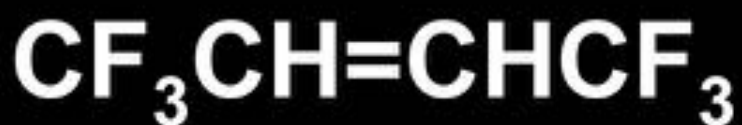
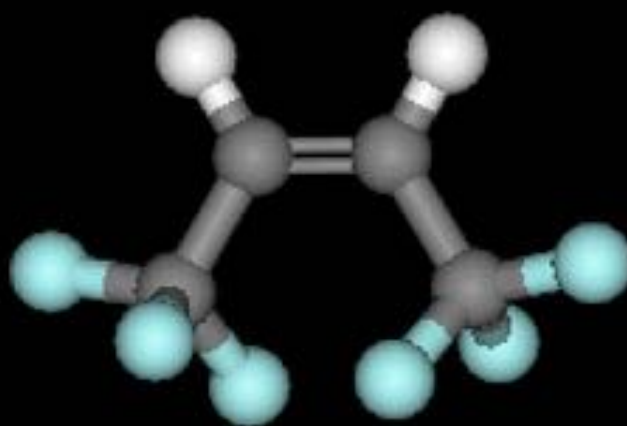




# DRILLING FLUIDS FOR DEEP CORING IN CENTRAL ANTARCTICA



Pavel G. Talalay

Polar Research Center  
Jilin University, China  
December 2011

# DRILLING FLUIDS FOR DEEP CORING IN CENTRAL ANTARCTICA

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**Abstract:** Deep ice drilling requires a fluid with a density closely matched to that of the ice to prevent ice-overburden pressure from causing borehole closure. Looking over the properties of the low-temperature drilling fluids for oil and gas well drilling confirms that they are not suitable for deep drilling in central Antarctica. Only special fluids, or mixture of fluids, can satisfy very strict criteria for deep drilling in ice. The main properties of existing and potential drilling fluids were described in the report of *Talalay and Gundestrup*, 1999, concluding that all recent borehole fluids cannot be qualified as intelligent choices because of the safety, environmental, and other technological standpoints. Several new drilling fluids have been proposed in the past several years. The present report aims to update the state of drilling-fluid research with newly available data, and to point out new directions of drilling fluid research.

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**Cover:** Structure of DuPont™ Fluoroproduct FEA-1100, 4<sup>th</sup> Generation foam expansion agent, potential densifier of two-component kerosene base drilling fluid (*DuPont™ FEA1100® Foam Expansion Agent*, presentation in India, 24 Oct. 2011)

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## 1. INTRODUCTION

Drilling in the central part of Antarctic Ice Sheet is planned by various national and international projects (Dome A, Antarctica's Gamburtsev Province Project, The Oldest Ice Coring, and others) for the study of climate change, glacier dynamics, ancient life, the subglacial environment, etc. The first experience of deep drilling showed significant closure in an open hole. The deepest 'dry' boreholes were 415 m at Vatnajökull glacier, Iceland (*Árnason et al.*, 1974) and 952 m at Vostok Station, Central Antarctica, 1972 (*Korotkevich and Kudryashov*, 1976).

For drilling at greater depth it is necessary to prevent hole closure by filling the borehole with a fluid. More properly, fluid is introduced into an open borehole for two main purposes (*Talalay and Gundestrup*, 2002a). First, a circulating fluid in the borehole provides a mechanism for sweeping chips away from the drill head and into the screen section, where they are sequestered for ultimate removal. Second, the presence of a density-balanced fluid in the hole prevents it from closing in on itself through plastic deformation ('*creep*').

The first drilling in ice with a fluid-filled borehole was by *U.S. Army Cold Regions Research and Engineering Laboratory* (CRREL) at Camp Century, Greenland in 1966. The method was subsequently used at Byrd Station, West Antarctica in 1967-1968 (*Ueda and Garfield*, 1968; 1969). The lower part of the boreholes were filled by the aqueous ethylene glycol solution and the upper part was filled by a mixture of diesel fuel (arctic blend DF-A) with the trichlorethylene as a density-increasing additive ('*densifier*').

For the next fifty years, nearly twenty deep, fluid-filled boreholes were drilled in Antarctic and Greenland ice sheets using cable-suspended electromechanical rotary drills. But, previous drilling fluids are now considered very harmful agents for Polar Region environments because they can contaminate large quantities of air, surface- and near-surface snow and firn layers, ice cuttings, and subglacial water resources. The possibility of impact on subglacial water biota from the drilling fluid can occur at almost any inland drilling site. Subsequent effects of drilling fluids are particularly important if the fluid is to be left in the hole: because of the movement of the ice, fluid in the hole will eventually reach the sea after a period of many thousands of years.

Since 2004, the international scientific community has been discussing the problems of the deep-drilling technology within *International Partnerships in Ice Core*

*Sciences* (IPICS). Two IPICS Workshops (Algonkian Regional Park, 2004 and Brussels, 2005) and two Steering Committee business meetings (Vienna, 2008 and Corvallis, 2009) declared that searching for a new drilling fluid (or fluids) is the most important ice-core drilling technical challenge. Members of IPICS concluded: “*The identification of a non-toxic, non-flammable, density appropriate, hydrophobic, inexpensive, environmentally friendly and readily available fluid(s) with predictable performance characteristics has become somewhat of a Holy Grail in the ice-drilling community.*” (IPICS, 2004).

The main properties of existing and potential drilling fluids were described in the report of *Talalay and Gundestrup*, 1999. The present report aims to update the statement of drilling fluid research by a new available data and to point out new directions for drilling fluid research.

### 2. DESIRABLE PROPERTIES

The ideal drilling fluid would simultaneous meet several desirable and somewhat conflicting properties.

**Density** is perhaps the most important fluid property, so that the pressure of the fluid column should be sufficient to prevent closure of the borehole. Making unfortunate choices of the fluid density and its column-height has frequently caused sticking of the drill. For example, drills were stuck several times at Vostok Station (*Ueda and Talalay*, 2007), and once at Dome F (*Takahashi et al.*, 2002). In order to prevent hole closure, the hydrostatic pressure difference between the ice and the borehole fluid should ideally be equal to zero at any depth (*Talalay and Gundestrup*, 2002b). It is not sufficient to have excess pressure in the borehole because the borehole will then expand and the column height will drop; this has the potential to cause at least partial closure at higher levels in the borehole. As a first approximation, the desirable average fluid density in the borehole can be estimated as:

$$\bar{\rho}_f = \frac{\bar{\rho}_{ice}(z - H_1)}{(z - H_0)}, \quad (1)$$

where  $\bar{\rho}_{ice}$  is the average value of ice density, kg/m<sup>3</sup>;  $z$  is depth of the hole, m;  $H_1$  is often named as ‘*firn correction*’, and its value depends on the ice accumulation conditions (for example, *Tchistyakov et al.*, 1994 suggested to use  $H_1 = 34$  m at Vostok Station), m;  $H_0$  is the fluid level in the borehole, m (usually  $H_0 = 80-100$  m).

The ice density  $\rho_{ice}$  can be estimated according to (Hobbs, 1974):

$$\rho_{ice} = 916,8(1 - 1,53 \times 10^{-4} t), \quad (2)$$

where  $t$  is the temperature, °C.

As a result of the pressure increase with burial, and the resulting compression of air bubbles, glacial ice density increases with depth. The temperature usually increases with depth also, and thermal expansion may at least partially offset the effect of pressure on density, and even reverse that trend. For example, at Byrd Station the density reaches a maximum of 920.6 kg/m<sup>3</sup> at a depth of 1000 m and then decreases to 917 kg/m<sup>3</sup> at 2164 m (Gow, 1971). At Vostok station the density smoothly increases from 918 kg/m<sup>3</sup> at a depth of 200 m, to 924 kg/m<sup>3</sup> at 1000 m, and then the density decreases to 921 kg/m<sup>3</sup> at 2600 m (Lipenkov *et al.*, 1997). Generally the influence of pressure and of temperature is mutually compensated, and the density of ice may be taken as constant at an average value. For example, at Vostok Station the average density of ice is 923 kg/m<sup>3</sup> up to the depth of 3000 m (V. Lipenkov, pers. comm., 1998).

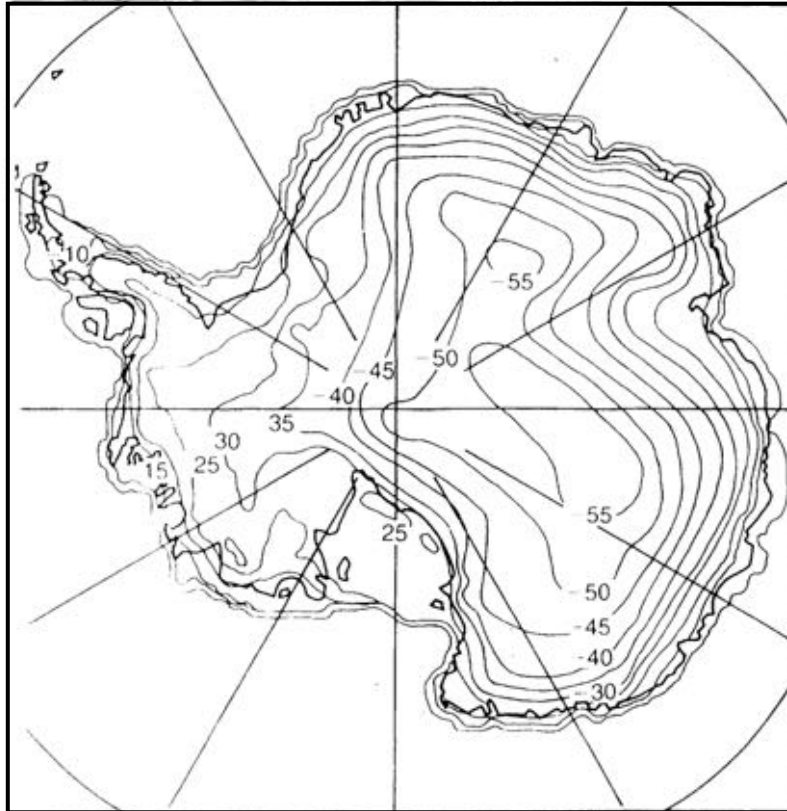
Taking the average density of ice  $\bar{\rho}_{ice} = 923 \text{ kg/m}^3$  and fluid level in the borehole  $H_0 = 80 \text{ m}$ , we can assume that the average fluid density in a borehole in central Antarctica should be ~970 kg/m<sup>3</sup> at a depth of 1000 m, and ~940 kg/m<sup>3</sup> at a depth of 3000 m.

**Viscosity** of the fluid influences the travel time of the drill string, winching power requirements and, finally, the total time of drilling. In fact, there are two alternative ways for achieving the drill's desired lowering rate: either a low-viscosity fluid must be used, or boreholes with a larger clearance between drill and borehole walls must be drilled to lower the viscous drag. The main disadvantages of a larger-diameter borehole are lower rate of penetration, increased cuttings, and higher energy consumption. Thus, a low viscosity (less than 5-10 cSt, Talalay and Gundestrup, 2002a) is an essential requirement for a practical drilling fluid.

**Freezing point** of the fluid should be higher not only than the minimal temperature in the borehole but also the temperature of the air outside the drilling shelter (where the fluid is usually stored). This is important especially for the drilling sites in central Antarctica where winter temperatures drop to -70...-80 °C. Vostok station holds the record for the lowest ever temperature recorded at the surface of the Earth (-89.2 °C, 21<sup>st</sup> July, 1983<sup>1</sup>). The annual average temperatures in central Antarctica are -50...-58 °C (Fig. 1).

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<sup>1</sup> [http://www.aari.aq/stations/vostok/vostok\\_ru.html](http://www.aari.aq/stations/vostok/vostok_ru.html)



**Fig. 1.** Annual mean surface temperature in Antarctica, inferred from measurements at 10 m depth in the snow (King and Turner, 1997).

**Stability** of the drilling fluid should be sufficient to maintain key properties during storage, transportation and during use in the borehole.

**Reactivity** of the drilling fluid should be minimized; it should be essentially inert. Drilling fluid should be non-aggressive to the drill and to cable components; stable with respect to water, air, oxygen, metals, wood, paper; compatible with most plastics and elastomers; and inert with respect to ice at sub-zero temperatures.

**Volatility** of the drilling fluid would be as high as possible, so that it would evaporate cleanly, completely and rapidly from the surface of the ice core.

**Flammability:** The fluid would be non-flammable and non-explosive, particularly in consideration of desirable high volatility.

**Cost** of the fluid should be relatively low, and fluid should be readily available from markets near the site of drilling operations because considerable expense comes not only from the purchase of the drilling fluid, but from its transportation to remote Polar sites.

**Toxicological and environmental properties** of drilling fluids became the key point for forthcoming drilling projects in Antarctica because fluids in current use cannot be regarded as intelligent choice from the point of view of health and environmental safety

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(Talalay and Gundestrup, 2002a; Gerasimoff, 2003). An ideal drilling fluid would be completely non-toxic to humans and animals, and biodegradable. Article 3 of the Protocol on Environmental Protection to the Antarctic Treaty declared (*Antarctica Agreements*, 2010): “The protection of the Antarctic environment and dependent and associated ecosystems ... shall be fundamental considerations in the planning and conduct of all activities in the Antarctic Treaty area.” This Protocol entered into force on 14 January 1998, following ratification by all *Antarctic Treaty Consultative Parties*.

## 3. LOW-TEMPERATURE DRILLING FLUIDS FOR OIL AND GAS WELL DRILLING

Drilling fluids are used extensively in the oil and gas industry, and are critical to ensuring a safe and productive oil or gas well. There are two primary types of drilling fluids: water based fluids (WBFs) and non-aqueous drilling fluids (NADFs).

**WBFs** consist of water mixed with bentonite clay and barium sulphate (barite) to control drilling fluid density and thus, hydrostatic pressure. Others substances are added to gain the desired drilling properties. WBFs have water as the primary phase (typically ~75 % by weight), which is either freshwater, seawater or brine. A combination of salts may be used to provide specific brine-phase properties. Freezing point of the seawater and brines is less than 0 °C (Table 1) but it is not low enough for drilling in cold ice sheets. Moreover, there are other undesirable properties of the seawater and brines like high viscosity, electrical conductivity, ice dissolution, corrosion of metals, etc. When brines are cooling, salts are concentrated, and crystallohydrates are formed.

Table 1

Freezing point of sodium chloride and seawater, °C		
Concentration, g/l	Sodium chloride (NaCl)	Seawater
10	0.12	-0.52
20	-0.8	-1.08
30	-1.7	-1.63
40	-2.59	-2.19
50	-3.47	-2.75
100	-7.59	-
150	-11.32	-
200	-14.64	-
250	-17.57	-
300	-20.09	-
350	-22.22	-
400	-23.94	-
450	-25.27	-
500	-26.19	-
550	-26.72	-
600	-26.84	-

Source: Zelinskaya and Voronina, 2009



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**NADFs** are emulsions with the external phase such as diesel oil, mineral oil, synthetic hydrocarbons; chemicals such as brine, glycols, acetates, and nitrates comprise the internal phase. As with WBFs, additives are used to control various properties of NADFs. According to the *International Association of Oil & Gas Producers* (OGP) definition (*Drilling fluids and Health Risk Management*, 2009) for low-temperature applications the most attractive base of NADFs are synthetic low-, or negligible-, aromatic-content fluids, and those highly refined mineral oils containing total aromatics below 0.5 % and polycyclic aromatic hydrocarbons (PAH) below 0.001 % (Table 2).

Table 2

Low-temperature NADFs-based fluids technical data

Name	Density, kg/m <sup>3</sup>	Flash point, °C	Pour point, °C	Aroma- tics, %	Viscosity, cSt		Aniline point, °C	Boiling point range, °C
					20 °C	40 °C		
DF1	820	75	-50	0.15	2.4	1.7	73	198–254
EDC99DW	811	100	-51	<0.01	-	2.3	80	230–270
HDF 150	808	95	-45	-	-	2.7	84	215
LVT200	814	94	-46	0.5	-	2.1	78	216
LVT52	808	93	-60	3	-	1.56	-	179
PureDrill IA-35LV	816	96	-63	<0.1	-	2.64	82	-
SIP 4\0	827.5	132	-57	0	-	3.8	92	>249
SIPDRIL 4.0	820	104	-51	<0.01	-	2.7	84	230–310

Source: *Drilling fluids and health risk management*, 2009

Densities of these components are in the range of 808-827.5 kg/m<sup>3</sup> (at room temperature), and itself, does not have sufficient density to accomplish full hydrostatic compensation of overburden pressure of ice. Among low-temperature NADFs-based fluids, PureDrill IA-35LV has the lowest pour point. It is a synthetic isoalkane and is completely colorless, odorless, readily biodegradable and non-toxic to humans, marine and wildlife. This fluid is manufactured by Petro-Canada, Mississauga, Ontario (*Synthetic drilling mud base fluids provide options*, 2001). Viscosity of PureDrill IA-35LV is high: 7.39 cSt at 0 °C (*Petro-Canada Data Sheet*<sup>1</sup>) and ~17-19 cSt at -50 °C (according to allowable extrapolation). Such high viscosity will not allow for optimal drill travel time.

So, we can conclude that the low-temperature drilling fluids for oil and gas well drilling are *not* suitable for deep drilling in the central Antarctica, but could be considered as the basis for a two-compound fluid for drilling in temperate glaciers if the minimal temperatures is not less than about -30 °C (e.g., Arctic ice caps, mountain glaciers, Greenland, margins of Antarctica). In any case, their density should be boosted by blending with another, higher-density compound.

<sup>1</sup> [http://www.online.petro-canada.ca/datasheets/en\\_CA/iaf35lv.pdf](http://www.online.petro-canada.ca/datasheets/en_CA/iaf35lv.pdf)

### 4. CLASSIFICATION OF SPECIAL LOW-TEMPERATURE DRILLING FLUIDS FOR DEEP ICE DRILLING

The various special low-temperature drilling fluids were proposed for coring in ice (*Talalay and Gundestrup, 1999*). In the practice of deep ice core drilling, four types of borehole fluids have been used:

- 1) Two-component petroleum base fluids;
- 2) Aqueous ethylene glycol or ethanol solutions;
- 3) n-Butyl acetate;
- 4) Two-component ESTISOL™ ester-base fluids.

It was also proposed to use the low-molecular dimethylsiloxane oils as borehole fluid (*Talalay, 2007*), but they have never been used in ice-core drilling projects; the final conclusion about their applicability for deep ice drilling could be made only after field experiments in a test borehole and also laboratory tests to assure that they are compatible with currently used and anticipated analytical methods and instruments, as suggested by *Gerasimoff (2003)*.

According to ice/water solubility, drilling fluids are divided to *hydrophobic liquids* that are stable to the water and ice, and *hydrophilic liquids* that are able to blend with water in any concentration and thereby dissolve ice at sub-zero temperatures.

Hydrophilic liquids include those consisting of aqueous ethylene glycol or ethanol solutions. The main drawback of these results from the dissolving of ice from borehole walls until equilibrium concentration of the solution is reached. The equilibrium concentration of hydrophilic liquids depends on the temperature and, therefore, as the borehole temperature changes there is the precipitation of frozen water from aqueous solutions, and the formation of slush in the borehole. For the purposes of deep electromechanical drilling in very cold ice (with temperatures less than about  $-30^{\circ}\text{C}$ ), especially given that the borehole may be required to stay accessible for many years, experience has demonstrated that hydrophilic fluids are not suitable (*Gerasimoff, 2003*).

n-Butyl acetate has low initial purchase cost, but is an ongoing liability from a safety (fire and explosion), acute- and chronic-health-hazard standpoint. The main problem of using n-butyl acetate as the drilling fluid is the hazard it presents to the physical and mental health of the people who work at the coring site. It is impossible to use n-butyl acetate without sufficient ventilation and some means of removing the n-butyl acetate vapors from inhaled air. n-Butyl acetate is a very aggressive solvent: there are no elastomers that can able operate in n-butyl acetate for a long time. Moreover, the fire

hazard of n-butyl acetate is very high (flash point is only 22 °C). So, this fluid cannot be considered as an intelligent choice for future drilling projects.

