

**COMPATIBILITY OF REFRIGERANTS
AND LUBRICANTS
WITH MOTOR MATERIALS
UNDER RETROFIT CONDITIONS**

Final Report

Volume IV

PICTURES

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FORMAT FOR THE FINAL REPORT

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 (148 pages) contains the abstract, introduction, significant results, conclusions, material identification, experimental procedures and summary data tables. This volume provides the results of the study and other information of interest to most readers. The other volumes are necessary only if the reader is interested in the individual data measurements rather than summaries or averages of the data sets.

Volume II (250 pages) contains the measurements from tests on the three high pressure refrigerant-lubricant combinations and their alternatives.

Original Refrigerant	Alternative Refrigerant	Exposure Temperature
R-12/Mineral Oil	R-134a/Polyol Ester	127°C (260°F)
R-22/Mineral Oil	R-407C/Polyol Ester	127°C (260°F)
R-502/Mineral Oil	R-404A/Polyol Ester	127°C (260°F)

Volume III (155 pages) contains the measurements from tests on the three low pressure refrigerant-lubricant combinations and their alternatives.

Original Refrigerant	Alternative Refrigerant	Exposure Temperature
R-11/Mineral Oil	R-123/Mineral Oil	100°C (212°F)
R-11/Mineral Oil	R-245ca/Polyol Ester	100°C (212°F)
R-123/Mineral Oil	R-245ca/Polyol Ester	100°C (212°F)

Volume IV (44 pages) contains the photographs of the motor materials after exposure to the six refrigerant-lubricant combinations and their alternatives.

COMPATIBILITY OF REFRIGERANTS AND LUBRICANTS WITH MOTOR MATERIALS UNDER RETROFIT CONDITIONS

Robert G. Doerr and Todd D. Waite
The Trane Company

ABSTRACT

Compatibility tests were conducted on motor materials to determine if exposure to the original refrigerant/mineral oil would affect compatibility of the motor materials after retrofit to the alternative refrigerant/lubricant. The motor materials were exposed at elevated temperature to the original refrigerant and mineral oil for 500 hours, followed by exposure to the alternative refrigerant and lubricant for 500 hours. Measurements were also taken after 168 and 336 hours. As a control, some samples were exposed to the original refrigerant/mineral oil for a total of 1000 hours. The original refrigerants and the alternatives tested for retrofit were as follows:

Original Refrigerant	Alternative Refrigerant	Exposure Temperature
R-12/Mineral Oil	R-134a/Polyol Ester	127°C (260°F)
R-22/Mineral Oil	R-407C/Polyol Ester	127°C (260°F)
R-502/Mineral Oil	R-404A/Polyol Ester	127°C (260°F)
R-11/Mineral Oil	R-123/Mineral Oil	100°C (212°F)
R-11/Mineral Oil	R-245ca/Polyol Ester	100°C (212°F)
R-123/Mineral Oil	R-245ca/Polyol Ester	100°C (212°F)

Most motor materials exposed to the alternative refrigerant and lubricant (after an initial exposure to the original refrigerant and mineral oil) were compatible with the alternative refrigerant and lubricant. The only concern was delamination and blistering of the sheet insulation containing Nomex, especially after removal of absorbed refrigerant. This was attributed to solution of the adhesive and not to the Nomex itself. Embrittlement of the polyethylene terephthalate (PET) found in Mylar and Melinex sheet and sleeving insulations was initially observed, but subsequent tests under dry conditions showed that embrittlement of the PET materials was caused by moisture present during the exposure.

Compatibility tests of elastomers with R-245ca, retrofitted from R-11 and R-123, showed that the nitrile was compatible with both R-11 and R-245ca, but not with R-123. The neoprene was unsatisfactory because of shrinkage in the R-245ca.

