Fomblin®

SOLVAY

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Fomblin® PFPE Lubes

for Vacuum Applications

SPECIALTY POLYMERS

Fomblin® PFPE: Vacuum Pump Oils

Fomblin® Y grades are perfluorinated polyether inert fluids for use as lubricants in vacuum pumps. Fomblin® PFPE fluids are a mixture of fluorinated polymers obtained by a photochemical process that begins with hexafluoropropylene. Since the Fomblin® PFPE chemical chain contains only carbon, fluorine and oxygen atoms, these fluids have exceptional properties such as:

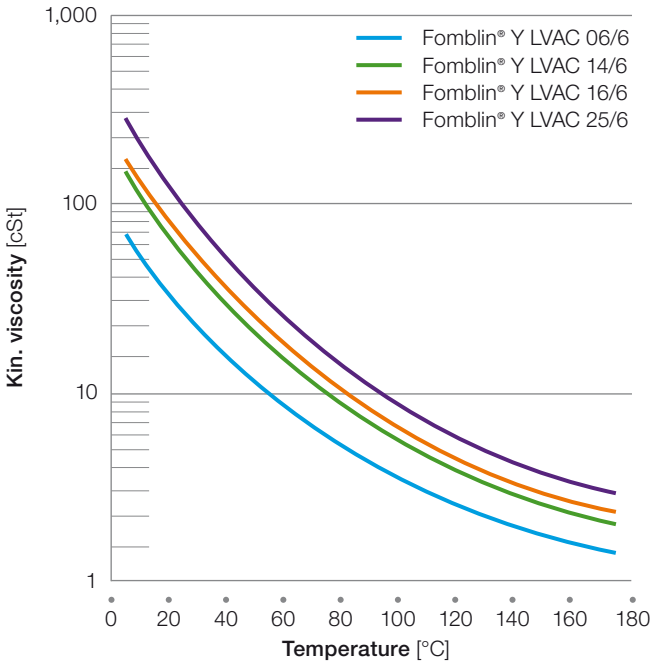
- Low vapor pressure
- Chemical inertness
- High thermal stability
- Good lubricant properties
- No flash or fire point
- Non-toxicity
- Excellent compatibility with metals, plastics, elastomers
- Good aqueous and non-aqueous solvent resistance
- High dielectric properties
- Low surface tension
- Good radiation stability
- Environmentally acceptable

	Y LVAC Grades				Y LVAC RP Grades Anti-rust Additivated			Y HVAC Grades			
Application	**06/6**	**14/6**	**16/6**	**25/6**	**06/6RP**	**14/6RP**	**25/6RP**	**18/8**	**25/9**	**40/11**	**140/13**
Rotary pumps – sealing & lubricant fluid	●	●		●	●	●	●				
Turbomolecular pumps – lubrication	●				●						
Roots pumps – lubrication			●	●			●				
Diffusion pumps – working fluid								●	●	●	●

