DOE/CE/23810-3D

COMPATIBILITY OF REFRIGERANTS AND LUBRICANTS WITH MOTOR MATERIALS

Quarterly Technical Progress Report

1 April 1992 - 30 June 1992

Robert Doerr
Stephen Kujak

The Trane Company
3600 Pammel Creek Road
La Crosse, Wisconsin 54601-7599

July1992

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 93.94% of allowable costs. Funding from non-government sources supporting this project consists of direct cost sharing of 6.06% of allowable costs; and in-kind contributions form the air-conditioning and refrigeration industry.

DOE/CE/23810--3D

DE93 000540

TABLE OF CONTENTS

ABSTRACT	2
SCOPE	2
SIGNIFICANT RESULTS	3
Magnet Wire A-ester base with amide imide overcoat	3-5
Magnet Wire B-daglass served wire	5-8
Magnet Wire C-ester imide overcoated with amide imide	8-10
Varnish Disks	11
Sheet Insulation	11-13
Sleeving Material	13-14
Lead Wire	14-15
Tapes and Tie Cord	15-16
ANALYSIS OF RESULTS	17
COMPLIANCE WITH AGREEMENT	18
PRINCIPAL INVESTIGATOR EFFORT	18

COMPATIBILITY OF REFRIGERANT AND LUBRICANTS WITH MOTOR MATERIALS

Second Quarterly Report
July 23, 1992

Abstract

During this last quarter, evaluations were completed on the motor materials after 500 hour exposures to refrigerants HCFC-123, HFC-134a and HCFC-22 at 90°C(194°F). Materials were also evaluated after exposure to Nitrogen at 127°C(260°F) to determine the effect of the thermal exposure. Other exposures were started during this quarter with refrigerants HCFC-124, HFC-125, HFC-143a, HFC-32 and HFC-152a. One 500 hour exposure is setup per week and one is analyzed the same week. This will enable Trane to complete the 500 hour exposures by the end of the year.

Scope

Work performed during this quarter includes the analysis of motor materials after 500 hour exposures to refrigerants HCFC-123, HFC-134a, HCFC-22 at 90°C(194°F) and to Nitrogen at 127°C(260°F). Each of the motor materials was tested for a variety of different properties listed below. Properties after exposures were compared to the properties of unexposed samples.

Magnet Wire-	Weight Change Dielectric Strength Burnout Flexibility Appearance
Varnish-	Weight Change Flexibility Appearance Bond Strength
Sheet Insulation-	Elongation Weight Change Tensile Strength Elongation Dielectric Strength Appearance
Sleeving-	Weight Change Appearance
Lead Wire-	Weight Change Appearance Dielectric Strength
Tape - Tie Cords	Weight Change Appearance Breaking Load Elongation

Data from all the evaluations were compiled in spread sheets. The results are presented in this report as percent changes after exposures compared to unexposed samples. All of the final calculated data was transferred to summary spreadsheets for easy comparative analysis. Nitrogen in the tables refers to changes in properties after 500 hour exposures to Nitrogen at 127°C(260°F).

Significant Results

I. Magnet Wire A-ester base with amide imide overcoat.

A. Dielectric Strength

1. After 500 hour exposure to refrigerant @ 90°C(194°F).

		% change from Unexposed			
Varnish	Unexposed	HCFC-123	HCFC-22	HFC-134a	*Nitrogen
Uncoated	15.8 Kv	-17.7	-8.0	6.9	-2.5
U-475EH	16.2 Kv	-1.2	5.9	6.4	-53.5
Y-390PG	18.8 Kv	-15.0	6.6	-4.6	-32.1
ER-610	15.6 Kv	-9.0	-5.0	3.8	-19.1
Y-833	12.0 Kv	13.2	-3.7	1.0	1.0
No. 923	16.8 Kv	-44.3	11.0	16.5	-43.6
Iso-800	19.0 Kv	-18.4	-4.0	-18.5	-34.1

Table IA1.

