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Material Compatibility Evaluations of HFC-245ca, HFC-245fa, HFE-125, HFC-236ea, and HFC-236fa

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Abstract

This paper presents data pertaining to stability and material compatibilities determined for HFC-245ca, HFC-245fa, HFC-236fa, HFC-236ea, and HFE-125. Following ASHRAE guidelines, material compatibility tests using 11 elastomers, 4 plastics, 5 metals, and 4 desiccants were conducted with the aforementioned refrigerants both in the presence and absence of a polyolester (POE) lubricant. The metals (copper, steel, aluminum, brass, and bronze) were found to be compatible with both the refrigerants and POE oil. Three of four MOLSIV® type desiccants (4A-XH-6, XH-7, and XH-9) yielded no discernible amount of fluoride, while a small amount was found in 4A-XH-5. However, trace amounts of fluorine-containing byproducts were detected by GC/MS for all four desiccants. Based on physical characteristics, unsatisfactory performance across all refrigerants with and without lubricant was found with fluoropolymers, hydrogenated nitrile butyl rubber, natural rubber, and Neoprene®.

Introduction

Four relatively new hydrofluorocarbons (HFCs) and one hydrofluoroether (HFE) were subjected to sealed tube stability and compatibility testing with several metals, desiccants, elastomers, and plastics. HFC-245ca has received attention as a potential alternative for chlorofluorocarbon (CFC)-11 and hydrochlorofluorocarbon (HCFC)-123 in low pressure chillers. HFC-245fa has also been considered for use in chillers and is currently being evaluated as a blowing agent for polyurethane foams. HFC-236ea has several attributes that make it a strong contender as an alternative refrigerant for CFC-114 and as a foam blowing agent. HFC-236fa is an alternative refrigerant for CFC-114 in chillers and is also being marketed as a fire extinguishing agent. HFE-125 has thermophysical properties that make it an excellent candidate alone or blended with other refrigerants to replace R-502. However, the measured reaction rate of HFE-125 with hydroxyl (OH) radical is sufficiently slow to warrant some concern about the direct global warming potential of HFE-125.

Results of preliminary studies of the compatibilities of HFC-245ca, HFC-245fa, and HFC-236ea with selected lubricants and engineering materials common to refrigeration systems have been reported previously.[1-3] Investigations of the compatibility of several HCFCs and HFCs (including HFC-245ca) with various motor materials (e.g., wire coatings, sheet insulation, and tie cords) have been conducted by the Trane Company in work performed for the Air-Conditioning and Refrigeration Technology Institute (ARTI).[4] A similar compatibility study of these same refrigerants (but excluding HFC-245ca) with elastomers was performed by the University of Akron for ARTI.[5] Spauchus Associates also performed sealed tube comparisons of the compatibility of the desiccants with various lubricants and refrigerants but did not include any of the refrigerants reported here.[6] The present study was undertaken to expand the compatibility database for the propane-based HFCs. In addition, it will help to determine if commonalities or trends in the compatibilities of these structurally related refrigerants and HFEs exist which might make future selection of optimum materials easier. An exhaustive survey of the numerous elastomer formulations, plastics, and desiccants commercially available was not attempted. Motor materials except for Mylar® also were not included in the matrix of materials examined in this work since the earlier ARTI study focused on these materials and included HFC-245ca among the refrigerants studied.

Experimental Methods

All refrigerants were obtained commercially from chemical suppliers and were determined to have a purity greater than 99.5% except some of the HFC-245fa samples which had a purity of 98.7%. For all refrigerants except HFE-125, a fully formulated commercially available polyolester (POE) lubricant with a viscosity of 68 centistokes (cSt)[c] was used. A similar commercial lubricant of 32 cSt viscosity was used with the HFE-125. All lubricants were dried under vacuum to contain no more than 50 ppm water prior to use. Moisture content in the lubricants was determined by Karl Fischer titration.

As a preliminary evaluation of the thermal and hydrolytic stability of these refrigerants and their compatibility with common engineering materials, a series of sealed tube samples was prepared. These samples were subjected to sustained heating for a period of 14 days in accordance with the methods described in ANSI/ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) Standard 97-1989[7].

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[c] 1 cSt = 1x 10^{-6} m^2/s

Thermal stability tests for these refrigerants were carried out with metals at 175°C for 14 days. Compatibility tests of plastics, desiccants, and elastomers were carried out in an analogous way but at 125 °C. All materials were tested with refrigerants both in the presence and absence of the POE lubricant. Duplicates of each sample combination were tested. Elastomers were commercially available O-rings (except Geolast® which was obtained as a 3 mm thick sheet) while plastics were either O-rings (Teflon®) or rectangular strips (Mylar®, Nomex®, nylon 6,6) cut to a size convenient for insertion into the 7-mm inside diameter borosilicate tubes.

A Hewlett-Packard 5890 Gas Chromatograph equipped with Flame Ionization Detector (GC/FID) and Chrompack column, a Hewlett-Packard 5970 GC equipped with a Mass Spectroscopy Detector (GC/MSD), and a Nicolet Magna 550 Fourier Transform Infrared (FTIR) Spectrometer interfaced with a Hewlett-Packard 5890 Chromatograph were employed for gas-phase analysis of both fresh and aged refrigerant. Fresh and aged POE lubricants were analyzed using the Nicolet Magna 550 FTIR Spectrometer with Horizontal Attenuated Total Reflectance (FTIR/HATR). Conditions for GC/FID measurement were: 40 °C isothermal column temperature, 10 minutes run time, and 10.0 µL sample injection by a 10-µL SGE or Hamilton #1701 gastight syringe.

