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COMPATIBILITY OF REFRIGERANTS AND LUBRICANTS WITH MOTOR MATERIALS

Final Report
Volume I

SEP 09 1993
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May 1993

Prepared for
The Air-Conditioning and Refrigeration Technology Institute
Under
ARTI MCLR Project Number 650-50400

This research project is supported, in whole or in part, by U.S. Department of Energy grant DE-FG02-91CE23810: Materials Compatibility and Lubricants Research (MCLR) on CFC-Refrigerant Substitutes. Federal funding supporting this project constitutes 93.67% of allowable costs. Funding from non-government sources supporting this project consists of direct cost sharing of 6.33% of allowable costs; and in-kind contributions from the air-conditioning and refrigeration industry.

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ACKNOWLEDGMENTS

The authors would like to acknowledge the following people and companies for their contributions to this project. The people listed worked with the authors on the project. The companies listed provided motor materials, refrigerants and lubricants without charge.

People

Richard Ernst
Aaron Clark
Fred Howard
John Miller
Dennis Lambert
Raymond Schafer
Daryl Steinke
Todd Waite

Companies

A.O. Smith Electrical Products Co.
Allied Signal
Ato Chem
Carolina Narrow Fabric Co.
Dow Chemical
DuPont
Electrolock Inc.
Essex Group Inc.
Henkel Corp.
ICI Americas Inc.
Insulation Sales Inc.
Ludlow Textiles Co.
P.D. George Co.(Sterling Chemical Co.)
Phelps Dodge Magnet Wire Co.
Schenectady Chemical Inc.
Schrieve Chemical Products
Westinghouse Electrical Corp
Witco Corp.

A special thanks to the Department of Energy for a majority of the funding and to ARTI and their project monitoring group for the administration of the project.

COMPATIBILITY OF REFRIGERANTS AND LUBRICANTS WITH MOTOR MATERIALS

Final Report Format Volume I

Because of the large scope of this project and the large amount of data recorded, the final report is divided into four volumes.

Volume I contains the abstract, scope, discussion of results, charts of motor material compatibility, test procedures, material identifications and 84 pages of data summary tables. This volume provides results of the study and other information of interest to most users of the information.

Volume II contains all the recorded measurements from the tests on the motor materials after exposures to the 11 pure refrigerants and to nitrogen at the same temperatures.

Volume III contains all the recorded measurements from the tests on the motor materials after exposure to the 17 refrigerant-lubricant combinations and to nitrogen at the same temperatures.

Volume IV contains the photographs of motor materials after exposures to pure refrigerants and to refrigerant-lubricant combinations.

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COMPATIBILITY OF REFRIGERANTS AND LUBRICANTS WITH MOTOR MATERIALS

Final Report
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ABSTRACT

Compatibility test results for 11 pure refrigerants and 17 refrigerant-lubricant combinations with 24 motor materials are included in this report. The report is presented in four volumes. Volume I contains the abstract, scope, discussion of the results, charts of motor material compatibility, test procedures, material identification and 84 pages of data summary tables of the motor materials. Volumes II and III contain the complete data (40,000 measurements) for all of the refrigerant and refrigerant-lubricant compatibility tests. Volume IV contains photographs that document observations on materials after the exposures.

The greatest effect on the motor materials was caused by absorption followed by desorption of refrigerants at higher temperatures. The high internal pressure of the absorbed refrigerants and the tendency of these refrigerants to evolve from the materials resulted in blisters, cracks, internal bubbles in the varnish and delamination or bubbles in the sheet insulations. Desorption of HCFC-22, and to a lesser extent HFC-32, HFC-134 and HFC-152a, had the greatest effect on varnish integrity.

The second effect of exposure to the refrigerant or refrigerant-lubricants on the motor materials was extraction or dissolution of materials that lead to embrittlement of some sheet insulations. Exposure to HCFC-22/Mineral oil combinations caused the polyester materials to become brittle. Exposure of the sheet insulation materials to the alkylbenzene lubricant combinations resulted in a greater loss of flexibility than exposure to the other synthetic lubricants. The PAG diol caused complete delamination of composite sheet insulation material by dissolving the adhesive used to bond the layers.

Exposure to HCFC-22 and HCFC-22/mineral oil produced the most deleterious effects on the motor materials. However, since many of the materials tested have excellent reliability with HCFC-22/mineral oil in current applications, the materials are expected to be reliable when used with most of the new refrigerants and lubricants.

SCOPE

This project covers compatibility tests of 24 commercially used motor materials exposed to 11 pure refrigerants and 17 refrigerant-lubricant combinations. Materials were evaluated immediately after a 500-hour exposure and after a 500-hour exposure followed by an additional 24-hour bake at 150°C(302°F) in air to remove absorbed refrigerant. The effect of heat alone was determined by exposures in nitrogen gas.

The refrigerants, refrigerant-lubricant combinations, motor materials tested and the tests performed on the motor materials are listed below: Experimental procedures including the refrigerant/lubricant mixtures are given in Appendix B.

REFRIGERANTS AND LUBRICANTS

The motor materials were exposed to the following 11 pure refrigerants and 17 refrigerant-lubricant combinations at the temperatures indicated below:

Refrigerants

HCFC-22 @ 90°C(194°F)	HFC-134 @ 90°C(194°F)
HCFC-123 @ 90°C(194°F)	HFC-32 @ 60°C(140°F)
HCFC-124 @ 90°C(194°F)	HFC-125 @ 60°C(140°F)
HCFC-142b @ 90°C(194°F)	HFC-143a @ 60°C(140°F)
HFC-152a @ 90°C(194°F)	HFC-245ca @ 121°C(250°F)
HFC-134a @ 90°C(194°F)	

Refrigerant-Lubricant Combinations exposed @ 127°C(260°F).

HCFC-22/Mineral	HFC-134/Ester, Branched Acid
HCFC-124/Alkylbenzene	HFC-245ca/Ester, Branched Acid
HCFC-142b/Alkylbenzene	HFC-134a/PAG, Butyl Monoether
HFC-152a/Alkylbenzene	HFC-32/PAG, Butyl Monoether
HFC-134a/Ester, Mixed Acid	HFC-125/PAG, Butyl Monoether
HFC-134a/Ester, Branched Acid	HFC-134a/PAG, Modified
HFC-32/Ester, Branched Acid	HFC-125/PAG, Modified
HFC-125/Ester, Branched Acid	HFC-134a/PAG, Diol
HFC-143a/Ester, Branched Acid	

MOTOR MATERIALS

The 24 commercially used motor materials were:

Magnet Wires

A-Modified polyester overcoated with polyamide imide per Section MW 73 of NEMA Standard MW 1000

B-Modified polyester overcoated with polyamide imide and epoxy saturated glass per Section MW 73 and MW 46 of NEMA Standard MW 1000

C-Polyester imide over coated with polyamide imide

Varnishes

- U475EH, solvent epoxy
- Y390PG, solvent epoxy-phenolic
- ER610, 93% solids epoxy
- Y833, 100% solids VPI epoxy

Lead Wire Insulations

- Dacron/Mylar/Dacron
- Dacron/Teflon/Mylar/Dacron

- 923, solvent epoxy
- Isopoxy 800, water-borne epoxy

Sheet Insulations, Slot Liners and Phase Separators

- Nomex/Mylar/Nomex
- Dacron/Mylar/Dacron
- Mylar MO
- Nomex 410
- Nomex Mica 418
- Melinex 228

Tapes

- Heat Cleaned Glass
- Heat Shrinkable polyester Braid
- Glass/acrylic

Spiral Wrapped Sleeve Insulations

- Nomex
- Mylar
- Nomex/Mylar

Tie Cord

- Polyester

EVALUATIONS PERFORMED

The evaluations shown below, in addition to visual examinations were performed on the 24 motor materials both before and after the exposures:

Varnish

- Weight Change

Lead Wire

- Weight Change
- Dielectric Strength

Tie Cord

- Weight Change
- Break Load Strength

Magnet Wire/Varnish

- Bond Strength
- Burnout Resistance
- Dielectric Strength
- Weight Change

Magnet Wire/Unvarnished

- Weight Change
- Burnout Resistance
- Dielectric Strength

Sheet Insulation

- Weight Change
- Tensile Strength
- Elongation
- Dielectric Strength

Tapes

- Weight Change
- Break Load Strength

Spiral Wrapped Sleeve

- Weight Change

INTRODUCTION

To develop an environmentally acceptable refrigerant molecule, it is necessary to include hydrogen to decrease atmospheric life and to remove chlorine to eliminate ozone depletion. The result is a more polar refrigerant that is less miscible with classical mineral or alkylbenzene lubricants. For most hydrofluorocarbon(HFC) refrigerants, it is necessary to use a polar synthetic lubricant such as a polyolester or a polyalkylene glycol to achieve acceptable miscibility. Effects of alternative refrigerants and synthetic lubricants on commercial motor materials are discussed in this report.

The compatibility of polymeric insulation material with refrigerants and refrigerant-lubricant combinations depends on three primary modes of interaction: absorption, extraction and chemical dissolution by the refrigerant and/or lubricant.

Absorption of the refrigerant can affect the insulation material by changing its dielectric strength or physical integrity. Absorption can cause excessive swelling, softening or decreased strength. In addition to the direct effect of the absorbed

refrigerant, a more deleterious effect may occur due to rapid desorption of the refrigerant. Absorption and desorption can result in blisters, crazing, surface craters or bubbles within the insulation material. A pronounced decrease in the dielectric and physical strength of the material is often observed.

Extraction of material by the refrigerant results in a range of effects varying from complete dissolution to only a slight change in properties as a result of dissolving only unpolymerized material. The usual effect of the extraction on insulation materials is embrittlement caused by extraction of low molecular weight polymers(oligomers) or plasticizers. Extraction or chemical dissolution of a material can also cause serious problems within hermetic systems by causing components to stick or by clogging passages such as capillary tubes.

The data presented in this report show the effects of absorption, desorption and extraction on the physical properties of the insulating materials. Results immediately after exposures illustrate the effects of absorbed refrigerant on insulation properties such as bond strength, burnout resistance, dielectric strength, elongation, break load strength and tensile strength. The results after 150°C(302°F) bake in air following the refrigerant or refrigerant-lubricant exposures indicate the effects of desorption on the same properties.

The information presented in this report can best be interpreted by comparisons to the HCFC-22 or HCFC-22/Mineral oil exposures. HCFC-22 applications have an excellent reliability history with many of these materials.

SIGNIFICANT RESULTS

Thermal Stability Studies

Thermal stability studies were conducted on each of the refrigerant-lubricant combinations prior to testing the motor materials to verify that the refrigerants and lubricants were thermally stable at the planned exposure conditions. Two refrigerant-lubricant combinations were not tested(HFC-134/Ester-branched acid and HFC-245ca/Ester-branched acid) because the two refrigerants(HFC-134 and HFC-245ca) were not received until late in the project.

Each refrigerant-lubricant combination was charged into 125 milliliter stainless steel pressure vessels and was exposed at 300 psi pressure for 500-hours at 127°C(260°F). After the exposures, the refrigerants and lubricants were analyzed to detect any decomposition products. Refrigerants were tested by Gas Chromatography(GC) for relative purity before and after the exposures. The lubricants were tested for acid number(TAN) and moisture content before and after the exposures. Results are tabulated on the following pages.

Relative Refrigerant Purity Before and After Exposures.

Refrigerant/Lubricant <u>Combination</u>	Initial Refrigerant <u>Purity(Volume%)</u>	Refrigerant Purity <u>After Exposure</u>
HCFC-22/Mineral	99.8%	99.6%
HCFC-124/Alkylbenzene	99.5%	99.3%
HCFC-142b/Alkylbenzene	99.9%	99.9%
HFC-152a/Alkylbenzene	99.9%	99.3%

HFC-134a/Ester, Mixed Acid	99.9%	99.9%
HFC-134a/Ester, Branched Acid	99.9%	99.7%
HFC-32/Ester, Branched Acid	99.9%	99.5%
HFC-125/Ester, Branched Acid	99.3%	97.5%
HFC-143a/Ester, Branched Acid	99.4%	98.8%
HFC-134/Ester, Branched Acid	n/t	n/t
HFC-245ca/Ester, Branched Acid	n/t	n/t
HFC-134a/PAG, Butyl Monoether	99.9%	99.9%
HFC-32/PAG, Butyl Monoether	99.8%	97.1%
HFC-125/PAG, Butyl Monoether	99.3%	98.5%
HFC-134a/PAG, Modified	99.9%	99.7%
HFC-125/PAG, Modified	99.3%	99.2%
HFC-134a/PAG Diol	99.9%	99.7%

Accuracy of the analysis was estimated to be $\pm 0.5\%$.

n/t-combination not tested.

Although purities of several of the refrigerants changed after the 500-hour exposure, no refrigerant decomposition products were detected by Gas Chromatography(GC) or by Gas Chromatographic/Mass Spectrum(GC/MS). For those cases where the refrigerant purities changed, non-condensables were formed that changed the relative purity. The non-condensables were believed to have formed by slight decomposition of some lubricants as discussed below. Based on the analysis of the refrigerants, no significant breakdown occurred. The planned test conditions were judged to be acceptable. Formation of the non-condensables were not judged to be significant, because a small amount of non-condensables can cause a large change in the relative purity of the refrigerant.

Lubricant Moisture Before and After Exposure.

Refrigerant/Lubricant <u>Combination</u>	Initial Moisture <u>Content(ppm)</u>	Moisture After <u>Exposure(ppm)</u>
HCFC-22/Mineral	10	9
HCFC-124/Alkylbenzene	20	33
HCFC-142b/Alkylbenzene	29	19
HFC-152a/Alkylbenzene	25	29
HFC-134a/Ester, Mixed Acid	25	76
HFC-134a/Ester, Branched Acid	35	52
HFC-32/Ester, Branched Acid	42	164
HFC-125/Ester, Branched Acid	38	63
HFC-143a/Ester, Branched Acid	35	133
HFC-134/Ester, Branched Acid	n/t	n/t
HFC-245ca/Ester, Branched Acid	n/t	n/t
HFC-134a/PAG, Butyl Monoether	19	65
HFC-32/PAG, Butyl Monoether	44	88
HFC-125/PAG, Butyl Monoether	44	107
HFC-134a/PAG, Modified	41	146
HFC-125/PAG, Modified	35	127
HFC-134a/PAG Diol	41	40

n/t-combination not tested.

Lubricant Acid Numbers Before and After Exposure.

Refrigerant/Lubricant Combination	Initial Acid Number(mg KOH/g oil)	Acid Number After Exposure(mg KOH/g oil)
HCFC-22/Mineral	0.008	0.034
HCFC-124/Alkylbenzene	0.017	0.013
HCFC-142b/Alkylbenzene	0.005	0.074
HFC-152a/Alkylbenzene	0.005	0.007
HFC-134a/Ester, Mixed Acid	0.009	0.034
HFC-134a/Ester, Branched Acid	0.017	0.044
HFC-32/Ester, Branched Acid	0.017	0.055
HFC-125/Ester, Branched Acid	0.022	0.028
HFC-143a/Ester, Branched Acid	0.017	0.281
HFC-134/Ester, Branched Acid	n/t	n/t
HFC-245ca/Ester, Branched Acid	n/t	n/t
HFC-134a/PAG, Butyl Monoether	0.022	0.054
HFC-32/PAG, Butyl Monoether	0.022	0.037
HFC-125/PAG, Butyl Monoether	0.022	0.034
HFC-134a/PAG, Modified	0.017	0.040
HFC-125/PAG, Modified	0.017	0.028
HFC-134a/PAG Diol	0.044	0.052
n/t-combination not tested.		

Increases were measured for both moisture content and acid numbers for many of the lubricants following the 500-hour exposures. A large increase in acid number was observed for the HFC-143a/Ester-Branched Acid combination, however a GC/MS analysis of the refrigerant charge indicated no refrigerant breakdown had occurred during the test. The GC/MS did indicate the formation of non-condensables(mainly carbon dioxide). The carbon dioxide may have formed by the breakdown of the lubricant alone in the presence of residual oxygen.

These results indicated apparent slight decomposition of the lubricants. However, the extent of decomposition was considered acceptable(low acid numbers were not expected to significantly degrade materials) when weighed against the option of lowering the test temperature and/or time.

Compatibility of Varnishes

Before discussing the effects of refrigerants on the bond, dielectric and burnout strengths of varnished magnet wires, it is best to examine the effects on pure varnish cast in the form of thin disks. Data are given in Appendixes C, D and E.

HCFC-123 was absorbed to the greatest extent(13.9% to 44.0%) by all varnishes followed by HCFC-22(7.4% to 18.7%). Other refrigerants such as HCFC-124 (0.9-13.2%) and HCFC-142b (0-10.0%) were also absorbed in fairly large amounts by the varnishes. This trend suggested that HCFC's with some chlorine were generally absorbed to greater amounts than HFC's. However, HFC-32 (4.8-9.5%), HFC-134 (1.1-9.1%) and HFC-152a (0.1-9.1%) are absorbed to an extent similar to HCFC-124 and HCFC-142b, suggesting that other factors are involved besides the presence or absence of chlorine.

The high absorption values for HCFC-123 lead to the expectation that HCFC-123 should cause the greatest compatibility concerns with varnishes. However, only the 833 varnish with 44% absorption, was found to be incompatible with HCFC-123 by this study and by previous studies at Trane¹.

Varnishes exposed to HCFC-22, and to a lesser extent HFC-32, HFC-134 and HFC-152a, exhibited internal bubbles and external blisters after the 150°C(302°F) bake, but varnishes exposed to HCFC-123 and the other refrigerants did not exhibit this phenomena. This may have been due to different rates of refrigerant desorption and/or low internal pressures.

Absorption of most refrigerants and lubricants by the varnishes was low (-1 to 11%) except for the PAG Diol(7.9% to 25.9%). Baking the exposed samples at 150°C(302°F) removed most of the refrigerant and/or lubricant from the samples except for the PAG Diol, but did not cause degradation of the varnish. Weight losses(0 to -8.6%) were observed after the air bake for most refrigerant and lubricant exposures suggesting extraction. These extraction values were similar in magnitude to those observed after exposure to pure refrigerants. However for the PAG Diol, most of the absorbed refrigerant and/or lubricant was retained in the varnishes after the bake. Increased weights from absorbed refrigerant and/or lubricant were also observed for the HCFC-142b and alkylbenzene lubricant after the bake.

Compatibility of Magnet Wires

The effects of refrigerants and refrigerants-lubricants on the relatively thick varnish disks(0.05 inch) are only indications of potential problems that may occur with varnished magnet wire in actual motors. The varnish thickness on magnet wire in actual motors is only about 0.002 inch. As a further step, studies were conducted on actual varnished magnet wires. The three magnet wire types were tested unvarnished and varnished with six different varnishes. Data are given in Appendixes C, D and E.

Varnish Bond Strength

The greatest effect of the refrigerant absorption/desorption phenomena was exhibited by changes in the helical coil bond strength.

Refrigerant HCFC-22 had the greatest effects on the bond strengths(-20% to -49%) of magnet wire A(polyester base with an amide imide overcoat) with the six varnishes as measured immediately after the exposure. After bakeout of HCFC-22 the bond strength was reduced -38 to -95%. Exposure to HFC-32 (-19 to -86%) and HFC-152a (-19 to -91%) also produced greatly decreased bond strengths after bakeout. Significant decreases in bond strengths were also observed for magnet wire B (glass served) with the six varnishes after exposures to HFC-22 (-20 to -59%), HFC-32 (-6 to -75%), HFC-152a (-7 to -59%) and HCFC-123 (+1 to -80%). For magnet wire C (ester- imide/amide-imide) similar losses of bond strength were measured for HCFC-22 (-45 to -84%) and HFC-32 (+13 to -95%) but not for HFC-152a, HFC-123 or other refrigerants.

¹R. Doerr, "Absorption of HCFC-123 and CFC-11 by Epoxy Motor Varnishes", ASHRAE Annual Meeting, Baltimore, MD, June 30, 1992. Transactions Vol. 98(2), pp. 227-234. Varnish C is Y-833.

The effects of refrigerants-lubricants on the bond strengths of the three magnet wires is given in Appendix C. For magnet wire A (polyester base with an amide imide overcoat), the lubricant showing the greatest overall decrease in bond strengths was the alkylbenzene lubricant, -7.7 to -64.5%. After bakeout at 150°C (302°F) the alkylbenzene lubricant with HCFC-142b showed the greatest effects, -45.0% to -84.5%. However these effects are less than were caused by the pure refrigerants, where bond strengths were reduced by as much as -94.6% for HCFC-22, -91.2% for HFC-152a and -92.9% for HFC-32. The magnitude of the effects of HCFC-142b and alkylbenzene lubricant compared to other refrigerant-lubricants may be due to the fact that significantly more HCFC-142b by weight was required to reach the 300 psi exposure condition. In general, the polyolesters and polyalkylene glycol's had relatively little effect on bond strengths. This is especially true considering that exposure to heat alone in a nitrogen atmosphere reduced bond strengths from -29.9% to -59.7% after the 500 hour exposure.

In general, the helical coil bond strengths of the varnished magnet wires was decreased by the effects of absorption and desorption of refrigerants. The refrigerant having the greatest effect was HCFC-22. Refrigerant-lubricant exposures at 127°C (260°F) appeared to have less effect on varnished magnet wire B (polyester-glass served wire) than on magnet wire A (polyester with amide imide overcoat) and magnet wire C (ester imide with amide imide overcoat). Data for the 833 varnish should not be compared to data for other varnishes because the 833 is used primarily for its electrical insulation properties rather than its bond strength.

Burnout Strength

Burnout strength was also measured on the varnished and unvarnished magnet wires before and after exposures to refrigerants and refrigerants-lubricants. The burnout test simulates the effects of high current loads on motor stators that may occur during start up or other transient conditions. The burnout test applies a 120 volt AC current over time through twisted pairs, causing resistance heating of the wire and records the time at which the insulation fails. Equilibrium temperatures of a twisted pair sample were measured with a thermocouple attached to the sample during a test. Temperatures of the sample at different times during the burnout test are shown below.

<u>Test Time(seconds)</u>	<u>Specimen Temperature Max</u>
0-180	193°C(380°F)
181-360	216°C(420°F)
361-540	271°C(520°F)
541-720	343°C(650°F)
721-900	>371°C(>700°F)

There appears to be a relationship between the amount of refrigerant absorbed and the decrease in burnout strength. Desorption of refrigerant at 150°C (302°F) shows much less effect on burnout strength than on other properties. This results because the burnout test heated the wire similar to the bake out, except to higher temperatures and faster. In many instances, the effects on the burnout strengths of the wires was greater when the absorbed refrigerant was not completely expelled prior to the test.

The most important information revealed from the burnout test is the superior performance of magnet wire B (glass served) compared with the other types of magnet wires. The unexposed magnet wire B shows a burnout time of 736 to 755 seconds compared to 430 to 600 seconds for magnet wire A(ester with amide-imide overcoat) and 469 to 632 seconds for magnet wire C(ester-imide with amide-imide overcoat). These times translate into significant differences in temperature resistance of the three types of wire insulation. Secondly, exposures to refrigerants had very little effect on the burnout time of magnet wire B compared to the other wire types.

Exposure of varnished and unvarnished magnet wire to refrigerant-lubricant combinations showed similar effects on burnout strength to that caused by exposure to pure refrigerants. The alkylbenzene lubricants showed somewhat greater effects than the other lubricants. The additional 24-hour bake at 150°C(302°F) did not adversely effect the burnout strengths of the wires exposed to refrigerants-lubricants. Effect of refrigerant-lubricant combinations on burnout strengths of varnished and unvarnished magnet wire is not expected to be a compatibility concern.

Dielectric Strength

The test for dielectric strength of magnet wire used the same type of twisted pairs that were used for the burnout test. Rather than increasing the current with time, the voltage between the two wires was increased until dielectric breakdown occurred through the insulation. This dielectric breakdown voltage was automatically recorded.

For magnet wire A(ester with amide-imide overcoat), the greatest decrease in dielectric breakdown voltage resulted after desorption of refrigerant. As observed previously from the degradation of varnish disks, the greatest effects resulted from exposures to HCFC-22 (+8.8 to -69.9%), HFC-32 (-2.2 to -59.0%) and R-152a (-1.0 to -50.1%). Results for magnet wire C(ester-imide with amide-imide overcoat) were very similar to those for magnet wire A. The dielectric strength of magnet wire B(Dacron-glass served) was less affected by refrigerant exposure than the other magnet wire types. Surprisingly the dielectric strength of unexposed magnet wire B was less than the dielectric strength of other magnet wires.

Compared to the effects of pure refrigerants, the refrigerant-lubricant combinations had less effect on the dielectric strength of the varnished and unvarnished magnet wires. In some cases the dielectric strength increased suggesting the lubricant acted as an electrical insulator. This is especially true for magnet wire B (polyester-glass served).

Compatibility of Sheet Insulations

Results of refrigerant and refrigerant-lubricant exposures on sheet insulation materials are given in Appendixes C, D and E.

Absorption of refrigerant by the sheet insulation materials was not as high as absorption by the varnishes. The greatest absorption by sheet insulation resulted from exposure to HCFC-123 (0.7 to 21.0%) followed by HCFC-22 (2.9 to 6.7%). HFC-134 and HFC-32 were absorbed to higher levels than the other non chlorinated refrigerants.

Absorption of refrigerant-lubricant mixtures by the sheet insulation was somewhat higher than absorption of pure refrigerants. The porous Nomex-Mica

absorbed the most refrigerant-lubricant and bakeout at 150°C(302°F) did not remove all the lubricant. There was a significant decrease in tensile strength and elongation for the Nomex-Mica. This may be due more to the effect of temperature than the effect of refrigerants and lubricants. Exposure to nitrogen at 127°C(260°F) for 500-hours followed by exposure at 150°C(302°F) for 24 hours caused a decrease in tensile strength as great as 97.8% and a decrease in elongation as great as 96.8%.

Removal of absorbed refrigerants from the sheet insulations by the 150°C (302°F) bake showed little effect except for bubbles between the laminates of the Nomex/Mylar/Nomex after exposure to HCFC-22, HCFC-123, HCFC-142b, HFC-134a, HFC-134, HCFC-124, and HFC-125. Weight losses from the Dacron/Mylar/Dacron after exposure to HCFC-22, HCFC-123, and HFC-125 (-1.2, -1.3, and -1.0%, respectively) and from the Nomex after exposure to HCFC-124 and HFC-125 (-1.4 and -2.9%, respectively) were higher than for other sheet materials. These weight losses did not significantly decrease the tensile strengths or elongations, but may contaminate the refrigerant with extracted material. The HFC-134a/PAG Diol caused complete delamination of Nomex-Mylar-Nomex and the Dacron-Mylar-Dacron by dissolving the adhesive. A white precipitate was observed in cooled HCFC-22/mineral oil after the 500 hour exposure. Analysis of the precipitate by FTIR(Fourier Transform Infrared) showed it was polyester dissolved from the Mylar, Dacron or Melinex materials. This polyester precipitate was not observed after tests with the other lubricants.

Refrigerants or the refrigerant-lubricant combinations had little effect on the measured dielectric strengths of the sheet insulation materials. In most cases, the dielectric discharge flashed through the air around the edges of the sheet insulation rather than passing through the materials.

Except for the effects of some refrigerant-lubricant combinations on the adhesives used with the composite sheet insulations and the embrittlement of the polyester sheet insulations, materials compatibility appears acceptable for most of the combinations tested.

Compatibility of Spiral Wrapped Sleeving Insulations

Results of refrigerant and refrigerant-lubricant exposures on spiral wrapped sleeving insulation materials are given in Appendixes C, D and E.

The spiral wrapped sleeving insulation absorbed a considerable amount of HCFC-123 (22.6 to 56.9%), HCFC-22 (7.2 to 15.3), HFC-152a (8.9 to 17.2%) and HCFC-124 (5.3 to 12.4%). In most cases absorption in the Nomex was higher than in the Mylar. This absorption did not degrade the Nomex. Weight losses after the 150°C(302°F) bake were highest for HCFC-123, HFC-125, HCFC-142b, HFC-32 and HCFC-22 especially in the Nomex and the Nomex/Mylar ranging from -1.25 to -3.80%. Although the sleeving materials absorbed considerable amounts of some refrigerants, no damage was observed.

Unlike the sheet insulation materials, the spiral wrapped sleeving did not delaminate after exposure to HFC-134a/PAG diol. However, the layers of insulation that made up the sleeveings could be pulled apart by hand after exposures to HCFC-22/mineral oil and after exposure to HCFC-142b/alkylbenzene.

Compatibility of Lead Wires

Results of refrigerant and refrigerant-lubricant exposures on lead wire materials are given in Appendixes C, D and E.

After exposures to refrigerants or refrigerants-lubricants, no significant losses in weight or dielectric strengths were measured for the lead wires. The dielectric strength of the Dacron-Mylar-Teflon-Dacron(DMTD) actually increased after most of the exposures. Absorption of refrigerants and refrigerant-lubricant combinations by the lead wires was moderate. Neither the Dacron-Mylar-Dacron or the DMTD insulations on the lead wires showed signs of compatibility problems.

Compatibility of Tapes and Tie Cord

Results of refrigerant and refrigerant-lubricant exposures on tapes and tie cord materials are given in Appendixes C, D and E.

Refrigerant exposures had little effect on the break load strengths of the tapes and tie cords. Of concern was the high weight loss of the Permacel Assembly Tape after exposure to refrigerants followed by the 150°C (302°F) bake. Weight loss was as high as 14.5% in HCFC-123 indicating significant extraction.

The tapes, especially the polyester and glass-acrylic tape, were affected by the refrigerant-lubricant combination to a greater extent than by pure refrigerants. Absorption as high as 47.9% was observed. A decrease in break load strength of -78.6% was noted for the HCFC-22/mineral oil combination. This effect appears to be caused by the refrigerant-lubricant, because controlled exposure in nitrogen at 127°C(260°F) did not result in the same effect. The tie cords were not adversely affected by the refrigerant-lubricant combinations. The brittleness and decreased strength of the polyester and glass-acrylic tape is a concern. The greatest effects were observed after exposure to HCFC-22/mineral oil, however, these materials have a good reliability in HCFC-22/mineral oil applications in the field.

SUMMARY OF RESULTS

Absorption of HCFC-123 by most motor materials was higher than for other refrigerants. However, absorption of HCFC-22, HFC-32, HFC-134 and HFC-152a followed by desorption at higher temperatures, resulted in greater damage to the insulation material than was observed with HCFC-123. This result suggests that high internal pressures and rate of refrigerant desorption is as important as the amount of refrigerant absorbed. Desorption of refrigerant caused blisters, cracks, internal bubbles and delamination in some materials. The measured effects on properties of some materials was a decrease of bond strength(as high as 95%), a decrease of dielectric strength(as high as 70%), and a decrease of the physical integrity of the material. Compared to the bond and dielectric strengths, burnout was less influenced by desorption prior to the test. The burnout test caused desorption of refrigerant during the test. Magnet wire with polyester-glass serving had the best burnout resistance and was influenced much less by the exposure to absorbed refrigerant.

In most cases, the refrigerant-lubricant combinations had less effect on the motor materials than exposure to pure refrigerants. No evidence of varnish degradation due to desorption of refrigerant or lubricant was observed after the refrigerant-lubricant exposures. The primary concerns were delamination of the sheet insulation after exposure by the PAG diol lubricant and decreased strength of the tapes. The alkylbenzene lubricants appeared to cause greater embrittlement of polyester sheet insulation than the other synthetic lubricants. Precipitation of a polyester material was observed after the exposure to the HCFC-22/mineral oil. No evidence of polyester precipitate was observed after exposure to the synthetic lubricants, suggesting sticking valves or clogged capillaries may be less of a problem with the new lubricants.

Of the eleven refrigerants tested, HCFC-22 produced the greatest effects on motor materials. However, since HCFC-22 has an excellent reliability history with many of these materials, the alternative refrigerants are also expected to be compatible with most materials.

MOTOR MATERIAL COMPATIBILITY CHARTS

Compatibility of the motor materials are summarized in the following charts. Three compatibility designations were used in the charts:

Yes/Compatible

Yes signifies that the material is compatible. No evidence was observed or measured that would indicate that the materials would be unsuitable for use under field conditions similar to or less stringent than the test conditions. However, each user of the "compatible" motor materials is encouraged to consider any unique conditions of their particular application that might affect the compatibility.

Incompatible

Incompatible signifies that the test results caution against use of these materials under field conditions similar to that of the compatibility test exposure. Use of these materials may be acceptable under less stringent field conditions, or under the unique situation of a particular application. Additional compatibility testing is suggested before these materials are used with the respective refrigerants and/or lubricants cited.

Concern

Concern signifies that the material may be compatible under field conditions similar to or less stringent than the test conditions. However, observations or test results suggest that caution or further testing be exercised before use of these materials. In some instances a "concern" designation has been used for materials and refrigerant-lubricant combinations with known reliability histories. This result may suggest that the test conditions used in the study are more severe than some field conditions.

