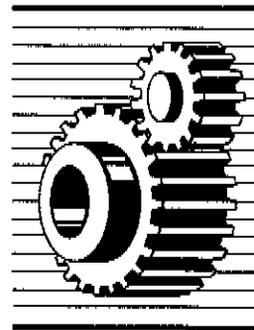
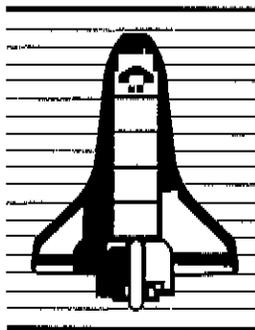
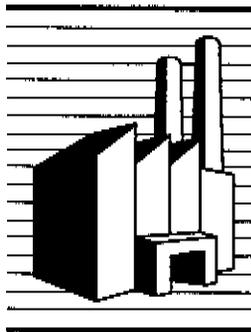
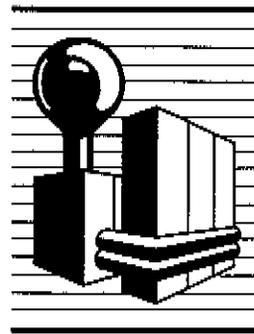
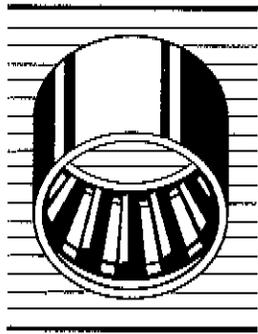




DuPont Specialty Chemicals

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(All sites)
(HW disk 5B)



Krytox[®]
Performance Lubricants

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Krytox®

Performance Lubricants

Krytox Products

There are three fundamental Krytox product categories. They all possess the same chemical properties, have similar reactivities, and are from the DuPont fluoropolymer products family that also includes Teflon®, Kalrez®, and Viton®.

Because of different uses, Krytox products' physical characteristics are adjusted for their performance characteristics or for applications in specific industries.

Krytox Product	Typical Industry Application
Krytox General Purpose Lubricants (GPL)—Oil and Grease	Automotive, textile, paper, petroleum, chemical, nuclear and fossil fuel power
Krytox Vacuum Pump Fluids and Vacuum Grease	Vacuum processing, semiconductor and electronics
Krytox 143 Oils Krytox 240 Greases	Aerospace, military and industrial applications

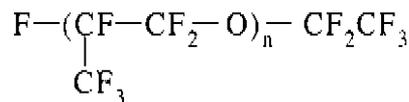
Military and aerospace applications require critical processing and specification testing. Semiconductor manufacturers require tight control of vapor pressure and viscosity. Krytox general purpose lubricants incorporate broader distillation cuts while maintaining all of the outstanding physical properties.

Krytox products are available in a variety of viscosity or consistency grades. Depending on the specific grade, extended service temperatures range from -54° to $>340^{\circ}\text{C}$ (-70° to $>655^{\circ}\text{F}$).

Composition

Krytox is a perfluoropolyether (PFPE)—also called perfluoroalkylether (PFAE) or perfluoropolyalkylether (PFPAE).

Krytox fluorinated oils are a series of low molecular weight, fluorine end-capped, homopolymers of hexafluoropropylene epoxide with the following chemical structure:



where $n = 10-60$.

The polymer chain is completely saturated and contains only the elements carbon, oxygen, and fluorine; hydrogen is not present. On a weight basis, a typical Krytox oil contains 21.6% carbon, 9.4% oxygen, and 69.0% fluorine.

The Chemical Abstracts Index name for Krytox fluorinated oils is oxirane, trifluoro (trifluoromethyl)-, homopolymer and the CAS Registry Number is 60164-51-4.

Applications

Broad Range of Applications

Krytox oils and greases are the products of choice for applications where complete nonflammability, oxygen compatibility, and resistance to aggressive chemicals are primary requirements. In less demanding systems, they also provide superior performance and extended life as lubricants, sealants, and dielectrics.

- Aerospace
 - Bearing lubricant
 - Sealant
 - O-ring lubricant
 - Oxygen systems

- Automotive
 - Antilock braking systems
 - Bearing lubricant
 - Weatherstrip lubricant
 - CV joints
- Industrial applications
 - Paper corrugating bearings
 - Chemical plant maintenance
 - Valve lubricant
 - High-temperature equipment
 - Clean rooms
 - Nonreactive seal fluids
 - Chlorine and oxygen service
 - Textile equipment
- Vacuum systems
 - Vacuum pump fluids
 - High vacuum greases
 - Vacuum system sealant

Rolling Bearings

Krytox greases and oils provide a high lubricating film for bearings. This lubrication reduces metal-to-metal contact in the bearings, resulting in superior load-carrying capability.

Before adding Krytox to a bearing, the bearing should be cleaned of all existing greases, oils, or preservative oils used to protect it during storage. If left in the bearing, these hydrocarbon oils can form carbon deposits at higher temperatures, which may accelerate bearing failure. Chlorinated solvents should not be used because they can leave chlorine, which can cause corrosion. If a bearing has previously been packed with another grease, mechanical agitation or an ultrasonic bath should be used to be sure of removing all of the grease.

After the bearing surfaces are clean of grease and rust inhibitor, they should be lubricated/wiped with Krytox and properly stored to prevent corrosion. If they are not going to be packed with Krytox immediately, or if they are going to be in storage for an extended period, they can be dipped in a solution of Krytox oil and Krytox fluorosurfactant to coat the surface and protect against rust.

Proper lubrication is achieved by using the correct amount of grease. Too little grease in the bearings causes premature failure. Too much grease at the initial fill or during relubrication can cause overheating of bearings that are running at medium to high speed, resulting in bearing failure. The amount of grease to put in the bearing depends on the application and operating speed of the bearing. For applications such as conveyor rollers and low-speed machinery with DN values (inner race ID in mm \times rpm) below 50,000, the bearing can be filled to capacity. For medium-speed applications, i.e., DN 50,000 to 200,000, the bearing can be filled 50–70%. For higher-speed systems, the fill is typically 30–40%. Some extreme-speed special applications have grease fills of only 10–15% (see Speed Factor for definition of DN values). Because Krytox is heavier than hydrocarbon lubricants, its higher density must be considered when determining the fill quantity by weight.

Grease fittings should be changed to a different style, such as button-head or pin type, to ensure that another type of grease is not accidentally put into the bearing. A dedicated grease gun that matches the fitting should be used.

Bearings that are converted from oil to grease lubrication generally run hotter internally because grease does not remove heat as does circulating oil. This higher temperature gradient causes the bearing to expand more and can lead to failure if the bearing does not have adequate internal clearance. Depending on the type of equipment and operating conditions, a bearing with a larger internal clearance might be needed. The bearing or equipment manufacturer should be consulted before converting equipment from oil to grease.

For additional guidance on grades and additives, contact our technical service department.

Anticorrosion Greases

Additives are combined with Krytox to enhance its ability to protect metallic surfaces from corrosion caused by moisture and oxygen.

Antiwear Greases

Krytox greases containing antiwear additives have properties that give high specific load-carrying capacity and the highest protection against wear.

