Inert Lubricants

Oils

Greases

Waxes

Halocarbon

PRODUCTS CORPORATION

The Halocarbon Story

Inert, nonflammable, good lubricity, noncorrosive, low odor, low toxicity...these are properties that describe Halocarbon oils, greases and waxes. These materials, with the tongue-twisting chemical name polychlorotrifluoroethylene, were first used as lubricants by scientists separating uranium isotopes during World War II. After the war, some of those scientists formed Halocarbon Products Corporation with the idea of offering the same lubricants for industrial uses.

This inertness proved to be extremely helpful in the safe handling of highly reactive liquid and gaseous oxygen. As a result, these lubricants soon became the standard for oxygen manufacturers and users. Other users of reactive chemicals, such as chlorine and nitric acid, were soon to follow. These lubricants, now including two classes of greases and several waxes, are currently used widely in industry wherever aggressive chemicals are handled and inertness and nonflammability are required.

For over 50 years, Halocarbon Products Corporation has been a manufacturer and a worldwide supplier of specialty fluorinated chemicals and fluorinated anesthetics.

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Chemical Composition

Halocarbon® oils, greases and waxes are chemically inert, nonflammable, have high thermal stability, good lubricity, high dielectric strength, high density, low compressibility and nonpolar characteristics.

Chemically, Halocarbon oils are low molecular weight polymers of chlorotrifluoroethylene (PCTFE) having the formula $-(CF_2CFCl)_n-$ with n varying from 2 to about 10.

Halocarbon greases are made by incorporating gelling agents with Halocarbon oils to form two classes of grease. In one grease class, the thickening agent is a polymer of the same monomer used to make the oils themselves. Therefore, the chemical properties of this class of grease are identical to the oils. The other class is made from oils thickened with silica. While this thickening agent brings about certain beneficial properties, it also brings along the chemical properties of silica (see Chemical Inertness, page 6).

Both the oils and greases are available with a conventional hydrocarbon rust inhibitor added to give extra protection to steel in corrosive applications. The presence of the inhibitor does not compromise the inertness of Halocarbon lubricants to oxygen (see Oxygen Inertness Tests, page 7).

Physical Properties

As the viscosity of the Halocarbon oil increases, so does the density, pour point and cloud point. Table 1 (see page 4) lists these and other physical properties. The vapor pressure decreases as the molecular weight of the oils increases as shown in Figure 1 (see back inside cover). These data will help in the choice of the appropriate oil.

The polymer changes from liquid to wax as the molecular weight increases. The waxes are all white solids at room temperature which melt upon heating. They have initial boiling points above 500°F (260°C) and densities of about 1.89g/mL at 210°F (99°C). Drop melting point and viscosity data are given in Table 2 (see page 4).

The properties of Halocarbon greases depend upon the base oil used and how heavily they are gelled. Table 3 (see page 5) gives penetration, service temperature range and drop melting point data.

Solubility in Other Solvents

The lower viscosity Halocarbon oils are soluble in most organic liquids but solubility decreases as viscosity increases. All Halocarbon fluids are insoluble in aqueous acidic, alkaline or neutral solutions.

Solubility of Other Liquids in Halocarbon Oils

Halocarbon oils will dissolve most organic liquids and certain volatile anhydrous inorganic salts (such as titanium tetrachloride). Some organic compounds that Halocarbon fluids are miscible with are:

Acetone	Glacial acetic acid
Amyl acetate	Hexane
Benzene	Kerosene
n-Butyl alcohol	Methanol
Carbon tetrachloride	Methyl ethyl ketone
Carbon disulfide	Methyl isobutyl ketone
Chloroform	Methylene chloride
Dibutyl phthalate	Mineral oils
Dimethyl foramide	Silicone oils
Dioctyl phthalate	Trichlorobenzene
Dioctyl sebacate	Tetrachloroethylene
Ethanol	Tetrahydrofuran
Ether	Trichloroethylene

Solubility of Gases in Halocarbon Oils

Halocarbon fluids dissolve gases readily. Chlorine, for example, is soluble to the extent of several weight percent at ambient conditions. Oxygen, nitrogen and carbon dioxide dissolve to the extent of 0.15, 0.26 and 1.3 mL of gas per mL of liquid, respectively (in Halocarbon 27 oil at 77°F and atmospheric pressure). Gas solubility increases with an increase in pressure. Halocarbon 27 oil dissolves 10.2 mL of nitrogen gas per mL of liquid at 1000 psig at 100°F (37.8°C) but Halocarbon 6.3 oil dissolves only 5.4 mL of gas per mL of liquid under the same conditions.

Both viscosity and density are reduced appreciably by dissolved gas.

Bulk Modulus

The bulk modulus of Halocarbon oils are well over 200,000 psi at 100°F (37.8°C) with applied pressures up to 10,000 psig. Halocarbon oils have compressibilities similar to mineral oils and they are much less compressible than perfluoropolyethers.

Thermal Properties

Heats of vaporization for Halocarbon oils vary from 36 to 54 BTU/lb (20 to 30 cal/g). Their specific heats range from 0.2 to 0.25 BTU/(lb)(°F) or cal/(g)(°C) as the molecular weight increases.

Surface Tension

Halocarbon oils have low surface tensions because of their chemical composition. The low values (23 to 30 dynes/cm) result in easy wetting of most materials, which is helpful for lubricity and other properties.

Electrical Properties

The typical volume resistivity of Halocarbon oil is in the range of 10^{13} to 10^{14} ohm-cm. The dielectric constant is quite low. It varies from 2.25 to 4.0 depending on the frequency and temperature.

Typical Physical Properties For Oils, Greases, Waxes[1]

Table 1. Halocarbon Oils

Oil		0.8	1.8	4.2	6.3	27	56	95	200	400	700	1000N
Flash and Fire Points		None										
Pour Point, ASTM D97												
	°F	–200	–135	–100	–95	–40	–30	–15	10	15	40	50
	°C	–129	–93	–73	–71	–40	–34	–26	–12	–9	5	10
Cloud Point, ASTM D2500												
	°F	<–200	<–135	<–125	<–125	<–95	–30	–5	35	50	55	65
	°C	<–129	<–93	<–87	<–87	<–71	–34	–21	2	10	13	18
Viscosity, ASTM D445												
@–65°F (–54°C)												
Centistokes		5.7	143	—	—	—	—	—	—	—	—	—
Centipoises		10	271	—	—	—	—	—	—	—	—	—
@100°F (37.8°C)												
Centistokes		0.8	1.8	4.2	6.3	27	56	95	200	400	700	1000
Centipoises		1.3	3.5	7.8	12	51	108	182	390	780	1365	1950
@160°F (71.1°C)												
Centistokes		0.54	1.1	1.9	2.6	6.8	11	16	26	40	62	83
Centipoises		0.89	1.9	3.4	4.7	13	21	30	49	75	118	158
@210°F (99°C)												
Centistokes		—	0.8	1.2	1.6	3.1	4.9	6.3	9	12	17	22
Centipoises		—	1.4	2.1	2.8	5.6	8.9	12	16	22	32	41
Density, g/mL												
100°F (37.8°C)		1.71	1.82	1.85	1.87	1.90	1.92	1.92	1.95	1.95	1.95	1.95
160°F (71.1°C)		1.65	1.76	1.80	1.82	1.85	1.87	1.87	1.89	1.89	1.90	1.90
210°F (99°C)		1.60	1.71	1.75	1.77	1.81	1.82	1.82	1.85	1.85	1.86	1.86
Refractive Index												
n_D^{20} (typical)		1.383	1.395	1.401	1.403	1.407	1.409	1.411	1.412	1.412	1.414	1.415

Oil grade followed by "S" indicates rust inhibitor has been added. Oxygen compatibility remains the same.

