3. CHEMICAL AND PHYSICAL INFORMATION

3.1 Chemical Identity

Information regarding the chemical identity of hydraulic fluid products is located in Table 3-l. This table contains information representative of three types of hydraulic fluids: mineral oil, organophosphate ester, and polyalphaolefin.

Early fluid power systems used water as the hydraulic medium. Because of its corrosive effect on the metallic parts and lack of lubricity, water was replaced by petroleum-based oil. The petroleum-based fluids discussed in this profile are mineral oil and water-in-oil emulsion fluids. Water-in-oil emulsions consist of 35-40% water, $\leq$60% mineral oil, and emulsifiers and additives. The water is dispersed in fine droplets in the oil phase. However, these fluids containing oil are readily ignited (NFPA 1991). Some water-in-oil emulsion hydraulic fluids contain ethylene glycol; however, ethylene glycol represents $\leq$10% of the total volume of water-in-oil emulsion hydraulic fluids. The carbon number range in mineral oil hydraulic fluids will vary depending on the application, but probably is in the range of C_{15} to C_{50}(IARC 1984). The hydrocarbon components of mineral oil (and ethylene glycol) are used in numerous other applications, so the presence of these components in the environment cannot be uniquely associated with mineral oil-based hydraulic fluid use.

Most mineral oil hydraulic fluids are made from dewaxed paraffin-based crude oils that are blended with additives to impart appropriate properties for the specific use (Newton 1989; Papay 1989, 1991; Wills 1980). The types of additives, which are summarized below, are quite numerous and in some cases (Mattie et al. 1993) may contain organophosphate esters. These additives include extreme pressure additives, which help prevent surface damage under severe loading (organic sulfur-, phosphorus-, and chlorine-containing compounds); anti-wear additives, which prevent wearing under light loads (fatty acids and derivatives, organophosphate esters); corrosion inhibitors, which prevent corrosion by oxygen and water (fatty acids, sulfonates, and salts of fatty acids); oxidation inhibitors, which inhibit oxidation of the hydraulic fluid (phenols, amines, and sulfides); defoamers, which prevent foam formation (silicone oils); viscosity index improvers, which reduce the dependence of viscosity on temperature (polyalphaolefins, polymethacrylates, and polyalkylstyrenes); pour point depressants, which lower the pour point temperature (polymethacrylates and condensation products); demulsifiers, which allow separation of oil and water (ionogenic and nonionogenic polar compounds); and dispersants, which prevent unwanted deposits (sulfonates and amides) (Moller 1989).

Table 3-1. Chemical Identity of Hydraulic Fluid Products

Characteristic	Houghto-Safe 5047F[a]	Pyroguard A-433[b]	Quintolubric 95830W[b]
Class	Water-in-oil	Water-in-oil	Water-in-oil
Product description	No data	No data	No data
Registered trade name(s)	Houghto-Safe 5047F	Pyroguard A-433	Quintolubric 95830W
Components	Mineral oil (30–60%); ethylene glycol (1–10%); remainder water	Mineral oil (60%); water (40%)	Mineral oil (60%); water (40%)
Identification numbers:			
CAS registry	No data	No data	No data
NIOSH RTECS	No data	No data	No data
EPA hazardous waste	No data	No data	No data
OHM/TADS	No data	No data	No data
DOT/UN/NA/IMCO shipping	No data	No data	No data
HSDB	No data	No data	No data
NCI	No data	No data	No data
Characteristic	**Sunsafe F[a]**	**Cellulube 220[c]**	**Durad 110[d]**
Class	Water-in-oil	Phosphate ester	Phosphate ester
Product description	No data	Triaryl phosphate	Isopropylated triphenyl phosphate mixture
Registered trade name(s)	Sunsafe F	Cellulube 220*	Durad 110
Components	Mineral oil (60%); water (40%); <2% ethylene glycol	Triphenyl phosphate; tricresyl phosphates, trixylenyl phosphates; trialkyl phenyl phosphates	Isopropylated triphenyl phosphate; triphenyl phosphate
Identification numbers:			
CAS registry	No data	No data	No data
NIOSH RTECS	No data	No data	No data
EPA hazardous waste	No data	No data	No data
OHM/TADS	No data	No data	No data
DOT/UN/NA/IMCO shipping	No data	No data	Not applicable
HSDB	No data	No data	No data
NCI	No data	No data	No data

Table 3-1. Chemical Identity of Hydraulic Fluid Products (continued)

Characteristic	Durad 125[e] (additive)	Durad 220[f] (additive)	Durad 220B[g]
Class	Phosphate ester	Phosphate ester	Phosphate ester
Product description	Tricresyl phosphate	Isopropylphenyl phosphate	t-Butylphenyl diphenyl phosphate mixture
Registered trade name(s)	Durad 125	Durad 220	Durad 220B; MIL-H-19457C[x]
Components	Tricresyl phosphates; currently less than 1% total *ortho* isomer, no detectable tri-*ortho*-cresyl phosphate	Isopropylphenyl phosphate blend	t-Butylphenyl phenyl phosphate; triphenyl phosphate
Identification numbers:			
CAS registry	No data	No data	28777-70-0[w]
NIOSH RTECS	No data	No data	TC8625000[x]
EPA hazardous waste	No data	No data	No data
OHM/TADS	No data	No data	No data
DOT/UN/NA/IMCO shipping	No data	No data	Not applicable
HSDB	No data	No data	No data
NCI	No data	No data	No data

Characteristic	Durad 300[h]	Durad 550B[i]	Durad MP280B[j] (hydraulic fluid) (now known as Reolube$_R$)
Class	Phosphate ester	Phosphate ester	Phosphate ester
Product description	Isopropylated triphenyl phosphate mixture	t-Butylated triphenyl phosphate mixture	Mixed triaryl phosphate
Registered trade name(s)	Durad 300	Durad 550B	Durad MP280B (Reolube$_R$)
Components	Isopropylated triphenyl phosphate; triphenyl phosphate (15%)	Not specified	t-butylphenyl phenyl phosphate, triphenyl phosphate; additives
Identification numbers:			
CAS registry	No data	No data	68937-40-6
NIOSH RTECS	No data	No data	No data
EPA hazardous waste	No data	No data	No data
OHM/TADS	No data	No data	No data
DOT/UN/NA/IMCO shipping	Not applicable	Not applicable	No data
HSDB	No data	No data	No data
NCI	No data	No data	No data

Table 3-1. Chemical Identity of Hydraulic Fluid Products (continued)