Extreme Pressure (EP) Greases

These heavy-duty greases are used for high loading or slow speeds. EP greases have high load-carrying capability and good characteristics under boundary and mixed friction conditions. Krytox is a naturally good EP lubricant, but additional high-pressure additives can be included in the grease.

Soft/Fluid Greases

These soft or fluid greases have free-flowing characteristics. They belong to NLGI penetration classes 0 to 000 and are often used for lubrication of sealed gear drives.

Channeling Greases

Some applications require a grease that is stiff and does not fall back easily into the bearing races. Often, these systems run at higher speeds. Harder NLGI grade 3 Krytox greases are recommended for these applications.

High-Vacuum Greases

A special low-vapor-pressure Krytox oil is used to formulate a grease for high-vacuum applications. It is also useful for sealing laboratory glassware connections and as a thread lubricant/sealant.

Table 1
NLGI Consistency of Grades of Greases

NLGI Grade	ASTM Worked Penetration mm/10 at 25°C (77°F)	Appearance
000	445 to 475	Fluid
00	400 to 430	Almost Fluid
0	355 to 385	Semifluid
1	310 to 340	Very Soft
2*	265 to 295	Soft
3	220 to 250	Cup Grease
4	175 to 205	Cup Grease
5	130 to 160	Cup Grease
6	85 to 115	Block Grease

*Standard grade. Others available upon request.

High-Temperature Greases

Because of its thermal stability and nonoxidizing characteristics, Krytox is a natural high-temperature lubricant. It is thickened with PTFE like Teflon, which is one of the most thermally stable thickeners for high-temperature, long-term greases. Krytox grease has no

defined drop point but the thickener begins to melt at 325°C (617°F). Krytox greases are available with useful temperature ranges up to 288°C (550°F) for continuous use. Special thickener formulations have been blended to give useful lubrication up to 371°–399°C (700°–750°F) with spikes at 427°C (800°F) or higher with more frequent relubrication.

Low-Temperature Greases

Krytox grades formulated with low viscosity oils can be used at temperatures as low as -57°C (-70°F).

Low-Torque Greases

These grades reduce power usage because of their low apparent dynamic viscosity.

Valve Lubricants

Krytox is used in all types of valves to lubricate moving parts, seal connections, and packing and to protect surfaces from corrosion and degradation. Krytox lubricates the valve packing and allows it to expand and contract without binding, reducing leakage around the stem. Valves operate more smoothly because Krytox eliminates sticking and jumping. It is used on safety relief valves to prevent sticking and overpressurization.

O-Ring/Plastic/Rubber Lubricants

Krytox lubricants for elastomers and plastic materials do not cause damage to the plastic or rubber material and are compatible with all plastic and synthetic rubber material.

Mechanical Seals

Mechanical seals are used in many aggressive chemical reactions. Conventional barrier fluids can violently react with some chemicals. Krytox can be used as a seal barrier fluid in reactive chemical systems without fear of reaction occurring between the chemicals and the barrier fluid. Chlorination, fluorination, bromination, nitration, and other aggressive reactions can safely be sealed inside the reaction vessel.

Chain Greases

Drive chains, such as roller chains, require lubrication. They are often exposed to the atmosphere and require a lubricant with anticorrosion properties. The lubricant must also have good adhesion and the ability to wet the chain links—characteristics provided by Krytox. Often, EP additives are included to reduce chain wear caused by oscillating and sliding friction.

Vacuum Pump Fluids

Krytox vacuum pump fluids are used in applications where conventional vacuum pump oils cause safety, waste disposal, and maintenance problems. They are nonflammable and reduce the chance of fire in pumps. They are nonreactive and safe to use in oxygen systems. They can replace any competitive PFPE fluid as well as any other type of vacuum fluid. Krytox fluids do not contain acetal groups, which are susceptible to attack by Lewis acids. This gives Krytox superior stability as a vacuum pump fluid.

Krytox vacuum fluids are precisely distilled to provide low vapor pressures and give superior performance.

Nuclear Industry Greases

Many parts of a nuclear power plant are exposed to high heat and humidity or are difficult to access for re-greasing. The use of Krytox with its longer life and high-temperature capabilities allows these parts to run without relubrication for the full fuel cycle. Tests have shown that Krytox can be used in radiation up to 10^7 rads.

Aerospace Greases

The Krytox 240 grease series meets a variety of military and industrial specifications. Some of the more common MIL specs and Krytox products are:

Specification	Krytox Product
MIL-G-27617 Type I	240 AZ
MIL-G-27617 Type II	240 AB
MIL-G-27617 Type III	240 AC

Cost Effectiveness

As **Table 2** demonstrates, Krytox lubricants are cost effective across a wide range of applications because of their long, useful life relative to traditional hydrocarbons.

Table 2

Application	Life/Cost/Reliability	
	Typical Hydrocarbon Lubricant	Krytox
Electric motor 227°C (440°F) at 1,750 rpm	5 days	9 months
Heated rolls 199°C (390°F) at 5,000 rpm	8 months	24 months
Textile roll 225°C (437°F) at 5,400 rpm	1 month	24 months
Pressure relief valves	50% failures	Less than 1% failure
Paper corrugating machine	\$144,000	\$3,000

Table 3
Typical Lubricants Wear and Load-Carrying Ability

Oil	4-Ball Wear Scar, mm ^a	Falex Pin/V-Block Fail Load, lb
PFPE	0.36	>4,500 ^b
Chlorotrifluoroethylene	0.37	>4,500 ^b
Fluorosilicone	0.43	1,150
Diester	0.61	2,300
Petroleum oil	0.69	1,300

^aAt 20 kgf/107°C (225°F)/1,200 rpm/60 min/52100 steel on steel

^bTest was stopped at 4,500 lb

Relative Performance

Many synthetic lubricants show excellent performance in one or more categories, but only Krytox combines stability, nonflammability, and chemical inertness with outstanding lubrication performance under a variety of conditions. **Table 4** compares the relative performance of a variety of synthetic lubricants.

Call our technical service department for specific grades for your application.

Table 4
Relative Performance of Synthetic Lubricants

	Synthetic Lubricants							
	Krytox	Chloro-trifluoro-ethylene	Silicone	Fluoro-silicone	Synthetic Hydrocarbon	Polyphenyl Ether	Ester	Phosphate
Chemically Resistant	✓							
Nonflammable	✓	✓						
High Density	✓	✓						
Oxidation Resistant	✓	✓				✓		
Compressible	✓		✓	✓				
Good Viscosity/ Temperature Range	✓		✓	✓	✓		✓	
Does Not Promote Rust or Corrosion	✓		✓	✓	✓	✓	✓	
Rubber and Plastic Compatible	✓	✓	✓	✓	✓	✓		
Water Resistant	✓	✓	✓	✓	✓	✓		
Good Lubricant	✓	✓		✓		✓	✓	✓
Continuously Useful at:*								
-51°C (-60°F)	✓	✓	✓		✓		✓	
-28°C (-20°F)	✓	✓	✓	✓	✓		✓	✓
204°C (400°F)	✓	✓	✓	✓	✓	✓	✓	✓
210°C (500°F)	✓	✓	✓	✓		✓		
316°C (600°F)	✓							

*Depending on fluid viscosity range.

Stability

Nonflammable

Krytox lubricants contain only carbon, oxygen, and fluorine. Because hydrogen is not present, these products are nonflammable. They will not burn or support combustion even in 100% liquid or gaseous oxygen.