2. After 500 hour exposure to refrigerant @ 90°C(194°F) plus a 24 hour air bake @ 150°C(302°F).

		% change from Unexposed			
Varnish	Unexposed	HCFC-123	HCFC-22	HFC-134a	*Nitrogen
Uncoated	15.8 Kv	-15.0	8.8	-20.4	-5.2
U-475EH	16.2 Kv	-3.0	-18.4	-18.1	-37.9
Y-390PG	18.8 Kv	-20.0	-44.8	-17.1	-22.6
ER-610	15.6 Kv	-2.1	-42.0	-14.2	-9.9
Y-833	12.0 Kv	9.1	-2.9	-18.3	1.9
No. 923	16.8 Kv	-3.0	-16.1	8.4	-20.5
Iso-800	19.1 Kv	-27.0	-70.0	-20.5	-48.4

Table IA2.

B. Burnout

1. After 500 hour exposure to refrigerant @ 90°C(194°F).

		% change from Unexposed			
Varnish	Unexposed	HCFC-123	HCFC-22	HFC-134a	*Nitrogen
Uncoated	576 sec	-28.9	-27.7	-23.0	-5.3
U-475EH	430 sec	-41.4	-16.7	4.9	3.8
Y-390PG	510 sec	-37.0	-22.9	-14.0	11.8
ER-610	442 sec	-10.1	-22.7	-14.8	-4.1
Y-833	578 sec	-24.9	-14.0	-4.3	-4.5
No. 923	606 sec	-54.3	-12.6	-12.5	-7.6
Iso-800	580 sec	-56.6	-33.6	-9.7	-11.8

Table IB1.

*--Nitrogen Exposure at 127°C(260°F)

2. After 500 hour exposure to refrigerant @ 90°C(194°F) plus a 24 hour air bake @ 150°C(302°F).

		% change from Unexposed			
Varnish	Unexposed	HCFC-123	HCFC-22	HFC-134a	*Nitrogen
Uncoated	576 sec	-28.2	-8.9	-1.5	-3.2
U-475EH	430 sec	-35.1	-24.0	-32.5	15.4
Y-390PG	510 sec	-35.6	-16.2	-18.4	17.8
ER-610	442 sec	-9.7	-29.7	-6.9	-5.5
Y-833	578 sec	-24.1	-15.1	-6.5	-1.3
No. 923	606 sec	-55.0	-35.3	-8.7	-2.5
Iso-800	580 sec	-47.7	-43.6	-8.1	-3.7

Table IB2.

C. Bond Strength.

1. After 500 hour exposure to refrigerant @ 90°C(194°F).

		% change from Unexposed			
Varnish	Unexposed	HCFC-123	HCFC-22	HFC-134a	*Nitrogen
U-475EH	73.7 lbs	-4.7	-49.2	-5.4	-29.9
Y-390PG	43.8 lbs	0.7	-20.2	-1.2	-42.8
ER-610	51.8 lbs	-29.4	-35.4	11.2	-36.6
Y-833	9.9 lbs	39.7	54.3	98.7	-5.8
No. 923	41.3 lbs	-18.0	-23.8	-9.9	-40.9
Iso-800	45.0 lbs	-15.0	-35.4	-2.8	-59.7

Table IC1.

2. After 500 hour exposure to refrigerant @ 90°C(194°F) plus a 24 hour air bake @ 150°C(302°F).

		% change from Unexposed			
Varnish	Unexposed	HCFC-123	HCFC-22	HFC-134a	*Nitrogen
U-475EH	73.7 lbs	-1.0	-94.6	19.0	-8.3
Y-390PG	43.8 lbs	12.8	-79.6	-11.1	-30.0
ER-610	51.8 lbs	-59.9	-90.4	7.6	-11.1
Y-833	9.9 lbs	49.7	14.7	4.6	31.0
No. 923	41.3 lbs	6.0	-83.9	7.5	-35.0
Iso-800	45.0 lbs	18.1	-37.6	5.7	-28.4

Table IC2.

*--Nitrogen Exposure at 127°C(260°F)

D. Flexibility

1. After 500 hour exposure to refrigerant @ 90°C(194°F).

Varnish	Unexposed	HCFC-123	HCFC-22	HFC-134a	*Nitrogen
Uncoated	yes	yes	yes	yes	yes
U-475EH	yes	yes	yes	no	no
Y-390PG	no	no	no	no	no
ER-610	yes	yes	yes	yes	no
Y-833	yes	yes	yes	no	yes
No. 923	no	no	no	no	no
Iso-800	no	yes	yes	yes	no

Table ID1.