All dimensional measurements of the elastomers and plastics were made within 12 hours following removal of the materials from the sealed tubes. Tensile properties (e.g., elongation-to-break) were determined by an Instron Mini-55 within 24 hours after removal of the materials from the sealed tubes. Weight change was measured within 30 minutes following removal of the materials from the sealed tubes and is accurate within ±0.5 percent. Volume change within ±3 percent was determined by measuring the physical dimensions of the materials with a digital caliper and applying appropriate mensuration formulae. Linear swell was likewise determined by dimensional measurement and is deemed accurate to ±2 percent. Hardness was determined with a Shore M Type Durometer to within ±2 percent.

Detailed formulations (e.g., percentages of base polymer, fillers, plasticizers, mold release agents, curatives, and accelerators) for the individual elastomers studied were not available from the supplier. Therefore, the extent to which variations in the formulations for the elastomers could affect the compatibility results was not evaluated. It is possible that different formulations for a particular generic type of elastomer could result in slightly different behavior than reported here. A description of the polymeric materials is given in Table 1.

Evidence for refrigerant degradation was sought by comparison of the infrared spectra and gas chromatograms of the vapor phase from each of the aged samples against those of unaged refrigerants. Degradation of aged lubricants in the samples was assessed by infrared spectral comparison with the unaged lubricant.

Four molecular sieve desiccants (beads) were also tested with the refrigerants and refrigerant/POE oil mixtures, with the exception of HFE-125. The nominal pore sizes of the molecular sieves are 4.0 Å for 4A-XH-5 and 3.0 Å for the other desiccants. These desiccants were activated before use by heating in an oven at 275 °C for at least 2 hours. Specifically, each desiccant type was analyzed for any fluoride content which might have been deposited as a result of refrigerant degradation during accelerated aging. Fluoride determinations were performed on the aqueous distillate collected after passing steam over a bed of desiccant mixed with a small amount of vanadium pentoxide in a nickel tube heated to 975 °C. Fluoride concentrations in the resulting distillates were measured with a fluoride ion selective electrode.

RESULTS

Metals

None of the five metals (i.e., aluminum, copper, cast iron, brass, and bronze) were found to cause chemical breakdown within the detection limits of our GC and GC/FTIR instrumentation. Thus, these metals are deemed to be appropriate for use with the alternative refrigerants and POE lubricant.

Desiccants

None of the four desiccants tested contained measurable amounts of fluoride ion prior to aging with the refrigerants and lubricants. Following the aging process, only 4A-XH5 showed the presence of fluoride ion (< 4 percent). This increase of fluoride content occurred with this desiccant in contact with HFC-245fa, HFC-236fa, and HFC-236ea, with and without the lubricant present. This result suggests that these refrigerants were slightly degraded in contact with 4A-XH-5 but not with the other three desiccants. GC and spectral examination of the vapor in the tubes following the aging process indicated trace amounts of possible refrigerant degradation products regardless of the desiccant used. The complete data are shown in Table 2.

Elastomers and Plastics

Infrared spectral changes observed in the liquid phase for some of the samples containing elastomers/plastics could not be attributed unambiguously to degradation of the elastomers/plastics, lubricant, or both. The most likely source of these new infrared absorption features seem to be leaching of some components of the polymeric materials, such as fillers, accelerators, or plasticizers.

In addition to gas and liquid phase analyses, physical characterizations were also performed on the elastomers and plastics. Tables 3 - 5 tabulate the observed changes in hardness/weight, elongation-to-break, and linear swell/volume, respectively, for the elastomers and plastics tested. Values represent averages of the duplicate samples for each material.

To distinguish the performance of various elastomers and plastics, the set of criteria shown in Table 6 was applied to the data. Some swelling of elastomeric materials is acceptable for gaskets and O-rings to form a good seal in equipment. However, volume increases of greater than 20 percent or linear swell of greater than 5 percent may be considered excessive and detrimental. Also, any shrinkage of the material is not desired. A change in hardness of ±10 percent may indicate excessive softening or embrittlement and may be considered unacceptable. Depending on where in the equipment the engineering materials are placed, the O-ring and gasket materials may experience contact primarily with the refrigerant or with a combination of refrigerant and lubricant. Therefore, a given elastomer or plastic may be suitable for use in one section of the equipment and not in another. Although the data are herein analyzed according to the criteria listed in Table 6, readers may wish to select other values that may be more appropriate for the intended application.

Applying Table 6 criteria, the observed property changes can be plotted as in Figures 1 - 10. To simplify the presentation, these figures show the data for only those materials that performed marginally or unsatisfactorily. In each of these figures, any percentage change beyond the solid line indicates that the specimen performed unsatisfactorily, while any percentage change between the solid and dotted lines indicates a marginal performance. The solid and dotted lines incorporate the uncertainties in measurements with Table 6 criteria. It should be emphasized that the materials that performed well with the refrigerants and refrigerants combined with POE oil are not shown in these figures.

Table 4 shows the change in the percent of elongation at the maximum load for each elastomer. Elongation results are available for all refrigerants except HFC-245fa and HFE-125. In this case, the materials are evaluated to the point of failure which may be indicative of their structural integrity. The data indicate that the elastomers in our test matrix, except S-70, experienced some degree of deterioration during the aging process. These reductions in tensile performance range from 10 percent for Teflon to almost 80 percent for E-70.

