMP DOW GLYCOL ETHERS INTO ANY SEWERS, ON THE GROUND, OR INTO ANY BODY OF WATER.

For unused or uncontaminated material, the preferred management options are to send it to a licensed recycler, reclaimer, or incinerator. The same management options are recommended for used or contaminated material, although additional evaluation is required. (See for example, 40CFR Part 261, "Identification and Listing of Hazardous Waste.") Any disposal practice must be in compliance with federal, state, provincial, and local laws and regulations. Check with appropriate agencies for your location.

For additional information concerning the disposal of DOW glycol ethers contact your local Dow sales office, or write to The Dow Chemical company, Performance Products Department, 100 Larkin Center, Midland, Michigan 48674, or phone 1-800-447-4369.