Characteristic	Fyrquel 150[k]	Fyrquel 220[l]	Fyrquel EHC[m]
Class	Phosphate ester mixture	Phosphate ester mixture	Phosphate ester mixture
Product description	Butylated triphenyl phosphate	Mixed triaryl phosphate	Mixed triaryl phosphate
Registered trade name(s)	Fyrquel 150	Fyrquel 220	Fyrquel EHC
Components	Butylated triphenyl phosphate ≈100%; triphenyl phosphate 15–20%	t-Butylphenyl diphenyl phosphate 35–40%; di(t-butylphenyl) phenyl phosphate 25–30%; triphenyl phosphate 15–20%; tri (p-t-butylphenyl) phosphate 6–10%; butylated triphenyl phosphate 6–10%	Mixed triaryl phosphate ≈50%; mixed xylenyl phosphate ≈ 50%; triphenyl phosphate ≈7–10%
Identification numbers:			
CAS registry	No data	55957-10-3[w]	No data
NIOSH RTECS	No data	No data	No data
EPA hazardous waste	No data	No data	No data
OHM/TADS	No data	No data	No data
DOT/UN/NA/IMCO shipping	No data	No data	No data
HSDB	No data	No data	No data
NCI	No data	No data	No data

Characteristic	Hyjet IV[n]	Pydraul 29ELT[o]	Pydraul 50E[o]
Class	Organophosphate	Phosphate ester	Phosphate ester
Product description	Trialkyl phosphate	Mixed triaryl phosphate	Phosphate ester mixture
Registered trade name(s)	Hyjet IV	Pydraul 29ELT	Pydraul 50E
Components	Tributyl phosphate (79%); cycloaliphatic epoxide (2.0%) additives, including a triaryl phophate (21.0%)	Mixture of 2-ethylhexyl diphenyl blend; p-t-butyl phenyl blend; triphenyl phosphate; $di_{(7\text{-}9\text{-}11)}$phthalate blend; di-2-ethylhexyl phenyl phosphate	Nonylphenyl diphenyl phosphate (≈41%); cumylphenyl diphenyl phosphate (≈23%); triphenyl phosphate (≈36%)[w]
Identification numbers:			
CAS registry	No data	No data	66594-31-8[w]
NIOSH RTECS	No data	No data	No data
EPA hazardous waste	No data	No data	No data
OHM/TADS	No data	No data	No data
DOT/UN/NA/IMCO shipping	UN3082	No data	Not applicable
HSDB	No data	No data	No data
NCI	No data	No data	No data

Table 3-1. Chemical Identity of Hydraulic Fluid Products (continued)

Characteristic	Pydraul 90E[o]	Reofos 50[p]	Reofos 65[q]	Reolube HYD46[r]
Class	Phosphate ester	Phosphate ester	Phosphate ester	Phosphate ester blend
Product description	Mixed triaryl phosphate	Isopropylated triphenyl phosphate mixture	Isopropylated triphenyl phosphate mixture	Isopropylated triphenyl phosphate blend
Registered trade name(s)	Pydraul 90E	Reofos 50	Reofos 65	Reolube HYD46
Components	Mixture of nonylphenyl diphenyl phosphate; cumylphenyl phosphate; cumylphenyl diphenyl phosphate; triphenyl phosphate; performance additives—phosphate ester blends including CAS# 6630-28-3	Not specified	Mixture of triphenyl phosphate; o-isopropylphenyl diphenyl phosphate; bis(o-isopropylphenyl)phenyl phosphate; tris(o-isopropylphenyl)phosphate	Not specified
Identification numbers:				
CAS registry	No data	63848-94-2[w]	No data	107028-44-4[w]
NIOSH RTECS	No data	No data	No data	No data
EPA hazardous waste	No data	No data	No data	No data
OHM/TADS	No data	No data	No data	No data
DOT/UN/NA/IMCO shipping	No data	No data	No data	No data
HSDB	No data	No data	No data	No data
NCI	No data	No data	No data	No data

Table 3-1. Chemical Identity of Hydraulic Fluid Products (continued)

Characteristic	Skydrol 500B-4[s]	Skydrol LD-4[t]	Cyclotriphosphazene[u]	Polyalphaolefin
Class	Phosphate ester mixture	Phosphate ester mixture	Phosphazene ester	Polyalphaolefin
Product description			Cyclotriphosphazene	Hydrogenated oligomers of alphaolefins
Registered trade name(s)	Skydrol 500B, Skydrol 500B-4	Skydrol LD-4		See Table 3-2
Components	Skydrol 500B: tri-n-butyl-phosphate (65–75%); di-n-butyl phenyl phosphate (10–15%); n-butyl diphenyl phosphate (10–15%); Skydrol 500B-4[y]: tributyl phosphate; dibutyl phenyl phosphate; butyl diphenyl phosphate	Skydrol LD: tri-n-butyl-phosphate[y] Skydrol LD-4: tributyl phosphate; dibutyl phenyl phosphate; 2,5-di-tert-butyl-p-cresol (minor component); butyl diphenyl phosphate	Dimers, trimers and tetramers of cyclotriphosphazene ester and 0.1% tolyltriazole $(P_3N_3)_n$	Mixture of oligomers of linear alphaolefins having 6 or more carbon atoms[v] $(C{=}C\text{–}C\text{–}C\text{–}C\text{–}C\text{–})_n$
Identification numbers:				
CAS registry	50815-84-4[w]	55962-27-1[w]	291-37-2	See Table 3-2
NIOSH RTECS	VX5500000[x]	No data	No data	
EPA hazardous waste	No data	No data	No data	
OHM/TADS	No data	No data	No data	
DOT/UN/NA/IMCO shipping	Not applicable	Not applicable	No data	
HSDB	No data	No data	No data	
NCI	No data	No data	No data	

[a] Houghton 1992
[b] Kinkead et al. 1987a
[c] Carpenter et al. 1956, 1959*
[d] FMC 1991d
[e] FMC 1992f
[f] FMC 1994
[g] FMC 1992e
[h] FMC 1991c
[i] FMC 1992c
[j] FMC 1992d
[k] Akzo 1989
[l] Akzo 1992
[m] Akzo 1991
[n] Chevron1994
[o] Monsanto 1986b
[p] FMC 1995
[q] Mortensen and Ladefoged 1992
[r] FMC 1990, 1995
[s] Monsanto 1992a
[t] Monsanto 1992b
[u] Kinkead et al. 1992a
[v] Shubkin 1993
[w] CAS 1995a
[x] RTECS 1996
[y] Monsanto 1990

*A fluid designated "TAP-1" described by Siegel et al. (1965) appears to be very similar if not identical to Cellulube 220.

CAS = Chemical Abstracts Service; DOT/UN/NA/IMO = Dept. of Transportation/United Nations/North America/International Maritime Dangerous Goods Code; EPA = Environmental Protection Agency; HSDB = Hazardous Substances Data Bank; NCI = National Cancer Institute; NIOSH = National Institute for Occupational Safety and Health; OHM/TADS = Oil and Hazardous Materials/Technical Assistance Data System; RTECS = Registry of Toxic Effects of Chemical Substances

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The exact nature of each of these additives appears to be trade secret information since none of the Material Safety Data Sheets describing the hydraulic fluids presented in this profile identify these materials. In addition, no information concerning the exact production methods used in manufacturing these hydraulic fluids was located in the available literature. Nonetheless, they are probably manufactured in batch processes and then tested to insure that they conform to the specifications for which they are sold. The number, nature, and amount of each additive used in a batch may depend on availability, cost, or performance.