2. After 500 hour exposure to refrigerant @ 90°C(194°F) plus a 24 hour air bake @ 150°C(302°F).

Varnish	Unexposed	HCFC-123	HCFC-22	HFC-134a	*Nitrogen
Uncoated	yes	yes	yes	yes	yes
U-475EH	yes	no	yes	no	no
Y-390PG	no	no	no	no	no
ER-610	yes	yes	yes	no	no
Y-833	yes	no	yes	no	yes
No. 923	no	no	no	no	no
Iso-800	no	yes	yes	yes	no

Table ID2.

II. Magnet Wire B- Daglass served wire.

A. Dielectric Strength

1. After 500 hour exposure to refrigerant @ 90°C(194°F).

		% change from Unexposed			
Varnish	Unexposed	HCFC-123	HCFC-22	HFC-134a	*Nitrogen
Uncoated	11.6 Kv	-7.4	-.1	3.0	-6.9
U-475EH	13.3 Kv	6.5	-4.2	-13.1	-8.9
Y-390PG	12.3 Kv	59.4	35.2	9.7	-2.9
ER-610	12.7 Kv	-.1	1.1	9.7	-4.9
Y-833	12.5 Kv	3.6	1.6	3.6	-6.0
No. 923	14.4 Kv	22.4	39.1	8.0	-14.7
Iso-800	12.3 Kv	5.7	30.6	10.6	-2.0

Table IIA1.

*--Nitrogen Exposure at 127°C(260°F)

2. After 500 hour exposure to refrigerant @ 90°C(194°F) plus a 24 hour air bake @ 150°C(302°F).

		% change from Unexposed			
Varnish	Unexposed	HCFC-123	HCFC-22	HFC-134a	*Nitrogen
Uncoated	11.6 Kv	4.6	4.0	-8.5	-8.1
U-475EH	13.3 Kv	-2.0	-8.4	-83.1	-10.9
Y-390PG	12.3 Kv	6.6	-11.9	11.1	-15.4
ER-610	12.7 Kv	-7.4	-5.6	-10.5	-9.9
Y-833	12.5 Kv	-.6	5.6	-.7	-13.2
No. 923	14.4 Kv	-10.7	-19.4	-8.4	-18.2
Iso-800	12.3 Kv	-2.3	6.8	-4.4	-17.9

Table IIA2.

B. Burnout

1. After 500 hour exposure to refrigerant @ 90°C(194°F).

		% change from Unexposed			
Varnish	Unexposed	HCFC-123	HCFC-22	HFC-134a	*Nitrogen
Uncoated	736 sec	-1.6	-.3	-2.1	-3.3
U-475EH	746 sec	-11.9	-2.1	-3.4	-1.8
Y-390PG	755 sec	-2.1	-1.9	-4.4	-3.1
ER-610	734 sec	-.5	-2.5	-1.7	-1.0
Y-833	734 sec	-.8	-.6	-1.7	-.4
No. 923	742 sec	-.94	-.99	-2.6	-1.4
Iso-800	747 sec	-2.5	-2.6	-3.4	-2.2

Table IIB1.

2. After 500 hour exposure to refrigerant @ 90°C(194°F) plus a 24 hour air bake @ 150°C(302°F).

		% change from Unexposed			
Varnish	Unexposed	HCFC-123	HCFC-22	HFC-134a	*Nitrogen
Uncoated	736 sec	-.9	-2.0	-6.3	-1.9
U-475EH	746 sec	-2.5	-2.1	-3.3	-3.1
Y-390PG	755 sec	-3.7	-1.7	-4.4	-4.3
ER-610	734 sec	-.6	-4.6	-4.4	-1.1
Y-833	734 sec	-1.5	-1.2	-1.8	-1.5
No. 923	742 sec	-1.2	0.9	3.0	-2.6
Iso-800	747 sec	-2.7	-2.7	-3.6	-3.2

Table IIB2.

*--Nitrogen Exposure at 127°C(260°F)

C. Bond Strength.

1. After 500 hour exposure to refrigerant @ 90°C(194°F).

		% change from Unexposed			
Varnish	Unexposed	HCFC-123	HCFC-22	HFC-134a	*Nitrogen
U-475EH	40.1 lbs	34.9	59.5	-9.5	-30.3
Y-390PG	36.1 lbs	25.5	60.5	.6	-11.1
ER-610	36.0 lbs	-4.6	28.7	-14.7	-36.8
Y-833	33.1 lbs	-75.5	-51.1	2.7	-43.5
No. 923	40.5 lbs	5.5	31.2	11.8	-26.6
Iso-800	20.2 lbs	5.2	29.3	-7.0	-12.5

Table IIC1.