Chart of Motor Material Compatibility

	Refrigerant Exposure			
	HCFC-22	HCFC-123	HCFC-124	HCFC-142b
<u>Magnet Wires</u>				
-Modified polyester overcoated with polyamide imide	yes	yes	yes	yes
-Modified polyester overcoated with polyamide imide and epoxy saturated glass	yes	yes	yes	yes
-Polyester imide overcoated with polyamide imide	yes	yes	yes	yes
<u>Varnishes</u>				
U-475 EH (solvent epoxy)	yes	yes	yes	yes
Y-390PG (solvent epoxy-phenolic)	yes	yes	yes	yes
ER-610 (93 % solids epoxy)	yes	yes	yes	yes
Y-833 (100% solids VPI epoxy)	concern ¹	incompatible ⁵	yes	yes
No. 923 (solvent epoxy)	yes	yes	yes	yes
Isopoxy 800 (water-borne epoxy)	yes	yes	yes	yes
<u>Sheet Insulations</u>				
Nomex/Mylar/Nomex	concern ²	concern ²	concern ²	concern ²
Dacron/Mylar/Dacron	concern ³	yes	yes	yes
Mylar MO	yes	yes	yes	yes
Nomex 410	yes	yes	yes	yes
Nomex Mica 418	yes	yes	yes	yes
Melinex 228	yes	yes	yes	yes
<u>Sleeving Insulations</u>				
Nomex	yes	yes	yes	yes
Mylar	yes	yes	yes	yes
Nomex/Mylar	yes	yes	yes	yes
<u>Tapes</u>				
Heat Cleaned Glass	yes	yes	yes	yes
Heat Shrinkable Polyester	yes	yes	yes	yes
glass/acrylic	yes	incompatible ⁴	yes	yes
<u>Lead Wire Insulation</u>				
Dacron/Mylar/Dacron	yes	yes	yes	yes
Dacron/Mylar/Teflon/Dacron	yes	yes	yes	yes
<u>Tie Cord</u>				
Polyester	yes	yes	yes	yes

Chart of Motor Material Compatibility

	Refrigerant Exposure			
	HFC-134a	HFC-125	HFC-143a	HFC-32
<u>Magnet Wires</u>				
-Modified polyester overcoated with polyamide imide	yes	yes	yes	yes
-Modified polyester overcoated with polyamide imide and epoxy saturated glass	yes	yes	yes	yes
-Polyester imide overcoated with polyamide imide	yes	yes	yes	yes
<u>Varnishes</u>				
U-475 EH (solvent epoxy)	yes	yes	yes	yes
Y-390PG (solvent epoxy-phenolic)	yes	yes	yes	yes
ER-610 (93 % solids epoxy)	yes	yes	yes	yes
Y-833 (100% solids VPI epoxy)	yes	yes	yes	yes
No. 923 (solvent epoxy)	yes	yes	yes	yes
Isopoxy 800 (water-borne epoxy)	yes	yes	yes	yes
<u>Sheet Insulations</u>				
Nomex/Mylar/Nomex	yes	yes	yes	yes
Dacron/Mylar/Dacron	yes	yes	yes	yes
Mylar MO	yes	yes	yes	yes
Nomex 410	yes	concern ⁶	yes	yes
Nomex Mica 418	yes	concern ⁶	yes	yes
Melinex 228	yes	yes	yes	yes
<u>Sleeving Insulations</u>				
Nomex	yes	yes	yes	yes
Mylar	yes	yes	yes	yes
Nomex/Mylar	yes	yes	yes	yes
<u>Tapes</u>				
Heat Cleaned Glass	yes	yes	yes	yes
Heat Shrinkable Polyester	yes	yes	yes	yes
glass/acrylic	yes	yes	yes	yes
<u>Lead Wire Insulation</u>				
Dacron/Mylar/Dacron	yes	yes	yes	yes
Dacron/Mylar/Teflon/Dacron	yes	yes	yes	yes
<u>Tie Cord</u>				
Polyester	yes	yes	yes	yes

Chart of Motor Material Compatibility

	Refrigerant Exposure		
	HFC-152a	HFC-134	HFC-245ca
<u>Magnet Wires</u>			
-Modified polyester overcoated with polyamide imide	yes	yes	yes
-Modified polyester overcoated with polyamide imide and epoxy saturated glass	yes	yes	yes
-Polyester imide overcoated with polyamide imide	yes	yes	yes
<u>Varnishes</u>			
U-475 EH (solvent epoxy)	yes	yes	yes
Y-390PG (solvent epoxy-phenolic)	yes	yes	yes
ER-610 (93 % solids epoxy)	yes	yes	yes
Y-833 (100% solids VPI epoxy)	yes	yes	yes
No. 923 (solvent epoxy)	yes	yes	yes
Isopoxy 800 (water-borne epoxy)	yes	yes	yes
<u>Sheet Insulations</u>			
Nomex/Mylar/Nomex	yes	concern ²	yes
Dacron/Mylar/Dacron	yes	yes	concern ⁷
Mylar MO	yes	yes	yes
Nomex 410	yes	yes	yes
Nomex Mica 418	yes	yes	yes
Melinex 228	yes	yes	yes
<u>Sleeving Insulations</u>			
Nomex	yes	yes	yes
Mylar	yes	yes	yes
Nomex/Mylar	yes	yes	yes
<u>Tapes</u>			
Heat Cleaned Glass	yes	yes	yes
Heat Shrinkable Polyester glass/acrylic	yes	yes	yes
<u>Lead Wire Insulation</u>			
Dacron/Mylar/Dacron	yes	yes	yes
Dacron/Mylar/Teflon/Dacron	yes	yes	yes
<u>Tie Cord</u>			
Polyester	yes	yes	yes

Chart of Motor Material Compatibility

	Refrigerant/Lubricant Exposure			
	HCFC-22/ Mineral	HCFC-124/ Alkylbenzene	HCFC-142b/ Alkylbenzene	HFC-152a/ Alkylbenzene
<u>Magnet Wires</u>				
-Modified polyester overcoated with polyamide imide	yes	yes	yes	yes
-Modified polyester overcoated with polyamide imide and epoxy saturated glass	yes	yes	yes	yes
-Polyester imide overcoated with polyamide imide	yes	yes	yes	yes
<u>Varnishes</u>				
U-475 EH (solvent epoxy)	yes	yes	yes	yes
Y-390PG (solvent epoxy-phenolic)	yes	yes	yes	yes
ER-610 (93 % solids epoxy)	yes	yes	yes	yes
Y-833 (100% solids VPI epoxy)	yes	yes	yes	yes
No. 923 (solvent epoxy)	yes	yes	yes	yes
Isopoxy 800 (water-borne epoxy)	yes	yes	yes	yes
<u>Sheet Insulations</u>				
Nomex/Mylar/Nomex	concern ⁸	concern ¹⁰	concern ¹⁰	concern ¹⁰
Dacron/Mylar/Dacron	concern ⁸	concern ¹⁰	concern ¹⁰	concern ¹⁰
Mylar MO	concern ⁸	concern ¹⁰	concern ¹⁰	concern ¹⁰
Nomex 410	yes	yes	yes	yes
Nomex Mica 418	yes	yes	yes	yes
Melinex 228	concern ⁸	concern ¹⁰	concern ¹⁰	concern ¹⁰
<u>Sleeving Insulations</u>				
Nomex	concern ⁹	yes	yes	yes
Mylar	concern ⁹	concern ⁹	yes	yes
Nomex/Mylar	yes	concern ⁹	yes	yes
<u>Tapes</u>				
Heat Cleaned Glass	yes	yes	yes	yes
Heat Shrinkable Polyester	yes	yes	yes	yes
glass/acrylic	yes	yes	yes	yes
<u>Lead Wire Insulation</u>				
Dacron/Mylar/Dacron	yes	yes	yes	yes
Dacron/Mylar/Teflon/Dacron	yes	yes	yes	yes
<u>Tie Cord</u>				
Polyester	yes	yes	yes	yes

Chart of Motor Material Compatibility

	Refrigerant/ Lubricant Exposure		
	HFC-134a/ ester mixed acid	HFC-134a/ ester branched acid	HFC-32/ ester branched acid
<u>Magnet Wires</u>			
-Modified polyester overcoated with polyamide imide	yes	yes	yes
-Modified polyester overcoated with polyamide imide and epoxy saturated glass	yes	yes	yes
-Polyester imide overcoated with polyamide imide	yes	yes	yes
<u>Varnishes</u>			
U-475 EH (solvent epoxy)	yes	yes	yes
Y-390PG (solvent epoxy-phenolic)	yes	yes	yes
ER-610 (93 % solids epoxy)	yes	yes	yes
Y-833 (100% solids VPI epoxy)	yes	yes	yes
No. 923 (solvent epoxy)	yes	yes	yes
Isopoxy 800 (water-borne epoxy)	yes	yes	yes
<u>Sheet Insulations</u>			
Nomex/Mylar/Nomex	concern ²	concern ²	concern ¹¹
Dacron/Mylar/Dacron	yes	yes	yes
Mylar MO	yes	yes	yes
Nomex 410	yes	yes	yes
Nomex Mica 418	yes	yes	yes
Melinex 228	yes	yes	yes
<u>Sleeving Insulations</u>			
Nomex	yes	yes	yes
Mylar	yes	yes	yes
Nomex/Mylar	yes	yes	yes
<u>Tapes</u>			
Heat Cleaned Glass	yes	yes	yes
Heat Shrinkable Polyester	yes	yes	yes
glass/acrylic	yes	yes	concern ¹²
<u>Lead Wire Insulation</u>			
Dacron/Mylar/Dacron	yes	yes	yes
Dacron/Mylar/Teflon/Dacron	yes	yes	yes
<u>Tie Cord</u>			
Polyester	yes	yes	yes

Chart of Motor Material Compatibility

	Refrigerant/ Lubricant Exposure		
	HFC-125/ ester branched acid	HFC-134/ ester branched acid	HFC-143a/ ester branched acid
<u>Magnet Wires</u>			
-Modified polyester overcoated with polyamide imide	yes	yes	yes
-Modified polyester overcoated with polyamide imide and epoxy saturated glass	yes	yes	yes
-Polyester imide overcoated with polyamide imide	yes	yes	yes
<u>Varnishes</u>			
U-475 EH (solvent epoxy)	yes	yes	yes
Y-390PG (solvent epoxy-phenolic)	yes	yes	yes
ER-610 (93 % solids epoxy)	yes	yes	yes
Y-833 (100% solids VPI epoxy)	yes	yes	yes
No. 923 (solvent epoxy)	yes	yes	yes
Isopoxy 800 (water-borne epoxy)	yes	yes	yes
<u>Sheet Insulations</u>			
Nomex/Mylar/Nomex	concern ²	concern ²	concern ²
Dacron/Mylar/Dacron	yes	yes	yes
Mylar MO	yes	yes	yes
Nomex 410	yes	yes	yes
Nomex Mica 418	yes	yes	yes
Melinex 228	yes	yes	yes
<u>Sleeving Insulations</u>			
Nomex	yes	yes	yes
Mylar	yes	yes	yes
Nomex/Mylar	yes	yes	yes
<u>Tapes</u>			
Heat Cleaned Glass	yes	yes	yes
Heat Shrinkable Polyester	yes	yes	yes
glass/acrylic	concern ¹²	concern ¹²	concern ¹²
<u>Lead Wire Insulation</u>			
Dacron/Mylar/Dacron	yes	yes	yes
Dacron/Mylar/Teflon/Dacron	yes	yes	yes
<u>Tie Cord</u>			
Polyester	yes	yes	yes

Chart of Motor Material Compatibility

	Refrigerant/ Lubricant Exposure		
	HFC-245ca/ ester branched acid	HFC-134a/ PAG, butyl monoether	HFC-32/ PAG, butyl monoether
<u>Magnet Wires</u>			
-Modified polyester overcoated with polyamide imide	yes	yes	yes
-Modified polyester overcoated with polyamide imide and epoxy saturated glass	yes	yes	yes
-Polyester imide overcoated with polyamide imide	yes	yes	yes
<u>Varnishes</u>			
U-475 EH (solvent epoxy)	yes	yes	yes
Y-390PG (solvent epoxy-phenolic)	yes	yes	yes
ER-610 (93 % solids epoxy)	yes	yes	yes
Y-833 (100% solids VPI epoxy)	yes	yes	yes
No. 923 (solvent epoxy)	yes	yes	yes
Isopoxy 800 (water-borne epoxy)	yes	yes	yes
<u>Sheet Insulations</u>			
Nomex/Mylar/Nomex	yes	concern ¹¹	concern ¹¹
Dacron/Mylar/Dacron	yes	concern ¹³	yes
Mylar MO	yes	yes	yes
Nomex 410	yes	yes	yes
Nomex Mica 418	yes	yes	yes
Melinex 228	yes	yes	yes
<u>Sleeving Insulations</u>			
Nomex	yes	yes	yes
Mylar	yes	yes	yes
Nomex/Mylar	yes	yes	yes
<u>Tapes</u>			
Heat Cleaned Glass	yes	yes	yes
Heat Shrinkable Polyester glass/acrylic	yes	yes	yes
	yes	concern ¹²	concern ¹²
<u>Lead Wire Insulation</u>			
Dacron/Mylar/Dacron	yes	yes	yes
Dacron/Mylar/Teflon/Dacron	yes	yes	yes
<u>Tie Cord</u>			
Polyester	yes	yes	yes

Chart of Motor Material Compatibility

	Refrigerant/Lubricant Exposure			
	HFC-125/ PAG, butyl monoether	HFC-134a/ Modified Polyglycol	HFC-125/ Modified Polyglycol	HFC-134a/ PAG, Diol
<u>Magnet Wires</u>				
-Modified polyester overcoated with polyamide imide	yes	yes	yes	yes
-Modified polyester overcoated with polyamide imide and epoxy saturated glass	yes	yes	yes	yes
-Polyester imide overcoated with polyamide imide	yes	yes	yes	yes
<u>Varnishes</u>				
U-475 EH (solvent epoxy)	yes	yes	yes	yes
Y-390PG (solvent epoxy-phenolic)	yes	yes	yes	yes
ER-610 (93 % solids epoxy)	yes	yes	yes	yes
Y-833 (100% solids VPI epoxy)	yes	yes	yes	yes
No. 923 (solvent epoxy)	yes	yes	yes	yes
Isopoxy 800 (water-borne epoxy)	yes	yes	yes	yes
<u>Sheet Insulations</u>				
Nomex/Mylar/Nomex	concern ²	concern ²	concern ²	incompatible ¹⁴
Dacron/Mylar/Dacron	yes	concern ¹³	yes	incompatible ¹⁴
Mylar MO	yes	yes	yes	yes
Nomex 410	yes	yes	yes	yes
Nomex Mica 418	yes	yes	yes	yes
Melinex 228	yes	yes	yes	yes
<u>Sleeving Insulations</u>				
Nomex	yes	yes	yes	yes
Mylar	yes	yes	yes	yes
Nomex/Mylar	yes	yes	yes	yes
<u>Tapes</u>				
Heat-Cleaned Glass	yes	yes	yes	yes
Heat-Shrinkable Polyester glass/acrylic	yes	yes	yes	yes
	concern ¹²	yes	concern ¹²	concern ¹²
<u>Lead Wire Insulation</u>				
Dacron/Mylar/Dacron	yes	yes	yes	yes
Dacron/Mylar/Teflon/Dacron	yes	yes	yes	yes
<u>Tie Cord</u>				
Polyester	yes	yes	yes	yes

Notes for the Compatibility Charts

1. A compatibility concern was raised about the Y-833 varnish when the varnish disks were severely crazed and limp after the exposure to HCFC-22.
2. A concern about the compatibility of the Nomex/Mylar/Nomex sheet insulation was raised when pockets of delamination appeared between the Nomex and the Mylar sheet insulations. These pockets appeared after the 500-hour exposure plus a 24-hour air bake at 150°C(302°F).
3. A concern about the compatibility of the Dacron/Mylar/Dacron sheet insulation was raised when the sheet insulation exhibited a significant weight loss after the 500-hour exposure plus a 24-hour air bake at 150°C(302°F).
4. This tape was considered not compatible with HCFC-123 because of the large weight loss experienced after the 500-hour exposure plus a 24-hour air bake at 150°C(302°F). Another compatibility problem was the tape had rolled up, turned green in color and the backing separated after the 500-hour exposure to HCFC-123.
5. This varnish was considered not compatible because the varnish was soft, limp and crazed after the 500-hour exposure to HCFC-123. These physical properties were observed with the varnish disks and the helical coils. This varnish had absorbed large amounts of refrigerant HCFC-123.
6. A compatibility concern was raised about this sheet insulation because a significant weight loss was observed after the 500-hour exposure to HFC-125 plus a 24-hour air bake at 150°C(302°F).
7. A concern about the compatibility of the Dacron/Mylar/Dacron sheet insulation was raised when the sheet insulation exhibited a significant weight loss after the 500-hour refrigerant exposure plus a 24-hour air bake at 150°C(302°F). A polyester material was identified by FTIR(Fourier Transform Infrared) after a small amount of the HFC-245ca was evaporated.
8. There was concern about the compatibility of the PET(polyethylene terephthalate) materials(Mylar and Melinex) in HCFC-22/Mineral oil. These polymer materials lost most of their flexibility and broke sometimes when bent. A solid precipitate was filtered from the oil and was identified by FTIR to be a form of a polyester(terephthalic acid based compound).
*However, these materials have been used in a HCFC-22/Mineral oil applications for 20 to 30 years and have shown no compatibility problems.
9. The adhesive used to bond the layers of sheet insulation together in these sleeving materials was weakened by this refrigerant-lubricant exposure. The layers could be pulled apart by hand. This could be a possible compatibility concern. *However, these materials have been used in HCFC-22/Mineral oil applications for 20 to 30 years and have shown no compatibility problems.
10. A concern about the compatibility of the PET(polyethylene terephthalate) materials(Mylar and Melinex) was raised after the exposure to alkylbenzene lubricants. Some of these polyethylene terephthalate materials became brittle and/or lost their ability to stretch(elongate). However, these losses in physical properties were not any greater than the losses shown in the HCFC-22/Mineral oil exposure. The relative severity of each exposure on the motor materials as compared the HCFC-22/ mineral oil exposure are as follows:
HCFC-22/Mineral oil $\geq$ HCFC-124/Alkylbenzene > HCFC-142b/Alkylbenzene > HFC-152a/Alkylbenzene.

Notes for the Compatibility Charts

11. A concern about the compatibility of the Nomex/Mylar/Nomex sheet insulation was raised when pockets of delamination were observed between the Nomex and the Mylar sheet insulations. These pockets appeared after the 500-hour exposure and after the 500-hour exposure plus a 24-hour air bake at 150°C(302°F). These delamination pockets were different than those previously described for the Nomex/Mylar delamination(note 2). The Nomex was almost totally detached from the Mylar and the delamination pockets appeared after 500-hour exposure and after the 24-hour air bake.

12. This tape was curled up and the backing was easily rubbed off after the 500-hour exposure. However after the material was heated for 24-hour at 150°C(302°F), the tape regained the original unexposed form.

13. A concern about the compatibility of the Dacron/Mylar/Dacron sheet insulation was raised when the sheet insulation exhibited a significant weight loss after the 500-hour refrigerant-lubricant exposure plus a 24-hour air bake at 150°C(302°F).

14. The Nomex/Mylar/Nomex and Dacron/Mylar/Dacron materials were considered not compatible with HFC-134a/PAG diol refrigerant-lubricant combination because the sheet insulation(Nomex or Dacron) separated from the Mylar layer. The adhesive holding the layers together had been dissolved.

COMPLIANCE WITH AGREEMENT

All work performed during this project was in full compliance with the requirements of the original Work Statement or as amended during the course of this project.

PRINCIPAL INVESTIGATOR'S EFFORTS

Robert Doerr(Project Manager) devoted 32% of his available work hours over the entire length of this project.

Stephen Kujak(Principal Investigator) devoted 72% of his available work hours over the entire length of this project.

Appendix A

Material Identification

Material Identification

Motor Materials

Magnet Wires

-Phelps Dodge, Armored Poly-Thermaleze 2000

Basecoat(BC):	THEIC Polyester
Topcoat(TC):	PD-amideimide
Glasscoat(GC):	none
Coat Construction:	5 coats-BC/2 coats-TC
Wire Size	18 gauge

-Phelps Dodge, Armored Poly-Thermaleze Daglass 2000

Basecoat(BC):	THEIC Polyester
Topcoat(TP):	PD-amideimide
Glasscoat(GC):	Dacron/glass/epoxy
Coat Construction:	5 coats-BC/2 coats-TC/2 coat-GC
Wire Size	18 gauge

-Phelps Dodge/Schenectady Chemical; Polyester imide overcoated with polyamide imide

Basecoat:	THEIC Esterimide
Topcoat:	PD-amideimide
Glasscoat:	none
Coat Construction:	5 coats-BC/2 coats-TC
Wire Size:	18 gauge

Varnishes

-Sterling U-475EH

-Sterling Y-390PG

-Sterling ER-610

-Sterling Y-833

-P.D. George No. 923

-Schenectady Chemical Co., Isopoxy 800

Sheet Insulations

-Westinghouse, Nomex/Mylar/Nomex

Description:	Nomex 410/Mylar Film/Nomex 410 Sheet Insulation
Composite Thickness:	0.020 inches
Thickness breakdown:	0.005 inches Nomex/0.010 inches Mylar/0.005 inches Nomex

-Westinghouse, Dacron/Mylar/Dacron

Description:	Nomex 410/Mylar Film/Nomex 410 Sheet Insulation
Composite Thickness:	0.020 inches
Thickness breakdown:	0.005 inches Nomex/0.010 inches Mylar/0.005 inches Nomex

-Dupont, Mylar MO

Description:	Mylar 900 MO Sheet Insulation
Nominal Thickness:	0.009 inches

-Dupont, Nomex 410

Description: Nomex 410 Sheet Insulation
Nominal Thickness: 0.010 inches

-Dupont, Nomex/Mica 418

Description: Nomex/Mica 418 Sheet Insulation
Nominal Thickness: 0.008 inches

-ICI, Melinex 228

Description: Melinex 228 Sheet Insulation
Nominal Thickness: 0.009 inches

Spiral Wrapped Sheet Insulations

-Insulation Sales, Nomex

Description: Spirally wound Nomex electrical insulation sleeving
Sleeving Composites: Nomex-aramid paper
Sleeving Thickness: 0.008 inches

-Insulation Sales, Mylar

Description: Spirally wound Mylar electrical insulation sleeving
Sleeving Composites: Mylar
Sleeving Thickness: 0.006 inches

-Insulation Sales, Nomex/Mylar

Description: Spirally wound Mylar and Nomex electrical insulation sleeving
Sleeving Composites: Mylar outside/Nomex inside
Sleeving Thickness: 0.005 inches

Lead Wires

-A.O. Smith, Dacron/Mylar/Dacron

Description: A brand of Dacron thread over the bare copper wire, then a wrap of Mylar tape half lapped, then a final braid of Dacron thread.
Sleeving Composites: Dacron outside/Mylar 1 mil middle/Dacron over wire

-A.O. Smith, Dacron/Mylar/Teflon/Dacron

Description: A brand of Dacron thread over the bare copper wire, a wrap of Teflon tape half lapped, then a layer of Mylar half lapped, then a final braid of Dacron thread.
Sleeving Composites: Dacron outside/Mylar 1 mil middle/Teflon tape/Dacron over wire

Tapes

-Carolina Narrow, Heat Cleaned Fiberglass

Description: Woven Fiberglass Tape, Style 2276-2
Width: 0.75 inches
Thickness: 0.007 inches

• -Electrolock Inc., Heat Shrinkable Braided Polyester

Description:	Heat Shrinkable Polyester Woven Tape
Width:	0.75 inches
Thickness	0.005 inches

-Essex Insulation, Permacel P247 glass/acrylic

Description:	Permacel P-247 Electrical Insulating Tape
Composites:	Polyester film reinforced with glass filaments
Width:	0.75 inches

Tie Cord

-Ludlow Textiles, Polyester Tie Cord

Description:	A 4-ply soft, polyester tie cord on 1000 Denier polyester fiber twisted and cabled at 8.0 "Z" x 5.0 "S"
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Lubricants

Mineral Oils

Witco 3GS, ISO-32

Alkylbenzenes

Shrieve Zerol-150, ISO-32

Ester, Mixed Acid

ICI Emkarate RL244, ISO-22

Ester, Branched Acid

Henkel/Emery 2927, ISO-32

PAG, Butyl Monoether

ICI Emkarox VG32, ISO-32

PAG, Modified

Allied Signal BRL-150, ISO-32

PAG, Diol

Dow P-425, ISO-32

Appendix B

Experimental Procedures

Experimental Procedures

Evaluation of Motor Materials

Exposed and unexposed motor materials were evaluated by the following methods:

Magnet Wires

The three types of magnet wire were tested, both alone and in combination with six varnishes. Tests conducted on the magnet wire measured weight change, flexibility, burnout strength and dielectric strength.

Weight Change

1. The Twisted Pairs(TP), Helical Coils(HC), and Single Strands(SS) were weighed before the exposure without the tag to the nearest 0.0001 grams.
2. The TP, HC and SS were weighed after the exposure without the tag to the nearest 0.0001 grams.
3. The difference in 1 and 2 is the weight change.

Appearance

The TP, HC, and SS after an exposure were checked against unexposed TP, HC, and SS of the same type to see if there was a visible change.

Flexibility(Single Strands Only)

The Single Strands after an exposure were checked for flexibility using:

ASTM D-1676, Sections 141 to 148

Parameters:

Mandrel Diameter=0.20 inches

Mandrel rotation speed=<240 revolutions per minute.

This ASTM procedure was used for film coated magnet wire. We used this with film coated magnet wire and magnet wire coated with varnish.

Twisted Pair Fabrication

Film Coated Magnet Wire

Film coated magnet wires were fabricated into twisted pairs using:

Motorized Dielectric Twist Specimen Fabricator(MW-3)

From: A/Z-Tech Inc.

A Division of Indiana Institute of Technology

Fort Wayne, Indiana 46803

Served Magnet Wire

Served magnet wire was fabricated into twisted pairs using:

Motorized Wire Twist Fabricator(MW-3B)
From: A/Z-Tech Inc.
A Division of Indiana Institute of Technology
Fort Wayne, Indiana 46803

Burnout Strength(Twisted Pairs Only)

The Twisted pairs after an exposure were checked for burnout strength using:

ASTM D-1676, Sections 13 to 21.

Test instrument used: Wire Burnout Tester
A/Z-Tech Inc.
A Division of Indiana Institute of Technology
Fort Wayne, Indiana 46803

Dielectric Strength(Twisted Pairs Only)

The twisted pairs after an exposure were checked for dielectric strength using:

ASTM D-1676, Sections 69 to 75.

Test instrument used: Automatic Dielectric Breakdown Tester, 20 KV (MW-2)
A/Z-Tech Inc.
A Division of Indiana Institute of Technology
Fort Wayne, Indiana 46803

Varnishes

Six types of varnishes were tested, both alone in the form of varnish disks and coated on helical coils of the three types of magnet wire. Tests conducted on the varnishes measured weight change, flexibility and varnish bond strength. Procedures for the dipping of the magnet wire materials and the cure times used for each varnish for the varnish coated magnet wire materials and varnish disks are included in this section.

Weight Change

1. The varnish disks and helical coils were weighed before the exposure without the tag to the nearest 0.0001 grams.
2. The varnish disks and helical coils were weighed after the exposure without the tag to the nearest 0.0001 grams.
3. The difference in 1 and 2 is the weight change.

Appearance

The varnish disks after an exposure were checked against unexposed varnish disks of the same type to see if there was a visible change in their appearance.

Flexibility

The varnish disks after an exposure were checked against unexposed varnish disks of the same type to see if there was a change in the flexibility.

Bond Strength(Helical Coils)

The Helical Coils after exposure are checked for bond strength using:

ASTM D-2519.

Curing Procedure for Varnish Disks

A selected weight of liquid varnish was placed in a tarred aluminum weighing dish to give a cured disk that was approximately 0.05 inches. The varnish was cured according to the suppliers recommendation, except that a step cure was often used to avoid solvent bubbles. Table 1 gives the varnish weight, step cure, final cure and percent solids.

Varnish	Weight(g)	Step Cure		Final Cure		Solids
		Hours	Temp.	Hours	Temp.	
U-475EH	4.0	4	121°C(250°F)	4	163°F(325°F)	63%
Y-390PG	5.1	4	100°C(212°F)	4	163°F(325°F)	48%
ER 610	2.8	None	None	4	163°F(325°F)	95%
Y-833	3.2	4	121°C(250°F)	4	163°F(325°F)	80%
923	4.0	24	100°C(212°F)	4	163°F(325°F)	50%
800	6.0	24	100°C(212°F)	6	149°C(300°F)	32%

Varnishing and Curing Procedure for Magnet Wire Materials

Helical coils(HC), twisted pairs(TP) and single strands(SS) were made from each of the three magnet wires. The varnish dip bake process for the six varnishes used in the project are as follows:

- The HC, TP and SS were preheated to 175°C(350°F) for 2 hours prior to varnishing.
- HC, TP and SS were cooled to approximately 93°C(200°F).
- Sets of hot HC, TP and SS were dipped into the varnish and removed at a rate of 4 inches per minute.
- HC, TP and SS were allowed to drip until no further dripping was noticed. The helical coils were inspected to make certain they were not plugged with varnish.
- Sets of HC, TP, and SS were suspended in an oven for a step cure of 2 hours at 100°C(212°F).
- Oven temperature was then increased to 163°C(325°F) and samples were cured an additional ten hours.
- Invert the HC, TP and SS.
- Again the HC, TP and SS were heated to 163°C(325°F) and cooled to approximately 93°C(200°F).
- The samples were inverted and dipped a second time into the varnish and removed at a rate of 4 inches per minute.
- The HC, TP and SS were allowed to drip until no further dripping was noticed. The helical coils were inspected to make certain they were not plugged with varnish.
- Sets of coils were suspended in an oven for a step cure of 2 hours at 100°C(212°F).
- The oven temperature was increased to 163°C(325°F) and samples cured an additional 10 hours.

Sheet Insulations

The six types of sheet insulation were evaluated for weight change, appearance, tensile strength, percent elongation and dielectric strength.

Weight Change

1. The sheet insulations were weighed before the exposure without the tag to the nearest 0.0001 grams.
2. The sheet insulations were weighed after the exposure without the tag to the nearest 0.0001 grams.
3. The difference in 1 and 2 is the weight change.

Appearance

The sheet insulations after an exposure were checked against unexposed sheet insulations of the same type to see if there was a visible change.

Tensile Strength

The sheet insulations were tested for tensile strength using the following procedure:

ASTM D-882
"Tensile Properties of Thin Plastic Sheeting.

Test parameters used for each sheet insulation:

<u>Sheet Insulation type</u>	<u>Head Distance(in)</u>	<u>Rate(in/min)</u>
Nomex/Mylar/Nomex	4.0	2.0
Dacron/Mylar/Dacron	2.0	20.0
Mylar MO	2.0	20.0
Nomex 410	4.0	2.0
Nomex-Mica 418	4.0	2.0
Melinex 228	2.0	20.0

Sample size

1/2in x6 in

Percent(%) Elongation

The percent(%) elongation was determined by how far the head distance changed from the original preset head distance and converted to a percent.

Dielectric Strength

The sheet insulations after an exposure were checked for dielectric strength using:

ASTM D-149

Sample size

1-1/2in x 3 in

Spiral Wrapped Sleeving Insulations

The three types of spiral wrapped sleeving insulations were evaluated for weight change and appearance change after exposure.

Weight Change

1. The spiral wrapped sleeving insulations were weighed before the exposure without the tag to the nearest 0.0001 grams.
2. The spiral wrapped sleeving insulations were weighed after the exposure without the tag to the nearest 0.0001 grams.
3. The difference in 1 and 2 is the weight change.

Appearance

The spiral wrapped sleeving insulations after an exposure were checked against unexposed spiral wrapped sleeving insulations of the same type to see if there was a visible change.

Tapes

The three types of tapes were evaluated for weight change, appearance change, break load strength and percent(%) elongation.

Weight Change

1. The Tapes were weighed before the exposure without the tag to the nearest 0.0001 grams.
2. The Tapes were weighed after the exposure without the tag to the nearest 0.0001 grams.
3. The difference in 1 and 2 is the weight change.

Appearance

The tapes after an exposure were checked against unexposed tapes of the same type to see if there was a visible change.

Break Load

The tapes were tested for break load using the following procedure:

ASTM D-882

"Tensile Properties of Thin plastic Sheeting.

*The same procedure was followed as for the sheet insulation, but the break load(lbs.) that was achieved was recorded instead of calculating a tensile strength.

Parameters for each Tapes:

<u>Tape type</u>	<u>Head Distance(in)</u>	<u>Rate(in/min)</u>
Fiberglass	2.0	2.0
Polyester	2.0	2.0
Permacel	2.0	2.0

Sample Size

6 inches

Percent(%) Elongation

The percent(%) elongation was determined by how far the head distance changes from the original preset head distance and converted to percent change.

Tapes

The polyester tie cord was evaluated for weight change, appearance change, break load strength and percent(%) elongation.

Weight Change

1. The tie cords were weighed before the exposure without the tag to the nearest 0.0001 grams.
2. The tie cords were weighed after the exposure without the tag to the nearest 0.0001 grams.
3. The difference in 1 and 2 is the weight change.

Appearance

The tie cords after an exposure were checked against unexposed tie cords of the same type to see if there was a visible change.

Break Load

The tie cords were tested for break load using the following procedure:

ASTM D-882

"Tensile Properties of Thin plastic Sheeting.

*The same procedure was followed as for the sheet insulation, but the break load(lbs.) that was achieved was recorded instead of calculating a tensile strength.

