

DuPont Performance Lubricants

DuPont™ Krytox® for Vacuum Systems

**Setting the Standard for Safety, Reliability,
and Cost Effectiveness**



The miracles of science™

DuPont™ Krytox® Perfluorinated Oils and Greases

- Overview of DuPont™ Krytox® offering
- Krytox® Fluid and Grease Applications
- Performance Characteristics at a Glance
- Physical Properties
- Typical Customers and Industry Applications
- Rationale for Converting from Hydrocarbon
- Krytox® Regeneration Service
- Additional Krytox® Products

Overview of DuPont™ Krytox® offering

- ISO-9002 facility
- Stable supply based on 50 years of experience
- Complete product portfolio including soluble additives, Ultra-high temperature, and linear oils and greases
- Competitive pricing on all product offerings
- Cost savings from reliable supply and performance – less downtime
- Technical support and sales expertise
- Superior fluid regeneration quality and service

DuPont™ Krytox® Fluid and Grease Applications

- **DuPont™ Krytox® Fluids**

- ✓ Mechanical Pumps
- ✓ Dry Vacuum Pump Gear Boxes

- **DuPont™ Krytox® Greases**

- ✓ Valves, seals, bearings, slides, ball screws, O-rings
- ✓ Sealant and thread lubricant
- ✓ Conveyor roller bearings
- ✓ Optical equipment and glassware
- ✓ Dry vacuum pump bearings
- ✓ Non-Vacuum applications requiring low metals content greases (DuPont™ KryPro®)

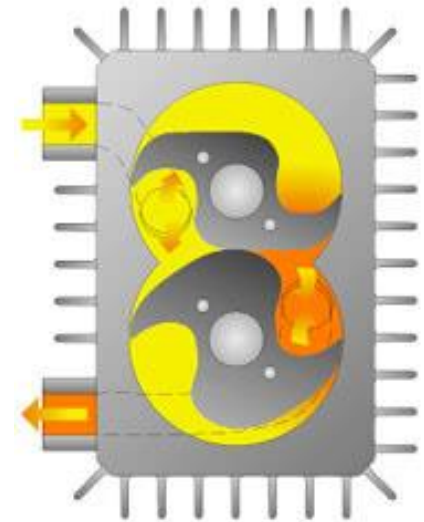
Common vacuum pumps that have used DuPont™ Krytox® lubricants



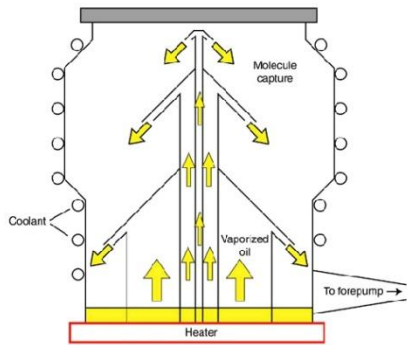
Vane type pump



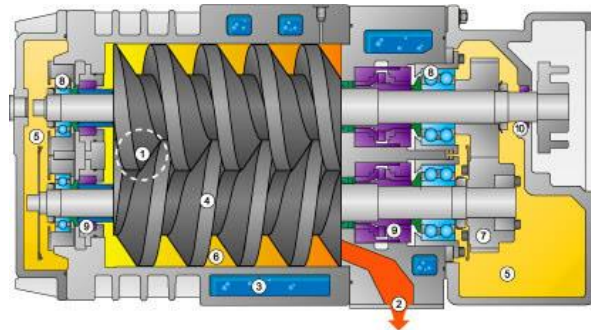
Turbomolecular pump



Claw type dry pump

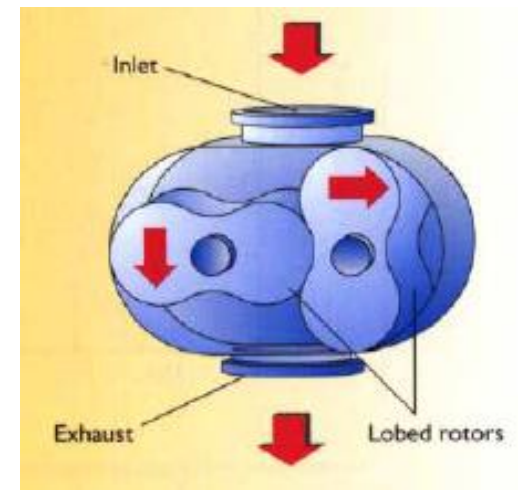


Diffusion pump



Dry screw pump

Roots type pump



Performance Characteristics at a Glance

DuPont™ Krytox® Vacuum Pump Fluids

- Nontoxic
- Biologically inert
- Compatible with plastics and elastomers
- Unaffected by common organic solvents and water
- High density
- Low surface tension
- Resistant to Lewis acids
- H-1 food grade fluids available