2. After 500 hour exposure to refrigerant @ 90°C(194°F) plus a 24 hour air bake @ 150°C(302°F).

		% change from Unexposed			
Varnish	Unexposed	HCFC-123	HCFC-22	HFC-134a	*Nitrogen
U-475EH	40.1 lbs.	-53.0	-51.7	0.0	-35.5
Y-390PG	36.1 lbs	-78.8	-58.7	-2.2	-11.0
ER-610	36.0 lbs	-17.0	-19.9	-5.5	-24.0
Y-833	33.1 lbs	-69.8	-77.0	-11.5	-44.5
No. 923	40.5 lbs	-80.4	-51.7	.4	-16.6
Iso-800	20.2 lbs	-1.2	-58.8	-6.8	-25.7

Table IIC2.

D. Flexibility

1. After 500 hour exposure to refrigerant @ 90°C(194°F).

Varnish	Unexposed	HCFC-123	HCFC-22	HFC-134a	*Nitrogen
Uncoated	yes	yes	yes	yes	yes
U-475EH	yes	yes	yes	no	no
Y-390PG	no	no	no	no	no
ER-610	yes	yes	yes	yes	yes
Y-833	yes	yes	yes	yes	yes
No. 923	no	no	no	no	no
Iso-800	no	yes	yes	no	no

Table IID1.

*--Nitrogen Exposure at 127°C(260°F)

2. **After 500 hour exposure to refrigerant @ 90°C(194°F) plus a 24 hour air bake @ 150°C(302°F).**

Varnish	Unexposed	HCFC-123	HCFC-22	HFC-134a	*Nitrogen
Uncoated	yes	yes	yes	yes	yes
U-475EH	yes	no	yes	no	no
Y-390PG	no	no	no	no	no
ER-610	yes	yes	yes	yes	yes
Y-833	yes	yes	yes	yes	yes
No. 923	no	no	no	no	no
Iso-800	no	no	no	no	no

Table IID2.

III. Magnet Wire C- ester imide over coated with amide imide.

A. Dielectric Strength

1. **After 500 hour exposure to refrigerant @ 90°C(194°F).**

		% change from Unexposed			
Varnish	Unexposed	HCFC-123	HCFC-22	HFC-134a	*Nitrogen
Uncoated	16.6 Kv	-17.0	-4.2	-20.4	-21.4
U-475EH	15.1 Kv	-17.0	11.2	-10.3	-16.4
Y-390PG	18.2 Kv	-7.9	6.6	.3	-35.0
ER-610	14.5 Kv	-7.8	-7.8	-7.2	-16.3
Y-833	11.4 Kv	7.5	20.9	-.2	16.9
No. 923	15.9 Kv	23.6	23.2	-.6	-42.8
Iso-800	14.8 Kv	19.3	25.5	9.4	-4.1

Table IIIA1.

2. **After 500 hour exposure to refrigerant @ 90°C(194°F) plus a 24 hour air bake @ 150°C(302°F).**

		% change from Unexposed			
Varnish	Unexposed	HCFC-123	HCFC-22	HFC-134a	*Nitrogen
Uncoated	16.6 Kv	-28.3	-5.0	-12.6	-15.7
U-475EH	15.1 Kv	-15.3	-15.3	-9.5	-5.5
Y-390PG	18.2 Kv	-26.8	-44.9	-17.5	2.1
ER-610	14.5 Kv	-5.2	-42.3	-24.3	-45.6
Y-833	11.4 Kv	.4	7.0	-20.5	9.7
No. 923	15.9 Kv	16.1	-61.4	-6.6	-32.0
Iso-800	14.8 Kv	-2.4	-14.5	-8.5	-1.3

Table IIIA2.

*--Nitrogen Exposure at 127°C(260°F)

B. Burnout

1. After 500 hour exposure to refrigerant @ 90°C(194°F).

Varnish	Unexposed	% change from Unexposed HCFC-123	HCFC-22	HFC-134a	*Nitrogen
Uncoated	579 sec	-29.5	-55.3	-24.8	4.8
U-475EH	469 sec	-36.8	-12.7	-11.0	6.1
Y-390PG	473 sec	34.5	-2.3	-11.4	14.5
ER-610	494 sec	19.4	-47.6	-16.9	-11.9
Y-833	557 sec	-19.2	-48.1	-2.2	-7.1
No. 923	503 sec	-38.6	3.4	-12.1	7.8
Iso-800	632 sec	-61.2	-36.3	-12.6	-7.0

Table IIIB1.