Parameters for each Tapes:

<u>Tie Cord type</u> __	<u>Head Distance(in)</u>	<u>Rate(in/min)</u>
Polyester Tie Cord	4.0	2.0

Sample Size

6 inches

Percent(%) Elongation

The percent(%) elongation was determined by how far the head distance changes from the original preset head distance and converted to a percent change.

Lead Wire

The lead wires were evaluated for weight change, appearance change and dielectric strength.

Weight Change

1. The lead wire were weighed before the exposure without the tag to the nearest 0.0001 grams.
2. The lead wire were weighed after the exposure without the tag to the nearest 0.0001 grams.
3. The difference in 1 and 2 is the weight change.

Appearance

The lead wire after an exposure were checked against unexposed lead wire of the same type to see if there was a visible change.

Dielectric Strength

The lead wires were checked for dielectric strength using the following procedure.

-A 1/2 inch by 1 inch piece of aluminum foil was cut.

-A 4 " piece of copper wire was attached to one end of the aluminum foil.

- The aluminum foil was wrapped around the center of the lead wire.
- The copper wire was connected to one pole of the dielectric tester and the lead wire to the other pole.
- Voltage was applied at 500 volts/second until a dielectric breakdown of the insulation occurred.
- Breakdown voltage to the nearest 0.01 Kilovolt(kV) was recorded.
- A new piece of aluminum foil was used for each lead wire.

Other Procedures

Procedures listed in this section include Exposure Setup, which includes loading of materials into the Parr bombs and charging of the Parr bombs with refrigerant and/or lubricant, Gas Chromatography (GC) analysis and the analysis of oil samples.

Exposure Setup

Loading of Pressure Vessels* with Motor Materials.

Three 2000 ml and one 300 ml pressure vessels were used to hold all the motor materials samples needed for each refrigerant or refrigerant-lubricant exposure. The samples were as follows:

<u>Pressure Vessel</u>	<u>Motor Materials Loaded into the Vessels</u>
#1 2000 ml bomb	Twisted Pairs Single Strands
#2 2000 ml bomb	Helical Coils Varnish Disks Lead Wire
#3 2000 ml bomb	Sheet Insulation Sleeving 2 of the Tapes Tie Cords
#4 300 ml bomb	Permacel Tape Isopoxy 800 disks

*This is generally how the motor materials were loaded into the pressure vessels. For the first few exposures the Permacel tape and the Isopoxy 800 disks were placed in bomb #2. For later exposures the Isopoxy 800 disks and Permacel tape were tested separate from other items because of the large amount of extract. Sheet insulation were always kept separate from any varnished items.

Charging of the Pressure Vessels with Refrigerant and/or Lubricant

Refrigerant Exposures

* Pressure vessels used were T 316 Stainless Steel General Purpose Bombs from the Parr Instrument Company, Moline, IL.

The first refrigerant exposure setup was with HCFC-123. The motor materials were loaded into the appropriate bombs and volumes of HCFC-123 were added until the motor materials were covered with refrigerant. The known volumes of HCFC-123 were used to determine the milliliters of refrigerant needed for each bomb. For each additional exposure, the new refrigerants density was used to calculate the number of grams required to cover the materials.

Refrigerant-Lubricant Exposures

The motor materials were placed in each appropriate pressure vessel and lubricant was poured over the materials until the materials were almost covered. Then the vessels was sealed and evacuated for 30 minutes. Next, an appropriate amount of refrigerant was placed in the vessel to give a refrigerant pressure of greater than 2109 kPa(300 psi). After the bombs were heated for 24 hours the pressure was measured. If the pressure was greater than 2109 kPa(300 psi), refrigerant was removed until the pressure was 2109 kPa(300 psi). If it was less than 2109 kPa(300 psi), the vessel was charged with more refrigerant. The vessels were checked again at 48 hour, 168 hour, 336 hours and 500 hours to maintain a pressure of 2109 kPa(300 psi).

Weight % Refrigerant in Lubricants used for Exposures

<u>Refrigerant-Lubricant Combination</u>	<u>Weight % Refrigerant at 121°C(260°F) to yield approximately 300 psi.</u>
HCFC-22/Suniso 3GS, ISO-32	19.5-21.5
HCFC-124/Shrieve Zerol-150, ISO-32	42.0-45.0
HCFC-142b/Shrieve Zerol-150, ISO-32	48.5-51.0
HFC-152a/Shrieve Zerol-150, ISO-32	18.5-20.0
HFC-134a/ICI Emkarate RL244, ISO-32	24.5-26.0
HFC-134a/Henkel-Emery 2927, ISO-32	25.0-26.5
HFC-32/Henkel-Emery 2927, ISO-32	17.5-19.5
HFC-125/Henkel-Emery 2927, ISO-32	18.5-20.5
HFC-143a/Henkel-Emery 2927, ISO-32	22.0-23.5
HFC-134/Henkel-Emery 2927, ISO-32	34.0-37.0
HFC-245ca/Henkel-Emery 2927, ISO-32	50.0*
HFC-134a/ICI Emkarox VG32, ISO-32	22.0-23.5
HFC-32/ICI Emkarox VG32, ISO-32	18.5-20.0
HFC-125/ICI Emkarox VG32, ISO-32	19.0-21.0
HFC-134a/Allied Signal BRL-150, ISO-32	25.0-26.5
HFC-125/Allied Signal BRL-150, ISO-32	21.0-22.5
HFC-134a/Dow P-425, ISO-32	23.0-24.0

*300 psi was not reached using 50% HFC-245ca.

Gas Chromatographic (GC) Analysis

All GC analyses were performed on a Varian 3700 gas chromatographic instrument using a Flame Ionization Detector(FID). The column used for the analyses was a 5% Fluorcol column of 10 feet in length. Gas samples were injected on the column using a six way gas sampling valve with a 250 ul gas sampling loop. After high vacuum was drawn on sample loop assembly, the assembly was charged with refrigerant to 15 psig and the sample was injected onto the column. The column was operated under the following conditions.

Injector Temperature	200°C
Detector Temperature	250°C
Carrier Gas	Helium

Flow Rate	30 ml/min
Column Temperature	50°C
Sample Size	250 ul loop

GC results, i.e. peak areas, retention times and area percents for each measurable peak in the chromatogram, were obtained on a Hitachi 833A Data Processor.

Oil Analysis

The two analyses that were performed on all lubricants of the project were acid number and moisture. Each procedure is listed below:

Acid Number

Acid numbers of an oil were determined by the procedure given in ASTM D-974 " Acid and Base Number by Color-Indicator Titration".

Moisture

Moisture in lubricant was evaluated by injecting a known amount of lubricant into a Fisher Scientific Coulometer K-F Titrimeter Model 447. After the water was titrated, the moisture in the lubricant was calculated in parts per million.

Appendix C

Experimental Data for the Unexposed Motor Materials

Code Chart For Motor Material Exposures

Magnet Wire

Code

- A -Modified polyester overcoated with polyamide imide, as described in Section MW 73 of NEMA Standard MW 1000.
- B -Modified polyester overcoated with polyamide imide and epoxy saturated glass as described in Section MW 73 and MW 46 of NEMA Standard MW 1000.
- C -Polyester imide over coated with polyamide imide.

Varnishes

Code

- A -U-475EH solvent epoxy
- B -Y-390PG solvent epoxy-phenolic
- C -ER-610 93% solids epoxy
- D -Y-833 100% solids VPI epoxy
- E -923 solvent epoxy
- F -Isopoxy 800 water-borne epoxy

Sheet Insulation, Slot Liners and Phase Separators

Code

- A -Nomex/Mylar/Nomex
- B -Dacron/Mylar/Dacron
- C -Mylar MO
- D -Nomex 410
- E -Nomex Mica 418
- F -Melinex 228

Spiral Wrapped Sleeving Insulation

Code

- A -Nomex
- B -Mylar
- C -Nomex/Mylar

Lead Wire Insulation

Code

- A -Dacron/Mylar/Dacron
- B -Dacron/Teflon/Mylar/Dacron

Tapes

Code

- A -Heat Cleaned Glass
- B -Heat Shrinkable Braided Polyester
- C -Permacel P247 glass/acrylic

Tie Cords

Code

- A-Polyester

#1-after 500 hour exposure to refrigerant or refrigerant/lubricant.

#2-after 500 hour exposure plus 24 hours at 127°C(302°F).

MCLR PROJECT

DATE: May 5, 1992

TOPIC:

Baseline tests for uncoated magnet wire.

TEST PERFORMED:

Dielectric Strength

PARAMETERS

ASTM D-1676
RATE = 500 V/s

CODE

Same as used for MCLR Project.

	(A) (KILOVOLTS)	(B) (KILOVOLTS)	(C) (KILOVOLTS)
1	17.14	11.23	15.89
2	17.00	12.01	16.85
3	11.58	12.10	17.48
4	14.44	11.77	16.90
5	17.64	11.36	13.19
6	14.12	11.38	16.35
7	17.17	10.65	18.24
8	15.12	12.49	17.54
9	17.40	12.05	17.86
10	<u>16.42</u>	<u>11.11</u>	<u>15.48</u>
	Ave = 15.80kV	Ave = 11.62kV	Ave = 16.58 kV

MCLR PROJECT

DATE: May 5, 1992

TOPIC:

Baseline tests for U-475EH varnish coated magnet wire.

TEST PERFORMED:

Dielectric Strength

PARAMETERS

ASTM D-1676

RATE = 500 V/s

CODE

Same as used for MCLR Project.

	(A) (KILOVOLTS)	(B) (KILOVOLTS)	(C) (KILOVOLTS)
1	15.59	13.18	17.07
2	18.01	13.51	15.09
3	15.18	12.84	13.79
4	13.72	13.37	11.51
5	<u>18.72</u>	<u>13.32</u>	<u>18.03</u>
	16.24kV	13.32kV	15.10kV

MCLR PROJECT

DATE: May 5, 1992

TOPIC:

Baseline tests for Y-390 varnish coated magnet.

TEST PERFORMED:

Dielectric Strength

Parameters

Code

ASTM D1676

Same as used for MCLR Program

Rate 500 V/s

	(A) (KILOVOLTS)	(B) (KILOVOLTS)	(C) (KILOVOLTS)
1	17.48	11.49	18.83
2	18.41	13.20	17.89
3	18.31	11.80	19.62
4	19.81	12.17	17.93
5	<u>19.86</u>	<u>12.68</u>	<u>16.95</u>
	18.77kV	12.28kV	18.24kV

MCLR PROJECT

DATE: May 5, 1992

TOPIC:

Baseline tests for ER-610 varnish coated magnet wire.

TEST PERFORMED:

Dielectric Strength

PARAMETERS

ASTM D-1676
RATE = 500 V/s

CODE

Same as used for MCLR Project.

	(A) (KILOVOLTS)	(B) (KILOVOLTS)	(C) (KILOVOLTS)
1	15.96	12.16	12.96
2	16.90	12.84	13.10
3	16.46	12.45	15.74
4	13.13	12.74	16.70
5	<u>15.40</u>	<u>13.44</u>	<u>14.14</u>
	15.57 kV	12.73 kV	14.53 kV

MCLR PROJECT

DATE: May 5, 1992

TOPIC:

Baseline tests for Y-833 varnish coated magnet wire.

TEST PERFORMED:

Dielectric Strength

PARAMETERS

ASTM D-1676

RATE = 500 V/s

CODE

Same as used for MCLR Project.

	(A) (KILOVOLTS)	(B) (KILOVOLTS)	(C) (KILOVOLTS)
1	12.14	12.62	10.70
2	11.13	11.98	11.99
3	14.68	11.88	10.91
4	11.16	12.73	11.03
5	<u>11.12</u>	<u>13.25</u>	<u>12.27</u>
	12.04 kV	12.49 kV	11.38 kV

MCLR PROJECT

DATE: May 5, 1992

TOPIC:

Baseline tests for No. 923 Varnish Coated Magnet Wire.

TEST PERFORMED:

Dielectric Strength

PARAMETERS

ASTM D-1676
RATE = 500 V/s

CODE

Same as used for MCLR Project.

	(A) (KILOVOLTS)	(B) (KILOVOLTS)	(C) (KILOVOLTS)
1	16.58	15.83	15.43
2	19.65	14.78	15.80
3	16.97	14.18	17.58
4	15.62	13.98	14.77
5	<u>14.997</u>	<u>13.11</u>	<u>15.65</u>
	16.76 kV	14.38 kV	15.85 kV

MCLR PROJECT

DATE: May 5, 1992

TOPIC:

Baseline tests for ISO-800 Varnish Coated Magnet Wire.

TEST PERFORMED:

Dielectric Strength

PARAMETERS

ASTM D-1676
RATE = 500 V/s

CODE

Same as used for MCLR Project.

	(A) (KILOVOLTS)	(B) (KILOVOLTS)	(C) (KILOVOLTS)
1	19.43	12.49	12.58
2	19.82	13.19	14.03
3	18.07	13.36	16.59
4	18.23	11.54	12.90
5	<u>19.86</u>	<u>10.85</u>	<u>17.65</u>
	19.08 kV	12.29 kV	14.75 kV

MCLR

DATE: May 21, 1992

TOPIC:

Baseline Burnout Results on Twisted Pairs on all varnish types.

TEST PERFORMED:

Burnout.

PARAMETERS:

ASTM D-1676

CODE:

Same as used for MCLR Project.

	<u>TEST #1</u> (sec.)	<u>TEST #2</u> (sec.)	<u>TEST #3</u> (sec.)	<u>AVE (SEC.)</u> (sec.)
WIRE - UNCODED				
A	580	577	571	576
B	738	737	732	736
C	555	592	591	579
WIRE - A				
U475	467	430	392	430
Y390PG	523	545	462	510
ER610	433	441	452	442
Y-833	589	579	565	578
923	607	610	600	606
ISO 800	595	527	617	580
WIRE - B				
U475EH	741	750	758	746
Y350PG	759	761	746	755
ER610	733	731	738	734
Y833	737	732	733	734
923	753	741	733	742
ISO-800	744	744	752	747
WIRE - C				
U475EH	441	454	512	469
Y390PG	493	483	442	473
ER610	487	450	546	494
Y-833	557	567	546	557
923	517	480	512	503
ISO 800	649	617	631	632

MCLR PROJECT

DATE: 5/5/92

TOPIC

Baseline bond strengths for all varnishes on the three types of magnet wire.

ASTM 2519

Magnet Wire Type: A, B, C from page 3
Rate: 2 in/min.

RESULTS

<u>Varnish Type</u>	<u>#1 (lbs)</u>	<u>#2 (lbs)</u>	<u>#3 (lbs)</u>	<u>#4 (lbs)</u>	<u>#5 (lbs)</u>	<u>Ave lbs/on⁻¹</u>
<u>WIRE A</u>						
U475SH	58.97	86.2	67.07	71.50	84.90	73.73
Y390PG	43.17	46.52	41.42	47.35	40.42	43.78
ER610	53.42	51.62	47.85	52.92	53.25	51.81
Y-833	9.46	9.83	12.07	7.88	10.03	9.85
923	39.02	42.40	41.20	40.85	42.92	41.28
ISO-800	43.80	51.15	42.95	40.82	46.22	45.01
<u>WIRE B</u>						
U475SH	42.35	37.95	35.55	44.70	37.62	40.14
Y390PG	38.35	36.22	32.82	35.72	37.50	36.12
ER610	37.72	36.05	29.22	30.37	29.62	35.96
Y-833	30.97	31.47	32.12	32.92	38.22	33.14
923	46.30	40.02	38.51	26.75	41.00	40.52
ISO-800	22.50	21.47	19.30	18.72	19.02	20.20
<u>WIRE C</u>						
U475	51.37	57.17	54.70	56.02	46.77	51.21
Y390	57.32	56.20	45.50	43.82	50.75	50.72
SR610	59.07	55.80	63.47	54.62	58.67	58.33
Y-833	5.2	5.4	4.2	8.2	6.2	5.84
923	48.50	48.70	45.75	53.55	49.82	49.26
ISO-800	39.20	34.22	36.25	36.47	34.21	36.08

* All test numbers in pounds (lbs) of force

MCLR PROJECT

DATE: 4/20/92

TOPIC:

Baseline tests for 0.005in Nomex/0.010in Mylar/0.005in Nomex sheet insulation

Test Performed: Tensile Strength
% Elongation
Dielectric Strength

PARAMETERS:

ASTM D-882

Head Distance = 4.00 in.
Rate = 2.0 in/min
Sample length = 6 in (tensile)
Sample Size = 3 in x 1.5 in (dielectric)
Sample Thickness = 0.020 in

RESULTS:

Tensile & % Elongation

<u>Test No.</u>	<u>Width (in)</u>	<u>Lbs.</u>	<u>ksi</u>	<u>Stretch (in)</u>	<u>% Elongation</u>
1	0.32	107.0	16.7	0.50	13%
2	0.44	163.2	18.1	1.10	28
3	0.41	143.8	<u>17.5</u>	0.78	<u>20</u>
		Ave = 17.4 ksi			Ave = 20%

ksi=1000 pounds per square inch.

Dielectric Strength

<u>Test No.</u>	<u>Dielectric (Kilovolts)</u>
1	>19.57
2	>18.36
3	<u>>19.00</u>
	Ave = 18.97 kV

MCLR PROJECT

DATE: 4/20/92

TOPIC:

Baseline tests for 0.005 in Dacron/0.010 in Mylar/0.005 in Dacron

Test Performed: Tensile Strength
% Elongation
Dielectric Strength

PARAMETERS:

ASTM D-882

Head Distance = 2.00 in.
Rate = 20.0 in/min
Sample length = 6 in (tensile)
Sample Size = 3 in x 1.5 in (dielectric)
Sample Thickness = 0.020 in

RESULTS:

Tensile & % Elongation

<u>Test No.</u>	<u>Width(in)</u>	<u>Lbs.</u>	<u>ksi</u>	<u>Stretch (in)</u>	<u>% Elongation</u>
1	0.40	111.1	13.9	0.90	45
2	0.43	118.0	13.7	0.74	37
3	0.48	132.1	<u>13.8</u>	1.09	<u>55</u>
Ave = 13.7 ksi				Ave = 46%	

ksi=1000 pounds per square inch

Dielectric Strength

<u>Test No.</u>	<u>Dielectric (Kilovolts)</u>
1	>15.56
2	>15.54
3	<u>>14.72</u>
Ave = 15.27 kV	

MCLR PROJECT

DATE: 4/20/92

TOPIC:

Baseline tests for Mylar MO sheet insulation

Test Performed: Tensile Strength
% Elongation
Dielectric Strength

PARAMETERS:

ASTM D-882

Head Distance = 2.00 in.
Rate = 20.0 in/min
Sample length = 6 in(tensile)
Sample Size = 3 in x 1.5 in(dielectric)
Sample Thickness = 0.009 in

RESULTS:

Tensile & % Elongation

<u>Test No.</u>	<u>Width(in)</u>	<u>Lbs.</u>	<u>ksi</u>	<u>Stretch(ksi)</u>	<u>% Elongation</u>
1	0.53	107.5	22.5	2.89	145
2	0.66	128.7	21.7	2.58	129
3	0.55	103.3	<u>20.9</u>	2.37	<u>119</u>
		Ave = 21.7 ksi			Ave = 131%

Dielectric Strength

<u>Test No.</u>	<u>Dielectric (Kilovolts)</u>
1	>14.56
2	>14.82
3	<u>>15.35</u>
	Ave = 14.91 kV

MCLR PROJECT

DATE: 4/20/92

TOPIC:

Baseline tests for Nomex 410 sheet insulation

Test Performed: Tensile Strength
% Elongation
Dielectric Strength

PARAMETERS:

ASTM D-882

Head Distance = 4.00 in.
Rate = 2.0 in/min
Sample length = 6 in (tensile)
Sample Size = 3 in x 1.5 in (dielectric)
Sample Thickness = 0.010 in

RESULTS:

Tensile & % Elongation

<u>Test No.</u>	<u>Width (in)</u>	<u>Lbs.</u>	<u>ksi</u>	<u>Stretch (in)</u>	<u>% Elongation</u>
1	0.44	82.25	18.7	0.64	16
2	0.54	102.8	19.0	0.79	20
3	0.51	93.87	<u>18.4</u>	0.56	<u>14</u>
		Ave = 18.7	ksi		Ave = 17%

ksi=1000 pounds per square inch.

Dielectric Strength

<u>Test No.</u>	<u>Dielectric (Kilovolts)</u>
1	11.36
2	11.20
3	10.30
4	10.03
5	10.84
6	11.10
7	10.06
8	10.59
9	10.18
10	<u>11.03</u>
	Ave = 10.67 kV

MCLR PROJECT

DATE: 4/20/92

TOPIC:

Baseline tests for Nomex-Mica 418 Sheet Insulation

Test Performed: Tensile Strength
% Elongation
Dielectric Strength

PARAMETERS:

ASTM D-882

Head Distance = 4.00 in.
Rate = 2.0 in/min
Sample length = 6in(tensile)
Sample Size = 3in x 1.5in(dielectric)
Sample Thickness = 0.008 in

RESULTS:

Tensile & % Elongation

<u>Test No.</u>	<u>Width (in)</u>	<u>Lbs.</u>	<u>ksi</u>	<u>Stretch(in)</u>	<u>% Elongation</u>
1	0.43	26.85	7.8	0.07	4
2	0.48	28.35	7.4	0.07	4
3	0.41	24.05	7.3	0.07	4
			Ave = 7.5ksi		Ave = 4%

ksi=1000pounds per square inch.

Dielectric Strength

<u>Test No.</u>	<u>Dielectric (Kilovolts)</u>
1	11.24
2	9.76
3	10.36
4	10.20
5	10.30
6	9.99
7	9.90
8	10.44
9	10.34
10	9.76
Ave = 10.23 kV	

MCLR PROJECT

DATE: 4/20/92

TOPIC:

Baseline tests for Melinex 228 sheet insulation

Test Performed: Tensile Strength
% Elongation
Dielectric Strength

PARAMETERS:

ASTM D-882

Head Distance = 2.00 in.
Rate = 20 in/min
Sample length = 6 in(tensile)
Sample Size = 3 in x 1.5 in(dielectric)
Sample Thickness = 0.009 in

RESULTS:

Tensile & % Elongation

<u>Test No.</u>	<u>Width(in)</u>	<u>Lbs.</u>	<u>ksi</u>	<u>Stretch (in)</u>	<u>% Elongation</u>
1	0.36	71.80	22.2	3.11	156
2	0.43	83.20	21.5	3.28	164
3	0.45	86.95	<u>21.5</u>	3.19	<u>160</u>
		Ave =	21.7 ksi		Ave = 160%

ksi=1000 pounds per square inch.

Dielectric Strength

<u>Test No.</u>	<u>Dielectric (Kilovolts)</u>
1	>13.58
2	>14.45
3	<u>>14.64</u>
	Ave = 14.22 kV

MCLR PROJECT

DATE: 4/20/92

TOPIC:

Baseline tests for lead wire insulation.

Test Performed: Dielectric Strength

PARAMETERS:

ASTM D-1676

Sample length = 4in

1 cm aluminum foil electrode

TYPE:

A = Dacron/Mylar/Dacron

B = Dacron/Mylar/Teflon/Dacron

<u>Test No.</u>	<u>A (Kilovolts)</u>	<u>B (Kilovolts)</u>
1	8.14	8.82
2	10.37	10.63
3	10.30	8.66
4	9.24	11.35
5	10.39	8.39
6	8.99	10.65
7	9.19	10.54
8	9.86	11.41
9	10.54	10.12
10	<u>9.06</u>	<u>8.93</u>
	Ave = 9.61 kV	Ave = 9.95 kV

MCLR PROJECT

DATE: 4/20/92

TOPIC:

Baseline tests for Fiberglass, Polyester, and Permacel Tape.

Test Performed: Breaking Strength
% Elongation

PARAMETERS:

ASTM D-882

Head Distance = 2.00 in.

Rate = 2.0 in/min

Sample length = 6 in (before curing)

<u>Tape Type</u>	<u>Breaking Strength</u> (lbs.)	<u>Stretch (in)</u>	<u>% Elongation</u>
Fiberglass	38.80, 36.60, 41.65 Ave = 39.02 lbs.	0.05, 0.03, 0.04	2.5, 1.5, 2.0 Ave = 2.0%
Polyester	52.25, 57.95, 58.15 Ave = 56.12 lbs.	0.48, 0.63, 0.57	24, 32, 27 Ave = 28%
Permacel	81.75, 93.35, 90.40 Ave = 88.50 lbs.	0.10, 0.12, 0.10	5, 6, 5 Ave = 5%

MCLR PROJECT

DATE: 4/20/92

TOPIC:

Baseline tests for Polyester Tie Cords.

Test Performed: Breaking Strength
% Elongation

PARAMETERS:

ASTM D-882

Head Distance = 4.00 in.
Rate = 2.0 in/min
Sample length = 6 in

RESULTS:

<u>Test No.</u>	<u>Breaking Strength</u> (lbs.)	<u>Stretch (in)</u>	<u>% Elongation</u>
1	28.20	0.28	14
2	28.90	0.31	16
3	26.25	0.28	14
4	<u>30.10</u>	0.34	<u>17</u>
	Ave = 28.36 lbs.		Ave = 15%

Appendix D

**Summary Tables of the Experimental Data
for the Refrigerant Exposures**

Varnish Disks-% Change in Weight

Results after 500-hour exposure

Exposure with:

Nitrogen @ 60°C(140°F)
 Nitrogen @ 90°C(194°F)
 HCFC-22 @ 90°C(194°F)
 HCFC-123 @ 90°C(194°F)
 HCFC-124 @ 90°C(194°F)
 HCFC-142b @ 90°C(194°F)
 HFC-152a @ 90°C(194°F)
 HFC-134a @ 90°C(194°F)
 HFC-134 @ 90°C(194°F)
 HFC-125 @ 60°C(140°F)
 HFC-32 @ 60°C(140°F)
 HFC-143a @ 60°C(140°F)
 HFC-245ca @ 121°C(250°F)

Varnish Type						
U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800	
% Change in Weight						
0.3%	0.3%	0.4%	0.2%	0.3%	0.2%	
0.0%	0.3%	0.3%	0.0%	-0.1%	-0.3%	
16.9%	12.5%	18.7%	15.4%	14.4%	7.4%	
27.6%	24.6%	25.5%	44.0%	26.2%	13.9%	
4.8%	2.4%	7.4%	13.2%	1.8%	0.9%	
6.1%	6.5%	10.0%	6.3%	6.2%	0.0%	
6.4%	4.9%	9.1%	8.1%	5.2%	0.1%	
1.7%	1.2%	2.8%	4.7%	1.5%	0.9%	
7.5%	4.5%	9.1%	7.6%	7.3%	-1.1%	
1.6%	2.4%	2.4%	2.0%	2.6%	1.0%	
8.1%	6.8%	9.2%	9.5%	6.1%	4.8%	
1.2%	8.5%	4.2%	5.1%	1.7%	0.1%	
7.2%	4.6%	9.6%	8.4%	3.2%	2.3%	

Varnish Disks-% Change in Weight

Results after 500-hour exposure plus a 24-hour air bake @ 150°C(302°F)

	Varnish Type					
	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
	% Change in Weight					
Exposure with:						
Nitrogen @ 60°C(140°F)	-0.8%	-1.4%	-0.3%	0.1%	0.0%	-1.6%
Nitrogen @ 90°C(194°F)	-0.7%	-1.3%	-0.3%	0.0%	-0.3%	-3.7%
HCFC-22 @ 90°C(194°F)	-1.6%	-2.2%	-1.1%	-4.2%	-2.8%	-4.5%
HCFC-123 @ 90°C(194°F)	0.5%	1.7%	-1.1%	0.7%	3.5%	-2.2%
HCFC-124 @ 90°C(194°F)	0.4%	-0.4%	2.0%	1.3%	0.4%	-1.9%
HCFC-142b @ 90°C(194°F)	-1.5%	-2.9%	-0.2%	-6.1%	-0.3%	-5.3%
HFC-152a @ 90°C(194°F)	-1.3%	-3.2%	0.5%	-7.5%	-1.6%	-5.7%
HFC-134a @ 90°C(194°F)	-1.7%	-1.9%	-0.7%	0.1%	-0.2%	-2.8%
HFC-134 @ 90°C(194°F)	0.9%	-1.1%	1.5%	-2.7%	1.1%	-7.8%
HFC-125 @ 60°C(140°F)	-1.7%	-2.2%	-0.9%	-0.8%	-0.7%	-2.6%
HFC-32 @ 60°C(140°F)	-2.0%	-2.4%	3.0%	-2.5%	-5.4%	-3.5%
HFC-143a @ 60°C(140°F)	-0.4%	-0.8%	-0.2%	0.2%	0.0%	-1.9%
HFC-245ca @ 121°C(250°F)	1.7%	2.0%	2.3%	6.0%	2.1%	-1.0%

Bond Strength

Varnish Coated on Magnet Wire A(ester base with amide imide overcoat)

Results after 500-hour exposure

		Varnish Type					
		U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Unexposed		73.7 lbs.	43.8 lbs.	51.8 lbs.	9.9 lbs	41.3 lbs	45.0 lbs

		% Change from Unexposed					
Exposure with:		U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Nitrogen @ 60°C(140°F)		-33.1%	38.3%	4.5%	-8.6%	3.4%	-27.9%
Nitrogen @ 90°C(194°F)		-11.0%	6.8%	10.5%	188.2%	0.2%	10.2%
HCFC-22 @ 90°C(194°F)		-49.2%	-20.2%	-35.4%	54.3%	-23.8%	-35.4%
HCFC-123 @ 90°C(194°F)		-4.7%	0.7%	-29.4%	39.7%	-18.0%	-15.0%
HCFC-124 @ 90°C(194°F)		-5.8%	7.6%	9.8%	58.8%	3.2%	-8.3%
HCFC-142b @ 90°C(194°F)		-23.1%	16.3%	-2.6%	16.7%	5.2%	-8.7%
HFC-152a @ 90°C(194°F)		-23.3%	-5.7%	9.3%	181.0%	-27.6%	-1.4%
HFC-134a @ 90°C(194°F)		-5.4%	-1.2%	11.2%	98.7%	-9.9%	-2.8%
HFC-134 @ 90°C(194°F)		-31.0%	28.5%	-10.2%	66.2%	10.8%	-5.8%
HFC-125 @ 60°C(140°F)		-24.3%	-0.9%	2.8%	-27.6%	-10.0%	3.1%
HFC-32 @ 60°C(140°F)		-11.6%	9.1%	-0.5%	114.0%	-21.2%	-38.6%
HFC-143a @ 60°C(140°F)		-6.3%	43.3%	13.5%	8.3%	6.9%	13.2%
HFC-245ca @ 121°C(250°F)		-38.6%	-34.3%	-4.3%	87.2%	-15.3%	-20.0%

Bond Strength

Varnish Coated on Magnet Wire A(ester base with amide imide overcoat)

Results after 500-hour exposure plus a 24-hour air bake @ 150°C(302°F).

Varnish Type	
U-475EH	Y-390PG
ER-610	Y-833
No.923	Iso-800
Unexposed	
73.7 lbs.	43.8 lbs.
51.8 lbs.	9.9 lbs
41.3 lbs	45.0 lbs

% Change from Unexposed	
U-475EH	Y-390PG
ER-610	Y-833
No.923	Iso-800
Exposure with:	
Nitrogen @ 60°C(140°F)	-5.8%
Nitrogen @ 90°C(194°F)	-15.9%
HCFC-22 @ 90°C(194°F)	-94.6%
HCFC-123 @ 90°C(194°F)	-1.0%
HCFC-124 @ 90°C(194°F)	0.3%
HCFC-142b @ 90°C(194°F)	-9.7%
HFC-152a @ 90°C(194°F)	-91.2%
HFC-134a @ 90°C(194°F)	19.0%
HFC-134 @ 90°C(194°F)	-31.1%
HFC-125 @ 60°C(140°F)	-10.7%
HFC-32 @ 60°C(140°F)	-86.2%
HFC-143a @ 60°C(140°F)	4.7%
HFC-245ca @ 121°C(250°F)	-40.8%
	23.8%
	28.0%
	-79.6%
	12.8%
	22.7%
	30.5%
	-83.1%
	-11.1%
	45.5%
	42.0%
	-80.1%
	22.3%
	13.4%
	6.9%
	37.8%
	-90.4%
	-59.9%
	27.3%
	22.3%
	-84.8%
	7.6%
	-23.3%
	13.5%
	-92.9%
	12.5%
	-7.8%
	56.2%
	353.0%
	14.7%
	49.7%
	134.0%
	36.1%
	152.0%
	4.6%
	201.0%
	-29.1%
	-26.9%
	13.4%
	177.0%
	12.9%
	7.9%
	-83.9%
	6.0%
	6.2%
	25.5%
	-19.4%
	7.5%
	2.1%
	-11.5%
	-56.0%
	20.1%
	3.8%
	-23.5%
	-1.4%
	-37.6%
	18.1%
	6.5%
	13.4%
	-36.7%
	5.7%
	0.2%
	2.1%
	-19.0%
	-3.3%
	10.1%

Bond Strength

Varnish Coated on Magnet Wire B(Dacron/Glass served wire)

Results after 500-hour exposure

Varnish Type	
U-475EH	Y-390PG
ER-610	Y-833
No.923	Iso-800
Unexposed	
40.1 lbs.	36.1 lbs.
36.0 lbs.	33.1 lbs.
40.5 lbs.	20.2 lbs.