DuPont™ Krytox® LVP High-Vacuum Grease

- Very low vapor pressure
- High degree of chemical inertness
- Compatible with metals, plastics, and elastomers

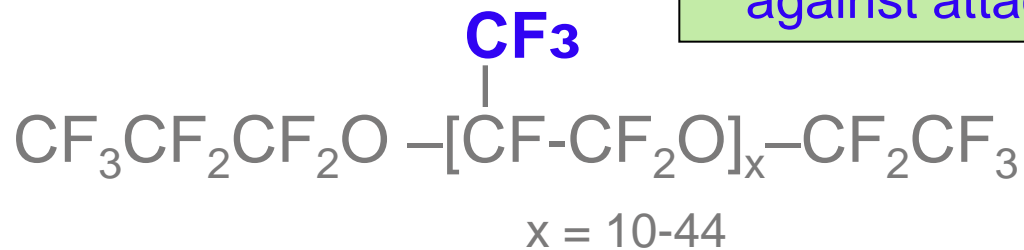
And, of course, all DuPont™ Krytox® oils and greases are completely nonflammable, have excellent thermal and oxidation resistance, and provide outstanding lubricity

Physical Properties of DuPont™ Krytox® in Vacuum Pump Fluids

- Close manufacturing tolerances maintain the vapor pressure - viscosity relationship
- Wide range of viscosities and vapor pressures
- Viscosity range and pour points are:
 - ✓ similar to those of hydrocarbon oils
 - ✓ superior to those of chlorofluorocarbon oils
- Minimum backstreaming maximizes system vacuum

Chemical Comparison

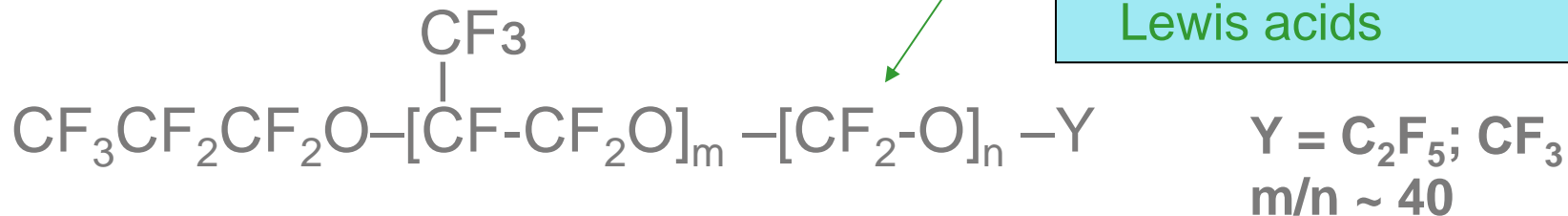
DuPont™ Krytox®:



CF₃ group:

- acts as a shield
- gives **Krytox® superior stability** against attack by Lewis acids

Competitive product:

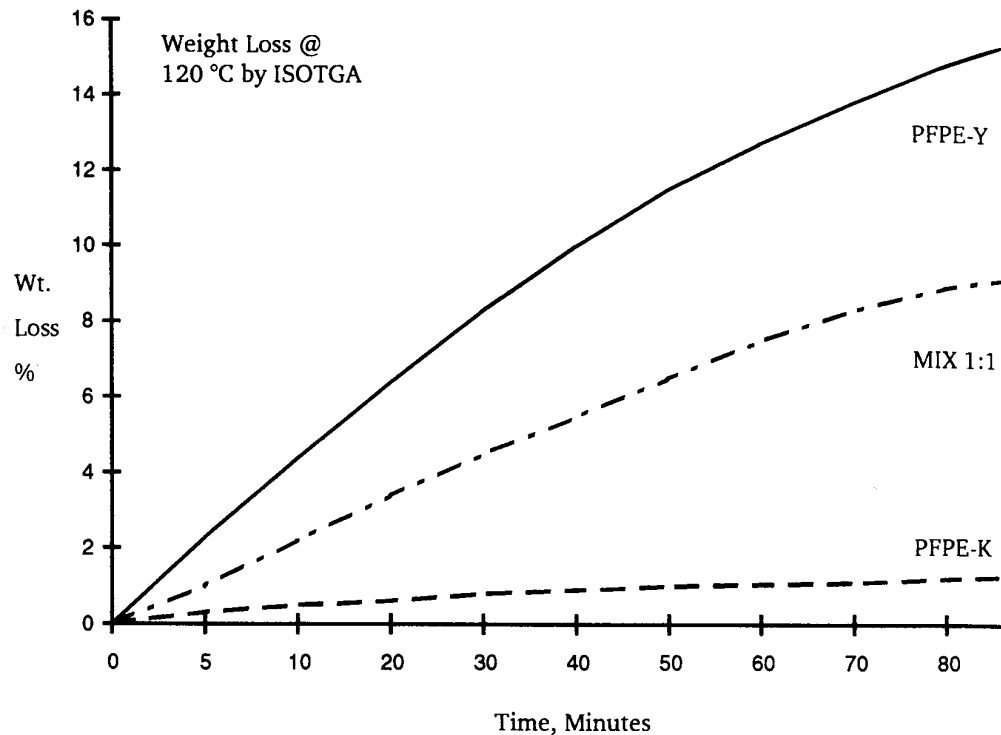


No CF₃ group:

- makes **competitive product susceptible to attack** by Lewis acids

Even gases and chemicals used in semiconductor manufacturing do not react with Krytox® oils in a vacuum pump environment

Superior Chemical Resistance: Fluid degradation with Lewis acids: 15% wt AlCl_3 , at 120 °C



**Competitive
product**

**1:1 Mix of DuPont™ Krytox®
and competitive product**

Krytox®

As a vacuum pump fluid, DuPont™ Krytox® delivers superior performance in the presence of Lewis acids and outperforms the leading competitor in extreme environments

DuPont™ Krytox® Vacuum Pump Fluids

...meeting or exceeding the warranty requirements of all major pump manufacturers

Product	Viscosity*			Vapor Pressure**		Pour Point*** °C
	20 °C cSt	50 °C cSt	100 °C cSt	20 °C, Torr	100 °C, Torr	
Krytox® 1506	60	15	4	10 ⁻⁷	10 ⁻³	-60
Krytox® 1514	140	30	7	10 ⁻⁷	10 ⁻⁴	-54
Krytox® 1525	250	50	10	10 ⁻⁷	10 ⁻⁵	-48
Krytox® 1531	310	63	12.5	10 ⁻⁷	10 ⁻⁵	-41
Krytox® 1618	180	38	8	10 ⁻⁸	10 ⁻⁵	-40
Krytox® 1645	450	80	16	10 ⁻¹¹	10 ⁻⁷	-35
Krytox® 16256	2717	444	63	10 ⁻¹⁴	10 ⁻⁹	-15
Krytox® 16350	3500	600	85	10 ⁻¹⁵	10 ⁻¹⁰	-5
<p>*Viscosity, centistokes or square millimeters per second—plus or minus 10% indicated values</p> <p>**Vapor pressure torr (Knudsen Method) – equal to or less than indicated values</p> <p>***Pour point, °C—equal to or lower than indicated values</p>						

DuPont™ Krytox® Vacuum Pump Greases

Vapor Pressure Data

	Viscosity cSt @ 20 °C	Vapor Pressure
240 AB	230	1 x 10 ⁻⁶
240AC	800	2 x 10 ⁻⁸
240AD	1600	1 x 10 ⁻⁹
EG2000	800	2 x 10 ⁻⁸
EG3000	1600	1 x 10 ⁻⁹
LVP	2700	1 x 10 ⁻¹³
L-150	350	1 x 10 ⁻⁹
L-220	540	1 x 10 ⁻¹⁰

DuPont™ Krytox® LVP High Vacuum Grease

- Less than 1×10^{-13} torr. vapor pressure at 20 °C (68 °F)
- Less than 1×10^{-5} torr. vapor pressure at 200 °C (392 °F)
- Chemically inert and nonflammable
- Oxygen compatible
- Thermally stable to 300 °C+ (650 °F+)
- Very good lubricant
- One grease replaces many (hydrocarbons/silicones)
- Competitively priced vs. all other greases

Grease Typical Properties	
NLGI Consistency	Grade 2 penetration
Vapor Pressure	
Torr at 20°C (68°F)	-1.0×10^{-13}
Torr at 200°C (392°F)	-1.0×10^{-5}
kPa at 20°C (68°F)	-1.0×10^{-14}
kPa at 200°C (392°F)	-1.0×10^{-6}
Evaporation Loss, 4 x 10 ⁻⁸ torr at 150°C (302°F)	
(30 min) wt%	0.1
(60 min) wt%	0.2
(120 min) wt%	0.2
Evaporation Loss, 22 hr at 200°C (392°F)	
	<0.3%
Density, 25°C (77°F), g/cc	1.94
Base Oil Typical Properties	
Average Molecular Weight	11,000
Kinematic Viscosity, cSt	
40°C (104°F)	740
100°C (212°F)	64.5
200°C (392°F)	8.8
Pour Point	-15°C (5°F)