CONCLUSIONS

Tables 7 and 8 rate each of the polymers with regard to each criterion (listed in Table 6) as "satisfactory," "marginal," or "poor" (blank, O, ●, respectively). Based on our criteria, across all refrigerants with and without lubricant, Buna-N, Geolast, Hypalon, Buna-S, S-70, and E-70 appeared to be acceptable performers overall.

Fluoropolymers, namely, Viton-A, Kalrez-C, and Teflon, were especially susceptible to absorption of the refrigerants resulting in unacceptable swelling. HNBR and natural rubber showed excessive swelling in the presence of POE oil. Neoprene was deemed unsuitable due to shrinkage and embrittlement in the presence of refrigerant with and without POE oil. Thiokol was also examined early in the test program, but was discontinued because this material easily degraded to the point that measurements could not be performed. Therefore, these materials are *probably not* suitable for use with these refrigerants/lubricant systems. In contrast, the aluminum, cast iron, copper, brass, and bronze appeared to work well with all refrigerants and refrigerant/POE oil combinations. On balance, the MOLSIV desiccants appeared to be compatible with all refrigerants and lubricants with a possible exception of 4A-XH-5.

Sealed tube compatibility tests such as described here are meant to be only suggestive of possible incompatibilities in actual practice. However, these results have proven in the past to be helpful in narrowing the initial choices of engineering materials for operating systems. The final selection of a material is application specific, and many factors need to be considered, including operating temperature, operating pressure, contact with other materials, mechanical construction of equipment, expected lifetime, and cost.

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Table 1. Description of Polymeric Materials

Materials *	Description
Buna™-N	Copolymer of 1,3-butadiene (70 %) and acrylonitrile (30 %)
E-70 or EPDM	Ethylene propylene diene polymethylene rubber
Geolast®	Nitrile polypropylene
HNBR	Hydrogenated nitrile butyl rubber, hydrogenated butadiene acrylonitrile copolymer
HYP or Hypalon®	Chlorosulfonated polyethylene
Kalrez®-C	Perfluoropolymer of tetrafluoroethylene and perfluoromethyl vinyl ether
Natural rubber or PG-35	Isoprene polymer
Buna™-S	Copolymer of 1,3-butadiene (70-75%) and styrene (25-30%)
Neoprene 3229	Polychloroprene
S-70 or SI	Silicone rubber
Viton®-A	Copolymer of vinylidene fluoride and hexafluoropropylene
Mylar®	Polyethylene teraphthalate
Nomex®	Polymer of m-phenylenediamine and isophthalic acid chloride
Nylon 6,6	Polymer of adipic acid and hexamethylenediamine
Teflon®	Polymer of tetrafluoroethylene

* Thiokol™ was also examined early in the test program, but was discontinued because this material easily degraded.

Table 2. Percent Fluoride in Activated Desiccants*

	% CHANGE WITHOUT POE					% CHANGE WITH POE				
Desiccants	HFC 245ca	HFC 245fa	HFC 236fa	HFC 236ea	HFE 125	HFC 245ca	HFC 245fa	HFC 236fa	HFC 236ea	HFE 125
XH-5	0	2.67	1.66	3.02	0	0	2.43	0.12	2.02	0
XH-6	0	0	0	0	0	0	0	0.30	0	0
XH-7	0	0	0	0	0	0	0	0	0	0
XH-9	0	0	0	0	0	0	0	0	0	0

- HFE-125 - no desiccant data available; all desiccants are of the form 8x12 beads.

Table 3. Percent Change in Hardness and Weight for Polymers

Polymers	% CHANGE WITHOUT POE HARDNESS					% CHANGE WITH POE HARDNESS					% CHANGE WITHOUT POE WEIGHT					% CHANGE WITH POE WEIGHT				
	HFC 245ca	HFC 245fa	HFC 236fa	HFC 236ea	HFE 125	HFC 245ca	HFC 245fa	HFC 236fa	HFC 236ea	HFE 125	HFC 245ca	HFC 245fa	HFC 236fa	HFC 236ea	HFE 125	HFC 245ca	HFC 245fa	HFC 236fa	HFC 236ea	HFE 125
Buna-N	- 6.82	9.33	- 4.51	- 7.51	20.83	- 6.57	4.55	- 5.00	- 5.59	-10.28	31.54	8.99	9.43	26.43	2.57	22.95	14.52	5.85	12.76	24.27
E-70	2.61	6.08	- 1.96	- 8.56	4.47	14.96	7.57	4.61	7.82	- 1.32	5.02	2.46	2.06	2.40	1.38	- 3.45	6.67	- 3.13	- 1.91	8.51
HNBR	- 9.14	- 6.18	- 5.91	-11.27	12.58	- 9.29	7.99	- 8.78	-11.52	- 2.42	60.98	35.12	15.12	45.56	10.27	49.02	31.42	26.33	48.18	26.66
Hypalon	1.47	11.69	0.57	0.46	10.87	- 2.52	9.49	- 3.42	- 3.20	-13.47	5.02	4.59	1.89	3.50	0.30	9.41	10.21	10.99	9.48	25.65
Kalrez C	-19.39	-19.27	-19.64	-18.92	-18.83	-15.11	-17.06	-19.53	-18.95	-17.52	41.31	54.19	21.10	21.46	33.11	18.93	17.05	20.81	16.43	12.91
Nat. rubber	- 6.87	- 3.56	- 5.16	- 5.87	-14.30	-23.88	-24.48	-40.61	-26.78	-50.64	8.34	5.21	1.73	3.12	2.70	2.05	22.12	26.17	20.73	12.63
Buna-S	- 2.15	2.76	- 5.31	- 1.93	3.50	9.67	14.47	- 4.72	- 1.93	- 2.15	2.81	2.64	3.11	2.36	2.43	- 9.01	- 8.58	- 1.29	- 3.25	- 1.90
Neoprene	13.88	11.16	5.86	21.09	11.04	12.80	12.80	3.19	23.09	5.75	3.37	- 1.93	0.99	2.22	- 3.08	5.74	2.98	10.02	5.76	- 2.61
S-70	- 5.94	29.47	-17.03	8.11	25.25	-11.55	28.57	-25.56	- 0.51	10.15	7.92	1.43	0.86	0.18	2.45	9.97	4.00	7.33	5.71	7.73
Viton	-12.26	- 2.74	-11.33	-16.47	- 9.04	-12.01	- 3.84	-14.45	-14.23	-15.30	72.21	30.53	18.42	31.56	21.96	31.53	31.95	24.24	15.53	47.17
Geolast	-11.24	-10.22	- 6.58	- 1.59	- 7.86	- 3.09	- 9.64	- 5.36	4.15	- 3.59	41.77	23.32	8.50	20.14	6.30	19.17	16.49	12.61	9.90	11.12
Teflon	*	*	*	*	*	*	*	*	*	*	3.19	2.92	3.57	4.15	6.30	2.31	2.42	3.37	2.99	4.86
Mylar	*	*	*	*	*	*	*	*	*	*	4.17	*	1.01	2.17	0.61	2.55	*	0.76	1.64	0.35
Nomex	*	*	*	*	*	*	*	*	*	*	- 2.45	*	- 1.00	0.13	7.69	8.80	*	5.62	8.59	- 1.50
Nylon 6,6	*	*	*	*	*	*	*	*	*	*	- 2.36	*	2.43	3.75	-13.20	-10.77	*	-12.16	-10.02	0.13