Hereafter, the new two-component petroleum base and ESTISOL™ ester-base fluids are reviewed and discussed.

### 5. PREPARATION OF TWO-COMPONENT DRILLING FLUID

For the preparation of two-component fluid with the density  $\rho_{fl}$  the volume of densifier  $V_2$  at given temperature is estimated according to:

$$V_2 = V \frac{\rho_{fl} - \rho_1}{\rho_2 - \rho_1}, \quad (3)$$

where  $V$  is the volume of mixture,  $m^3$ ;  $\rho_1$  and  $\rho_2$  are the density of the base fluid and the densifier respectively,  $kg/m^3$ .

The density of mixture at atmospheric pressure is

$$\rho_{fl} = (1 - C_V)\rho_1 + C_V\rho_2, \quad (4)$$

or

$$\rho_{fl} = \frac{\rho_1}{1 - C_M \frac{\rho_2 - \rho_1}{\rho_2}}, \quad (5)$$

where  $C_V$  and  $C_M$  are the volume and mass concentration of densifier, respectively, as parts of unity.

The volume and mass concentrations can be calculated due to the following equations:

$$C_V = \frac{\rho_{fl} - \rho_1}{\rho_2 - \rho_1}; \quad (6)$$

$$C_M = \frac{\rho_2 (\rho_{fl} - \rho_1)}{\rho_{fl} (\rho_2 - \rho_1)}. \quad (7)$$

The volume concentration slightly depends on the temperature; therefore, it's preferable to use the mass concentration. The relation between volume- and mass-concentrations is given by:

$$C_V = C_M \frac{\rho_{fl}}{\rho_2}; \quad (8)$$

or

$$C_V = \left[ \frac{\rho_2}{\rho_1} \left( \frac{1}{C_M} + 1 \right) \right]^{-1} \quad (9)$$

## 6. TWO-COMPONENT PETROLEUM BASE FLUIDS

### 6.1. General considerations

Usually two-component drilling fluids are based on the kerosene-like product such as low-temperature fuels DF-A, Jet A1, JP-8; or solvents of the Exxsol D-series, Isopar K, etc. Functionally, these are all very similar and differ by the content of aromatics, waxes, sulfur, and other impurities. Kerosenes have the density of about 800-850 kg/m<sup>3</sup> at –30 °C, compared to 917-924 kg/m<sup>3</sup> for ice. Therefore, they are made denser by mixing with fluorocarbons or other compounds that have a density that significantly exceeds the density of ice.

The hydrochlorofluorocarbon of HCFC-141b type with density of 1332.5 kg/m<sup>3</sup> at –30 °C has the best properties to be blend with petroleum fluids (*Talalay and Gundestrup*, 1999). During the past years, several holes were successfully completed in Antarctica using mixture of kerosene-like fluid and HCFC-141b (3270 m, EPICA Dome C2; 2872 m, EPICA DML; 998 m, Berkner Island; 1620 m, Talos Dome).

Two deep drilling projects with HCFC-141b as densifier are on-going in Antarctica, at Vostok Station and at West Antarctic Ice Sheet (WAIS) ice-flow divide. Drilling of the deepest hole in ice at Vostok station (3737.5 m, 12<sup>th</sup> Jan. 2012<sup>1</sup>) continues with drilling fluid blended from Jet A1 and HCFC-141b (*Vasiliev et al.*, 2011). The U.S. research community is conducting a deep ice-coring project at WAIS Divide, where for the first time Isopar™ K solvent as the base for blending with HCFC-141b was used (*Shturmakov et al.*, 2007). The WAIS Divide borehole was bottomed to a depth of 3405.1 m, 31<sup>st</sup> Dec. 2011<sup>2</sup>.

The Montreal Protocol placed HCFC-141b on its Class II substance list. Originally, Class II compounds were slated for restrictions starting in year 2015 and outright prohibition by 2030. Some of the countries accelerated that process, and HCFC-141b is now under a production-and-import ban. In Europe HCFCs are banned since 2004, in North America U.S. Environmental Protection Agency (EPA) has forced HCFC-141b phase-out in 2003. In 2007, Montreal Protocol Parties have decided to accelerate the phase-out of consumption and production of HCFC.

<sup>1</sup> <http://www.aari.nw.ru/news/text/2012/120112-%D0%A0%D0%90%D0%AD.pdf>

<sup>2</sup> [http://www.waisdivide.unh.edu/docs/sitrep/DISC\\_SITREP7\\_Dec25-31\\_2011.pdf](http://www.waisdivide.unh.edu/docs/sitrep/DISC_SITREP7_Dec25-31_2011.pdf)

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Nevertheless, some countries continue to produce and to use HCFC-141b without any restrictions. For example, the government of China will cap and reduce the production and consumption of HCFC-141b gradually starting in 2015, but now it is still available on the market (*Tony Jiang Ping Li*<sup>1</sup>, pers. comm., 2011). The dealer's price of HCFC-141b is 7.9 USD/kg. Considering the Exxsol™ D-40 price of 75.37 RUB/kg<sup>2</sup> (~2.4 USD/kg), the two-component fluid mixed from Exxsol™ D-40 and 34.2 % (vol.) HCFC-141b will cost of ~4.6 USD/liter.

### 6.2. Two-component fluid based on Isopar™ K solvent

Isopar™ K is a highly refined, de-aromatized isoparaffinic solvent with narrow boiling range (Table 3). *Gerasimoff*, 2003 mentioned that Isopar™ K is so pure as to be applicable to the manufacture of cosmetics and the application of waxes and other coatings to food products. *Shturmakov et al.*, 2007 asserted that Isopar™ K presents fewer health and safety concerns than Exxsol™ D40. In fact, it does not reflect reality.

Table 3

Main properties of solvents Exxsol™ D-series and Isopar™ K

Properties	Exxsol™ D30	Exxsol™ D40	Exxsol™ D60	Isopar™ K
Density 15 °C, kg/m <sup>3</sup>	762	775	792	763
Flash point, °C	29	42	63	54
Pour point, °C	<-55	<-55	<-55	<-18
Aromatic content, wt. %	0.001	0.003	0.06	0.003
Viscosity 20 °C, cP	0.75	0.96	1.29	1.84
Aniline point, °C	64	67	70	83
Distillation range, °C	143 – 165	160 – 190	187 – 216	178 – 197
Evaporation rate (nBuAc=100)	44	14	3.4	6.0

Source: Exxon Mobil Corporation data

The manufacturer's recommended Time Weighted Average (TWA) for Exxsol™ D40 is 197 ppm or 1200 mg/m<sup>3</sup> (Attachment 1). At the same time, vapor concentrations of Isopar™ K greater than approximately 1000 ppm are irritating to the eyes and the respiratory tract, and may cause headaches, dizziness, anesthesia, drowsiness, unconsciousness, and other central nervous effects, including death (Attachment 2). Skin contact may aggravate existing dermatitis. Moreover, other technological properties of Isopar™ K are worse than properties of Exxsol™ D40: the density is lower, viscosity two times higher, and evaporation much slower.

<sup>1</sup> Business Development Leader of DuPont China Holding Co., Ltd., 18/F Tower A, Gemdale Plaza, No.91 Jianguo. Road, Chaoyang District, Beijing 100022, China

<sup>2</sup> [http://www.b2b-bashneft.ru/market/view.html?id=79811&lang=eng&switch\\_price\\_both\\_view=1](http://www.b2b-bashneft.ru/market/view.html?id=79811&lang=eng&switch_price_both_view=1)

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During drilling in the season 2010/2011 at WAIS Divide wastes of the drilling fluid were estimated by author as ~29.3 % (Table 4).

**Table 4**

**Consumption of the drilling fluid at WAIS Divide**

Parameters	Season 2010/2011
Drilling depths, m	2564.37 – 3331.54
Drilled interval, m	767.17
Drill fluid used, liters, including	23 027 (100 %)
Isopar™ K	16 307 (70.8 %)
HCFC 141b	6 720 (29.2 %)
Drilling fluid consumption*, liters/m	30.0
Drilling fluid consumption for filling of drilled-in hole interval*, liters/m	21.2

Source: Johnson, 2011; \*Estimations of P. Talalay

## 6.3. Abandoned densifiers

### 6.3.1. Hydrofluoroether HFE-7100

The *Ice Drilling Design and Operations* group (IDDO, University of Wisconsin – Madison, USA) tested two-compound fluid consisted from Isopar™ K and segregated hydrofluoroether HFE-7100 produced by 3M Corporation as densifier. The segregated HFE's have low viscosity, low toxicity, and no flash point (Table 5). HFE-7100 is described chemically as a mixture of two inseparable isomeric chemicals: methoxynonafluoroisobutane, and methoxynonafluorobutane. HFE-7100 is used as a cleaning and a heat-transfer agent, a solvent for the manufacture of cosmetic products, including personal care products (skin, hair and bath care), fragrances and room scents.

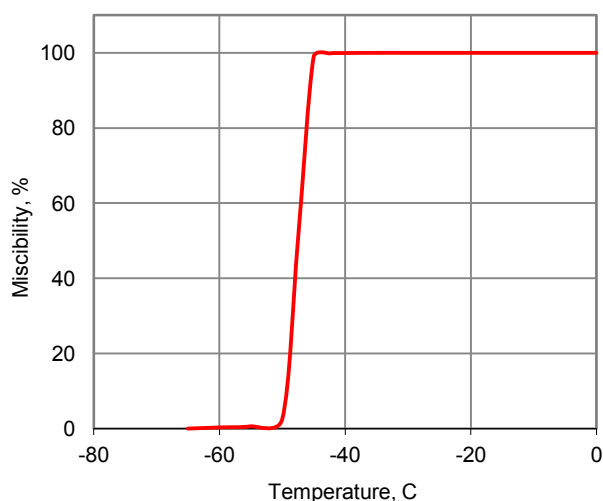
**Table 5**

**Main properties of hydrofluoroether HFE-7100**

Properties	HFE-7100
Molecular weight	250
Molecular formula	(C <sub>5</sub> H <sub>3</sub> F <sub>9</sub> O) (C <sub>5</sub> H <sub>3</sub> F <sub>9</sub> O)
Density 20 °C, kg/m <sup>3</sup>	1 530.5
Viscosity 25 °C, cSt	0.37
Evaporation rate (nBAc=1)	49
Freezing point, °C	-135
Water solubility, mg/L	8.47
Vapour pressure 25°C, kPa	27.736
Appearance	Clear, colourless liquid
Flash point, °C	No flash point
Surface tension, mN/m	13.86
Autoignition temperature, °C	397
Explosive properties	Not explosive
Flammability limits	Not flammable
Reactivity/stability	Not reactive

Source: HFE-7100, 2006

HFE-7100 has low acute oral and inhalation toxicity. It is not an eye or skin irritant and is not a skin sensitizer and is not classified as a hazardous chemical. Ordinary the segregated HFE's have zero Ozone Depletion Potential, but they exhibit extremely high (low hundreds to about 15 000) Global Warming Potential.



**Fig. 2. Miscibility of Isopar™ K solvent with HFE-7100**  
(*M.Gerasimoff, in Shturmakov, 2004*)

Experimental tests (*M. Gerasimoff, pers. comm., 2004*) showed that the mixture of Isopar™ K with HFE-7100 separate into two phases over a very narrow temperature range at about  $-45^{\circ}\text{C}$ ; this makes its use impossible to in boreholes in extremely cold ice (Fig. 2).

## 6.3.2. Lusolvan® FBH

Lusolvan® FBH is di-isobutyl-ester of succinyl-, glutar- and adipinacid (2:4:3) (*Steffensen et al., 2004*). The acids are extracts from amber, red, and green beets. It is colourless and almost odourless, and it has a relatively high density (Table 6).

**Table 6**

**Main properties of Lusolvan® FBH**

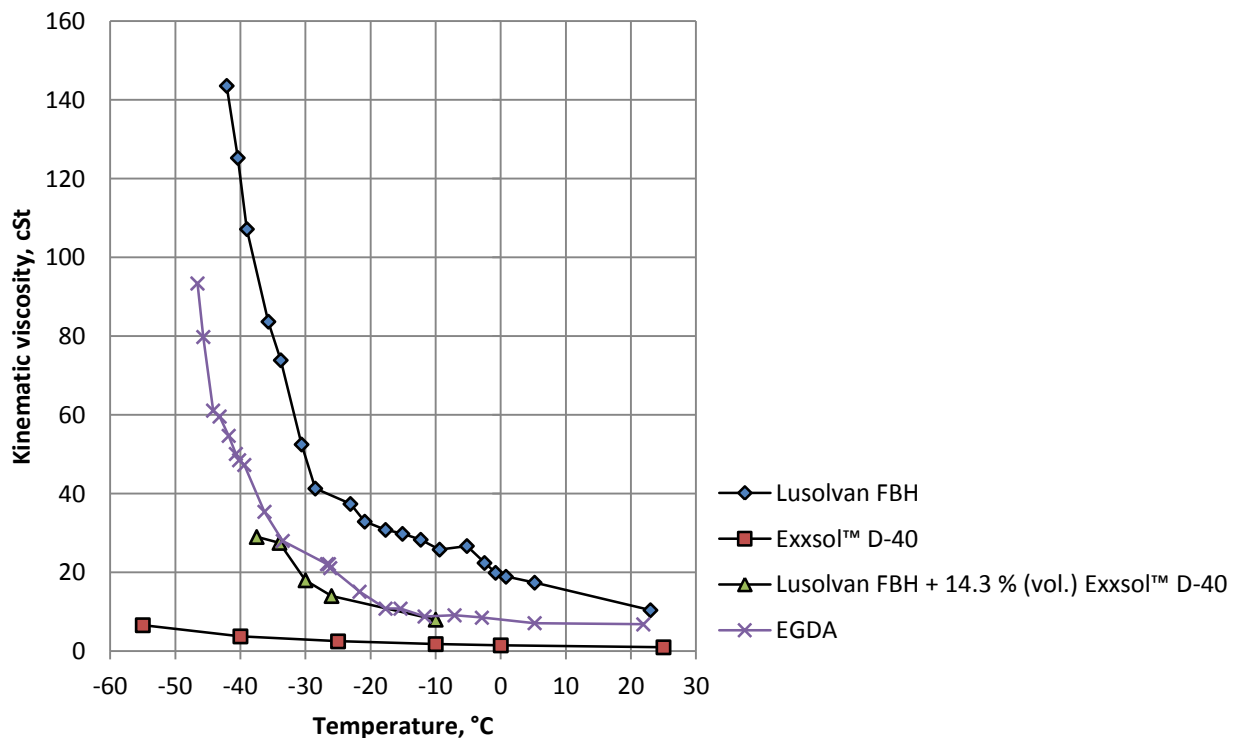
Parameters	Lusolvan® FBH
Density 20 °C, kg/m <sup>3</sup>	960
Viscosity 20 °C, cSt	7
Freezing point, °C	<-60
Vapour pressure 20°C, kPa	0.001
Flash point, °C	131
Autoignition temperature, °C	400
Explosive limit. % (vol.)	0.6-4.7
Boiling point, °C	>260

Source: *Steffensen et al., 2004*

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Lusolvan® FBH is used by the paint industry to obtain the slow and even drying of paint. It is described as “a very effective coalescent”. It is a low toxicity and biodegradable liquid: no risk is involved in inhaling a highly saturated air-vapour mixture; no skin, throat, lung or nose irritation was observed on test animals. Lusolvan® presents no known health risks. Standard industrial protection and hygiene is, however, recommended by manufacturers.

The *Glaciology Group*, now reorganized as *The Centre for Ice and Climate* at Copenhagen University, investigated Lusolvan® FBH and mixtures of this compound with Exxsol™ D-40 solvent at low-temperatures. Lusolvan® FBH is readily miscible with Exxsol™ D-40 solvent. This allows adjusting density to 930 kg/m<sup>3</sup> at –30 °C by mixing of Lusolvan® FBH and Exxsol™ D-40 in the ratio 6:1 (vol.). Viscosity of this mixture is very high: 18 cSt at –30 °C (Fig. 3). Nitrile rubber O-rings were observed to swell in this mixture. Lusolvan® FBH has low vapour pressure, which could result in unacceptably slow drying of freshly drilled ice cores.



**Fig. 3. Viscosity vs temperature:** 1) Lusolvan® FBH (*Sheldon, 2011*);  
2) Exxsol™ D-40 (*Talalay and Gundestrup, 1999*);  
3) two-component fluid mixed from Lusolvan® FBH and 14.3 % (vol.) Exxsol™ D-40 (*Sheldon, 2011*)  
4) EGDA (*Sheldon, 2011*)



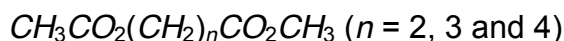
The very high viscosity of Lusolvan® FBH and Exxsol™ D-40 mixtures leads to a significant decrease in the free-falling speed of an ice core drill. Due to the steep increase of viscosity at low temperatures, it is not suitable as a component of drilling fluid in environment colder than about –35 °C.

Lussolvan® FBH is produced by BASF chemical company. Almost the same type of linear alcohols coalescent is produced by Chemoxy as COASOL™. This compound was used as densifier of two-component fluid with base-fluid ESTISOL™ 240 in NEEM borehole, Greenland (*see Subchapter 7.2*).

### 6.4. Promising densifiers

#### 6.4.1. ESTASOL™

ESTASOL™ is a mixture of refined dimethyl esters of adipic, glutaric and succinic acids characterised by its mild odor and low vapor pressure (Table 7)<sup>1</sup>. The chemical index of ESTASOL™ dimethyl esters is referred as following:



ESTASOL™ is a strong polar solvent for use as an alternative to the chlorinated solvents, aromatics and ketones in cleaning and in a wide range of functional fluids. ESTASOL™ has low toxicity, high solvency, high boiling point, high flash point, low vapor pressure. It is biodegradable, non-flammable, non-volatile organic compound (non-VOC) (Attachment 3).

ESTASOL™ is used in can and coil coatings, foundry core-binders, acrylic lacquers, wood finishes, printing inks, paint strippers, various industrial cleaning applications including metal degreasing, resin cleaning, hand cleaning, grouting, sealants and wax formulations, etc.

This product is not classified as dangerous according to EC criteria. Specific safe use and handling information are listed in the Attachment 3.

ESTASOL™ is compatible with most commonly used solvents, and often blended with the other solvents to optimize properties in formulations. ESTASOL™ is miscible in all parts with hydrocarbons, but there are no data for sub-zero temperatures. Presumably, it could be used as densifier for a two-component fluid based on Exxsol™ D-series (Fig. 4).

The price of ESTASOL™ is 2300 USD/220-kg drum (*I. Rumoroso*<sup>1</sup>, pers. comm., 2011). Assuming that the price of Exxsol™ D-40 is 2.4 USD/kg, the two-component fluid

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<sup>1</sup> <http://www.dow.com/custproc/products/estasol.htm>

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mixed from Exxsol™ D-40 and 36.6 % (vol.) ESTASOL™ will cost of ~5.4 USD/liter (Table 8).