The carbon number range (hence, viscosity) in mineral oil hydraulic fluids will vary depending on the application of the fluid (IARC 1984; Papay 1989, 1991, 1993; Wills 1980), but probably are in the range of C_{15} to C_{50}. The higher the carbon number, the higher the viscosity; viscosity is a major factor in determining the base stock of a hydraulic fluid (Moller 1989; Papay 1989, 1991, 1993; Shubkin 1993; Wills 1980). A more highly refined mineral oil will have better viscosity properties (i.e., high viscosity index or low dependence of viscosity on temperature) (Moller 1989; Shubkin 1993).

In the past, hydraulic fluids using mineral oils sometimes included such additives as PCBs to improve the thermal resistance or other properties of the resulting fluids. While such uses of PCBs have been discontinued, PCBs at NPL sites may be encountered as a component where hydraulic fluids are a site contaminant (ATSDR 1993b).

Synthetic fire-resistant fluids have been developed to replace petroleum-based fluids for many applications. Although there are several types of these less hazardous fluids, the only synthetic fluids discussed in this profile are phosphate esters and polyalphaolefins. The phosphate esters are tertiary esters of *ortho*phosphoric acid, $O=P(OH)_3$, and may be triaryl, trialkyl, and alkyl/aryl. The polyalphaolefins are usually based on 2-decene and contain a mixture of oligomers (dimers, trimers, etc.).

The first commercial trialkyl phosphate esters (TAP) were tricresyl phosphate (TCP) and trixylenyl phosphate (TXP), referred to as “natural” phosphate esters because the cresols and xylenols used as raw materials are derived from petroleum oil or coal tar (Marino and Placek 1994). These products are not commercially significant at present; however, at waste disposal sites, contaminants from older product formulations may be encountered, particularly those containing the neurotoxic tri-*ortho*-cresyl phosphate isomer. “Synthetic” phosphate esters are derived from synthetic feedstocks. Specific synthetic reactions have been developed to produce triaryl, trialkyl, and alkyl\aryl esters. The triaryl phosphates are currently the most significant commercial products (Marino 1992). All three organic groups can be the same, such as tricresyl

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or trixylenyl phosphate, or they may be different, as iso-propylphenyl diphenyl phosphate or cresyl diphenyl phosphate. Of the trialkyl phosphate esters, tributyl phosphate is the most important of the synthetic base stocks. Most are used in aircraft hydraulic fluids (Marino 1992). Dibutyl phenyl phosphate, also used as an aircraft hydraulic fluid, is the most important of the alkyl/aryl phosphate esters (Marino 1992).

Products may be either mixtures of phosphate ester compounds resulting directly from the manufacturing process or mixtures resulting from post-blending or compounding with additives.

One of the main human health concerns about organophosphate esters is the potential for neurotoxicity reactions, in particular a condition known as organophosphate-induced delayed neurotoxicity (OPIDN). Tri-*ortho*- cresyl phosphate (TOCP) has been identified as one of the more potent OPIDN neurotoxins in humans, and was formerly a constituent in some organophosphate ester hydraulic fluid products (Marino 1992; Marino and Placek 1994). Production processes now routinely remove virtually all the TOCP. For instance, tricresyl phosphate (TCP) products now typically are manufactured to contain over 98% meta and para isomers and virtually no TOCP (Marino and Placek 1994). Products containing these compounds associated with OPIDN have now entirely disappeared from commercial use, and the vast majority of the industrial organophosphate esters are based on triaryl phosphates with no halogenated components (Marino 1992). At waste disposal sites, however, site contaminants from older product formulations containing the *ortho* form may be encountered.

In addition, organophosphate esters also are used as antiwear additives in hydraulic fluids and other lubricants; of the organophosphate esters discussed in this profile, Durad 110, 125, 220B, and 300 are categorized by their manufacturers as antiwear additives and not as hydraulic fluids (FMC 1991c, 1991d, 1992a, 1992b; Marino and Placek 1994).

Before the 1960s products were introduced based on alkyl aryl phosphates that could contain chlorinated aromatic hydrocarbons. Such products have now entirely disappeared from commercial use, and the vast majority of the industrial organophosphate esters are based on triaryl phosphates with no halogenated components (Marino 1992). However, at older waste disposal sites, hydraulic fluid site contaminants could contain chlorinated hydrocarbons. As with the PCBs formerly included as additives in other forms of hydraulic fluids, these additives may present more toxicity risks than the primary ingredients of the hydraulic fluids.

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A typical polyalphaolefin oil prepared from 1-decene and $BF_3 \cdot n\text{-}C_4H_9OH$ catalyst at 30 °C contains predominantly trimer (C_{30}hydrocarbons) with much smaller amounts of dimer, tetramer, pentamer, and hexamer. While 1 -decene is the most common starting material, other alphaolefins can be used, depending on the needs of the product oil.

The final oil contains a large number of isomers (e.g., the trimer of 1 -decene contains many C_{30} isomers, the tetramer contains many C_{40} isomers) which result from skeletal branching during the oligomerization (Shubkin 1993). Polyalphaolefin oils are many times classified by their kinematic viscosity at 100 °C; the higher the viscosity, the longer the average chain length of the polyalphaolefin. The isomer distribution of a polyalphaolefin oil used in a particular hydraulic fluid will depend on the application. A polyalphaolefin oil contains a narrower range of molecular weights than a comparable mineral oil (Chrisope and Landry 1993;Shubkin 1993).

Most hydraulic fluids contain additives that impart needed properties (Papay 1989, 1991; Wills 1980). The exact composition and proportion of these additives in a certain type of fluid depends on the intended use. Hydraulic fluids are compounded to conform to performance-based standards such as Military or ASTM (American Society for Testing and Materials) specifications. Some examples of Military specifications are shown in Table 3-2. Many different formulations can be compounded to conform to one performance standard. It should be noted that the variability among these products or even within products with the same trade names may confuse efforts to determine environmental and health effects of hydraulic fluids at hazardous waste landfills since hydraulic fluids that are currently used may or may not contain the same components present in old products of the same name.

Table 3-3 contains information regarding the chemical identity of principal components of hydraulic fluids. Trade names are included when the component constitutes 100% (or nearly 100%) of the product. Information has also been included for several representative types of mineral oil. It should be noted, however, that the term “mineral oil” encompasses a wide variety of petroleum-based products. Several phosphate esters used as hydraulic fluid additives are also included in Table 3-3.