Table 2. Halocarbon Waxes

Wax		40	600	1500	2300
Minimum Drop Melting Point, ASTM D127					
	°F	—	135	270	>270
	°C	—	57	132	>132
Viscosity, ASTM D445, Centistokes @160°F (71.1°C)		190	1000	—	—

Table 3. Halocarbon Greases

Grease	ASTM D217 Penetration	Service Temperature	Minimum Drop Melting Point	NLGI	Description
Silica Thickened Greases					
32	330	–15 to 350°F –25 to 175°C	None	1	Softest grease with broad temperature range.
28	280	–15 to 350°F –25 to 175°C	None	2	Medium grease with broad temperature range.
28LT	280	–50 to 200°F –45 to 95°C	None	2	This grease is designed for low temperature applications.
25-5S	230	0 to 350°F –20 to 175°C	None	3	All purpose grease for a wide temperature range.
19	190	–15 to 350°F –25 to 175°C	None	4	Hardest grease with broad temperature range.
Polymer Thickened Greases					
25-10M	300	30 to 275°F 0 to 135°C	300°F 150°C	1	Softest grease with broad temperature service.
X90-10M	330	–40 to 200°F –40 to 95°C	300°F 150°C	1	This grease is designed for low temperature applications.
25-20M	200	20 to 300°F –5 to 150°C	320°F 160°C	4	Hardest grease with a broad temperature range.

All Halocarbon greases are available with rust inhibitors.

1. These tables give typical properties (not specifications) based on historical production performance. Halocarbon Products Corporation does not make any express or implied warranty that these products will continue to have these typical properties.

Chemical Inertness

Halocarbon oils, greases and waxes are inert toward practically all compounds and solutions. In addition, Halocarbon oils have no flash or fire points and are low in toxicity. They are among the safest lubricants you can buy.

The silica-thickened greases are prone to attack by chemicals active toward silica, such as alkalis, hydrofluoric acid and fluorinating agents. These greases should not be used in these applications unless testing indicates otherwise. Polymer thickened greases are not subject to this attack.

Halocarbon lubricants are compatible with the following chemicals and many others:

Aluminum chloride	Hydroiodic acid
Ammonium nitrate	Iodine
Ammonium perchlorate	Muriatic acid
Antimony trichloride	Nitrogen oxides (all)
Boron trichloride	Nitrogen trifluoride
Boron trifluoride	Oleum
Bromine	Oxygen (liquid and gaseous)
Bromine trifluoride (gaseous)	Ozone
Calcium hypochlorite	Phosphoric acid
Carbon dioxide	Phosphorus oxychloride
Chlorinated cyanurates	Potassium perchlorate
Chlorine	Potassium persulfate
Chlorine dioxide	Propylene oxide
Chlorine trifluoride (gaseous)	Silane
Chlorosilanes	Silicon tetrachloride
Chlorosulfonic acid	Sodium chlorate
Chromic acid	Sodium hydroxide (all concentrations)
Chromyl nitrate	Sodium hypochlorite
Ethylene oxide	Sodium perchlorate
Fluorine (gaseous)	Sulfur dioxide
Fuming nitric acid	Sulfur hexafluoride
Hydrogen	Sulfur trioxide
Hydrogen bromide	Sulfuric acid
Hydrogen chloride	Thionyl chloride
Hydrogen fluoride	Titanium tetrachloride
Hydrogen peroxide (all concentrations)	Uranium hexafluoride
Hydrogen sulfide	

We do not recommend Halocarbon lubricants in contact with sodium or potassium metal, amines including amine additives (antioxidants, etc.), liquid fluorine or liquid chlorine trifluoride. Caution should be used with aluminum and magnesium under conditions of large shear forces such as those found in threaded connections. A bench test may be required to determine if such a condition exists.

Halocarbon oils, greases and waxes also will not contribute fuel in fire-prone applications. Halocarbon oils are frequently used in systems with low flash point materials, such as ethylene and propylene oxides, to avoid having additional combustible material available. Another example would be the handling of silane, a pyrophoric gas, by the semiconductor industry. The silane would ignite hydrocarbon vacuum pump fluids when it ignites. A silane fire could be much less serious if Halocarbon oils were used instead.

Oxidizer Inertness Tests

Because of industry's ever expanding use of strong oxidizing agents, many test procedures have been developed to determine the safety of lubricants in contact with these agents. The results of one method, ASTM G72-82 "Standard Test Method for Autogenous Ignition Temperature of Liquids and Solids in a High-Pressure Oxygen-Enriched Environment", are given for several Halocarbon oils and greases in Table 4 (see page 7). None of Halocarbon's lubricants, including those with rust inhibitor, ignite throughout the entire testing range, exceeding 400°C (752°F) and 2000 psig oxygen.

Also in Table 4 are the results of a test similar to ASTM D2512-95 "Test for Compatibility of Materials with Liquid Oxygen (Impact Sensitivity Threshold Technique)". The apparatus used has upper limits in excess of the ASTM method. Here again, none of Halocarbon's lubricants showed any sensitivity at the highest impact loading.

Table 5 (see page 7) shows how insensitive Halocarbon oils are to shock in the presence of 90% hydrogen peroxide or liquid oxygen.

Our oils and greases have been successfully tested to the German Federal Institute for Materials Testing (BAM), method 8104-411 for oxygen compatibility. Some of our products have also been successfully evaluated per the European Standard EN ISO 4114-3 and EN 1797-1.

