



## **HUSKEY Specialty Lubricants**

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### **Applications and Benefits of Perfluoropolyether (PFPE) Lubricants**

In this introduction to Perfluoropolyether (PFPE) lubricants we will highlight the general properties, current uses, application techniques, and special considerations. In addition, we will discuss specifically the properties of **HUSKEY™ PF-30**.

#### **INTRODUCTION**

Perfluoropolyether (PFPE) lubricants were first developed in the early 1960's and used in fuel and oil resistant lubricant applications. The first military (USAF) PFPE specification was developed in November 1962, and contained a performance characteristic that the lubricant be non-reactive with liquid and gaseous oxygen. The emphasis on oxygen compatibility confined the choice to fully fluorinated fluids such as PFPE lubricants. In addition, their use with oxidative and reactive chemicals are now routinely used in place of more traditional lubricants for a variety of commercial and automotive applications.

#### **IMPORTANT FEATURES**

Perfluoropolyethers are a unique class of lubricants and functional fluids, which can be used, in dramatically different applications because of their versatility. Some of this product group's important features are listed below (**HUSKEY™ PF-30** Properties are shown in parentheses):

- Low volatility for extended life (weight loss at 204 °C for 22 Hours is <2 %)
- Chemical inertness (fuming sulfuric acid, chlorine gas, oxygen, solvents, etc.)
- Low surface tension (21 dyne/cm at 20 °C)
- High Oxidative and Thermal Stability (+288 °C upper temperature limit due to Teflon®)
- Wide Temperature Range (-40 °C to 288 °C, The -40 °C is to meet automotive requirements.)
- Good lubricating properties (makes it own antiwear additive in the contact region, iron fluoride)
- Non-toxic and biologically inert (PFPE used as a blood substitute, applying for NSF H1)
- Good radiation resistance (no gamma ray degradation)
- Superior extreme pressure characteristics ( 800+ KG four ball EP weld load, The limit for the four ball EP test is 800 KG.)
- High volume resistivity (  $10^{14}$  ohm cm at 20 °C)
- Non-flammable (no flash point)
- Compatible with all common plastics, seals, metals and paints

## WHY CONSIDER PFPE'S

PFPE fluids and greases should be considered where a hostile chemical, clean room, or vacuum environment would preclude the use of an ordinary lubricant. If you are designing a system that will operate hotter and/or longer than its predecessor, determine how these changes will affect lubricant life. If you have a "problem" component that makes too much or unusual noise, and fails frequently, or a lubricated for life application the simple solution may be PFPE's.

PFPE's are generally considered non-toxic under normal operating conditions, nonflammable, and exhibit unusually high load carry capabilities.

PFPE greases and fluids can be enhanced with extreme pressure additives as are sometimes required in heavily loaded gears. Rust-inhibited versions are also available. **HUSKEY™ PF-30** is corrosion inhibited, and has an extreme pressure agent.

Due to the perfluoropolyethers inherent inertness, they are excellent lubricants for reactive and aggressive environments requiring direct contact with the lubricant and reactive chemical contact (i.e., hydrazine, nitrogen tetroxide, concentrated hydrogen peroxide, liquid and gaseous chlorine, nitric acid, and hydrogen fluoride).

## Perfluoropolyether Fluids & Greases

### TYPICAL APPLICATIONS

- ❖ Aircraft instrument bearing grease.
- ❖ Taper plug valve, gaskets, and joint bearings in aircraft fuel systems.
- ❖ Valve and o-ring lubricant in oxygen service.
- ❖ Impregnate for O-rings in pharmaceutical equipment.
- ❖ Pump seal and bearing lubricant in chlorine or strong oxidizer service.
- ❖ Rack and pinion disk drive lubricant.
- ❖ Spindle and actuator bearings in disk drives.
- ❖ Lubricate gears, bearings, and pulleys in Class 100 or cleaner manufacturing areas.
- ❖ Mechanical components of cameras used in deep space.
- ❖ Astronaut space suit bearing and breathing apparatus lubricant.
- ❖ Oven conveyor chain and bearing lubricant.
- ❖ Mold release agent for plastic injection molding.
- ❖ Plasma etching equipment lubricant.
- ❖ Robots in wafer handling, clean room, and commercial environments.
- ❖ Air conditioning bearing and cabin pressurization valves on aircraft.
- ❖ Vacuum grease in semiconductor processing.
- ❖ Top coating lubricant on computer disc drives.