**Table 7**

**Specification and physical properties of potential densifiers**

Properties	ESTASOL™	EGDA
Dimethyl Succinate, % wt/wt	15 - 25	-
Dimethyl Glutarate, % wt/wt	55 - 65	-
Dimethyl Adipate, % wt/wt	12 - 23	-
Water, % wt/wt max	0.2	-
Diester content, % wt/wt min	99	-
Acidity, mg KOH/g max	0.5	-
Appearance	Clear, colourless liquid with ester odor	Colourless liquid with ester odor
Molecular wt (average)	160	146.14
Density, kg/m <sup>3</sup>	1085 – 1095 @ 15.5 °C	1128 @ 20 °C
Viscosity 25 °C, cSt	2.4 - 2.5	6.8
Evaporation rate (nBAc=1)	0.01	0.02
Vapour pressure 20 °C, mmHg	0.06	0.2
Hansen solubility parameters, MPa <sup>1/2</sup>		
Nonpolar	16.9	7.9
Polar	4.7	2.3
Hydrogen Bonding	9.8	4.8
Refractive index (N20-D)	1.423 - 1.425	1.416
Distillation range IBP, °C	200	-
DP, °C	230	-
Freezing point, °C	-25	-42
Flash point, °C	102	82
Boiling point, °C	200-230	186-187
Solubility in water 20°C, % wt/wt	5	14
Vapor density (air = 1)	-	5.04
Coefficient of expansion per °C	0.00094	0.00095
Auto ignition, °C	365	481
Flammable limits in air, %	1.5 – 12.5	1.6 – 8.4
Electrical resistance 24°C, megohms	0.5	5

Sources: <http://www.dow.com/custproc/products/estasol.htm>

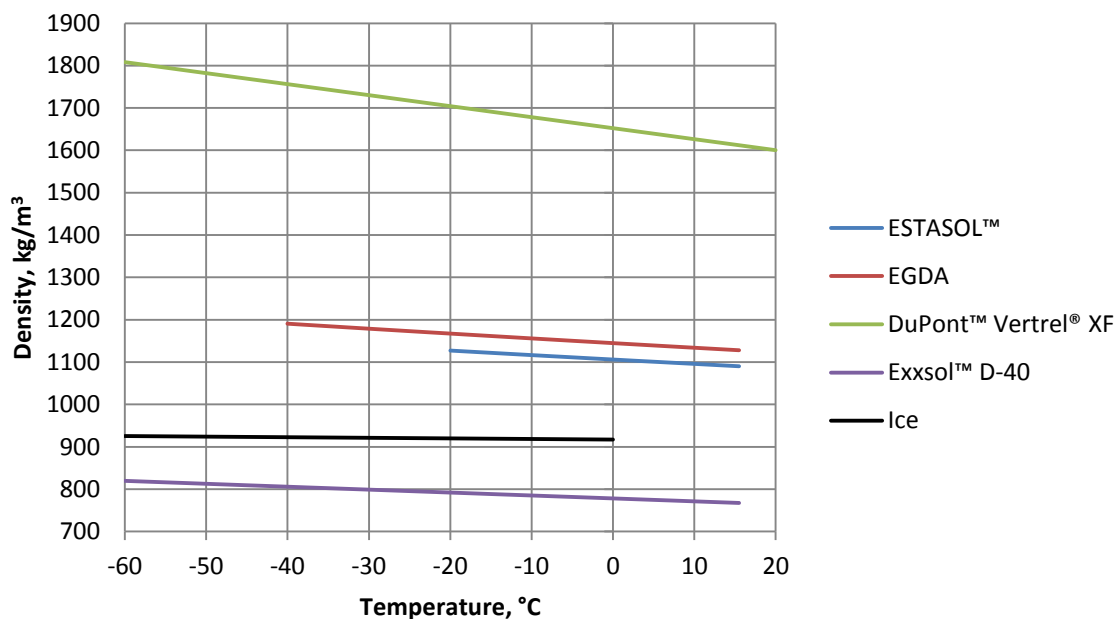
[http://ws.eastman.com/ProductCatalogApps/PageControllers/ProdDatasheet\\_PC.aspx?product=71001081](http://ws.eastman.com/ProductCatalogApps/PageControllers/ProdDatasheet_PC.aspx?product=71001081)

**Table 8**

**Potential compositions of Exxsol™ D40 base fluids with presumable density of 940 kg/m<sup>3</sup> at – 50 °C**

Compositions	Contents, % (vol.)	Approximate price, USD/liter
Exxsol™ D40	63.4	5.4
ESTASOL™	36.6	
Exxsol™ D40	67.4	2.0
EGDA	32.6	
Exxsol™ D40	86.9	14.0
DuPont™ Vertrel® XF	13.1	
Exxsol™ D40	70.3	?
DuPont™ FEA-1100	29.7	

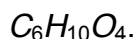
<sup>1</sup> Commercial Development Manager, Chemoxy International Ltd, Cargo Fleet Road, Middlesbrough TS3 6AF UK



**Fig. 4. Density vs temperature:** 1) ESTASOL™ with coefficient of expansion  $0.00094 \text{ K}^{-1}$ ; 2) EGDA with coefficient of expansion  $0.00095 \text{ K}^{-1}$ ; 3) DuPont™ Vertrel® XF in the range  $-20 \dots +20 \text{ }^{\circ}\text{C}$  according to manufacturer's data and below  $-20 \text{ }^{\circ}\text{C}$  due to extrapolation; 4) Exxsol™ D-40 (Talalay and Gundestrup, 1999); 5) ice according to eq. (2)

## 6.4.2. Ethylene Glycol Diacetate (EGDA)

EGDA is a colorless, low odor, very slow-evaporating solvent with empirical formula<sup>1</sup>:



EGDA gives good flow-out to baking lacquers and enamels, and its major uses are in thermoplastic acrylic coatings, as a reflow solvent, and in foundry core-binder applications. EGDA is also utilized as a perfume fixative.

This product is biodegradable and is not classified as dangerous according to EC criteria (Attachment 4). Viscosity of pure EGDA is very high at low temperatures (see Fig. 3), but being mixed with low-viscosity Exxsol™ D-40 solvent should significantly reduce this effect. Hypothetically, to obtain density of  $940 \text{ kg/m}^3$  at  $-50 \text{ }^{\circ}\text{C}$  the solvent Exxsol™ D-40 should be mixed with 32.6 % (vol.) EGDA.

The price of EDGA is  $\sim 2.3 \text{ USD/liter}$  (Sheldon, 2011), and the two-component fluid mixed from Exxsol™ D-40 and 32.6 % (vol.) EGDA costs only  $\sim 2.0 \text{ USD/liter}$  (see Table 8).

<sup>1</sup> [http://ws.eastman.com/ProductCatalogApps/PageControllers/ProdDatasheet\\_PC.aspx?product=71001081](http://ws.eastman.com/ProductCatalogApps/PageControllers/ProdDatasheet_PC.aspx?product=71001081)

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### 6.4.3. DuPont™ Vertrel® XF (HFC 43-10mee)

DuPont™ Vertrel® XF is HFC 43-10mee or 2,3-dihydrodecafluoropentane (also known as, decafluoropentane). It is a proprietary hydrofluorocarbon fluid with “zero” ozone depletion and a low global warming potential (Table 9) suited for use in vapor degreasing equipment for cleaning, rinsing, and drying. Typical applications of DuPont™ Vertrel® XF are cleaning and rinsing agent, drying fluid, particulate remover, fluorocarbon lubricant carrier, solvent and dispersion media, heat-transfer media, and a dielectric fluid. It can replace current hydro-chlorofluorocarbon and perfluorocarbon fluids in most applications.

Table 9

Properties of foam expansion agents

Properties	1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>		4 <sup>th</sup>	
	Generation	Generation	Generation		Generation	
	CFC-11	HCFC-141b	HFC-245fa	HFC-365mfc	HFC 43-10mee	FEA-1100
Chemical formula	$\text{CFCl}_3$	$\text{CCl}_2\text{FCH}_3$	$\text{CF}_3\text{CH}_2\text{CHF}_2$	$\text{CF}_3\text{CH}_2\text{CF}_2\text{CH}_3$	$\text{C}_5\text{H}_2\text{F}_{10}$	$\text{CF}_3\text{CHCHCF}_3$
ODP	1	0.12	0	0	0	0
GWP (100 year ITH)	4750	725	1020	782	1300	5
Flash point, °C	non	none	none	-25	none	none
Boiling point, °C	23.9	32.1	15.3	40	55	33

DuPont™ Vertrel® XF is a clear, colorless liquid with high density, low viscosity, and low surface tension (Table 10). This combined with non-flammability, chemical and thermal stability, low toxicity.

Table 10

Main properties of DuPont™ Vertrel® XF

Properties	DuPont™ Vertrel® XF
Molecular weight	252
Surface tension, N/m	0.0141
Liquid density, kg/m <sup>3</sup>	1580
Freezing point, °C	-80
Solubility in water, ppm	140
Solubility of water, ppm	490
Critical temperature, °C	181
Critical pressure, atm	22.6
Critical volume, ltr/mol	0.433
Vapor pressure, atm	0.297
Viscosity, cPs	0.67

Source: DuPont™ Vertrel® XF. Specialty Fluid: Technical Information

A large variety of plastics and elastomers can be safely exposed to DuPont™ Vertrel® XF. It is fully compatible with the stainless steel, zinc, aluminum, copper, brass after exposure for two weeks at 100°C. DuPont™ Vertrel® XF is not compatible with strong bases; therefore, contact with highly basic process materials is not recommended.

## DRILLING FLUIDS FOR DEEP CORING IN CENTRAL ANTARCTICA

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DuPont™ Vertrel® XF has relatively low inhalation toxicity: acceptable exposure (TWA) limit is 200 ppm (as established by DuPont™). It is a slight skin and eye irritant.

DuPont™ Vertrel® XF is accepted by the U.S. Environmental Protection Agency (EPA) under the Significant New Alternatives Policy (SNAP) program as a substitute for ozone-depleting substances. DuPont™ Vertrel® XF is exempt from classification as a VOC by the EPA. It is not a hazardous air pollutant, and therefore not subject to *National Emission Standards for Hazardous Air Pollutants* (NESHAP) regulation<sup>1</sup>. Atmospheric lifetime is 17.1 years.

The solvency of DuPont™ Vertrel® XF is selective. It is completely miscible with most esters, ketones, ethers, ether-alcohols, and with the lower alcohols such as methanol, ethanol, and isopropanol. The lower hydrocarbons, such as hexane and heptane, are also soluble. Neat DuPont™ Vertrel® XF has limited solvency for many higher molecular weight materials, such as hydrocarbon oils, silicone oils, waxes, and greases; in the latter case, combination of Vertrel® XF with a third compound such as the many readily miscible esters, alcohols, and lower hydrocarbons, can enhance co-solubility.

So, the miscibility of DuPont™ Vertrel® XF with Exxsol™ D-series is questionable. Probably using of DuPont™ Vertrel® XF as densifier of petroleum base drilling fluid is possible only by initial blending with miscible component (e.g. ester) and following mixing with kerosene type fluid.

The price of DuPont™ Vertrel® XF is very high at about 60 USD/kg (*Tony Jiang Ping Li*, pers. comm., 2011).

### 6.4.4. DuPont™ FEA-1100 (HFO-1336mzz)

DuPont™ FEA-1100 is a hydrofluoroolefin of the HFO-1336mzz type, a 4<sup>th</sup> generation foam-expansion agent (*Loh et al.*, 2009). It is characterized by zero ozone depletion potential, very low acute toxicity, and has a low GWP value of 5 (see Table 9). Recent estimates indicate that DuPont™ FEA-1100 has a very short atmospheric lifetime of approximately 16 days. Molecular weight of DuPont™ FEA-1100 is 164, and a density of more than 1200 kg/m<sup>3</sup> at room temperature. It has good solubility properties.

DuPont™ FEA-1100 has been shown to be non-flammable. Testing according to ASTM E681 *Standard Test Method for Concentration Limits of Flammability of Chemicals*

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<sup>1</sup> The National Emissions Standards for Hazardous Air Pollutants (NESHAP) are emissions standards set by the U.S. EPA for an air pollutant not covered by the National Ambient Air Quality Standards (NAAQS) that may cause an increase in fatalities or in serious, irreversible, or incapacitating illness.

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(*Vapors and Gases*) indicated non-flammability at temperatures of 60°C and at 100°C. Toxicological testing performed to date indicates that DuPont™ FEA-1100 can be safely used in different applications (Table 11).

Table 11

DuPont™ FEA-1100 toxicological assessments

Test	Results
ALC and LC-50	Very low acute toxicity
Skin irritation	Non-irritating
Mutagenicity-ames	Non-mutagenic
Chromosomal aberration	No genetic material damage when tested in bacterial and mammalian cell cultures
Cardiac sensitization	Favorable cardiac sensitization potential profile
28 day repeated inhalation	Favorable repeated inhalation profile

Source: Loh *et al.*, 2009

Compatibility tests for DuPont™ FEA-1100 with metals were performed in sealed tubes. Metal coupons (copper, brass, carbon steel, stainless steel and aluminum) were immersed in DuPont™ FEA-1100 and heated in an oven for 14 days at 100°C, and changes in weight and appearance of the metal coupons were recorded. The liquid solutions were also evaluated for appearance and decomposition products such as fluoride. There were no weight change, no sign of corrosion, no fluoride detected. A large variety of plastics and elastomers can be safely exposed to DuPont™ FEA-1100.

DuPont™ FEA-1100 is characterized by good environmental properties, compatibility with metals, plastics and elastomers, and most likely can be employed as densifier of two-component petroleum base fluids. Commercial sales of DuPont™ FEA-1100 are planning to start at the end of 2012 (Fig. 5).

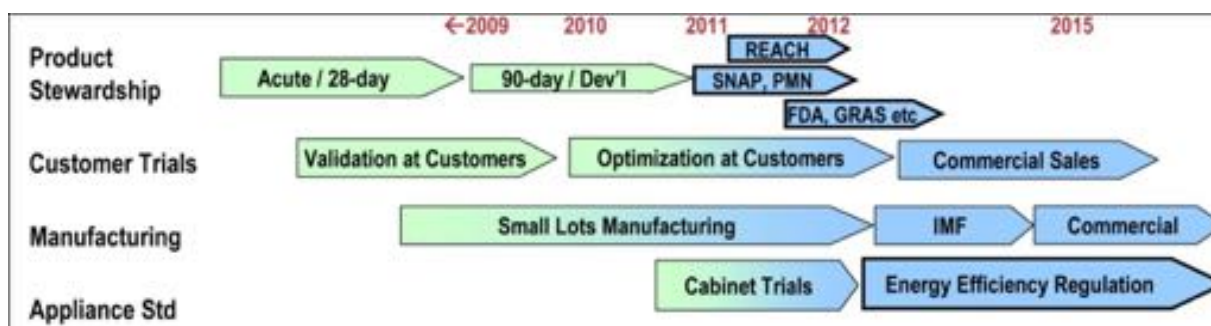


Fig. 5. DuPont™ FEA-1100 project timeline

## 7. TWO-COMPONENT ESTISOL™ ESTER BASE FLUIDS

### 7.1. ESTISOL™ esters

ESTISOL™ esters have developed to be the formulator's preferred alternative to aliphatic and aromatic hydrocarbons in many chemical products (Table 12). ESTISOL™ esters may reduce, or eliminate, the VOC content; they improve the product's health and safety profile, and ensure an environmentally sound product profile.

Table 12

Main properties of ESTISOL™ esters (selectively)

ESTISOL™ grade	Raw material base	Viscosity 25°C, cP	Boiling range, °C	Flash point, °C	Pour point, °C	Density 20°, kg/m <sup>3</sup>
140	Synthetic	1.3	199	75	-93	870
150	Synthetic	2.5	220-225	102	-25	1085
165	Synthetic	3	180-190	81	<-30	1100
170	Vegetable	4	180-300	78	<-20	873
180	Vegetable	4	210-230	95	<-10	872
240	Vegetable	4	250-290	130	<-50	855
256	Synthetic	3	265-280	144	<-40	859
312	Vegetable	6	300-320	172	-30	860
F2887	Synthetic	7	>280	167	<-10	1083

Source: Esti Chem A/S

ESTISOL™ esters can act as straight replacements, solvency boosters, or carrier fluids in formulated products such as industrial cleaners, degreasers, blanket and roller washes, printing inks, hand cleaners, paint strippers, and oil field chemicals.

### 7.2. ESTISOL™ 240 and COASOL™

Danish specialists from *The Centre for Ice and Climate*, University of Copenhagen chose for the laboratory and field tests mixture of ESTISOL™ 240 and COASOL™.

ESTISOL™ 240 is based on the natural fatty acids derived from coconut oil. The product is a strong polar solvent with a high flash point and very good environmental properties. ESTISOL™ 240 is recommended as a component in industrial cleaning fluids such as degreasing agents, blanket and roller washes for off-set printing inks, automotive and hand cleaners. ESTISOL™ 240 is also applied in formulation of the mineral-oil-free printing inks. ESTISOL™ 240 is recommended to replace traditional solvents such as aromatics, kerosene, and white spirit.

COASOL™ is a mixture of refined di-isobutyl esters of adipic acid, glutaric acid and succinic acid and is characterized by being of low odour and of low vapour pressure (Table 13). COASOL™ is generally the same product as Lusolvan FBH (*see Subchapter*



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6.3.2). COASOL™ is used as coalescing agent in water-based coatings, a solvent in industrial cleaners, and a solvent in polymer applications. It is non-VOC and hydrolytically stable. COASOL™ does not contain chlorinated compounds and has high solvency power for polar and non-polar soils. COASOL™ is miscible with most commonly used solvents including alcohols, glycol ethers, esters, terpenes, hydrocarbons, chlorinated solvents, glycol ether acetates, and ketones. It dissolves most resins.

**Table 13**

**Main properties of COASOL™**

Properties	COASOL™
<b>Chemical description % w/w</b>	
Di-isobutyl succinate	15 – 25
Di-isobutyl glutarate	55 – 65
Di-isobutyl adipate	12 – 25
<b>Appearance</b>	clear, colourless liquid
<b>Odour</b>	low
<b>Density, 20°C kg/m<sup>3</sup></b>	958-960
<b>Viscosity, mPas</b>	5.3
<b>Freezing point, °C</b>	– 60
<b>Flash point, °C</b>	131
<b>Vapour pressure at 20 °C, hPa</b>	max. 0.004
<b>Flammable limits in air, % (vol.)</b>	0.6 – 4.7
<b>Autoignition temperature, °C</b>	400
<b>Solubility in water</b>	Insoluble
<b>Boiling range, °C</b>	274-289
<b>Evaporation rate (nBAc=1)</b>	<0.001

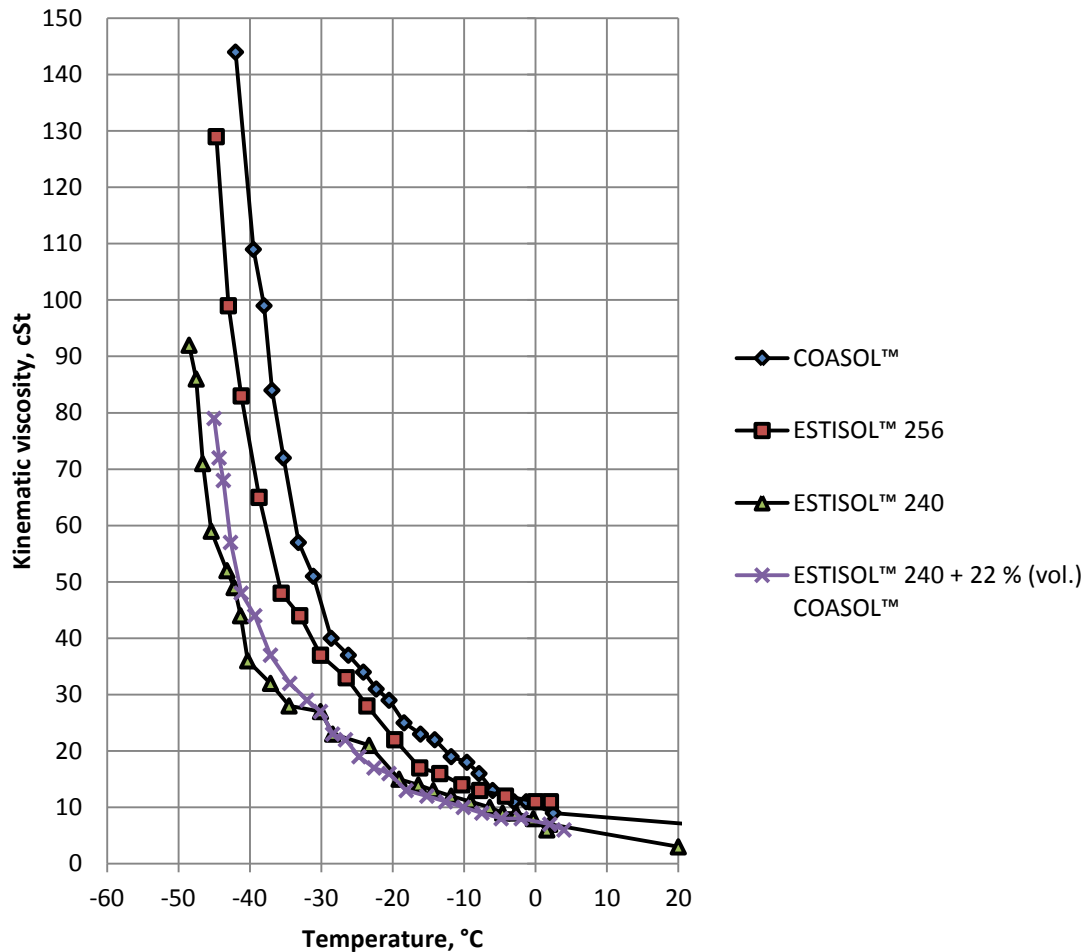
Source: Dow Haltermann. COASOL™ Di-Ester for Applications in Water-borne Coatings, Industrial Cleaners & Polymer Industry.