Chemically Inert

Krytox performance lubricants are not only resistant to oxygen but are inert to virtually all chemicals used in a variety of industries. They are insoluble in most solvents but can be soluble in some supercritical fluids and highly fluorinated fluids.

Thermal and Oxidative Stability

The temperature at which thermal decomposition of Krytox oils takes place depends on the test method used and how the point of incipient deterioration is measured. By differential thermal analysis, deterioration occurs at about 470°C (878°F) in the absence of air.

The isoteniscope technique shows an initial decomposition point of 355°C (671°F) as measured by excess pressure increase. At 355°C (671°F), the decomposition rate is approximately 0.03 wt% per day. At 399°C (750°F), the decomposition rate increases to 1.3 wt% per day. When tested under nitrogen for 6 hours at 371°C (700°F), Krytox showed no increase in neutralization number and no significant change in viscosity.

The presence of air does not substantially lower the decomposition point of Krytox oils. However, in the presence of certain metal oxides, depolymerization of the oil can start as low as 288°C (550°F). During depolymerization, gaseous decomposition products are given off and the remaining fluid is less viscous, but no sludge or gummy deposits are formed.

In most applications, Krytox oils have proven serviceable for long periods at continuous temperatures up to 288°C (550°F) and intermittent temperatures of 427°C (800°F).

Figure 1. Typical Thermal Stability of Krytox 240AC Fluorinated Grease. All grease grades are similar.

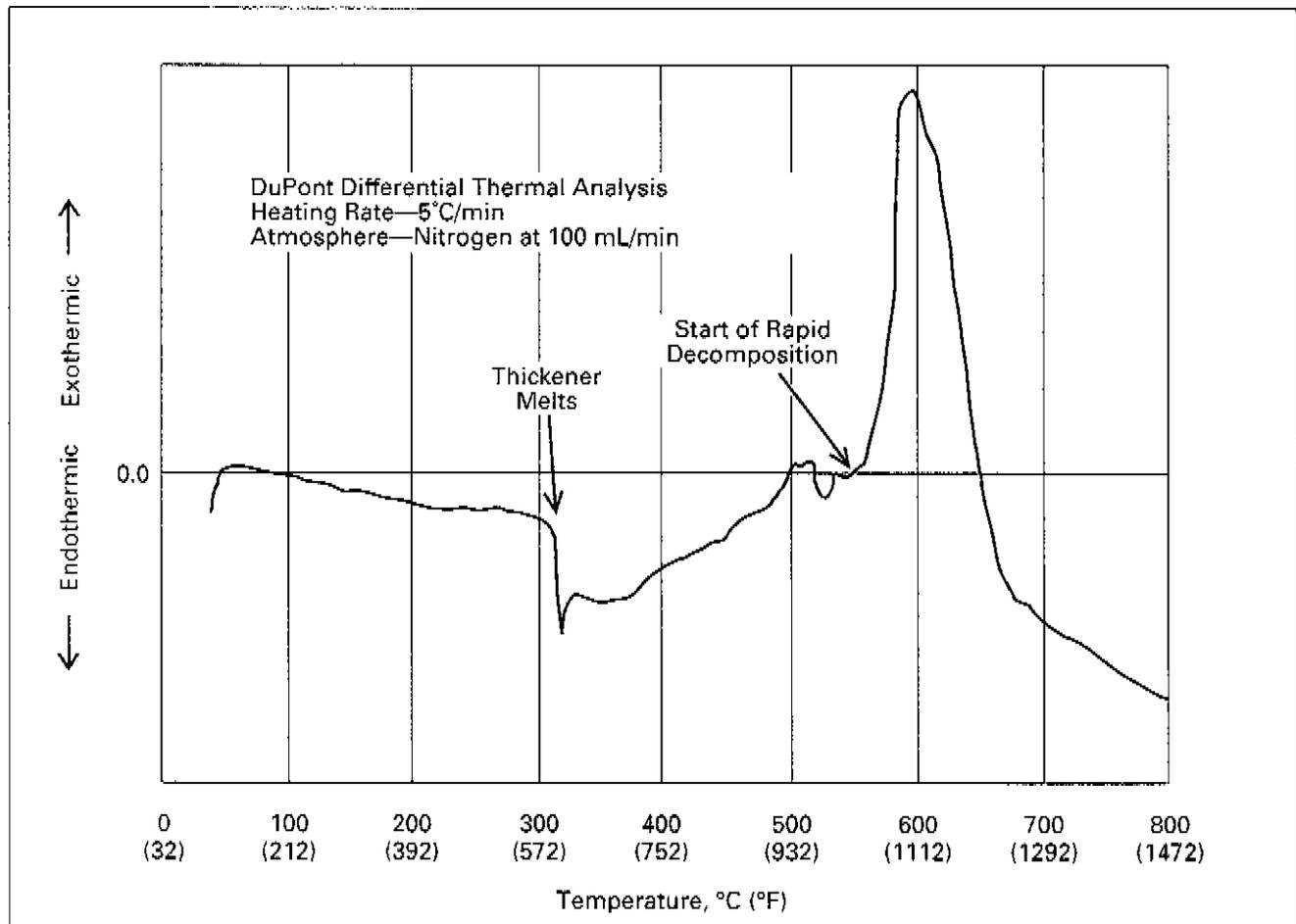


Table 5
Oxygen Compatibility of Krytox Performance Lubricants
(Krytox has never failed an oxygen compatibility test)

Test Type	Temperature, °C (°F)	Oxygen Pressure, MPa (psi)	Impact Energy, Joules (ft-lb)	Test Result
Ignition in gaseous oxygen ^a	400 (752)	13 (1,886)		No ignition
Pressure drop in gaseous oxygen bomb ^b	99 (210)	0.7 (100)		No pressure drop after 600 hr
Mechanical impact in liquid oxygen	Ambient		98 (72)	No reaction in 20 trials ^{c,d,e}
Mechanical impact in liquid oxygen	Ambient		122 (90)	No reaction in 10 trials ^e
Mechanical impact in liquid oxygen	Ambient		736 (543)	No reaction in multiple trials ^f

^aBritish Specification 3100.

^bAmerican Society for Testing and Materials, D-942.

^cMarshall Space Flight Center Specification 106B.

^dNational Aeronautics and Space Administration Handbook, 8060.1B, Test 13, Part 1.

^eAmerican Society for Testing and Materials, D-2512.

^fWest German Federal Institute for Materials Testing (BAM), 8104-411.

Compatibility

Compatible with Metals

Because of their low surface tensions, Krytox lubricants easily wet metallic surfaces. Krytox lubricants are chemically inert, and therefore have no adverse effect on metals when the temperature is below 288°C (550°F). Above 288°C (550°F) many alloy steels, stainless steels, and other metals such as aluminum alloy, titanium alloy, nickel alloy, and cobalt alloy can be used with Krytox.

Compatible with Elastomers and Plastics

Krytox is compatible with both elastomeric seal materials and engineering plastics. The limiting factor when using Krytox with any material is the thermal stability of the elastomer or plastic.