- ❖ Fluid medium in ferrofluidic type seals
- ❖ Moderate to high radiation resistant lubrication applications.
- ❖ Anti-seize compounds.
- ❖ Non-dynamic cryogenic lubricant applications
- ❖ Gyroscope lubricant in aircraft, automotive, naval vessel, and space craft navigation systems.
- ❖ Scanning Electron Microscope(SEM) elastomer and position table lubricant.
- ❖ Automotive 'ABS' Braking Systems.

### LIMITATIONS

Perfluoropolyethers may suffer degradation at high temperatures (usually **above 204°C/400° F**) **in the presence of certain construction materials, especially non-passivated aluminum and titanium** alloys. Small amounts of gases released by such degradation are toxic and corrosive. Adequate ventilation should be used when working in close proximity to lubricants subjected to these conditions. Lewis Acids, such as aluminum chloride, may cause lubricant degradation at lower temperatures. Newly exposed rubbing surfaces of aluminum, titanium, or magnesium may react adversely with halogenated lubricants at elevated temperatures. Rubbing contact surface passivation will retard or eliminate these problems under most conditions.

Water vapor can permeate a PFPE lubricant. If ferric construction materials are not stainless steel then a rust-inhibited grease or fluid is preferred. **HUSKEY™ PF-30** is corrosion inhibited by a very good additive.

One must **clean the metal surface of any petroleum-based products** before applying PFPE lubricants. The PFPE is not compatible with mineral oils and cannot get to the metal surface to lubricate. The cleaning procedure is given below.

### GREASE LUBRICANTS

Perfluoroether greases, based upon a PFPE oil and thickened with a fluorinated polymer such as tetrafluoroethylene (PTFE), are typically described as being smooth, buttery, white or off-white transparent lubricants. The inclusion of additives such as molybdenum disulfide can dramatically alter the lubricants color in addition to its performance properties.

