COMPATIBILITY

The fully fluorinated structure of the "Fluorinert" Liquids results in a high degree of compatibility with most metals, plastics and elastomers used in the construction of components or equipment. The characteristics of the liquids, as well as the materials in contact with them, remain essentially unchanged for the products boiling below 155°C. The "Fluorinert" Liquids FC-40, FC-43, FC-70, FC-71, when used at their boiling points, may liberate trace amounts of decomposition products that can form corrosive acids in the presence of water. The rate of decomposition will increase with an increase in boiling temperature.

Table 10 lists some of the common metals that are used in contact with the "Fluorinert" Liquids at their boiling points below 155°C. The discoloration sometimes observed with bright copper has been shown to be due to dissolved oxygen in otherwise uncontaminated "Fluorinert" Liquids. It would not occur with carefully deaerated liquids.

Tables 11A through 11E summarize the effects of several "Fluorinert" Liquids on various elastomers and plastics at several temperatures. An examination of these data will provide the user with some general indications of compatibility.

For example, the volume change of elastomers and plastics is extremely low in "Fluorinert" Liquids. Some tests involved several weeks' exposure at 100°C. Less than 3% volume swell was found in all cases except polypropylene and fluorinated elastomers. The polypropylene showed 9 to 11% swell, but also showed 9% swell in air. The fluorinated elastomers showed less than 10% swell, which is not excessive for a material similar in chemical composition (i.e. both are fluorinated organic compounds).

A comparison of volume change of a typical elastomer in "Fluorinert" Liquids vs. some common solvents gives a good perspective of the excellent compatibility properties of "Fluorinert" Liquids. Chloroprene (polychlorobutadiene) elastomer in FC-77, FC-43 or FC-75 under goes a slight change in volume (about ±1% at 75 to 110°C, Tables 11A and 11C). Tests show this elastomer undergoes an increase in volume in some common solvents at 54°C[2] — over 200% in trichloroethylene or methyl chloroform, 37% in Stoddard Solvent, and 9% in Refrigerant 113.

Tables 11A and 11B show that changes in some properties may be due to temperature rather than an effect of the "Fluorinert" Liquid. Tensile strength, hardness and volume exhibit about the same amount of change in air as in "Fluorinert" Liquids in many cases.

[1]Lee, Linda H., **Corrosion-NACE**, 26(12), 529-32 (1970)

[2]Calculated from linear swell data given in Freon® Solvent data, Bulletin FST-1, E.I. DuPont de Nemours & Co., Wilmington, Delaware.

Polypropylene became brittle after 6 months at 75°C in air as well as in FC-77 and FC-43. It also showed about the same increase in volume in all three cases. Hardness changes in most cases were about the same in air as in FC-77 and FC-43. PTFE became somewhat softer in the "Fluorinert" Liquids than it did in air, as might be expected, and silicone elastomer became somewhat harder. Fluorinated elastomers and PTFE decreased more in tensile strength in FC-77 than in air, but silicone elastomers increased in tensile strength after exposure to "Fluorinert" Liquids while showing no change in air.

The tabulated data represent random samples of standard commercial materials. Compounding formulations, curing conditions, the presence or absence of additives such as plasticizers, lubricants, fillers, etc. vary between manufacturers. Because of their excellent wetting characteristics, the "Fluorinert" Liquids tend to displace additives such as plasticizers which may then become dispersed in the "Fluorinert" Liquid. Such contamination is most likely at elevated temperatures and, if redeposited, could be harmful in some applications.

For the above reasons the user is cautioned against using the tabulated data alone as a basis for deciding on the suitability of a particular product.

The first step in selecting a product for use with "Fluorinert" Liquids is to make certain it has the required heat resistance at the expected operating temperature. The next step is to determine whether the product can be formulated without plasticizer and still meet hardness and flexibility requirements. For example, ethylene-propylene rubber is inexpensive and has good heat resistance, but is ordinarily compounded with large amounts of plasticizer and fillers. If the properties of the unplasticized product are not acceptable, it may be necessary to use the more expensive silicone or fluorinated elastomers.

In most applications at moderate temperatures, butyl, chlorosulfonated polyethylene, nitrile, or chloroprene elastomers are entirely satisfactory with "Flourinert" Liquids. Because of the wide variety of formulations available, however, it is usually advisable for the user to test the compatibility under use conditions.

TABLE 10
ANTICIPATED EFFECTS OF BOILING "FLUORINERT" LIQUIDS ON VARIOUS METALS

PRODUCT (Boiling Point)	FC-72 (56°C)	FC-84 (80°C)	FC-77 (97°C)	FC-104 (101°C)	FC-75 (102°C)
METALS (10 days minimum exposure)					
ALUMINUM	A	A	A	A	A
MAGNESIUM	A	A	A	A	A
STAINLESS STEEL	A	A	A	A	A
COPPER	B	B	B	B	B
BERYLLIUM	A	A	A	A	A
BE-CU-ALLOY (98% Cu)	A	A	A	A	A

A. No discoloration or destruction of fluid or metal at temperatures indicated.
B. Possible discoloration of metal due to dissolved oxygen.