% Change from Unexposed	
U-475EH	Y-390PG
ER-610	Y-833
No.923	Iso-800
Exposure with:	
Nitrogen @ 60°C(140°F)	-15.0%
Nitrogen @ 90°C(194°F)	-13.7%
HCFC-22 @ 90°C(194°F)	59.5%
HCFC-123 @ 90°C(194°F)	34.9%
HCFC-124 @ 90°C(194°F)	-16.8%
HCFC-142b @ 90°C(194°F)	6.7%
HFC-152a @ 90°C(194°F)	23.6%
HFC-134a @ 90°C(194°F)	-9.5%
HFC-134 @ 90°C(194°F)	5.4%
HFC-125 @ 60°C(140°F)	-7.6%
HFC-32 @ 60°C(140°F)	38.1%
HFC-143a @ 60°C(140°F)	8.1%
HFC-245ca @ 121°C(250°F)	4.6%
	-10.6%
	-0.8%
	60.5%
	25.5%
	0.7%
	9.5%
	43.3%
	0.6%
	40.5%
	-2.1%
	75.2%
	-17.8%
	3.7%
	-9.4%
	-17.6%
	28.7%
	-4.6%
	-5.9%
	-1.0%
	24.7%
	-14.7%
	2.6%
	-5.2%
	34.6%
	-15.3%
	-6.7%
	-20.6%
	-39.1%
	-51.1%
	-75.5%
	-8.4%
	-38.1%
	-59.3%
	-19.5%
	83.8%
	51.2%
	27.8%
	-7.3%
	-20.1%
	31.2%
	5.5%
	22.9%
	-8.3%
	10.4%
	11.8%
	2.0%
	-3.7%
	21.8%
	-23.8%
	-3.6%
	-3.5%
	16.6%
	29.3%
	5.2%
	-7.2%
	-11.8%
	40.4%
	-6.9%
	11.9%
	-2.6%
	28.6%
	33.6%
	9.0%

Bond Strength

Varnish Coated on Magnet Wire B(Dacron/Glass served wire)

Results after 500-hour exposure plus a 24 hour air bake @ 150°C(302°F).

Varnish Type

Unexposed

U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
40.1 lbs.	36.1 lbs.	36.0 lbs.	33.1 lbs	40.5 lbs	20.2 lbs

% Change from Unexposed

Exposure with:

	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Nitrogen @ 60°C(140°F)	-7.1%	-9.5%	2.2%	-10.0%	-9.4%	-4.2%
Nitrogen @ 90°C(194°F)	-22.4%	-1.8%	-7.6%	-40.1%	-27.7%	-10.5%
HCFC-22 @ 90°C(194°F)	-51.7%	-58.7%	-19.9%	-77.0%	-51.7%	-58.8%
HCFC-123 @ 90°C(194°F)	-53.0%	-78.8%	-16.8%	-69.8%	-80.4%	1.2%
HCFC-124 @ 90°C(194°F)	-9.5%	0.2%	6.7%	8.9%	1.8%	-5.6%
HCFC-142b @ 90°C(194°F)	-8.1%	-1.8%	-0.5%	-16.1%	-19.4%	-2.4%
HFC-152a @ 90°C(194°F)	-38.6%	-47.6%	-22.8%	-48.5%	-52.1%	-6.9%
HFC-134a @ 90°C(194°F)	0.0%	-2.2%	-5.5%	-11.5%	0.4%	-6.8%
HFC-134 @ 90°C(194°F)	-5.9%	13.5%	-8.2%	-47.3%	-11.9%	6.8%
HFC-125 @ 60°C(140°F)	-10.8%	-10.0%	-8.9%	-6.3%	-12.5%	-41.7%
HFC-32 @ 60°C(140°F)	-34.9%	-36.8%	-31.6%	-17.9%	-74.6%	-5.7%
HFC-143a @ 60°C(140°F)	23.5%	-10.4%	-5.1%	37.0%	-16.0%	15.2%
HFC-245ca @ 121°C(250°F)	-6.3%	-6.1%	-9.4%	-36.7%	-18.7%	-21.2%

Bond Strength

Varnish Coated on Magnet Wire C(ester imide overcoated with amide imide)

Results after 500-hour exposure

Varnish Type						
	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Unexposed	51.2 lbs.	50.7 lbs.	58.3 lbs.	5.8 lbs	49.3 lbs	36.1 lbs

	% Change from Unexposed					
Exposure with:	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Nitrogen @ 60°C(140°F)	30.7%	2.1%	-0.7%	54.1%	-19.3%	12.9%
Nitrogen @ 90°C(194°F)	18.8%	-4.1%	-10.4%	223.0%	-14.1%	38.2%
HCFC-22 @ 90°C(194°F)	-1.7%	-23.8%	-35.3%	304.0%	-30.0%	0.4%
HCFC-123 @ 90°C(194°F)	5.2%	-11.2%	-51.3%	193.0%	14.8%	-24.9%
HCFC-124 @ 90°C(194°F)	5.5%	20.9%	5.9%	170.0%	-20.0%	25.5%
HCFC-142b @ 90°C(194°F)	26.2%	-12.6%	-11.5%	306.0%	-17.1%	41.9%
HFC-152a @ 90°C(194°F)	17.0%	-3.2%	-16.3%	44.7%	-35.3%	38.4%
HFC-134a @ 90°C(194°F)	18.4%	-4.4%	5.1%	327.0%	-14.7%	20.0%
HFC-134 @ 90°C(194°F)	2.5%	13.2%	-25.0%	18.2%	-18.5%	41.2%
HFC-125 @ 60°C(140°F)	-8.3%	8.1%	-10.5%	20.7%	-20.2%	42.4%
HFC-32 @ 60°C(140°F)	4.4%	-8.4%	-15.3%	215.0%	-27.6%	-19.8%
HFC-143a @ 60°C(140°F)	8.1%	-17.8%	-15.3%	51.2%	-23.8%	33.6%
HFC-245ca @ 121°C(250°F)	-17.8%	-20.2%	-22.4%	265.0%	-47.5%	-8.7%

Bond Strength

Varnish Coated on Magnet Wire C(ester imide overcoated with amide imide)

Results after 500-hour exposure plus a 24-hour air bake @ 150°C(302°F)

	Varnish Type					
	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Unexposed	51.2 lbs.	50.7 lbs.	58.3 lbs.	5.8 lbs	49.3 lbs	36.1 lbs

	% Change from Unexposed					
Exposure with:	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Nitrogen @ 60°C(140°F)	42.7%	9.8%	-8.4%	190.0%	-8.1%	45.4%
Nitrogen @ 90°C(194°F)	29.8%	-6.0%	4.5%	194.0%	-10.8%	46.6%
HCFC-22 @ 90°C(194°F)	-45.4%	-82.5%	-58.6%	445.0%	-83.8%	-71.2%
HCFC-123 @ 90°C(194°F)	5.4%	11.3%	-64.2%	214.0%	0.7%	14.9%
HCFC-124 @ 90°C(194°F)	11.2%	23.0%	6.3%	160.0%	-4.6%	2.4%
HCFC-142b @ 90°C(194°F)	10.2%	-11.6%	10.2%	528.0%	1.7%	38.7%
HFC-152a @ 90°C(194°F)	16.0%	13.4%	0.0%	155.0%	-39.1%	83.6%
HFC-134a @ 90°C(194°F)	22.9%	-15.0%	11.0%	395.0%	9.8%	-12.3%
HFC-134 @ 90°C(194°F)	-46.6%	-6.0%	-3.2%	334.0%	-1.5%	29.0%
HFC-125 @ 60°C(140°F)	40.6%	13.2%	-7.2%	-65.8%	-10.8%	47.1%
HFC-32 @ 60°C(140°F)	-21.0%	-41.8%	-94.5%	-9.3%	-82.9%	13.4%
HFC-143a @ 60°C(140°F)	23.5%	-10.4%	-5.1%	37.0%	-16.0%	15.2%
	16.1%	9.8%	8.9%	405.0%	-19.2%	20.1%

Burnout Strength

Varnish Coated on Magnet Wire A(ester base with amide imide overcoat)

Results after 500-hour exposure

	Varnish Type						
	Uncoated	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Unexposed	576 sec	430 sec	510 sec	442 sec	578 sec	606 sec	580 sec

Exposure with:	% Change from Unexposed						
	Uncoated	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Nitrogen @ 60°C(140°F)	-4.3%	-6.5%	-22.5%	2.1%	-2.2%	4.8%	-17.3%
Nitrogen @ 90°C(194°F)	-2.3%	-24.4%	-0.5%	-5.6%	-5.4%	-17.6%	-10.4%
HCFC-22 @ 90°C(194°F)	-27.7%	-16.7%	-22.9%	-22.7%	-14.0%	-12.6%	-33.6%
HCFC-123 @ 90°C(194°F)	-28.9%	-41.4%	-37.0%	-10.1%	-24.9%	-54.3%	-56.6%
HCFC-124 @ 90°C(194°F)	-21.0%	-27.1%	-18.8%	-7.2%	-21.2%	-32.5%	-1.9%
HCFC-142b @ 90°C(194°F)	-54.9%	-54.7%	-24.3%	-30.2%	-34.8%	-41.1%	-47.9%
HFC-152a @ 90°C(194°F)	-28.4%	-12.2%	-41.2%	2.0%	-26.4%	-12.1%	-14.2%
HFC-134a @ 90°C(194°F)	-23.0%	4.9%	-14.0%	-14.8%	-4.3%	-12.5%	-9.7%
HFC-134 @ 90°C(194°F)	-23.1%	-8.8%	-0.1%	-21.9%	-16.4%	-7.3%	-17.9%
HFC-125 @ 60°C(140°F)	-11.1%	-21.1%	-18.8%	-9.4%	-3.1%	-30.6%	-8.2%
HFC-32 @ 60°C(140°F)	-9.3%	-8.1%	-7.9%	-24.3%	-22.4%	-9.9%	-19.4%
HFC-143a @ 60°C(140°F)	-6.5%	-22.3%	-7.8%	-14.5%	-4.3%	-25.9%	-10.7%
HFC-245ca @ 121°C(250°F)	-27.0%	-0.9%	-6.9%	-20.9%	-3.3%	-10.0%	-3.2%

Burnout Strength

Varnish Coated on Magnet Wire A(ester base with amide imide overcoat)

Results after 500-hour exposure plus a 24-hour air bake @ 150°C(302°F)

	Varnish Type						
	Uncoated	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Unexposed	576 sec	430 sec	510 sec	442 sec	578 sec	606 sec	580 sec

Exposure with:	% Change from Unexposed						
	Uncoated	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Nitrogen @ 60°C(140°F)	-4.3%	-21.0%	-6.8%	-5.2%	-4.7%	-26.6%	-1.2%
Nitrogen @ 90°C(194°F)	-3.0%	-12.6%	9.2%	-12.2%	-9.7%	-24.2%	-0.1%
HCFC-22 @ 90°C(194°F)	-8.9%	-24.0%	-16.2%	-29.7%	-15.1%	-35.3%	-43.6%
HCFC-123 @ 90°C(194°F)	-28.2%	-35.1%	-35.6%	-9.7%	-24.1%	-55.0%	-47.7%
HCFC-124 @ 90°C(194°F)	-19.7%	-36.7%	-10.6%	-2.9%	-7.7%	-37.0%	-1.1%
HCFC-142b @ 90°C(194°F)	-12.7%	-47.6%	-23.5%	-16.5%	-12.0%	-45.8%	-22.9%
HFC-152a @ 90°C(194°F)	-11.2%	-22.3%	-30.9%	-1.1%	-12.1%	-12.2%	-16.6%
HFC-134a @ 90°C(194°F)	-1.5%	-32.5%	-18.4%	-6.9%	-6.5%	-8.7%	-8.1%
HFC-134 @ 90°C(194°F)	-19.5%	-18.2%	-0.2%	-17.7%	-15.9%	-20.4%	-3.7%
HFC-125 @ 60°C(140°F)	-2.4%	-16.0%	-4.4%	-6.3%	-10.6%	-29.6%	-8.5%
HFC-32 @ 60°C(140°F)	-7.5%	-36.3%	-9.2%	-22.4%	-10.3%	-16.5%	-12.2%
HFC-143a @ 60°C(140°F)	-0.6%	-19.5%	-4.4%	-13.0%	-14.1%	-19.8%	-10.6%
HFC-245ca @ 121°C(250°F)	-13.5%	16.2%	-19.0%	-22.0%	-9.9%	-11.1%	-0.1%

Burnout Strength

Varnish Coated on Magnet Wire B(Dacron/ Glass served wire)

Results after 500-hour exposure

		Varnish Type						
		Uncoated	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Unexposed		736 sec	746 sec	755 sec	734 sec	734 sec	742 sec	747 sec
		% Change from Unexposed						
Exposure with:		Uncoated	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Nitrogen @ 60°C(140°F)		-0. 9%	-3. 4%	-3. 5%	-1. 2%	-3. 9%	-0. 9%	-0. 9%
Nitrogen @ 90°C(194°F)		-1. 3%	-2. 0%	-1. 8%	-0. 3%	-1. 7%	-0. 7%	-0. 7%
HCFC-22 @ 90°C(194°F)		-0. 3%	-2. 1%	-1. 9%	-2. 5%	-0. 6%	-1. 0%	-2. 6%
HCFC-123 @ 90°C(194°F)		-1. 6%	-11. 9%	-2. 1%	-5. 0%	-8. 2%	-9. 4%	-2. 5%
HCFC-124 @ 90°C(194°F)		-0. 7%	-3. 6%	-2. 4%	-0. 8%	-1. 4%	-1. 5%	-4. 4%
HCFC-142b @ 90°C(194°F)		-0. 5%	-10. 1%	-9. 4%	-12. 7%	-11. 4%	-8. 5%	-2. 8%
HFC-152a @ 90°C(194°F)		-3. 5%	-9. 3%	-3. 9%	-3. 9%	-8. 4%	-3. 7%	-2. 6%
HFC-134a @ 90°C(194°F)		-2. 1%	-3. 4%	-4. 4%	-1. 7%	-1. 7%	-2. 6%	-3. 4%
HFC-134 @ 90°C(194°F)		-1. 7%	-1. 0%	-2. 2%	-0. 9%	-0. 1%	0. 7%	0. 0%
HFC-125 @ 60°C(140°F)		-5. 4%	-5. 4%	-2. 0%	-4. 6%	-0. 7%	-1. 4%	-3. 1%
HFC-32 @ 60°C(140°F)		-2. 6%	-6. 3%	-3. 8%	-2. 4%	-0. 9%	-2. 1%	1. 2%
HFC-143a @ 60°C(140°F)		-0. 3%	-4. 8%	-2. 6%	-4. 8%	-7. 1%	-2. 3%	-2. 3%
HFC-245ca @ 121°C(250°F)		-1.2%	-1.0%	-1.8%	-0.6%	-0.6%	1.0%	-1.7%

Burnout Strength

Varnish Coated on Magnet Wire B(Dacron/ Glass served wire)

Results after 500-hour exposure plus a 24-hour air bake @ 150°C(302°F)

	Varnish Type						
	Uncoated	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Unexposed	736 sec	746 sec	755 sec	734 sec	734 sec	742 sec	747 sec

	% Change from Unexposed						
	Uncoated	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Exposure with:							
Nitrogen @ 60°C(140°F)	-1. 0%	-2. 5%	-3. 1%	-0. 6%	-5. 0%	-2. 2%	-1. 0%
Nitrogen @ 90°C(194°F)	-0. 4%	-2. 3%	-2. 9%	-5. 9%	-2. 7%	-0. 8%	-1. 0%
HCFC-22 @ 90°C(194°F)	-2. 8%	-2. 1%	-1. 7%	-4. 6%	-1. 2%	0. 9%	-2. 7%
HCFC-123 @ 90°C(194°F)	-0. 9%	-2. 5%	-3. 7%	-0. 6%	-1. 5%	-1. 2%	-2. 7%
HCFC-124 @ 90°C(194°F)	0. 3%	-2. 1%	-3. 1%	-5. 1%	-1. 0%	-2. 0%	-2. 1%
HCFC-142b @ 90°C(194°F)	-8. 0%	-8. 0%	-8. 6%	-10. 6%	-12. 7%	-7. 4%	-2. 9%
HFC-152a @ 90°C(194°F)	-5. 8%	-6. 0%	-3. 6%	-6. 9%	-8. 1%	-10. 0%	-2. 1%
HFC-134a @ 90°C(194°F)	-6. 3%	-3. 3%	-4. 4%	-4. 4%	-1. 8%	-3. 0%	-3. 6%
HFC-134 @ 90°C(194°F)	-0. 6%	-1. 0%	-1. 7%	-0. 7%	-0. 7%	0. 8%	-1. 3%
HFC-125 @ 60°C(140°F)	-4. 4%	-3. 7%	-1. 3%	-9. 9%	-2. 0%	-1. 1%	-1. 9%
HFC-32 @ 60°C(140°F)	-5. 6%	-5. 4%	-3. 4%	-6. 8%	-3. 6%	-4. 2%	-1. 4%
HFC-143a @ 60°C(140°F)	-0. 8%	-5. 5%	-2. 5%	-0. 6%	-5. 6%	-2. 3%	-11. 2%
HFC-245ca @ 121°C(250°F)	-1. 2%	-2. 6%	-0. 8%	-0. 8%	-1. 0%	0. 8%	-0. 8%

Burnout Strength

Varnish Coated on Magnet Wire C(ester imide overcoated with amide imide)

Results after 500-hour exposure

		Varnish Type						
		Uncoated	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Unexposed		579 sec	469 sec	473 sec	494 sec	557 sec	503 sec	632 sec
		% Change from Unexposed						
Exposure with:		Uncoated	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Nitrogen @ 60°C(140°F)		-6.3%	-39.7%	-5.1%	-30.4%	-41.3%	-4.4%	-10.5%
Nitrogen @ 90°C(194°F)		0.5%	18.7%	-2.3%	-11.4%	-42.0%	-13.7%	-9.1%
HCFC-22 @ 90°C(194°F)		-55.3%	-12.7%	-2.3%	-47.6%	-48.1%	3.4%	-36.3%
HCFC-123 @ 90°C(194°F)		-29.5%	-36.8%	-34.5%	-19.4%	-19.2%	-38.6%	-61.2%
HCFC-124 @ 90°C(194°F)		-13.6%	-35.8%	-6.3%	-34.6%	-2.9%	-20.8%	-9.2%
HCFC-142b @ 90°C(194°F)		-54.9%	-31.9%	-24.0%	-49.0%	-59.6%	-30.7%	-45.7%
HFC-152a @ 90°C(194°F)		-18.9%	-6.1%	-8.3%	-36.8%	-4.3%	11.5%	-11.1%
HFC-134a @ 90°C(194°F)		-23.0%	-11.0%	-11.4%	-16.9%	-2.2%	-12.1%	-12.6%
HFC-134 @ 90°C(194°F)		-30.1%	10.7%	-1.9%	-21.1%	-26.5%	-3.8%	-13.3%
HFC-125 @ 60°C(140°F)		0.4%	-36.1%	-3.5%	-22.1%	-0.9%	-5.7%	-14.7%
HFC-32 @ 60°C(140°F)		-24.0%	0.9%	13.1%	-37.7%	-7.7%	-3.6%	-24.5%
HFC-143a @ 60°C(140°F)		-10.1%	-23.7%	2.7%	-21.9%	-6.3%	-10.4%	-13.8%
HFC-245ca @ 121°C(250°F)		-2.7%	-17.6%	25.9%	-29.5%	-9.9%	-3.9%	-12.1%

Burnout Strength

Varnish Coated on Magnet Wire C(ester imide overcoated with amide imide)

Results after 500-hour exposure plus a 24-hour air bake @ 150°C(302°F)

	Varnish Type						
	Uncoated	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Unexposed	579 sec	469 sec	473 sec	494 sec	557 sec	503 sec	632 sec

	% Change from Unexposed						
	Uncoated	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Exposure with:							
Nitrogen @ 60°C(140°F)	-3.4%	-27.9%	1.2%	-28.1%	-39.7%	-12.3%	-11.5%
Nitrogen @ 90°C(194°F)	-29.8%	10.2%	9.3%	-20.6%	-35.9%	-4.8%	-8.2%
HCFC-22 @ 90°C(194°F)	-5.9%	-38.0%	-12.7%	-25.0%	-21.5%	-23.2%	-53.7%
HCFC-123 @ 90°C(194°F)	-22.7%	-41.9%	-37.9%	-13.5%	-16.5%	-40.4%	-50.4%
HCFC-124 @ 90°C(194°F)	-9.9%	-48.1%	-14.2%	-26.5%	-6.2%	-18.8%	-15.8%
HCFC-142b @ 90°C(194°F)	-28.4%	-9.8%	-17.4%	-41.8%	-59.6%	-36.1%	-33.8%
HFC-152a @ 90°C(194°F)	-15.8%	3.6%	-2.9%	-29.8%	-37.5%	2.7%	-16.2%
HFC-134a @ 90°C(194°F)	-2.9%	-30.3%	2.8%	-2.5%	-12.0%	-16.4%	-10.0%
HFC-134 @ 90°C(194°F)	-1.8%	-38.0%	15.2%	-27.1%	-5.9%	0.9%	-18.0%
HFC-125 @ 60°C(140°F)	-5.0%	-43.0%	-17.2%	-10.5%	5.8%	-5.7%	-9.3%
HFC-32 @ 60°C(140°F)	-6.0%	4.9%	2.4%	-30.9%	-1.7%	-1.1%	-9.6%
HFC-143a @ 60°C(140°F)	-16.5%	-41.4%	1.1%	-24.9%	-16.4%	12.1%	-8.8%
HFC-245ca @ 121°C(250°F)	-2.7%	-15.1%	19.7%	-17.6%	-6.0%	9.0%	-9.0%

Dielectric Strength

Varnish Coated on Magnet Wire A(ester base with amide imide overcoat)

Results after 500-hour exposure

	Varnish Type						
	Uncoated	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Unexposed	15.8 kV	16.2 kV	18.8 kV	15.6 kV	12.0 kV	16.8 kV	19.1 kV

Exposure with:	% Change from Unexposed						
	Uncoated	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Nitrogen @ 60°C(140°F)	2.3%	-6.5%	-22.5%	2.1%	-2.2%	4.8%	-17.3%
Nitrogen @ 90°C(194°F)	-7.9%	11.1%	-1.2%	2.8%	-7.2%	-22.6%	-26.7%
HCFC-22 @ 90°C(194°F)	-8.0%	5.9%	6.6%	-5.0%	3.7%	11.0%	-4.0%
HCFC-123 @ 90°C(194°F)	-17.7%	-1.2%	-15.0%	-9.0%	13.2%	-44.3%	-18.4%
HCFC-124 @ 90°C(194°F)	3.1%	-5.3%	4.2%	-15.2%	-6.2%	-5.6%	-25.4%
HCFC-142b @ 90°C(194°F)	7.5%	2.8%	1.6%	-13.1%	-4.4%	3.9%	-2.0%
HFC-152a @ 90°C(194°F)	7.5%	-18.2%	-15.2%	-9.1%	-5.2%	-23.3%	-21.4%
HFC-134a @ 90°C(194°F)	6.9%	6.4%	-4.6%	3.8%	1.0%	16.5%	-18.5%
HFC-134 @ 90°C(194°F)	-27.0%	-9.4%	-5.7%	14.1%	-2.8%	2.9%	1.6%
HFC-125 @ 60°C(140°F)	0.0%	-24.9%	-21.7%	10.8%	-4.4%	-29.2%	-2.7%
HFC-32 @ 60°C(140°F)	-13.6%	-18.5%	-24.7%	-17.7%	-15.9%	2.5%	-0.2%
HFC-143a @ 60°C(140°F)	18.4%	12.6%	-23.9%	-9.5%	-7.3%	19.3%	4.6%
HFC-245ca @ 121°C(250°F)	-11.8%	-16.8%	2.0%	-13.4%	-16.8%	3.0%	-21.9%

Dielectric Strength

Varnish Coated on Magnet Wire A(ester base with amide imide overcoat)

Results after 500-hour exposure plus a 24-hour air bake @ 150°C(302°F)

	Varnish Type						
	Uncoated	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Unexposed	15.8 kV	16.2 kV	18.8 kV	15.6 kV	12.0 kV	16.8 kV	19.1 kV

Exposure with:	% Change from Unexposed						
	Uncoated	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Nitrogen @ 60°C(140°F)	9.4%	-11.0%	-12.4%	-19.4%	-9.3%	-30.2%	-11.8%
Nitrogen @ 90°C(194°F)	-14.2%	8.5%	-11.2%	10.2%	-5.7%	-15.4%	-7.6%
HCFC-22 @ 90°C(194°F)	8.8%	-18.4%	-44.8%	-42.0%	-2.9%	-16.1%	-69.9%
HCFC-123 @ 90°C(194°F)	-15.0%	-3.0%	-19.9%	-2.1%	9.1%	-3.0%	-26.9%
HCFC-124 @ 90°C(194°F)	-2.8%	-5.5%	-7.6%	-21.5%	-12.2%	19.3%	-13.8%
HCFC-142b @ 90°C(194°F)	-9.8%	0.0%	-8.0%	-9.2%	-11.7%	-9.5%	-2.9%
HFC-152a @ 90°C(194°F)	-1.0%	-8.4%	-40.5%	-26.1%	-6.4%	-50.1%	-24.6%
HFC-134a @ 90°C(194°F)	-20.4%	-18.1%	-17.1%	-14.2%	-18.3%	8.4%	-20.5%
HFC-134 @ 90°C(194°F)	-22.7%	-25.9%	-38.2%	-21.9%	-18.8%	-30.8%	-7.9%
HFC-125 @ 60°C(140°F)	13.2%	-7.3%	-21.4%	-18.3%	-3.4%	7.5%	-2.3%
HFC-32 @ 60°C(140°F)	-2.2%	-21.0%	-54.0%	-54.7%	-7.0%	-59.0%	-28.9%
HFC-143a @ 60°C(140°F)	-0.1%	23.2%	6.6%	-4.7%	-0.1%	19.3%	-19.2%
HFC-245ca @ 121°C(250°F)	-18.2%	16.2%	-19.0%	-22.0%	-9.9%	-11.1%	-0.1%

Dielectric Strength

Varnish Coated on Magnet Wire B(Dacron/Glass served wire)

Results after 500-hour exposure

	Varnish Type						
	Uncoated	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Unexposed	11.6 kV	13.3 kV	12.3 kV	12.8 kV	12.5 kV	14.4 kV	12.3 kV

Exposure with:	% Change from Unexposed						
	Uncoated	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Nitrogen @ 60°C(140°F)	6.7%	9.4%	4.3%	-9.5%	-8.8%	-6.9%	3.9%
Nitrogen @ 90°C(194°F)	5.1%	-0.9%	-6.5%	-7.0%	-6.0%	-19.5%	-3.9%
HCFC-22 @ 90°C(194°F)	-0.1%	-4.2%	35.2%	1.1%	1.6%	39.1%	30.6%
HCFC-123 @ 90°C(194°F)	7.4%	6.5%	59.4%	-0.1%	3.6%	22.4%	5.7%
HCFC-124 @ 90°C(194°F)	1.5%	-3.6%	-2.4%	-0.8%	-1.4%	-1.5%	-4.4%
HCFC-142b @ 90°C(194°F)	5.1%	18.5%	-5.7%	9.7%	0.7%	-17.5%	1.3%
HFC-152a @ 90°C(194°F)	7.8%	-6.9%	2.4%	1.3%	-6.1%	-21.0%	3.6%
HFC-134a @ 90°C(194°F)	3.0%	-13.1%	9.7%	9.7%	3.6%	8.0%	10.6%
HFC-134 @ 90°C(194°F)	7.0%	-4.6%	-4.0%	-5.5%	1.6%	-21.1%	-5.8%
HFC-125 @ 60°C(140°F)	0.1%	1.2%	2.2%	7.0%	-1.0%	-7.9%	0.8%
HFC-32 @ 60°C(140°F)	-5.1%	-1.8%	11.8%	-0.9%	-10.8%	-3.2%	-0.2%
HFC-143a @ 60°C(140°F)	1.5%	-13.1%	-5.4%	-5.0%	-7.2%	-19.8%	2.0%
HFC-245ca @ 121°C(250°F)	3.6%	19.6%	-29.7%	13.6%	-2.4%	28.1%	8.6%

Dielectric Strength

Varnish Coated on Magnet Wire B(Dacron/Glass served wire)

Results after 500-hour exposure plus a 24-hour air bake @ 150°C(302°F)

	Varnish Type						
	Uncoated	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Unexposed	11.6 kV	13.3 kV	12.3 kV	12.8 kV	12.5 kV	14.4 kV	12.3 kV

Exposure with:	% Change from Unexposed						
	Uncoated	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Nitrogen @ 60°C(140°F)	0.0%	-3.1%	-1.1%	-13.8%	-5.6%	-6.7%	-1.1%
Nitrogen @ 90°C(194°F)	5.5%	-7.4%	-0.7%	1.9%	-6.6%	34.3%	-1.9%
HCFC-22 @ 90°C(194°F)	4.0%	-8.4%	-11.9%	-5.6%	5.6%	-19.4%	6.9%
HCFC-123 @ 90°C(194°F)	4.6%	-2.0%	6.6%	-7.4%	-0.6%	-10.7%	-2.3%
HCFC-124 @ 90°C(194°F)	0.3%	-6.4%	6.3%	-0.8%	-1.3%	-5.1%	-10.3%
HCFC-142b @ 90°C(194°F)	6.0%	-1.9%	-3.6%	-6.4%	0.3%	-17.6%	1.8%
HFC-152a @ 90°C(194°F)	-5.1%	-6.0%	-3.6%	-6.9%	-8.1%	-10.0%	-2.1%
HFC-134a @ 90°C(194°F)	-8.5%	-8.3%	11.1%	-10.5%	-6.7%	-8.4%	-4.4%
HFC-134 @ 90°C(194°F)	3.0%	-5.6%	-8.6%	-6.5%	-2.9%	-20.9%	-5.6%
HFC-125 @ 60°C(140°F)	2.0%	-8.7%	2.5%	2.8%	0.5%	-8.4%	-0.8%
HFC-32 @ 60°C(140°F)	0.1%	-10.7%	-11.1%	-14.5%	-7.8%	-33.6%	-1.2%
HFC-143a @ 60°C(140°F)	-8.0%	-0.4%	1.2%	-14.6%	-10.7%	-16.1%	-1.4%
HFC-245ca @ 121°C(250°F)	-5.7%	-11.2%	12.7%	-8.0%	-6.0%	-14.4%	-3.2%

Dielectric Strength

Varnish Coated on Magnet Wire C(ester imide overcoated with amide imide)

Results after 500-hour exposure

	Varnish Type						
	Uncoated	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Unexposed	16.6 kV	15.1 kV	18.2 kV	14.5 kV	11.4 kV	15.9 kV	14.8 kV

Exposure with:	% Change from Unexposed						
	Uncoated	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Nitrogen @ 60°C(140°F)	-3.8%	-37.5%	-7.0%	-37.2%	27.4%	-0.8%	18.7%
Nitrogen @ 90°C(194°F)	0.5%	-19.8%	-23.3%	3.1%	44.0%	20.7%	-11.0%
HCFC-22 @ 90°C(194°F)	4.2%	11.2%	6.6%	-7.8%	20.9%	23.2%	25.5%
HCFC-123 @ 90°C(194°F)	-17.0%	-17.0%	-7.9%	-7.8%	7.5%	23.6%	19.3%
HCFC-124 @ 90°C(194°F)	-17.0%	5.5%	-11.8%	7.9%	-4.1%	12.7%	25.8%
HCFC-142b @ 90°C(194°F)	-54.9%	-25.7%	-29.8%	14.8%	19.2%	20.2%	20.8%
HFC-152a @ 90°C(194°F)	-18.9%	-34.6%	9.7%	-8.3%	42.8%	-12.1%	-8.8%
HFC-134a @ 90°C(194°F)	-1.2%	10.3%	0.3%	-7.3%	1.5%	-0.6%	9.4%
HFC-134 @ 90°C(194°F)	10.2%	-20.5%	9.7%	-0.4%	61.5%	-17.7%	19.4%
HFC-125 @ 60°C(140°F)	4.3%	-43.2%	-2.4%	8.6%	2.6%	16.3%	5.9%
HFC-32 @ 60°C(140°F)	-13.6%	-33.7%	-2.9%	-8.8%	35.9%	-21.5%	19.4%
HFC-143a @ 60°C(140°F)	-12.8%	-6.3%	-10.4%	-6.0%	-1.6%	-29.8%	21.5%
HFC-245ca @ 121°C(250°F)	-15.7%	-3.7%	-3.2%	-24.7%	-8.9%	3.6%	13.9%

Dielectric Strength

Varnish Coated on Magnet Wire C(ester imide overcoated with amide imide)

Results after 500-hour exposure plus a 24-hour air bake @ 150°C(302°F)