Both of the liquids are characterized by low vapor pressure, almost no odor, low toxicity, good bio-degradable properties. By varying the mixing ratio of ESTISOL™ 240 and COASOL™ fluid, the densities between 860 and 965 kg/m<sup>3</sup> can be obtained. Density of two-component fluid mixed from ESTISOL™ 240 and 22 % (vol.) COASOL™ is 935 kg/m<sup>3</sup> at -24 °C (*NEEM Field Season 2011*, 2011).

The main disadvantage of this mixture is the very high viscosity: ~20 cSt at –25 °C and ~30 cSt at –35 °C (Fig. 6). To achieve the optimal drill's lowering/hoisting rate, the borehole with larger clearance between the drill and the borehole walls must be drilled. This will lead to significant increasing of cuttings, shortening of run penetration, decreasing of ice production rate, and so on.

The price of ESTISOL™ 240 is 5.5 USD/kg and of COASOL™ is 4.6 USD/kg. A two-component fluid mixed from ESTISOL™ 240 and 22 % (vol.) COASOL™ costs 4.64 USD/liter.





**Fig. 6. Viscosity vs temperature** (Sheldon, 2011): 1) COASOL™; 2) ESTISOL™ 256; 3) ESTISOL™ 240; 3) two-component fluid mixed from ESTISOL™ 240 and 22 % (vol.) COASOL™

ESTISOL™ 240 was field-tested as a drilling liquid at Flade Isblink, Greenland during 2006 with a 4"-diameter ice-coring Hans Tausen electromechanical drill to a depth of 423.3 m. About 260 m of this core was drilled using this new drilling fluid. The ice core quality was 'good', no problems were encountered during cleaning and processing of the ice core; the mixture has a slippery feel with no discernible odour. The liquid is very slippery when spilt on smooth wooden flooring, which presents a potential hazard. In this fluid mixture, the Hans Tausen drill descends at speeds of 0.95 m/s at drill liquid temperature of -16 °C. By increasing the borehole diameter by 4.4 mm (from 129.6 to 134 mm) a 36 % descent speed increase was achieved (to ~1.28 m/s).

These field tests brought to light another disadvantage of the mixture consisted from ESTISOL™ 240 and COASOL™. Although declared non-hazardous material and handling protocols are very simple, this mixture being spilled on the floor of the drilling shelter totally destroyed the rubber soles of boots. It is difficult to say that a fluid with such

aggressive properties is an intelligent choice for health-and-safety, and that it is also an ecologically-friendly material.

Nonetheless, a two-component mixture consisting of ESTISOL™ 240 and COASOL™ was successfully used at the NEEM deep drilling project in north-west Greenland. The minimal temperature in the hole was approximately  $-30^{\circ}\text{C}$ . After two seasons the drillers reached basal material that could not be penetrated at 2537.35 m depth on 27<sup>th</sup> July, 2010<sup>1</sup>. The new drilling fluid did not create unforeseen problems. Moreover, the drillers speculated that the viscous drilling fluid might have helped to solve the usual penetration problems in 'warm' ice (*S. Hansen*, pers. comm., 2011).

A combination of ESTISOL™ 240 and COASOL™ is planned to be used for drilling project Roosevelt Island in Antarctica with target depth of  $744\pm 10$  m. The project was initiated by the *New Zealand Ice Core Group*, University of Wellington. The average annual temperature at the drilling site at 10-m firm was estimated as  $-23.4^{\circ}\text{C}$  (*Roosevelt Island Climate Evolution*, 2010).

Use of a two-component drilling fluid mixed from ESTISOL™ 240 and COASOL™ is unpromising in very cold ice environments because viscosity of this mixture increases rapidly at temperatures below about  $-30$  to  $-35^{\circ}\text{C}$ .

### 7.3. ESTISOL™ 140, -165 and -F2887

ESTISOL™ 140 is an aliphatic synthetic ester. It has a high flash point and a low viscosity. ESTISOL™ 140 is used as a solvent in industrial cleaners, coatings, adhesives and other formulated chemical products. ESTISOL™ 140 is a clear fluid with fruit-like odour. It is not miscible with water. When used and handled according to specification, ESTISOL™ 140 does not have any harmful effects (Attachment 5). There are no skin irritant effects, and no eye irritating effect. ESTISOL™ 140 might be used as an alternative to hydrocarbon solvents or fuel-stock in drilling fluids.

ESTISOL™ 165 is a clear liquid is mild odour. It is slight irritant to skin and mucous membranes (Attachment 6). It has also irritating eye effect. The usual precautionary measures (gloves, safety glasses) are to be adhered to when handling chemical.

ESTISOL™ F2887 is a synthetic ester made from a polyvalent alcohol. It is recommended as a co-solvent in foundry sand binder systems, coatings and adhesives. It could be used to replace highly polar solvents with suitable polymer compatibility and

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<sup>1</sup> <http://neem.dk/>

## DRILLING FLUIDS FOR DEEP CORING IN CENTRAL ANTARCTICA

limited plasticizing property. ESTISOL™ F2887 is often used in a combination of other polar solvents. No special measures are required for safe handling (Attachment 7).

The main properties of ESTISOL™ 140, -165 and -F2887 are presented in Table 12.

The values of the pour point of ESTISOL™ 165 and ESTISOL™ F2887 in technical data sheets are  $<-30$  °C and  $<-10$  °C, respectively. The manufacturer has not tested the fluid appearance at such low temperatures, and it is likely that the pour points are much lower than those indicated.

All three esters are not considered to be hazardous according to the calculation procedure of the “*General Classification guideline for preparations of the EU*”, and they are readily biodegradable. They are not classified (i.e., hazardous) substances for transport by road or air cargo, and do not present an explosion hazard.

The miscibility between ESTISOL™ 165 and aliphatic hydrocarbons is not 100% in all proportions; especially at low temperatures (*T. Mathiesen*<sup>1</sup>, pers. comm., 2011). ESTISOL™ 165 is approx. 5% soluble in water at 20°C. ESTISOL™ 140 and ESTISOL™ F2887 are miscible with hydrocarbons and they are no soluble in water.

The typical density of the ESTISOL™ 140 is 870 kg/m<sup>3</sup> at 20 °C varying according to specification from 860 to 880 kg/m<sup>3</sup>. Assuming coefficient of expansion  $\sim 0.001$  K<sup>-1</sup>, the density of ESTISOL™ 140 should be equal to 935 kg/m<sup>3</sup> at  $-50$  °C. Therefore it is almost sufficiently dense by itself to compensate for ice-overburden pressure.

The densities of ESTISOL™ 165 and ESTISOL™ F2887 are 1100 kg/m<sup>3</sup> and 1083 kg/m<sup>3</sup> at 20 °C, respectively, and they could be used as densifiers of low-temperature drilling fluids. We can propose for future testing and using the following mixtures that can meet requirements to low-temperature drilling fluids (Table 14).

Table 14

Potential compositions of ESTISOL™ ester base fluids  
with presumable density of 940 kg/m<sup>3</sup> at  $-50$  °C

Compositions	Contents, % (vol.)	Approximate price, USD/liter
ESTISOL™ 140	98.2	2.7
ESTISOL™ 165	1.8	
ESTISOL™ 140	98.1	2.7
ESTISOL™ F2887	1.9	
Exxsol™ D40	64.3	2.6
ESTISOL™ F2887	35.7	

<sup>1</sup> Managing Director, Esti Chem A/S, DK-4621 Gadstrup, Denmark

The manufacturer, *Esti Chem A/S*, indicates price in drums as: ESTISOL™ 140 – 2.30 EUR/kg; ESTISOL™ 165 – 2.30 EUR/kg; ESTISOL™ F2887 – 2.80 EUR/kg. The price of the two-component ESTISOL™ 140 base fluid are two times lower than two-component fluid mixed from ESTISOL™ 240 and COASOL™ (see Table 14).

### CONCLUSIONS

The search for a new environmental-friendly drilling fluid for coring in central Antarctica is still one of the most pressing problems of future drilling projects. Looking over the properties of the low-temperature drilling fluids for oil and gas well drilling confirms that they are not suitable for deep drilling in cold ice.

The most common drilling fluid of many recent projects was composed from kerosene type fluid and HCFC-141b, but as the latter component is no longer widely available, a substitute must be found. Even though restrictions for HCFC-141b technically do not until year 2015, many of the countries have accelerated this process, and HCFC-141b is now under a production-and-import ban virtually everywhere.

Danish specialists from *The Centre for Ice and Climate*, University of Copenhagen used for deep drilling at NEEM, northwest Greenland, mixture of ESTISOL™ 240 and COASOL™. Both of the liquids are characterized by low vapor pressure, almost no odor, low toxicity, and good bio-degradability. The main disadvantage of this mixture is the very high viscosity, such that it is ineffective for our purposes in an environment colder than –35 °C.

Four new chemicals can be considered as promising densifiers of two-component, kerosene-based drilling fluids: ESTASOL™, Ethylene Glycol Diacetate (EGDA), DuPont™ Vertrel® XF (HFC 43-10mee), and DuPont™ FEA-1100 (HFO-1336mzz). Exssol™ D-series solvent can be used as the base of such a drilling fluid in lieu of kerosene-like fuels that contain harmful levels of aromatic hydrocarbons.

Low-molecular dimethylsiloxane oils (DSO's) can also be considered as good alternative for borehole fluids, and are discussed at some length elsewhere (*Talalay, 2007*). Low-molecular DSO's are clear, water-white, tasteless, odorless and neutral liquids. They are hydrophobic and essentially inert substances that are stable to water, air, oxygen, metals, wood, paper, and plastics. From the wide range of DSO's, two grades of silicones – KF96-1,5cs and KF96-2,0cs – most fully fit the requirements for borehole fluids. The price of KF96-2,0cs is rather high. In 1999 the price indicated by *Shin-Etsu Silicones*

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*Europe B.V.* (Almere, The Netherlands) was 7.5 USD/kg. In 2011 the price of KF96-2,0cs offered by *Shanghai Yazu Science and Technology of the Chemical Industry, Ltd.* (China) has risen to 23 USD/kg. The final conclusion about DSO's applicability to deep ice drilling might be made after field experiments in a test borehole.

The new direction of drilling fluids research is connected with testing of ESTISOL™ 140, -165 and -F2887 esters. All of them are considered non-hazardous due to the calculation procedure of the "*General Classification guideline for preparations of the EU*". They are low-toxic, relatively cheap, readily biodegradable, are not classified as hazardous for transport by road or air cargo, and do not present an explosion hazard. The applicable of these agents as components of low-temperature drilling fluids is planning to be tested in *Polar Research Center*, Jilin University.

### ACKNOWLEDGMENTS

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## MATERIAL SAFETY DATA SHEET

SECTION 1	PRODUCT AND COMPANY IDENTIFICATION
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**PRODUCT**  
Product Name: EXXSOL D40 FLUID  
Product Description: Dearomatized Hydrocarbons  
Product Code:  
Intended Use: Solvent

**COMPANY IDENTIFICATION**  
Supplier: EXXONMOBIL CHEMICAL COMPANY  
P.O. BOX 3272  
HOUSTON, TX. 77253-3272 USA  
24 Hour Health Emergency (800) 726-2015  
Transportation Emergency Phone (800) 424-9300 CHEMTREC  
Product Technical Information (281) 870-6000/Health & Medical (281) 870-6884  
Supplier General Contact (281) 870-6000

SECTION 2	COMPOSITION / INFORMATION ON INGREDIENTS
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Reportable Hazardous Substance(s) or Complex Substance(s)

Name	CAS#	Concentration*
DISTILLATES (PETROLEUM), HYDROTREATED LIGHT	64742-47-8	100%

\* All concentrations are percent by weight unless material is a gas. Gas concentrations are in percent by volume.

SECTION 3	HAZARDS IDENTIFICATION
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This material is considered to be hazardous according to regulatory guidelines (see (M)SDS Section 15).

**POTENTIAL PHYSICAL / CHEMICAL EFFECTS**  
Combustible. Material can release vapors that readily form flammable mixtures. Vapor accumulation could flash and/or explode if ignited. Material can accumulate static charges which may cause an incendiary electrical discharge.

**POTENTIAL HEALTH EFFECTS**  
Repeated exposure may cause skin dryness or cracking. If swallowed, may be aspirated and cause lung damage. May be irritating to the eyes, nose, throat, and lungs.

**NFPA Hazard ID:** Health: 1 Flammability: 2 Reactivity: 0  
**HMIS Hazard ID:** Health: 1 Flammability: 2 Reactivity: 0

**NOTE:** This material should not be used for any other purpose than the intended use in Section 1 without expert advice. Health studies have shown that chemical exposure may cause potential human health risks which may vary from person to person.

SECTION 4	FIRST AID MEASURES
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## INHALATION

Remove from further exposure. For those providing assistance, avoid exposure to yourself or others. Use adequate respiratory protection. If respiratory irritation, dizziness, nausea, or unconsciousness occurs, seek immediate medical assistance. If breathing has stopped, assist ventilation with a mechanical device or use mouth-to-mouth resuscitation.

## SKIN CONTACT

Wash contact areas with soap and water. Remove contaminated clothing. Launder contaminated clothing before reuse.

## EYE CONTACT

Flush thoroughly with water. If irritation occurs, get medical assistance.

## INGESTION

Seek immediate medical attention. Do not induce vomiting.

## NOTE TO PHYSICIAN

If ingested, material may be aspirated into the lungs and cause chemical pneumonitis. Treat appropriately.

## SECTION 5 FIRE FIGHTING MEASURES

### EXTINGUISHING MEDIA

**Appropriate Extinguishing Media:** Use water fog, foam, dry chemical or carbon dioxide (CO<sub>2</sub>) to extinguish flames.

**Inappropriate Extinguishing Media:** Straight Streams of Water

### FIRE FIGHTING

**Fire Fighting Instructions:** Evacuate area. Prevent runoff from fire control or dilution from entering streams, sewers, or drinking water supply. Firefighters should use standard protective equipment and in enclosed spaces, self-contained breathing apparatus (SCBA). Use water spray to cool fire exposed surfaces and to protect personnel.

**Unusual Fire Hazards:** Combustible. Vapors are flammable and heavier than air. Vapors may travel across the ground and reach remote ignition sources causing a flashback fire danger. Hazardous material. Firefighters should consider protective equipment indicated in Section 8.

**Hazardous Combustion Products:** Smoke, Fume, Oxides of carbon, Incomplete combustion products

### FLAMMABILITY PROPERTIES

**Flash Point [Method]:** >40C (104F) [ASTM D-56]

**Flammable Limits (Approximate volume % in air):** LEL: 0.8 UEL: 5.6

**Autoignition Temperature:** 260°C (500°F)

## SECTION 6 ACCIDENTAL RELEASE MEASURES

### NOTIFICATION PROCEDURES

In the event of a spill or accidental release, notify relevant authorities in accordance with all applicable regulations. U.S. regulations require reporting releases of this material to the environment which exceed the



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reportable quantity or oil spills which could reach any waterway including intermittent dry creeks. The National Response Center can be reached at (800)424-8802.

## PROTECTIVE MEASURES

Avoid contact with spilled material. Warn or evacuate occupants in surrounding and downwind areas if required due to toxicity or flammability of the material. See Section 5 for fire fighting information. See Section 3 for Significant Hazards. See Section 4 for First Aid Advice. See Section 8 for Personal Protective Equipment.

## SPILL MANAGEMENT

**Land Spill:** Eliminate all ignition sources (no smoking, flares, sparks or flames in immediate area). Stop leak if you can do it without risk. All equipment used when handling the product must be grounded. Do not touch or walk through spilled material. Prevent entry into waterways, sewer, basements or confined areas. A vapor suppressing foam may be used to reduce vapors. Use clean non-sparking tools to collect absorbed material. Absorb or cover with dry earth, sand or other non-combustible material and transfer to containers. Large Spills: Water spray may reduce vapor, but may not prevent ignition in closed spaces. Recover by pumping or with suitable absorbent.

**Water Spill:** Stop leak if you can do it without risk. Eliminate sources of ignition. Warn other shipping. If the Flash Point exceeds the Ambient Temperature by 10 degrees C or more, use containment booms and remove from the surface by skimming or with suitable absorbents when conditions permit. If the Flash Point does not exceed the Ambient Temperature by 10 degrees C or is less than the Ambient Temperature, use booms as a barrier to protect shorelines and allow the material to evaporate. Seek the advice of a specialist before using dispersants.

Water spill and land spill recommendations are based on the most likely spill scenario for this material; however, geographic conditions, wind, temperature, (and in the case of a water spill) wave and current direction and speed may greatly influence the appropriate action to be taken. For this reason, local experts should be consulted. Note: Local regulations may prescribe or limit action to be taken.

## ENVIRONMENTAL PRECAUTIONS

Large Spills: Dike far ahead of liquid spill for later recovery and disposal. Prevent entry into waterways, sewers, basements or confined areas.

## SECTION 7

## HANDLING AND STORAGE

### HANDLING

Avoid contact with skin. Use proper bonding and/or grounding procedures. Prevent small spills and leakage to avoid slip hazard. Material can accumulate static charges which may cause an electrical spark (ignition source).

**Loading/Unloading Temperature:** [Ambient]

**Transport Temperature:** [Ambient]

**Transport Pressure:** [Ambient]

**Static Accumulator:** This material is a static accumulator.

### STORAGE

Keep container closed. Handle containers with care. Open slowly in order to control possible pressure release. Store in a cool, well-ventilated area. Storage containers should be grounded and bonded. Drums must be grounded and bonded and equipped with self-closing valves, pressure vacuum bungs and flame arresters.



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Storage Temperature: [Ambient]  
Storage Pressure: [Ambient]

Suitable Containers/Packing: Railcars; Drums; Barges; Tank Trucks  
Suitable Materials and Coatings: Carbon Steel; Stainless Steel; Polyethylene; Polypropylene; Teflon  
Unsuitable Materials and Coatings: Natural Rubber; Butyl Rubber; Ethylene-propylene-diene monomer (EPDM); Polystyrene

## SECTION 8 EXPOSURE CONTROLS / PERSONAL PROTECTION

### EXPOSURE LIMIT VALUES

Exposure limits/standards (Note: Exposure limits are not additive)

Source	Form	Limit / Standard			Note	Source
DISTILLATES (PETROLEUM), HYDROTREATED LIGHT	Vapor.	RCP - TWA	197 ppm	1200 mg/m <sup>3</sup>	Total Hydrocarbons	ExxonMobil

NOTE: Limits/standards shown for guidance only. Follow applicable regulations.

### ENGINEERING CONTROLS

The level of protection and types of controls necessary will vary depending upon potential exposure conditions. Control measures to consider:  
Adequate ventilation should be provided so that exposure limits are not exceeded. Use explosion-proof ventilation equipment.

### PERSONAL PROTECTION

Personal protective equipment selections vary based on potential exposure conditions such as applications, handling practices, concentration and ventilation. Information on the selection of protective equipment for use with this material, as provided below, is based upon intended, normal usage.

**Respiratory Protection:** If engineering controls do not maintain airborne contaminant concentrations at a level which is adequate to protect worker health, an approved respirator may be appropriate. Respirator selection, use, and maintenance must be in accordance with regulatory requirements, if applicable. Types of respirators to be considered for this material include:  
Half-face filter respirator

For high airborne concentrations, use an approved supplied-air respirator, operated in positive pressure mode. Supplied air respirators with an escape bottle may be appropriate when oxygen levels are inadequate, gas/vapor warning properties are poor, or if air purifying filter capacity/rating may be exceeded.