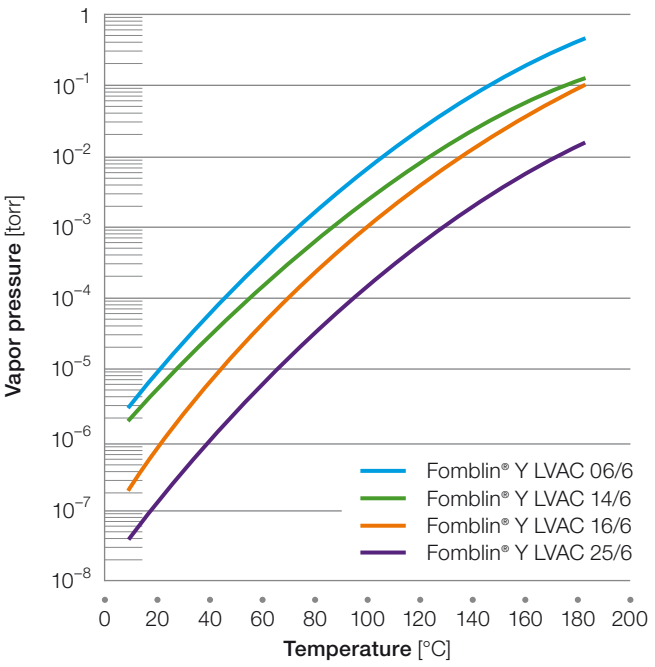
Fomblin® Y LVAC Grades

		Fomblin® Y LVAC Grades			
Typical Properties	**Units**	**06/6**	**14/6**	**16/6**	**25/6**
Average molecular weight	amu	1,800	2,500	2,700	3,300
Density at 20 °C (68 °F)	g/cm^3	1.88	1.89	1.89	1.90
Kinematic viscosity at 20 °C (68 °F)	cSt	64	148	168	276
Viscosity index		71	97	110	113
Vapor pressure					
at 25 °C (68 °F)	torr	$8{\cdot}10^{-7}$	$1{\cdot}10^{-7}$	$9{\cdot}10^{-8}$	$6{\cdot}10^{-8}$
at 100 °C (212 °F)	torr	$3{\cdot}10^{-3}$	$2{\cdot}10^{-4}$	$2{\cdot}10^{-4}$	$6{\cdot}10^{-5}$
Pour point	°C °F	−50 −58	−45 −49	−45 −49	−35 −31
Heat of vaporization at 200 °C (392 °F)	cal/g	11	8	8	7
Surface tension at 20 °C (68 °F)	dyne/cm	21	22	22	22
Evaporation loss (22 hrs; 149 °C for 14/6, 16/6, and 25/6, 120 °C for 06/6)	% by wt.	2.8	2.6	3.9	0.6

Fomblin® Y LVAC – kinematic viscosity vs. temperature



Fomblin® Y LVAC – vapor pressure vs. temperature



Fomblin® Y LVAC RP Grades

Additivated Grades for Anti-Rust and Anti-Wear

Rust Preventive formulation (LVAC RP) was studied to reduce or prevent rusting when huge amount of water vapors has to be pumped or when metal surfaces of the pump are exposed to moisture. An optimum concentration of additive in Fomblin® Y LVAC grades was studied to provide protection against rust and at the same time to guarantee the physical properties and the vacuum performance of the grade.

Anti-rust property evaluation

- Fog chamber (method ASTM B117)
- Conditions: temperature = 45 °C, humidity = 90 %

Sample	Fluid	Fog Chamber Time	Corrosion Degree	Fog Chamber Time	Corrosion Degree
Cast iron	**Y LVAC**	40 mins	5	1 hour	> 5
Low carbon steel	**Y LVAC**	40 mins	4	1 hour	5
Cast iron	**Y LVAC RP**	24 hours	0	96 hours	1–2
Low carbon steel	**Y LVAC RP**	24 hours	0	96 hours	2

Rating

0 – No corrosion
1 – Not more than three small spots of corrosion
2 – Small areas of corrosion covering up to 1 % of the surface
3 – Small areas of corrosion covering from 1 % to 5 % of the surface
4 – Small areas of corrosion covering from 6 % to 10 % of the surface
5 – Small areas of corrosion covering more than 10 % of the surface

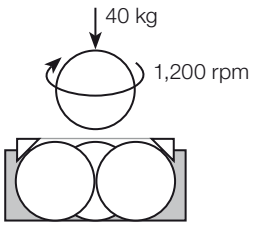
In addition to its rust protection, Fomblin® LVAC RP shows exceptional anti-wear properties as well.

Anti-wear property evaluation

- 4 ball wear test (ASTM D2266)
- Conditions:
  speed = 1,200 rpm, load 40 kg, time = 60 min.