		Varnish Type						
		Uncoated	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Unexposed		16.6 kV	15.1 kV	18.2 kV	14.5 kV	11.4 kV	15.9 kV	14.8 kV
		% Change from Unexposed						
Exposure with:		Uncoated	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Nitrogen @ 60°C(140°F)		-2.7%	-19.6%	-36.9%	-11.8%	52.0%	-11.2%	6.5%
Nitrogen @ 90°C(194°F)		-5.1%	-28.6%	-5.4%	5.1%	36.6%	-10.7%	-4.4%
HCFC-22 @ 90°C(194°F)		-5.9%	-15.3%	-44.9%	-42.3%	7.0%	-61.4%	-14.5%
HCFC-123 @ 90°C(194°F)		-28.3%	-15.3%	-26.8%	-5.2%	0.4%	16.1%	-2.4%
HCFC-124 @ 90°C(194°F)		-9.9%	3.2%	-5.6%	-10.1%	-6.4%	-7.6%	18.2%
HCFC-142b @ 90°C(194°F)		10.4%	-26.1%	-22.9%	5.2%	47.0%	1.4%	1.5%
HFC-152a @ 90°C(194°F)		-15.8%	-31.4%	-36.3%	-9.6%	12.4%	-3.0%	-32.6%
HFC-134a @ 90°C(194°F)		-12.6%	-9.5%	-17.5%	-24.3%	-20.5%	-6.7%	-8.5%
HFC-134 @ 90°C(194°F)		-30.1%	-38.0%	15.2%	-27.1%	-5.9%	0.9%	-18.0%
HFC-125 @ 60°C(140°F)		-5.0%	10.8%	-15.0%	14.8%	3.3%	26.2%	-9.9%
HFC-32 @ 60°C(140°F)		-3.2%	-34.8%	-43.4%	-15.1%	-8.2%	-56.4%	-14.1%
HFC-143a @ 60°C(140°F)		-12.4%	-10.3%	-31.0%	-14.6%	-2.8%	26.2%	8.4%
HFC-245ca @ 121°C(250°F)		-15.1%	-15.1%	19.7%	-17.6%	-6.0%	9.0%	-9.0%

Sheet Insulation

% Change in Weight

Results after 500-hour exposure

Exposure with:

Nitrogen @ 60°C(140°F)
 Nitrogen @ 90°C(194°F)
 HCFC-22 @ 90°C(194°F)
 HCFC-123 @ 90°C(194°F)
 HCFC-124 @ 90°C(194°F)
 HCFC-142b @ 90°C(194°F)
 HFC-152a @ 90°C(194°F)
 HFC-134a @ 90°C(194°F)
 HFC-134 @ 90°C(194°F)
 HFC-125 @ 60°C(140°F)
 HFC-32 @ 60°C(140°F)
 HFC-143a @ 60°C(140°F)
 HFC-245ca @ 121°C(250°F)

Sheet Insulation Type					
Nomex/Mylar Nomex	Dacron/Mylar Dacron	Mylar MQ	Nomex	Nomex Mica	Melinex
% Change in Weight					
0.0%	0.1%	0.0%	0.3%	0.2%	0.0%
0.1%	0.1%	0.2%	0.2%	0.2%	0.2%
6.7%	6.2%	6.1%	6.1%	2.9%	6.4%
21.0%	7.7%	8.2%	15.1%	0.7%	8.1%
6.0%	4.4%	3.9%	3.0%	0.2%	2.3%
3.4%	3.9%	3.3%	0.5%	3.9%	4.2%
4.1%	2.9%	2.9%	5.1%	2.0%	3.0%
3.0%	4.0%	2.4%	4.0%	1.3%	2.5%
6.6%	5.6%	5.0%	2.8%	2.5%	5.1%
0.0%	1.2%	0.1%	-0.6%	-0.5%	0.1%
5.7%	3.7%	4.0%	6.3%	2.2%	4.8%
1.4%	2.2%	0.4%	2.2%	1.4%	0.5%
15.5%	2.4%	4.1%	18.0%	1.6%	4.8%

Sheet Insulation

% Change in Weight

Results after 500-hour exposure plus a 24-hour air bake @ 150°C(302°F)

	Sheet Insulation Type					
	Nomex/Mylar Nomex	Dacron/Mylar Dacron	Mylar MQ	Nomex	Nomex Mica	Melinex
	% Change in Weight					
Nitrogen @ 60°C(140°F)	-0.1%	0.0%	0.0%	-0.2%	-0.3%	0.1%
Nitrogen @ 90°C(194°F)	-0.4%	-0.2%	0.0%	0.2%	-0.6%	0.0%
HCFC-22 @ 90°C(194°F)	-0.1%	-1.2%	-0.6%	0.7%	0.3%	-0.2%
HCFC-123 @ 90°C(194°F)	-0.4%	-1.3%	-0.5%	0.1%	0.0%	-0.2%
HCFC-124 @ 90°C(194°F)	0.1%	0.6%	0.0%	-1.4%	0.8%	0.2%
HCFC-142b @ 90°C(194°F)	0.3%	-0.4%	-0.2%	-0.6%	-0.9%	-0.2%
HFC-152a @ 90°C(194°F)	-0.1%	-0.4%	0.8%	-0.2%	-0.4%	0.0%
HFC-134a @ 90°C(194°F)	-0.3%	0.2%	0.0%	0.5%	0.2%	0.0%
HFC-134 @ 90°C(194°F)	0.2%	-0.4%	0.0%	0.5%	0.1%	0.1%
HFC-125 @ 60°C(140°F)	-0.1%	-1.0%	-0.1%	-2.9%	-1.6%	-0.2%
HFC-32 @ 60°C(140°F)	-0.1%	-0.1%	0.3%	-0.2%	0.0%	0.2%
HFC-143a @ 60°C(140°F)	0.0%	-0.1%	0.1%	0.0%	0.2%	-0.1%
HFC-245ca @ 121°C(250°F)	-0.1%	-2.8%	-0.9%	1.3%	0.7%	-0.2%

Sheet Insulation

% Change in Tensile Strength

Results after 500-hour exposure

Sheet Insulation Type

Nomex/Mylar <u>Nomex</u>	Dacron/Mylar <u>Dacron</u>	<u>Mylar MO</u>	<u>Nomex</u>	Nomex <u>Mica</u>	<u>Melinex</u>
17.4 ksi	13.7 ksi	21.7 ksi	18.7 ksi	7.5 ksi	21.7 ksi

Unexposed

Exposure with:

Nitrogen @ 60°C(140°F)
 Nitrogen @ 90°C(194°F)
 HCFC-22 @ 90°C(194°F)
 HCFC-123 @ 90°C(194°F)
 HCFC-124 @ 90°C(194°F)
 HCFC-142b @ 90°C(194°F)
 HFC-152a @ 90°C(194°F)
 HFC-134a @ 90°C(194°F)
 HFC-134 @ 90°C(194°F)
 HFC-125 @ 60°C(140°F)
 HFC-32 @ 60°C(140°F)
 HFC-143a @ 60°C(140°F)
 HFC-245ca @ 121°C(250°F)

% Change from Unexposed					
-10.2%	-0.9%	-7.6%	0.5%	-17.5%	-10.7%
-8.5%	-6.5%	-6.8%	1.1%	-18.7%	-10.2%
-18.0%	-23.1%	-15.1%	-9.6%	-21.3%	-28.9%
-19.0%	-25.1%	-7.7%	-12.5%	-23.9%	-20.2%
-7.2%	-9.7%	-13.9%	6.5%	-17.0%	-18.4%
-5.2%	-7.7%	-8.7%	2.8%	-20.0%	-12.4%
-4.2%	-6.4%	-9.2%	6.7%	-28.4%	-15.2%
-30.7%	29.3%	-12.0%	-6.6%	-18.9%	-20.0%
-7.7%	-11.2%	-13.8%	3.9%	-31.3%	-18.0%
-5.1%	-3.8%	-12.1%	-6.5%	-16.6%	-13.3%
-12.1%	-12.2%	-6.7%	-7.7%	-24.9%	-11.4%
-5.9%	-2.7%	-15.4%	-6.3%	-22.6%	-20.9%
-14.7%	-8.2%	-26.8%	-14.7%	-8.5%	-28.5%

Sheet Insulation

% Change in Tensile Strength

Results after 500-hour exposure plus a 24-hour air bake @ 150°C(302°F)

Sheet Insulation Type

Nomex/Mylar <u>Nomex</u>	Dacron/Mylar <u>Dacron</u>	<u>Mylar MQ</u>	<u>Nomex</u>	Nomex <u>Mica</u>	<u>Melinex</u>
17.4 ksi	13.7 ksi	21.7 ksi	18.7 ksi	7.5 ksi	21.7 ksi

Unexposed

Exposure with:

Nitrogen @ 60°C(140°F)
 Nitrogen @ 90°C(194°F)
 HCFC-22 @ 90°C(194°F)
 HCFC-123 @ 90°C(194°F)
 HCFC-124 @ 90°C(194°F)
 HCFC-142b @ 90°C(194°F)
 HFC-152a @ 90°C(194°F)
 HFC-134a @ 90°C(194°F)
 HFC-134 @ 90°C(194°F)
 HFC-125 @ 60°C(140°F)
 HFC-32 @ 60°C(140°F)
 HFC-143a @ 60°C(140°F)
 HFC-245ca @ 121°C(250°F)

% Change from Unexposed					
-7.2%	1.2%	-5.1%	-4.7%	-21.6%	-11.1%
-2.3%	-1.3%	-9.4%	9.2%	-19.2%	-9.9%
-4.7%	-6.9%	-1.7%	-1.9%	-27.3%	-20.7%
-7.1%	-7.2%	-11.5%	4.2%	-22.7%	-15.4%
-4.0%	-4.6%	-13.9%	7.7%	-23.0%	-14.7%
-4.8%	-3.9%	-13.4%	5.3%	-21.5%	-12.8%
-1.8%	0.1%	-10.3%	3.2%	-26.2%	-9.4%
-26.4%	32.9%	-13.6%	-4.7%	-11.9%	-30.6%
-6.5%	-1.4%	-8.7%	11.2%	-24.1%	-10.2%
-17.0%	-2.4%	-12.2%	-3.6%	-14.3%	-11.8%
1.5%	-0.5%	-7.6%	11.0%	-19.4%	-15.8%
-0.4%	-3.1%	-6.8%	-5.6%	-22.0%	-18.4%
-8.5%	-0.1%	-18.9%	3.6%	-7.7%	-21.2%

Sheet Insulation

% Change in Elongation

Results after 500-hour exposure

Sheet Insulation Type

Nomex/Mylar <u>Nomex</u>	Dacron/Mylar <u>Dacron</u>	<u>Mylar MO</u>	<u>Nomex</u>	Nomex <u>Mica</u>	<u>Melinex</u>
20.0%	46.0%	131.0%	17.0%	4.0%	160.0%

Unexposed

Exposure with:

Nitrogen @ 60°C(140°F)
 Nitrogen @ 90°C(194°F)
 HCFC-22 @ 90°C(194°F)
 HCFC-123 @ 90°C(194°F)
 HCFC-124 @ 90°C(194°F)
 HCFC-142b @ 90°C(194°F)
 HFC-152a @ 90°C(194°F)
 HFC-134a @ 90°C(194°F)
 HFC-134 @ 90°C(194°F)
 HFC-125 @ 60°C(140°F)
 HFC-32 @ 60°C(140°F)
 HFC-143a @ 60°C(140°F)
 HFC-245ca @ 121°C(250°F)

% Change from Unexposed					
-40.0%	-36.2%	5.5%	-11.8%	-43.8%	2.9%
-1.9%	-43.1%	15.8%	-24.0%	-60.4%	9.8%
20.8%	-28.6%	0.8%	-19.1%	-50.0%	-16.4%
-12.9%	-40.6%	-8.5%	-30.9%	-60.4%	3.9%
15.0%	-36.2%	-0.3%	-17.6%	-45.8%	6.9%
21.7%	-30.8%	17.2%	-26.0%	-54.2%	5.3%
55.8%	-31.2%	17.0%	11.3%	-27.1%	-5.2%
38.3%	-46.7%	-7.4%	-19.6%	-43.8%	-5.1%
37.9%	-35.9%	-1.9%	-13.7%	-29.2%	7.9%
2.5%	-33.2%	-10.2%	-11.3%	-45.8%	-5.3%
38.8%	-33.3%	21.9%	13.2%	-56.3%	9.7%
40.0%	-45.3%	-6.6%	-15.2%	-47.9%	-2.6%
-37.5%	-41.7%	-21.8%	-60.8%	-75.0%	5.9%

Sheet Insulation

% Change in Elongation

Results after 500-hour exposure plus a 24-hour air bake @ 150°C(302°F)

Sheet Insulation Type

Nomex/Mylar <u>Nomex</u>	Dacron/Mylar <u>Dacron</u>	<u>Mylar MQ</u>	<u>Nomex</u>	Nomex <u>Mica</u>	<u>Melinex</u>
20.0%	46.0%	131.0%	17.0%	4.0%	160.0%

Unexposed

Exposure with:

Nitrogen @ 60°C(140°F)
 Nitrogen @ 90°C(194°F)
 HCFC-22 @ 90°C(194°F)
 HCFC-123 @ 90°C(194°F)
 HCFC-124 @ 90°C(194°F)
 HCFC-142b @ 90°C(194°F)
 HFC-152a @ 90°C(194°F)
 HFC-134a @ 90°C(194°F)
 HFC-134 @ 90°C(194°F)
 HFC-125 @ 60°C(140°F)
 HFC-32 @ 60°C(140°F)
 HFC-143a @ 60°C(140°F)
 HFC-245ca @ 121°C(250°F)

% Change from Unexposed					
-42.5%	-40.2%	12.7%	-23.5%	-47.9%	0.3%
-6.7%	-38.8%	17.8%	-21.1%	-56.3%	9.4%
9.6%	-17.4%	-0.6%	-4.4%	-43.8%	-5.6%
-20.4%	-43.1%	13.5%	-32.4%	-66.7%	-7.8%
14.2%	-36.4%	-12.0%	-13.7%	-50.0%	-7.4%
-16.7%	-46.0%	6.7%	-23.0%	-47.9%	5.6%
-9.6%	-38.0%	8.9%	-30.4%	-56.3%	4.9%
31.3%	-48.2%	-11.2%	-28.4%	-56.3%	-42.5%
-37.1%	-40.2%	6.0%	-16.2%	-58.3%	3.2%
-16.9%	-47.5%	-1.4%	-20.6%	-56.3%	-2.5%
20.4%	-43.8%	10.1%	-3.4%	-58.3%	-0.8%
6.7%	-42.0%	16.4%	-25.0%	-43.8%	2.6%
-51.7%	-50.7%	-41.0%	-39.2%	-75.0%	-50.5%

Sheet Insulation

% Change in Dielectric Strength

Results after 500-hour exposure

Sheet Insulation Type

Nomex/Mylar <u>Nomex</u>	Dacron/Mylar <u>Dacron</u>	Mylar MO <u>Mylar MO</u>	Nomex <u>Nomex</u>	Nomex <u>Mica</u>	Melinex <u>Melinex</u>
flash	flash	flash	10.7 kV	10.2 kV	flash

Unexposed

Exposure with:

Nitrogen @ 60°C(140°F)
 Nitrogen @ 90°C(194°F)
 HCFC-22 @ 90°C(194°F)
 HCFC-123 @ 90°C(194°F)
 HCFC-124 @ 90°C(194°F)
 HCFC-142b @ 90°C(194°F)
 HFC-152a @ 90°C(194°F)
 HFC-134a @ 90°C(194°F)
 HFC-134 @ 90°C(194°F)
 HFC-125 @ 60°C(140°F)
 HFC-32 @ 60°C(140°F)
 HFC-143a @ 60°C(140°F)
 HFC-245ca @ 121°C(250°F)

% Change from Unexposed						
flash	flash	flash	0.9%	-14.5%	flash	flash
flash	flash	flash	-9.2%	-7.3%	flash	flash
flash	flash	flash	-1.6%	-4.0%	flash	flash
flash	flash	flash	7.8%	2.9%	flash	flash
flash	flash	flash	-6.4%	-3.6%	flash	flash
flash	flash	flash	-0.8%	-2.7%	flash	flash
flash	flash	flash	-0.1%	-9.0%	flash	flash
flash	flash	flash	6.0%	-2.7%	flash	flash
flash	flash	flash	2.0%	-7.8%	flash	flash
flash	flash	flash	16.4%	-5.9%	flash	flash
flash	flash	flash	3.3%	-6.1%	flash	flash
flash	flash	flash	-1.3%	-9.7%	flash	flash
flash	flash	flash	-4.3%	-2.1%	flash	flash

*Flash indicates dielectric went around sheet insulation not through.

Sheet Insulation

% Change in Dielectric Strength

Results after 500-hour exposure plus a 24-hour air bake @ 150°C(302°F)

Sheet Insulation Type

Nomex/Mylar Nomex	Dacron/Mylar Dacron	Mylar MQ	Nomex	Nomex Mica	Melinex
flash	flash	flash	10.7 kV	10.2 kV	flash

Unexposed

Exposure with:

Nitrogen @ 60°C(140°F)
 Nitrogen @ 90°C(194°F)
 HCFC-22 @ 90°C(194°F)
 HCFC-123 @ 90°C(194°F)
 HCFC-124 @ 90°C(194°F)
 HCFC-142b @ 90°C(194°F)
 HFC-152a @ 90°C(194°F)
 HFC-134a @ 90°C(194°F)
 HFC-134 @ 90°C(194°F)
 HFC-125 @ 60°C(140°F)
 HFC-32 @ 60°C(140°F)
 HFC-143a @ 60°C(140°F)
 HFC-245ca @ 121°C(250°F)

% Change from Unexposed						
flash	flash	flash	-4.0%	-12.6%	flash	flash
flash	flash	flash	3.7%	-12.1%	flash	flash
flash	flash	flash	-0.1%	-16.8%	flash	flash
flash	flash	flash	1.0%	-4.9%	flash	flash
flash	flash	flash	-3.0%	-5.7%	flash	flash
flash	flash	flash	-8.4%	-8.0%	flash	flash
flash	flash	flash	-2.9%	-12.1%	flash	flash
flash	flash	flash	3.9%	2.4%	flash	flash
flash	flash	flash	-1.3%	-17.3%	flash	flash
flash	flash	flash	-7.9%	-4.3%	flash	flash
flash	flash	flash	6.0%	-4.1%	flash	flash
flash	flash	flash	5.0%	-10.3%	flash	flash
flash	flash	flash	-3.3%	-10.1%	flash	flash

*Flash indicates dielectric went around sheet Insulation not through.

Spiral Wrapped Sleeving Insulation

% Change in Weight

Results after 500-hour exposure

Exposure with:

Nitrogen @ 60°C(140°F)
 Nitrogen @ 90°C(194°F)
 HCFC-22 @ 90°C(194°F)
 HCFC-123 @ 90°C(194°F)
 HCFC-124 @ 90°C(194°F)
 HCFC-142b @ 90°C(194°F)
 HFC-152a @ 90°C(194°F)
 HFC-134a @ 90°C(194°F)
 HFC-134 @ 90°C(194°F)
 HFC-125 @ 60°C(140°F)
 HFC-32 @ 60°C(140°F)
 HFC-143a @ 60°C(140°F)
 HFC-245ca @ 121°C(250°F)

Sleeving Insulation Type		
Nomex	Mylar	Nomex/Mylar
% Change in Weight		
-0.4%	0.1%	0.6%
-0.2%	0.9%	0.2%
15.3%	8.5%	7.2%
56.9%	23.8%	22.6%
13.4%	6.2%	5.3%
6.1%	8.6%	3.5%
11.8%	8.9%	17.2%
5.5%	3.2%	3.0%
9.3%	6.5%	5.4%
0.9%	1.0%	0.2%
1.4%	8.3%	4.2%
3.5%	1.6%	1.9%
22.0%	6.4%	8.5%

Spiral Wrapped Sleeving Insulation

% Change in Weight

Results after 500-hour exposure plus a 24-hour air bake @ 150°C(302°F)

Exposure with:

Nitrogen @ 60°C(140°F)
 Nitrogen @ 90°C(194°F)
 HCFC-22 @ 90°C(194°F)
 HCFC-123 @ 90°C(194°F)
 HCFC-124 @ 90°C(194°F)
 HCFC-142b @ 90°C(194°F)
 HFC-152a @ 90°C(194°F)
 HFC-134a @ 90°C(194°F)
 HFC-134 @ 90°C(194°F)
 HFC-125 @ 60°C(140°F)
 HFC-32 @ 60°C(140°F)
 HFC-143a @ 60°C(140°F)
 HFC-245ca @ 121°C(250°F)

Sleeving Insulation Type		
Nomex	Mylar	Nomex/Mylar
% Change in Weight		
-0.2%	0.1%	0.0%
0.3%	-0.1%	0.0%
0.9%	-0.9%	-1.3%
-3.5%	-1.6%	-2.6%
-0.9%	-0.5%	-0.4%
-2.3%	-0.3%	-0.8%
0.0%	-0.2%	-0.8%
0.4%	0.1%	-0.2%
0.3%	0.1%	0.4%
-3.8%	-0.7%	-3.1%
-1.8%	-0.8%	-0.5%
0.7%	0.6%	0.5%
-0.5%	-0.9%	-1.3%

Lead Wire

% Change in Weight

Results after 500-hour exposure

Exposure with:	Lead Wire Type	
	Dacron/Mylar/Dacron	Dacron/Mylar/Teflon/Dacron
	% Change in Weight	
Nitrogen @ 60°C(140°F)	-0.1%	0.0%
Nitrogen @ 90°C(194°F)	0.0%	0.0%
HCFC-22 @ 90°C(194°F)	0.8%	0.9%
HCFC-123 @ 90°C(194°F)	4.9%	3.9%
HCFC-124 @ 90°C(194°F)	0.5%	-0.3%
HCFC-142b @ 90°C(194°F)	0.5%	0.6%
HFC-152a @ 90°C(194°F)	0.5%	0.5%
HFC-134a @ 90°C(194°F)	0.4%	0.3%
HFC-134 @ 90°C(194°F)	0.7%	0.8%
HFC-125 @ 60°C(140°F)	0.1%	0.4%
HFC-32 @ 60°C(140°F)	0.4%	1.2%
HFC-143a @ 60°C(140°F)	0.3%	0.3%
HFC-245ca @ 121°C(250°F)	1.5%	2.0%

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Lead Wire

% Change in Weight

Results after 500-hour exposure plus a 24-hour air bake @ 150°C(302°F)

Exposure with:	Lead Wire Type	
	Dacron/Mylar/Dacron	Dacron/Mylar/Teflon/Dacron
	% Change in Weight	
Nitrogen @ 60°C(140°F)	-0.1%	0.0%
Nitrogen @ 90°C(194°F)	0.1%	-0.1%
HCFC-22 @ 90°C(194°F)	-0.2%	-0.2%
HCFC-123 @ 90°C(194°F)	-0.2%	-0.1%
HCFC-124 @ 90°C(194°F)	-0.1%	-0.1%
HCFC-142b @ 90°C(194°F)	0.0%	0.0%
HFC-152a @ 90°C(194°F)	-0.1%	-0.1%
HFC-134a @ 90°C(194°F)	0.0%	-0.1%
HFC-134 @ 90°C(194°F)	-0.1%	-0.1%
HFC-125 @ 60°C(140°F)	-0.2%	-0.2%
HFC-32 @ 60°C(140°F)	0.0%	0.0%
HFC-143a @ 60°C(140°F)	0.0%	0.0%
HFC-245ca @ 121°C(250°F)	-0.2%	-0.2%

Lead Wire

% Change in Dielectric Strength

Results after 500-hour exposure

	Lead Wire Type	
	Dacron/Mylar/Dacron	Dacron/Mylar/Teflon/Dacron
Unexposed	9.6 Kv	9.95 Kv
<u>Exposure with:</u>	% Change from Unexposed	
Nitrogen @ 60°C(140°F)	-0.3%	-1.2%
Nitrogen @ 90°C(194°F)	-5.5%	8.3%
HCFC-22 @ 90°C(194°F)	-4.5%	-16.2%
HCFC-123 @ 90°C(194°F)	-5.1%	42.8%
HCFC-124 @ 90°C(194°F)	-10.1%	3.6%
HCFC-142b @ 90°C(194°F)	-3.8%	11.3%
HFC-152a @ 90°C(194°F)	-11.5%	-9.1%
HFC-134a @ 90°C(194°F)	1.6%	-10.0%
HFC-134 @ 90°C(194°F)	-6.7%	2.0%
HFC-125 @ 60°C(140°F)	-0.1%	-2.6%
HFC-32 @ 60°C(140°F)	-4.1%	-9.4%
HFC-143a @ 60°C(140°F)	-11.9%	-5.6%
HFC-245ca @ 121°C(250°F)	-10.6%	-15.1%

Lead Wire

% Change in Dielectric Strength

Results after 500-hour exposure plus a 24-hour air bake @ 150°C(302°F)

Lead Wire Type	
Dacron/Mylar/Dacron	Dacron/Mylar/Teflon/Dacron
Unexposed 9.6 kV	9.95 kV

% Change from Unexposed	
Nitrogen @ 60°C(140°F)	-0.7% -7.5%
Nitrogen @ 90°C(194°F)	-5.9% -0.1%
HCFC-22 @ 90°C(194°F)	1.8% -15.3%
HCFC-123 @ 90°C(194°F)	-4.8% 6.1%
HCFC-124 @ 90°C(194°F)	-1.8% -9.5%
HCFC-142b @ 90°C(194°F)	-5.9% 0.4%
HFC-152a @ 90°C(194°F)	2.0% -0.4%
HFC-134a @ 90°C(194°F)	-9.4% 6.1%
HFC-134 @ 90°C(194°F)	-3.4% 2.2%
HFC-125 @ 60°C(140°F)	-10.4% -10.6%
HFC-32 @ 60°C(140°F)	-4.1% -4.3%
HFC-143a @ 60°C(140°F)	-4.0% -5.5%
HFC-245ca @ 121°C(250°F)	-8.7% -18.0%

Tapes

% Change in Weight

Results after 500-hour exposure

	Tape Type		
	Woven Glass	Polyester	Permace
	% Change in Weight		
Exposure with:			
Nitrogen @ 60°C(140°F)	-0.1%	0.5%	0.4%
Nitrogen @ 90°C(194°F)	0.2%	0.5%	-0.5%
HCFC-22 @ 90°C(194°F)	-0.6%	6.6%	1.7%
HCFC-123 @ 90°C(194°F)	2.2%	6.5%	-5.6%
HCFC-124 @ 90°C(194°F)	0.2%	3.8%	2.7%
HCFC-142b @ 90°C(194°F)	-0.1%	3.7%	7.1%
HFC-152a @ 90°C(194°F)	N/A	3.2%	3.6%
HFC-134a @ 90°C(194°F)	-0.1%	2.4%	3.4%
HFC-134 @ 90°C(194°F)	0.4%	5.5%	11.8%
HFC-125 @ 60°C(140°F)	-0.5%	1.4%	6.7%
HFC-32 @ 60°C(140°F)	0.1%	3.4%	0.4%
HFC-143a @ 60°C(140°F)	0.0%	1.6%	0.3%
HFC-245ca @ 121°C(250°F)	0.6%	4.0%	1.1%

Tapes

% Change in Weight

Results after 500-hour exposure plus a 24-hour air bake @ 150°C(302°F)

	Tape Type		
	Woven Glass	Polyester	Permacel
Exposure with:	% Change in Weight		
Nitrogen @ 60°C(140°F)	-0.1%	0.2%	-1.2%
Nitrogen @ 90°C(194°F)	0.3%	0.3%	-2.1%
HCFC-22 @ 90°C(194°F)	0.9%	-0.4%	-4.4%
HCFC-123 @ 90°C(194°F)	-0.1%	-1.5%	-14.5%
HCFC-124 @ 90°C(194°F)	-0.3%	-0.2%	-7.2%
HCFC-142b @ 90°C(194°F)	0.0%	0.4%	-6.0%
HFC-152a @ 90°C(194°F)	0.2%	0.0%	-3.4%
HFC-134a @ 90°C(194°F)	-0.6%	0.2%	-6.4%
HFC-134 @ 90°C(194°F)	0.2%	0.3%	-2.7%
HFC-125 @ 60°C(140°F)	-0.3%	-0.4%	-5.2%
HFC-32 @ 60°C(140°F)	0.2%	0.1%	-3.8%
HFC-143a @ 60°C(140°F)	-0.3%	0.6%	-1.9%
HFC-245ca @ 121°C(250°F)	0.1%	-0.3%	-0.3%

Tapes

% Change in Break Load

Results after 500-hour exposure

	Tape Type		
	Woven Glass	Polyester	Permacel
Unexposed	39.0 lbs	56.1 lbs	88.5 lbs
<u>Exposure with:</u>	% Change from Unexposed		
Nitrogen @ 60°C(140°F)	9.6%	5.4%	-31.4%
Nitrogen @ 90°C(194°F)	-5.5%	-1.6%	-6.9%
HCFC-22 @ 90°C(194°F)	35.3%	6.2%	15.1%
HCFC-123 @ 90°C(194°F)	0.7%	5.8%	-12.3%
HCFC-124 @ 90°C(194°F)	12.2%	5.6%	10.6%
HCFC-142b @ 90°C(194°F)	19.8%	5.1%	1.7%
HFC-152a @ 90°C(194°F)	43.6%	-7.9%	-15.2%
HFC-134a @ 90°C(194°F)	-0.1%	12.6%	27.3%
HFC-134 @ 90°C(194°F)	0.4%	5.5%	11.8%
HFC-125 @ 60°C(140°F)	-3.1%	5.7%	27.7%
HFC-32 @ 60°C(140°F)	15.8%	2.5%	-7.7%
HFC-143a @ 60°C(140°F)	2.0%	4.8%	-6.8%
HFC-245ca @ 121°C(250°F)	45.4%	0.4%	-0.5%

Tapes

% Change in Break Load

Results after 500-hour exposure plus a 24-hour air bake @ 150°C(302°F)

	Tape Type		
	Woven Glass	Polyester	Permacel
Unexposed	39.0 lbs	56.1 lbs	88.5 lbs

Exposure with:

Nitrogen @ 60°C(140°F)
 Nitrogen @ 90°C(194°F)
 HCFC-22 @ 90°C(194°F)
 HCFC-123 @ 90°C(194°F)
 HCFC-124 @ 90°C(194°F)
 HCFC-142b @ 90°C(194°F)
 HFC-152a @ 90°C(194°F)
 HFC-134a @ 90°C(194°F)
 HFC-134 @ 90°C(194°F)
 HFC-125 @ 60°C(140°F)
 HFC-32 @ 60°C(140°F)
 HFC-143a @ 60°C(140°F)
 HFC-245ca @ 121°C(250°F)

% Change from Unexposed		
-3.9%	1.5%	20.4%
4.1%	8.5%	0.0%
42.2%	1.5%	25.3%
18.8%	2.9%	20.5%
11.6%	4.4%	43.5%
18.0%	-3.0%	6.8%
0.5%	0.0%	-0.3%
16.4%	-8.2%	39.7%
-2.7%	0.3%	0.2%
30.7%	-0.6%	37.9%
23.6%	-17.1%	-11.3%
-2.4%	-1.4%	-13.3%
30.8%	-2.8%	12.8%

Tie Cord

% Change in Weight

Results after 500-hour exposure

Exposure with:

Nitrogen @ 60°C(140°F)
Nitrogen @ 90°C(194°F)
HCFC-22 @ 90°C(194°F)
HCFC-123 @ 90°C(194°F)
HCFC-124 @ 90°C(194°F)
HCFC-142b @ 90°C(194°F)
HFC-152a @ 90°C(194°F)
HFC-134a @ 90°C(194°F)
HFC-134 @ 90°C(194°F)
HFC-125 @ 60°C(140°F)
HFC-32 @ 60°C(140°F)
HFC-143a @ 60°C(140°F)
HFC-245ca @ 121°C(250°F)

Tie Cord Type	
Polyester	
% change in weight	
	0.5%
	0.0%
	6.8%
	6.0%
	2.9%
	2.6%
	4.0%
	1.9%
	4.8%
	0.4%
	1.9%
	3.5%
	2.4%

Tie Cord

% Change in Weight

Results after 500-hour exposure plus a 24-hour air bake @ 150°C(302°F)

Exposure with:

Nitrogen @ 60°C(140°F)
 Nitrogen @ 90°C(194°F)
 HCFC-22 @ 90°C(194°F)
 HCFC-123 @ 90°C(194°F)
 HCFC-124 @ 90°C(194°F)
 HCFC-142b @ 90°C(194°F)
 HFC-152a @ 90°C(194°F)
 HFC-134a @ 90°C(194°F)
 HFC-134 @ 90°C(194°F)
 HFC-125 @ 60°C(140°F)
 HFC-32 @ 60°C(140°F)
 HFC-143a @ 60°C(140°F)
 HFC-245ca @ 121°C(250°F)

Tie Cord Type	
Polyester	
% change in weight	
	0.3%
	-0.2%
	-0.3%
	1.6%
	0.4%
	-0.1%
	0.6%
	-0.5%
	0.4%
	-1.0%
	-2.1%
	0.2%
	-1.0%

Tie Cord

% Change in Break Load

Results after a 500-hour exposure

	Tie Cord Type	
	Polyester	
Unexposed	28.4 lbs.	
Exposure with:		% change from Unexposed
Nitrogen @ 60°C(140°F)		20.0%
Nitrogen @ 90°C(194°F)		23.5%
HCFC-22 @ 90°C(194°F)		14.8%
HCFC-123 @ 90°C(194°F)		10.1%
HCFC-124 @ 90°C(194°F)		35.8%
HCFC-142b @ 90°C(194°F)		14.4%
HFC-152a @ 90°C(194°F)		13.4%
HFC-134a @ 90°C(194°F)		14.0%
HFC-134 @ 90°C(194°F)		8.3%
HFC-125 @ 60°C(140°F)		38.5%
HFC-32 @ 60°C(140°F)		25.9%
HFC-143a @ 60°C(140°F)		12.8%
HFC-245ca @ 121°C(250°F)		15.7%