2. After 500 hour exposure to refrigerant @ 90°C(194°F) plus a 24 hour air bake @ 150°C(302°F).

Varnish	Unexposed	% change from Unexposed HCFC-123	HCFC-22	HFC-134a	*Nitrogen
Uncoated	579 sec	-22.7	-5.9	-2.9	3.9
U-475EH	469 sec	-41.9	-38	-30.3	-19.3
Y-390PG	473 sec	-37.9	-12.7	-2.8	-3.3
ER-610	494 sec	-13.5	-25.0	-2.5	-10.5
Y-833	557 sec	-16.5	-21.5	-12.0	-3.7
No. 923	503 sec	-40.4	-23.2	-16.4	-3.5
Iso-800	632 sec	-50.4	-53.7	-10.0	-9.5

Table IIIB2.

C. Bond Strength.

1. After 500 hour exposure to refrigerant @ 90°C(194°F).

Varnish	Unexposed	% change from Unexposed HCFC-123	HCFC-22	HFC-134a	*Nitrogen
U-475EH	51.2 lbs	5.2	-1.7	18.4	-56.6
Y-390PG	50.7 lbs	-11.2	-23.8	-4.4	-51.0
ER-610	58.3 lbs	-51.3	-35.3	5.1	-24.3
Y-833	5.8 lbs	193.5	304.1	327.6	109.8
No. 923	49.3 lbs	14.8	-29.9	-14.7	-49.9
Iso-800	36.1 lbs	-24.9	.4	20.0	-37.8

Table IIIC1.

*--Nitrogen Exposure at 127°C(260°F)

2. After 500 hour exposure to refrigerant @ 90°C(194°F) plus a 24 hour air bake @ 150°C(302°F).

Varnish	Unexposed	% change from Unexposed HCFC-123	HCFC-22	HFC-134a	*Nitrogen
U-475EH	51.2 lbs	5.40	-45.4	229	15.7
Y-390PG	50.7 lbs	11.3	-82.5	-15.0	-45.6
ER-610	58.3 lbs	-64.2	-58.6	11.0	3.7
Y-833	5.8 lbs	214.2	445.5	395.6	125.6
No. 923	49.3 lbs	.7	-83.8	9.8	-37.7
Iso-800	36.1 lbs	14.9	-71.2	-12.3	11.9

Table IIIC2.

D. Flexibility

1. After 500 hour exposure to refrigerant @ 90°C(194°F).

Varnish	Unexposed	HCFC-123	HCFC-22	HFC-134a	*Nitrogen
Uncoated	yes	yes	yes	yes	yes
U-475EH	no	yes	yes	yes	no
Y-390PG	no	yes	no	no	no
ER-610	yes	yes	yes	yes	yes
Y-833	yes	no	yes	yes	yes
No. 923	no	no	no	no	no
Iso-800	yes	no	yes	yes	no

Table IIID1.

2. After 500 hour exposure to refrigerant @ 90°C(194°F) plus a 24 hour air bake @ 150°C(302°F).

Varnish	Unexposed	HCFC-123	HCFC-22	HFC-134a	*Nitrogen
Uncoated	yes	yes	yes	yes	yes
U-475EH	no	no	no	no	yes
Y-390PG	no	no	no	no	no
ER-610	yes	yes	yes	yes	no
Y-833	yes	no	yes	no	yes
No. 923	no	no	no	no	no
Iso-800	yes	no	no	no	no

Table IIID2.

*--Nitrogen Exposure at 127°C(260°F)

IV. Varnish Disks

A. % change in weight.

1. After 500 hour exposure to refrigerant @ 90°C(194°F).

Varnish	% change in weight			
	HCFC-123	HCFC-22	HFC-134a	*Nitrogen
U-475EH	27.6	16.9	1.7	1.6
Y-390PG	24.6	12.5	1.2	1.5
ER-610	25.5	18.7	2.8	0.0
Y-833	44.0	15.4	4.7	0.6
No. 923	26.2	14.4	1.5	-1.4
Iso-800	13.9	7.4	0.9	-3.2

Table IVA1.