* data not available

Table 4. Percent Change in Elongation for Polymers

Polymers	% CHANGE WITHOUT POE					% CHANGE WITH POE				
	HFC-245ca	HFC-245fa	HFC-236fa	HFC-236ea	HFE-125	HFC-245ca	HFC-245fa	HFC-236fa	HFC-236ea	HFE-125
Buna-N	-17.54	*	-33.35	-36.90	*	-34.74	*	-38.48	-46.36	*
E-70	-59.57	*	-60.19	-62.11	*	-77.93	*	-74.58	-78.17	*
HNBR	-39.16	-27.15	-19.95	-31.16	*	-33.96	*	-13.54	-23.55	*
Hypalon	-52.91	*	-40.44	-49.22	*	-47.37	*	-42.29	-46.44	*
Kalrez C	-7.83	-36.53	-34.00	-31.48	*	-20.41	-19.71	-20.97	-20.55	*
Nat. rubber	-30.92	-42.43	-34.46	-29.15	*	-31.36	-23.83	-40.66	-34.90	*
Buna-S	-33.75	*	-20.33	-19.49	*	-32.91	*	-37.08	-54.71	*
Neoprene	-31.48	*	-64.53	-42.29	*	-41.28	*	-69.34	-62.13	*
S-70	17.63	*	-7.50	13.05	*	19.00	*	24.73	12.12	*
Viton	-19.05	*	-36.79	-40.67	*	-10.18	*	-38.46	-25.15	*
Teflon	-8.30	*	-30.42	11.33	*	-38.15	*	-2.20	-13.80	*

* Data not available

Table 5. Percent Change in Linear Swell and Volume for Polymers

Polymers	% CHANGE WITHOUT POE LINEAR SWELL					% CHANGE WITH POE LINEAR SWELL					% CHANGE WITHOUT POE VOLUME					% CHANGE WITH POE VOLUME				
	HFC 245ca	HFC 245fa	HFC 236fa	HFC 236ea	HFE 125	HFC 245ca	HFC 245fa	HFC 236fa	HFC 236ea	HFE 125	HFC 245ca	HFC 245fa	HFC 236fa	HFC 236ea	HFE 125	HFC 245ca	HFC 245fa	HFC 236fa	HFC 236ea	HFE 125
Buna-N	4.96	0.46	1.96	5.51	- 1.77	5.52	2.03	1.33	2.73	5.01	6.46	2.70	4.23	16.51	4.61	- 4.83	- 1.37	4.20	7.91	10.43
E-70	1.34	- 1.15	1.25	1.19	- 0.03	- 2.75	0.88	- 0.76	- 0.77	1.86	7.83	- 0.61	2.25	0.77	8.43	-17.10	4.45	- 4.39	- 4.49	6.63
HNBR	11.29	8.62	3.46	9.35	2.72	10.92	7.83	6.85	10.84	7.29	47.18	27.63	11.91	27.18	13.36	35.77	18.04	18.89	33.56	28.16
Hypalon	4.46	- 1.72	1.20	2.34	- 0.44	6.65	2.81	4.80	4.07	8.96	- 2.25	24.94	0.70	5.64	7.85	19.95	16.36	13.95	11.24	31.19
Kalrez C	14.06	13.75	8.84	8.26	17.02	10.10	6.50	8.17	6.50	4.54	28.11	49.68	25.04	30.67	59.86	3.76	26.74	28.38	26.60	15.66
Nat. rubber	1.49	1.42	1.31	1.32	1.07	7.73	6.34	8.30	6.91	2.42	7.77	5.97	3.29	3.56	7.82	23.31	21.68	25.44	20.74	- 6.67
Buna-S	2.42	- 1.26	1.26	1.33	- 0.33	- 1.55	- 3.54	- 0.06	- 0.02	- 2.17	12.93	- 4.32	2.13	3.96	11.20	- 7.38	8.54	- 1.34	- 0.52	3.51
Neoprene	1.42	- 2.66	1.86	0.87	- 2.14	3.80	- 0.38	5.50	1.64	- 0.89	- 7.31	14.36	2.81	3.67	4.89	- 5.71	29.17	14.48	5.52	-13.07
S-70	0.71	- 1.22	0.10	- 0.11	- 0.11	1.00	1.33	2.62	2.52	2.67	- 5.27	-11.40	2.36	-2.56	5.81	- 9.88	- 2.66	6.62	4.20	4.52
Viton	23.85	12.81	6.16	8.77	6.51	12.51	11.47	9.37	5.55	16.96	84.36	17.89	16.95	25.14	29.63	39.72	9.78	27.59	17.54	48.97
Geolast	7.84	4.74	2.55	3.32	0.91	3.53	3.63	1.43	1.93	0.91	27.55	11.59	8.36	19.13	2.22	14.29	10.02	2.92	9.20	7.93
Teflon	3.41	29.84	2.96	3.94	2.02	3.94	27.22	2.98	2.88	0.94	- 4.78	3.08	7.97	8.38	9.26	- 4.67	2.80	8.76	5.56	2.94
Mylar	- 1.00	*	-1.10	- 1.05	- 1.19	- 1.12	*	- 1.13	- 1.11	- 1.28	11.62	*	6.60	2.71	- 4.85	2.35	*	- 4.91	3.77	0.17
Nomex	- 0.78	*	-0.36	- 0.39	- 0.92	- 0.60	*	- 0.83	- 0.70	- 0.54	- 2.46	*	5.20	2.77	- 1.71	- 3.99	*	4.16	- 3.82	3.27
Nylon 6,6	- 1.72	*	0.46	0.23	- 4.94	- 4.18	*	- 4.34	- 3.87	- 0.57	-13.71	*	1.29	3.38	-14.70	-12.88	*	-12.13	- 9.49	- 2.04