Some of the products listed in the tables in Chapter 3 are not currently on the market. Information has been included for these products since components may be present at older waste disposal sites. For example, Cellulube 200 has not been a commercial product for over 20 years, Pydraul products are no longer sold commercially, and MIL-H- 19457B has been obsolete since 1981 (FMC 1995). In addition, some product

Table 3-2. Examples of Military Standards for Hydraulic Fluids

Property	MIL-H-5606[a]	MIL-H-5606F[b]	MIL-H-19457B[c]	MIL-H-19457C[c]	MIL-H-83282[b,d]	MIL-H-83306[e]
Class	Petroleum base	Petroleum base	Phosphate ester	Phosphate ester	Hydrogenated polyalphaolefin	Phosphate ester
Product description	No data	No data	No data	Butylated triphenyl phosphate mixture	No data	No data
Synonyms	MLO 82-585	No data	No data	MIL-H-19457D	MIL-H-83282C	No data
Major components[f]	Napthenic type petroleum oil	Petroleum products with additives	Trixylyl phosphate	Triphenyl phosphate; t-butyl phenyl diphenyl phosphate; di-t-butylphenyl phenyl phosphate; little to no tri-(t-butylphenyl) phosphate	Trimers of polyalphaolefin[e]	Tributyl-phosphate and dibutyl phenyl phosphate base stock
Operational temperature range	No data	-54–135 °C	No data	No data	-40–205 °C	No data
NATO Code	No data	H515	No data	No data	H-537	No data
Other	No data	No data	Obsolete since 1981	No data	No data	No data

[a] Kinkead et al. 1985
[b] Department of Defense 1993
[c] FMC 1995
[d] MIL-H-83282 LT is a candidate low-temperature hydraulic fluid
[e] Mattie et al. 1993
[f] Numerous chemicals may be added to the hydraulic fluid base stocks to improve fluid characteristics. Tricresyl or triphenyl phosphate may be added as antiwear additives (Department of Defense 1993). The amount of the ortho isomer of tricresyl phosphate may not exceed 1% of total tricresyl phosphate (Mattie et al. 1993).

Table 3-3. Chemical Identity of Hydraulic Fluid Components[a]

Characteristic	Tricresyl phosphate	Trixylyl phosphate	Cresyl diphenyl phosphate	Triphenyl phosphate
Type	Organophosphate ester	Organophosphate ester	Organophosphate ester	Organophosphate ester
Synonym(s)	TCP; tritolyl phosphate	Xylyl phosphate; TXP; trixylenyl phosphate	Diphenyl tolyl phosphate	TPP
Registered trade name(s)	Durad 125[b]	Durad 220X[c] Kronitex TXP[d] Reofos 95 Fyrquel 220[d]	Phosflex 112; Santicizer 140	Celluflex TPP; Disflamoll TP; Phosflex TPP
Major components	Mixture of isomers, predominantly m, p, little o	Mixture of isomers	Mixture of isomers	Triphenyl phosphate
Chemical formula	$C_{21}H_{21}O_4P$	$C_{24}H_{27}O_4P$	$C_{19}H_{17}O_4P$	$C_{18}H_{15}O_4P$
Chemical structure	(RO)(RO)(RO)P=O	(RO)(RO)(RO)P=O	(RO)(R'O)(R'O)P=O	(RO)(RO)(RO)P=O
Identification numbers:				
CAS registry	1330-78-5	25155-23-1	26444-49-5	115-86-6
NIOSH RTECS	68952-35-2[b]	No data	TC5520000	TC8400000
EPA hazardous waste	No data	No data	No data	No data
OHM/TADS	No data	No data	No data	No data
DOT/UN/NA/IMCO shipping	No data	No data	No data	No data
HSDB	6774	6094	6096	2536
NCI	No data	No data	No data	No data

Table 3-3. Chemical Identity of Hydraulic Fluid Components[a] (continued)

Characteristic	Isopropyl phenyl diphenyl ester	t-Butylphenyl diphenyl phosphate	Dibutyl phenyl phosphate	Nonylphenyl diphenyl phosphate
Type	Organophosphate ester	Organophosphate ester	Organophosphate ester	Organophosphate ester
Synonym(s)	No data		DBPP	No data
Registered trade name(s)	Phosflex 41P; Kronitex 100	Fyrquel GT; Saniticizer 100B; Santicizer 154	No data	No data
Major components	Mixture of isomers		Dibutyl phenyl phosphate	Nonylphenyl diphenyl phosphate
Chemical formula	$C_{21}H_{21}O_4P$	$C_{22}H_{23}O_4P$	$C_{14}H_{23}O_4P$	$C_{27}H_{33}O_4P$
Chemical structure	(RO)(RO')(RO')P=O	(RO)(R'O)(R'O)P=O	(RO)(RO)(R'O)P=O	(RO)(R'O)(R'O)P=O
Identification numbers:				
CAS registry	28108-99-8	56803-37-3	2528-36-1	38638-05-0
NIOSH RTECS	No data	No data	TB9626600	No data
EPA hazardous waste	No data	No data	No data	No data
OHM/TADS	No data	No data	No data	No data
DOT/UN/NA/IMCO shipping	No data	No data	No data	No data
HSDB	6795	6102	2604	No data
NCI	No data	No data	No data	No data

Table 3-3. Chemical Identity of Hydraulic Fluid Components[a] (continued)

Characteristic	2-Ethylhexyl diphenyl phosphate	Isodecyl diphenyl phosphate	Tri-n-butyl phosphate	Tris-isopropyl phenyl phosphate
Type	Organophosphate ester	Organophosphate ester	Organophosphate ester	Organophosphate ester
Synonym(s)	Diphenyl-2-ethylhexyl phosphate	Isodecyldiphenylphosphate	Tributyl phosphate; TBP; butyl phosphate;TNBP	No data
Registered trade name(s)	Saniticizer 141; Octicizer	Saniticizer 148[b]	Skydrol LD[d] Celluphos 4	Durad 110, Durad 300
Major components	2-Ethylhexyl diphenyl phosphate	Isodecyl diphenyl phosphate	Tri-n-butyl phosphate	Isopropylphenyl phosphate
Chemical formula	$C_{20}H_{27}O_4P$	$C_{22}H_{31}O_4P$	$C_{12}H_{27}O_4P$	$C_{27}H_{33}O_4P$
Chemical structure	(RO)(R'O)(R'O)P=O	(RO)(R'O)(R'O)P=O	(RO)(RO)(RO)P = O	(RO)(RO)(RO)P = O
Identification numbers:				
CAS registry	1241-94-7	29761-21-5	126-73-8	26967-76-0
NIOSH RTECS	TC6125000	No data	(55962-27-1 Skydrol LD)[b]	No data
EPA hazardous waste	No data	No data	TC7700000	No data
OHM/TADS	No data	No data	No data	No data
DOT/UN/NA/IMCO shipping	No data	No data	No data	No data
HSDB	370	6797	1678	6797
NCI	No data	No data	No data	No data