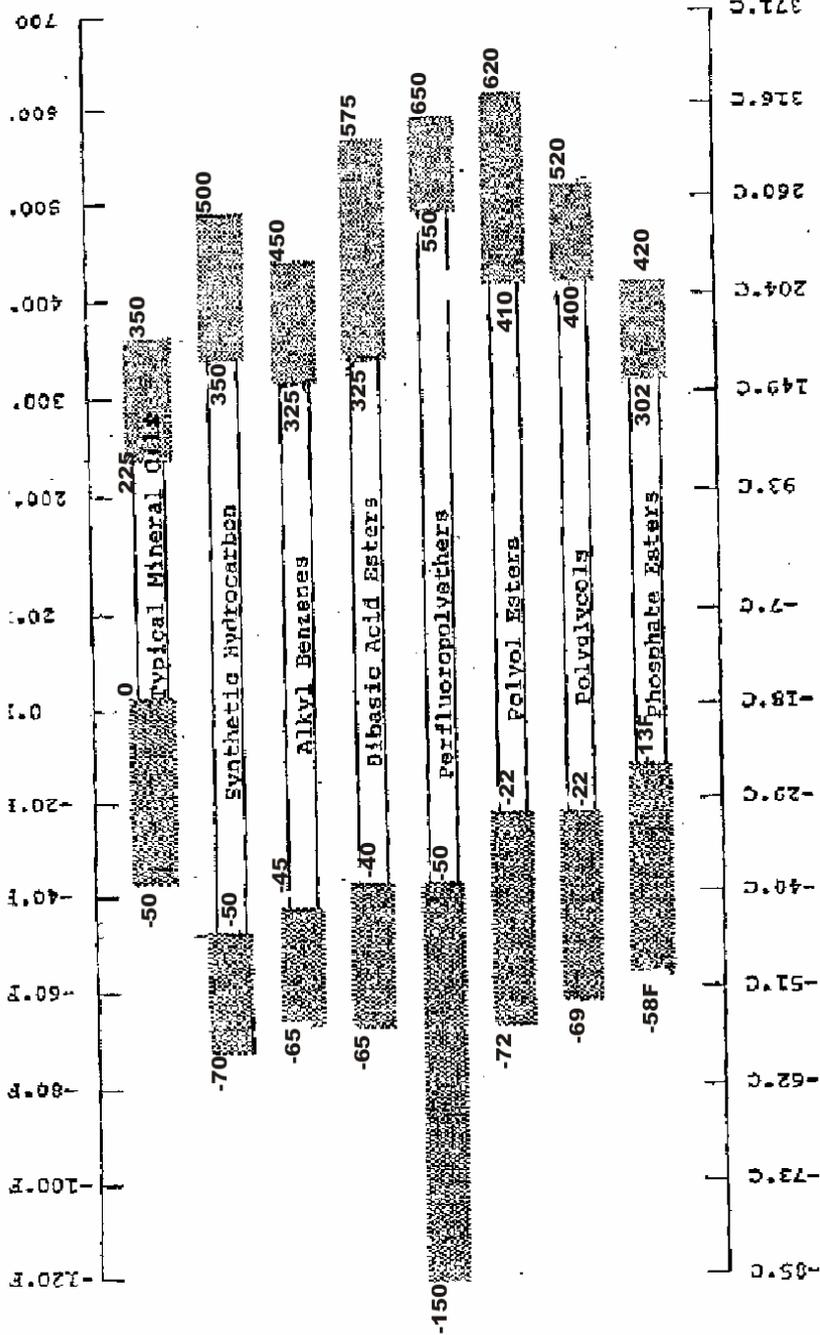
Assessment of the particular performance requirements of the end use will be required for proper selection of base oil, thickening agent characteristics, and types of additives.

Most hydrocarbon (petroleum) based greases will operate successfully in temperatures as high as 250 °F (121 °C). A few will handle 300 °F (149 °C) and a limited number 350 °F (177 °C). At temperatures above 350 °F, synthetic lubricants should be considered. In general, as the service temperature increases the frequency of re-lubrication increases.

The national Lubricating Grease Institute (NLGI) recommends the following re-lubrication intervals for rolling element bearings (assuming eight work hours per day) using petroleum based greases:

180 °F (82 °C), 6 months  
220 °F (104 °C), 3 months  
330 °F (149 °C), 1 month  
380 °F (193 °C), 1 week  
460 °F (238 °C), 1 day

Table A (Page 5) provides comparative temperature ranges of various petroleum and synthetic lubricants. In general, a PFPE may be considered when no other lubricant will work or when you need a long service life, i.e., ten years or more. PFPEs can succeed where hydrocarbon (petroleum) lubricants fail because of PFPE's volatility and chemical inertness.



Continuous service  
 Intermittent service

COMPARATIVE TEMPERATURE LIMITS - MINERAL OIL AND SYNTHETIC LUBRICANT

## **THIN FILM LUBRICATION**

**HUSKEY** recommends careful consideration of the amounts of PFPE lubricant used. Generally, half the quantity of PFPE oil or grease is required for equivalent or longer duty life when compared to traditional lubricants. In industrial applications, more equipment failures are due to excess increase running torque, or cause premature system failure. PFPEs are more stable and their evaporation is significantly less than hydrocarbons. Since the principal reason to apply “excess” lubricant to a bearing is to provide makeup reservoir for the life of the component, this volume can be dramatically reduced with the use of PFPE lubricants. PFPEs should be applied to clean surfaces.