Typical Customers of DuPont™ Krytox® Vacuum Pump Fluids

- Vacuum Pump Manufacturers (OEMs)
- OEM Aftermarket Repair/Service
- Large semiconductor fab plants
- Small, non-OEM vacuum pump repair specialists

Typical Industry End Users of Vacuum Pump Fluids

- Chemical Industry
- Electrical Industry
- Scientific Instruments
- Precision Mechanics Industry
- Utility Goods and Commodities Industry
- Incandescent Lamp and Electron Tube Production
- Refrigeration Industry
- Plastics Industry
- Medical Research
- Metallurgical Industry
- Food Processing Industry
- Optical Industry
- Pharmaceutical Industry
- Toy and Jewelry Industry
- Textile Industry
- Nuclear engineering
- Automobile Industry
- Research and Development

Why Convert to PFPE from Hydrocarbon?

- PFPE is nonflammable, eliminating risk of fire and/or explosion
- Using PFPE eliminates used oil waste and reduces fluid changes
- Fluid can always be regenerated to “new”
- PFPE is environmentally acceptable

Comparison by grade of DuPont™ Krytox® to competitive product

	Krytox®	Competitive Product
VPF Fluid	1506	6/6
	1514	14/6
	1514	16/6
	1525	25/6
	LVP	YVAC 3
Grease	EG3000	RT-15

DuPont Fluid Regeneration Service

- High recovery yields
- Equivalent performance
- Highly cost effective

Advantages of DuPont Regeneration Program

- Safe handling by skilled technicians
- All work done at DuPont's primary manufacturing facility
- Yields of 95-98% achieved from regenerated PFPE fluid
- Safe and legal disposal of contaminants
- Regenerated fluid equal to original finished product specs
- Technical support / analysis available
- Fluid collection drums available upon request
- Reduces customer in-house handling of waste
- Eliminate disposal costs of fluid waste
- Cost savings achieved through reduced new fluid consumption
- Assistance with shipping needs and labeling requirements

Can Vacuum Oils Be Reclaimed?*

“Clean vacuum oil is one of the most important factors in ensuring good performance and long life of vacuum pumps. If the oil isn’t reclaimed properly, it can damage your pump.”

Adequate reclamation is a lengthy process that includes the following steps:

Analyzing the used oil to determine its chemical content

Choosing the correct materials to neutralize the particular contaminants in the oil

Filtering coarse and fine particulates

Degassing

Vacuum molecular distillation to remove volatile components

Final filtration to remove particulates

Analyzing the reclaimed oil to ensure it meets its original specification

Reclamation of perfluoropolyether oil could also include a fluorination step.

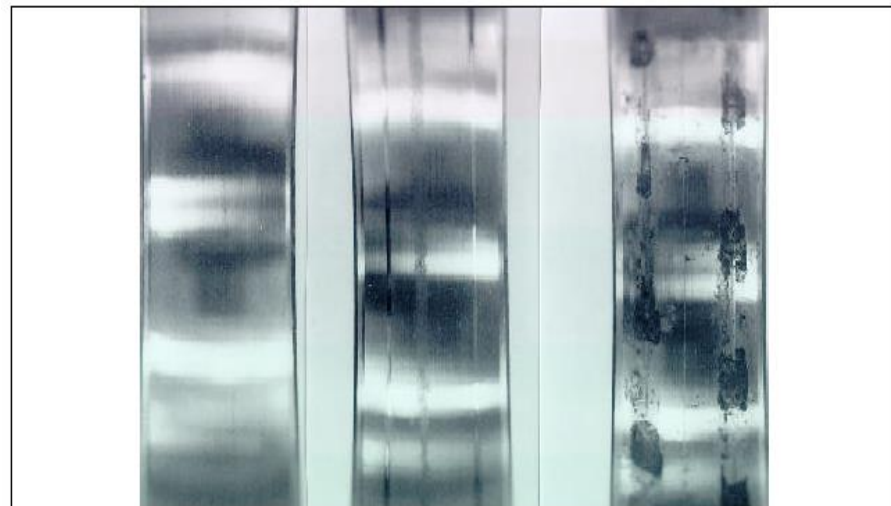
** Excerpted from Leybold Engineering Notes*

More DuPont™ Krytox® products for your industries . . .