Insoluble Layers are a Safety Hazard

Hydrocarbons dissolve in Halocarbon oils to some extent and quantities of up to 1000 ppm will not affect oxygen inertness. However, in systems not thoroughly cleaned before installing Halocarbon oils, the hydrocarbon solubility may be exceeded and a second layer may form. If a separate layer of hydrocarbon is present, *the system will be no safer than if the system were using a pure hydrocarbon lubricant. Systems using perfluoropolyethers are especially vulnerable to this hazard because hydrocarbons are not soluble in these oils at all.*

Table 4. Oxygen Inertness Tests

		Autogenous Ignition Temp.[1] (°C)	Impact Sensitivity[2] (foot-pounds)
Halocarbon Oils	4.2	>400 (752°F)[3]	>114[3]
	4.2S	>400	>114
	56	>400	>114
	56S	>400	>114
	700	>400	>114
	700S	>400	>114
HaloVac® Oils[4]	100	>400	>114
	190	>400	>114
Halocarbon Greases	25-5S	>400	>114
	25-5SI	>400	>114
	25-10M	>400	>114
	25-10MS	>400	>114

1. ASTM G72 "Standard Test Method for Autogenous Ignition Temperature of Liquids and Solids in a High-Pressure Oxygen-Enriched Environment".
2. Similar to ASTM D2512 "Test for Compatibility of Materials with Liquid Oxygen (Impact Sensitivity Threshold Technique)". See Text.
3. Upper limit of test.
4. See Vacuum Pump Fluids, page 13.

Table 5. Shock Sensitivity[1]

	Oxidizer	
	H2O2(90%)	LOX
Oxidizer/Oil		
8/1	None	—
4/1	None	—
2/1	None	—
1/1	—	None
Pretreatment Temp.[2] °F	160	–300
°C	71.1	–184
Test Temp. °F	70	–300
°C	21	–184

1. Tests run on a Picatinny Arsenal type impact tester (see Picatinny Technical Report 1401, Revision 1,1950).
2. Mixtures of Halocarbon oil and 90% H_2O_2 held at constant temperature for 24 hours prior to test.

The thermal stability of Halocarbon oils extends up to the decomposition temperature of the carbon chain. The decomposition to toxic, nonsludge-forming volatiles occurs rapidly at 620°F (327°C), noticeably at 580°F (304°C) and in lesser amounts at lower temperatures. The maximum safe operating temperature recommended, therefore, is 400°F (204°C) and maximum short-term temperature recommended is 500°F (260°C) in scrupulously clean systems. Oils containing our rust inhibitor discolor after some exposure to temperatures of approximately 250°F (121°C) due to decomposition of the inhibitor. The oil is unchanged.

Lubricity

Halocarbon oils can be used interchangeably (see page 14) with hydrocarbon oils to lubricate a wide range of equipment such as bearings, compressors, gear boxes and pumps. Occasionally, some equipment modification may be required because of density, viscosity and vapor pressure differences from hydrocarbon lubricants.

Extreme-pressure tests using the four-ball method (see Table 6) show that Halocarbon oils and greases are very good lubricants. The oils exhibit no seizure even at the final applied load of 800 kg. These greases and oils show load wear indexes that are appreciably better than hydrocarbon oils. These same data show reasonable scar diameters increasing uniformly with load.

Halocarbon oil has been used successfully in all types of equipment for over 50 years. However, if there is any question of direct interchangeability, a monitored test in the piece of equipment is advisable.

Table 6. Typical Load Wear Indexes[1]

Halocarbon Oils	**4.2**	**6.3**	**27**	**56**	**700**
Applied Load (Kg)			**Scar diameter (mm)**		
100	0.51	0.52	0.52	0.55	0.53
126	0.62	0.55	0.55	0.59	0.55
160	0.66	0.62	0.71	0.64	0.64
200	0.74	0.72	0.76	0.69	0.68
250	0.90	0.80	0.81	0.80	0.76
315	0.95	0.87	0.90	0.85	0.87
400	1.09	1.02	1.03	1.00	1.04
500	1.21	1.20	1.18	1.10	1.08
620	1.30	1.24	1.31	1.25	1.13
800	1.61	1.50	1.66	1.46	1.53
Load Wear Index	>205.1	>217.4	>208.3	>221.1	>224.2
Weld Point	None	None	None	None	None

HaloVac® Oils[2]	**HV100**	**HV125**	**HV190**
Applied Load (Kg)		**Scar diameter (mm)**	
100	0.56	0.50	0.51
126	0.57	0.56	0.58
160	0.65	0.62	0.67
200	0.75	0.70	0.72
250	0.80	0.80	0.80
315	0.88	0.88	0.89
400	0.97	0.97	0.96
500	1.13	1.10	1.06
620	1.28	1.21	1.25
800	1.62	1.50	1.51
Load Wear Index	>213.9	>222.6	>220.5
Weld Point	None	None	None

Halocarbon Greases	**19**	**25-5S**	**28LTI**	**X90-10M**	**25-10M**	**25-20M**
Applied Load (Kg)			**Scar diameter (mm)**			
100	0.58	0.56	0.53	0.61	0.57	0.54
126	0.58	0.57	0.63	0.62	0.60	0.58
160	0.69	0.59	0.69	0.64	0.63	0.62
200	0.72	0.64	0.71	0.75	0.64	0.70
250	0.73	0.80	0.85	0.78	0.76	0.79
315	0.87	0.85	0.93	0.90	0.88	0.97
400	1.01	1.11	1.06	1.11	1.06	1.14
500	1.30	1.21	1.12	1.25	1.15	1.25
620	1.30	1.47	1.41	1.36	1.47	1.49
800	1.44	1.68	1.43	Weld	1.53	1.72
Load Wear Index	214.7	>206.7	211.3	169.3	>211.8	>199.5
Weld Point	None	None	None	800kg	None	None

1. ASTM D2783 for Oils and ASTM D2596 for Greases.
2. See Vacuum Pump Fluids, page 13.

Material Compatibility

Elastomers and Plastics

The major portion of any elastomer is a specific cross-linked polymer, but its properties depend in large part upon fillers, plasticizers and other additives. In fact, the composition of the final item such as an O-ring or gasket is usually proprietary. Therefore, predictions about compatibility for a named elastomer must be viewed with caution. Plastics may also have additives in the finished product. A prudent approach would involve bench tests with the specific product under operating conditions.

Keeping these cautions in mind, we can report that Halocarbon oils have been found compatible with specific formulations of the following elastomers and plastics:

Ethylene propylene rubber
Polyvinyl alcohol
Neoprene
Teflon and other fluorinated plastics
Chlorinated polyethylene
Rigid PVC
Rigid CPVC
Viton, Fluorel
Polyimides
Polycarbonates
Fluorosilicone
Cured epoxies
Urethanes
EPDM (ethylene propylene diene rubber)

Most solvent-resistant elastomers and plastics are unaffected by Halocarbon fluids. However, within certain temperature ranges the fluids may dissolve in and seriously weaken the following materials:

Buna-N (butadiene/acrylonitrile)
Buna-S (butadiene/styrene) rubber
Silicone rubbers
Natural rubber
Polymers or copolymers of chlorotrifluoroethylene
PVC (polyvinyl chloride)

Metals

Halocarbon materials wet metallic surfaces readily and form lubricating films as do the more common lubricants.

Steel parts that have been lubricated with Halocarbon oils and then disassembled for inspection appear to have benefited from the lubrication even in severe service. However, it has been reported that the cleaned, disassembled parts rust rapidly on exposure to air. Rusting can be inhibited by keeping a thin film of oil on the part and where necessary using Halocarbon oil with rust inhibitor.