**TABLE OF CONTENTS
PICTURES, VOLUME IV**

	<u>Section</u>
PICTURES OF PROCEDURES AND UNEXPOSED MATERIALS	1
R-12/MINERAL OIL TO R-134a/POLYOLESTER PICTURES	2
R-22/MINERAL OIL TO R-407C/POLYOLESTER PICTURES	3
PICTURES OF SHEET INSULATION EXPOSED TO R-12/R-134a AND R-22/R-407C UNDER DRY CONDITIONS	4
R-502/MINERAL OIL TO R-404A/POLYOLESTER PICTURES	5
R-11/MINERAL OIL TO R-123/MINERAL OIL PICTURES	6
R-11/MINERAL OIL TO R-245ca/POLYOLESTER PICTURES	7
R-123/MINERAL OIL TO R-245ca/POLYOLESTER PICTURES	8

**NUMBERING ORDER FOR
ALL PICTURES**

Upper Left:	1, 5, 9, 13
Lower Left:	2, 6, 10, 14
Upper Right:	3, 7, 11, 15
Lower Right:	4, 8, 12, 16

1, 5,	3, 7,
2, 6,	4, 8,

**PICTURES
SECTION 1**

**PROCEDURES AND
UNEXPOSED
MATERIALS**

PROCEDURES AND UNEXPOSED MATERIALS

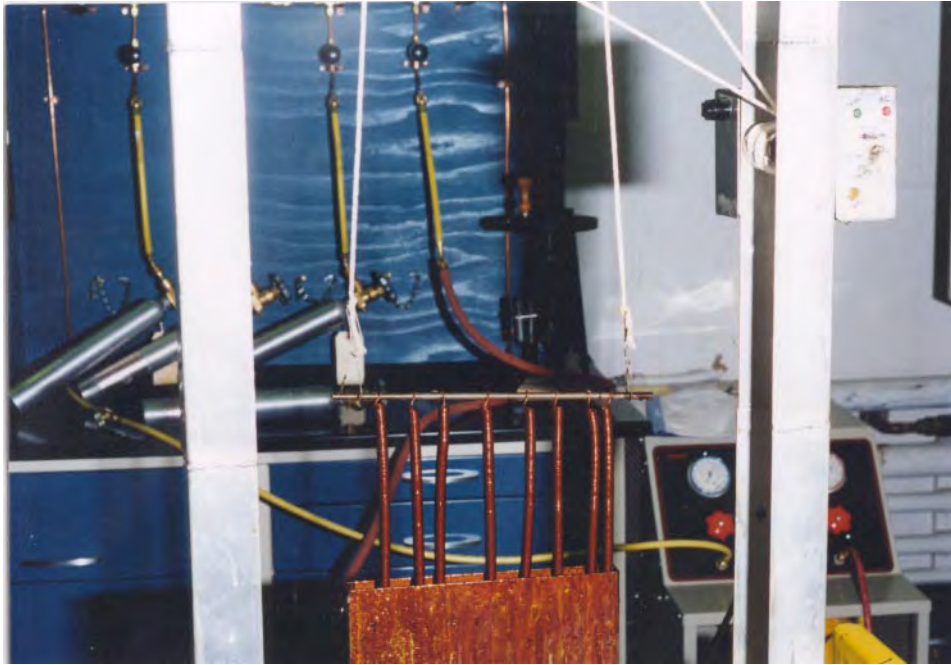
PICTURE

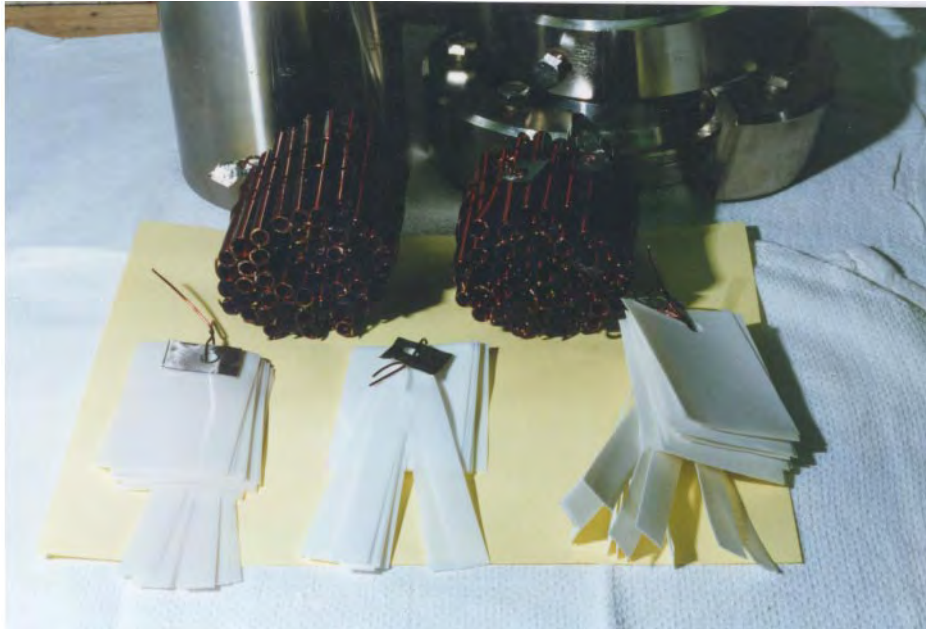
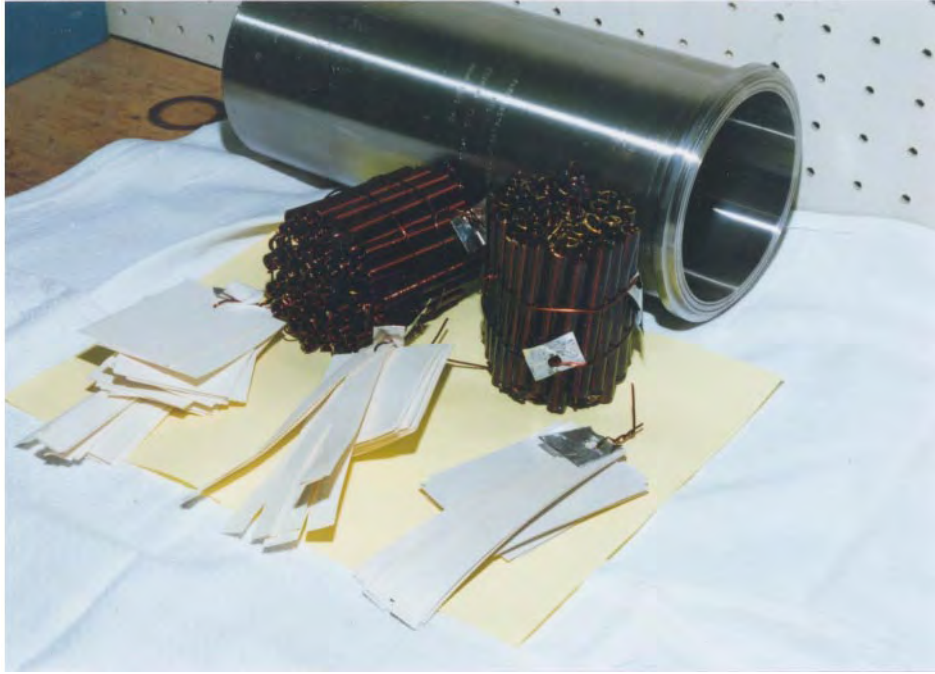
PROCEDURES

1. Dipping Helical Coils
2. Reclaiming Refrigerant
3. Removing Lubricant From Parr Bombs After Exposures

UNEXPOSED MATERIALS

4. Bomb 1: Unexposed Motorettes, Tapes, Tie Cords and Lead Wires
5. Bomb 2: Unexposed Helical Coils and Three Sheet Insulations
6. Bomb 3: Unexposed Helical Coils and Three Sheet Insulations
7. Bomb 4: Unexposed Twisted Pairs
8. Bomb 5: Unexposed Motorettes, Varnish Disks, and Sleeving





PICTURES

SECTION 2

**R-12/Mineral Oil to
R-134a/Polyolester**

R-12/MINERAL OIL TO R-134a/POLYOLESTER PICTURES

PICTURE

R12/Mineral Oil 500 Hour Exposure.