2. After 500 hour exposure to refrigerant @ 90°C(194°F) plus a 24 hour air bake @ 150°C(302°F).

Varnish	% change in weight			
	HCFC-123	HCFC-22	HFC-134a	*Nitrogen
U-475EH	0.5	-1.6	-1.7	-1.2
Y-390PG	1.7	-2.2	-1.9	1.9
ER-610	-1.1	-0.1	-0.7	-0.5
Y-833	0.7	-4.2	0.1	0.7
No. 923	3.5	-2.8	-0.2	-1.3
Iso-800	-2.2	-4.5	-2.8	-3.1

Table IVA2.

V. Sheet Insulation

A. % change in tensile strength.

1. After 500 hour exposure to refrigerant @ 90°C(194°F).

Sheet Insulation	Unexposed	% change from Unexposed			
		HCFC-123	HCFC-22	HFC-134a	*Nitrogen
Nomex/Mylar/Nomex	17.4 Ksi	-19.0	-18.0	-30.7	-48.5
Dacron/Mylar/Dacron	13.7 Ksi	-25.1	-23.1	29.3	-92.0
Mylar MO	21.7 Ksi	-7.7	-15.1	-12.0	-84.7
Nomex	18.7 Ksi	-12.5	-9.6	-6.7	-6.5
Nomex Mica	7.5 Ksi	-23.9	-21.3	-18.9	-17.1
Melinex	21.7 Ksi	-20.2	-28.9	-20.0	-89.9

Table VA1.

*--Nitrogen Exposure at 127°C(260°F)

2. After 500 hour exposure to refrigerant @ 90°C(194°F) plus a 24 hour air bake @ 150°C(302°F).

Sheet Insulation	Unexposed	% change from Unexposed			
		HCFC-123	HCFC-22	HFC-134a	*Nitrogen
Nomex/Mylar/Nomex	17.4 Ksi	-7.1	-4.7	-26.4	-76.7
Dacron/Mylar/Dacron	13.7 Ksi	-7.2	-6.9	-32.9	-83.6
Mylar MO	21.7 Ksi	-11.5	-1.7	-13.6	-97.8
Nomex	18.7 Ksi	4.2	-1.9	-4.7	-2.7
Nomex Mica	7.5 Ksi	-22.7	-27.3	-11.9	-26.3
Melinex	21.7 Ksi	-15.4	-20.7	-30.6	-65.9

Table VA2.

B. % change in weight

1. After 500 hour exposure to refrigerant @ 90°C(194°F).

Sheet Insulation	% change in weight			
	HCFC-123	HCFC-22	HFC-134a	*Nitrogen
Nomex/Mylar/Nomex	21.00	6.73	3.00	0.29
Dacron/Mylar/Dacron	7.66	6.23	3.96	-0.29
Mylar MO	8.21	6.01	2.40	0.41
Nomex	15.07	6.10	4.00	0.56
Nomex Mica	0.73	2.86	1.25	0.45
Melinex	8.12	6.43	2.51	0.37

Table VB1.

2. After 500 hour exposure to refrigerant @ 90°C(194°F) plus a 24 hour air bake @ 150°C(302°F).

Sheet Insulation	% change in weight			
	HCFC-123	HCFC-22	HFC-134a	*Nitrogen
Nomex/Mylar/Nomex	-0.40	-0.08	-2.90	-0.19
Dacron/Mylar/Dacron	-1.23	-1.15	0.16	-0.75
Mylar MO	-0.45	-0.64	-0.01	0.33
Nomex	0.10	-0.65	0.47	-0.06
Nomex Mica	0.03	-0.34	0.17	0.09
Melinex	-0.18	-0.15	0.00	0.21

Table VB2.

*--Nitrogen Exposure at 127°C(260°F)

C. % change in Elongation.

1. After 500 hour exposure to refrigerant @ 90°C(194°F).

		% change from Unexposed			
Sheet Insulation	Unexposed(%elong)	HCFC-123	HCFC-22	HFC-134a	*Nitrogen
Nomex/Mylar/Nomex	20.0	-12.90	20.80	38.30	-51.30
Dacron/Mylar/Dacron	46.0	-40.58	-28.60	-46.70	-90.20
Mylar MO	131.0	-8.52	0.80	-7.40	-99.20
Nomex	17.0	-30.88	-19.10	-19.60	-33.30
Nomex Mica	4.0	-60.42	-50.00	-43.80	-56.30
Melinex	160.0	3.85	-16.40	-51.00	-100.00

Table VC1.