Halocarbon oils and greases are noncorrosive toward metals at temperatures up to about 350°F (177°C). However, copper and some of its alloys will discolor at temperatures over 120°F (49°C). Prior testing should be done on all metals for applications above 350°F (177°C) and on copper for applications above 120°F (49°C).

Applications

Aerospace Industry

The U.S. space and missile efforts use Halocarbon oils extensively as lubricants in the oxidizer section of the power plant. Oxygen loading systems for the space shuttles and emergency oxygen containers utilize Halocarbon oils and greases.

Many gyroscopes and accelerometers in inertial guidance systems depend upon custom tailored Halocarbon oils as the flotation and damping media needed for extreme accuracy. Halocarbon fluids for these uses are made to very narrow tolerances in density, viscosity, molecular weight distribution and other properties as required by the customer's specifications.

Chemical Industry

The widespread manufacture and use of aggressive chemicals has resulted in a growing need for Halocarbon oils, greases and waxes. They have proven to be safe and cost-effective in many applications where hydrocarbons, silicones and other fluids are not recommended because of the danger of rapid reaction, ignition or explosion.

Companies producing or using chlorine, bromine, sodium chlorate, sulfur trioxide, pulp and paper and swimming pool chemicals have used Halocarbon oils for years.

Diverse chemical applications for Halocarbon oils, greases and waxes include the following:

- Assembly of valves for hydrogen peroxide service
- Sodium or potassium chlorate pump oils
- Oil for bin vibrator in ammonium perchlorate service
- Bearing lubricant for perchlorate salts
- Lubrication of equipment used in fluorination process for blow-molded plastic bottles
- Fill fluid for mechanical seals (see page 12)
- Fill fluid for gauges in corrosive service
- Lubricant for pumps, gear boxes, conveyors used in tabletting and packaging swimming pool chemicals
- Die release in tabletting swimming pool chemicals
- Hydrogen sulfide service
- Water treatment systems
- Waste treatment systems
- Chlorine service:
  - Pump oils - vacuum and non-vacuum pump applications
  - Oil injected helical screw compressors
  - Valve and plugcock grease
  - Chlorine vaporizer lubrication
  - Valve stem lubricant
  - Assembly and repair of chlorine cylinder valves
  - Tank car maintenance
  - Thread lubricant

Cryogenic Gases

The expanding use of oxygen by industry has made necessary the continuing development and production of oxygen-compatible industrial plant equipment. Pumps, valves, compressors, seals and all accessory equipment currently in use have been developed to safely handle the everyday use of oxygen in industry. Halocarbon oils and greases are used to assist in the assembly of components and during their operation. Halocarbon waxes are used as protective coatings for inventoried parts cleaned for oxygen service.

Liquid oxygen (LOX) tank wagon pumps are lubricated with Halocarbon oil. In fact, cryogenic gas companies also use Halocarbon lubricants in their liquid nitrogen (LN_2) pumps to permit LN_2 tank wagons to be used in either LOX or LN_2 service. Before Halocarbon oil is used for the first time in such service, the unit must be made LOX clean. The use of Halocarbon oil will then qualify the unit as a LOX pump.

Note: For safety, special cleaning procedures must be used for components in LOX service. Special procedures are also required with oxygen enriched gases and other oxidizers. These procedures should be discussed with the supplier. Further information is also available from ASTM, CGA and NFPA.

Halocarbon lubricants have been used in the following services:

- Oxygen compressors with 10,000 psi output
- LOX pumps with 10,000 psi output
- Air compressors with 15,000 psi output
- Diaphragm compressor oil handling high pressure oxygen and other oxidizing gases
- Gearbox oil for cylinder-filling LOX pump
- Vacuum pump oils for evacuating oxygen cylinders
- Lubricants for oxy-acetylene welding equipment
- Lubricants for swivel joints in oxygen delivery systems to basic oxygen furnaces and space shuttle oxidizer tanks
- Lubricants for diving gear and self-contained breathing apparatus
- Oil for helium compressor
- Oxygen thread lubricant
- Oxygen rotary meter

Electrical Uses

Halocarbon oils have low dielectric constants and high resistivity. These properties, along with their inertness, make the oils useful for many electrical applications such as dielectric fluids.

Hydraulic Fluids

Halocarbon fluids are used in many hydraulic applications where nonreactive and nonflammable fluids are a necessity.

The U.S. Air Force, in seeking a nonflammable hydraulic fluid, has done extensive testing. Their tests have proved that Halocarbon fluids are nonflammable, exhibiting no flash or fire point under severe test conditions. In one test, Halocarbon oil is sprayed on a glowing red manifold at a temperature in excess of 1700°F (927°C) with no ignition. In another test, a fine mist of Halocarbon oil is sprayed into a propane-air flame. The Halocarbon oil does not ignite. Fluid classes the U.S. Air Force rejected as too flammable include phosphate esters, synthetic hydrocarbons and chlorophenyl substituted silicones. A number of fluid classes were rejected for failure to meet other critical physical properties, such as compressibility. Halocarbon oil was selected as the primary candidate for further fluid development research after an extensive evaluation program at the United States Air Force Research Laboratory, Wright-Patterson Air Force Base, Ohio.

The U.S. Army Tank Command has been interested in Halocarbon oils as nonflammable hydraulic fluids for a variety of uses in military vehicles.

Factory Mutual has approved several of our oils as Less Flammable Industrial Fluids.

Index Matching Fluids

Halocarbon fluids have refractive indexes ranging from 1.40 to 1.45. At the higher end, these fluids are close to matching silica's refractive index. They can be used as an index matching fluid in fiber optic connections and interfaces to avoid Fresnel reflection effects. An added feature is that these fluids are transparent to light in many wavelength regions, thus having low energy losses by absorbance.

Instrument Fill Fluids

Halocarbon oils are used in fluid-filled instruments where nonflammability, inertness and low compressibility are required. Strong oxidizing agents, such as oxygen, chlorine, fluorine (gaseous), nitric acid and hydrogen peroxide preclude the use of the more commonly used glycerine or silicone fill fluids. Halocarbon 4.2 and 6.3 oils are frequently used in this application. Halocarbon 27 oil is sometimes used where higher viscosity is preferable. Examples of instruments using Halocarbon oils are:

- Differential pressure transmitters
- Liquid level gauges/transmitters
- Pressure gauges
- Manometers
- Isolating diaphragms (snubbers)
- Process sensors
- Deadweight testers

Laboratory Apparatus

Substantial quantities of Halocarbon greases are used in laboratory apparatus as stopcock and ground joint lubricants and seals. Environmental Protection Agency Method 7—Determination of Nitrogen Oxide Emissions From Stationary Sources—mentions that a high-vacuum, high-temperature grease is required and that Halocarbon 25-5S grease has been found effective. Unlike many other synthetic lubricants, Halocarbon greases can be readily removed from glassware, ceramics and metal with common organic solvents.