1. Bomb 1: Motorettes, Tapes, Tie Cords and Lead Wires
2. Bomb 2: Helical Coils and Three Sheet Insulations
3. Bomb 3: Helical Coils and Three Sheet Insulations
4. Bomb 4: Twisted Pairs
5. Bomb 5: Motorettes, Varnish Disks, and Sleeving
6. Sleeving Showing Brittleness.

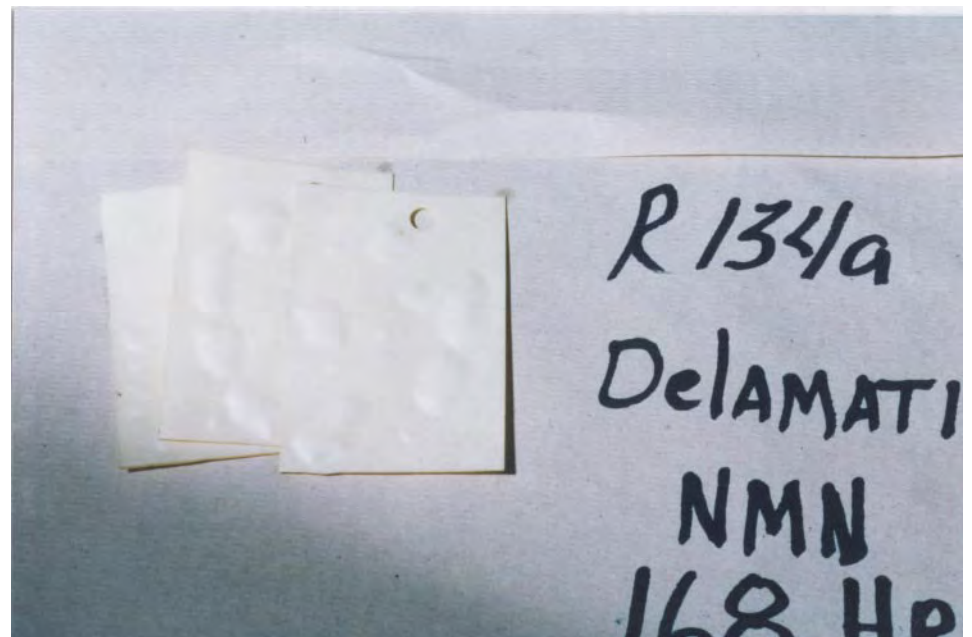
R12/Mineral Oil 500 Hour plus R-134a/Polyolester 168 hour Exposure

7. All Materials Except Motorettes
8. Nomex-Mylar-Nomex (NMN), Blistered.

R12/Mineral Oil 500 Hour plus R-134a/Polyolester 336 hour Exposure

9. All Materials Except Motorettes.







PICTURES SECTION 3

**R-22/Mineral Oil to
R-407C/Polyolester**

R-22/MINERAL OIL TO R-407C/POLYOLESTER PICTURES

PICTURE

R22/Mineral Oil 500 Hour Exposure.

1. Bomb 1: Motorettes, Tapes, Tie Cords and Lead Wires
2. Bomb 2: Helical Coils and Three Sheet Insulations
3. Bomb 3: Helical Coils and Three Sheet Insulations
4. Bomb 5: Motorettes, Varnish Disks, and Sleeving
5. Sheet Insulation and Varnish
6. Sheet Insulation and Varnish
7. Parr Bomb Cover Showing Polyethylene Terephthalate (PET) Precipitate
8. Parr Bomb Cover Showing Polyethylene Terephthalate (PET) Precipitate

R22/Mineral Oil 1000 Hour Exposure.

9. All Materials Except Motorettes
10. Magnet Wire with PET Residue
11. Nomex-Mylar-Nomex (NMN) showing blistering
12. Delamination of NMN Sheet Insulation
13. Blisters in NMN Sheet Insulation