Table 3-3. Chemical Identity of Hydraulic Fluid Components[a] (continued)

Characteristic	Tri-o-cresyl phosphate	Mineral Oil[e]	Mineral Oil[e]
Type	Organophosphate ester	Mineral oil	Mineral oil
Synonym(s)	o-Tolyl phosphate; TOCP; TOTP	Petroleum distillates; solvent-refined light paraffinic	Petroleum distillates, straight-run middle
Registered trade name(s)	Past contaminant of tricresyl phosphate	No data	No data
Major components	Tri-o-cresyl phosphate	Predominantly saturated hydrocarbons predominantly in the range C15 through C30	Hydrocarbons predominantly in the range C11 through C20
Chemical formula	$C_{21}H_{21}O_4P$		
Chemical structure	(RO)(RO)(RO)P=O		
Identification numbers:			
CAS registry	78-30-8	64741-89-5	64741-44-2
NIOSH RTECS	TD0350000	PY8041500	LX329600
EPA hazardous waste	No data	No data	No data
OHM/TADS	No data	No data	No data
DOT/UN/NA/IMCO shipping	UN 2574; IMO 6.1	No data	No data
HSDB	4084	No data	No data
NCI	No data	No data	No data

[a] All information from HSDB 1995 unless otherwise noted.
[b] FMC 1994
[c] Muir 1984
[d] Nobile et al. 1980
[e] RTECS 1996

CAS = Chemical Abstracts Service; DOT/UN/NA/IMO = Dept. of Transportation/United Nations/North America/International Maritime Dangerous Goods Code; EPA = Environmental Protection Agency; HSDB = Hazardous Substances Data Bank; NCI = National Cancer Institute; NIOSH = National Institute for Occupational Safety and Health; OHM/TADS = Oil and Hazardous Materials/Technical Assistance Data System; RTECS = Registry of Toxic Effects of Chemical Substances

names and designations have changed. For example, Durad MP 280B is now known as a Reolube (effective January 1995) (FMC 1995).

3.2 Physical and Chemical Properties

Information regarding the physical and chemical properties of selected hydraulic fluid products is shown in Table 3-4. Physical and chemical properties of selected hydraulic fluid components are shown in Table 3-5.

The physical properties important for the projected use of hydraulic fluids are viscosity, density, foaming behavior, and fire resistance. There is no generally recognized test method for measuring flammability of hydraulic fluids, although various test methods may be utilized (Moller 1989).

Physical data important for describing environmental behavior (K_{OC}, K_{OW}, vapor pressure, water solubility, and Henry's law constant) are incomplete. In general, hydraulic fluids have relatively low water solubilities.

A summary of the hydraulic fluids discussed in this profile is found in Table 3-6. Data on some of the components of hydraulic fluids are shown in Tables 3-7 through 3-9.

Table 3-4. Physical and Chemical Properties of Hydraulic Fluid Products

Property	Houghto-Safe 5047F[a]	Pyroguard A-433[b]	Quintolubric 95830W[b]	Sunsafe F[b]
Molecular weight	Not applicable	Not applicable	Not applicable	Not applicable
Color	Opaque white	Milky white	Milky white	Milky white
Physical state	Liquid	Liquid	Liquid	Liquid
Melting point	No data	No data	No data	No data
Boiling point	102 °C	100 °C	100 °C	100 °C
Density	0.927 g/mL	0.92 g/mL	0.96 g/mL	0.92 g/mL
Odor	Bland	No data	No data	No data
Odor threshold: Water Air	No data	No data	No data	No data
Solubility: Water Organic solvents	 Emulsion No data	 No data No data	 No data No data	 No data No data
Partition coefficients: Log K_{ow} Log K_{oc}	No data	No data	No data	No data
Vapor pressure	No data	No data	No data	No data
Henry's law constant	No data	No data	No data	No data
Autoignition temperature	No data	No data	No data	No data
Flashpoint	No data	No data	No data	No data
Flammability limits	No data	No data	No data	No data
Conversion factors	No data	No data	No data	No data
Explosive limits	No data	No data	No data	No data

Table 3-4. Physical and Chemical Properties of Hydraulic Fluid Products (continued)

Property	Cellulube 220	Durad 110[c]	Durad 125[d]	Durad 220
Molecular weight	No data	No data	368.36[e]	No data
Color	No data	Clear	Practically colorless	No data
Physical state	No data	Liquid	Liquid	No data
Melting point	No data	No data	No data	No data
Boiling point	No data	220–270 °C at 4 mm Hg	420 °C	No data
Density	No data	1.1–1.17 g/mL at 20 °C	1.162 at 25 °C	No data
Odor	No data	Odorless	Odorless	No data
Odor threshold: Water Air	No data	No data	No data	No data
Solubility: Water	No data	No data	0.36 mg/L at 25 °C; insoluble (<0.002% at 85 °C)[e]	No data
Organic solvents	No data	No data	Miscible with common solvents and thinners, vegetable oils[e]	No data
Partition coefficients: Log K_{ow} Log K_{oc}	No data No data	No data No data	5.11; 6.34 (est.)[f] No data	No data No data
Vapor pressure	No data	0.026 mm Hg at 150 °C	$1x10^{-7}$ at 10 °C	No data
Henry's law constant	No data	No data	$5.35x10^{-8}$ atm-m^3/mol (est.)	No data
Autoignition temperature	No data	551 °C	420 °C	No data
Flashpoint	No data	199 °C (closed cup)	427 °C (760 mm Hg)[g]	No data
Flammability limits	No data	No data	225–235 °C (Pensky-Martin closed cup)[g]	No data
Conversion factors	No data	No data	No data	No data
Explosive limits	No data	No explosion hazard	No data	No data

Table 3-4. Physical and Chemical Properties of Hydraulic Fluid Products (continued)

Property	Durad 220B[h]	Durad 300[i]	Durad 550B[j]	Durad MP280B[j]
Molecular weight	No data	No data	No data	No data
Color	Clear blue	Clear	Clear	Clear blue
Physical state	Liquid	Liquid	Liquid	Liquid
Melting point	-20 °C	No data	No data	No data
Boiling point	416 °C	220–270 °C at 4 mm Hg	No data	No data
Density	1.145–1.165 g/mL at 20 °C	1.15–1.17 g/mL at 20 °C	1.124 g/mL at 20 °C	1.145–1.165 g/mL at 20 °C
Odor	Odorless	Odorless	Odorless	No data
Odor threshold: Water Air	No data	No data	No data	No data
Solubility: Water Organic solvents	 Insoluble No data	 Insoluble No data	 Insoluble No data	 Insoluble No data
Partition coefficients: Log K_{ow} Log K_{oc}	No data No data	No data No data No data	No data No data No data	No data
Vapor pressure	0.033 mm Hg at 22 °C	0.026 mm Hg at 150 °C	<0.033 mm Hg at 150 °C	0.033 mm Hg at 150 °C
Henry's law constant	No data	No data	No data	No data
Autoignition temperature	535 °C	551 °C	480 °C	No data
Flashpoint	243 °C (closed cup)	199 °C (closed cup)	254 °C (open cup)	243 °C (closed cup)
Flammability limits	No data	No data	No data	No data
Conversion factors	No data	No data	No data	No data
Explosive limits	No data	No data	No data	No data