Halocarbon greases are also used in standard taper joints in custom and stock glassware.

Life Support Systems and Diving Equipment

Halocarbon oils and greases are used to lubricate life support systems where an oxygen-enriched atmosphere (>25%) or high-pressure air is required. Examples are:

- Diving gear and nitrox systems
- Hyperbaric oxygen chambers
- Hospital oxygen systems
- Hospital nitrous oxide systems
- Home oxygen units
- Liquid oxygen respiratory equipment
- Anesthesia machines
- Portable oxygen generating plants
- Systems for evacuating and refilling oxygen bottles

Applications

Low-Temperature Bath Fluids

Constant-temperature baths used for calibrating instruments over a wide temperature range use Halocarbon 0.8 oil, particularly at low temperatures. It is nonflammable, has a low pour point (-200°F/-129°C), is easily pumped at low-temperatures and is not miscible with water. Any ice formed in the bath will float on the oil and is easily removed.

Halocarbon 0.8 oil can be used as a substitute in a number of low temperature applications where fluids currently used include ethylene glycol mixtures, methyl alcohol, isopentane and chlorinated solvents.

Mechanical Seals

Mechanical seals are employed in equipment used with many aggressive chemicals. In some cases the reaction between conventional barrier fluids and aggressive chemicals could be explosive. Halocarbon oils can be used as the mechanical seal barrier fluid in bromination, chlorination, fluorination, nitration, sulfonation reactions and many others.

Metalworking

The use of Halocarbon lubricants in precision machining or forming of high-tech metals is growing very rapidly.

For many years Halocarbon oil has been used in the machining of molybdenum. The Halocarbon oil dramatically increases tool life and eliminates the use of chlorinated solvents as a cutting oil in this application. Halocarbon oils are also used to machine tungsten metal.

Halocarbon oils have been found to be quite beneficial in the forming of tantalum, niobium and tungsten parts and the drawing of tantalum wire.

A Halocarbon wax is being used as a lubricant for the drawing of stainless steel pipe and wire. Woven wire and cable, used in aggressive service, are manufactured using Halocarbon oils as a processing lubricant.

Nuclear Industry

Halocarbon oils were originally developed for use in gaseous diffusion plants where isotopes of uranium were separated as uranium hexafluoride, an extremely reactive compound. Due to their chemical inertness, they were the ideal choice and were utilized as oils, greases and plastics. Halocarbon oils and greases are still being used by the nuclear industry where inert and nonflammable lubricants are required.

Pulp and Paper Industry

Many highly reactive chemicals such as chlorine, chlorine dioxide, sodium chlorate, calcium hypochlorite, sodium hypochlorite, oxygen, hydrogen peroxide, ozone and caustic soda are used in the pulping and bleaching processes. Halocarbon oils and greases are compatible with these chemicals and are finding increasing use in this industry.

While the use of elemental chlorine is declining as a bleaching agent, the use of oxygen and hydrogen peroxide is growing rapidly. The use of inert lubricants in these services is critical for safety.

Spill Control

A very effective application is the use of a thixotropic mixture of Halocarbon oil, silica and hollow glass microspheres to control the fuming from a sulfur trioxide spill. This mixture can be brought to the scene of the spill and applied as a fluid from a stirred vessel. Because of the mixture’s low bulk density, it will float on the surface of the spill. In minutes, a continuous film is formed preventing fuming and sealing out moist air. With the fuming under control, the spill can be approached for remediation.

Steel Industry

Halocarbon greases and oils are widely used in lances and swivel joints in systems feeding oxygen to steel making furnaces.

Vacuum Pump Fluids

Halocarbon oils are often used in applications where the reactivity of conventional oils presents severe safety and maintenance problems. For example, if a conventional vacuum pump oil is used in a pump evacuating a chlorine-containing system, the oil will sludge so badly that even one effective evacuation may not be possible. Explosive reactions can also occur.

Halocarbon has developed the HaloVac® line of oils to meet the needs of industry for inert, nonflammable, reliable vacuum pump oils. HaloVac oils are carefully tailored to specifications which combine low vapor pressures with viscosity characteristics suitable for mechanical pump systems. They are widely used in the semiconductor and printed wiring board industries where plasma etching, low pressure chemical vapor deposition and low temperature oxidation processes require inert vacuum pump oils. HaloVac oils are especially useful for aluminum etching processes where the aluminum chloride produced reacts with and decomposes perfluoropolyether vacuum pump oils.

In some processes, particulates, acids and other reactive materials end up in the pump oil. While none of these will affect HaloVac oils, filtration systems are available to remove them to keep the pump functioning.

Typical vacuum pump applications include:

- Plasma etching of semiconductors, printed wiring boards and photo-voltaic devices
- Plasma etching of aluminum with chlorine producing aluminum chloride
- Chemical vapor deposition and low temperature oxidation processes in the semiconductor industry
- Sampling of effluent gases for EPA testing
- Laser systems
- Plasma cleaning of electronic and medical devices
- Vacuum metallizing
- Surface treatment of plastics
- High purity graphite production
- Fluorination processes used for blow-molded plastic bottles

Further information about HaloVac oils is available upon request.

Other Applications

Halocarbon oils, greases and waxes also have many diverse applications not previously discussed. They include:

- Mold release agents for rubber and plastics
- Plasticizer for fluorinated plastics
- Component of specialty greases and engine oil additives
- Component of anti-seize compounds
- Potting and sealing waxes
- Heat transfer fluids
- Impregnant for gaskets and packings
- Valve lubricant in silane service
- Grease for semiconductor processing equipment
- Staging oil for microscopic biological specimens
- Fluid for suspension of mulls in infrared analysis
- Fluid for coal density tests
- Inert process fluids

Recycling Halocarbon Oils

With proper usage and maintenance, Halocarbon fluids can be restored to almost their original properties. They may not have to be disposed of or incinerated. In the long run this reduces your lubrication costs. Contact us about recycling your fluids.

Selecting a Halocarbon Oil

When replacing a conventional lubricant with a Halocarbon oil, there are practical and theoretical approaches to choosing the appropriate grade. Through experience we have found that a good choice is the Halocarbon grade numerically similar to the ISO Grade of viscosities. Table 7 shows the alignment of the commonly used viscosity systems as designated by the American Gear Manufacturers Association (AGMA). For example, Halocarbon 95 would be the choice to replace ISO 100 or other values in the same row.

If there are reasons for being more precise in grade selection, other factors should be considered. When changing to a Halocarbon oil, the viscosity in centipoises should be comparable to the fluid being replaced. The high density of Halocarbon oils means that the absolute viscosity, expressed in centipoises, is about twice the kinematic viscosity, expressed in centistokes. Even if the conventional lubricant viscosity is given in centistokes, the centipoise value (usually similar for fluids of density close to one) should be used. For Halocarbon oils, both the centipoise and centistoke values are given in Table 1 (see page 4) at several temperatures.