Tie Cord

% Change in Break Load

Results after a 500-hour exposure plus a 24-hour air bake @ 150°C(302°F)

Tie Cord Type	
Polyester	
28.4 lbs.	
Unexposed	
% change from Unexposed	
Nitrogen @ 60°C(140°F)	29.3%
Nitrogen @ 90°C(194°F)	16.0%
HCFC-22 @ 90°C(194°F)	-1.8%
HCFC-123 @ 90°C(194°F)	5.0%
HCFC-124 @ 90°C(194°F)	12.7%
HCFC-142b @ 90°C(194°F)	-2.2%
HFC-152a @ 90°C(194°F)	14.4%
HFC-134a @ 90°C(194°F)	0.9%
HFC-134 @ 90°C(194°F)	4.8%
HFC-125 @ 60°C(140°F)	9.0%
HFC-32 @ 60°C(140°F)	8.1%
HFC-143a @ 60°C(140°F)	14.2%
HFC-245ca @ 121°C(250°F)	2.6%

Appendix E

**Summary Tables of the Experimental Data
for the Refrigerant-Lubricant Exposures**

Varnish Disks

% Change in Weight

Results after a 500-hour exposure @ 127°C(260°F)

Exposure with:

Nitrogen
 HCFC-22/Mineral
 HCFC-124/Alkylbenzene
 HCFC-142b/Alkylbenzene
 HFC-152a/Alkylbenzene
 HFC-134a/Ester, Mixed Acid
 HFC-134a/Ester, Branched Acid
 HFC-32/Ester, Branched Acid
 HFC-125/Ester, Branched Acid
 HFC-143a/Ester, Branched Acid
 HFC-134/Ester, Branched Acid
 HFC-245ca/Ester, Branched Acid
 HFC-134a/PAG, Butyl Monoether
 HFC-32/PAG, Butyl Monoether
 HFC-125/PAG, Butyl Monoether
 HFC-134a/PAG, Modified
 HFC-125/PAG, Modified
 HFC-134a/PAG Diol

Varnish Type					
U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
% Change in Weight					
1.6%	1.5%	0.0%	0.6%	-1.4%	-3.2%
4.6%	4.7%	6.0%	3.9%	0.6%	-3.0%
2.0%	0.6%	5.4%	2.9%	0.9%	-1.3%
5.0%	6.3%	10.9%	6.7%	5.9%	-0.9%
4.6%	1.7%	6.8%	-0.7%	2.4%	-2.5%
1.6%	0.6%	3.1%	1.3%	-0.2%	-3.3%
1.2%	0.7%	3.2%	1.6%	-0.1%	-5.4%
0.8%	1.4%	-1.7%	-0.8%	-1.9%	-8.6%
-2.2%	1.8%	0.8%	0.8%	-2.0%	-1.6%
-0.8%	3.1%	1.2%	0.0%	-2.0%	-2.7%
0.1%	2.1%	2.8%	1.7%	-1.4%	-0.9%
1.2%	0.1%	3.8%	2.7%	-0.9%	-1.4%
0.7%	0.4%	3.1%	2.4%	-1.9%	-2.0%
-0.2%	0.3%	2.9%	0.7%	-3.0%	-1.1%
-1.6%	2.0%	0.7%	-1.5%	-1.7%	-0.8%
-1.2%	1.5%	2.2%	2.0%	-1.0%	-0.5%
0.7%	2.8%	3.9%	4.2%	2.6%	1.5%
10.7%	18.7%	7.9%	8.4%	13.4%	25.9%

Varnish Disks

% Change in Weight

Results after 500-hour exposure @ 127°C(260°F) plus a 24-hour air bake @ 150°C(302°F)

	Varnish Type					
	U-475EH	Y-390PG	ER-610	Y-833	No. 923	Iso-800
<u>Exposure with:</u>	% Change in Weight					
Nitrogen	-1.2%	-1.9%	-0.5%	0.7%	-1.3%	-3.1%
HCFC-22/Mineral	0.7%	-1.6%	2.4%	1.3%	-1.6%	-4.6%
HCFC-124/Alkylbenzene	0.0%	-0.5%	1.7%	1.6%	0.4%	-0.6%
HCFC-142b/Alkylbenzene	1.8%	2.0%	2.1%	4.4%	2.6%	-4.2%
HFC-152a/Alkylbenzene	-0.1%	-1.1%	1.9%	-4.4%	-0.7%	-4.1%
HFC-134a/Ester, Mixed Acid	-0.8%	-2.3%	0.5%	1.4%	-1.0%	-4.0%
HFC-134a/Ester, Branched Acid	-0.4%	-2.6%	0.0%	-3.1%	-1.5%	-8.8%
HFC-32/Ester, Branched Acid	-1.2%	-3.3%	0.3%	-3.5%	-3.2%	-8.4%
HFC-125/Ester, Branched Acid	-3.0%	-2.8%	-0.4%	0.4%	-2.2%	-2.3%
HFC-143a/Ester, Branched Acid	-2.3%	-5.6%	-1.2%	-1.7%	-2.8%	-3.6%
HFC-134/Ester, Branched Acid	-3.4%	-2.6%	-0.4%	-0.4%	-3.1%	-3.3%
HFC-245ca/Ester, Branched Acid	-1.5%	-0.7%	0.7%	0.2%	-1.7%	-3.5%
HFC-134a/PAG, Butyl Monoether	-2.3%	-2.7%	0.0%	-0.6%	-2.6%	-2.6%
HFC-32/PAG, Butyl Monoether	-2.8%	-2.6%	0.1%	-3.9%	-4.3%	-2.8%
HFC-125/PAG, Butyl Monoether	-2.7%	-1.9%	0.0%	0.2%	-2.1%	-1.6%
HFC-134a/PAG, Modified	-2.9%	-3.1%	-0.7%	0.3%	-3.0%	-2.8%
HFC-125/PAG, Modified	-1.8%	1.4%	0.7%	-0.1%	1.1%	-1.1%
HFC-134a/PAG Diol	4.6%	17.8%	3.4%	4.3%	7.6%	12.9%

Varnish Bond Strength

Varnish Coated on Magnet Wire A(ester base with amide imide overcoat)

Results after 500-hour exposure @ 127°C(260°F)

	Varnish Type					
	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Unexposed	73.7 lbs.	43.8 lbs.	51.8 lbs.	9.9 lbs	41.3 lbs	45.0 lbs

Exposure with:	% Change from Unexposed					
	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Nitrogen	-29.9%	-42.8%	-36.6%	-5.8%	-40.9%	-59.7%
HCFC-22/Mineral	-23.8%	-10.2%	-23.1%	184.8%	-24.8%	-7.4%
HCFC-124/Alkylbenzene	-47.4%	-33.8%	-62.6%	40.5%	-16.3%	-11.3%
HCFC-142b/Alkylbenzene	-51.4%	-34.7%	-36.1%	40.3%	-32.9%	-30.3%
HFC-152a/Alkylbenzene	-64.5%	-42.2%	-47.5%	78.2%	-20.2%	-7.7%
HFC-134a/Ester, Mixed Acid	-19.4%	-27.6%	12.8%	102.2%	-18.9%	-14.7%
HFC-134a/Ester, Branched Acid	-20.0%	-34.2%	11.1%	30.7%	-19.6%	-42.3%
HFC-32/Ester, Branched Acid	-61.3%	-36.4%	-8.1%	94.9%	-28.0%	-2.8%
HFC-125/Ester, Branched Acid	-9.8%	-27.7%	12.3%	172.3%	-22.6%	14.2%
HFC-143a/Ester, Branched Acid	-34.5%	-32.7%	-26.1%	149.1%	-29.4%	-15.9%
HFC-134/Ester, Branched Acid	-24.7%	-17.6%	18.0%	336.4%	-14.3%	10.9%
HFC-245ca/Ester, Branched Acid	-21.5%	-29.8%	6.7%	102.0%	-20.7%	-21.8%
HFC-134a/PAG, Butyl Monoether	-15.3%	-21.9%	0.9%	113.2%	-25.0%	-1.3%
HFC-32/PAG, Butyl Monoether	-26.9%	37.3%	25.5%	284.2%	-17.2%	7.1%
HFC-125/PAG, Butyl Monoether	-9.4%	29.2%	3.6%	480.2%	-10.6%	-4.6%
HFC-134a/PAG, Modified	-25.7%	-39.8%	5.8%	51.7%	-23.0%	-14.0%
HFC-125/PAG, Modified	-2.0%	56.9%	9.9%	141.2%	-3.5%	-1.5%
HFC-134a/PAG Diol	-35.4%	14.4%	11.4%	316.6%	-30.0%	-22.9%

Varnish Bond Strength

Varnish Coated on Magnet Wire A(ester base with amide imide overcoat)

Results after 500-hour exposure @ 127°C(260°F) plus a 24-hour air bake @ 150°C(302°F)

		Varnish Type					
		U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Unexposed		73.7 lbs.	43.8 lbs.	51.8 lbs.	9.9 lbs	41.3 lbs	45.0 lbs
		% Change from Unexposed					
<u>Exposure with:</u>		U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Nitrogen		-8.3%	-30.0%	-11.1%	31.0%	-35.0%	-28.4%
HCFC-22/Mineral		-21.2%	7.5%	-0.7%	199.2%	4.5%	3.1%
HCFC-124/Alkylbenzene		-23.7%	-41.3%	-30.2%	123.7%	-16.3%	-18.5%
HCFC-142b/Alkylbenzene		-84.5%	-67.7%	-74.1%	-25.2%	-45.0%	-65.5%
HFC-152a/Alkylbenzene		-42.8%	-48.4%	-70.1%	79.3%	-61.7%	-1.4%
HFC-134a/Ester, Mixed Acid		-24.4%	-9.0%	-5.1%	125.7%	-4.7%	-1.6%
HFC-134a/Ester, Branched Acid		-26.2%	-15.3%	-10.0%	177.5%	-10.1%	-31.3%
HFC-32/Ester, Branched Acid		-32.0%	-20.9%	-23.4%	172.1%	-8.8%	6.5%
HFC-125/Ester, Branched Acid		-2.5%	12.4%	31.7%	301.9%	-12.4%	-1.9%
HFC-143a/Ester, Branched Acid		-37.3%	-37.3%	-38.3%	150.3%	10.6%	6.5%
HFC-134/Ester, Branched Acid		-2.7%	1.3%	13.4%	535.5%	-0.3%	-2.0%
HFC-245ca/Ester, Branched Acid		3.6%	9.7%	2.8%	82.1%	-16.4%	5.3%
HFC-134a/PAG, Butyl Monoether		0.0%	-2.5%	16.0%	200.2%	6.1%	14.8%
HFC-32/PAG, Butyl Monoether		-19.5%	9.1%	28.7%	323.0%	-4.0%	1.6%
HFC-125/PAG, Butyl Monoether		10.8%	21.8%	29.8%	351.1%	6.8%	6.6%
HFC-134a/PAG, Modified		5.7%	-7.4%	19.2%	127.3%	-11.7%	-2.7%
HFC-125/PAG, Modified		-7.2%	37.7%	27.0%	234.9%	-18.4%	-22.1%
HFC-134a/PAG Diol		-62.9%	-24.6%	23.1%	204.7%	-26.3%	-18.9%

Varnish Bond Strength

Varnish Coated on Magnet Wire B(Dacron/Glass served wire)

Results after 500-hour exposure @ 127°C(260°F)

Unexposed

Varnish Type

U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
40.1 lbs	36.1 lbs	36.0 lbs	33.1 lbs	40.5 lbs	20.2 lbs

% Change from Unexposed

Exposure with:

	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Nitrogen	-30.3%	-11.1%	-36.8%	-43.5%	-26.6%	-12.5%
HCFC-22/Mineral	-19.6%	-3.8%	-27.6%	-45.7%	-8.5%	10.3%
HCFC-124/Alkylbenzene	-16.8%	-1.0%	-27.6%	-45.1%	-11.5%	-3.6%
HCFC-142b/Alkylbenzene	-2.8%	12.2%	-14.6%	-18.0%	-14.1%	22.3%
HFC-152a/Alkylbenzene	-8.5%	5.7%	-1.0%	-31.6%	-5.6%	-9.5%
HFC-134a/Ester, Mixed Acid	-22.6%	5.2%	-19.3%	-26.0%	2.4%	27.1%
HFC-134a/Ester, Branched Acid	-6.2%	-9.0%	-5.1%	-28.8%	-12.2%	16.0%
HFC-32/Ester, Branched Acid	-25.6%	-8.6%	-28.9%	-47.6%	-20.8%	-3.1%
HFC-125/Ester, Branched Acid	-25.1%	14.4%	-20.9%	20.1%	-8.8%	-26.7%
HFC-143a/Ester, Branched Acid	-25.8%	-0.3%	-10.9%	-41.7%	-13.8%	-3.8%
HFC-134/Ester, Branched Acid	-1.0%	26.2%	-8.3%	53.8%	11.3%	-0.5%
HFC-245ca/Ester, Branched Acid	-21.7%	14.2%	-19.0%	-11.9%	-3.3%	6.6%
HFC-134a/PAG, Butyl Monoether	-7.6%	37.1%	-18.5%	6.4%	-0.5%	-7.4%
HFC-32/PAG, Butyl Monoether	22.6%	48.6%	-4.2%	-10.5%	8.9%	10.1%
HFC-125/PAG, Butyl Monoether	-18.2%	16.5%	-2.9%	13.4%	-5.3%	5.9%
HFC-134a/PAG, Modified	-12.0%	40.6%	-13.1%	4.2%	-5.5%	3.3%
HFC-125/PAG, Modified	22.9%	51.6%	13.5%	30.6%	23.6%	36.0%
HFC-134a/PAG Diol	2.6%	21.0%	8.0%	10.3%	0.1%	16.3%

Varnish Bond Strength

Varnish Coated on Magnet Wire B(Dacron/Glass served wire)

Results after 500-hour exposure @ 127°C(260°F) plus a 24-hour air bake @ 150°C(302°F)

	Varnish Type					
	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Unexposed	40.1 lbs	36.1 lbs	36.0 lbs	33.1 lbs	40.5 lbs	20.2 lbs

<u>Exposure with:</u>	% Change from Unexposed					
	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Nitrogen	-35.5%	-11.0%	-24.0%	-44.5%	-16.6%	-25.7%
HCFC-22/Mineral	-17.0%	-6.5%	-21.4%	-51.2%	-21.0%	-6.6%
HCFC-124/Alkylbenzene	-19.8%	-11.2%	-21.0%	-38.0%	-29.6%	-6.4%
HCFC-142b/Alkylbenzene	-30.5%	-28.0%	-24.1%	-46.4%	-32.1%	-14.8%
HFC-152a/Alkylbenzene	-25.4%	-12.8%	-13.1%	-39.2%	-20.8%	-25.5%
HFC-134a/Ester, Mixed Acid	-14.4%	6.7%	-13.1%	-24.8%	-4.5%	5.4%
HFC-134a/Ester, Branched Acid	-15.9%	-8.3%	-5.3%	-54.7%	-14.8%	1.6%
HFC-32/Ester, Branched Acid	-22.6%	-16.7%	-31.1%	-70.4%	-32.9%	-23.4%
HFC-125/Ester, Branched Acid	-16.4%	15.4%	-15.2%	7.9%	-19.5%	-3.2%
HFC-143a/Ester, Branched Acid	-23.5%	-21.8%	-29.3%	-35.8%	-30.0%	-26.1%
HFC-134/Ester, Branched Acid	-3.0%	19.7%	-17.5%	-6.7%	-8.5%	-2.1%
HFC-245ca/Ester, Branched Acid	-18.7%	6.9%	-17.1%	-8.8%	-9.6%	-7.4%
HFC-134a/PAG, Butyl Monoether	-23.1%	33.1%	-14.8%	-0.4%	-15.4%	-17.4%
HFC-32/PAG, Butyl Monoether	-12.5%	13.6%	-16.4%	16.1%	3.3%	2.6%
HFC-125/PAG, Butyl Monoether	16.4%	24.3%	1.5%	37.3%	19.4%	42.6%
HFC-134a/PAG, Modified	-18.4%	23.2%	-11.6%	-12.0%	-8.5%	7.5%
HFC-125/PAG, Modified	-3.6%	38.7%	-8.3%	0.5%	1.0%	4.9%
HFC-134a/PAG Diol	-12.3%	-52.9%	-15.3%	-56.3%	-11.2%	0.0%

Varnish Bond Strength

Varnish Coated on Magnet Wire C(ester imide overcoated with amide imide)

Results after 500-hour exposure @ 127°C(260°F)

	Varnish Type					
	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Unexposed	51.2 lbs.	50.7 lbs.	58.3 lbs.	5.8 lbs	49.3 lbs	36.1 lbs

Exposure with:	% Change from Unexposed					
	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Nitrogen	-56.6%	-51.0%	-24.3%	109.8%	-49.9%	-37.8%
HCFC-22/Mineral	-0.6%	-46.3%	-38.8%	201.4%	-49.7%	-22.5%
HCFC-124/Alkylbenzene	-27.1%	-46.6%	-56.8%	99.4%	-46.9%	4.8%
HCFC-142b/Alkylbenzene	-7.4%	-50.4%	-47.1%	62.7%	-55.9%	-25.5%
HFC-152a/Alkylbenzene	-46.5%	-53.5%	-52.3%	89.2%	-49.4%	23.6%
HFC-134a/Ester, Mixed Acid	8.7%	-46.6%	-28.8%	56.7%	-55.2%	-51.8%
HFC-134a/Ester, Branched Acid	26.4%	-45.3%	-41.1%	97.9%	-52.8%	-11.4%
HFC-32/Ester, Branched Acid	3.4%	-50.4%	-46.3%	67.1%	-46.8%	-13.4%
HFC-125/Ester, Branched Acid	18.2%	-42.8%	-20.5%	-70.3%	-50.0%	-37.5%
HFC-143a/Ester, Branched Acid	-25.8%	-0.3%	-10.9%	-41.7%	-13.8%	-3.8%
HFC-134/Ester, Branched Acid	23.3%	-30.2%	1.1%	459.2%	-40.3%	47.2%
HFC-245ca/Ester, Branched Acid	3.0%	-34.6%	-11.1%	274.0%	-49.8%	-38.4%
HFC-134a/PAG, Butyl Monoether	-35.9%	-51.5%	-39.2%	74.7%	-54.3%	-37.3%
HFC-32/PAG, Butyl Monoether	28.1%	-38.4%	8.9%	170.8%	-50.2%	-30.9%
HFC-125/PAG, Butyl Monoether	8.0%	-18.5%	13.8%	588.6%	-40.5%	9.6%
HFC-134a/PAG, Modified	26.5%	-49.4%	-14.0%	-8.4%	-46.7%	-48.4%
HFC-125/PAG, Modified	31.8%	-6.3%	21.3%	432.2%	-43.2%	54.5%
HFC-134a/PAG Diol	-18.1%	-33.5%	-26.5%	89.5%	-40.7%	-52.8%

Varnish Bond Strength

Varnish Coated on Magnet Wire C(ester imide overcoated with amide imide)

Results after 500-hour exposure @ 127°C(260°F) plus a 24-hour air bake @ 150°C(302°F)

Varnish Type	
U-475EH	Y-390PG
ER-610	Y-833
No.923	Iso-800
Unexposed	51.2 lbs.
	50.7 lbs.
	58.3 lbs.
	5.8 lbs
	49.3 lbs
	36.1 lbs

% Change from Unexposed	
Exposure with:	U-475EH
	Y-390PG
	ER-610
	Y-833
	No.923
	Iso-800
Nitrogen	15.7%
HCFC-22/Mineral	-1.5%
HCFC-124/Alkylbenzene	37.8%
HCFC-142b/Alkylbenzene	-81.2%
HFC-152a/Alkylbenzene	-46.2%
HFC-134a/Ester, Mixed Acid	4.7%
HFC-134a/Ester, Branched Acid	5.0%
HFC-32/Ester, Branched Acid	19.0%
HFC-125/Ester, Branched Acid	34.6%
HFC-143a/Ester, Branched Acid	-5.8%
HFC-134/Ester, Branched Acid	16.6%
HFC-245ca/Ester, Branched Acid	14.7%
HFC-134a/PAG, Butyl Monoether	34.2%
HFC-32/PAG, Butyl Monoether	30.3%
HFC-125/PAG, Butyl Monoether	43.0%
HFC-134a/PAG, Modified	36.0%
HFC-125/PAG, Modified	20.4%
HFC-134a/PAG Diol	2.8%
	-45.6%
	-15.4%
	-23.6%
	-38.7%
	-71.3%
	-51.1%
	-39.4%
	-34.9%
	-31.3%
	-22.7%
	-46.0%
	-29.0%
	-4.9%
	-21.4%
	-18.9%
	-2.5%
	114.4%
	-2.0%
	-22.7%
	3.7%
	125.6%
	-37.7%
	11.9%
	192.0%
	-18.0%
	-0.9%
	123.0%
	-50.0%
	21.3%
	151.4%
	-49.9%
	-17.1%
	144.8%
	-51.9%
	46.1%
	35.9%
	-34.2%
	-34.2%
	219.9%
	-40.4%
	-29.7%
	116.8%
	-42.0%
	21.6%
	168.7%
	-33.8%
	-28.9%
	152.1%
	-44.3%
	-12.6%
	401.8%
	-19.3%
	20.6%
	442.0%
	-25.4%
	-26.1%
	-15.0%
	-31.7%
	-3.0%
	325.2%
	-26.6%
	-24.2%
	681.7%
	-19.3%
	42.7%
	220.4%
	-28.0%
	-28.0%
	366.3%
	-39.8%
	10.7%
	-84.0%
	-53.4%
	-34.0%

Burnout Strength

Magnet Wire A(ester base with amide imide overcoat)

Results after 500-hour exposure @ 127°C(260°F)

Varnish Type

Unexposed

Uncoated	U-475EH	Y-390PG	ER-61Q	Y-833	No.923	Iso-800
576 sec	430 sec	510 sec	442 sec	578 sec	606 sec	580 sec

% Change from Unexposed

Exposure with:

	Uncoated	U-475EH	Y-390PG	ER-61Q	Y-833	No.923	Iso-800
Nitrogen	-5.3%	3.8%	11.8%	-4.1%	-4.5%	-7.6%	-11.7%
HCFC-22/Mineral	-31.1%	-20.8%	-22.5%	-37.8%	-33.2%	-35.6%	-33.7%
HCFC-124/Alkylbenzene	-30.6%	15.8%	-12.6%	-18.8%	-12.6%	-2.4%	-17.6%
HCFC-142b/Alkylbenzene	-37.3%	-18.9%	-18.4%	-41.6%	-38.0%	-28.5%	-35.9%
HFC-152a/Alkylbenzene	-13.1%	-1.0%	4.6%	-20.1%	-10.8%	-5.1%	-3.1%
HFC-134a/Ester, Mixed Acid	-9.9%	2.9%	-30.3%	-19.1%	-8.0%	-13.3%	0.4%
HFC-134a/Ester, Branched Acid	-16.7%	8.9%	4.8%	-8.3%	-9.3%	-4.1%	-13.3%
HFC-32/Ester, Branched Acid	-12.4%	-17.4%	0.5%	-29.0%	-6.1%	-20.0%	-27.8%
HFC-125/Ester, Branched Acid	-17.6%	-23.6%	-21.4%	-14.1%	-20.9%	-17.9%	-4.4%
HFC-143a/Ester, Branched Acid	-22.6%	12.4%	13.7%	-16.5%	-7.0%	-20.2%	-9.9%
HFC-134/Ester, Branched Acid	-9.1%	-25.4%	-5.4%	-22.6%	-17.5%	-5.9%	-8.9%
HFC-245ca/Ester, Branched Acid	-9.5%	-29.5%	-14.4%	-8.8%	-18.6%	-26.7%	0.9%
HFC-134a/PAG, Butyl Monoether	-4.1%	34.3%	5.6%	-20.0%	-16.9%	-4.7%	-12.9%
HFC-32/PAG, Butyl Monoether	-30.2%	0.2%	-2.9%	2.4%	0.6%	-23.8%	-8.7%
HFC-125/PAG, Butyl Monoether	-3.0%	0.3%	-1.3%	-16.4%	-33.6%	-12.5%	-5.3%
HFC-134a/PAG, Modified	-9.9%	-25.4%	-5.4%	-22.6%	-17.5%	-5.9%	-8.9%
HFC-125/PAG, Modified	-11.6%	21.9%	-15.6%	-25.3%	-15.9%	-14.4%	-4.2%
HFC-134a/PAG Diol	-12.2%	-25.2%	2.7%	-26.2%	-14.5%	-6.9%	-7.1%

Burnout Strength

Magnet Wire A(ester base with amide imide overcoat)

Results after 500-hour exposure @ 127°C(260°F) plus a 24-hour air bake @ 150C(302°F)

	Varnish Type						
	Uncoated	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
	576 sec	430 sec	510 sec	442 sec	578 sec	606 sec	580 sec
Unexposed							
Exposure with:	% Change from Unexposed						
	Uncoated	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Nitrogen	-3.2%	15.4%	17.8%	-5.5%	-1.3%	-2.5%	-3.7%
HCFC-22/Mineral	-14.4%	-41.2%	-15.7%	-27.2%	-32.9%	-25.8%	-51.8%
HCFC-124/Alkylbenzene	-14.7%	-30.1%	8.6%	-32.7%	-19.8%	-3.7%	-22.9%
HCFC-142b/Alkylbenzene	-34.5%	-32.5%	-6.8%	-22.3%	-34.5%	-24.4%	-30.7%
HFC-152a/Alkylbenzene	-3.8%	5.4%	7.7%	-34.4%	-24.3%	-8.6%	-8.1%
HFC-134a/Ester, Mixed Acid	-7.6%	-16.3%	-24.9%	-24.1%	-11.6%	-9.3%	-6.1%
HFC-134a/Ester, Branched Acid	-11.9%	-4.8%	11.6%	-35.1%	-25.6%	-13.7%	-14.0%
HFC-32/Ester, Branched Acid	-6.4%	-13.0%	-17.4%	-17.8%	-5.1%	-27.8%	-33.7%
HFC-125/Ester, Branched Acid	-24.7%	-12.8%	-23.7%	-12.1%	-19.1%	-11.3%	-7.0%
HFC-143a/Ester, Branched Acid	-22.7%	-16.2%	-6.0%	-24.4%	-18.2%	-26.3%	-6.3%
HFC-134/Ester, Branched Acid	-4.6%	-12.3%	-4.4%	-15.2%	-10.8%	-22.5%	1.5%
HFC-245ca/Ester, Branched Acid	-13.0%	36.0%	-11.2%	-14.8%	-1.9%	-25.3%	0.6%
HFC-134a/PAG, Butyl Monoether	-21.4%	-14.9%	-5.0%	-19.8%	-17.1%	-19.6%	-29.8%
HFC-32/PAG, Butyl Monoether	-8.3%	-16.9%	-9.8%	4.1%	32.1%	-8.6%	-9.7%
HFC-125/PAG, Butyl Monoether	-12.0%	20.3%	10.0%	-9.7%	-11.5%	-24.0%	1.0%
HFC-134a/PAG, Modified	-7.8%	-12.3%	-4.4%	-15.2%	-10.8%	-22.5%	1.5%
HFC-125/PAG, Modified	-16.7%	13.5%	10.0%	-28.8%	-13.6%	-24.8%	-19.5%
HFC-134a/PAG Diol	-15.3%	1.3%	-2.6%	-24.4%	-12.3%	-3.7%	0.7%

Burnout Strength

Magnet Wire B(Dacron/Glass served wire)

Results after 500-hour exposure @ 127°C(260°F)

	Varnish Type						
	Uncoated	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
	736 sec	746 sec	755 sec	734 sec	734 sec	742 sec	743 sec
Unexposed							
Exposure with:	% Change from Unexposed						
	Uncoated	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Nitrogen	-3.3%	-1.8%	-3.1%	-1.0%	-0.4%	-1.4%	-2.2%
HCFC-22/Mineral	-0.9%	-2.2%	-2.3%	-0.4%	-0.5%	-1.2%	-0.7%
HCFC-124/Alkylbenzene	-2.1%	-2.0%	-1.9%	-0.7%	-5.5%	-0.7%	-0.7%
HCFC-142b/Alkylbenzene	-6.7%	-2.7%	-3.2%	-5.5%	-0.3%	-0.3%	-2.1%
HFC-152a/Alkylbenzene	-0.3%	-2.1%	-4.7%	-3.8%	-0.3%	-0.4%	-1.5%
HFC-134a/Ester, Mixed Acid	-0.2%	-2.4%	-2.5%	-0.4%	-1.5%	-0.1%	-0.9%
HFC-134a/Ester, Branched Acid	-6.8%	-2.1%	-2.2%	-0.2%	-5.3%	1.6%	-1.2%
HFC-32/Ester, Branched Acid	-4.1%	-0.3%	-1.8%	-0.2%	-0.8%	1.9%	-1.2%
HFC-125/Ester, Branched Acid	-7.0%	-1.7%	-2.2%	-0.3%	-0.5%	0.5%	-1.3%
HFC-143a/Ester, Branched Acid	-10.8%	-1.1%	-2.0%	0.2%	-0.1%	0.9%	-0.6%
HFC-134/Ester, Branched Acid	-0.3%	-1.5%	-0.9%	-0.5%	0.1%	0.7%	-0.9%
HFC-245ca/Ester, Branched Acid	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
HFC-134a/PAG, Butyl Monoether	-6.0%	-1.3%	-2.1%	-0.4%	-0.3%	1.0%	-0.4%
HFC-32/PAG, Butyl Monoether	-5.4%	-0.9%	-2.0%	-0.2%	-0.5%	0.2%	-1.4%
HFC-125/PAG, Butyl Monoether	-2.7%	-1.7%	-0.8%	-2.3%	-0.2%	1.1%	-1.4%
HFC-134a/PAG, Modified	-0.6%	-1.3%	-1.7%	-0.1%	-0.2%	1.3%	-1.0%
HFC-125/PAG, Modified	-4.4%	-1.0%	-1.4%	-0.3%	-0.1%	0.5%	-0.6%
HFC-134a/PAG Diol	-6.7%	-1.1%	-2.9%	-0.5%	-0.6%	-0.6%	-1.6%

Burnout Strength

Magnet Wire B(Dacron/Glass served wire)

Results after 500-hour exposure plus a 24-hour air bake @ 150C(302°F)

Varnish Type

Unexposed

Uncoated	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
736 sec	746 sec	755 sec	734 sec	734 sec	742 sec	743 sec

% Change from Unexposed

Exposure with:

	Uncoated	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Nitrogen	-1.9%	-3.1%	-4.3%	-1.1%	-1.5%	-2.6%	-3.2%
HCFC-22/Mineral	-1.0%	-0.5%	-3.6%	-1.5%	-24.0%	-1.8%	-1.1%
HCFC-124/Alkylbenzene	-2.1%	-2.6%	-2.1%	-0.5%	-3.5%	-1.4%	-1.7%
HCFC-142b/Alkylbenzene	-0.4%	-4.2%	-2.3%	-0.3%	-2.7%	-2.6%	-1.0%
HFC-152a/Alkylbenzene	-0.5%	-1.8%	-2.1%	-0.4%	-0.6%	-1.1%	-0.2%
HFC-134a/Ester, Mixed Acid	-0.7%	-2.4%	-1.7%	-0.4%	-0.5%	1.6%	-0.6%
HFC-134a/Ester, Branched Acid	-0.5%	-2.1%	-0.9%	-0.2%	-2.0%	1.9%	-1.0%
HFC-32/Ester, Branched Acid	-3.5%	-0.3%	-1.4%	-0.5%	-2.5%	1.1%	-1.8%
HFC-125/Ester, Branched Acid	-7.6%	-1.8%	-2.5%	-0.9%	-0.2%	-1.5%	-0.9%
HFC-143a/Ester, Branched Acid	-3.5%	-0.2%	-1.3%	-0.5%	-0.4%	1.1%	-0.7%
HFC-134/Ester, Branched Acid	-0.9%	-1.9%	-1.9%	-0.8%	-0.7%	0.0%	-0.9%
HFC-245ca/Ester, Branched Acid	-4.9%	-1.4%	-13.0%	-3.1%	-2.5%	-1.6%	0.3%
HFC-134a/PAG, Butyl Monoether	-3.4%	-1.3%	-2.3%	-0.4%	-0.6%	-1.5%	0.3%
HFC-32/PAG, Butyl Monoether	-7.4%	-1.5%	-2.1%	-1.3%	0.3%	2.0%	-1.9%
HFC-125/PAG, Butyl Monoether	-1.1%	-1.9%	-1.9%	-0.9%	-0.3%	1.5%	-0.9%
HFC-134a/PAG, Modified	-0.9%	0.8%	-2.5%	-0.5%	-0.4%	1.5%	-0.9%
HFC-125/PAG, Modified	-1.1%	-1.3%	-2.9%	-0.7%	-0.6%	0.8%	-2.1%
HFC-134a/PAG Diol	-1.1%	-1.0%	-1.4%	-0.6%	-0.6%	1.4%	-1.1%

Burnout Strength

Magnet Wire C(ester imide overcoated with amide imide)

Results after 500-hour exposure @ 127°C(260°F)

		Varnish Type						
		Uncoated	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Unexposed		579 sec	469 sec	473 sec	494 sec	557 sec	505 sec	632 sec