TABLE 11A
COMPATIBILITY OF VARIOUS ELASTOMERS WITH FC-77 AND FC-43 COMPARED TO AIR, 6 MONTHS EXPOSURE AT 75° C

Property	Test Medium	Elastomer Type			
		Butyl	Chloroprene	Fluorinated	Silicone
% Change in Tensile Strength	Air	−28	−11	+1	0
	FC-77	−38	−15	−20	+6
	FC-43	−34	−17	−12	+5
Change in Shore A Hardness	Air	+3	−3	−3	+3
	FC-77	+3	−3	−4	+6
	FC-43	+3	−3	−2	+6
% Change in Weight	FC-77	+0.9	+0.3	+4.9	−3.2
	FC-43	+1.2	+0.3	+2.1	−2.0
% Change in Volume	Air	−1.2	−0.8	−0.7	-
	FC-77	−0.3	−1.0	+0.4	-
	FC-43	−1.6	−0.3	+1.0	-
Change in Appearance	Air	None	None	None	None
	FC-77	None	None	None	None
	FC-43	None	None	None	None

TABLE 11B
COMPATIBILITY OF VARIOUS PLASTICS WITH FC-77 AND FC-43 COMPARED TO AIR 6 MONTHS EXPOSURE AT 75° C

Property	Test Medium	Plastic Type				
		PCTFE[1]	PTFE[2]	Poly-propylene	Nylon	Poly-ethylene
% Change in Tensile Strength	Air	−12	−4	brittle	−	+3
	FC-77	−12	−20	brittle	−1	brittle
	FC-43	−12	+4	brittle	−7	+3
Change in Shore D Hardness	Air	+2	0	0	+3	
	FC-77	+2	−11	0	+3	
	FC-43	+2	−7	0	+2	
% Change in Weight	FC-77	+0.4	+7.3	+0.8	0	−0.8
	FC-43	+0.3	+6.5	+1.8	+0.7	−0.3
% Change in Volume	Air	+1.1	+1.3	+ 9.1	+0.6	
	FC-77	+1.1	+3.0	+11.4	+9.2	
	FC-43	+0.9	+2.5	+ 9.3	−0.2	
Change in Appearance	Air	None	None	Dark	Discolored	None
	FC-77	None	None	Dark	Discolored	None
	FC-43	None	None	Dark	Discolored	None

[1]Polychlorotrifluoroethylene
[2]Polytetrafluoroethylene

TABLE 11C
COMPATIBILITY OF "O" RINGS WITH FC-75
7 DAYS EXPOSURE AT 110° C

Elastomer Type*	Property		
	Change in Shore A Hardness	% Change in Weight	% Change in Volume
Butyl #1	+5	+0.3	+1.9
Butyl #2	+13	+0.1	+0.3
Chlorosulfonated polyethylene	+11	−0.6	+0.1
Chloroprene #1	+7	−0.1	+0.4
Chloroprene #2	+9	−0.7	+1.2
Nitrile #1	+8	−0.3	−0.8
Nitrile #2	+10	−0.2	+0.8
Silicone #1	+2	+4.0	+2.1
Silicone #2	+6	+2.5	+1.6
Polysulfide #1	+11	−1.7	+0.2
Polysulfide #2	0	−0.7	+1.3
Fluorinated #1	+4	+7.4	+5.0
Fluorinated #2	+1	+8.5	+9.2

*#1 and #2 refer to different "O" ring manufacturers.

TABLE 11D
COMPATIBILITY OF "O" RINGS WITH FC-77

Elastomer Type	Exposure		Property		
	Temp. ° C	Time	Change in Shore A Hardness	% Change in Weight	% Change in Volume
Chloroprene	25	1 week	+1	-0.1	-0.2
	100	1 week	+6	-0.4	-0.8
Nitrile	25	1 week	−2	−0.1	0
	100	1 week	+2	−0.8	−1.1
	25	12 weeks	+1	−0.2	−0.4
Silicone #1	25	1 week	0	−0.3	+0.4
	100	1 week	+2	−0.7	+1.1
	25	12 weeks	0	−0.3	−0.6
	100	12 weeks	0	−0.5	−0.7
Silicone #2	25	1 week	+3	−0.3	+0.8
	100	1 week	+3	−0.3	+1.8
	25	12 weeks	0	0	−0.2
	100	12 weeks	+1	−0.1	−0.2
Ethylene-propylene	25	1 week	+2	0	-0.1
	100	1 week	+1	−0.1	-0.2
	25	12 weeks	0	0	-0.2
	100	12 weeks	+1	0	-0.1
Fluorinated	25	12 weeks	+1	+0.5	+0.1
	100	12 weeks	−2	+6.2	+7.2

TABLE 11E

COMPATIBILITY OF VARIOUS MATERIALS
SUMMARY OF USER'S REPORT
FC-77 EXPOSURE, 4 WEEKS AT 49°C

Material	Comments
Epoxy	Five of six epoxies tested OK. Sixth showed excess hardness increase (14 Shore D units)
Polyimide	OK
Silicone Conformal Coating	Very Good
Polyester	Two tested fully compatible