DuPont™ Krytox® XP Lubricant family

- Formulated with patented, soluble additives added to enhance the performance of Krytox® PFPE greases and oils
 - ✓ Soluble additives cannot be washed away or left behind with grease thickener
 - ✓ Bearings run quieter – no solid additives to make noise
 - ✓ Lower wear extends bearing and component life
 - ✓ Anticorrosion protection reduces rusting and allows longer grease and bearing life
 - ✓ Extreme pressure properties of additive protects bearings under high loads

The bearing race on the left clearly shows there is no corrosion when the XP additive is present. The bearing in the center shows traces of rust with standard additives, and the bearing on the right shows heavy rusting with no additives.



Linear DuPont™ Krytox® Vacuum Greases

- All are chemically inert & nonflammable
- All are thermally stable to 300 °C (590 °F)
- All have excellent viscosity index
- All have low vapor pressures
- All perform over broadest temp range
- Competitively priced vs. linear greases
- Competitive with Nye, Castrol Braycote, Fomblin Z, LTI, ALI

Base Oil Characteristics

ASTM D 445	Base Oil Viscosity, cSt at	
	20°C (68°F)	540
	40°C (104°F)	220
	100°C (212°F)	40
ASTM D 2270	Oil Viscosity Index	228
	Molecular Weight	10,500
Knudsen	Vapor Pressure	
	Torr at 20°C (68°F)	6×10^{-11}
	Torr at 200°C (392°F)	4×10^{-5}
ASTM D 97	Oil Pour Point, °C (°F)	-60 (-76)
	Oil Density, g/mL, 24°C (75°F)	1.87
ASTM D 972	Base Oil Volatility, % in 22 hr at 260°C (500°F)	1.5

Predicted typical properties, not for specifications

Typical Properties of Krytox® L-220 Grease

Test Method	Description	Result
	Useful Temperature Range, °C (°F)	-60 to 315 (-76 to 599)
ASTM D6184	Oil Separation, 30 hr, 204°C (400°F), wt%	9.9
ASTM D 3336	High Temperature Bearing Life, 10,000 rpm at 220°C (428°F)	Not tested
ASTM E-595	Determination of TML and CVCM from Thermal Outgassing	TML = 0.131% CVCM = 0.092%

Linear DuPont™ Krytox® Vacuum Greases

- L100 Grease
 - ✓ ambient temps (-60 °C to 220 °C) (-76 °F to 428 °F)
 - ✓ very good vapor pressure
- L150 Grease
 - ✓ moderate temps (-55 °C to 250 °C) (-67 °F to 482 °F)
 - ✓ excellent vapor pressure
- L220 Grease
 - ✓ highest temps (-50 °C to 300 °C) (-58 °F to 572 °F)
 - ✓ outstanding vapor pressure

DuPont™ KryPro® EG 2500 Cleanroom Grease

- Designed for non-vacuum applications, such as ball bearings, linear screws, lead screws, linear rails, etc.
- Cleanroom friendly (high purity/low metals)
- Low noise/low vibration
- Excellent anti-wear properties
- COF is 5X lower than competitive lubes
- Extremely low metals content

Property	ASTM Method	KryPro™ EG 2500
Color	Visual	Tan
Appearance	Visual	Smooth
Specific Gravity, 20°C	Pycnometer	0.89
NLGI Grade	ASTM D217	2
SRV, 300 N, 1 hr, 50°C, 1 mm, 50 hz	—	—
Coefficient of Friction at 1 hr	ASTM D 5707 (modified)	.11
Ball Scar Diameter, mm	ASTM D 5707 (modified)	0.4
Disc Scar Width, mm	ASTM D 5707 (modified)	.b
Oil Separation, % Loss 24 hr at 100°C 30 hr at 149°C	ASTM D6184	0.1 0.6
Evaporation, 24 hr at 100°C, %	ASTM D2595	0.25
Dropping Point, °C	ASTM D2265	>260
O ₂ Stability, 168 hr at 100°C, psi	ASTM D942	2.5

DuPont™ Krytox® GBO Oils for Dry Pumps

- Krytox GBO 14 & GBO 25
 - ✓ Designed for dry pump gear boxes
 - ✓ GBO 14 viscosity equivalent to 1514
 - ✓ GBO 25 viscosity equivalent to 1525
 - ✓ All properties equivalent to VPF grades except vapor pressure
 - ✓ Lower cost than VPF

Krytox® GBO Typical Properties		
	Krytox® GBO 14	Krytox® GBO 25
Base oil viscosity, 40°C (104°F), cSt	50	81
Volatility, 24 hr, 100°C (212°F), %	2.1	1.1
Base oil density, g/mL	1.9	1.9
Typical properties. Not for specifications.		



The miracles of science™



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