		% Change from Unexposed						
Exposure with:		Uncoated	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Nitrogen		4.8%	6.1%	14.5%	-11.9%	-7.1%	7.8%	-7.0%
HCFC-22/Mineral		-37.2%	-40.8%	-17.1%	-37.7%	-44.0%	-26.2%	-49.7%
HCFC-124/Alkylbenzene		-61.8%	2.1%	-9.9%	-0.9%	-39.7%	-9.5%	-27.7%
HCFC-142b/Alkylbenzene		-53.1%	-39.9%	-21.4%	-52.2%	-58.1%	-37.4%	-42.0%
HFC-152a/Alkylbenzene		-1.0%	-3.0%	13.0%	-23.1%	-10.9%	7.2%	-9.5%
HFC-134a/Ester, Mixed Acid		-14.6%	-35.3%	-10.6%	-16.5%	-12.6%	3.7%	-5.9%
HFC-134a/Ester, Branched Acid		-22.9%	11.0%	20.5%	15.8%	-34.7%	22.8%	-8.3%
HFC-32/Ester, Branched Acid		-27.9%	-11.5%	-5.3%	-34.8%	-25.9%	4.4%	-27.1%
HFC-125/Ester, Branched Acid		-12.4%	-35.0%	3.1%	-48.1%	-23.6%	14.7%	-9.4%
HFC-143a/Ester, Branched Acid		-3.6%	-9.0%	5.1%	-28.2%	-1.0%	0.0%	-11.9%
HFC-134/Ester, Branched Acid		-10.4%	-11.4%	24.9%	-22.1%	-4.6%	13.0%	-8.3%
HFC-245ca/Ester, Branched Acid		-7.6%	24.3%	23.0%	-28.5%	-13.2%	11.6%	-4.7%
HFC-134a/PAG, Butyl Monoether		-7.6%	-0.6%	18.0%	-26.7%	-12.0%	13.7%	-25.0%
HFC-32/PAG, Butyl Monoether		-20.8%	-1.6%	19.2%	-22.1%	-16.1%	-6.0%	-9.5%
HFC-125/PAG, Butyl Monoether		0.6%	-26.4%	14.5%	-29.9%	-1.9%	2.7%	-2.2%
HFC-134a/PAG, Modified		-9.6%	-2.1%	13.5%	-37.0%	-1.1%	14.8%	-5.3%
HFC-125/PAG, Modified		-10.8%	4.8%	7.4%	-35.5%	2.6%	12.0%	-16.8%
HFC-134a/PAG Diol		-22.6%	-2.5%	24.7%	-40.9%	-5.2%	20.9%	-11.5%

Burnout Strength

Magnet Wire C(ester imide overcoated with amide imide)

Results after 500-hour exposure @ 127°C(260°F) plus a 24-hour air bake @ 150C(302°F)

	Varnish Type						
	Uncoated	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Unexposed	579 sec	469 sec	473 sec	494 sec	557 sec	505 sec	632 sec

	% Change from Unexposed						
Exposure with:	Uncoated	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Nitrogen	3.9%	-19.3%	-3.3%	-10.5%	-3.7%	-3.5%	-9.5%
HCFC-22/Mineral	-36.3%	-33.6%	-17.7%	-29.3%	-55.3%	-26.1%	-60.3%
HCFC-124/Alkylbenzene	-22.6%	0.3%	-3.5%	-3.2%	-34.5%	-9.5%	-14.5%
HCFC-142b/Alkylbenzene	-45.8%	-49.8%	-21.6%	-57.6%	-56.4%	-14.3%	-44.3%
HFC-152a/Alkylbenzene	-8.9%	-3.6%	6.6%	-26.8%	-13.4%	-17.2%	2.3%
HFC-134a/Ester, Mixed Acid	-3.9%	-33.4%	9.2%	-21.7%	-8.6%	7.6%	-8.5%
HFC-134a/Ester, Branched Acid	-16.5%	-7.8%	9.2%	-19.5%	-4.4%	11.0%	-10.7%
HFC-32/Ester, Branched Acid	-14.7%	-37.2%	0.6%	-32.5%	-2.8%	8.5%	-26.6%
HFC-125/Ester, Branched Acid	-20.8%	-11.2%	1.6%	-26.3%	-6.5%	13.4%	-21.0%
HFC-143a/Ester, Branched Acid	-16.9%	-21.0%	-1.5%	-23.6%	6.0%	12.9%	-13.2%
HFC-134/Ester, Branched Acid	-7.4%	-16.6%	21.6%	-20.5%	4.4%	17.2%	-0.6%
HFC-245ca/Ester, Branched Acid	-4.7%	28.4%	8.7%	-23.1%	-4.1%	17.4%	-11.1%
HFC-134a/PAG, Butyl Monoether	-12.0%	-0.6%	18.0%	-26.7%	-12.0%	13.7%	-25.0%
HFC-32/PAG, Butyl Monoether	-5.6%	-13.1%	4.5%	-15.5%	-15.5%	-14.5%	-9.7%
HFC-125/PAG, Butyl Monoether	-8.9%	15.6%	0.7%	-22.5%	-5.3%	-0.3%	-1.6%
HFC-134a/PAG, Modified	-5.6%	-0.8%	9.4%	-33.4%	0.4%	14.7%	-8.1%
HFC-125/PAG, Modified	-17.0%	-26.7%	19.7%	-30.4%	-21.7%	13.0%	-18.6%
HFC-134a/PAG Diol	-17.7%	17.6%	25.1%	-21.5%	-10.0%	13.5%	-8.7%

Dielectric Strength

Magnet Wire A(ester base with amide imide overcoat)

Results after a 500-hour exposure @127°C(260°F)

	Varnish Type						
	Uncoated	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Unexposed	15.8 kV	16.2 kV	18.8 kV	15.6 kV	12.0 kV	16.8 kV	19.1 kV
<u>Exposure with:</u>	% Change from Unexposed						
	Uncoated	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Nitrogen	-2.5%	-53.5%	-32.1%	-19.1%	1.0%	-43.6%	-34.1%
HCFC-22/Mineral	-5.4%	-11.5%	-13.3%	-2.7%	0.2%	-25.7%	-13.6%
HCFC-124/Alkylbenzene	-5.0%	-8.9%	-17.5%	-3.2%	1.7%	-0.4%	-21.4%
HCFC-142b/Alkylbenzene	-19.2%	-8.1%	-11.0%	5.8%	-8.8%	-11.4%	-7.2%
HFC-152a/Alkylbenzene	-4.9%	16.1%	-27.9%	-6.3%	-1.5%	-17.8%	-20.7%
HFC-134a/Ester, Mixed Acid	-16.6%	16.1%	-21.8%	-13.4%	17.7%	12.7%	-4.2%
HFC-134a/Ester, Branched Acid	3.0%	-29.6%	1.9%	-11.7%	21.5%	14.2%	-3.4%
HFC-32/Ester, Branched Acid	3.3%	-16.8%	-10.1%	-5.2%	23.0%	10.6%	-13.6%
HFC-125/Ester, Branched Acid	-5.0%	-14.8%	-5.8%	-22.4%	10.3%	-11.2%	-5.2%
HFC-143a/Ester, Branched Acid	-18.5%	7.8%	-14.0%	-6.6%	35.1%	13.1%	-21.5%
HFC-134/Ester, Branched Acid	-2.6%	-25.4%	-5.4%	-22.6%	-17.5%	-5.9%	-8.9%
HFC-245ca/Ester, Branched Acid	-11.8%	9.7%	-4.3%	-14.6%	2.6%	9.4%	-9.6%
HFC-134a/PAG, Butyl Monoether	3.2%	-1.3%	-23.7%	-4.3%	-0.6%	-10.3%	-13.9%
HFC-32/PAG, Butyl Monoether	-9.3%	4.2%	-1.9%	-2.1%	25.7%	5.3%	-2.3%
HFC-125/PAG, Butyl Monoether	-4.6%	7.6%	1.9%	-1.7%	8.0%	-3.7%	-1.6%
HFC-134a/PAG, Modified	-14.4%	-19.4%	-18.9%	-10.2%	-3.9%	14.0%	-6.4%
HFC-125/PAG, Modified	-8.6%	12.7%	-2.6%	-34.1%	4.9%	19.0%	-18.7%
HFC-134a/PAG Diol	-0.2%	-24.3%	0.8%	0.4%	7.0%	3.7%	0.2%

Dielectric Strength

Magnet Wire A(ester base with amide imide overcoat)

Results after a 500-hour exposure @ 127°C(260°F) plus a 24-hour air bake @ 150C(302°F)

	Varnish Type						
	Uncoated	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Unexposed	15.8 kV	16.2 kV	18.8 kV	15.6 kV	12.0 kV	16.8 kV	19.1 kV

Exposure with:	% Change from Unexposed						
	Uncoated	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Nitrogen	-5.2%	-37.9%	-22.6%	-9.9%	1.9%	-20.5%	-48.4%
HCFC-22/Mineral	-11.0%	-4.9%	-8.2%	-11.6%	-0.9%	-29.0%	-22.1%
HCFC-124/Alkylbenzene	-1.4%	4.7%	-36.4%	-6.4%	-10.9%	0.5%	-8.1%
HCFC-142b/Alkylbenzene	-3.1%	-11.2%	-16.2%	-12.6%	-0.5%	-14.2%	-24.4%
HFC-152a/Alkylbenzene	-9.2%	-24.2%	-29.8%	-4.8%	-7.1%	-10.0%	-40.9%
HFC-134a/Ester, Mixed Acid	-11.0%	3.9%	-23.8%	-8.3%	14.6%	10.4%	-6.1%
HFC-134a/Ester, Branched Acid	-6.9%	-12.9%	-18.6%	-16.5%	-3.7%	-10.2%	-8.5%
HFC-32/Ester, Branched Acid	-18.8%	-32.2%	-33.7%	-20.9%	-4.1%	-26.3%	-15.6%
HFC-125/Ester, Branched Acid	-10.2%	-34.5%	-1.2%	-19.7%	-7.8%	8.9%	-29.3%
HFC-143a/Ester, Branched Acid	-13.1%	-0.1%	-12.8%	-14.0%	-8.8%	-25.5%	-26.9%
HFC-134/Ester, Branched Acid	-13.0%	-16.8%	-22.7%	-16.3%	3.7%	-13.4%	-16.5%
HFC-245ca/Ester, Branched Acid	-15.8%	36.0%	-11.2%	-14.8%	-1.9%	-25.3%	0.1%
HFC-134a/PAG, Butyl Monoether	-16.6%	-9.2%	-25.8%	-13.5%	-11.7%	-32.3%	-33.5%
HFC-32/PAG, Butyl Monoether	-14.6%	-10.7%	-6.0%	-26.3%	-6.0%	5.7%	-11.5%
HFC-125/PAG, Butyl Monoether	-14.6%	-16.7%	-10.9%	-14.9%	-11.5%	6.1%	-28.1%
HFC-134a/PAG, Modified	-8.1%	-23.4%	-34.6%	-16.2%	-13.3%	-22.6%	1.8%
HFC-125/PAG, Modified	-11.2%	18.0%	3.3%	-31.1%	-13.7%	9.7%	-16.8%
HFC-134a/PAG Diol	-30.0%	-16.5%	-50.7%	-19.4%	-6.6%	-8.4%	-20.6%

Dielectric Strength

Magnet Wire B(Dacron/Glass served wire)

Results after 500-hour exposure @127°C(260°F)

Varnish Type

	Uncoated	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Unexposed	11.6 kV	13.3 kV	12.3 kV	12.7 kV	12.5 kV	14.4 kV	13.3 kV

% Change from Unexposed

Exposure with:

	Uncoated	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Nitrogen	-6.9%	-8.9%	-2.9%	-4.9%	-6.0%	-14.7%	-2.0%
HCFC-22/Mineral	13.3%	11.0%	1.3%	5.2%	0.6%	-25.7%	16.0%
HCFC-124/Alkylbenzene	6.5%	2.5%	-0.1%	1.4%	-2.0%	16.1%	8.7%
HCFC-142b/Alkylbenzene	8.3%	13.1%	32.0%	0.1%	2.6%	37.6%	13.9%
HFC-152a/Alkylbenzene	-4.3%	-5.7%	-6.4%	-23.6%	-35.8%	-3.5%	9.0%
HFC-134a/Ester, Mixed Acid	28.0%	6.5%	5.5%	10.4%	6.4%	2.4%	11.5%
HFC-134a/Ester, Branched Acid	12.1%	8.3%	5.4%	1.1%	-4.0%	8.3%	15.8%
HFC-32/Ester, Branched Acid	0.4%	-17.2%	-3.3%	-8.5%	-6.8%	-4.1%	5.4%
HFC-125/Ester, Branched Acid	2.5%	40.6%	1.2%	6.2%	-0.2%	8.7%	7.2%
HFC-143a/Ester, Branched Acid	11.8%	28.9%	-5.9%	0.7%	0.9%	-15.2%	4.9%
HFC-134/Ester, Branched Acid	9.0%	19.4%	10.0%	9.6%	5.3%	10.2%	7.2%
HFC-245ca/Ester, Branched Acid	3.8%	5.5%	-13.5%	3.6%	-0.9%	-9.0%	-3.8%
HFC-134a/PAG, Butyl Monoether	5.6%	5.3%	-24.3%	11.4%	4.3%	19.3%	9.7%
HFC-32/PAG, Butyl Monoether	27.1%	10.8%	-6.9%	11.5%	5.4%	-25.5%	10.3%
HFC-125/PAG, Butyl Monoether	22.7%	-17.8%	-3.3%	-6.2%	2.7%	12.7%	7.4%
HFC-134a/PAG, Modified	23.6%	-4.2%	10.2%	1.2%	7.4%	26.8%	11.4%
HFC-125/PAG, Modified	-7.0%	-1.5%	2.9%	5.4%	-0.8%	-3.8%	10.1%
HFC-134a/PAG Diol	29.7%	49.2%	60.6%	24.5%	14.2%	8.7%	38.4%

Dielectric Strength

Magnet Wire B(Dacron/Glass served wire)

Results after a 500-hour exposure @ 127°C(260°F) plus a 24-hour air bake @ 150C(302°F)

	Varnish Type						
	Uncoated	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Unexposed	11.6 kV	13.3 kV	12.3 kV	12.7 kV	12.5 kV	14.4 kV	13.3 kV

Exposure with:	% Change from Unexposed						
	Uncoated	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Nitrogen	-8.1%	-10.9%	-15.4%	-9.9%	-13.2%	-18.2%	-17.9%
HCFC-22/Mineral	0.2%	-17.6%	-5.4%	-11.2%	-14.0%	-12.4%	-4.0%
HCFC-124/Alkylbenzene	-3.6%	-1.2%	9.9%	-6.5%	-6.5%	-6.7%	-0.3%
HCFC-142b/Alkylbenzene	-6.1%	-13.4%	-2.3%	-0.6%	-9.5%	-12.6%	-10.5%
HFC-152a/Alkylbenzene	-2.7%	-15.4%	-3.9%	-6.7%	-8.1%	1.0%	-4.0%
HFC-134a/Ester, Mixed Acid	13.4%	1.2%	8.6%	7.4%	-0.4%	-4.0%	5.8%
HFC-134a/Ester, Branched Acid	-1.1%	-11.9%	-2.4%	-9.3%	-3.8%	-8.2%	-1.6%
HFC-32/Ester, Branched Acid	1.1%	-0.7%	-3.6%	-10.8%	-7.4%	-17.7%	2.1%
HFC-125/Ester, Branched Acid	-3.7%	-13.6%	1.2%	-5.1%	-3.1%	-0.5%	-3.4%
HFC-143a/Ester, Branched Acid	-2.1%	-7.5%	2.4%	-5.7%	4.5%	-15.4%	-3.3%
HFC-134/Ester, Branched Acid	-2.0%	5.7%	8.6%	-5.2%	0.4%	-23.0%	4.4%
HFC-245ca/Ester, Branched Acid	0.9%	-10.5%	-1.9%	0.3%	-5.1%	1.5%	-1.6%
HFC-134a/PAG, Butyl Monoether	1.3%	-10.5%	10.1%	-4.1%	-8.0%	-16.8%	-4.3%
HFC-32/PAG, Butyl Monoether	3.1%	0.5%	-8.2%	-1.6%	-0.5%	-14.8%	-1.8%
HFC-125/PAG, Butyl Monoether	2.2%	-9.7%	14.9%	1.9%	-0.6%	1.5%	-2.3%
HFC-134a/PAG, Modified	1.1%	-7.7%	3.1%	-11.0%	-7.5%	-25.2%	1.2%
HFC-125/PAG, Modified	0.0%	-17.7%	15.6%	-1.3%	-5.6%	-7.5%	-10.4%
HFC-134a/PAG Diol	-6.8%	-9.5%	-3.3%	-5.7%	-3.7%	-14.2%	-16.3%

Dielectric Strength

Magnet Wire C(ester imide overcoated with amide imide)

Results after a 500-hour exposure @ 127°C(260°F)

	Varnish Type						
	Uncoated	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Unexposed	16.6 kV	15.1 kV	18.2 kV	14.5 kV	11.4 kV	15.9 kV	14.8 kV
	% Change from Unexposed						
<u>Exposure with:</u>	Uncoated	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Nitrogen	-21.4%	-16.4%	-35.0%	-16.3%	16.9%	-42.8%	4.1%
HCFC-22/Mineral	6.4%	-27.2%	9.7%	25.5%	25.6%	6.5%	-7.4%
HCFC-124/Alkylbenzene	-18.6%	-25.0%	2.2%	20.6%	15.8%	-12.2%	9.0%
HCFC-142b/Alkylbenzene	-16.8%	11.8%	-6.5%	17.4%	0.4%	14.9%	17.9%
HFC-152a/Alkylbenzene	7.1%	-25.2%	-21.5%	0.0%	20.7%	11.6%	24.1%
HFC-134a/Ester, Mixed Acid	-0.6%	8.8%	-10.5%	6.5%	62.8%	-24.0%	15.9%
HFC-134a/Ester, Branched Acid	-11.2%	-2.9%	0.9%	3.5%	10.8%	6.7%	11.6%
HFC-32/Ester, Branched Acid	-10.0%	-15.3%	2.4%	-5.1%	12.1%	-1.2%	18.2%
HFC-125/Ester, Branched Acid	-4.0%	9.1%	1.9%	-1.3%	2.8%	25.8%	0.6%
HFC-143a/Ester, Branched Acid	-9.5%	15.7%	4.8%	-11.8%	16.4%	-5.1%	0.9%
HFC-134/Ester, Branched Acid	-18.9%	4.5%	-1.4%	-1.2%	-9.2%	15.1%	-6.9%
HFC-245ca/Ester, Branched Acid	-24.1%	27.26	9.3%	5.2%	37.1%	7.3%	16.5%
HFC-134a/PAG, Butyl Monoether	-8.4%	7.3%	5.4%	9.7%	32.8%	10.6%	33.0%
HFC-32/PAG, Butyl Monoether	-16.6%	19.3%	8.8%	1.3%	23.8%	17.0%	-6.4%
HFC-125/PAG, Butyl Monoether	-30.9%	11.2%	-7.6%	4.2%	31.2%	17.8%	27.8%
HFC-134a/PAG, Modified	-12.6%	14.6%	1.5%	-5.4%	-23.7%	-25.1%	27.7%
HFC-125/PAG, Modified	-17.8%	5.5%	5.4%	0.6%	28.2%	10.1%	9.1%
HFC-134a/PAG Diol	-12.2%	21.1%	8.4%	0.8%	12.3%	24.7%	29.9%

Dielectric Strength

Magnet Wire C(ester imide overcoated with amide imide)

Results after a 500-hour exposure @ 127°C(260°F) plus a 24-hour air bake @ 150°C(302°F)

	Varnish Type						
	Uncoated	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Unexposed	16.6 kV	15.1 kV	18.2 kV	14.5 kV	11.4 kV	15.9 kV	14.8 kV
Exposure with:	% Change from Unexposed						
	Uncoated	U-475EH	Y-390PG	ER-610	Y-833	No.923	Iso-800
Nitrogen	-15.7%	-5.5%	2.1%	-45.6%	9.7%	-32.0%	-1.3%
HCFC-22/Mineral	-9.1%	-21.5%	-12.6%	0.8%	5.1%	5.3%	12.7%
HCFC-124/Alkylbenzene	-1.0%	-23.8%	8.8%	-22.9%	51.6%	6.0%	24.1%
HCFC-142b/Alkylbenzene	-10.9%	-1.0%	-11.5%	4.5%	-1.7%	-2.2%	20.3%
HFC-152a/Alkylbenzene	-17.9%	-1.8%	-18.4%	12.0%	31.5%	-17.2%	5.9%
HFC-134a/Ester, Mixed Acid	-3.6%	24.5%	-1.0%	0.2%	36.1%	-4.9%	32.4%
HFC-134a/Ester, Branched Acid	-4.5%	-21.4%	2.2%	-4.3%	-8.6%	-29.7%	19.3%
HFC-32/Ester, Branched Acid	-26.4%	8.3%	-37.0%	-7.8%	-6.3%	10.4%	-9.4%
HFC-125/Ester, Branched Acid	-22.0%	-3.2%	-0.9%	1.1%	-2.5%	9.0%	17.2%
HFC-143a/Ester, Branched Acid	-14.7%	-1.8%	-36.8%	7.5%	-1.3%	-0.4%	12.6%
HFC-134/Ester, Branched Acid	-16.6%	-3.7%	-1.2%	-8.5%	-25.8%	-0.6%	0.3%
HFC-245ca/Ester, Branched Acid	-15.8%	13.9%	-2.5%	-20.8%	-2.0%	3.1%	12.6%
HFC-134a/PAG, Butyl Monoether	-29.6%	5.3%	-28.0%	-11.7%	0.3%	17.7%	-14.0%
HFC-32/PAG, Butyl Monoether	-13.8%	17.3%	-34.2%	-5.9%	16.8%	11.6%	14.5%
HFC-125/PAG, Butyl Monoether	-12.4%	29.8%	6.5%	-3.8%	13.1%	14.6%	25.8%
HFC-134a/PAG, Modified	-14.9%	-11.6%	-4.8%	2.0%	-9.5%	-30.6%	26.0%
HFC-125/PAG, Modified	-11.2%	-9.0%	-3.5%	-27.6%	20.8%	20.9%	15.1%
HFC-134a/PAG Diol	-27.9%	6.7%	0.8%	1.1%	4.6%	6.3%	-8.0%

Sheet Insulation

% Change in Weight

Results after 500-hour exposure @127°C(260°F)

Exposure with:	Sheet Insulation Type					
	Nomex/Mylar	Dacron/Mylar			Nomex	
	Nomex	Dacron	Mylar MQ	Nomex	Mica	Melinex
	% Change in Weight					
Nitrogen	0.1%	0.1%	0.1%	0.2%	0.3%	0.1%
HCFC-22/Mineral	9.3%	3.3%	5.2%	14.4%	20.0%	6.1%
HCFC-124/Alkylbenzene	6.6%	1.1%	2.5%	11.6%	26.7%	1.2%
HCFC-142b/Alkylbenzene	6.2%	1.0%	2.1%	10.7%	19.1%	2.9%
HFC-152a/Alkylbenzene	6.0%	-0.2%	0.5%	10.0%	14.8%	2.2%
HFC-134a/Ester, Mixed Acid	7.1%	3.8%	1.5%	12.3%	21.3%	1.8%
HFC-134a/Ester, Branched Acid	7.4%	4.9%	1.2%	13.0%	18.6%	1.5%
HFC-32/Ester, Branched Acid	7.4%	-1.0%	1.1%	12.7%	19.8%	1.7%
HFC-125/Ester, Branched Acid	6.1%	0.5%	0.7%	11.7%	16.4%	0.9%
HFC-143a/Ester, Branched Acid	5.4%	1.4%	0.7%	11.5%	16.2%	1.0%
HFC-134/Ester, Branched Acid	8.6%	1.2%	1.5%	14.9%	32.1%	1.7%
HFC-245ca/Ester, Branched Acid	7.5%	4.3%	1.0%	13.7%	35.6%	1.2%
HFC-134a/PAG, Butyl Monoether	6.7%	-0.4%	1.3%	12.4%	17.8%	2.1%
HFC-32/PAG, Butyl Monoether	7.6%	1.4%	1.1%	14.0%	22.7%	1.6%
HFC-125/PAG, Butyl Monoether	6.8%	0.2%	0.4%	13.6%	25.2%	0.8%
HFC-134a/PAG, Modified	7.4%	0.1%	1.0%	14.0%	19.6%	1.4%
HFC-125/PAG, Modified	7.7%	2.0%	2.8%	14.1%	24.4%	3.1%
HFC-134a/PAG Diol	8.4%	-3.4%	2.3%	13.8%	22.9%	2.5%

Sheet Insulation

% Change in Weight

Results after 500-hour exposure @ 127°C(260°F) plus a 24-hour air bake @ 150°C(302°F)

Sheet Insulation Type

Exposure with:

	Nomex/Mylar Nomex	Dacron/Mylar Dacron	Mylar MQ	Nomex	Nomex Mica	Melinex
	% Change in Weight					
Nitrogen	0.5%	0.0%	0.2%	1.5%	0.8%	0.1%
HCFC-22/Mineral	3.7%	1.4%	0.0%	4.3%	9.0%	0.0%
HCFC-124/Alkylbenzene	1.5%	-0.4%	0.2%	4.7%	7.2%	0.3%
HCFC-142b/Alkylbenzene	1.1%	-2.3%	-0.6%	3.9%	5.7%	-0.2%
HFC-152a/Alkylbenzene	2.4%	-2.4%	-1.0%	3.8%	5.8%	0.0%
HFC-134a/Ester, Mixed Acid	4.3%	4.9%	0.7%	8.6%	24.1%	0.6%
HFC-134a/Ester, Branched Acid	4.1%	2.5%	-0.1%	7.1%	19.0%	0.2%
HFC-32/Ester, Branched Acid	3.9%	-1.0%	-0.3%	8.4%	17.7%	0.4%
HFC-125/Ester, Branched Acid	3.9%	-0.6%	0.6%	7.5%	16.6%	0.3%
HFC-143a/Ester, Branched Acid	2.7%	-1.1%	-0.1%	5.7%	11.8%	0.1%
HFC-134/Ester, Branched Acid	3.4%	-0.5%	5.2%	8.5%	23.7%	0.3%
HFC-245ca/Ester, Branched Acid	5.1%	1.9%	0.1%	8.9%	27.9%	0.4%
HFC-134a/PAG, Butyl Monoether	1.1%	-1.7%	-0.3%	2.6%	0.6%	0.0%
HFC-32/PAG, Butyl Monoether	2.3%	-0.3%	-0.3%	3.7%	1.0%	0.2%
HFC-125/PAG, Butyl Monoether	2.0%	-0.7%	-0.1%	3.6%	0.8%	0.1%
HFC-134a/PAG, Modified	1.0%	-1.2%	0.0%	2.3%	0.8%	0.1%
HFC-125/PAG, Modified	2.0%	-0.9%	-0.2%	3.9%	1.5%	0.3%
HFC-134a/PAG Diol	1.7%	0.0%	0.2%	2.7%	0.8%	6.6%

Sheet Insulation

% Change in Tensile Strength

Results after 500-hour exposure @ 127°C(260°F)

Sheet Insulation Type

Nomex/Mylar <u>Nomex</u>	Dacron/Mylar <u>Dacron</u>	<u>Mylar MQ</u>	<u>Nomex</u>	Nomex <u>Mica</u>	<u>Melinex</u>
17.4 ksi	13.7 ksi	21.7 ksi	18.7 ksi	7.5 ksi	21.7 ksi

Unexposed

Exposure with:

Nitrogen
 HCFC-22/Mineral
 HCFC-124/Alkylbenzene
 HCFC-142b/Alkylbenzene
 HFC-152a/Alkylbenzene
 HFC-134a/Ester, Mixed Acid
 HFC-134a/Ester, Branched Acid
 HFC-32/Ester, Branched Acid
 HFC-125/Ester, Branched Acid
 HFC-143a/Ester, Branched Acid
 HFC-134/Ester, Branched Acid
 HFC-245ca/Ester, Branched Acid
 HFC-134a/PAG, Butyl Monoether
 HFC-32/PAG, Butyl Monoether
 HFC-125/PAG, Butyl Monoether
 HFC-134a/PAG, Modified
 HFC-125/PAG, Modified
 HFC-134a/PAG Diol

% Change from Unexposed					
-49.6%	-8.6%	-24.0%	-9.0%	-5.9%	-21.5%
-17.2%	-10.7%	-35.2%	-11.6%	-25.6%	-29.5%
-50.5%	-84.8%	-100.0%	-1.9%	5.1%	-100.0%
-12.2%	-17.7%	-27.7%	-5.6%	-18.6%	-29.8%
-37.6%	-21.6%	-33.3%	-4.3%	-23.1%	-27.7%
-21.6%	-11.0%	-32.1%	4.0%	-21.2%	-34.8%
-10.3%	-5.4%	-23.7%	-1.5%	-15.0%	-25.4%
-11.3%	-8.5%	-24.8%	-3.2%	-18.5%	-27.7%
-4.9%	-5.0%	-17.8%	-1.4%	-14.7%	-21.8%
-7.1%	-2.6%	-22.3%	0.4%	-23.0%	-24.2%
-3.7%	4.3%	-11.7%	-0.4%	-1.9%	-13.7%
-6.9%	-5.2%	-15.9%	-5.4%	-13.3%	-35.1%
-8.3%	-7.5%	-17.5%	-8.0%	-23.1%	-18.9%
-8.8%	-6.8%	-18.8%	-5.6%	-16.1%	-17.5%
-0.9%	0.2%	-13.9%	0.3%	-14.8%	-22.0%
-10.6%	-2.1%	-27.3%	-23.5%	-17.0%	-23.9%
-14.1%	-6.9%	-22.2%	-11.6%	-15.8%	-27.8%
-13.2%	-16.9%	-23.2%	-2.5%	-17.9%	-28.7%

ksi=1,000 pounds per square inch.

Sheet Insulation

% Change in Tensile Strength

Results after 500-hour exposure @ 127°C(260°F) plus a 24-hour air bake @ 150°C(302°F)

Sheet Insulation Type

Nomex/Mylar Nomex	Dacron/Mylar Dacron	Mylar MO	Nomex	Nomex Mica	Melinex
17.4 ksi	13.7 ksi	21.7 ksi	18.7 ksi	7.5 ksi	21.7 ksi

Unexposed

Exposure with:

	% Change from Unexposed					
Nitrogen	-76.7%	-83.6%	-97.8%	-2.7%	-26.3%	-65.9%
HCFC-22/Mineral	-16.4%	-11.5%	-93.9%	-3.0%	-18.8%	-16.3%
HCFC-124/Alkylbenzene	-55.0%	-93.2%	-100.0%	4.1%	-24.0%	-100.0%
HCFC-142b/Alkylbenzene	-41.9%	-39.8%	-24.4%	2.7%	-24.7%	-21.0%
HFC-152a/Alkylbenzene	-36.3%	-63.8%	-25.0%	-0.1%	-24.5%	-21.1%
HFC-134a/Ester, Mixed Acid	-36.6%	-39.8%	-25.5%	8.4%	-23.7%	-20.1%
HFC-134a/Ester, Branched Acid	-4.2%	-5.1%	-27.1%	0.9%	-17.9%	-22.5%
HFC-32/Ester, Branched Acid	-9.1%	-6.2%	-24.8%	3.3%	-16.9%	-22.2%
HFC-125/Ester, Branched Acid	-5.3%	-1.1%	-22.1%	-5.8%	-16.0%	-22.4%
HFC-143a/Ester, Branched Acid	-2.1%	-4.9%	-23.0%	2.8%	-17.5%	-21.6%
HFC-134/Ester, Branched Acid	-4.0%	-1.2%	-16.6%	2.0%	-12.7%	-24.2%
HFC-245ca/Ester, Branched Acid	-3.0%	-4.8%	-26.2%	-11.0%	-5.4%	-12.7%
HFC-134a/PAG, Butyl Monoether	-0.6%	-6.7%	-20.8%	6.4%	-19.0%	-23.1%
HFC-32/PAG, Butyl Monoether	-3.5%	-4.5%	-26.2%	1.8%	-17.5%	-21.8%
HFC-125/PAG, Butyl Monoether	-4.4%	-0.9%	-17.7%	7.5%	-21.9%	-23.9%
HFC-134a/PAG, Modified	-6.5%	-0.9%	-22.4%	7.2%	-22.4%	-22.7%
HFC-125/PAG, Modified	-52.4%	-6.9%	-11.6%	3.4%	-25.0%	-22.9%
HFC-134a/PAG Diol	-12.4%	-16.5%	-48.6%	3.2%	-29.1%	-27.0%

ksi=1,000 pounds per square inch.