Another factor to be considered is the operating temperature. The viscosity of Halocarbon oil decreases as the temperature increases as shown in Figure 2 (see inside back cover). If the viscosity is known at the operating temperature for the specific application, this point can be located on Figure 2 (using the centipoise scale on the right) and the closest Halocarbon grade can be selected.

Table 7. Industrial Lubricant Viscosity Ratings

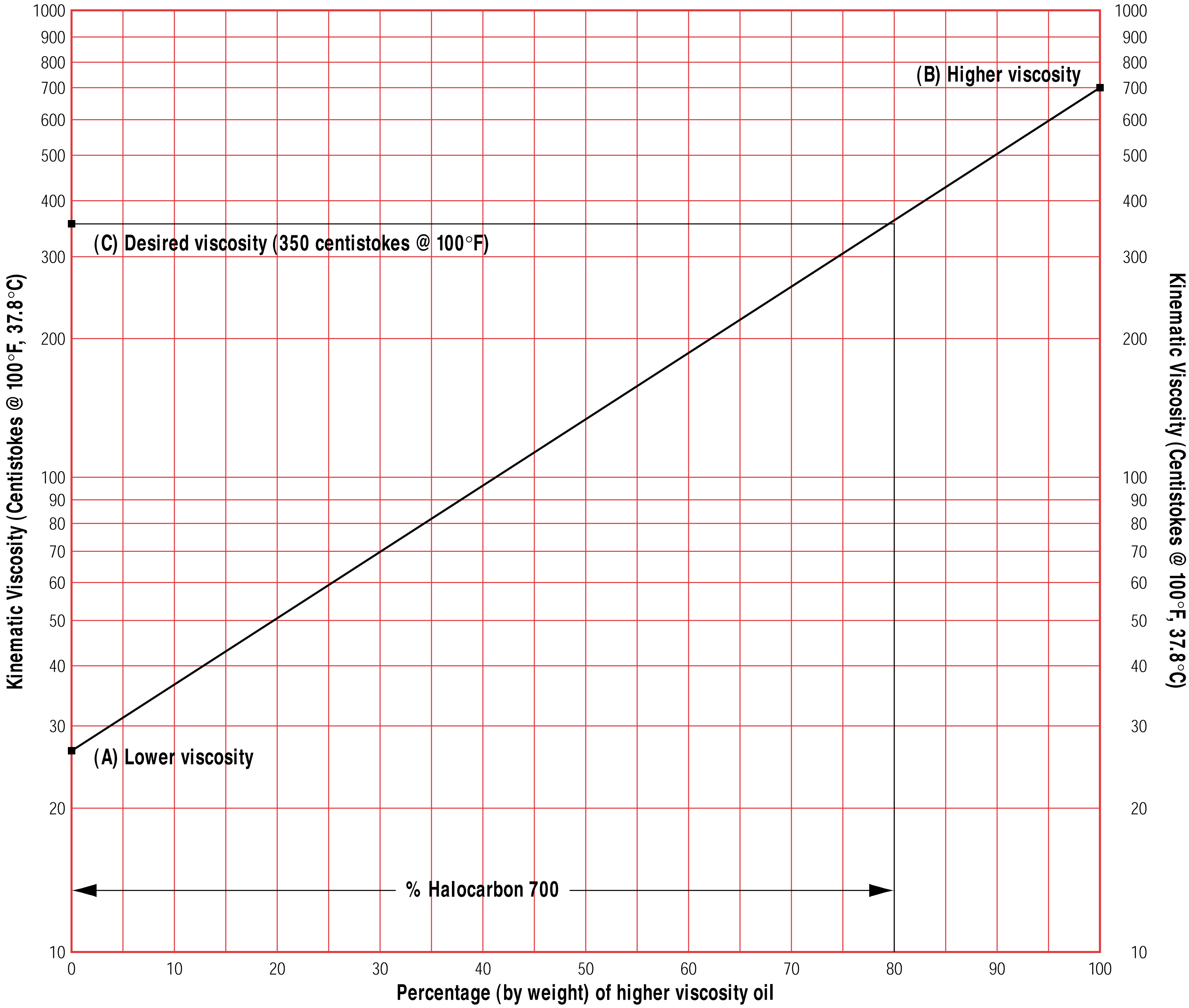
Halocarbon Oil Viscosity (Cs @ 100°F)	ISO Grade	AGMA Grade No. (Approx.)	S.A.E. Viscosity No. (Approx.)	S.A.E. GEAR Lubricant No. (Approx.)	Viscosity SUS at 100°F. (Approx.)
0.8					
1.8	2	—	—	—	29-35
4.2	5	—	—	—	36-44
6	10	—	—	—	54-66
	15	—	—	—	68-82
	22	—	—	—	95-115
27	32	—	10W	75W	135-165
	46	1	10	—	194-236
56	68	2	20	80W	284-346
95	100	3	30	—	419-511
	150	4	40	85W	630-770
200	220	5	50	90	900-1100
400	320	6	60	—	1350-1650
	460	7	70	140	1935-2365
700	680	8	—	—	2835-3465
1000					

Blending to a Custom Viscosity

Oils with viscosities between regular grades can be obtained from Halocarbon. Quantities can easily be blended also by the customer from two standard grades. For example, to obtain a 350 centistoke oil from Halocarbon 27 and Halocarbon 700 oils, the following procedure should be used with the aid of Figure 3:

1. Draw a line from 27 (A) on the left viscosity scale to 700 (B) on the right viscosity scale.
2. Locate the desired viscosity (C) on left scale.
3. Draw a horizontal line from this point to where it intersects the drawn line.
4. Draw a vertical line from the intersect to the bottom of the blending chart and read the required weight percent of 700 oil (i.e. 80 percent).
5. The required weight percent of 27 oil is 100 percent minus 80 percent or 20 percent.

Figure 3. Oil Blending Chart



Quality Assurance

Halocarbon oils are inert because the carbon chain, the backbone of the molecule, is completely halogenated. On the other hand, hydrocarbon oils and silicone oils contain a significant number of hydrogen atoms which react readily with aggressive chemicals. To be sure there are no hydrocarbon impurities in our lubricants, we rigorously exclude them in our processing. Our finished oils are analyzed by a method which can detect less than 10 ppm of hydrocarbon.

As rigorous as our control on hydrocarbon content is, we do have to recognize an exception. When a rust inhibitor is needed, 0.1% of a hydrogen-containing inhibitor is deliberately added. However, careful studies have shown that our rust-inhibited oils have the same oxygen compatibility as pure oils (Oxygen Inertness Tests, page 6).

Another possible reactive site is what chemists call “unsaturation” (carbon-carbon double bonds). If unsaturation is present, it will react, in time, with air and moisture to form strong acids which are corrosive to metals. The oil processing is carefully controlled to eliminate any unsaturation. Our specification involves a very sensitive permanganate oxidation test for unsaturation in our oils.