2. After 500 hour exposure to refrigerant @ 90°C(194°F) plus a 24 hour air bake @ 150°C(302°F).

		% change from Unexposed			
Sheet Insulation	Unexposed(%elong)	HCFC-123	HCFC-22	HFC-134a	*Nitrogen
Nomex/Mylar/Nomex	20.0	-20.42	9.60	31.30	-96.30
Dacron/Mylar/Dacron	46.0	-43.12	-17.40	-48.20	-96.70
Mylar MO	131.0	13.49	-0.06	-11.20	-100.00
Nomex	17.0	-32.35	-4.00	-28.40	-26.50
Nomex Mica	4.0	-66.67	-43.80	-56.30	-60.40
Melinex	160.0	-7.81	-5.60	-42.50	-99.00

Table VC2.

VI. Sleeving material.

A. % change in weight.

1. After 500 hour exposure to refrigerant @ 90°C(194°F).

	% change in weight			
Sheet Insulation	HCFC-123	HCFC-22	HFC-134a	*Nitrogen
Nomex	56.87	15.31	5.51	0.28
Mylar	23.84	8.48	3.16	-0.06
Nomex/Mylar	22.57	7.20	3.00	0.10

Table VIA1.

*--Nitrogen Exposure at 127°C(260°F)

2. After 500 hour exposure to refrigerant @ 90°C(194°F) plus a 24 hour air bake @ 150°C(302°F).

	% change in weight			
Sheet Insulation	HCFC-123	HCFC-22	HFC-134a	*Nitrogen
Nomex	-3.47	0.90	0.43	-0.78
Mylar	-1.63	-0.88	0.05	-0.92
Mylar/Nomex	-2.62	-1.25	-0.18	-0.99

Table VIA2.

VII. Lead Wire

A. % change in weight.

1. After 500 hour exposure to refrigerant @ 90°C(194°F).

	% change in weight			
Lead Wire	HCFC-123	HCFC-22	HFC-134a	*Nitrogen
Dacron/Mylar/Dacron	4.87	0.84	0.37	0.00
Dacron/Mylar/Teflon/Dacron	3.94	0.86	0.31	0.00

Table VIIA1.

2. After 500 hour exposure to refrigerant @ 90°C(194°F) plus a 24 hour air bake @ 150°C(302°F).

	% change in weight			
Lead Wire	HCFC-123	HCFC-22	HFC-134a	*Nitrogen
Dacron/Mylar/Dacron	-0.15	-0.21	-0.04	0.00
Dacron/Mylar/Teflon/Dacron	-0.14	-0.23	-0.12	-0.04

Table VIIA2.

B. % change in dielectric.

1. After 500 hour exposure to refrigerant @ 90°C(194°F).

		% change from Unexposed			
Lead Wire	Unexposed	HCFC-123	HCFC-22	HFC-134a	*Nitrogen
Dacron/Mylar/Dacron	9.61 Kv	-5.06	-4.51	1.63	3.02
Dacron/Mylar/Teflon/Dacron	9.95 Kv	42.78	-16.18	-10.02	-12.23

Table VIIB1.

*--Nitrogen Exposure at 127°C(260°F)

2. After 500 hour exposure to refrigerant @ 90°C(194°F) plus a 24 hour air bake @ 150°C(302°F).

		% change from Unexposed			
Lead Wire	Unexposed	HCFC-123	HCFC-22	HFC-134a	*Nitrogen
Dacron/Mylar/Dacron	9.61 Kv	-4.82	1.77	-9.43	-9.05
Dacron/Mylar/Teflon/Dacron	9.95 Kv	6.10	-15.28	6.10	-7.91

Table VIIB2.

VIII. Tapes and Tie Cord

A. % change in weight.

1. After 500 hour exposure to refrigerant @ 90°C(194°F).

	% change in weight			
Tapes and Tie Cord	HCFC-123	HCFC-22	HFC-134a	*Nitrogen
Woven Glass Tape	2.16	-0.55	-0.06	-0.41
Polyester Tape	6.49	6.63	2.44	-0.07
Permacel Tape	-5.62	1.67	3.40	-0.50
Polyester Tie Cord	5.98	6.75	1.86	-0.23

Table VIIIA1.