Anti-wear evaluation of oil

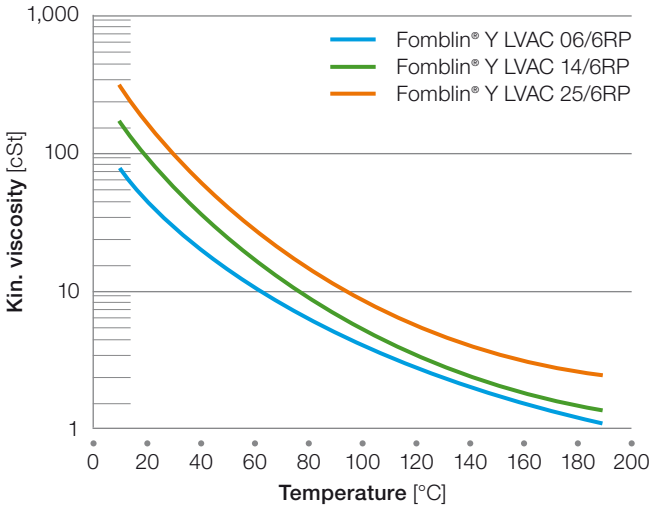
Grade	T = 75 °C	Diff [%]	T = 150 °C	Diff [%]
Fomblin® Y LVAC 25/6	1.1	–	0.85	–
Fomblin® Y LVAC 25/6 RP	0.96	–13	0.74	–13



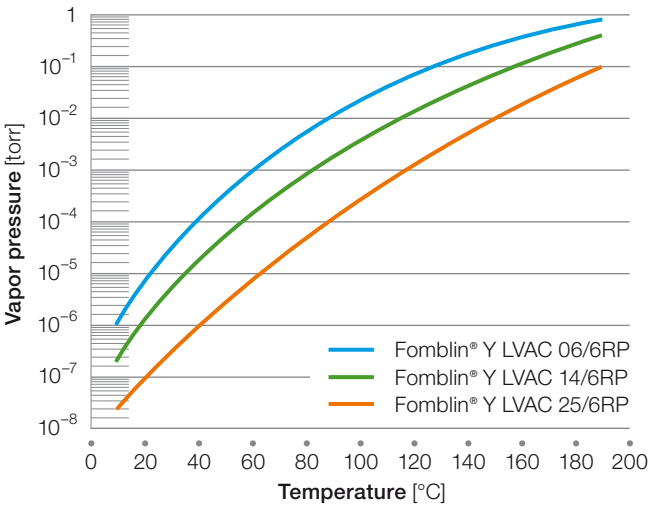
		Fomblin® Y LVAC RP Grades		
Typical Properties	**Units**	**06/6RP**	**14/6RP**	**25/6RP**
Average molecular weight	amu	1,800	2,500	3,300
Density at 20 °C (68 °F)	g/cm^3	1.88	1.89	1.90
Kinematic viscosity at 20 °C (68 °F)	cSt	73	165	305
Viscosity index		71	97	113
Vapor pressure				
at 25 °C (68 °F)	torr	$5{\cdot}10^{-6}$	$3{\cdot}10^{-7}$	$1{\cdot}10^{-7}$
at 100 °C (212 °F)	torr	$3{\cdot}10^{-3}$	$2{\cdot}10^{-4}$	$6{\cdot}10^{-5}$
Pour point	°C °F	−50 −58	−45 −49	−35 −31
Heat of vaporization at 200 °C (392 °F)	cal/g	11	8	7
Surface tension at 20 °C (68 °F)	dyne/cm	21	22	22
Evaporation loss (22 hrs; 149 °C for 14/6RP and 25/6RP, 120 °C for 06/6RP)	% by wt.	3.1	2.9	0.9

Fomblin® PFPE anti-rust additivated grades maintain the same viscosity and vapor pressure behavior than not additivated ones. As the following charts show:

Fomblin® Y LVAC RP – kinematic viscosity vs. temperature



Fomblin® Y LVAC RP – vapor pressure vs. temperature



Fomblin® Y HVAC Fluids

Perfluoropolyether Fluids for Diffusion Pumps

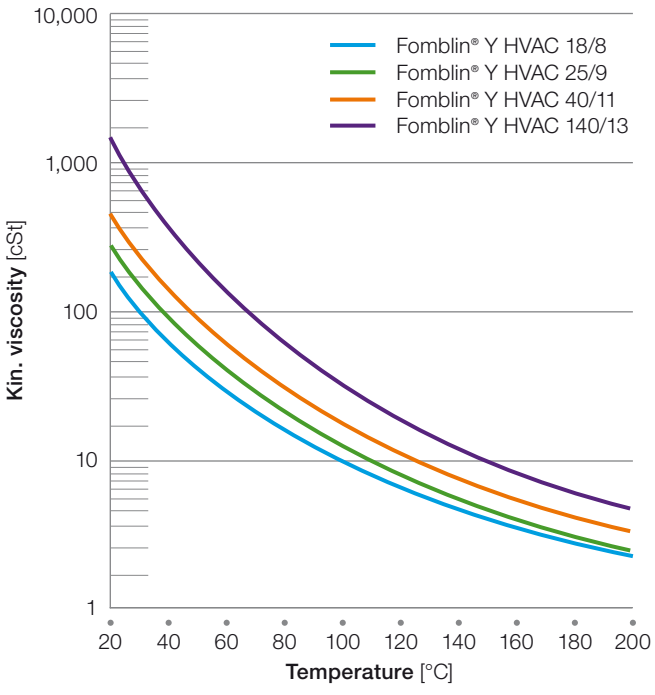
There are several advantages to using Fomblin® Y HVAC fluids in diffusion pumps:

- Will not polymerize when exposed to oxygen, ionizing radiation or accelerated subatomic particles. The system stays free of varnish and deposits from fluid decomposition
- Non-flammable
- Resistant to oxidation of explosion and hot fluid can be exposed repeatedly to air without harm to the fluid while running the pumps
- Inert to most reactive chemicals, the fluid can be used in direct contact with materials such as UF_6, F_2, PCl_3, BF_3, without harm to the fluid

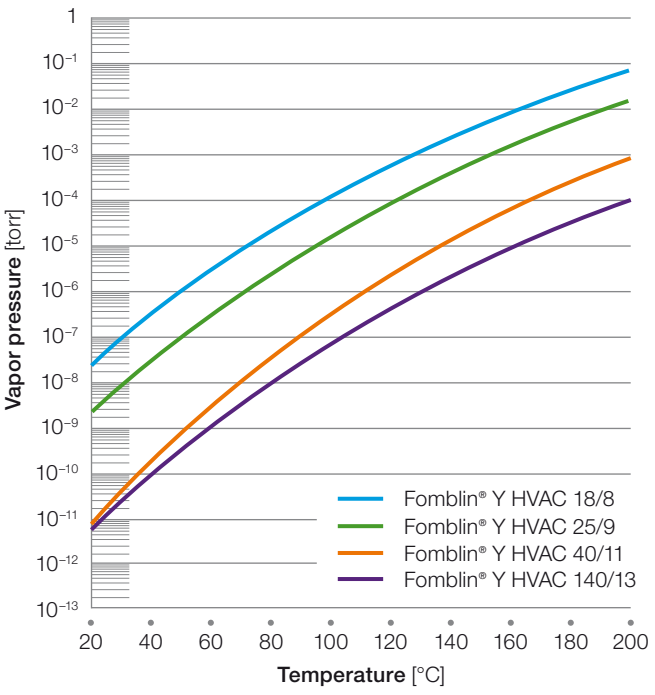
Fomblin® Y HVAC fluids have been specially developed in order to combine narrow molecular weight range and controlled viscosity with an extremely low vapor pressure. Thus, they provide superior performance in high vacuum applications, especially systems exposed to aggressive gases.