* Data not available

Table 6. Performance Criteria and Measurement Uncertainties for Polymers

Parameters	**Unsatisfactory**	**Marginal**	**Good**	**Uncertainties**
Hardness	-10 %≤ x ≥ +10%	-6 %≤ x ≥ +6%	-6 %≥ x ≤ +6%	± 2%
Volume	0 % ≤ x ≥ +20%	0 % ≤ x ≥ +12%	0 % ≥ x ≤ +12%	± 3%
Linear Swell	0% ≤ x ≥ +5%	0% ≤ x ≥ +6%	0% ≥ x ≤ +6%	± 2%
Elongation	-40% ≤ x ≥ +40%	-24% ≤ x ≥ +24%	-24% ≥ x ≤ +24%	± 8%
Weight	-20% ≤ x ≥ +20%	-12% ≤ x ≥ +12%	-12% ≥ x ≤ +12%	± 0.5%

Table 7. Summary of Elongation Performance Based on Criteria in Table 6

Polymers	**HFC-245ca**	**HFC-245fa**	**HFC-236fa**	**HFC-236ea**	**HFE-125**	**HFC-245ca POE**	**HFC-245fa POE**	**HFC-236fa POE**	**HFC-236ea POE**	**HFE-125 POE**
Buna-N		*	○	○		○		○	○	*
E-70	●	*	●	●		●		●	●	*
HNBR	○	*				○				*
Hypalon	●	*	○	●		○		○	○	*
Kalrez C		○	○							*
Nat. rubber		○	○					○	○	*
Buna-S	○	*				○		○	●	*
Neoprene		*	●	○		○		●	●	*
S-70	○	*				○		○		*
Viton		*	○	○				○		*
Geolast	*	*	*	*	*	*	*	*	*	*
Teflon						○				

(blank = satisfactory, ○ = marginal, ● = poor). * Data not available

Table 8. Performance Summary of Polymers Based on Criteria Specified in Table 6

Polymers	Linear Swell										Weight									
	HFC-245ca	HFC-245fa	HFC-236fa	HFC-236ea	HFE-125	HFC-245ca POE	HFC-245fa POE	HFC-236fa POE	HFC-236ea POE	HFE-125 POE	HFC 245ca	HFC-245fa	HFC-236fa	HFC-236ea	HFE-125	HFC-245ca POE	HFC-245fa POE	HFC-236fa POE	HFC-236ea POE	HFE-125 POE
Buna-N	○		○	○		○	○	○	○	○	●			●		●	○		○	●
E-70	○		○	○		●				○										
HNBR	●	●	○	●	○	●	●	○	●	●	●	●	○	●		●	●	●	●	●
Hypalon	○		○	○		○	○	○	○	●										●
Kalrez C	●	●	●	●	●	●	○	●	○	○	●	●	●	●	●	○	○	●	○	○
Nat. rubber	○	○	○	○	○	●	○	●	○	○						●	●	●	●	○
Buna-S	○		○	○			●			●										
Neoprene	○	●	○		●	○		○	○											
S-70							○	○	○	○										
Viton	●	●	○	●	○	●	●	●	○	●	●	●	○	●	●	●	●	●	○	●
Geolast	●	○	○	○		○	○	○	○		●	●		○		○	○	○		
Teflon	○	●	○	○	○	○	●	○	○											
Mylar												*					*			
Nomex												*					*			
Nylon 6,6					●	●		●	●			*			○		*			