Acidity, for obvious reasons, is undesirable in lubricating fluids. Halocarbon specifies that our oils contain less acidity than that measured by 0.0002 mg KOH/g of oil; that is essentially nil. Oils containing the rust inhibitor, which contains carboxylic acid groups, will show acidity by this test but these groups are weak and noncorrosive.

Toxicity

There have been several toxicity studies on various grades of Halocarbon oils. The most significant of these studies was performed on a 3 centistoke oil, using the inhalation route of administration on both rodents and primates. Based on all the available data in three species of animals, limited exposure to Halocarbon oil should not be harmful to any portion of the human anatomy. Studies conducted by the Air Force have demonstrated liver toxicity in rodents, but not in primates. The observed liver toxicity is believed to be specific for rodents and not relevant to humans.

Halocarbon oil is not irritating to skin but simple skin protection should be used to prevent repeated exposure and the possibility of sensitization.

All mutagenicity studies were negative.

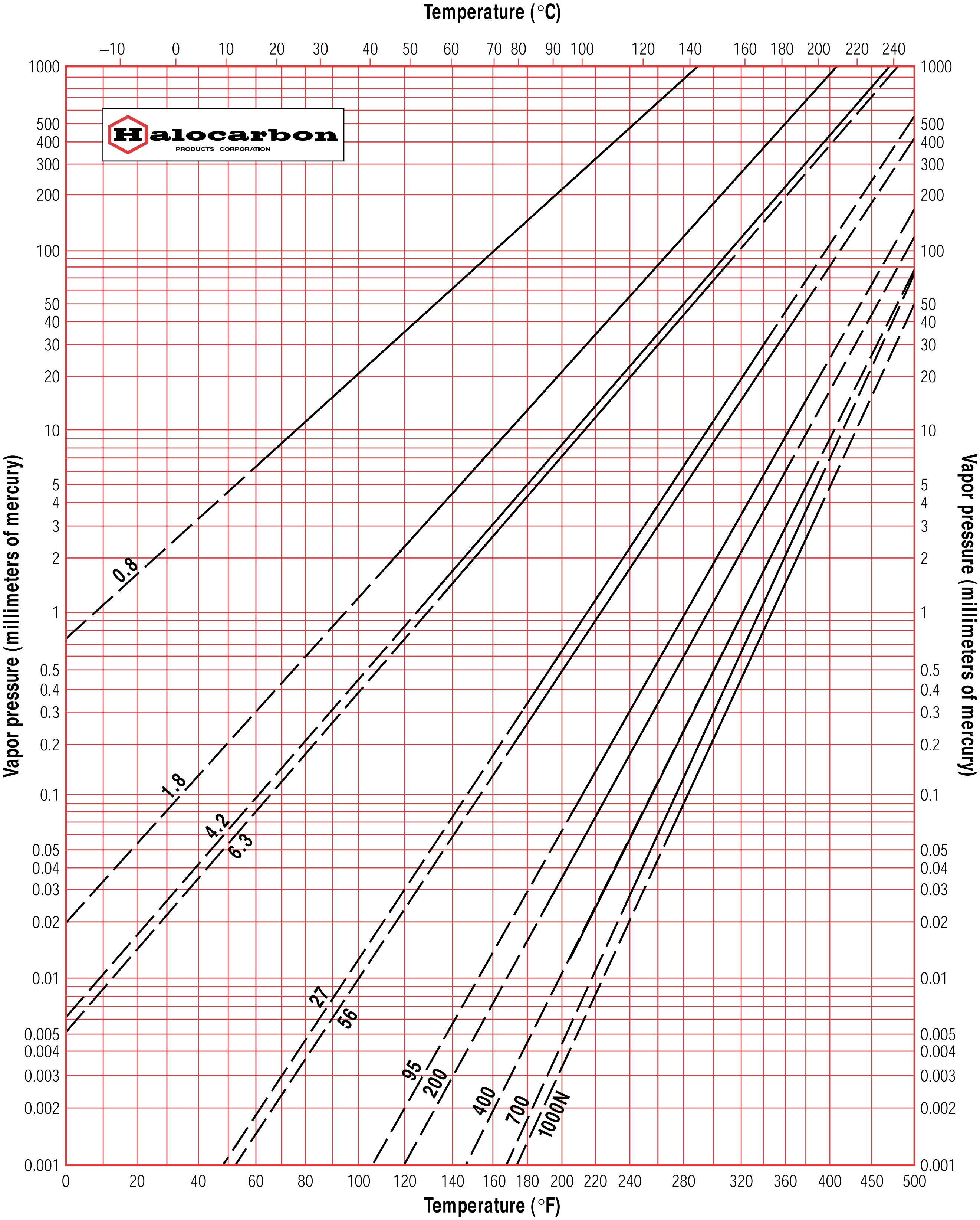
Oral toxicity studies were performed with Halocarbon 27 oil. This oil caused no deaths in rats dosed daily for 21 days with 2.5 g/kg orally. Symptoms attributed to fluoride poisoning by metabolism in the liver were noted. Enlargement of the livers and kidneys in the treated animal support this conclusion.

Please consult the appropriate MSDS before use.

Toxicity at Temperatures Above 500°F (260°C)

As mentioned earlier, the oils are subject to thermal cracking above 580°F (304°C) with rapid breakdown occurring above 620°F (327°C). This breakdown may occur from heating in a vessel or operating equipment, or from the vapors coming in contact with an open flame. Breakdown products in air form acidic substances which produce harmful physiological effects.