**Hand Protection:** Any specific glove information provided is based on published literature and glove manufacturer data. Work conditions can greatly effect glove durability; inspect and replace worn or damaged gloves. The types of gloves to be considered for this material include:  
If prolonged or repeated contact is likely, chemical resistant gloves are recommended. If contact with forearms is likely, wear gauntlet style gloves.



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**Eye Protection:** If contact is likely, safety glasses with side shields are recommended.

**Skin and Body Protection:** Any specific clothing information provided is based on published literature or manufacturer data. The types of clothing to be considered for this material include:  
If prolonged or repeated contact is likely, chemical, and oil resistant clothing is recommended.

**Specific Hygiene Measures:** Always observe good personal hygiene measures, such as washing after handling the material and before eating, drinking, and/or smoking. Routinely wash work clothing and protective equipment to remove contaminants. Discard contaminated clothing and footwear that cannot be cleaned. Practice good housekeeping.

## ENVIRONMENTAL CONTROLS

See Sections 6, 7, 12, 13.

## SECTION 9

## PHYSICAL AND CHEMICAL PROPERTIES

Typical physical and chemical properties are given below. Consult the Supplier in Section 1 for additional data.

### GENERAL INFORMATION

Physical State: Liquid  
Form: Clear  
Color: Colorless  
Odor: Mild Petroleum/Solvent  
Odor Threshold: N/D

### IMPORTANT HEALTH, SAFETY, AND ENVIRONMENTAL INFORMATION

Relative Density (at 15.6 C): 0.776  
Density: 777 kg/m<sup>3</sup> (6.48 lbs/gal, 0.78 kg/dm<sup>3</sup>)  
Flash Point [Method]: >40C (104F) [ASTM D-56]  
Flammable Limits (Approximate volume % in air): LEL: 0.8 UEL: 5.6  
Autoignition Temperature: 260°C (500°F)  
Boiling Point / Range: 161C (322F) - 198C (388F)  
Vapor Density (Air = 1): 4.9 at 101 kPa  
Vapor Pressure: 0.27 kPa (2.03 mm Hg) at 20 C  
Evaporation Rate (n-butyl acetate = 1): 0.18  
pH: N/A  
Log Pow (n-Octanol/Water Partition Coefficient): N/D  
Solubility in Water: Negligible  
Viscosity: 1.09 cSt (1.09 mm<sup>2</sup>/sec) at 40 C | 1.3 cSt (1.3 mm<sup>2</sup>/sec) at 25C  
Oxidizing Properties: See Sections 3, 15, 16.

### OTHER INFORMATION

Freezing Point: <-75°C (-103°F)  
Melting Point: N/D  
Pour Point: -57°C (-71°F)  
Molecular Weight: 143  
Hygroscopic: No  
Coefficient of Thermal Expansion: 0.00077 V/V/DEGC



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## SECTION 10 STABILITY AND REACTIVITY

**STABILITY:** Material is stable under normal conditions.

**CONDITIONS TO AVOID:** Avoid heat, sparks, open flames and other ignition sources.

**MATERIALS TO AVOID:** Strong oxidizers

**HAZARDOUS DECOMPOSITION PRODUCTS:** Material does not decompose at ambient temperatures.

**HAZARDOUS POLYMERIZATION:** Will not occur.

## SECTION 11 TOXICOLOGICAL INFORMATION

### ACUTE TOXICITY

Route of Exposure	Conclusion / Remarks
<b>Inhalation</b>	
Toxicity: Data available.	Minimally Toxic. Based on test data for structurally similar materials.
Irritation: Data available.	Negligible hazard at ambient/normal handling temperatures. Based on test data for structurally similar materials.
<b>Ingestion</b>	
Toxicity: LD50 > 15000 mg/kg	Minimally Toxic. Based on test data for structurally similar materials.
<b>Skin</b>	
Toxicity: LD50 > 3160 mg/kg	Minimally Toxic. Based on test data for structurally similar materials.
Irritation: Data available.	Mildly irritating to skin with prolonged exposure. Based on test data for structurally similar materials.
<b>Eye</b>	
Irritation: Data available.	May cause mild, short-lasting discomfort to eyes. Based on test data for structurally similar materials.

### CHRONIC/OTHER EFFECTS

#### For the product itself:

Vapor/aerosol concentrations above recommended exposure levels are irritating to the eyes and respiratory tract, may cause headaches, dizziness, anesthesia, drowsiness, unconsciousness and other central nervous system effects including death.

Prolonged and/or repeated skin contact with low viscosity materials may defat the skin resulting in possible irritation and dermatitis.

Small amounts of liquid aspirated into the lungs during ingestion or from vomiting may cause chemical pneumonitis or pulmonary edema.

Additional information is available by request.

The following ingredients are cited on the lists below: None.

--REGULATORY LISTS SEARCHED--

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1 = NTP CARC  
2 = NTP SUS

3 = IARC 1  
4 = IARC 2A

5 = IARC 2B  
6 = OSHA CARC

## SECTION 12 ECOLOGICAL INFORMATION

The information given is based on data available for the material, the components of the material, and similar materials.

### ECOTOXICITY

Material -- Not expected to be harmful to aquatic organisms.

Material -- Not expected to demonstrate chronic toxicity to aquatic organisms.

### PERSISTENCE AND DEGRADABILITY

#### Biodegradation:

Material -- Expected to be readily biodegradable.

#### Hydrolysis:

Material -- Transformation due to hydrolysis not expected to be significant.

#### Photolysis:

Material -- Transformation due to photolysis not expected to be significant.

#### Atmospheric Oxidation:

Material -- Expected to degrade rapidly in air

### OTHER ECOLOGICAL INFORMATION

VOC (EPA Method 24): 6.476 lbs/gal

## SECTION 13 DISPOSAL CONSIDERATIONS

Disposal recommendations based on material as supplied. Disposal must be in accordance with current applicable laws and regulations, and material characteristics at time of disposal.

### DISPOSAL RECOMMENDATIONS

Product is suitable for burning in an enclosed controlled burner for fuel value or disposal by supervised incineration at very high temperatures to prevent formation of undesirable combustion products.

### REGULATORY DISPOSAL INFORMATION

RCRA Information: Disposal of unused product may be subject to RCRA regulations (40 CFR 261). Disposal of the used product may also be regulated due to ignitability, corrosivity, reactivity or toxicity as determined by the Toxicity Characteristic Leaching Procedure (TCLP). Potential RCRA characteristics: IGNITABILITY.

**Empty Container Warning** PRECAUTIONARY LABEL TEXT: Empty containers may retain residue and can be dangerous. DO NOT PRESSURIZE, CUT, WELD, BRAZE, SOLDER, DRILL, GRIND OR EXPOSE SUCH CONTAINERS TO HEAT, FLAME, SPARKS, STATIC ELECTRICITY, OR OTHER SOURCES OF IGNITION; THEY MAY EXPLODE AND CAUSE INJURY OR DEATH. Do not attempt to refill or clean container since residue is difficult to remove. Empty drums should be completely drained, properly bunged and promptly returned to a drum reconditioner. All containers should be disposed of in an environmentally safe manner and in accordance with governmental regulations.

## SECTION 14 TRANSPORT INFORMATION

# DRILLING FLUIDS FOR DEEP CORING IN CENTRAL ANTARCTICA



Product Name: EXXSOL D40 FLUID  
Revision Date: 28Aug2006  
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## LAND (DOT)

Proper Shipping Name: PETROLEUM DISTILLATES, N.O.S.  
Hazard Class & Division: COMBUSTIBLE LIQUID  
ID Number: 1268  
Packing Group: III  
ERG Number: 128  
Label(s): NONE  
Transport Document Name: PETROLEUM DISTILLATES, N.O.S., COMBUSTIBLE LIQUID, UN1268, PG III

Footnote: The flash point of this material is greater than 100 F. Regulatory classification of this material varies. DOT: Flammable liquid or combustible liquid. OSHA: Combustible liquid. IATA/IMO: Flammable liquid. This material is not regulated under 49 CFR in a container of 119 gallon capacity or less when transported solely by land, as long as the material is not a hazardous waste, a marine pollutant, or specifically listed as a hazardous substance.

## LAND (TDG)

Proper Shipping Name: PETROLEUM DISTILLATES, N.O.S.  
Hazard Class & Division: 3  
UN Number: 1268  
Packing Group: III

## SEA (IMDG)

Proper Shipping Name: PETROLEUM DISTILLATES, N.O.S.  
Hazard Class & Division: 3  
EMS Number: F-E, S-E  
UN Number: 1268  
Packing Group: III  
Label(s): 3  
Transport Document Name: PETROLEUM DISTILLATES, N.O.S., 3, UN1268, PG III, (40°C c.c.)

## AIR (IATA)

Proper Shipping Name: PETROLEUM DISTILLATES, N.O.S.  
Hazard Class & Division: 3  
UN Number: 1268  
Packing Group: III  
Label(s): 3  
Transport Document Name: PETROLEUM DISTILLATES, N.O.S., 3, UN1268, PG III

## SECTION 15 REGULATORY INFORMATION

**OSHA HAZARD COMMUNICATION STANDARD:** When used for its intended purpose, this material is classified as hazardous in accordance with OSHA 29CFR 1910.1200.

**NATIONAL CHEMICAL INVENTORY LISTING:** AICS, IECSC, DSL, EINECS, ENCS, KECI, PICCS, TSCA

**EPCRA:** This material contains no extremely hazardous substances.

**SARA (311/312) REPORTABLE HAZARD CATEGORIES:** Fire.

**SARA (313) TOXIC RELEASE INVENTORY:** This material contains no chemicals subject to the supplier notification

# DRILLING FLUIDS FOR DEEP CORING IN CENTRAL ANTARCTICA



Product Name: EXXSOL D40 FLUID  
Revision Date: 28Aug2006  
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requirements of the SARA 313 Toxic Release Program.

The Following Ingredients are Cited on the Lists Below:\* None.

#### --REGULATORY LISTS SEARCHED--

1 = ACGIH ALL	6 = TSCA 5a2	11 = CA P65 REPRO	16 = MN RTK
2 = ACGIH A1	7 = TSCA 5e	12 = CA RTK	17 = NJ RTK
3 = ACGIH A2	8 = TSCA 6	13 = IL RTK	18 = PA RTK
4 = OSHA Z	9 = TSCA 12b	14 = LA RTK	19 = RI RTK
5 = TSCA 4	10 = CA P65 CARC	15 = MI 293	

Code key: CARC=Carcinogen; REPRO=Reproductive

\* EPA recently added new chemical substances to its TSCA Section 4 test rules. Please contact the supplier to confirm whether the ingredients in this product currently appear on a TSCA 4 or TSCA 12b list.

#### SECTION 16 OTHER INFORMATION

N/D = Not determined, N/A = Not applicable

#### THIS SAFETY DATA SHEET CONTAINS THE FOLLOWING REVISIONS:

No revision information is available.

#### PRECAUTIONARY LABEL TEXT:

Contains: DISTILLATES (PETROLEUM), HYDROTREATED LIGHT

CAUTION!

#### HEALTH HAZARDS

Repeated exposure may cause skin dryness or cracking. If swallowed, may be aspirated and cause lung damage.

#### PHYSICAL HAZARDS

Combustible. Material can accumulate static charges which may cause an incendiary electrical discharge.

#### PRECAUTIONS

Avoid contact with skin. Use proper bonding and/or grounding procedures.

#### FIRST AID

**Inhalation:** Remove from further exposure. For those providing assistance, avoid exposure to yourself or others. Use adequate respiratory protection. If respiratory irritation, dizziness, nausea, or unconsciousness occurs, seek immediate medical assistance. If breathing has stopped, assist ventilation with a mechanical device or use mouth-to-mouth resuscitation.

**Eye:** Flush thoroughly with water. If irritation occurs, get medical assistance.

**Oral:** Seek immediate medical attention. Do not induce vomiting.

**Skin:** Wash contact areas with soap and water. Remove contaminated clothing. Launder contaminated clothing before reuse.

#### FIRE FIGHTING MEDIA

Use water fog, foam, dry chemical or carbon dioxide (CO<sub>2</sub>) to extinguish flames.

#### SPILL/LEAK

**Land Spill:** Eliminate all ignition sources (no smoking, flares, sparks or flames in immediate area). Stop leak if you



# DRILLING FLUIDS FOR DEEP CORING IN CENTRAL ANTARCTICA



Product Name: EXXSOL D40 FLUID

Revision Date: 28Aug2006

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can do it without risk. Prevent entry into waterways, sewer, basements or confined areas. A vapor suppressing foam may be used to reduce vapors. Absorb or cover with dry earth, sand or other non-combustible material and transfer to containers. Recover by pumping or with suitable absorbent.

**Water Spill:** Stop leak if you can do it without risk. Eliminate sources of ignition. Warn other shipping. If the Flash Point exceeds the Ambient Temperature by 10 degrees C or more, use containment booms and remove from the surface by skimming or with suitable absorbents when conditions permit. If the Flash Point does not exceed the Ambient Temperature by 10 degrees C or is less than the Ambient Temperature, use booms as a barrier to protect shorelines and allow the material to evaporate. Seek the advice of a specialist before using dispersants.

The information and recommendations contained herein are, to the best of ExxonMobil's knowledge and belief, accurate and reliable as of the date issued. You can contact ExxonMobil to insure that this document is the most current available from ExxonMobil. The information and recommendations are offered for the user's consideration and examination. It is the user's responsibility to satisfy itself that the product is suitable for the intended use. If buyer repackages this product, it is the user's responsibility to insure proper health, safety and other necessary information is included with and/or on the container. Appropriate warnings and safe-handling procedures should be provided to handlers and users. Alteration of this document is strictly prohibited. Except to the extent required by law, re-publication or retransmission of this document, in whole or in part, is not permitted. The term, "ExxonMobil" is used for convenience, and may include any one or more of ExxonMobil Chemical Company, Exxon Mobil Corporation, or any affiliates in which they directly or indirectly hold any interest.

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MHC: 1A, 0, 0, 0, 2, 0

DGN: 4400210HUS (1007646)

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# DRILLING FLUIDS FOR DEEP CORING IN CENTRAL ANTARCTICA

## Attachment 2

ISOPARK

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ExxonMobil  
Lubricants &  
Petroleum Specialties

ISOPARK

DATE ISSUED: 09/19/00  
SUPERSEDES DATE: 01/21/00

### MATERIAL SAFETY DATA SHEET

#### SECTION 1: PRODUCT AND COMPANY IDENTIFICATION

COMPANY: ExxonMobil Corporation  
ExxonMobil Lubricants & Petroleum  
Specialties Company  
3225 Gallows Road  
Fairfax, VA 22037-0001

PRODUCT NAME  
ISOPARK

PRODUCT CODE  
133467

PRODUCT CATEGORY  
Hydrocarbon Fluid

MEDICAL EMERGENCY TELEPHONE NUMBER: (713) 656-3424

TRANSPORTATION EMERGENCY TELEPHONE NUMBERS  
(BAYTOWN) (281) 834-3296 (CHEMTREC) 1-800-424-9300

Product Information and Technical Assistance: 1-800-443-9966

FAXED MSDSs: 1-800-298-4007 MAILED MSDSs OR OTHER ASSISTANCE: (713) 656-5949

#### SECTION 2: COMPOSITION/INFORMATION ON INGREDIENTS

COMPONENTS	CAS NO. OF COMPONENTS	APPROXIMATE CONCENTRATION
Naphtha (petroleum), hydrotreated heavy	64742-48-9	100%

This product consists predominantly of C11-C12 isoparaffinic hydrocarbons.

SEE SECTION 8 FOR EXPOSURE LIMITS

#### SECTION 3: HAZARDS IDENTIFICATION

##### EMERGENCY OVERVIEW

##### OSHA REQUIRED LABEL INFORMATION

In compliance with hazard and right-to-know requirements, where applicable OSHA Hazard Warnings may be found on the label, bill of lading or invoice accompanying this shipment.

DANGER!  
COMBUSTIBLE

[http://www.exxon.com/exxon\\_productdata/msds/in133467.html](http://www.exxon.com/exxon_productdata/msds/in133467.html)

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# DRILLING FLUIDS FOR DEEP CORING IN CENTRAL ANTARCTICA

## ISOPARK

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Note: Product label may contain non-OSHA related information also.

### HAZARDOUS MATERIALS IDENTIFICATION SYSTEM (HMS)

Health	Flammability	Reactivity	BASIS
1	2	0	Recommended by ExxonMobil

### NATIONAL FIRE PROTECTION ASSOCIATION (NFPA) - HAZARD IDENTIFICATION

Health	Flammability	Reactivity	BASIS
1	2	0	Recommended by ExxonMobil

### VARIABILITY AMONG INDIVIDUALS

Health studies have shown that many petroleum hydrocarbons and synthetic lubricants pose potential human health risks which may vary from person to person. As a precaution, exposure to liquids, vapors, mists or fumes should be minimized.

### EFFECTS OF OVEREXPOSURE (Signs and symptoms of exposure)

High vapor concentrations (greater than approximately 1000 ppm) are irritating to the eyes and the respiratory tract, and may cause headaches, dizziness, anesthesia, drowsiness, unconsciousness, and other central nervous system effects, including death.

### PRE-EXISTING MEDICAL CONDITIONS WHICH MAY BE AGGRAVATED BY EXPOSURE

Petroleum Solvents/Petroleum Hydrocarbons - Skin contact may aggravate an existing dermatitis.

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## SECTION 4: FIRST AID MEASURES

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### EYE CONTACT

If splashed into the eyes, flush with clear water for 15 minutes or until irritation subsides. If irritation persists, call a physician.

### SKIN

In case of skin contact, remove any contaminated clothing and wash skin with soap and water. Launder or dry-clean clothing before reuse. If product is injected into or under the skin, or into any part of the body, regardless of the appearance of the wound or its size, the individual should be evaluated immediately by a physician as a surgical emergency. Even though initial symptoms from high pressure injection may be minimal or absent, early surgical treatment within the first few hours may significantly reduce the ultimate extent of injury.

### INHALATION

If overcome by vapor, remove from exposure and call a physician immediately. If breathing is irregular or has stopped, start resuscitation, administer oxygen, if available.

### INGESTION

If ingested, DO NOT induce vomiting; call a physician immediately.

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## SECTION 5: FIRE-FIGHTING MEASURES

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### FLASH POINT (MINIMUM)

COMBUSTIBLE - Per DOT 49 CFR 173.120  
49~C (120~F)

### AUTOIGNITION TEMPERATURE

Approximately 349~C (660~F)

[http://www.exxon.com/exxon\\_productdata/msds/in133467.html](http://www.exxon.com/exxon_productdata/msds/in133467.html)

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# DRILLING FLUIDS FOR DEEP CORING IN CENTRAL ANTARCTICA

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ISOPARK

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ASTM D 56, Tag Closed Cup

ASTM E 659

## FLAMMABLE OR EXPLOSIVE LIMITS (APPROXIMATE PERCENT BY VOLUME IN AIR)

Estimated values: Lower Flammable Limit 1.2% Upper Flammable Limit 9.3%

## EXTINGUISHING MEDIA AND FIRE FIGHTING PROCEDURES

Foam, water spray (fog), dry chemical, carbon dioxide and vaporizing liquid type extinguishing agents may all be suitable for extinguishing fires involving this type of product, depending on size or potential size of fire and circumstances related to the situation. Plan fire protection and response strategy through consultation with local fire protection authorities or appropriate specialists.

The following procedures for this type of product are based on the recommendations in the National Fire Protection Association's "Fire Protection Guide on Hazardous Materials", Tenth Edition (1991):

Use dry chemical, foam or carbon dioxide to extinguish the fire. "Water may be ineffective", but water should be used to keep fire-exposed containers cool. If a leak or spill has ignited, use water spray to disperse the vapors and to protect persons attempting to stop a leak. Water spray may be used to flush spills away from exposures. Minimize breathing of gases, vapor, fumes or decomposition products. Use supplied-air breathing equipment for enclosed or confined spaces or as otherwise needed.

NOTE: The inclusion of the phrase "water may be ineffective" is to indicate that although water can be used to cool and protect exposed material, water may not extinguish the fire unless used under favorable conditions by experienced fire fighters trained in fighting all types of flammable liquid fires.