	Hardness										Volume									
Buna-N	○				●		○			○				○		●				○
E-70		○		○	○	●	○	○	○							●		●	●	
HNBR	○			○	●	○	○	○	○		●	●	○	●	○	●	○	○	●	●
Hypalon		○			○		○			●		●				○	○	○	○	●
Kalrez C	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●		●	●	●	○
Nat. Rubber					●	●	●	●	●	●						●	○	●	○	●
Buna-S						○	●				○	●			○	●				
Neoprene	●	○	○	●	○	●	●		●	○	●	○				●	●	○		●
S-70		●	●	○	●	○	●	●		○	●	●				●				
Viton	●		○	●	○	●		●	●	●	●	○	○	●	●	●	○	●	○	●
Geolast	○	○					○		○		●	○				○	○		○	
Teflon											●				○	●				
Mylar		*									○	*			●			●		
Nomex		*										*				●			●	
Nylon 6,6		*									●	*			●	●		●	●	

(blank = satisfactory, ○ = marginal, ● = poor). * Data not available

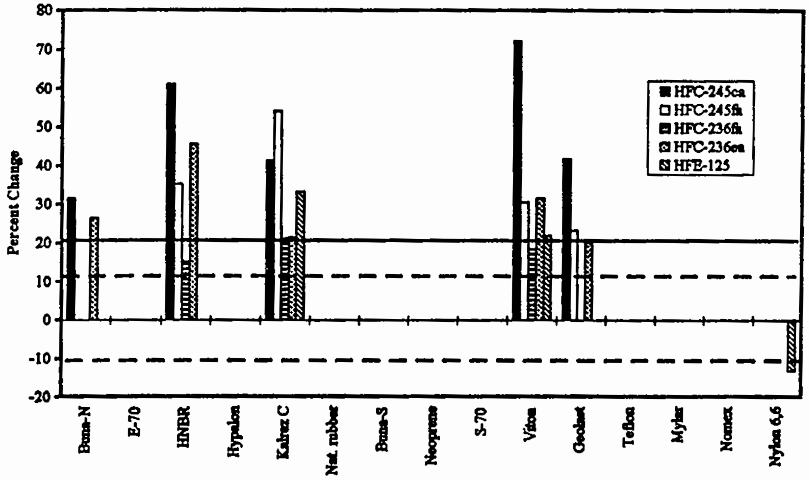

Figure 1. Weight Change of Elastomers and Plastics that Demonstrated Marginal or Unsatisfactory Performance after Exposure to Refrigerant

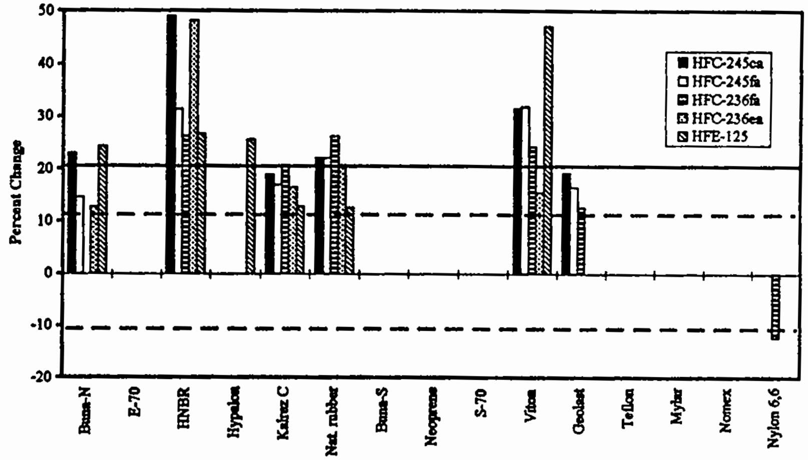

Figure 2. Weight Change of Elastomers and Plastics that Demonstrated Marginal or Unsatisfactory Performance after Exposure to Refrigerant and POE Lubricant

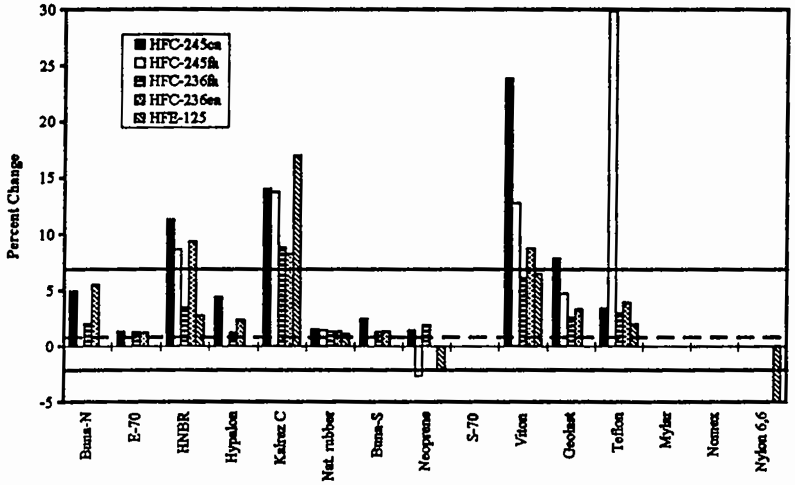

Figure 3. Linear Swell Change of Elastomers and Plastics that Demonstrated Marginal or Unsatisfactory Performance after Exposure to Refrigerant