Table 3-4. Physical and Chemical Properties of Hydraulic Fluid Products (continued)

Property	Fyrquel 150[k]	Fyrquel 220[l]	Fyrquel EHC[m]	Hyjet IV[h]
Molecular weight	~400 formula weight	No data	No data	265 (average)
Color	Clear	Clear	Clear	Clear purple
Physical state	Liquid	Liquid	Liquid	Liquid
Melting point	No data	No data	No data	No data
Boiling point	decomp. >352 °C	decomp. >352 °C	No data	288 °C
Density	No data	No data	No data	0.997 g/mL
Odor	Essentially none	Essentially none	Essentially none	Sweet
Odor threshold: Water Air	No data	No data	No data	No data
Solubility: Water Organic solvents	 Miscibility <0.1 mL No data	 <1000 ppm No data	 <1000 ppm No data	 Insoluble Soluble in hydrocarbon solvents
Partition coefficients: Log K_{ow} Log K_{oc}	No data	No data	No data	No data
Vapor pressure	<0.1 mm Hg at 37.8 °C	<0.1 mm Hg at 37.8 °C	<0.1 mm Hg at 37.8 °C	0.5 mm Hg at 93 °C
Henry's law constant	No data	No data	No data	No data
Autoignition temperature	No data	No data	No data	518 °C
Flashpoint	246 °C (closed cup)	246 °C (closed cup)	>235 °C (open cup)	182 °C (open cup)
Flammability limits	No data	No data	No data	No data
Conversion factors	No data	No data	No data	No data
Explosive limits	No data	No data	No data	No data

Table 3-4. Physical and Chemical Properties of Hydraulic Fluid Products (continued)

Property	Pydraul 29ELT[n]	Pydraul 50E[n]	Pydraul 90E[o]	Reofos 50[p]
Molecular weight	No data	No data	No data	No data
Color	Clear to slightly hazy blue	Blue to blue-green	Green to blue	No data
Physical state	Liquid	Liquid	Liquid	No data
Melting point	No data	No data	No data	No data
Boiling point	No data	399 °C	No data	No data
Density	1.09–1.10 at 25 °C	1.145–1.165 g/mL at 25 °C	1.147–1.167 g/mL at 25 °C	No data
Odor	No data	No data	No data	No data
Odor threshold: Water Air	No data	No data	No data	No data
Solubility: Water Organic solvents	 Practically insoluble No data	 160 mg/L No data	 Practically insoluble No data	 No data No data
Partition coefficients: Log K_{ow} Log K_{oc}	No data	No data	No data	No data
Vapor pressure	0.002 mm Hg at 93 °C	0.002 mm Hg at 93 °C	0.001 mm Hg at 93 °C	No data
Henry's law constant	No data	No data	No data	No data
Autoignition temperature	No data	465 °C	No data	No data
Flashpoint	No data	241 °C (open cup)	No data	No data
Flammability limits	No data	No data	No data	No data
Conversion factors	No data	No data	No data	No data
Explosive limits	No data	No data	No data	No data

Table 3-4. Physical and Chemical Properties of Hydraulic Fluid Products (continued)

Property	Reofos 65	Reolube HYD46[q]	Skydrol 500B-4[r]
Molecular weight	No data	No data	No data
Color	No data	Slightly hazy	Clear purple
Physical state	No data	Liquid	Liquid
Melting point	No data	No data	No data
Boiling point	No data	>400 °C (est.)	125 °C at 267 mm Hg (est.)
Density	No data	1.121 g/mL at 20 °C	1.052–1.060 g/mL at 25°C
Odor	No data	No data	No data
Odor threshold: Water Air	No data	No data	No data
Solubility: Water Organic solvents	No data	No data	No data
Partition coefficients: Log K_{ow} Log K_{oc}	No data	No data	No data
Vapor pressure	No data	No data	No data
Henry's law constant	No data	No data	No data
Autoignition temperature	No data	545 °C	399 °C
Flashpoint	No data	245 °C (open cup)	160 °C (open cup)
Flammability limits in air	No data	No data	No data
Conversion factors	No data	No data	No data
Explosive limits	No data	No data	No data

Table 3-4. Physical and Chemical Properties of Hydraulic Fluid Products (continued)

Property	Skydrol LD-4[s]	Cyclotriphosphazene[t]	Polyalphaolefin
Molecular weight	No data	No data	No data
Color	Clear purple	No data	No data
Physical state	Liquid	Liquid	No data
Melting point	No data	No data	No data
Boiling point	125 °C at 380 mm Hg (est.)	No data	No data
Density	1.004–1.014 g/mL at 25 °C	1.445 g/mL	No data
Odor	No data	No data	No data
Odor threshold: Water Air	No data	No data	No data
Solubility: Water at 25 °C Organic solvents	No data	No data	No data
Partition coefficients: Log K_{ow} Log K_{oc}	No data	No data	No data
Vapor pressure	No data	0.48 mm Hg at 65 °C	No data
Henry's law constant	No data	No data	No data
Autoignition temperature	399 °C	No data	No data
Flashpoint	160 °C (open cup)	No data	No data
Flammability limits in air	No data	No data	No data
Conversion factors	No data	No data	No data
Explosive limits	No data	No data	No data

[a] Houghton 1992
[b] Kinkead et al. 1987a, 1988
[c] FMC 1992e
[d] All information from HSDB 1995, except where noted
[e] Mayer et al. 1981
[f] SRC 1995
[g] FMC, Marino and Placek 1994
[h] Chevron 1994
[i] FMC 1991c
[j] FMC 1992c
[k] Akzo 1992
[l] Akzo 1991
[m] Akzo 1989
[n] Monsanto 1986b
[o] Monsanto 1986c
[p] FMC 1991d
[q] FMC 1995
[r] Monsanto 1992a
[s] Monsanto 1992b
[t] Kinkead et al. 1990

Table 3-5. Physical and Chemical Properties of Selected Hydraulic Fluid Components[a]