## DECOMPOSITION PRODUCTS UNDER FIRE CONDITIONS

Fumes, smoke, carbon monoxide, sulfur oxides, aldehydes and other decomposition products, in the case of incomplete combustion.

---

### SECTION 6: ACCIDENTAL RELEASE MEASURES

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#### CLEAN WATER ACT / OIL POLLUTION ACT

This product may be classified as an oil under Section 311 of the Clean Water Act, and under the Oil Pollution Act. Discharges or spills into or leading to surface waters that cause a sheen must be reported to the National Response Center (1-800-424-8802).

#### STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED

Shut off and eliminate all ignition sources. Keep people away. Recover free product. Add sand, earth or other suitable absorbent to spill area. Minimize breathing vapors. Minimize skin contact. Ventilate confined spaces. Open all windows and doors. Keep product out of sewers and watercourses by diking or impounding. Advise authorities if product has entered or may enter sewers, watercourses, or extensive land areas.

Assure conformity with applicable governmental regulations. Continue to observe precautions for volatile, combustible vapors from absorbed material.

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### SECTION 7: STORAGE AND HANDLING

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#### HANDLING PRECAUTIONS

This liquid is volatile and gives off invisible vapors. Either the liquid or

[http://www.exxon.com/exxon\\_productdata/msds/in133467.html](http://www.exxon.com/exxon_productdata/msds/in133467.html)

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# DRILLING FLUIDS FOR DEEP CORING IN CENTRAL ANTARCTICA

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## ISOPARK

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vapor may settle in low areas or travel some distance along the ground or surface to ignition sources where they may ignite or explode.

Keep product away from ignition sources, such as heat, sparks, pilot lights, static electricity, and open flames.

### "EMPTY" CONTAINER WARNING

"Empty" containers retain residue (liquid and/or vapor) and can be dangerous. DO NOT PRESSURIZE, CUT, WELD, BRAZE, SOLDER, DRILL, GRIND OR EXPOSE SUCH CONTAINERS TO HEAT, FLAME, SPARKS, STATIC ELECTRICITY, OR OTHER SOURCES OF IGNITION; THEY MAY EXPLODE AND CAUSE INJURY OR DEATH.

Do not attempt to refill or clean containers since residue is difficult to remove. "Empty" drums should be completely drained, properly bunged and promptly returned to a drum reconditioner. All other containers should be disposed of in an environmentally safe manner and in accordance with governmental regulations.

For work on tanks refer to Occupational Safety and Health Administration regulations, ANSI Z49.1, and other governmental and industrial references pertaining to cleaning, repairing, welding, or other contemplated operations.

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## SECTION 8: EXPOSURE CONTROLS/PERSONAL PROTECTION

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### EXPOSURE LIMIT FOR TOTAL PRODUCT

175 ppm (1200 mg/m<sup>3</sup>) based on total hydrocarbon for an 8-hour workday.

### BASIS

Recommended by ExxonMobil

### VENTILATION

Use only with ventilation sufficient to prevent exceeding recommended exposure limit or buildup of explosive concentrations of vapor in air. No smoking, or use of flame or other ignition sources.

### RESPIRATORY PROTECTION

Use supplied-air respiratory protection in confined or enclosed spaces, if needed.

### PROTECTIVE GLOVES

Use chemical-resistant gloves, if needed, to avoid prolonged or repeated skin contact.

### EYE PROTECTION

Use splash goggles or face shield when eye contact may occur.

### OTHER PROTECTIVE EQUIPMENT

Use chemical-resistant apron or other impervious clothing, if needed, to avoid contaminating regular clothing, which could result in prolonged or repeated skin contact.

### WORK PRACTICES / ENGINEERING CONTROLS

To prevent fire or explosion risk from static accumulation and discharge, effectively bond and/or ground product transfer system in accordance with (THE) National Fire Protection Association PUBLICATIONS.

Keep containers closed when not in use. Do not store near heat, sparks, flame or strong oxidants. To prevent fire or explosion risk from static accumulation and discharge, effectively bond and/or ground product transfer system in accordance with the National Fire Protection Association standard for petroleum products.

[http://www.exxon.com/exxon\\_productdata/msds/in133467.html](http://www.exxon.com/exxon_productdata/msds/in133467.html)

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# DRILLING FLUIDS FOR DEEP CORING IN CENTRAL ANTARCTICA

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In order to prevent fire or explosion hazards, use appropriate equipment.

Information on electrical equipment appropriate for use with this product may be found in the latest edition of the National Electrical Code (NFPA-70). This document is available from the National Fire Protection Association, Batterymarch Park, Quincy, Massachusetts 02269.

## PERSONAL HYGIENE

Minimize breathing vapor or mist. Avoid prolonged or repeated contact with skin. Remove contaminated clothing; launder or dry-clean before re-use. Remove contaminated shoes and thoroughly clean and dry before re-use. Cleanse skin thoroughly after contact, before breaks and meals, and at end of work period. Product is readily removed from skin by waterless hand cleaners followed by washing thoroughly with soap and water.

## SECTION 9: PHYSICAL AND CHEMICAL PROPERTIES

The following data are approximate or typical values and should not be used for precise design purposes.

BOILING RANGE  
177-197°C (351-387°F)

VAPOR PRESSURE  
0.9 mm Hg @ 20°C (68°F)  
ASTM D 2879

SPECIFIC GRAVITY (15.6 Deg C/15.6 Deg C)  
0.76 (6.34 lb/gal)

VAPOR DENSITY (AIR = 1)  
5.4

MOLECULAR WEIGHT  
164

PERCENT VOLATILE BY VOLUME  
Approximately 50% in 68 minutes  
@ 1 atm. and 25°C (77°F)

pH  
Essentially neutral

EVAPORATION RATE @ 1 ATM. & 25 Deg C  
(77 Deg F) (n-BUTYL ACETATE = 1)  
0.08

POUR, CONGEALING OR MELTING POINT  
Less than -18°C (0°F)  
Pour Point by ASTM D 97

SOLUBILITY IN WATER @ 1 ATM.  
AND 25 Deg C (77 Deg F)  
Negligible; 0.0001%

VISCOSITY  
1.84 cSt @ 25 Deg C (77 Deg F) ASTM D 445

PRODUCT APPEARANCE AND ODOR  
Clear water-white liquid  
Essentially odorless

## SECTION 10: STABILITY AND REACTIVITY

This product is stable and will not react violently with water. Hazardous polymerization will not occur. Avoid contact with strong oxidants such as liquid chlorine, concentrated oxygen, sodium hypochlorite, calcium hypochlorite, etc., as this presents a serious explosion hazard.

## SECTION 11: TOXICOLOGICAL INFORMATION

[http://www.exxon.com/exxon\\_productdata/msds/in133467.html](http://www.exxon.com/exxon_productdata/msds/in133467.html)

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# DRILLING FLUIDS FOR DEEP CORING IN CENTRAL ANTARCTICA

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## NATURE OF HAZARD AND TOXICITY INFORMATION

Prolonged or repeated skin contact with this product tends to remove skin oils, possibly leading to irritation and dermatitis; however, based on human experience and available toxicological data, this product is judged to be neither a "corrosive" nor an "irritant" by OSHA criteria.

Product contacting the eyes may cause eye irritation.

Product has a low order of acute oral and dermal toxicity, but minute amounts aspirated into the lungs during ingestion or vomiting may cause mild to severe pulmonary injury and possibly death.

This product is judged to have an acute oral LD50 (rat) greater than 5 g/kg of body weight, and an acute dermal LD50 (rabbit) greater than 3.16 g/kg of body weight.

---

## SECTION 12: ECOLOGICAL INFORMATION

Do not discharge this product into public waters or waterways unless authorized by a National Pollution Discharge Elimination System (NPDES) permit issued by the Environmental Protection Agency (EPA).

Environmental and Ecological data may be available for this product. Write or call ExxonMobil to obtain further information. Refer to Section 6 and Section 15 for Accidental Release information and Regulatory Reporting information.

---

## SECTION 13: DISPOSAL CONSIDERATION

Options for disposal of this product may depend on the conditions under which it was used. To determine the proper method of disposal, refer to RCRA (40 CFR 261), as well as federal EPA and state and local regulations.

Please refer to Sections 5, 6 and 15 for additional information.

---

## SECTION 14: TRANSPORTATION INFORMATION

### TRANSPORTATION INCIDENT INFORMATION

For further information relative to spills resulting from transportation incidents, refer to latest Department of Transportation Emergency Response Guidebook for Hazardous Materials Incidents.

### U.S. DOT HAZARDOUS MATERIALS SHIPPING DESCRIPTION

Transported by highway or rail:

Bulk packagings (capacity greater than 119 gallons)  
Petroleum Distillate, n.o.s., Combustible Liquid, UN1268, III

Non-bulk packagings (capacity less than or equal to 119 gallons)  
Not regulated

Transported by air or marine vessel:

Bulk or non-bulk packagings

[http://www.exxon.com/exxon\\_productdata/msds/in133467.html](http://www.exxon.com/exxon_productdata/msds/in133467.html)

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# DRILLING FLUIDS FOR DEEP CORING IN CENTRAL ANTARCTICA

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Petroleum Distillate, n.o.s., 3, UN1268, III

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## SECTION 15: REGULATORY INFORMATION

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### U.S. FEDERAL REGULATIONS

THE FOLLOWING INFORMATION MAY BE USEFUL IN COMPLYING WITH VARIOUS STATE AND FEDERAL LAWS AND REGULATIONS UNDER VARIOUS ENVIRONMENTAL STATUTES:

THRESHOLD PLANNING QUANTITY (TPQ), EPA REGULATION 40 CFR 355  
(SARA Sections 301-304)

No TPQ for product or any constituent greater than 1% or 0.1% (carcinogen).

TOXIC CHEMICAL RELEASE REPORTING, EPA REGULATION 40 CFR 372 (SARA Section 313)

No toxic chemical is present greater than 1% or 0.1% (carcinogen).

HAZARDOUS CHEMICAL REPORTING, EPA REGULATION 40 CFR 370 (SARA Sections 311-312)

EPA Hazard Classification Code: Fire

TOXIC SUBSTANCES CONTROL ACT (TSCA)

This product, as manufactured by ExxonMobil, does not contain polychlorinated biphenyls (PCB's).

All components of this product are listed on the U.S. TSCA inventory.

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## SECTION 16: OTHER INFORMATION

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The health and safety information presented herein must be used in conjunction with the pertinent standards for training, work practices and facilities design established by OSHA, NIOSH, NFPA, API, NEC, NSC, UNDERWRITERS, BUREAU OF MINES, and similar organizations.

The information and recommendations contained herein are, to the best of ExxonMobil's knowledge and belief, accurate and reliable as of the date issued. ExxonMobil does not warrant or guarantee their accuracy or reliability, and ExxonMobil shall not be liable for any loss or damage arising out of the use thereof.

The information and recommendations are offered for the user's consideration and examination, and it is the user's responsibility to satisfy itself that they are suitable and complete for its particular use. If buyer repackages this product, legal counsel should be consulted to insure proper health, safety and other necessary information is included on the container.

The Environmental Information included under Section 15 hereof as well as the Hazardous Materials Identification System (HMIS) and National Fire Protection Association (NFPA) ratings have been included by ExxonMobil Lubricants & Petroleum Specialties Company, in order to provide additional health and hazard classification information. The ratings recommended are based upon the criteria supplied by the developers of these rating systems, together with ExxonMobil's interpretation of the available data.

[http://www.exxon.com/exxon\\_productdata/msds/in133467.html](http://www.exxon.com/exxon_productdata/msds/in133467.html)

8/28/01



### Safety Data Sheet Dow Chemical Company Ltd

Product Name: ESTASOL (TM)

Revision Date: 2006/11/30  
Print Date: 07 Feb 2008

Dow Chemical Company Ltd encourages and expects you to read and understand the entire (M)SDS, as there is important information throughout the document. We expect you to follow the precautions identified in this document unless your use conditions would necessitate other appropriate methods or actions.

## 1. Identification of the substance/preparation and of the company/undertaking

Product Name  
ESTASOL (TM)

Use of the substance/preparation  
Solvent.

**COMPANY IDENTIFICATION**  
Dow Chemical Company Ltd  
Diamond House, Lotus Park  
Kingsbury Crescent  
TW18 3AG Staines, Middlesex  
United Kingdom

Customer Information Number: 0203 139 4000

**EMERGENCY TELEPHONE NUMBER**  
24-Hour Emergency Contact: +44 (0) 1553 761 251  
Local Emergency Contact: 00 44 155 37 61 251

## 2. Composition/information on ingredients

Component	Amount	Classification:	CAS #	EC #
Dimethyl succinate	>= 15.0 - <= 25.0 %	Not classified.	106-65-0	203-419-9
Dimethyl adipate	>= 10.0 - <= 25.0 %	Not classified.	627-93-0	211-020-6
Dimethyl glutarate	>= 55.0 - <= 65.0 %	Not classified.	1119-40-0	214-277-2

## 3. Hazards Identification

This product is not classified as dangerous according to EC criteria.

\* indicates a Trademark

Product Name: ESTASOL (TM)

Revision Date: 2006/11/30

## 4. First-aid measures

**Eye Contact:** Immediately flush eyes with water; remove contact lenses, if present, after the first 5 minutes, then continue flushing eyes for at least 15 minutes. Obtain medical attention without delay, preferably from an ophthalmologist.

**Skin Contact:** Wash skin with plenty of water.

**Inhalation:** Move person to fresh air; if effects occur, consult a physician.

**Ingestion:** If swallowed, seek medical attention. Do not induce vomiting unless directed to do so by medical personnel.

**Notes to Physician:** No specific antidote. Treatment of exposure should be directed at the control of symptoms and the clinical condition of the patient.

## 5. Fire Fighting Measures

**Extinguishing Media:** Water fog or fine spray. Dry chemical fire extinguishers. Carbon dioxide fire extinguishers. Foam. Do not use direct water stream. May spread fire. Alcohol resistant foams (ATC type) are preferred. General purpose synthetic foams (including AFFF) or protein foams may function, but will be less effective. Water fog, applied gently may be used as a blanket for fire extinguishment.

**Fire Fighting Procedures:** Keep people away. Isolate fire and deny unnecessary entry. Do not use direct water stream. May spread fire. Burning liquids may be moved by flushing with water to protect personnel and minimize property damage. Water fog, applied gently may be used as a blanket for fire extinguishment.

**Special Protective Equipment for Firefighters:** Wear positive-pressure self-contained breathing apparatus (SCBA) and protective fire fighting clothing (includes fire fighting helmet, coat, trousers, boots, and gloves). If protective equipment is not available or not used, fight fire from a protected location or safe distance.

**Unusual Fire and Explosion Hazards:** Violent steam generation or eruption may occur upon application of direct water stream to hot liquids.

**Hazardous Combustion Products:** During a fire, smoke may contain the original material in addition to combustion products of varying composition which may be toxic and/or irritating. Combustion products may include and are not limited to: Carbon monoxide. Carbon dioxide.

## 6. Accidental Release Measures

**Steps to be Taken if Material is Released or Spilled:** Absorb with materials such as: Sand. Sawdust. Collect in suitable and properly labeled containers. See Section 13, Disposal Considerations, for additional information.

**Personal Precautions:** Use appropriate safety equipment. For additional information, refer to Section 8, Exposure Controls and Personal Protection.

**Environmental Precautions:** Prevent from entering into soil, ditches, sewers, waterways and/or groundwater. See Section 12, Ecological Information.

## 7. Handling and Storage

### Handling

**General Handling:** Avoid contact with eyes, skin, and clothing. Wash thoroughly after handling.

### Storage

Store in original container.

Product Name: ESTASOL (TM)

Revision Date: 2006/11/30

## 8. Exposure Controls / Personal Protection

### Exposure Limits

None established

### Personal Protection

**Eye/Face Protection:** Use chemical goggles. Chemical goggles should be consistent with EN 166 or equivalent.

**Skin Protection:** Use protective clothing chemically resistant to this material. Selection of specific items such as face shield, boots, apron, or full body suit will depend on the task.

**Hand protection:** Use chemical resistant gloves classified under Standard EN374: Protective gloves against chemicals and micro-organisms. Examples of preferred glove barrier materials include: Butyl rubber, Chlorinated polyethylene, Polyethylene, Ethyl vinyl alcohol laminate ("EVAL"), Polyvinyl alcohol ("PVA"). Examples of acceptable glove barrier materials include: Natural rubber ("latex"), Neoprene, Nitrile/butadiene rubber ("nitrile" or "NBR"), Polyvinyl chloride ("PVC" or "vinyl"), Viton. When prolonged or frequently repeated contact may occur, a glove with a protection class of 4 or higher (breakthrough time greater than 120 minutes according to EN 374) is recommended. When only brief contact is expected, a glove with a protection class of 1 or higher (breakthrough time greater than 10 minutes according to EN 374) is recommended. **NOTICE:** The selection of a specific glove for a particular application and duration of use in a workplace should also take into account all relevant workplace factors such as, but not limited to: Other chemicals which may be handled, physical requirements (cut/puncture protection, dexterity, thermal protection), potential body reactions to glove materials, as well as the instructions/specifications provided by the glove supplier.

**Respiratory Protection:** Respiratory protection should be worn when there is a potential to exceed the exposure limit requirements or guidelines. If there are no applicable exposure limit requirements or guidelines, wear respiratory protection when adverse effects, such as respiratory irritation or discomfort have been experienced, or where indicated by your risk assessment process. Use the following CE approved air-purifying respirator: Organic vapor cartridge, type A (boiling point >65 °C)

**Ingestion:** Use good personal hygiene. Do not consume or store food in the work area. Wash hands before smoking or eating.

### Engineering Controls

**Ventilation:** Use local exhaust ventilation, or other engineering controls to maintain airborne levels below exposure limit requirements or guidelines. If there are no applicable exposure limit requirements or guidelines, general ventilation should be sufficient for most operations. Local exhaust ventilation may be necessary for some operations.

## 9. Physical and Chemical Properties

Physical State	Liquid
Color	Colorless
Odor	Ester
Flash Point - Closed Cup	108 °C Literature
Flammable Limits in Air	Lower: 1.5 %(V) Literature Upper: 12.5 %(V) Literature
Autoignition Temperature	370 °C Literature
Vapor Pressure	0.06 mmHg @ 20 °C Literature
Boiling Point (760 mmHg)	200 - 230 °C Literature (@ 1 atmosphere).
Vapor Density (air = 1)	No test data available
Specific Gravity (H2O = 1)	1.09 Literature
Freezing Point	-25 °C Literature
Melting Point	-25 °C Literature
Solubility in Water (by weight)	5 % @ 20 °C Literature
pH	5 - 6 Literature
Kinematic Viscosity	2.40 - 2.50 mm <sup>2</sup> /s @ 20 °C Literature



Product Name: ESTASOL (TM)

Revision Date: 2006/11/30

## 10. Stability and Reactivity

### Stability/Instability

Stable.

**Conditions to Avoid:** Exposure to elevated temperatures can cause product to decompose.

**Incompatible Materials:** Avoid contact with: Oxidizers.

### Hazardous Polymerization

Will not occur.

### Thermal Decomposition

Decomposition products depend upon temperature, air supply and the presence of other materials.

## 11. Toxicological Information

### Acute Toxicity

#### Ingestion

Very low toxicity if swallowed. Harmful effects not anticipated from swallowing small amounts.

Swallowing may result in gastrointestinal irritation.

Single dose oral LD50 has not been determined.

Based on information for component(s): Estimated LD50, Rat > 5,000 mg/kg

#### Eye Contact

May cause eye irritation. May cause corneal injury.

#### Skin Contact

Brief contact may cause skin irritation with local redness.

#### Skin Absorption

Prolonged skin contact is unlikely to result in absorption of harmful amounts.

The dermal LD50 has not been determined.

Based on information for component(s): Estimated LD50, Rabbit > 2,250 mg/kg

#### Inhalation

Vapor may cause irritation of the upper respiratory tract (nose and throat).

## 12. Ecological Information

### CHEMICAL FATE

Data for Component: Dimethyl sebacate

#### Movement & Partitioning

Bioconcentration potential is low (BCF < 100 or Log Pow < 3). Potential for mobility in soil is very high (Koc between 0 and 50).