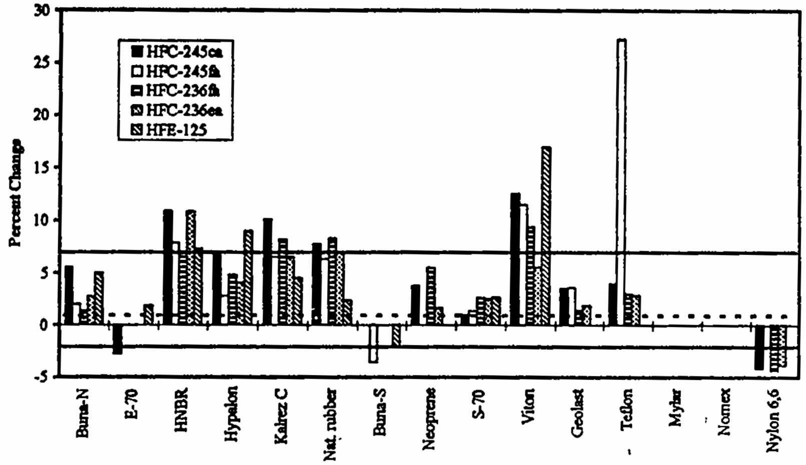

Figure 4. Linear Swell Change of Elastomers and Plastics that Demonstrated Marginal or Unsatisfactory Performance after Exposure to Refrigerant and POE Lubricant

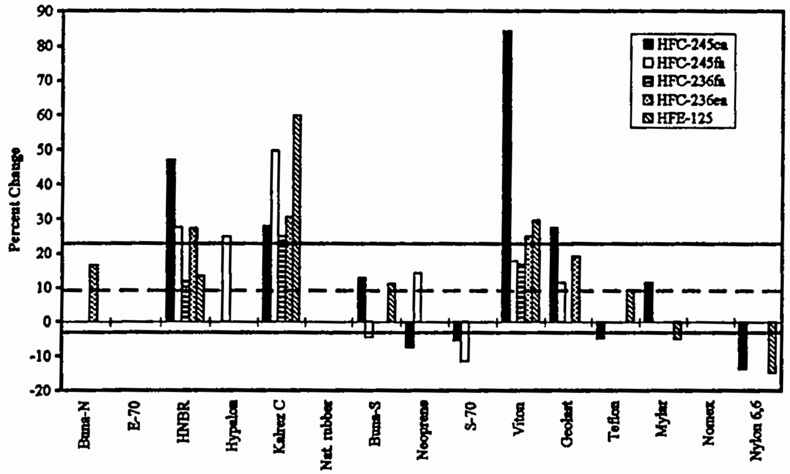

Figure 5. Volume Change of Elastomers and Plastics that Demonstrated Marginal or Unsatisfactory Performance after Exposure to Refrigerant

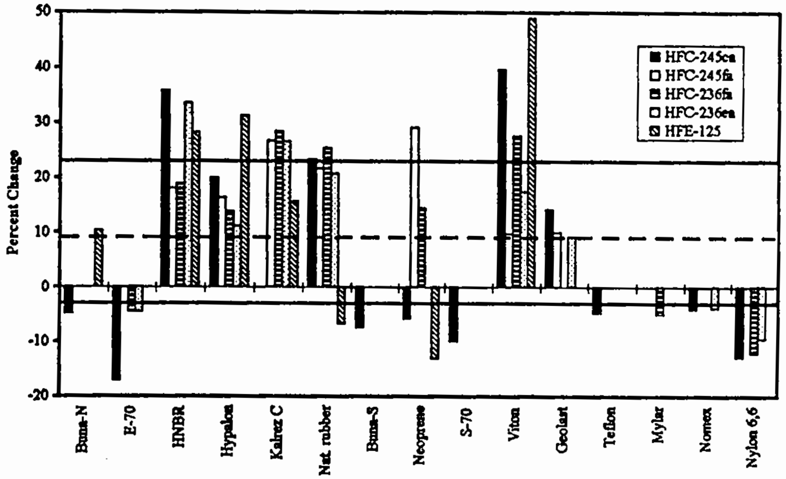

Figure 6. Volume Change of Elastomers and Plastics that Demonstrated Marginal or Unsatisfactory Performance after Exposure to Refrigerant and POE Lubricant

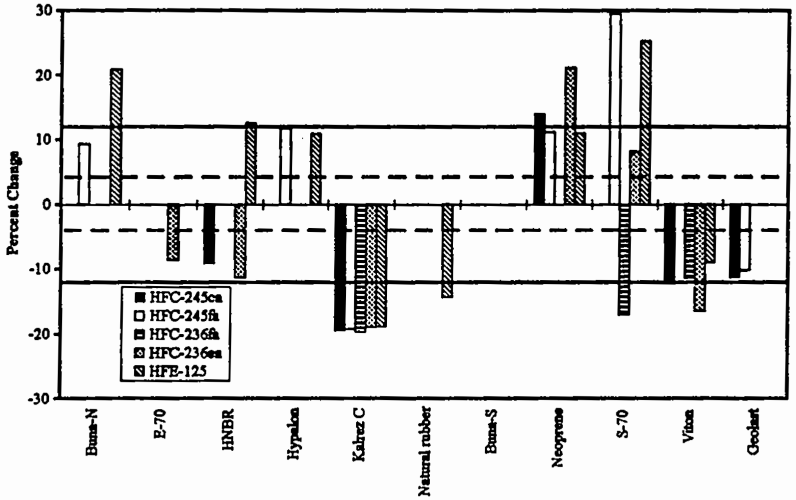

Figure 7. Hardness Change of Elastomers that Demonstrated Marginal or Unsatisfactory Performance after Exposure to Refrigerant