Krytox performance lubricants are compatible with the following common elastomers and plastics:

Fluorosilicone	Nycar 100 (Buna N)
Ethylacrylate	EPT, Peroxide Cure
Methyl Silicone	Nordel [®] Hydrocarbon
Viton A Fluoroelastomer	Rubber
Urethane	Delrin [®] Acetal
Hypalon [®] Synthetic	Zytel [®] Nylon
Rubber	VespeI [®]
Hytrel [®] Polyester	Teflon Fluoropolymer
Elastomer	Kalrez Fluoro-
Butyl 325	elastomer ¹
Neoprene WRT	

¹15-20 vol% swelling

Radiation Stability

Krytox oils are quite stable to radiation when compared with many materials used as lubricants or power fluids. In general, irradiation of Krytox oils causes minor depolymerization, with a consequent reduction in viscosity, and formation of volatile products but not solids or sludge. In one test, exposure of a Krytox sample to an electron bombardment of 10⁸ rad at ambient temperature in air resulted in a viscosity decrease of 21%. The irradiated sample contained no sludge and was unchanged in appearance.

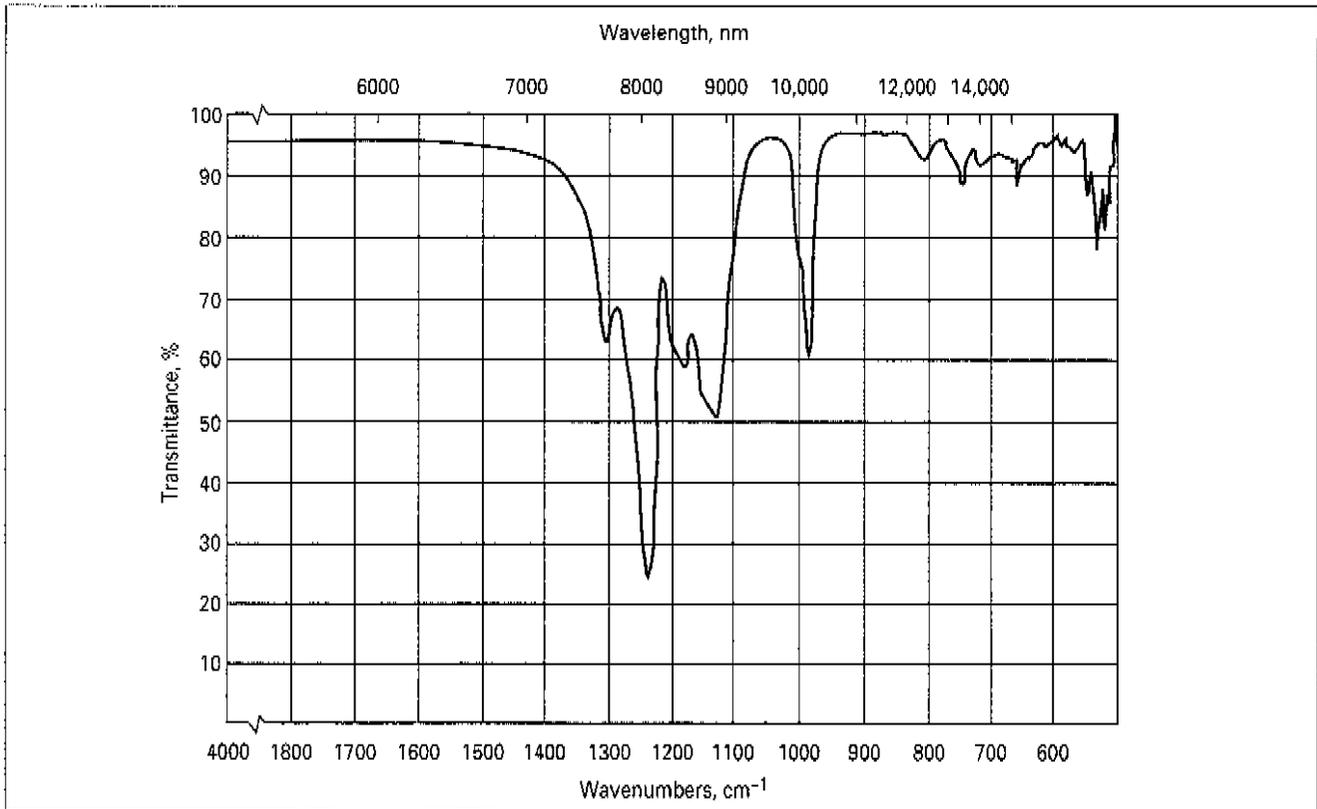
Biological Properties

Krytox fluorinated oils are biologically inert and are not metabolized. They are not biodegradable and do not support any type of biological growth.

Stable to Lewis Acids

Some depolymerization of all perfluoroalkylpolyethers occurs at elevated temperatures in the presence of aluminum trichloride, iron (ferric) or zinc chlorides, and boron trifluoride. These so-called Lewis acids, primarily seen in semiconductor manufacturing environments, have significantly less effect on Krytox than on competitive fluids, due to its molecular structure. Additional data are available upon request.

Figure 2. Infrared Spectrum of Krytox 143AC (sodium chloride cell, capillary film). Infrared absorption spectroscopy is generally the quickest and most definitive method of identifying Krytox oils. All viscosity grades of Krytox display a spectrum similar to Figure 2.



Viscosity

Viscosity Units

Viscosity is a measure of a fluid's resistance to flow when subjected to external forces. Viscosity expressed in this brochure is kinematic viscosity—the ratio of dynamic or absolute viscosity to density—at the same temperatures. Kinematic viscosity (ν) is the value usually measured, but is easily converted to dynamic viscosity (η) as follows (where ρ is density):

$$\nu \cdot \rho = \eta$$

Because of the high density of Krytox fluids, the dynamic viscosity is almost double the kinematic.

Grease Viscosity

Typically, greases are compared based on the viscosity of their base oil. Because greases are thickened, they have a viscosity that is much higher than the base oil. The grease viscosity is affected by temperature, hardness grades, and base oil viscosity. Values for Krytox GPL are about 9000 cSt at 25°C (77°F) and 6000 cSt at 100°C (212°F). The viscosity varies with shear rate.

Speed Factor

The speed factor indicates the permissible speed range for a grease in a rolling bearing. Values of DN of 100,000 to 400,000 have been achieved at temperatures of 204°–260°C (400°–500°F) in actual field service using Krytox greases.