Property	Tricresyl phosphate	Trixylyl phosphate	Cresyl diphenyl phosphate	Triphenyl phosphate
Molecular weight	368.36[m]	410.45	340.33	326.29[g]
Color	Practically colorless	No data	Clear	Colorless; white
Physical state	Liquid	Liquid	Liquid	Crystals[g]
Melting point, °C	No data		-38	50-51[g]
Boiling point, °C	420 °C	243–265 °C	390	245 (11 mm Hg)[g]
Density, g/cm^3	1.162 at 25 °C	1.155	1.208	1.2055 g/mL at 30 °C[g]
Odor	Odorless		Very slight odor	Characteristic, resembling phenol
Odor threshold: Water Air	No data	No data	No data	No data
Solubility:				
Water	0.36 mg/L at 25 °C; insoluble (<0.002% 85 °C)[b]	0.002% at 85 °C; 0.89 mg/mL	Insoluble	Insoluble[b]; 0.002% at 54 °C
Organic solvent(s)	Miscible with common solvents and thinners, vegetable oils[b]	No data	Soluble in most organic solvents except glycerol	Soluble in benzene, $CHCl_3$, ether, acetone[b]
Partition coefficients:				
Log K_{ow}	5.11; 6.34 (est.)[c]	5.63[l]; 7.98 (est.)[c]	No data	4.7 (est.)[c]
Log K_{oc}	No data	3.67–4.44 (est.)	No data	4.26 (est.)
Vapor pressure, mm Hg	1.1 x 10^{-7} at 10 °C	5.15x10^{-8} (30 °C)	No data	1 mm Hg at 193.5 °C
Henry's law constant	5.35x10^{-8} atm-m^3/mol (est.)[d]	7.19x10^{-8} atm-m^3/mol (est.)[d]	No data	<9.87x10^{-8} atm-m^3/mol[l]; 3.98x10^{-8} atm-m^3/mol (est.)[d]
Autoignition temperature	410 °C 427 °C (760 mm Hg)[e]	535–545 °C[e]	No data	No data
Flashpoint, °C	225-235 °C (Pensky-Martin closed cup)[e]	245–255 °C (Pensky-Martin closed cup)[e]	232 °C (closed cup)[f]	220 °C (closed cup)
Flammability limits	No data	No data	No data	Noncombustible
Conversion factors	No data	No data	1 ppm = 13.89 mg/m^3	1 ppm=13.32 mg/m^3
Explosive limits	No data	No data	No data	No data

Table 3-5. Physical and Chemical Properties of Selected Hydraulic Fluid Components[a] (continued)

Property	Isopropyl phenyl diphenyl ester	t-Butylphenyl diphenyl phosphate	Dibutyl phenyl phosphate
Molecular weight	368	382.40	286.34
Color	No data	No data	Clear, slightly yellow
Physical state	No data	No data	Liquid
Melting point, °C	No data	No data	No data
Boiling point, °C	No data	No data	131–132 °C
Density, g/cm^3	No data	No data	1.0691 at 25 °C
Odor	No data	No data	Butanolic
Odor threshold: Water Air	No data	No data	No data
Solubility: Water Organic solvent(s)	2.2 mg/mL No data	No data No data	Very low; 96 ppm No data
Partition coefficients: Log K_{ow} Log K_{oc}	6.16 (est.)[c]; 5.31 (est.) No data	6.61(est.)[c] No data	4.27 3.23
Vapor pressure, mm Hg	3.515x10^{-7} (25 °C, est.)	No data	2.3x10^{-4} mm Hg 25 °C (est.)
Henry's law constant	7.74x10^{-8} atm-m^3/mol (est.)[d]	2.15x10^{-5} atm-m^3/mol at 25 °C; 1.03x10^{-7} atm-m^3/mol[d]	5.04x10^{-7} atm-m^3/mol
Autoignition temperature	No data	No data	129 °C (closed cup)
Flashpoint	No data	No data	No data
Flammability limits	No data	No data	No data
Conversion factors	No data	No data	No data
Explosive limits	No data	No data	No data

Table 3-5. Physical and Chemical Properties of Selected Hydraulic Fluid Components[a] (continued)

Property	Nonylphenyl diphenyl phosphate	2-Ethylhexyl diphenyl phosphate	Isodecyl diphenyl phosphate
Molecular weight	452	362.41	390
Color	No data	No data	No data
Physical state	Liquid	Liquid	No data
Melting point, °C	No data	-30 °C	No data
Boiling point, °C	471	375 °C	249 at 1.33 kPa
Density, g/cm^3	No data	No data	1.070 g/mL
Odor	No data	No data	No data
Odor threshold:	No data	No data	No data
Water			
Air			
Solubility:			
Water	0.77 ng/L[b]	1.9 mg/L at 25 °C	0.75 mg/L at 25 °C
Organic solvent(s)	No data	No data	No data
Partition coefficients:			
Log K_{ow}	5.93[m] ; 9.2[c]	5.73	5.44
Log K_{oc}	3.69[h]	No data	4.34 (est.)
Vapor pressure, mm Hg	1.9x10^{-8} [h]	6.29 x 10^{-5} at 30 °C (est.)	1.6x10^{-5} at 25 °C (est.)
Henry's law constant	4.24x10^{-7} atm-m^3/mol (est.) [d]; 1.4x10^{-8} atm-m^3/mol[h]	5.42x10^{-5} atm-m^3/mol at 25 °C[i]	4.36x10^{-7} atm-m^3/mol (est.)[d]
Autoignition temperature	No data	No data	No data
Flashpoint	No data	No data	No data
Flammability limits	No data	No data	No data
Conversion factors	No data	No data	No data
Explosive limits	No data	No data	No data

Table 3-5. Physical and Chemical Properties of Selected Hydraulic Fluid Components[a] (continued)

Property	Tri-n-butyl phosphate	Tris(isopropyl phenyl)phosphate	Tri-o-cresyl phosphate
Molecular weight	266.32	452	368.37[g]
Color	Colorless	No data	Colorless or pale yellow[b]
Physical state	Liquid	Liquid	Liquid[b]
Melting point, °C	<-80 °C[g]	-25	11 °C[g]
Boiling point, °C	289 °C[g]	220–270 (0.53 kPa)	~410 °C[g]
Density	0.976 g/mL at 25 °C[g]	1.159 g/mL at 25 °C	1.1955 g/mL at 25 °C[g]
Odor	Odorless[n]	No data	Practically odorless
Odor threshold:	No data	No data	No data
Water			
Air			
Solubility:			
Water	1 mL dissolves in about 165 mL water[g]	No data	Sparingly soluble[b]
Organic solvent(s)	Soluble in ether, benzene carbon disulfide, alcohol[b]	No data	Soluble in alcohol, benzene, ether[b]; soluble in acetic acid[g]
Partition coefficients:			
Log K_{ow}	No data	No data	No data
Log K_{oc}	No data	No data	No data
Vapor pressure, mm Hg	127 mm Hg at 177 °C	No data	10 mm Hg at 265 °C
Henry's law constant	No data	No data	No data
Autoignition temperature	No data	No data	385 °C[f]
Flashpoint	146 °C[g]	No data	225 °C (closed cup)[f]
Flammability limits	No data	No data	No data
Conversion factors	No data	No data	No data
Explosive limits	No data	No data	No data