		Fomblin® Y HVAC Grades			
Typical Properties	**Units**	**18/8**	**25/9**	**40/11**	**140/13**
Average molecular weight	amu	2,800	3,400	4,100	6,600
Density at 20 °C (68 °F)	g/cm^3	1.89	1.90	1.91	1.92
Kinematic viscosity					
at 20 °C (68 °F)	cSt	190	285	474	1,508
at 100 °C (212 °F)	cSt	9	12	17	32
at 200 °C (392 °F)	cSt	2	2.6	3	5
Pour point	°C °F	−42 −43.6	−35 −31	−32 −25.6	−23 −9.4
Refractive index at 20 °C (68 °F)	n_{20} D	1.300	1.300	1.301	1.304
Specific heat at 38 °C (100 °F)	cal/g	0.24	0.24	0.24	0.24
Surface tension at 25 °C (77 °F)	dyne/cm	20	20	20	20
Heat of vaporization at 200 °C (392 °F)	cal/g	9	7	7	5

Fomblin® Y HVAC – kinematic viscosity vs. temperature



Fomblin® Y HVAC – vapor pressure vs. temperature



Usage

In most cases the Fomblin® PFPE fluid can be used in the diffusion pumps without any modification to the pump. The major advantage in changing to Fomblin® PFPE fluid is the reduction in contamination of the vacuum apparatus due to their very low backstreaming characteristics and elimination of solid deposit formation. Fomblin® Y HVAC fluids need adequate heating power in order to obtain optimum pumping speed and vacuum stability. Working in the appropriate temperature range, the use of a cooling baffle is not critical with regard to ultimate pressure value, but best stability performance have been obtained with a single water cooled baffle. Low ultimate pressure is a typical benefit. It is recommended that fluid temperature be kept below 280 °C for long fluid life. Under recommended operating procedures, Fomblin® PFPE fluids will not decompose. However, gross pump misuse above 290 °C could result in partial decomposition and release of toxic gases. Improved safety can be obtained by absorbing the gases in a glass tube filled with granular calcium oxide at the end of the vacuum system.

Total Fomblin® Vacuum Technology

The Roughing Pump

To obtain maximum benefit from the use of Fomblin® PFPE in the diffusion pump, it is desirable to minimize backstreaming of hydrocarbon vapors from the mechanical roughing pump. This can only be assured by changing the fluid in the roughing pump to the appropriate Fomblin® Y LVAC fluid, such as Y LVAC 06/6, 14/6, or 25/6. If hydrocarbon oil is used in the mechanical pump, it is desirable to insert an efficient trap (cryogenic, copper wool, alumina, zeolite) in the inlet line to the roughing pump.

Vacuum System Cleaning

Galden® Perfluorosolv PFS-2 or Galden® SV55 are excellent non-CFC cleaner solvent for pumping systems using PFPE-based fluids and greases.

Applications

Fomblin® Y HVAC fluids are suggested for applications requiring the highest quality vacuum such as in scanning electron and transmission microscopes, mass spectrometers, particle accelerators, ion implantation, plasma and vapor deposition processes. In addition, it is suggested for pumps handling reactive gases such as UF_6, F_2, oxygen, ozone and tritium, as the fluid can be used in direct contact with these gases without reaction and fluid degradation. Fomblin® Y HVAC 18/8 can be used as an alternative to Santovac 5. The heat of vaporization of Fomblin® Y HVAC 18/8 at 200 °C is 9 Kcal/kg while that of Santovac 5, at the same temperature, is 53 Kcal/kg. The lower value of Fomblin® PFPE means that the pump can be operated at only 85 % of the power used for Santovac, resulting in a 15 % energy saving. The higher molecular weight of Fomblin® PFPE may give a relatively lower pumping speed depending on the gas being pumped. Pumping speed depends on several factors including jet design, physio-chemical properties of the fluid, and molecular weight of the gas being pumped. Pumping speed is greater for light gases (H_2 and He) than for heavy gases.

Miscibility

Fomblin® PFPE Y HVAC 18/8 and Santovac 5 are not miscible. In order to switch to Fomblin® PFPE, the diffusion pump must be cleaned using the recommended procedure for Santovac. The pump should be cleaned as thoroughly as possible before filling to ensure that no traces of solvent are present which may affect vacuum performance. The procedure for cleaning diffusion pumps working with PFPE fluids is as follows:

1. Dismantle pump and extract inner bell,
2. Drain existing oil,
3. Wash three times with Galden® Perfluorosolv PFS-2 or Galden® SV55 solvents. All solvent to remain in pump for several minutes each time before draining,
4. Dry all metal parts in an oven to remove traces of solvent.

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