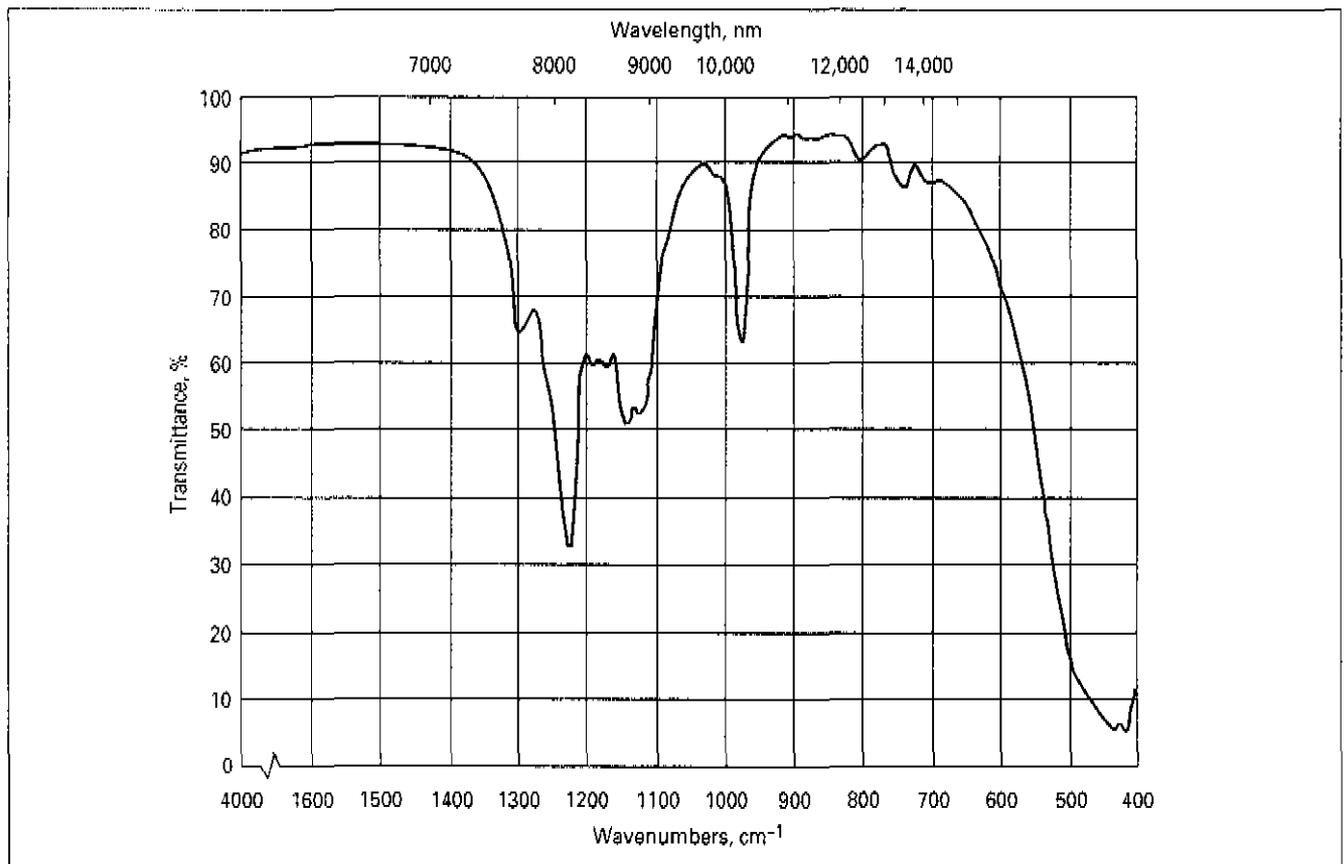
The speed factor is affected by the base oil type, in addition to viscosity and thickener type, and is a measure of the lubricant's internal friction. The limiting speed for grease-lubricated rolling bearings is dependent on the type of bearing, its load, speed, precision, and lubrication system. Call our technical service department to discuss your needs.

Electrical Properties

Krytox oils are good insulators. Their typical dielectric properties are shown in **Table 6**.

The electrical properties of additive-free Krytox greases approach those of the oils; however, incorporation of some additives may significantly alter these values. In fact, the conductivity of the grease may be increased, if desired, by incorporating a conductive additive, such as powdered copper metal.

Figure 3. Infrared Spectrum of Krytox 240AC (sodium chloride cell, capillary film). All grades of Krytox grease display a spectrum similar to Figure 3.



**Table 6
Electrical Properties of Krytox Fluorinated
Oils at Room Temperature**

Property*	Value	Test Method
Dielectric Breakdown Voltage, kV/0.1 in	38.0 to 41.0	ASTM D-877
Specific Resistivity, ohm-cm	$(0.6 \text{ to } 4.0) \times 10^{14}$	ASTM D-257
Dielectric Constant at 10^2 to 10^5 Hz	2.1 to 2.2	ASTM D-150
Dissipation Factor, % at 10^2 to 10^5 Hz	$(3.0 \text{ to } 7.0) \times 10^{-3}$	ASTM D-150

*Electrical properties are altered to a significant extent by the presence of trace amounts of moisture from exposure to a humid atmosphere or from other sources of water contamination. These data were obtained on routinely produced oil using no extraordinary drying techniques.

Other Properties

Additional properties of Krytox are listed in Table 7.

Environmental

Use of Krytox can help the environment. The original properties of the fluids can be regenerated by the manufacturer. This process removes contamination and renews the fluid. Used in valve packing, Krytox reduces emissions from stems. Using Krytox greases and oils reduces the need for hydrocarbon lubricants and their potential environmental impact. They last longer, so less lubricant is needed. Additionally, they are nontoxic and do not release volatile organic compounds to the atmosphere.

DuPont also has a remanufacturing program that reclaims used fluid and recovers the fluid from used filter elements. This lowers the cost of the fluids and eliminates safety and environmental disposal problems.

Table 7
Additional Typical Properties of
Krytox Fluorinated Oils

	Value
Density,* (see Figure 1)	
24°C (75°F), g/mL	1.86–1.91
204°C (400°F), g/mL	1.52–1.60
24°C (75°F), lb/gal	15.5–16.0
Refractive Index,* n _D ²⁵	1.296–1.301
Surface Tension,*	
26°C (79°F), mN/m (dyn/cm)	16–20
Isothermal Secant Bulk Modulus, 38°C (100°F) and 34.5 MPa (5000 psi)	
MPa (approx.)	1,034
psi (approx.)	150,000
Average Coefficient of Thermal Expansion,*	
per °C (25°–99°C)	0.00095–0.00109
per °F (77°–210°F)	0.00053–0.00061
Specific Heat, cal/g·°C or Btu/lb·°F*	
at –18°C (0°F)	0.20–0.21
at 38°C (100°F)	0.23–0.24
at 99°C (210°F)	0.25–0.26
at 204°C (400°F)	0.29–0.30
at –18°C, kJ/kg·K	0.84–0.88
at 38°C (100°F)	0.96–1.00
at 99°C (210°F)	1.05–1.09
at 204°C (400°F)	1.21–1.26
Thermal Conductivity,*	
Btu·ft/h·ft ² ·°F at 38°C (100°F)	0.048–0.054
Btu·ft/h·ft ² ·°F at 260°C (500°F)	0.040–0.051
W/m·K at 38°C (100°F)	0.0831–0.0934
W/m·K at 260°C (500°F)	0.0692–0.0883

*This table gives typical properties (not specifications) based on historical production performance. Viscosity may vary within ± 10%. DuPont does not make any express or implied warranty that these products will continue to have these typical properties.

Personal Safety, First Aid, and Storage and Handling

Use the most current Material Safety Data Sheet (MSDS) for product-specific information.

Additional Information and Literature Requests

The general physical characteristics of each Krytox fluorinated oil product category are described in this brochure. More detailed data sheets showing specific properties for each Krytox product are available.

For more information or technical assistance, call 800-424-7502.

Kalrez, Krytox, Delrin, Hypalon, Vespel, Hytrel, Nordel, Teflon, Viton, Vydax[®], and Zytel are registered trademarks of the DuPont Company. Only DuPont makes these products. For more information, call 800-441-7515.