Sheet Insulation

% Change in Elongation

Results after 500-hour exposure @ 127°C(260°F)

Sheet Insulation Type

Nomex/Mylar Nomex	Dacron/Mylar Dacron	Mylar MQ	Nomex	Nomex Mica	Melinex
20.0%	46.0%	131.0%	17.0%	4.0%	160.0%

Unexposed

Exposure with:

% Change from Unexposed					
-87.5%	-50.0%	-95.0%	-43.6%	-70.8%	-96.4%
-41.9%	-71.0%	-87.8%	-55.4%	-79.2%	-74.5%
-54.4%	98.2%	-100.0%	-45.1%	-72.9%	-100.0%
-49.4%	-64.5%	-72.0%	-56.4%	-79.2%	-89.0%
-85.0%	-78.6%	-85.6%	-40.2%	-66.7%	-87.5%
-13.8%	-47.8%	-10.7%	-48.0%	47.9%	-89.6%
-35.0%	-47.5%	-20.1%	-28.4%	-72.9%	-95.9%
-29.4%	-50.0%	-11.5%	-5.4%	-66.7%	-5.9%
-25.6%	-47.5%	5.3%	-27.9%	-72.9%	-17.6%
-31.9%	-44.2%	-17.7%	-18.6%	-62.5%	-95.6%
-26.3%	-39.1%	-3.1%	-34.3%	-72.9%	-4.2%
-50.0%	-54.3%	-42.0%	-44.6%	-79.2%	-63.9%
-28.8%	-47.8%	1.8%	-30.4%	-66.7%	1.5%
-16.9%	-47.8%	5.2%	-22.5%	-70.8%	-1.8%
-28.8%	-43.1%	6.5%	-28.4%	-75.0%	2.3%
-40.0%	-48.9%	-69.0%	-37.7%	-72.9%	-13.3%
-51.3%	-55.8%	-8.9%	-32.4%	-68.8%	-23.0%
-50.6%	-57.6%	-16.3%	-33.3%	-68.8%	-32.2%

Sheet Insulation

% Change in Elongation

Results after 500-hour exposure @ 127°C(260°F) plus a 24-hour air bake @ 150°C(302°F)

Sheet Insulation Type

	Nomex/Mylar Nomex	Dacron/Mylar Dacron	Mylar MQ	Nomex	Nomex Mica	Melinex
Unexposed	20.0%	46.0%	131.0%	17.0%	4.0%	160.0%

Exposure with:

	% Change from Unexposed					
Nitrogen	-66.7%	-54.3%	-95.4%	-54.4%	-68.8%	-96.8%
HCFC-22/Mineral	-75.4%	-75.4%	-99.1%	-61.3%	-77.1%	-95.8%
HCFC-124/Alkylbenzene	-57.5%	-96.7%	-100.0%	-40.7%	-66.7%	-100.0%
HCFC-142b/Alkylbenzene	-87.5%	-84.4%	-94.4%	-48.5%	-64.6%	-95.6%
HFC-152a/Alkylbenzene	-85.4%	-96.0%	-95.7%	-44.1%	-62.5%	-96.0%
HFC-134a/Ester, Mixed Acid	-34.2%	-47.8%	-19.3%	-36.3%	-68.8%	-96.0%
HFC-134a/Ester, Branched Acid	-23.3%	-48.6%	-94.7%	-43.6%	-70.8%	-95.7%
HFC-32/Ester, Branched Acid	-24.4%	-43.1%	-15.0%	-31.4%	-72.9%	-30.5%
HFC-125/Ester, Branched Acid	-24.4%	-46.4%	-9.7%	-52.9%	-68.8%	-5.9%
HFC-143a/Ester, Branched Acid	-29.2%	-52.9%	-14.9%	-45.6%	-68.8%	-95.6%
HFC-134/Ester, Branched Acid	-35.4%	-43.8%	4.3%	-46.1%	-75.0%	2.2%
HFC-245ca/Ester, Branched Acid	-39.4%	-49.3%	-47.5%	-62.7%	-72.9%	-49.2%
HFC-134a/PAG, Butyl Monoether	-40.4%	-53.3%	-6.7%	-48.5%	-77.1%	-10.2%
HFC-32/PAG, Butyl Monoether	-41.3%	-53.3%	-0.6%	-50.0%	-75.0%	-8.6%
HFC-125/PAG, Butyl Monoether	-37.1%	-42.4%	2.8%	-52.0%	-77.1%	-27.1%
HFC-134a/PAG, Modified	-39.6%	-54.3%	-63.1%	-39.7%	-77.1%	-4.1%
HFC-125/PAG, Modified	-69.2%	-40.6%	3.1%	-36.8%	-77.1%	-65.9%
HFC-134a/PAG Diol	-61.3%	-67.4%	-72.3%	-44.6%	-79.2%	-96.5%

Sheet Insulation

% Change in Dielectric Strength

Results after 500-hour exposure @ 127°C(260°F)

Sheet Insulation Type

Nomex/Mylar <u>Nomex</u>	Dacron/Mylar <u>Dacron</u>	<u>Mylar MQ</u>	<u>Nomex</u>	Nomex <u>Mica</u>	<u>Melinex</u>
flash	flash	flash	10.7 kV	10.2 kV	flash

Unexposed

Exposure with:

Nitrogen
 HCFC-22/Mineral
 HCFC-124/Alkylbenzene
 HCFC-142b/Alkylbenzene
 HFC-152a/Alkylbenzene
 HFC-134a/Ester, Mixed Acid
 HFC-134a/Ester, Branched Acid
 HFC-32/Ester, Branched Acid
 HFC-125/Ester, Branched Acid
 HFC-143a/Ester, Branched Acid
 HFC-134/Ester, Branched Acid
 HFC-245ca/Ester, Branched Acid
 HFC-134a/PAG, Butyl Monoether
 HFC-32/PAG, Butyl Monoether
 HFC-125/PAG, Butyl Monoether
 HFC-134a/PAG, Modified
 HFC-125/PAG, Modified
 HFC-134a/PAG Diol

% Change from Unexposed						
flash	flash	flash	2.7%	-9.7%	flash	flash
flash	flash	flash	flash	3.7%	flash	flash
flash	flash	flash	flash	14.0%	flash	flash
flash	flash	flash	0.4%	10.4%	flash	flash
flash	flash	flash	21.1%	-3.9%	flash	flash
flash	flash	flash	13.0%	15.1%	flash	flash
flash	flash	flash	flash	5.4%	flash	flash
flash	flash	flash	10.3%	7.5%	flash	flash
flash	flash	flash	flash	-14.2%	flash	flash
flash	flash	flash	flash	2.8%	flash	flash
flash	flash	flash	flash	flash	flash	flash
flash	flash	flash	flash	flash	flash	flash
flash	flash	flash	flash	-13.0%	flash	flash
flash	flash	flash	19.3%	-5.9%	flash	flash
flash	flash	flash	flash	15.1%	flash	flash
flash	flash	flash	flash	-1.9%	flash	flash
flash	flash	flash	28.7%	1.7%	flash	flash
flash	flash	flash	16.8%	9.0%	flash	flash

*Flash indicates dielectric went around sheet Insulation not through.

Sheet Insulation

% Change in Dielectric Strength

Results after 500-hour exposure @ 127°C(260°F) plus a 24-hour air bake @ 150°C(302°F)

Sheet Insulation Type

Nomex/Mylar <u>Nomex</u>	Dacron/Mylar <u>Dacron</u>	Mylar MO <u>Mylar MO</u>	Nomex <u>Nomex</u>	Nomex <u>Mica</u>	Melinex <u>Melinex</u>
flash	flash	flash	10.7 kV	10.2 kV	flash

Unexposed

Exposure with:

Nitrogen

HCFC-22/Mineral

HCFC-124/Alkylbenzene

HCFC-142b/Alkylbenzene

HFC-152a/Alkylbenzene

HFC-134a/Ester, Mixed Acid

HFC-134a/Ester, Branched Acid

HFC-32/Ester, Branched Acid

HFC-125/Ester, Branched Acid

HFC-143a/Ester, Branched Acid

HFC-134/Ester, Branched Acid

HFC-245ca/Ester, Branched Acid

HFC-134a/PAG, Butyl Monoether

HFC-32/PAG, Butyl Monoether

HFC-125/PAG, Butyl Monoether

HFC-134a/PAG, Modified

HFC-125/PAG, Modified

HFC-134a/PAG Diol

% Change from Unexposed						
flash	flash	flash	-1.8%	-4.6%	flash	flash
flash	flash	flash	0.6%	-6.9%	flash	flash
flash	flash	flash	-3.2%	-9.5%	flash	flash
flash	flash	flash	3.4%	1.1%	flash	flash
flash	flash	flash	-8.8%	-3.9%	flash	flash
flash	flash	flash	6.3%	14.7%	flash	flash
flash	flash	flash	6.3%	10.6%	flash	flash
flash	flash	flash	5.6%	11.0%	flash	flash
flash	flash	flash	8.9%	1.2%	flash	flash
flash	flash	flash	10.8%	-1.0%	flash	flash
flash	flash	flash	7.7%	17.2%	flash	flash
flash	flash	flash	7.0%	flash	flash	flash
flash	flash	flash	-3.4%	-4.2%	flash	flash
flash	flash	flash	1.4%	0.7%	flash	flash
flash	flash	flash	-12.3%	-2.5%	flash	flash
flash	flash	flash	-4.6%	-3.7%	flash	flash
flash	flash	flash	-22.6%	1.2%	flash	flash
flash	flash	flash	-21.7%	-6.5%	flash	flash

*Flash indicates dielectric went around sheet Insulation not through.

Spiral Wrapped Sleeving Insulation

% Change in Weight

Results after 500-hour exposure @ 127°C(260°F)

Exposure with:	Sleeving Insulation Type		
	Nomex	Mylar	Nomex/Mylar
	% Change in Weight		
Nitrogen	0.3%	-0.6%	0.1%
HCFC-22/Mineral	13.3%	3.3%	6.6%
HCFC-124/Alkylbenzene	12.1%	0.2%	4.5%
HCFC-142b/Alkylbenzene	11.9%	2.8%	5.5%
HFC-152a/Alkylbenzene	11.1%	2.5%	7.1%
HFC-134a/Ester, Mixed Acid	16.0%	4.4%	6.3%
HFC-134a/Ester, Branched Acid	12.1%	2.0%	4.6%
HFC-32/Ester, Branched Acid	13.1%	1.9%	4.8%
HFC-125/Ester, Branched Acid	13.2%	1.6%	4.7%
HFC-143a/Ester, Branched Acid	11.4%	1.4%	4.0%
HFC-134/Ester, Branched Acid	17.2%	3.0%	6.2%
HFC-245ca/Ester, Branched Acid	14.7%	2.4%	5.5%
HFC-134a/PAG, Butyl Monoether	14.2%	2.1%	5.0%
HFC-32/PAG, Butyl Monoether	14.6%	1.9%	5.9%
HFC-125/PAG, Butyl Monoether	13.3%	1.4%	4.8%
HFC-134a/PAG, Modified	14.4%	1.9%	5.5%
HFC-125/PAG, Modified	15.3%	3.9%	7.8%
HFC-134a/PAG Diol	15.5%	3.0%	5.2%

Spiral Wrapped Sleeving Insulation

% Change in Weight

Results after 500-hour exposure @ 127°C(260°F) plus a 24-hour air bake @ 150°C(302°F)

<u>Exposure with:</u>	Sleeving Insulation Type		
	Nomex	Mylar	Nomex/Mylar
	% Change in Weight		
Nitrogen	-0.8%	-0.9%	-1.0%
HCFC-22/Mineral	5.3%	0.2%	1.4%
HCFC-124/Alkylbenzene	2.7%	-0.6%	0.3%
HCFC-142b/Alkylbenzene	1.3%	-1.9%	-1.3%
HFC-152a/Alkylbenzene	3.9%	-0.2%	0.5%
HFC-134a/Ester, Mixed Acid	11.8%	2.7%	3.1%
HFC-134a/Ester, Branched Acid	8.3%	0.2%	2.5%
HFC-32/Ester, Branched Acid	7.2%	-0.2%	2.3%
HFC-125/Ester, Branched Acid	7.6%	0.9%	1.8%
HFC-143a/Ester, Branched Acid	6.2%	-0.2%	0.9%
HFC-134/Ester, Branched Acid	7.1%	0.3%	0.9%
HFC-245ca/Ester, Branched Acid	9.4%	-1.5%	-9.7%
HFC-134a/PAG, Butyl Monoether	4.5%	-0.5%	0.2%
HFC-32/PAG, Butyl Monoether	6.6%	0.5%	0.9%
HFC-125/PAG, Butyl Monoether	5.8%	0.4%	0.6%
HFC-134a/PAG, Modified	3.3%	0.1%	0.3%
HFC-125/PAG, Modified	5.5%	0.2%	1.0%
HFC-134a/PAG Diol	2.8%	-0.9%	-2.5%

Lead Wire

% Change in Weight

Results after 500-hour exposure @ 127°C(260°F)

Exposure with:	Lead Wire Type	
	Dacron/Mylar/Dacron	Dacron/Mylar/Teflon/Dacron
	% Change in Weight	
Nitrogen	0.0%	0.0%
HCFC-22/Mineral	4.8%	4.1%
HCFC-124/Alkylbenzene	4.2%	3.7%
HCFC-142b/Alkylbenzene	2.7%	3.1%
HFC-152a/Alkylbenzene	3.0%	3.5%
HFC-134a/Ester, Mixed Acid	4.8%	4.0%
HFC-134a/Ester, Branched Acid	4.0%	3.2%
HFC-32/Ester, Branched Acid	3.3%	2.7%
HFC-125/Ester, Branched Acid	4.2%	3.3%
HFC-143a/Ester, Branched Acid	3.4%	2.9%
HFC-134/Ester, Branched Acid	4.6%	4.4%
HFC-245ca/Ester, Branched Acid	7.3%	6.3%
HFC-134a/PAG, Butyl Monoether	3.5%	3.0%
HFC-32/PAG, Butyl Monoether	3.9%	3.1%
HFC-125/PAG, Butyl Monoether	3.6%	3.0%
HFC-134a/PAG, Modified	4.3%	3.5%
HFC-125/PAG, Modified	5.5%	4.4%
HFC-134a/PAG Diol	4.2%	3.2%

Lead Wire

% Change in Weight

Results after 500-hour exposure @ 127°C(260°F) plus 24-hour air bake @ 150°C(302°F)

Exposure with:	Lead Wire Type	
	Dacron/Mylar/Dacron	Dacron/Mylar/Teflon/Dacron
	% Change in Weight	
Nitrogen	0.0%	0.0%
HCFC-22/Mineral	0.3%	-3.1%
HCFC-124/Alkylbenzene	1.0%	0.9%
HCFC-142b/Alkylbenzene	2.7%	3.1%
HFC-152a/Alkylbenzene	0.7%	1.1%
HFC-134a/Ester, Mixed Acid	4.3%	3.6%
HFC-134a/Ester, Branched Acid	2.9%	2.3%
HFC-32/Ester, Branched Acid	1.9%	2.5%
HFC-125/Ester, Branched Acid	3.6%	3.0%
HFC-143a/Ester, Branched Acid	1.9%	1.1%
HFC-134/Ester, Branched Acid	3.8%	2.1%
HFC-245ca/Ester, Branched Acid	4.4%	3.2%
HFC-134a/PAG, Butyl Monoether	1.1%	0.7%
HFC-32/PAG, Butyl Monoether	1.3%	0.9%
HFC-125/PAG, Butyl Monoether	1.9%	0.6%
HFC-134a/PAG, Modified	1.2%	0.4%
HFC-125/PAG, Modified	2.4%	0.6%
HFC-134a/PAG Diol	1.9%	1.1%

Lead Wire

% Change in Dielectric Strength

Results after 500-hour exposure @ 127 °C(260°F)

	Lead Wire Type	
	Dacron/Mylar/Dacron	Dacron/Mylar/Teflon/Dacron
Unexposed	9.6 kV	9.95 kV
<u>Exposure with:</u>	% Change from Unexposed	
Nitrogen	3.0%	-12.2%
HCFC-22/Mineral	-8.8%	11.1%
HCFC-124/Alkylbenzene	-17.9%	30.4%
HCFC-142b/Alkylbenzene	27.2%	-13.6%
HFC-152a/Alkylbenzene	35.3%	-18.5%
HFC-134a/Ester, Mixed Acid	-9.6%	44.0%
HFC-134a/Ester, Branched Acid	-13.4%	22.4%
HFC-32/Ester, Branched Acid	-6.9%	21.2%
HFC-125/Ester, Branched Acid	-16.6%	31.1%
HFC-143a/Ester, Branched Acid	-18.7%	29.8%
HFC-134/Ester, Branched Acid	-20.2%	27.0%
HFC-245ca/Ester, Branched Acid	-12.9%	42.4%
HFC-134a/PAG, Butyl Monoether	-14.0%	23.9%
HFC-32/PAG, Butyl Monoether	-14.4%	30.6%
HFC-125/PAG, Butyl Monoether	-11.2%	26.2%
HFC-134a/PAG, Modified	-30.4%	29.5%
HFC-125/PAG, Modified	10.7%	41.9%
HFC-134a/PAG Diol	-4.3%	18.0%

Lead Wire

% Change in Dielectric Strength

Results after 500-hour exposure @ 127°C(260°F) plus a 24-hour air bake @ 150°C(302°F)

Lead Wire Type

Unexposed

Dacron/Mylar/Dacron	Dacron/Mylar/Teflon/Dacron
9.61 kV	9.95 kV

Exposure with:

% Change from Unexposed	
Nitrogen	-9.1%
HCFC-22/Mineral	-1.0%
HCFC-124/Alkylbenzene	1.7%
HCFC-142b/Alkylbenzene	29.7%
HFC-152a/Alkylbenzene	31.4%
HFC-134a/Ester, Mixed Acid	-2.8%
HFC-134a/Ester, Branched Acid	-6.9%
HFC-32/Ester, Branched Acid	-17.6%
HFC-125/Ester, Branched Acid	1.4%
HFC-143a/Ester, Branched Acid	0.4%
HFC-134/Ester, Branched Acid	-15.0%
HFC-245ca/Ester, Branched Acid	-6.6%
HFC-134a/PAG, Butyl Monoether	1.5%
HFC-32/PAG, Butyl Monoether	-11.2%
HFC-125/PAG, Butyl Monoether	-5.5%
HFC-134a/PAG, Modified	-5.6%
HFC-125/PAG, Modified	12.6%
HFC-134a/PAG Diol	-5.7%

Tapes

% Change in Weight

Results after 500-hour exposure @ 127°C(260°F)

Exposure with:	Tape Type		
	Woven Glass	Polyester	Permacel
	% Change in Weight		
Nitrogen	-0.4%	0.1%	-0.5%
HCFC-22/Mineral	0.8%	4.2%	7.1%
HCFC-124/Alkylbenzene	0.2%	2.1%	18.3%
HCFC-142b/Alkylbenzene	-0.1%	1.4%	7.6%
HFC-152a/Alkylbenzene	0.6%	1.7%	6.9%
HFC-134a/Ester, Mixed Acid	9.3%	16.2%	9.9%
HFC-134a/Ester, Branched Acid	0.1%	0.8%	7.6%
HFC-32/Ester, Branched Acid	0.5%	0.3%	47.9%
HFC-125/Ester, Branched Acid	7.2%	1.1%	44.8%
HFC-143a/Ester, Branched Acid	0.0%	0.8%	-0.5%
HFC-134/Ester, Branched Acid	0.2%	1.7%	12.0%
HFC-245ca/Ester, Branched Acid	0.6%	4.6%	36.0%
HFC-134a/PAG, Butyl Monoether	0.1%	1.5%	14.5%
HFC-32/PAG, Butyl Monoether	0.7%	1.8%	4.5%
HFC-125/PAG, Butyl Monoether	-0.2%	0.9%	14.9%
HFC-134a/PAG, Modified	0.1%	0.6%	26.3%
HFC-125/PAG, Modified	0.4%	1.7%	34.3%
HFC-134a/PAG Diol	0.4%	7.0%	33.2%

Tapes

% Change in Weight

Results after 500-hour exposure @ 127°C(260°F) plus a 24-hour air bake @ 150°C(302°F)

Exposure with:	Tape Type		
	Woven Glass	Polyester	Permacel
	% Change in Weight		
Nitrogen	-0.2%	0.0%	-4.2%
HCFC-22/Mineral	-0.3%	0.5%	-3.0%
HCFC-124/Alkylbenzene	-0.1%	0.5%	-4.1%
HCFC-142b/Alkylbenzene	-0.1%	-1.2%	-6.8%
HFC-152a/Alkylbenzene	0.1%	-0.8%	-0.8%
HFC-134a/Ester, Mixed Acid	11.4%	8.2%	0.4%
HFC-134a/Ester, Branched Acid	3.6%	-0.8%	2.2%
HFC-32/Ester, Branched Acid	2.7%	3.3%	43.6%
HFC-125/Ester, Branched Acid	-6.5%	0.3%	28.9%
HFC-143a/Ester, Branched Acid	-0.1%	-0.6%	-13.3%
HFC-134/Ester, Branched Acid	0.1%	-0.8%	-12.9%
HFC-245ca/Ester, Branched Acid	0.0%	0.0%	0.0%
HFC-134a/PAG, Butyl Monoether	-0.1%	-0.1%	-13.0%
HFC-32/PAG, Butyl Monoether	3.2%	-1.6%	22.1%
HFC-125/PAG, Butyl Monoether	-0.2%	-0.2%	-14.6%
HFC-134a/PAG, Modified	0.0%	0.1%	-3.6%
HFC-125/PAG, Modified	-0.2%	-0.6%	7.9%
HFC-134a/PAG Diol	0.2%	-1.2%	-10.4%

Tapes

% Change in Break Load

Results after 500-hour exposure @ 127°C(260°F)

Unexposed

Tape Type

Woven Glass	Polyester	Permacel
39.0 lbs	56.1 lbs	88.5 lbs

Exposure with:

Nitrogen

HCFC-22/Mineral

HCFC-124/Alkylbenzene

HCFC-142b/Alkylbenzene

HFC-152a/Alkylbenzene

HFC-134a/Ester, Mixed Acid

HFC-134a/Ester, Branched Acid

HFC-32/Ester, Branched Acid

HFC-125/Ester, Branched Acid

HFC-143a/Ester, Branched Acid

HFC-134/Ester, Branched Acid

HFC-245ca/Ester, Branched Acid

HFC-134a/PAG, Butyl Monoether

HFC-32/PAG, Butyl Monoether

HFC-125/PAG, Butyl Monoether

HFC-134a/PAG, Modified

HFC-125/PAG, Modified

HFC-134a/PAG Diol

% Change from Unexposed		
5.4%	-27.3%	6.5%
-56.4%	-60.3%	-69.3%
36.0%	-53.9%	-36.4%
49.5%	-7.5%	-1.1%
53.3%	-4.7%	4.1%
24.0%	5.6%	-14.0%
28.1%	5.3%	-5.0%
24.6%	5.1%	-46.9%
10.1%	-1.5%	-57.4%
41.6%	-4.8%	-18.2%
41.7%	7.1%	-26.7%
73.8%	1.8%	0.0%
37.2%	5.9%	15.0%
79.2%	6.0%	-55.1%
30.6%	3.1%	-46.9%
38.3%	3.7%	-21.7%
6.4%	2.8%	-11.1%
52.2%	8.2%	-47.1%

Tapes

% Change in Break Load

Results after 500-hour exposure @ 127°C(260°F) plus a 24-hour air bake @ 150°C(302°F)

Tape Type

Unexposed

Woven Glass	Polyester	Permacel
39.1 lbs.	56.1 lbs	88.5 lbs

Exposure with:

	% Change from Unexposed		
Nitrogen	14.8%	-29.1%	-11.4%
HCFC-22/Mineral	-39.4%	-60.6%	-78.6%
HCFC-124/Alkylbenzene	55.9%	-69.6%	-19.9%
HCFC-142b/Alkylbenzene	47.2%	-9.7%	-16.2%
HFC-152a/Alkylbenzene	43.9%	-22.4%	-15.3%
HFC-134a/Ester, Mixed Acid	29.0%	1.4%	-21.9%
HFC-134a/Ester, Branched Acid	18.7%	-2.3%	8.8%
HFC-32/Ester, Branched Acid	22.3%	-6.2%	-56.2%
HFC-125/Ester, Branched Acid	51.7%	3.7%	-16.1%
HFC-143a/Ester, Branched Acid	41.9%	-6.9%	2.2%
HFC-134/Ester, Branched Acid	42.8%	-5.0%	10.2%
HFC-245ca/Ester, Branched Acid	26.6%	-3.4%	-2.7%
HFC-134a/PAG, Butyl Monoether	59.2%	-2.5%	12.1%
HFC-32/PAG, Butyl Monoether	29.3%	-1.5%	-5.1%
HFC-125/PAG, Butyl Monoether	26.4%	-0.5%	-2.5%
HFC-134a/PAG, Modified	65.5%	1.4%	-2.4%
HFC-125/PAG, Modified	15.3%	-18.5%	6.4%
HFC-134a/PAG Diol	42.1%	-12.5%	-0.9%

Tie Cord

% Change in Weight

Results after 500-hour exposure @127°C(260°F)

Tie Cord Type	
Polyester	
Exposure with:	% change in weight
Nitrogen	0.0%
HCFC-22/Mineral	2.2%
HCFC-124/Alkylbenzene	0.8%
HCFC-142b/Alkylbenzene	0.2%
HFC-152a/Alkylbenzene	1.5%
HFC-134a/Ester, Mixed Acid	17.8%
HFC-134a/Ester, Branched Acid	0.8%
HFC-32/Ester, Branched Acid	-0.1%
HFC-125/Ester, Branched Acid	0.7%
HFC-143a/Ester, Branched Acid	0.0%
HFC-134/Ester, Branched Acid	0.8%
HFC-245ca/Ester, Branched Acid	0.9%
HFC-134a/PAG, Butyl Monoether	0.8%
HFC-32/PAG, Butyl Monoether	1.1%
HFC-125/PAG, Butyl Monoether	0.3%
HFC-134a/PAG, Modified	0.4%
HFC-125/PAG, Modified	5.4%
HFC-134a/PAG Diol	1.8%

Tie Cord

% Change in Weight

Results after 500-hour exposure @ 127°C(260°F) plus 24-hour air bake @ 150°C(302°F)

Tie Cord Type	
Polyester	
Exposure with:	% change in weight
Nitrogen	0.0%
HCFC-22/Mineral	0.0%
HCFC-124/Alkylbenzene	-0.3%
HCFC-142b/Alkylbenzene	1.6%
HFC-152a/Alkylbenzene	-0.3%
HFC-134a/Ester, Mixed Acid	8.1%
HFC-134a/Ester, Branched Acid	1.4%
HFC-32/Ester, Branched Acid	-0.1%
HFC-125/Ester, Branched Acid	-0.2%
HFC-143a/Ester, Branched Acid	-0.9%
HFC-134/Ester, Branched Acid	-0.1%
HFC-245ca/Ester, Branched Acid	0.2%
HFC-134a/PAG, Butyl Monoether	-1.1%
HFC-32/PAG, Butyl Monoether	-0.6%
HFC-125/PAG, Butyl Monoether	-0.9%
HFC-134a/PAG, Modified	-0.5%
HFC-125/PAG, Modified	-0.7%
HFC-134a/PAG Diol	-0.6%

Tie Cord

% Change in Break Load

Results after a 500-hour exposure @ 127°C(260°F)

Tie Cord Type	
Polyester	
28.4 lbs.	
Unexposed	
% change from Unexposed	
Nitrogen	-11.1%
HCFC-22/Mineral	-22.0%
HCFC-124/Alkylbenzene	32.2%
HCFC-142b/Alkylbenzene	15.3%
HFC-152a/Alkylbenzene	29.8%
HFC-134a/Ester, Mixed Acid	20.1%
HFC-134a/Ester, Branched Acid	14.1%
HFC-32/Ester, Branched Acid	15.2%
HFC-125/Ester, Branched Acid	21.8%
HFC-143a/Ester, Branched Acid	18.1%
HFC-134/Ester, Branched Acid	26.5%
HFC-245ca/Ester, Branched Acid	7.7%
HFC-134a/PAG, Butyl Monoether	15.7%
HFC-32/PAG, Butyl Monoether	16.1%
HFC-125/PAG, Butyl Monoether	10.9%
HFC-134a/PAG, Modified	29.6%
HFC-125/PAG, Modified	13.7%
HFC-134a/PAG Diol	16.2%

Tie Cord

% Change in Break Load

Results after 500-hour exposure @ 127°C(260°F) plus a 24-hour air bake @ 150°C(302°F)

Tie Cord Type

Unexposed

Polyester
28.4 lbs.

Exposure with:

	% change from Unexposed
Nitrogen	0.5%
HCFC-22/Mineral	-21.8%
HCFC-124/Alkylbenzene	15.9%
HCFC-142b/Alkylbenzene	9.2%
HFC-152a/Alkylbenzene	1.5%
HFC-134a/Ester, Mixed Acid	17.4%
HFC-134a/Ester, Branched Acid	9.4%
HFC-32/Ester, Branched Acid	15.2%
HFC-125/Ester, Branched Acid	18.7%
HFC-143a/Ester, Branched Acid	12.3%
HFC-134/Ester, Branched Acid	15.0%
HFC-245ca/Ester, Branched Acid	15.8%
HFC-134a/PAG, Butyl Monoether	12.6%
HFC-32/PAG, Butyl Monoether	25.8%
HFC-125/PAG, Butyl Monoether	10.7%
HFC-134a/PAG, Modified	37.8%
HFC-125/PAG, Modified	20.2%
HFC-134a/PAG Diol	23.5%

Appendix F

Topics Included are:

Acid Number of the Lubricants before and after Refrigerant-Lubricant Exposures.

Moisture of the Lubricants before and after Refrigerant-Lubricant Exposures.

Refrigerant Purity before and after Refrigerant Exposures.

Acid Numbers of Lubricants for MCLR Project by Exposure

Refrigerant/Lubricant	Acid Number(mg KOH/goil)				
	Before Exposure	After Exposure			
		A	B	C	D
HCFC-22/Mineral	0.009	0.029	0.029	0.066	0.029
HCFC-124/Alkylbenzene	0.017	0.018	0.024	0.084	0.020
HCFC-142b/Alkylbenzene	0.017	0.011	0.009	0.024	n/a
HFC-152a/Alkylbenzene	0.017	0.006	0.012	0.017	n/a
HFC-134a/Ester, Mixed Acid	0.010	0.069	0.247	0.103	0.148
HFC-134a/Ester, Branched Acid	0.017	0.038	0.038	0.043	0.097
HFC-32/Ester, Branched Acid	0.017	0.325	0.571	0.072	0.223
HFC-125/Ester, Branched Acid	0.017	0.025	0.025	0.024	0.110
HFC-143a/Ester, Branched Acid	0.017	0.183	0.238	0.095	0.213
HFC-134/Ester, Branched Acid	0.017	0.188	0.103	0.588	0.108
HFC-245ca/Ester, Branched Acid	0.017	0.068	0.202	n/a	n/a
HFC-134a/PAG, Butyl Monoether	0.026	0.026	0.032	0.012	0.092
HFC-32/PAG, Butyl Monoether	0.022	0.015	0.032	0.031	0.085
HFC-125/PAG, Butyl Monoether	0.024	0.031	0.033	0.185	0.091
HFC-134a/PAG, Modified	0.017	0.038	0.031	0.026	0.142
HFC-125/PAG, Modified	0.017	0.026	0.032	0.023	n/a
HFC-134a/PAG Diol	0.010	0.026	0.030	0.013	0.069

Pressure Vessel Identification

A=Twisted Pair,Single Strands

B=Helical Coils,Disks, Lead Wire

C=Sheet Insulation,Tapes, Tie Cord

D=Permacel Tape

n/a=no bomb setup of these materials.

Moisture of Lubricants for MCLR Project by Exposure

<u>Refrigerant/Lubricant</u>	Moisture(ppm)				
	Before	After Exposure			
	Exposure	A	B	C	D
HCFC-22/Mineral	26	27	31	32	20
HCFC-124/Alkylbenzene	28	29	29	60	44
HCFC-142b/Alkylbenzene	28	46	53	60	n/a
HFC-152a/Alkylbenzene	28	54	47	86	n/a
HFC-134a/Ester, Mixed Acid	36	328	386	194	466
HFC-134a/Ester, Branched Acid	44	49	89	86	62
HFC-32/Ester, Branched Acid	44	52	92	89	68
HFC-125/Ester, Branched Acid	35	110	130	126	110
HFC-143a/Ester, Branched Acid	35	92	160	120	142
HFC-134/Ester, Branched Acid	42	88	62	96	112
HFC-245ca/Ester, Branched Acid	27	28	190	n/a	n/a
HFC-134a/PAG, Butyl Monoether	42	226	218	188	128
HFC-32/PAG, Butyl Monoether	37	270	212	216	200
HFC-125/PAG, Butyl Monoether	19	212	211	167	207
HFC-134a/PAG, Modified	47	160	145	141	125
HFC-125/PAG, Modified	41	130	122	104	n/a
HFC-134a/PAG Diol	41	261	257	267	203

Bomb Identification

A=Twisted Pair,Single Strands

B=Helical Coils,Disks, Lead Wire

C=Sheet Insulation,Tapes, Tie Cord

D=Permacel Tape

n/a=no bomb setup of these materials

Gas Chromatographic Analysis of Refrigerants before and after the 500 hour Refrigerant Exposures

Refrigerant	Analysis After	
	Before Exposure*	500 hr. Exposure*
HCFC-22	99.9%	99.9%
HCFC-123	99.7%	99.8%
HCFC-124	99.0%	99.1%
HCFC-142b	99.9%	99.9%
HFC-152a	99.9%	99.8%
HFC-134a	99.9%	99.8%
HFC-134	99.6%	99.6%
HFC-125	99.3%	99.3%
HFC-32	99.9%	99.7%
HFC-143a	99.4%	99.4%
HFC-245ca	99.9%	99.9%

*Analysis results are in area%.

**DATE
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10/04/93

END