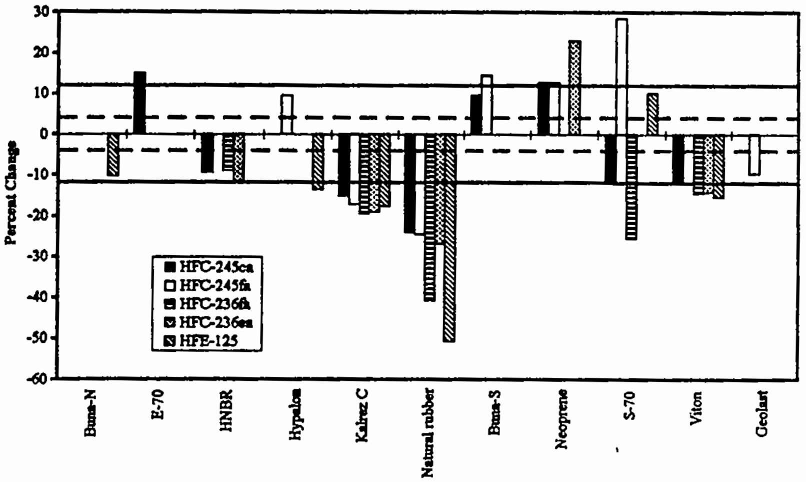

Figure 8. Hardness Change of Elastomers that Demonstrated Marginal or Unsatisfactory Performance after Exposure to Refrigerant and POE Lubricant

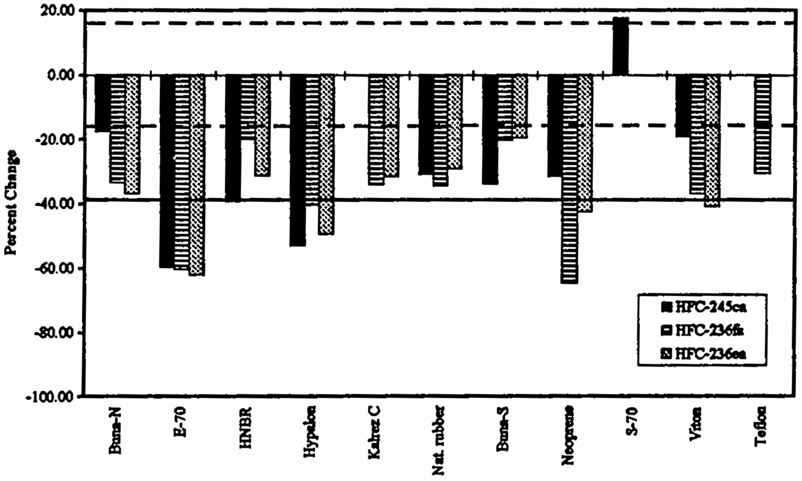

Figure 9. Elongation Change of Elastomers and Teflon that Demonstrated Marginal or Unsatisfactory Performance after Exposure to Refrigerant

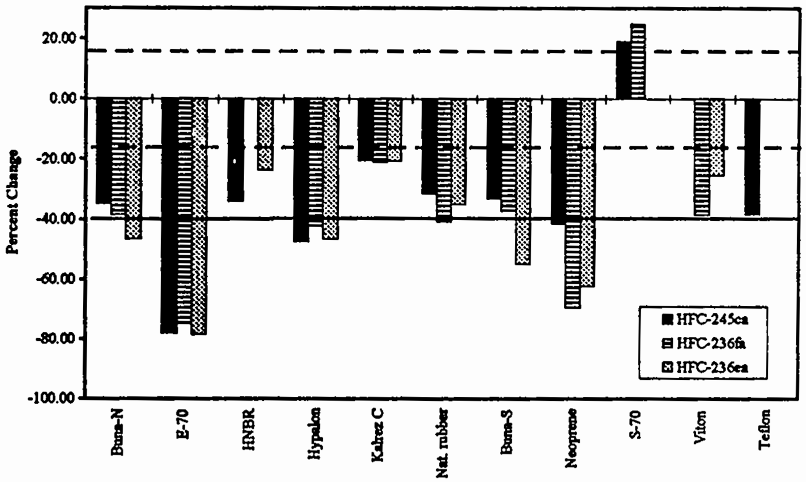

Figure 10. Elongation Change of Elastomers and Teflon that Demonstrated Marginal or Unsatisfactory Performance after Exposure to Refrigerant and POE Lubricant

NRMRL-RTP-P-146

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing

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16. ABSTRACT The paper presents data pertaining to stability and material compatibilities determined for HFC-245ca, HFC-245fa, HFE-125, HFC-236ea, and HFC-236fa. Following ASHRAE guidelines, material compatibility tests using 11 elastomers, 4 plastics, 5 metals, and 4 desiccants were conducted with the aforementioned refrigerants in both the presence and the absence of a polyolester (POE) lubricant. The metals (cupper, steel, aluminum, brass, and bronze) were found to be compatible with both the refrigerants and the POE oil. Three of four MOLSIV desiccants (4A-XH-6, XH-7, and XH-9) yielded no discernible amount of fluoride, while a small amount was found in 4A-XH-5. However, trace amounts of fluorine-containing byproducts were detected by gas chromatography/mass spectroscopy for all four desiccants. Based on physical characteristics, unsatisfactory performance across all refrigerants with and without lubricant was found with fluoropolymers, hydrogenated nitrile butyl rubber, natural rubber, and Neoprene.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group	
Pollution	Plastics	Pollution Prevention	13B	11I
Refrigerants		Stationary Sources	13A	
Propane		Material Compatibility	07C	
Halohydrocarbons		Hydrofluorocarbons		
Ethers		Hydrofluoroethers		
Metals			11F	07B
Desiccants			11G	

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