Additional References for PFPE Lubricants

1. *Synthetic Lubricants and High Performance Functional Fluids*, edited by Ronald L. Shubkin, Chapter 6, Marcel Dekker, Inc.
2. "Comparison of Synthetic Fluids," by Dr. Wilfried J. Bartz, page 765, October 1992, *Lubrication Engineering, Journal of STLE*.
3. *CRC Handbook of Lubrication and Tribology, Perfluoroalkyl Polyethers*, pp. 287–303, CRC Press, Inc.



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DuPont Specialty Chemicals



Krytox®

performance lubricants

Table 1
Typical Properties of Krytox General Purpose Oils¹

Product	100	101	102	103	104	105	106	107
ISO Grade ²	5	7	15	32	68	150	220	460
Viscosity, ³ cSt								
20°C	7	16	36	80	180	550	810	1600
40°C	4	8	15	30	60	160	240	440
100°C	—	2	3	5	9	18	25	42
Pour Point								
°C	<-54	<-54	<-50	-40	-35	-30	-25	-20
°F	<-65	<-65	<-60	-40	-30	-20	-15	-5
Density, g/mL								
0°C (32°F)	1.87	1.89	1.91	1.92	1.93	1.94	1.95	1.95
100°C (212°F)	1.67	1.70	1.72	1.74	1.75	1.76	1.77	1.78
Maximum Volatility, % in 22 hrs								
@ 66°C (150°F)	11	2	2	1	1	1	<1	—
@ 121°C (250°F)	87	29	20	7	3	2	1	—
@ 204°C (400°F)	—	—	—	—	—	10	<5	<1
Appearance	Clear, Colorless Fluid							
4-Ball Wear Test (20 kg/107°C [225°F]/ 1200 rpm/60 min)								
Wear Scar, mm (±0.01) ⁴	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.4
Friction Coefficient (±0.003) ⁴	0.08	0.07	0.07	0.08	0.07	0.07	0.08	0.08
Falex Pin/V-Block Load-Carrying Ability								
Max. Load, lbs	1375	1400	1250	1555	1450	>4500 ⁶	>4500 ⁶	>4500 ⁶
Torque at max load, in-lb	30	31	32	35	32	56	65	65
Estimated Useful Fluid Range ⁶								
°C	-54/66	-54/104	-50/132	-40/154	-35/179	-30/204	-25/260	-20/288
°F	-65/150	-65/220	-60/270	-40/310	-30/355	-20/400	-15/500	-5/550

¹ This table gives typical properties (not specifications) based on historical production performance. Viscosity may vary within ±10%. DuPont does not make any express or implied warranty that these products will continue to have these typical properties.

² Approximate.

³ Higher viscosity grades are available for special applications.

⁴ Average standard deviation.

⁵ Maximum load of test.

⁶ Based on pour point and where evaporation is approximately 10%.

Table 2
Typical Properties of Krytox General Purpose Greases¹

Product ²	200	201	202	203	204	205	206	207
Krytox GPL Base Oil Grade	100	101	102	103	104	105	106	107
Base Oil Viscosity cSt @ 20°C (68°F)	7	16	36	80	180	550	810	1600
Oil Separation Wt Loss, %/30 hrs @ 99°C (210°F)	10	9	8	9	4	4	3	3
@ 204°C (400°F)	—	—	—	—	—	—	11	10

¹ This table gives typical properties (not specifications) based on historical production performance. Viscosity may vary within ±10%. DuPont does not make any express or implied warranty that these products will continue to have these typical properties.

² Grease designations are derived from the viscosity range of Krytox general purpose oil used and additive content. Key 2C illustrates the general purpose grease codes and their composition. Key 2D indicates additive function.

Key 2A—Common Krytox Grease Properties

Appearance	White, buttery
Consistency	NLGI Grade 2
Thickener (Vydux [®] 1000)	
Melting Point	325°C (617°F)
Useful Temperature Range	(Corresponds with base oil in Table 1)

* Vydux fluorotelomer dispersions are made only by DuPont. Additional information about Vydux products is available.

Key 2B—Designations of Krytox General Purpose Lubricants

- First Number (XXX)—1 = oil, 2 = grease
- Second Number (XX)—Additive (0 = none)
- Third Number (XX)—Viscosity of base oil

Key 2C—Grease Additives**

Grease grades 200–207 can be formulated with the following additives:

GPL	Composition
200–207	Base Grease (General Purpose Oil and Thickener)
210–217	Base Grease + Molybdenum Disulfide (Black)
220–227	Base Grease + Sodium Nitrite
230–237	Base Grease + Graphite (Black)
260–267	Base Grease + Graphite + Sodium Nitrite (Black)

** Additives may alter the chemical resistance of the grease. Use caution when using additive grade greases in contact with chemicals.

Key 2D—Function of Additives

Molybdenum Disulfide

E.P. Additive—Enhance load-carrying ability

Sodium Nitrite

Anti-Rust/Anti-Corrosion Additive—Provides protection from rusting at ambient conditions, high temperature corrosion and anti-wear

Graphite

E.P. Additive—Compatible with sodium nitrite additive

For more information and technical assistance, call toll-free (800) 424-7502.

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Krytox[®]
performance lubricants



Krytox®

performance lubricants

Table 1
Typical Properties* of Krytox Fluorinated Oils
Aerospace Grade

Property	ASTM Test Method	Test Conditions	Units	Krytox Fluorinated Oils					
				143AZ	143AA	143AY	143AB	143AC	143AD
Number Average Molecular Weight	NMR		M _n	1850	2450	3000	3700	6250	8250
Viscosity (see Figure 1)	D445	-32°C (-25°F)	mm ² /s	3000	12000	22000	50000	—	—
		0°C (32°F)	(centistokes)	140	340	600	1000	4200	9000
		20°C (68°F)		40	85	150	230	800	1600
		38°C (100°F)		18	35	55	85	270	500
		99°C (210°F)		3.3	5.3	7.5	10.3	26	43
		204°C (400°F)		0.77	1.1	1.4	1.8	3.9	6.0
		260°C (500°F)		—	—	—	—	2.1	3.0
Viscosity Index	D2270			29	89	107	113	134	144
ASTM Slope				0.84	0.77	0.72	0.68	0.59	0.55
Pour Point	D97		°C	-55	-50	-45	-40	-35	-30
			°F	-70	-60	-50	-40	-30	-20
Distillation Range	D1160	53 Pa (0.4 torr)	°C	140-210	170-245	190-265	215-290	260-370	300-400+
			°F	285-410	340-475	375-510	420-555	500-700	570-750+
Vapor Pressure, (see Figure 2)	Knudsen	38°C (100°F)	torr	4 × 10 ⁻⁴	1 × 10 ⁻⁴	4 × 10 ⁻⁵	5 × 10 ⁻⁶	8 × 10 ⁻⁶	6 × 10 ⁻⁶
			260°C (500°F)	torr	1.5	0.8	0.15	3 × 10 ⁻²	2 × 10 ⁻³
		38°C (100°F)	kPa	5 × 10 ⁻⁵	1 × 10 ⁻⁵	5 × 10 ⁻⁶	7 × 10 ⁻⁷	1 × 10 ⁻⁶	8 × 10 ⁻¹⁰
			260°C (500°F)	kPa	0.2	0.1	2 × 10 ⁻²	4 × 10 ⁻³	3 × 10 ⁻⁴
Volatility	D972 (Mod.)	149°C (300°F)	wt % loss	10	5	1	—	—	—
			204°C (400°F)	in 6½ hrs	60	30	10	5	1
		260°C (500°F)		—	—	45	30	4	2
		149°C (300°F)	wt % loss	20	5	3	1	—	—
			204°C (400°F)	in 22 hrs	80	40	20	5	1
260°C (500°F)		—	—	60	40	6	3		

* This table gives typical properties (not specifications) based on historical production performance. Viscosity data may vary within ±10 percent. DuPont does not make any express or implied warranty that these products will continue to have these typical properties.