Figure 1. Typical Vapor Pressures of Halocarbon Oils



1 mm Hg (@0°C) = 1 torr = 133.32 Pa = 1.33mbar

Typical Viscosity vs. Temperature

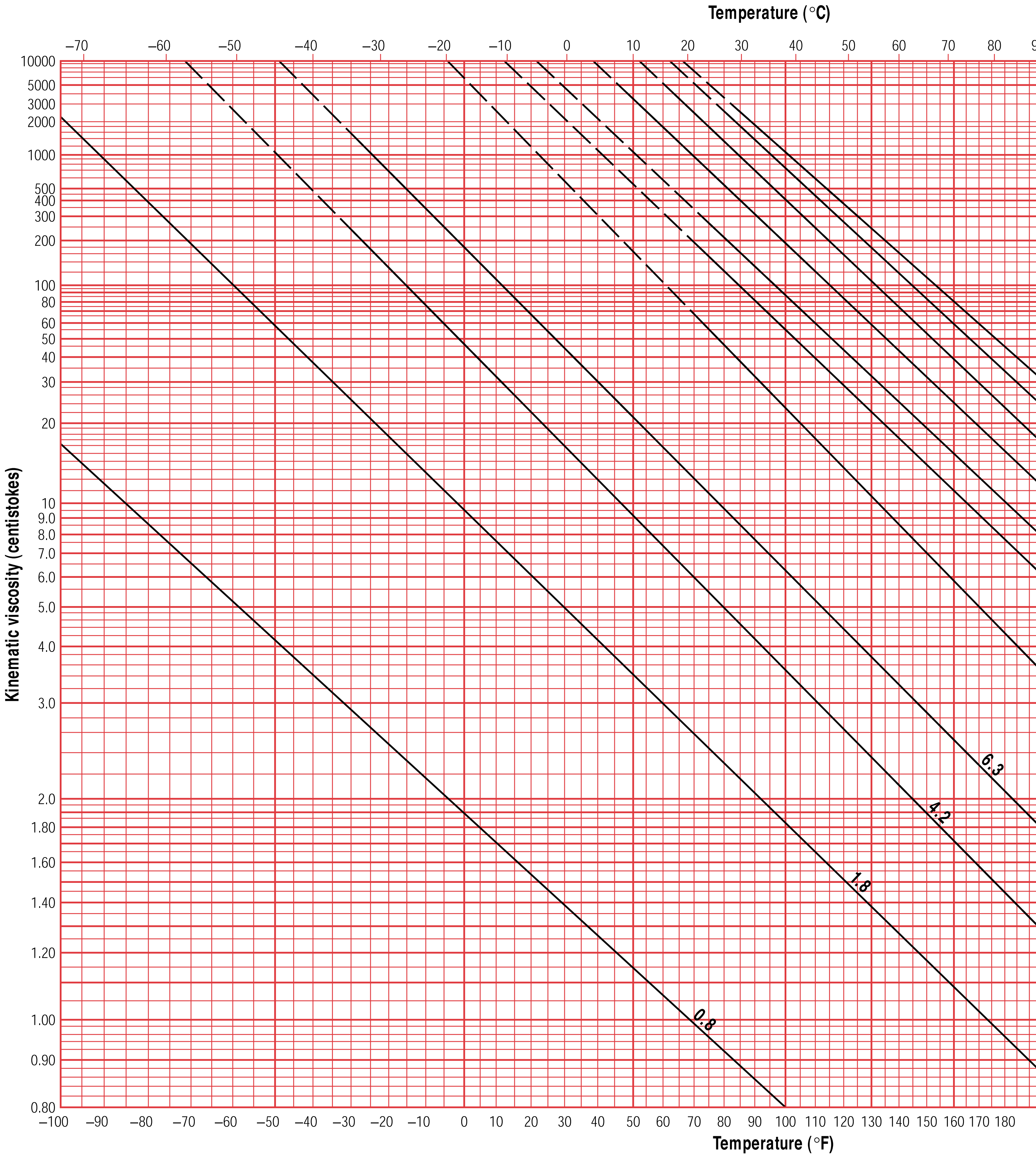
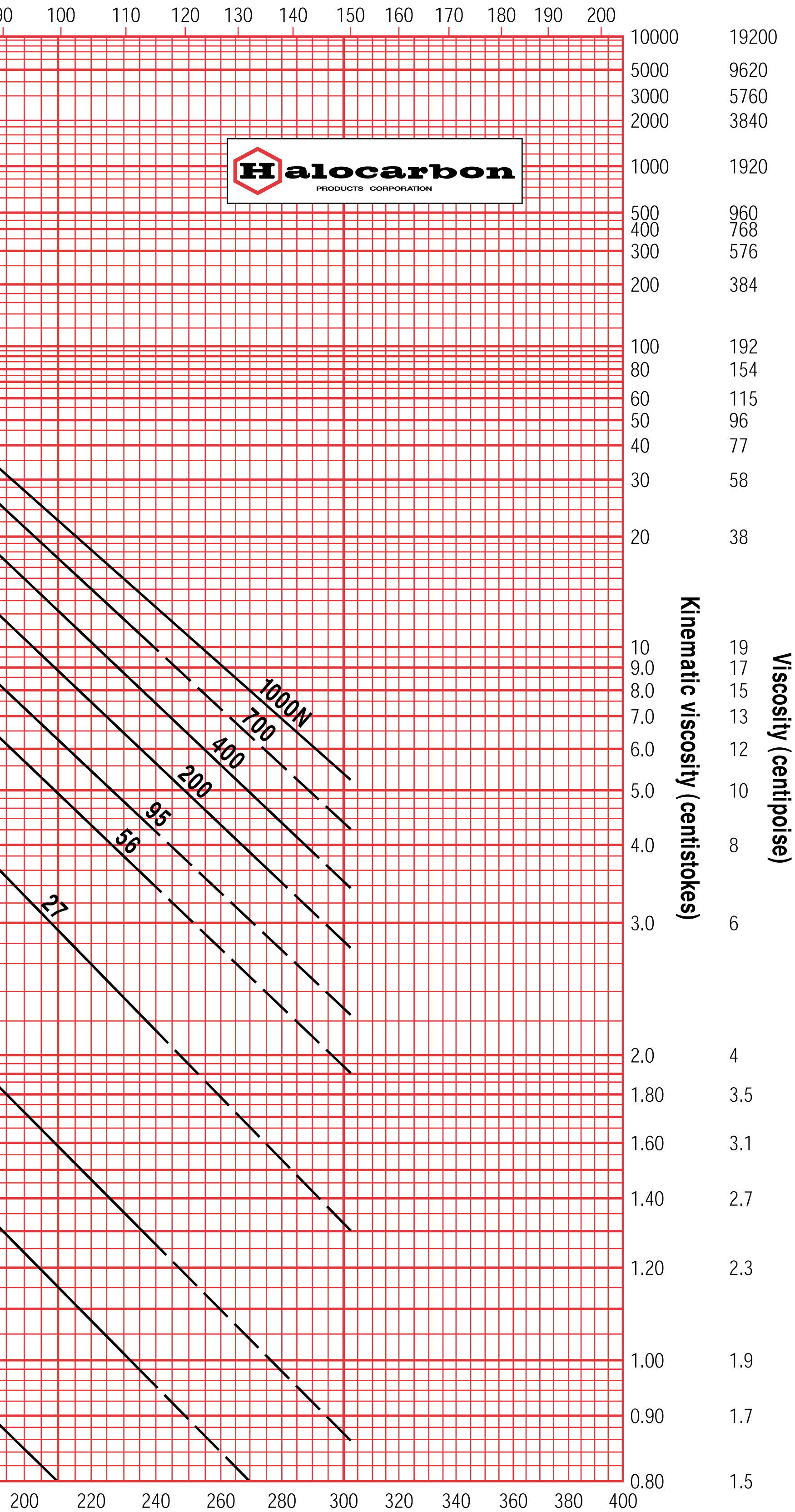


Figure 2. Typical Viscosity vs. Temperature of Halocarbon Oils

Modified ASTM D-341

(Centipoise scale assumes a density of 1.92g/mL)



Halocarbon's production facility in North Augusta, South Carolina.

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