[a] All information from HSDB, except where noted
[b] Mayer et al. 1981
[c] SRC 1995b KOWWIN
[d] SRC 1994a HENRYWIN
[e] FMC, Marino and Placek 1994
[f] NFPA 1991
[g] Merck 1989
[h] Boethling and Cooper 1985
[i] Muir et al. 1985

EPA = Environmental Protection Agency; HSDB = Hazardous Substances Data Bank; $CHCl_3$ = chloroform; est. = estimated; kPa = kilopascal

Table 3-6. Summary of Chemical Information for Selected Hydraulic Fluids

Name	Source	Identity/Composition	Physical and Chemical Properties
Mineral oil based fluids			
MIL-H-5606	Various[a]	Table 3-2	Meets specifications[b]
Houghto-Safe 5047F	Houghton	Table 3-1	Table 3-4
Sunsafe F	Sun	Table 3-1	Table 3-4
Pyroguard A-443	Mobil	Table 3-1	Table 3-4
Quintolubric 958 30W	Quaker	Table 3-1	Table 3-4
Organophosphate esters			
Fyrquel 150	Akzo	Table 3-1	Table 3-4
Fyrquel 220	Akzo	Table 3-1	Table 3-4
Fyrquel EHC	Akzo	Table 3-1	Table 3-4
Durad 110	FMC	Table 3-1	Table 3-4
Durad 125	FMC	Table 3-1	Table 3-5 (tricresyl phosphate)
Durad 220B	FMC	Table 3-1	Table 3-4
Durad 300	FMC	Table 3-1	Table 3-4
Durad 550B	FMC	Table 3-1	Table 3-4
Durad MP 280B[d]	FMC	Table 3-1	Table 3-4
Skydrol 500B	Monsanto	Table 3-1	Table 3-4
Skydrol 500B-4	Monsanto	Table 3-1	Table 3-4
Skydrol LD	Monsanto	Table 3-1	Table 3-4
Skydrol LD-4	Monsanto	Table 3-1	Table 3-4
Pydraul 29E LT[c,h]	Monsanto	Table 3-1	Table 3-4
Pydraul 50E[c,f]	Monsanto	Table 3-1	Table 3-4
Pydraul 90E[c,g]	Monsanto	Table 3-1	Table 3-4
Reofos 50[c]	FMC	Table 3-1	Table 3-4
Reofos 65[c]	FMC	Table 3-1	No data
Reolube HYD46	FMC	Table 3-1	Table 3-4
Cellulube 220[c]	FMC	Table 3-1	No data
Santicizer 141	Monsanto	2-Ethylhexyl diphenyl phosphate	Table 3-5 (2-Ethylhexyl diphenyl phosphate)
Santicizer 148	Monsanto	Isodecyl diphenyl phosphate[i]	Table 3-5 (isodecyl diphenyl phosphate)
MIL-H-19457B	Various[a]	Table 3-2	Meets specifications[b]
MIL-H-19457C	Various[a]	Table 3-2	Meets specifications[b]
MIL-H-83306	Various[a]	Table 3-2	Meets specifications[b]
Hyjet IV	Chevron	Table 3-1	Table 3-4

Table 3-6. Summary of Chemical Information for Selected Hydraulic Fluids (continued)

Name	Source	Identity/Composition	Physical and Chemical Properties
Polyalphaolefins			
MIL-H-83282	Various[a]	Table 3-2	Meets specifications[b]
MIL-H-83282LT	Various[a]	Low temperature version of MIL-H-83282. Dimer (49%)/-trimer (16.5%) blend ofpolyalphaolefin[e]	Meets specifications[b]
Other			
Cyclotriphosphazine	Not reported	Dimers, trimers and tetramers of cyclotriphosphazene[i]	Table 3-4

[a] Products from various producers may meet the specifications.
[b] Specifications have been established for properties such as viscosity, flammability, and shear stability. The range of physical properties of the available hydraulic fluids is not available.
[c] Discontinued product
[d] Reolube MP 280B effective January 1995
[e] Mattie et al. 1993
[f] Pydraul 50E is Fyrquel 220 (Akzo 1993)
[g] Pydraul 90E is Fyrquel 450 (Akzo 1993)
[h] Pydraul 20E LT is Fyrquel LT (Akzo 1993)
[i] Kinkead et al. 1990
[j] FMC 1994

Table 3-7. Water Solubility of Hydrocarbon Components of Mineral Oil Hydraulic Fluids

Hydrocarbon	Distilled water solubility (ppm)	Salt water solubility (ppm)
Tetradecane (C_{14})	2.2	1.7
Hexadecane (C_{16})	0.9	0.4
Octadecane (C_{18})	2.1	0.8
Eicosane (C_{20})	1.9	0.8
Hexaeicosane (C_{26})	1.7	0.1
Hexatricontane (C_{36})	1.7[a]	

[a]Shaw 1989

Source: Sutton and Calder 1974, except where noted

Table 3-8. Log K_{ow} Values for Organophosphate Ester Hydraulic Fluid Components

Chemical name	Log K_{ow}
Triphenyl phosphate	4.63
Tricresyl phosphate, mixed isomers	5.11
Trixylenyl phosphate, mixed isomers	5.63
Isopropylphenyl diphenyl phosphate, mixed isomers	5.31
2-Isopropylphenyl diphenyl phosphate	5.65
2,4-Diisopropylphenyl diphenyl phosphate	6.52
2,4,6-Triisopropylphenyl diphenyl phosphate	≈6.70
Nonylphenyl diphenyl phosphate, mixed isomers	5.93
Cumylylphenyl diphenyl phosphate, mixed isomers	6.08
t-Butylphenyl diphenyl phosphate, mixed isomers	5.12
2-Ethylhexyl diphenyl phosphate	5.73
Tributyl phosphate	4.00
Dibutyl phenyl phosphate	4.27

Sources: Ciba-Geigy 1986; Mayer et al. 1981; Saeger et al. 1979

Table 3-9. Water Solubilities for Organophosphate Ester Hydraulic Fluid Components

Chemical name	Water solubility (mg/L)
Triphenyl phosphate	1.9
Tricresyl phosphate, mixed isomers	0.36
Trixylenyl phosphate, mixed isomers	0.89[a]
Isopropylphenyl diphenyl phosphate, mixed isomers	2.2
Nonylphenyl diphenyl phosphate, mixed isomers	0.77
Cumylphenyl diphenyl phosphate, mixed isomers	0.063
t-Butylphenyl diphenyl phosphate, mixed isomers	3.2
2-Ethylhexyl diphenyl phosphate	1.9
Tributyl phosphate	280.0
Dibutyl phenyl phosphate	280.0

[a]Ofstad and Sletten (1985) reported a water solubility of 0.11 mg/L for trixylenyl phosphate, which is significantly lower than the one reported by Saeger et al. (1979).

Source: Mayer et al. 1981; Saeger et al. 1979