Figure 1. Viscosity of Krytox Fluorinated Oils

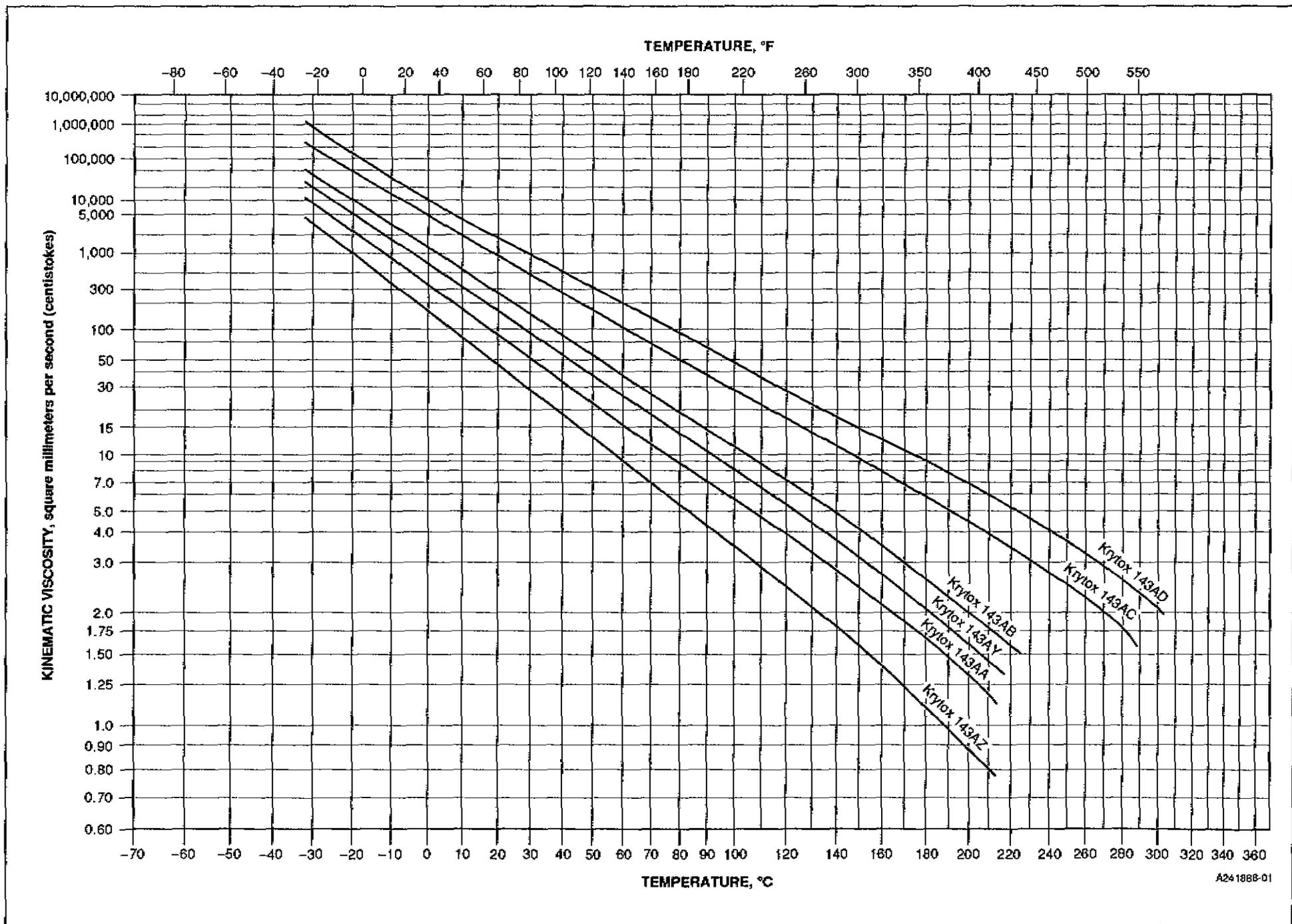
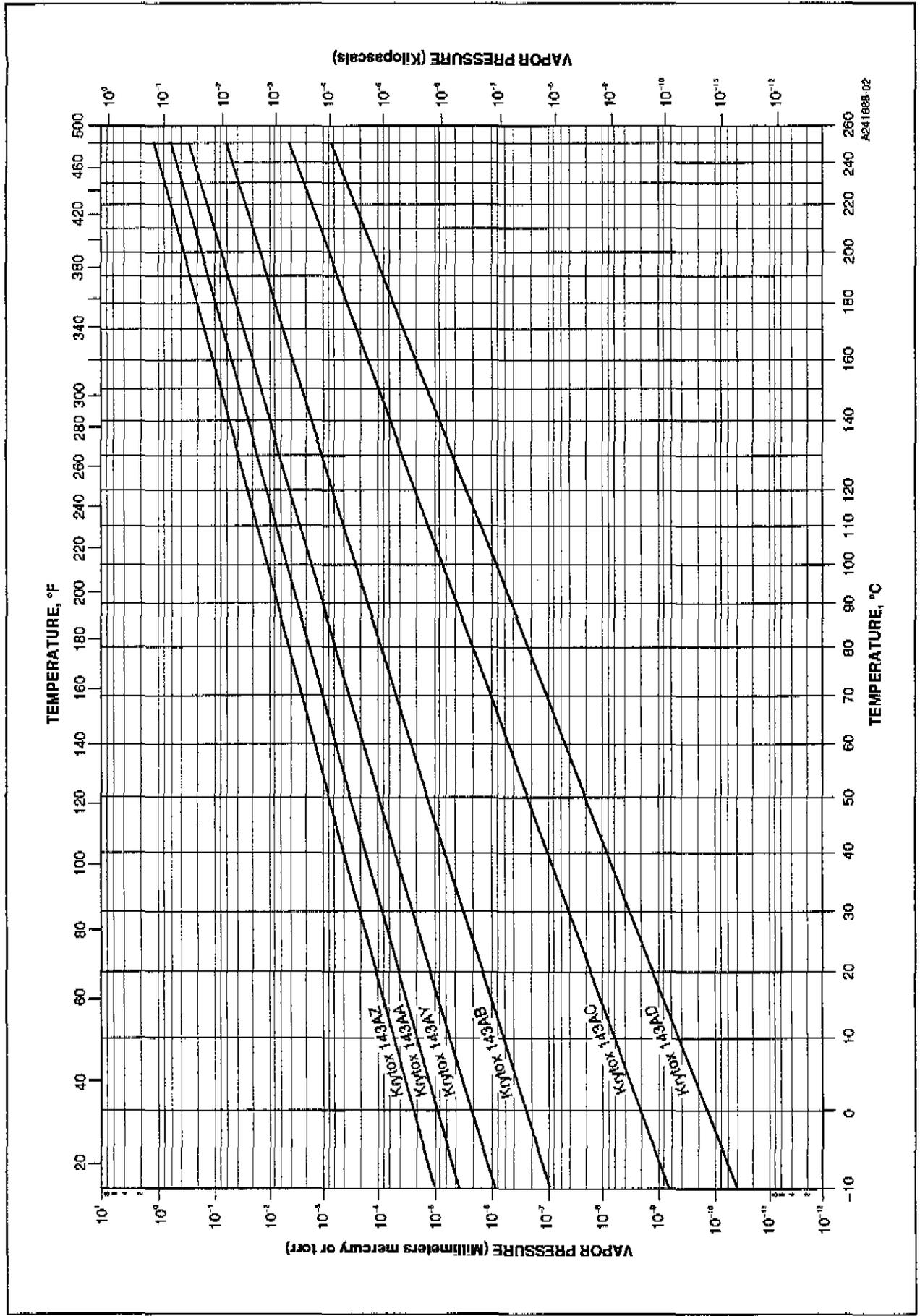