## **CLEANING OF METAL SURFACES TO BE LUBRICATED WITH PFPE LUBRICANTS**

This is a general recommendation for most metal surfaces lubricated with PFPEs. Many machined parts are coated with cutting oils, corrosion inhibitors, or light oils to protect the surfaces while in storage or transit. It is imperative that the protective lubricant be removed thoroughly. When greases of different thickeners are mixed, the mixture may be inferior in service performance or physical properties than either of the component products.

**First**, a petroleum solvent, Stoddard solvent or chlorinated hydrocarbon may be used to remove any process oils or corrosion inhibitors. Depending on the size of the parts, you may dip in solvent or brush on. Where possible, agitation may aid in the removal. For bearings, we recommend blowing out any grease and use a solvent like Stoddard solvent (P-D-680 Type I). These solvents can aid in the removal of the grease thickener.

**Second**, an ultrasonic cleaner may be used on some metal components, excluding assembled precision metal bearings, with Freon TF<sup>®</sup> \* or fluorinated solvent in the bath. This step is required when you have difficulty in removing a hydrocarbon grease.

**Finally**, a second rinse with Freon TF<sup>®</sup> or fluorinated solvent may be used. The surfaces should be allowed to dry, or drying accelerated with the use of warm forced air.

## **VACUUM IMPREGNATING OF PFPE OIL**

Vacuum impregnating is recommended when very thin films of lubricant are desired, especially when tight clearances are a concern. An impregnated part can weep oil over a long period of time in an application where grease may be undesirable. PFPE's are good candidates for vacuum impregnation, because of their low vapor pressure.

The vacuum impregnating system in its simplest form is merely a heated chamber, which can be pumped down to a vacuum. The parts to be impregnated are cleaned and dried under heat and vacuum; then they are immersed in PFPE oil and vacuum baked. After remaining at normal atmospheric pressure a few hours, excess oil is removed and parts are ready for use. A detailed process follows:

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\* Freon<sup>®</sup> TF is a registered trademark of E.I. duPont deNemours and Co., Inc.

## **VACUUM IMPREGNATION PROCESS**

1. Ultrasonically clean the disassembled bearings or retainers in suitable solvent for three minutes.
2. Vacuum bake at a minimum of 29 inches of mercury vacuum at 120 °F (50 °C) for at least one hour.
3. Break vacuum to admit oil, immerse bearings, O-rings or cages completely. Again vacuum bake a 120 °F (50 °C) for one hour or until bubbling ceases.
4. Release vacuum to atmospheric pressure and allow to remain for at least four hours in this condition. The atmospheric pressure forces the impregnate into the retainer. Typically, an inert gas is used as a blanking medium when the chamber is re-pressurized.
5. Remove parts from the oil and allow to drain, removing excess oil by centrifuge or other acceptable methods.

## **GREASE PLATING**

Grease plating is another technique for applying thin, uniform lubrication to precision bearings and metal components. Thin grease plate films can yield torque values slightly higher than fluid lubricants. The residual film which is still a grease acts as an oil reservoir and resists migration providing much longer service life that possible with oil alone.

A grease plate is prepared by reducing the base grease to a fluid state by mixing with suitable volatile solvents. This fluorinated solvent should be checked to insure sample compatibility with the end use.

A mixer of one part fluorinated solvent with one part PFPE grease should be stirred until uniform, adjust solvent until desired consistency is obtained. The bearings or parts are dipped in the grease-solvent mixture, and the excess material is removed by draining. The components are heated to drive off the solvent. The residual film thickness is dependent on the grease to solvent ratio. Not all lubricants can be grease plated. Plating solutions are stable for approximately six (6) hours when stored in a closed container to prevent solvent evaporation.

## **IN SUMMARY**

Perfluoropolyether lubricants comprise a family of highly inert oils and greases. They can be considered for a variety of industrial and specialty applications where ordinary lubricants fail. Their selection is based on the speed, temperature, and load of the system in addition to the system vapor pressure, cleanliness and economics

In general, a 50% reduction in fill quantity for greases and smaller reservoirs for oils is required. Specific applications should be referred to **HUSKEY** lubrication engineers. They would be glad to help you with the product and application recommendations.

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