2. After 500 hour exposure to refrigerant @ 90°C(194°F) plus a 24 hour air bake @ 150°C(302°F).

	% change in weight			
Tapes and Tie Cord	HCFC-123	HCFC-22	HFC-134a	*Nitrogen
Woven Glass Tape	-0.11	0.88	-0.57	-0.24
Polyester Tape	-1.54	-3.60	0.20	0.01
Permacel Tape	-14.53	-4.39	-6.36	-4.15
Polyester Tie Cord	1.56	-0.31	-0.49	-0.04

Table VIIIA2.

*--Nitrogen Exposure at 127°C(260°F)

B. **% change in breaking load.**

1. **After 500 hour exposure to refrigerant @ 90°C(194°F).**

Tapes and Tie Cord	Unexposed	% change from Unexposed			
		HCFC-123	HCFC-22	HFC-134a	*Nitrogen
Woven Glass Tape	39.02 lbs	0.69	35.32	25.11	5.42
Polyester Tape	56.12 lbs	5.81	6.20	12.56	-27.30
Permacel Tape	88.5 lbs	-12.34	15.12	27.34	6.48
Polyester Tie Cord	28.6 lbs	10.13	14.77	13.95	-11.14

Table VIIIB1.

2. **After 500 hour exposure to refrigerant @ 90°C(194°F) plus a 24 hour air bake @ 150°C(302°F).**

Tapes and Tie Cord	Unexposed	% change from Unexposed			
		HCFC-123	HCFC-22	HFC-134a	*Nitrogen
Woven Glass Tape	39.02 lbs	18.83	42.15	16.44	14.77
Polyester Tape	56.12 lbs	2.90	1.48	-8.17	-29.14
Permacel Tape	88.5 lbs	20.49	25.29	39.74	-11.41
Polyester Tie Cord	28.36 lbs	4.96	1.80	0.93	4.90

Table VIIIB2.

*--Nitrogen Exposure at 127°C(260°F)

IX. Analysis of Results.

Since the results reported are preliminary and research is still in progress, final conclusions and recommendations will be postponed until completion of the project. However at this time the following observations can be made:

There is a strong relationship between the magnet wire enamel and the varnishes. Because of the strong bonding of the varnishes to the magnet wire insulation and the low flexibility of some varnishes compared to the enamel, all enamels could be removed from the wire by flexing the varnished wire. Because the varnish is applied after the motor is wound, we would not expect this to be a major problem. However, because of a tendency of the end turns to move slightly during startup and operation of the motor, flexibility of the varnish in the refrigerant may be important.

The amount of refrigerant absorbed by the varnish and other insulation materials is very important. The HCFC's are absorbed to a greater extent than the HFC's. More important than the amount of refrigerant absorbed by the insulation, is the rate that it is desorbed on heating. In this respect HCFC-22 has the most deleterious effect of all refrigerants tested, worse than HCFC-123 which is absorbed to a greater extent, and much worse than the HFC's which are absorbed to only a few percent. Absorption of appreciable amount of refrigerant, followed by rapid desorption result in structural breakdown of the varnish and other materials. This results in lower bond strengths, dielectric breakdown voltages, and burnout times.

Polyethylene terephthalate type sheet insulation was degraded by heat, especially when combined with residual moisture and butyl cellosolve evolved from Isopoxy 800 varnish. Research is currently underway to better understand this phenomenon. The sheet insulation materials have been tested in separate vessels since the above discovery.

The HCFC refrigerants appear to have a greater effect than the HFC refrigerants on motor materials. HCFC-22 seems to exhibit the most compatibility concerns of any refrigerant tested. However, since motors used in HCFC-22 systems have performed reliably over the past 20 years, these materials should be reliable with HFC's.

X. Compliance with Agreement

The Trane Company has complied with all terms of the grant agreement during the second quarter of calendar year 1992.

XI. Principal Investigator Effort

Robert Doerr (Project Manager) has devoted 164 hours (33% of his available work hours) on this program this last quarter.

Stephen Kujak (Principal Investigator) has devoted 434 hours (86% of his available work hours) on this program this last quarter.

Other investigators worked approximately 740 hours on this project during the second quarter.

END

DATE FILMED

12 / 8 / 92