Figure 2. Typical Vapor Pressures of Krytox Fluorinated Oils (Knudsen Method)



**For more information and technical assistance, call toll-free 800-424-7502,
or call Wilmington, Delaware (302) 773-0774.**

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Krytox[®]
Only by DuPont

22310492 KRYTOX GPL 10X FLUORINATED OILS
Revised 7-OCT-1994 Printed 28-APR-1995

CHEMICAL PRODUCT/COMPANY IDENTIFICATION

Material Identification

Corporate MSDS Number : DU002678
Grade : X INDICATES BASE OIL VISCOSITY GRADE

Company Identification

MANUFACTURER/DISTRIBUTOR
DuPont
1007 MARKET STREET
WILMINGTON, DE 19898

PHONE NUMBERS

Product Information : 1-800-441-7515
Transport Emergency : CHEMTREC 1-800-424-9300
Medical Emergency : 1-800-441-3637

COMPOSITION/INFORMATION ON INGREDIENTS

Components

Material	CAS Number	%
PERFLUOROALKYLETHER	60164-51-4	100

HAZARDS IDENTIFICATION

Potential Health Effects

Skin contact may cause skin irritation with discomfort or rash. Prolonged skin contact may cause redness and inflammation of the hair follicles without skin sensitization.

Eye contact may cause eye irritation with discomfort, tearing or blurring of vision.

Inhalation of fluorine containing compounds released as decomposition products above 290 degC (554 degF) may cause lung irritation and pulmonary edema which require medical treatment. Inhalation of fumes or smoke from overheated or burning grease may cause polymer fume fever, a temporary flu-like illness accompanied by fever, chills, and sometimes cough, of approximately 24 hours duration.

(HAZARDS IDENTIFICATION - Continued)

Carcinogenicity Information

None of the components present in this material at concentrations equal to or greater than 0.1% are listed by IARC, NTP, OSHA or ACGIH as a carcinogen.

FIRST AID MEASURES

First Aid

INHALATION

If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Call a physician.

SKIN CONTACT

Flush skin with water after contact. Wash contaminated clothing before reuse.

EYE CONTACT

In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Call a physician.

INGESTION

If swallowed, do not induce vomiting. Immediately give 2 glasses of water. Never give anything by mouth to an unconscious person. Call a physician.

Notes to Physicians

Activated charcoal mixture may be administered. To prepare activated charcoal mixture, suspend 50 grams activated charcoal in 400 mL water and mix thoroughly. Administer 5 mL/kg, or 350 mL for an average adult.

FIRE FIGHTING MEASURES

Flammable Properties

Flash Point : Does not ignite
Method : PMCC

Fire and Explosion Hazards:

Non-combustible

(FIRE FIGHTING MEASURES - Continued)

Extinguishing Media

As appropriate for combustibles in area.

Fire Fighting Instructions

Wear self-contained breathing apparatus. Wear full protective equipment.

Decomposition at flame temperatures may form toxic fluorine compounds. Avoid breathing decomposition products.

ACCIDENTAL RELEASE MEASURES

Safeguards (Personnel)

NOTE: Review FIRE FIGHTING MEASURES and HANDLING (PERSONNEL) sections before proceeding with clean-up. Use appropriate PERSONAL PROTECTIVE EQUIPMENT during clean-up.

Spill Clean Up

Soak up with sawdust, sand, oil dry or other absorbent material. Shovel or sweep up.

Accidental Release Measures

Place in container for disposal. Remove source of heat and flame.

HANDLING AND STORAGE

Handling (Personnel)

Avoid contact with eyes. Avoid contact with skin. Wash thoroughly after handling. Do not store or consume food, drink or tobacco in areas where they may become contaminated with this material.

Storage

Keep container tightly closed. Do not store or consume food, drink or tobacco in areas where they may become contaminated with this material.

Keep away from heat and flames to avoid decomposition products.

EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls

Use only with adequate ventilation. Keep container tightly closed.

Keep away from heat and flames.

Personal Protective Equipment

EYE/FACE PROTECTION

Wear safety glasses or coverall chemical splash goggles.

RESPIRATOR

Wear NIOSH/MSHA approved respiratory protection as appropriate.

PROTECTIVE CLOTHING

Where there is potential for skin contact have available and wear as appropriate, impervious gloves, apron, pants, and jacket.

Exposure Guidelines

Exposure Limits

KRYTOX GPL 10X FLUORINATED OILS
PEL (OSHA) : None Established
TLV (ACGIH) : None Established

PHYSICAL AND CHEMICAL PROPERTIES

Physical Data

Solubility in Water : Negligible WT%
pH : Neutral
Odor : Odorless
Form : Liquid, Viscous oil
Color : Colorless
Specific Gravity : 1.86-1.91 @ 24 deg C (75 deg F)

Pour Point : -57 to -37.7 deg C (-70.6 to -35.9 deg F)

Treatment, storage, transportation, and disposal must be in accordance with applicable Federal, State/Provincial, and Local regulations. Do not flush to surface water or sanitary sewer system.

TRANSPORTATION INFORMATION

Shipping Information

DOT

Proper Shipping Name : Not regulated.

Shipping Containers

1 lb. polyethylene or glass bottles
4, 8, 16 lb. polyethylene bottles
5 gal. polyethylene drum-----
REGULATORY INFORMATION

U.S. Federal Regulations

TSCA Inventory Status : Reported/Included.

TITLE III HAZARD CLASSIFICATIONS SECTIONS 311, 312

Acute : Yes
Chronic : No
Fire : No
Reactivity : No
Pressure : No-----
OTHER INFORMATION

NFPA, NPCA-HMIS

NPCA-HMIS Rating

Health : 1
Flammability : 0
Reactivity : 0

Personal Protection rating to be supplied by user depending on use conditions.

The data in this Material Safety Data Sheet relates only to the specific material designated herein and does not relate to use in combination with any other material or in any process.Responsibility for MSDS : MSDS Coordinator
Address : DuPont Chemicals
Wilmington, DE 19898
Telephone : 800-441-9442

Indicates updated section.

End of MSDS