**Henry's Law Constant (H):** 3.154E-06 atm\*m3/mole; 25 °C Estimated from vapor pressure and water solubility.

**Partition coefficient, n-octanol/water (log Pow):** Measured

**Partition coefficient, soil organic carbon/water (Koc):** 10 Estimated

#### Persistence and Degradability

Indirect Photodegradation with OH Radicals

Rate Constant	Atmospheric Half-life	Method
1.1475E-12 cm <sup>3</sup> /s	9.3 d	Estimated

OECD Biodegradation Tests:

Biodegradation	Exposure Time	Method
> 95 %	3 - 10 d	OECD 302B Test

# DRILLING FLUIDS FOR DEEP CORING IN CENTRAL ANTARCTICA

Product Name: ESTASOL (TM)

Revision Date: 2006/11/30

Theoretical Oxygen Demand: 1.42 mg/mg

Data for Component: Dimethyl adipate

## **Movement & Partitioning**

Bioconcentration potential is low (BCF < 100 or Log Pow < 3). Potential for mobility in soil is very high (Koc between 0 and 50).

Henry's Law Constant (H): 2.31E-06 atm·m<sup>3</sup>/mole; 25 °C Estimated from vapor pressure and water solubility.

Partition coefficient, n-octanol/water (log Pow): Measured

Partition coefficient, soil organic carbon/water (Koc): 11 Estimated

## **Persistence and Degradability**

Indirect Photodegradation with OH Radicals

Rate Constant	Atmospheric Half-life	Method
3.9736E-12 cm <sup>3</sup> /s	2.7 d	Estimated

Data for Component: Dimethyl glutarate

## **Movement & Partitioning**

Bioconcentration potential is low (BCF < 100 or Log Pow < 3). Potential for mobility in soil is very high (Koc between 0 and 50). Given its very low Henry's constant, volatilization from natural bodies of water or moist soil is not expected to be an important fate process.

Henry's Law Constant (H): 6.430E-07 atm·m<sup>3</sup>/mole; 25 °C Estimated from vapor pressure and water solubility.

Partition coefficient, n-octanol/water (log Pow): 0.62 Measured

Partition coefficient, soil organic carbon/water (Koc): 10 Estimated

## **Persistence and Degradability**

Indirect Photodegradation with OH Radicals

Rate Constant	Atmospheric Half-life	Method
2.5605E-12 cm <sup>3</sup> /s	4.177 d	Estimated

OECD Biodegradation Tests:

Biodegradation	Exposure Time	Method
75 %	28 d	OECD 301C Test

Theoretical Oxygen Demand: 1.60 mg/mg

## **ECOTOXICITY**

Data for Component: Dimethyl succinate

### **Fish Acute & Prolonged Toxicity**

LC50, zebra fish (*Brachydanio rerio*), static, 96 h: 50 - 100 mg/l

### **Toxicity to Micro-organisms**

EC50, activated sludge, respiration inhibition, 3 h: > 1,000 mg/l

Data for Component: Dimethyl adipate

### **Aquatic Invertebrate Acute Toxicity**

EC50, water flea *Daphnia magna*, static, 48 h, immobilization: 72 mg/l

### **Aquatic Plant Toxicity**

EC50, green alga *Selenastrum capricornutum*, Growth rate inhibition, 72 h: > 100 mg/l

Data for Component: Dimethyl glutarate

### **Fish Acute & Prolonged Toxicity**

LC50, fathead minnow (*Pimephales promelas*), static, 96 h: 19.6 - 26.2 mg/l

### **Aquatic Invertebrate Acute Toxicity**

EC50, water flea *Daphnia magna*, 48 h, immobilization: 122.1 - 163.5 mg/l

## **13. Disposal Considerations**

**Product Name:** ESTASOL (TM)

**Revision Date:** 2006/11/30

All disposal practices must be in compliance with all Federal, State/Provincial and local laws and regulations. Do not dump into any sewers, on the ground, or into any body of water.

## 14. Transport Information

### ROAD & RAIL

NOT REGULATED

### OCEAN

NOT REGULATED

### AIR

NOT REGULATED

### INLAND WATERWAYS

NOT REGULATED

## 15. Regulatory Information

### European Inventory of Existing Commercial Chemical Substances (EINECS)

The components of this product are on the EINECS inventory or are exempt from inventory requirements.

### EC Classification and User Label Information

This product is not classified as dangerous according to EC criteria.

## 16. Other Information

### Revision

Identification Number: 70279 / 3005 / Issue Date 2006/11/30 / Version: 1.0

Most recent revision(s) are noted by the bold, double bars in left-hand margin throughout this document.

*Dow Chemical Company Ltd. urges each customer or recipient of this (M)SDS to study it carefully and consult appropriate expertise, as necessary or appropriate, to become aware of and understand the data contained in this (M)SDS and any hazards associated with the product. The information herein is provided in good faith and believed to be accurate as of the effective date shown above. However, no warranty, express or implied, is given. Regulatory requirements are subject to change and may differ between various locations. It is the buyer's/user's responsibility to ensure that his activities comply with all federal, state, provincial or local laws. The information presented here pertains only to the product as shipped. Since conditions for use of the product are not under the control of the manufacturer, it is the buyer's/user's duty to determine the conditions necessary for the safe use of this product. Due to the proliferation of sources for information such as manufacturer-specific (M)SDSs, we are not and cannot be responsible for (M)SDSs obtained from any source other than ourselves. If you have obtained an (M)SDS from another source or if you are not sure that the (M)SDS you have is current, please contact us for the most current version.*





## Safety Data Sheet Dow Chemical Company Ltd

Product Name: ETHYLENE GLYCOL DIACETATE PURE

Revision Date: 2007/05/14  
Print Date: 19 Aug 2008

Dow Chemical Company Ltd encourages and expects you to read and understand the entire (M)SDS, as there is important information throughout the document. We expect you to follow the precautions identified in this document unless your use conditions would necessitate other appropriate methods or actions.

### 1. Identification of the substance/preparation and of the company/undertaking

Product Name  
ETHYLENE GLYCOL DIACETATE PURE

Use of the substance/preparation  
Solvent.

**COMPANY IDENTIFICATION**  
Dow Chemical Company Ltd  
Diamond House, Lotus Park  
Kingsbury Crescent  
TW18 3AG Staines, Middlesex  
United Kingdom

Customer Information Number: 0203 139 4000

**EMERGENCY TELEPHONE NUMBER**  
24-Hour Emergency Contact: +44 (0) 1553 761 251  
Local Emergency Contact: 00 44 155 37 61 251

### 2. Composition/information on ingredients

Component	Amount	Classification:	CAS #	EC #
Ethylene diacetate	100.0 %	Not classified.	111-55-7	203-881-1

### 3. Hazards Identification

This product is not classified as dangerous according to EC criteria.

### 4. First-aid measures

\* indicates a Trademark

**Product Name:** ETHYLENE GLYCOL DIACETATE PURE

**Revision Date:** 2007/05/14

**Eye Contact:** Immediately flush eyes with water; remove contact lenses, if present, after the first 5 minutes, then continue flushing eyes for at least 15 minutes. Obtain medical attention without delay, preferably from an ophthalmologist.

**Skin Contact:** Wash skin with plenty of water.

**Inhalation:** Move person to fresh air; if effects occur, consult a physician.

**Ingestion:** No emergency medical treatment necessary.

**Notes to Physician:** No specific antidote. Treatment of exposure should be directed at the control of symptoms and the clinical condition of the patient.

## 5. Fire Fighting Measures

**Extinguishing Media:** Water fog or fine spray. Dry chemical fire extinguishers. Carbon dioxide fire extinguishers. Foam. Alcohol resistant foams (ATC type) are preferred. General purpose synthetic foams (including AFFF) or protein foams may function, but will be less effective. Water fog, applied gently may be used as a blanket for fire extinguishment.

**Fire Fighting Procedures:** Keep people away. Isolate fire and deny unnecessary entry. Burning liquids may be extinguished by dilution with water. Do not use direct water stream. May spread fire. Burning liquids may be moved by flushing with water to protect personnel and minimize property damage. Water fog, applied gently may be used as a blanket for fire extinguishment.

**Special Protective Equipment for Firefighters:** Wear positive-pressure self-contained breathing apparatus (SCBA) and protective fire fighting clothing (includes fire fighting helmet, coat, trousers, boots, and gloves). If protective equipment is not available or not used, fight fire from a protected location or safe distance.

**Unusual Fire and Explosion Hazards:** Violent steam generation or eruption may occur upon application of direct water stream to hot liquids.

**Hazardous Combustion Products:** During a fire, smoke may contain the original material in addition to combustion products of varying composition which may be toxic and/or irritating. Combustion products may include and are not limited to: Carbon monoxide. Carbon dioxide.

## 6. Accidental Release Measures

**Steps to be Taken if Material is Released or Spilled:** See Section 13, Disposal Considerations, for additional information. Contain spilled material if possible.

**Personal Precautions:** Isolate area. Refer to Section 7, Handling, for additional precautionary measures. Keep unnecessary and unprotected personnel from entering the area. No smoking in area. Use appropriate safety equipment. For additional information, refer to Section 8, Exposure Controls and Personal Protection.

**Environmental Precautions:** Prevent from entering into soil, ditches, sewers, waterways and/or groundwater. See Section 12, Ecological Information.

## 7. Handling and Storage

### Handling

**General Handling:** Avoid contact with eyes, skin, and clothing. Wash thoroughly after handling. See Section 8, EXPOSURE CONTROLS AND PERSONAL PROTECTION.

**Other Precautions:** Containers, even those that have been emptied, can contain vapors. Do not cut, drill, grind, weld, or perform similar operations on or near empty containers.

### Storage

Store in original container.

Product Name: ETHYLENE GLYCOL DIACETATE PURE

Revision Date: 2007/05/14

## 8. Exposure Controls / Personal Protection

### Exposure Limits

None established

### Personal Protection

**Eye/Face Protection:** Use chemical goggles. Chemical goggles should be consistent with EN 166 or equivalent.

**Skin Protection:** Use protective clothing chemically resistant to this material. Selection of specific items such as face shield, boots, apron, or full body suit will depend on the task.

**Hand protection:** Use chemical resistant gloves classified under Standard EN374: Protective gloves against chemicals and micro-organisms. Examples of preferred glove barrier materials include: Butyl rubber, Chlorinated polyethylene, Polyethylene, Ethyl vinyl alcohol laminate ("EVAL"), Polyvinyl alcohol ("PVA"). Examples of acceptable glove barrier materials include: Natural rubber ("latex"), Neoprene, Nitrile/butadiene rubber ("nitrile" or "NBR"), Polyvinyl chloride ("PVC" or "vinyl"), Viton. When prolonged or frequently repeated contact may occur, a glove with a protection class of 4 or higher (breakthrough time greater than 120 minutes according to EN 374) is recommended. When only brief contact is expected, a glove with a protection class of 1 or higher (breakthrough time greater than 10 minutes according to EN 374) is recommended. **NOTICE:** The selection of a specific glove for a particular application and duration of use in a workplace should also take into account all relevant workplace factors such as, but not limited to: Other chemicals which may be handled, physical requirements (cut/puncture protection, dexterity, thermal protection), potential body reactions to glove materials, as well as the instructions/specifications provided by the glove supplier.

**Respiratory Protection:** Respiratory protection should be worn when there is a potential to exceed the exposure limit requirements or guidelines. If there are no applicable exposure limit requirements or guidelines, wear respiratory protection when adverse effects, such as respiratory irritation or discomfort have been experienced, or where indicated by your risk assessment process. Use the following CE approved air-purifying respirator: Organic vapor cartridge, type A (boiling point >65 °C)

**Ingestion:** Use good personal hygiene. Do not consume or store food in the work area. Wash hands before smoking or eating.

### Engineering Controls

**Ventilation:** Use engineering controls to maintain airborne level below exposure limit requirements or guidelines. If there are no applicable exposure limit requirements or guidelines, use only with adequate ventilation. Local exhaust ventilation may be necessary for some operations.

## 9. Physical and Chemical Properties

Physical State	Liquid
Color	Colorless
Odor	Ester
Flash Point - Closed Cup	62 °C C&FC 100109
Flammable Limits in Air	Lower: 1.6 %(V) Vendor Upper: 8.4 %(V) Vendor
Autoignition Temperature	481 °C Vendor
Vapor Pressure	0.2 mmHg @ 20 °C Vendor
Boiling Point (760 mmHg)	186 - 187 °C C&FC 100106
Vapor Density (air = 1)	5.04 Vendor
Specific Gravity (H2O = 1)	1.128 20 °C/20 °C Vendor
Freezing Point	No test data available
Melting Point	-31 °C Literature
Solubility in Water (by weight)	14 % @ 20 °C Literature
pH	No test data available
Octanol/Water Partition Coefficient	0.40 Estimated

Product Name: ETHYLENE GLYCOL DIACETATE PURE

Revision Date: 2007/05/14

Kinematic Viscosity

No test data available

## 10. Stability and Reactivity

### Stability/Instability

Thermally stable at typical use temperatures.

**Conditions to Avoid:** Exposure to elevated temperatures can cause product to decompose.

**Incompatible Materials:** Avoid contact with: Oxidizers.

### Hazardous Polymerization

Will not occur.

### Thermal Decomposition

Decomposition products depend upon temperature, air supply and the presence of other materials.

## 11. Toxicological Information

### Acute Toxicity

#### Ingestion

Very low toxicity if swallowed. Harmful effects not anticipated from swallowing small amounts.

LD50, Rat: 6,850 mg/kg

#### Eye Contact

May cause eye irritation. May cause corneal injury.

#### Skin Contact

Brief contact may cause skin irritation with local redness.

#### Skin Absorption

Prolonged skin contact is unlikely to result in absorption of harmful amounts.

LD50, Rabbit: 8,480 mg/kg

#### Inhalation

Vapor may cause irritation of the upper respiratory tract (nose and throat).

## 12. Ecological Information

### CHEMICAL FATE

#### Movement & Partitioning

Bioconcentration potential is low (BCF < 100 or Log Pow < 3). Potential for mobility in soil is very high (Koc between 0 and 50).

Henry's Law Constant (H): 8.4E-08 atm\*m3/mole; 25 °C. Measured

Partition coefficient, n-octanol/water (log Pow): 0.40. Estimated

Partition coefficient, soil organic carbon/water (Koc): 10. Estimated

#### Persistence and Degradability

Indirect Photodegradation with OH Radicals

Rate Constant	Atmospheric Half-life	Method
3.7605E-12 cm3/s	2.8 d	Estimated

Theoretical Oxygen Demand: 1.42 mg/mg

### ECOTOXICITY

Material is harmful to aquatic organisms (LC50/EC50/IC50 between 10 and 100 mg/L in most sensitive species).

#### Fish Acute & Prolonged Toxicity

LC50, bluegill (*Lepomis macrochirus*), static, 96 h: 90 mg/l



<b>Product Name:</b> ETHYLENE GLYCOL DIACETATE PURE	<b>Revision Date:</b> 2007/05/14
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LC50, tidewater silverside (*Menidia beryllina*), static, 96 h: 76 mg/l

<b>13. Disposal Considerations</b>
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All disposal practices must be in compliance with all Federal, State/Provincial and local laws and regulations. Do not dump into any sewers, on the ground, or into any body of water.

<b>14. Transport Information</b>
----------------------------------

**ROAD & RAIL**  
NOT REGULATED

**OCEAN**  
NOT REGULATED

**AIR**  
NOT REGULATED

**INLAND WATERWAYS**  
**Proper Shipping Name:** SUBSTANCES with a flashpoint above 61°C but not more than 100°C, N.O.S.  
**Technical Name:** ETHYLENE DIACETATE  
**Hazard Class:** 9 **ID Number:** ID9003

<b>15. Regulatory Information</b>
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**European Inventory of Existing Commercial Chemical Substances (EINECS)**  
The components of this product are on the EINECS inventory or are exempt from inventory requirements.

**EC Classification and User Label Information**  
This product is not classified as dangerous according to EC criteria.

<b>16. Other Information</b>
------------------------------

**Revision**  
Identification Number: 70262 / 3005 / Issue Date 2007/05/14 / Version: 1.0  
Most recent revision(s) are noted by the bold, double bars in left-hand margin throughout this document.

*Dow Chemical Company Ltd urges each customer or recipient of this (M)SDS to study it carefully and consult appropriate expertise, as necessary or appropriate, to become aware of and understand the data contained in this (M)SDS and any hazards associated with the product. The information herein is provided in good faith and believed to be accurate as of the effective date shown above. However, no warranty, express or implied, is given. Regulatory requirements are subject to change and may differ between various locations. It is the buyer's/user's responsibility to ensure that his activities comply with all federal, state, provincial or local laws. The information presented here pertains only to the product*

## DRILLING FLUIDS FOR DEEP CORING IN CENTRAL ANTARCTICA

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**Product Name:** ETHYLENE GLYCOL DIACETATE PURE

**Revision Date:** 2007/05/14

*as shipped. Since conditions for use of the product are not under the control of the manufacturer, it is the buyer's/user's duty to determine the conditions necessary for the safe use of this product. Due to the proliferation of sources for information such as manufacturer-specific (M)SDSs, we are not and cannot be responsible for (M)SDSs obtained from any source other than ourselves. If you have obtained an (M)SDS from another source or if you are not sure that the (M)SDS you have is current, please contact us for the most current version.*

### Safety Data Sheet according to 1907/2006/EC, Article 31

Printing date: 09.12.2008

Revision: 09.12.2008

#### 1 Identification of the substance/preparation and of the company/undertaking

- **Product details**
- **Trade name:** ESTISOL 140
- **Application of the substance / the preparation:** Solvents
- **Manufacturer/Supplier:**  
Esti Chem A/S  
Erlingeværket 16  
DK - 4621 Godstrup  
Tel.: +45-36-63 33 72  
Fax.: +45-36-63 33 75
- **Further information obtainable from:**  
product safety department  
birgit.pape@esti-chemie.de
- **Information in case of emergency:** +45-36-63 33 72

#### 2 Hazards identification

- **Hazard description:** *Not applicable.*
- **Information concerning particular hazards for human and environment:**  
*The product does not have to be labelled due to the calculation procedure of the "General Classification guideline for preparations of the EU" in the latest valid version.*
- **Classification system:**  
*The classification is according to the latest editions of the EU-lists, and extended by company and literature data.*

#### 3 Composition/Information on ingredients

- **Chemical characterization**
- **Description:** *Mixture of substances listed below with non hazardous additions.*
- **Dangerous components:** *None*
- **Additional information:** *For the wording of the listed risk phrases refer to section 16.*

#### 4 First aid measures

- **General information:** *No special measures required.*
- **After inhalation:** *Supply fresh air; consult doctor in case of complaints.*
- **After skin contact:** *Immediately wash with water and soap and rinse thoroughly.*
- **After eye contact:** *Rinse opened eye for several minutes under running water.*
- **After swallowing:** *If symptoms persist consult doctor.*

#### 5 Fire-fighting measures

- **Suitable extinguishing agents:**  
*CO<sub>2</sub>, powder or water spray. Fight larger fires with water spray or alcohol resistant foam.*
- **Protective equipment:** *Wear self-contained respiratory protective device.*

#### 6 Accidental release measures

- **Person-related safety precautions:** *Wear protective clothing.*
- **Measures for environmental protection:** *Do not allow to enter sewers/ surface or ground water.*
- **Measures for cleansing/collection:**  
*Absorb with liquid-binding material (sand, diatomite, acid binders, universal binders, sawdust).*

(Cont. on page 2)

08



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**Safety Data Sheet**  
 according to 1907/2006/EC, Article 31

Printing date 09.12.2008 Revision: 09.12.2008

Trade name: ESTISOL 148	
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(Cont. of page 1)

Additional information: No dangerous substances are released.

**7 Handling and storage**

- Handling:
- Information for safe handling: No special measures required.
- Information about fire- and explosion protection: No special measures required.
- Storage:
- Requirements to be met by storeroom and receptacles: Provide solvent resistant, sealed floor.
- Information about storage in one common storage facility: Store away from foodstuffs.
- Further information about storage conditions: None.

**8 Exposure controls/personal protection**

- Additional information about design of technical facilities: No further data; see item 7.
- Ingredients with limit values that require monitoring at the workplace:  
The product does not contain any relevant quantities of materials with critical values that have to be monitored at the workplace.
- Additional information: The lists valid during the making were used as basis.
- Personal protective equipment:
- General protective and hygienic measures:  
The usual precautionary measures are to be adhered to when handling chemicals.
- Respiratory protection: Not required.
- Protection of hands:  
The glove material has to be impermeable and resistant to the product/ the substance/ the preparation.  
Due to missing data no recommendation to the glove material can be given for the product/ the preparation/ the chemical mixture.  
Selection of the glove material on consideration of the penetration times, rates of diffusion and the degradation.
- Material of gloves:  
The selection of the suitable gloves does not only depend on the material, but also on further marks of quality and varies from manufacturer to manufacturer. As the product is a preparation of several substances, the resistance of the glove material can not be calculated in advance and has therefore to be checked prior to the application.
- Penetration time of glove material:  
The exact break through time has to be found out by the manufacturer of the protective gloves and has to be observed.
- Eye protection: Goggles recommended during refilling

**9 Physical and chemical properties**

<b>General Information</b>	
Form:	Fluid
Colour:	Clear
Odour:	Fruit-like
<b>Change in condition</b>	
Melting point/Melting range: -93°C	
Boiling point/Boiling range: 199°C	
Flash point:	73°C
Ignition temperature:	270°C
Danger of explosion:	Product does not present an explosion hazard.

(Cont. on page 3)

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## Safety Data Sheet

according to 1907/2006/EC, Article 31

Printing date: 09.12.2008 Revision: 09.12.2008

Trade name: ESTESOL 140	
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(Cont. of page 2)

- <b>Explosion limits:</b> Lower: 1.1 Vol % Upper: 7.5 Vol %	
- <b>Density at 20°C:</b> 0.863 g/cm³	
- <b>Solubility in / Miscibility with water:</b> Not miscible	

### 10 Stability and reactivity

- Thermal decomposition / conditions to be avoided: No decomposition if used according to specifications.
- Dangerous reactions: No dangerous reactions known.
- Dangerous decomposition products: No dangerous decomposition products known.

### 11 Toxicological information

- Acute toxicity:
- LD/LC50 values relevant for classification:  

Oral (LD50) 1000 mg/kg (rat)
------------------------------
- Primary irritant effect:
- on the skin: No irritant effect.
- on the eyes: No irritating effect.
- Sensitization: No sensitizing effects known.
- Additional toxicological information:  
 The product is not subject to classification according to the calculation method of the General EU Classification Guidelines for Preparations as issued in the latest version.  
 When used and handled according to specifications, the product does not have any harmful effects to our experience and the information provided to us.

### 12 Ecological information

- General notes:  
 Water hazard class 1 (German Regulation) (Self-assessment): slightly hazardous for water.  
 Do not allow undiluted product or large quantities of it to reach ground water, water course or sewage system.

### 13 Disposal considerations

- Product:
- Recommendation:  
 Must not be disposed together with household garbage. Do not allow product to reach sewage system.
- Uncleaned packaging:
- Recommendation: Disposal must be made according to official regulations.

### 14 Transport information

- Land transport ADR/RID (cross-border): - ADR/RID class: -	
- Maritime transport IMDG: - IMDG Class: - - Marine pollutant: No	

(Cont. on page 4)

<b>Safety Data Sheet</b> according to 1907/2006/EC, Article 31		Page 4/4
Printing date 09.12.2008		Revision: 09.12.2008
Trade name: ESTISOL 140		
		(Contd. of page 3)
<ul style="list-style-type: none"><li>· Air transport ICAO-TI and IATA-DGR:</li><li>· ICAO/IATA Class: -</li></ul>		
<b>15 Regulatory information</b>		
<ul style="list-style-type: none"><li>· Labelling according to EU guidelines: Observe the general safety regulations when handling chemicals. The product is not subject to identification regulations under EU Directives and the Ordinance on Hazardous Materials (German GefStoffV).</li></ul>		
<b>16 Other information</b>		
<p>This information is based on our present knowledge. However, this shall not constitute a guarantee for any specific product features and shall not establish a legally valid contractual relationship.</p> <ul style="list-style-type: none"><li>· Department issuing MSDS: product safety department</li><li>· Contact: Mrs. Birgit Pape</li></ul>		

### Safety data sheet according to 1907/2006/EC, Article 31

Printing date 04.03.2011

Revision: 04.03.2011

#### 1 Identification of the substance/mixture and of the company/undertaking

- Product identifier
- Trade name: *ESTISOL 163*
- Application of the substance / the preparation *Solvents*
- Details of the supplier of the safety data sheet
- Manufacturer/Supplier:  
*Esti Chem A/S*  
*Erhvervsparken 16*  
*DK - 4621 Gadstrup*  
*Tel.: +45-56-65 33 72*  
*Fax: +45-56-65 33 75*
- Further information obtainable from:  
*product safety department*  
*hirsch.pape@additiv-chemie.de*
- Emergency telephone number: *+45-56-65 33 72*

#### 2 Hazards identification

- Classification of the substance or mixture
- Classification according to Directive 67/548/EEC or Directive 1999/45/EC *Not applicable.*
- Information concerning particular hazards for human and environment:  
*The product does not have to be labelled due to the calculation procedure of the "General Classification guideline for preparations of the EU" in the latest valid version.*
- Classification system:  
*The classification is according to the latest editions of the EU-lists, and extended by company and literature data.*
- Label elements
- Labelling according to EU guidelines:  
*Observe the general safety regulations when handling chemicals.*  
*The product is not subject to identification regulations under EU Directives and the Ordinance on Hazardous Materials (German GefStoffV).*
- Other hazards
- Results of PBT and vPvB assessment
- PBT: *Not applicable.*
- vPvB: *Not applicable.*

#### 3 Composition/information on ingredients

- Chemical characterization: *Mixtures*
- Description: *Synthetic Ester*
- Dangerous components: *Void*
- Additional information: *For the wording of the listed risk phrases refer to section 16.*

#### 4 First aid measures

- Description of first aid measures
- General information: *Immediately remove any clothing soiled by the product.*
- After inhalation: *Supply fresh air; consult doctor in case of complaints.*
- After skin contact: *Immediately wash with water and soap and rinse thoroughly.*
- After eye contact: *Rinse opened eye for several minutes under running water.*
- After swallowing: *If symptoms persist consult doctor.*

## Safety data sheet according to 1907/2006/EC, Article 31

Printing date 04.03.2011

Revision: 04.03.2011

Trade name: ESTISOL 165

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### 5 Firefighting measures

- *Extinguishing media*
- *Suitable extinguishing agents:*  
CO<sub>2</sub>, powder or water spray. Fight larger fires with water spray or alcohol resistant foam.
- *Advice for firefighters*
- *Protective equipment:* Wear self-contained respiratory protective device.

### 6 Accidental release measures

- *Personal precautions, protective equipment and emergency procedures:* Wear protective clothing.
- *Environmental precautions:* No special measures required.
- *Methods and material for containment and cleaning up:*  
Absorb with liquid-binding material (sand, diatomite, acid binders, universal binders, sawdust).
- *Reference to other sections:* No dangerous substances are released.

### 7 Handling and storage

- *Handling:*
- *Precautions for safe handling:* No special measures required.
- *Information about fire - and explosion protection:* No special measures required.
- *Conditions for safe storage, including any incompatibilities*
- *Storage:*
- *Requirements to be met by storerooms and receptacles:* Provide solvent resistant, sealed floor.
- *Information about storage in one common storage facility:* Store away from foodstuffs.
- *Further information about storage conditions:* None.

### 8 Exposure controls/personal protection

- *Additional information about design of technical facilities:* No further data; see item 7.
- *Control parameters*
- *Ingredients with limit values that require monitoring at the workplace:*  
The product does not contain any relevant quantities of materials with critical values that have to be monitored at the workplace.
- *Additional information:* The lists valid during the making were used as basis.
- *Exposure controls*
- *Personal protective equipment:*
- *General protective and hygienic measures:*  
The usual precautionary measures are to be adhered to when handling chemicals.
- *Respiratory protection:* Not required.
- *Protection of hands:*  
The glove material has to be impermeable and resistant to the product/ the substance/ the preparation.  
Due to mixing tests no recommendation to the glove material can be given for the product/ the preparation/ the chemical mixture.  
Selection of the glove material on consideration of the penetration times, rates of diffusion and the degradation.
- *Material of gloves*  
The selection of the suitable gloves does not only depend on the material, but also on further marks of quality and varies from manufacturer to manufacturer. As the product is a preparation of several substances, the resistance of the glove material can not be calculated in advance and has therefore to be checked prior to the application.

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## Safety data sheet according to 1907/2006/EC, Article 31

Printing date 04.03.2011

Revision: 04.03.2011

Trade name: ESTISOL 165

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- Penetration time of glove material  
The exact break through time has to be found out by the manufacturer of the protective gloves and has to be observed.
- Eye protection: Safety glasses

### 9 Physical and chemical properties

- Information on basic physical and chemical properties

- General Information

- Appearance:

Form:	Fluid
Colour:	Clear
Odour:	Mild

- Change in condition

Melting point/Melting range: Undetermined.

Boiling point/Boiling range: Undetermined.

- Flash point: > 70°C

- Self-igniting: Product is not selfigniting.

- Danger of explosion: Product does not present an explosion hazard.

- Density at 20°C: 1.1 g/cm<sup>3</sup>

- Solubility in / Miscibility with water: Soluble.

- Viscosity:  
Dynamic at 25°C: 3 mPas

### 10 Stability and reactivity

- Reactivity

- Chemical stability

- Thermal decomposition / conditions to be avoided: No decomposition if used according to specifications.

- Possibility of hazardous reactions: No dangerous reactions known.

- Hazardous decomposition products: No dangerous decomposition products known.

### 11 Toxicological information

- Information on toxicological effects

- Acute toxicity:

- LD<sub>50</sub>/LC<sub>50</sub> values relevant for classification:

Oral	LD <sub>50</sub>	6850 mg/kg (rat)
Dermal	LD <sub>50</sub>	8480 mg/kg (rabbit)

- Primary irritant effect:

- on the skin: Irritant to skin and mucous membranes.

- on the eye: Irritating effect.

- Sensitization: No sensitizing effects known.

- Additional toxicological information:

The product is not subject to classification according to the calculation method of the General EU Classification Guidelines for Preparations as issued in the latest version.

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## Safety data sheet according to 1907/2006/EC, Article 31

Printing date 04.03.2011

Revision: 04.03.2011

Trade name: ESTISOL 165

(Contd. of page 3)  
When used and handled according to specifications, the product does not have any harmful effects to our experience and the information provided to us.

### 12 Ecological information

- Toxicity
- Aquatic toxicity: No further relevant information available.
- Persistence and degradability
- Other information: The product is readily biodegradable (>60% / 28 days according OECD 301).
- Behaviour in environmental systems:
- Bioaccumulative potential No further relevant information available.
- Additional ecological information:
- General notes:  
Water hazard class 1 (German Regulation) (Self-assessment): slightly hazardous for water  
Do not allow undiluted product or large quantities of it to reach ground water, water course or sewage system.
- Results of PBT and vPvB assessment
- PBT: Not applicable.
- vPvB: Not applicable.

### 13 Disposal considerations

- Waste treatment methods
- Recommendation  
Must not be disposed together with household garbage. Do not allow product to reach sewage system.
- Uncleaned packaging:
- Recommendation: Disposal must be made according to official regulations.

### 14 Transport information

- Maritime transport IMDG:
- Marine pollutant: No
- Special precautions for user Not applicable.

### 15 Regulatory information

- Safety, health and environmental regulations/legislation specific for the substance or mixture
- National regulations:
- Other regulations, limitations and prohibitive regulations 1993 kode: 4-3
- Chemical safety assessment: A Chemical Safety Assessment has not been carried out.

### 16 Other information

- This information is based on our present knowledge. However, this shall not constitute a guarantee for any specific product features and shall not establish a legally valid contractual relationship.
- Department issuing MSDS: product safety department
  - Contact: Mrs. Birgit Pape

### Safety data sheet according to 1997/2006/EC, Article 31

Printing date 08.12.2011

Revision: 08.12.2011

#### 1 Identification of the substance/mixture and of the company/undertaking

- Product identifier
- Trade name: ESTISOL F2887
- Application of the substance / the preparation Solvents
- Details of the supplier of the safety data sheet
- Manufacturer/Supplier:  
Esti Chem A/S  
Erhvervsparken 16  
DK - 4621 Gadstrup  
Tel.: +45-56-65 33 72  
Fax.: +45-56-65 33 75
- Further information obtainable from:  
product safety department  
tjorgt.pape@addito-chemie.de
- Emergency telephone number: +45-56-65 33 72

#### 2 Hazards identification

- Classification of the substance or mixture
- Classification according to Directive 67/548/EEC or Directive 1999/45/EC Not applicable
- Information concerning particular hazards for human and environment:  
The product does not have to be labelled due to the calculation procedure of the "General Classification guideline for preparations of the EU" in the latest valid version.
- Classification system:  
The classification is according to the latest editions of the EU-lists, and extended by company and literature data.
- Label elements
- Labelling according to EU guidelines:  
Observe the general safety regulations when handling chemicals.  
The product is not subject to identification regulations under EU Directives and the Ordinance on Hazardous Materials (German GefStoffV).
- Other hazards
- Results of PBT and vPvB assessment
- PBT: Not applicable.
- vPvB: Not applicable.

#### 3 Composition/Information on ingredients

- Chemical characterization: Mixtures
- Description: Synthetic Ester
- Dangerous components: Void
- Additional information: For the wording of the listed risk phrases refer to section 16.

#### 4 First aid measures

- Description of first aid measures
- General information: No special measures required.
- After inhalation: Supply fresh air, consult doctor in case of complaints.
- After skin contact: Immediately wash with water and soap and rinse thoroughly.
- After eye contact: Rinse opened eye for several minutes under running water.
- After swallowing: If symptoms persist consult doctor.
- Information for doctor:
- Most important symptoms and effects, both acute and delayed No further relevant information available.

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## Safety data sheet according to 1907/2006/EC, Article 31

Printing date 08.12.2011

Revision: 08.12.2011

Trade name: ESTISOL F2887

· Indication of any immediate medical attention and special treatment needed  
No further relevant information available.

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### 5 Firefighting measures

- Extinguishing media
- Suitable extinguishing agents:  
CO<sub>2</sub>, powder or water spray. Fight larger fires with water spray or alcohol resistant foam.
- Special hazards arising from the substance or mixture No further relevant information available.
- Advice for firefighters
- Protective equipment: Wear self-contained respiratory protective device.

### 6 Accidental release measures

- Personal precautions, protective equipment and emergency procedures Wear protective clothing.
- Environmental precautions: No special measures required.
- Methods and material for containment and cleaning up:  
Absorb with liquid-binding material (sand, diatomite, acid binders, universal binders, sorbents).
- Reference to other sections  
No dangerous substances are released.  
See Section 7 for information on safe handling.  
See Section 8 for information on personal protection equipment.  
See Section 13 for disposal information.

### 7 Handling and storage

- Handling:
- Precautions for safe handling No special measures required.
- Information about fire - and explosion protection: No special measures required.
- Conditions for safe storage, including any incompatibilities
- Storage:
- Requirements to be met by storerooms and receptacles: Provide solvent resistant, sealed floor.
- Information about storage in one common storage facility: Store away from foodstuffs.
- Further information about storage conditions: None.
- Specific end use(s) No further relevant information available.

### 8 Exposure controls/personal protection

- Additional information about design of technical facilities: No further data; see item 7.
- Control parameters
- Ingredients with limit values that require monitoring at the workplace:  
The product does not contain any relevant quantities of materials with critical values that have to be monitored at the workplace.
- Additional information: The lists valid during the making were used as basis.
- Exposure controls
- Personal protective equipment:
- General protective and hygienic measures:  
The usual precautionary measures are to be adhered to when handling chemicals.
- Respiratory protection: Not required.
- Protection of hands:  
The glove material has to be impermeable and resistant to the product/ the substance/ the preparation.

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## Safety data sheet according to 1907/2006/EC, Article 31

Printing date 08.12.2011

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Trade name: ESTISOL F2887

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Due to missing tests no recommendation to the glove material can be given for the product/ the preparation/ the chemical mixture.

Selection of the glove material on consideration of the penetration times, rates of diffusion and the degradation

### Material of gloves

The selection of the suitable gloves does not only depend on the material, but also on further marks of quality and varies from manufacturer to manufacturer. As the product is a preparation of several substances, the resistance of the glove material can not be calculated in advance and has therefore to be checked prior to the application.

### Penetration time of glove material

The exact break through time has to be found out by the manufacturer of the protective gloves and has to be observed.

Eye protection: Safety glasses

## 9 Physical and chemical properties

### Information on basic physical and chemical properties

#### General Information

#### Appearance:

Form:	Fluid
Colour:	Clear
Odour:	Specific type
Odour threshold:	Not determined.

pH-value: Not determined.

#### Change in condition

Melting point/Melting range:	Undetermined.
Boiling point/Boiling range:	Undetermined.

Flash point: 167°C

#### Ignition temperature:

Decomposition temperature: Not determined.

Self-igniting: Product is not selfigniting.

Danger of explosion: Product does not present an explosion hazard

#### Explosion limits:

Lower:	Not determined.
Upper:	Not determined.

Vapour pressure: Not determined.

Density at 20°C: 1,083 g/cm<sup>3</sup>

Relative density: Not determined.

Vapour density: Not determined.

Evaporation rate: Not determined.

Solubility in / Miscibility with water:

Not miscible

Segregation coefficient (n-octanol/water): Not determined.

#### Viscosity:

Dynamic:	Not determined.
Kinematic:	Not determined.

Other information: No further relevant information available.

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## Safety data sheet according to 1907/2006/EC, Article 31

Printing date 08.12.2011

Revision: 08.12.2011

Trade name: ESTISOL F2887

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### 10 Stability and reactivity

- *Reactivity*
- *Chemical stability*
- *Thermal decomposition / conditions to be avoided:* No decomposition if used according to specifications.
- *Possibility of hazardous reactions:* No dangerous reactions known.
- *Conditions to avoid:* No further relevant information available.
- *Incompatible materials:* No further relevant information available.
- *Hazardous decomposition products:* No dangerous decomposition products known.

### 11 Toxicological information

- *Information on toxicological effects*
- *Acute toxicity:*
- *Primary irritant effect:*
- *on the skin:* No irritant effect.
- *on the eye:* No irritating effect.
- *Sensitization:* No sensitizing effects known.
- *Additional toxicological information:*  
The product is not subject to classification according to the calculation method of the General EU Classification Guidelines for Preparations as issued in the latest version.  
When used and handled according to specifications, the product does not have any harmful effects to our experience and the information provided to us.

### 12 Ecological information

- *Toxicity*
- *Aquatic toxicity:* No further relevant information available.
- *Persistence and degradability:* No further relevant information available.
- *Behaviour in environmental systems:*
- *Bioaccumulative potential:* No further relevant information available.
- *Mobility in soil:* No further relevant information available.
- *Results of PBT and vPvB assessment*
- *PBT:* Not applicable.
- *vPvB:* Not applicable.
- *Other adverse effects:* No further relevant information available.

### 13 Disposal considerations

- *Waste treatment methods*
- *Recommendation:*  
Must not be disposed together with household garbage. Do not allow product to reach sewage system.
- *Uncleaned packaging:*
- *Recommendation:* Disposal must be made according to official regulations.

### 14 Transport information

- *Maritime transport IMDG:*
- *Marine pollutant:* No
- *Special precautions for user:* Not applicable.
- *Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code:* Not applicable.

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**Safety data sheet**  
according to 1907/2006/EC, Article 31

Printing date 08.12.2011

Revision: 08.12.2011

Trade name: ESTISOL F2887

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## 15 Regulatory information

· Chemical safety assessment: A Chemical Safety Assessment has not been carried out.

## 16 Other information

*This information is based on our present knowledge. However, this shall not constitute a guarantee for any specific product features and shall not establish a legally valid contractual relationship.*

· Department issuing MSDS: product safety department  
· Contact: Mrs. Birgit Pape

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