R22/Mineral Oil 500 Hour plus R-407C/Polyolester 168 hour Exposure

14. All Materials Except Motorettes

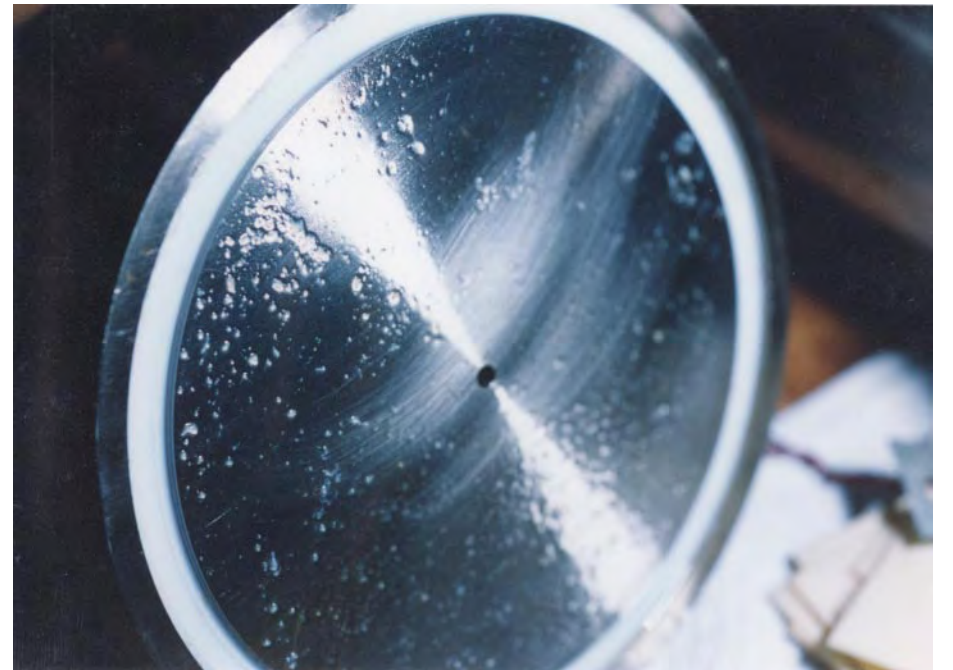
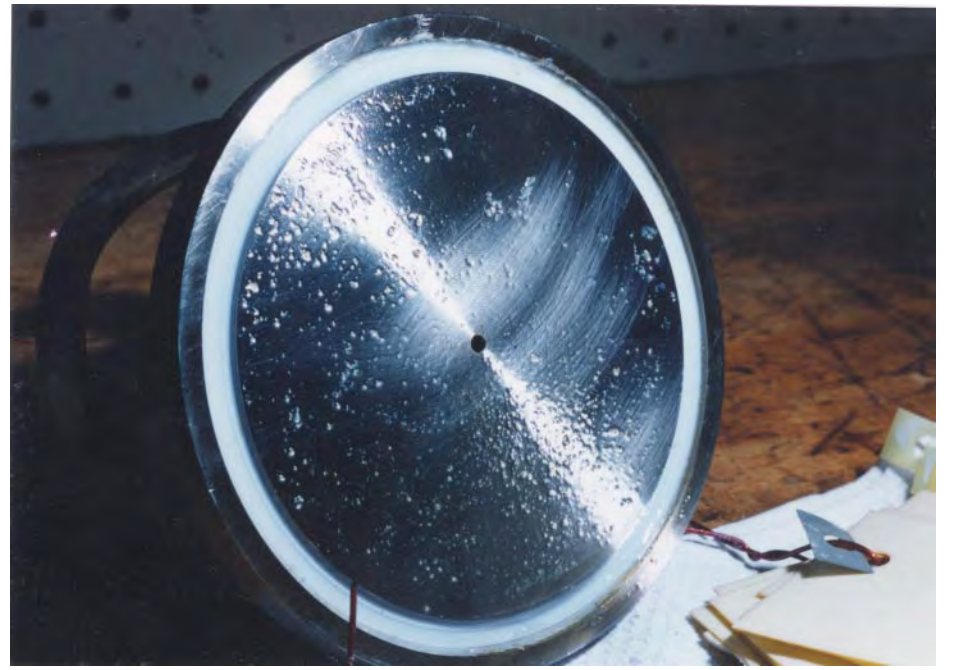
R22/Mineral Oil 500 Hour plus R-407C/Polyolester 336 hour Exposure

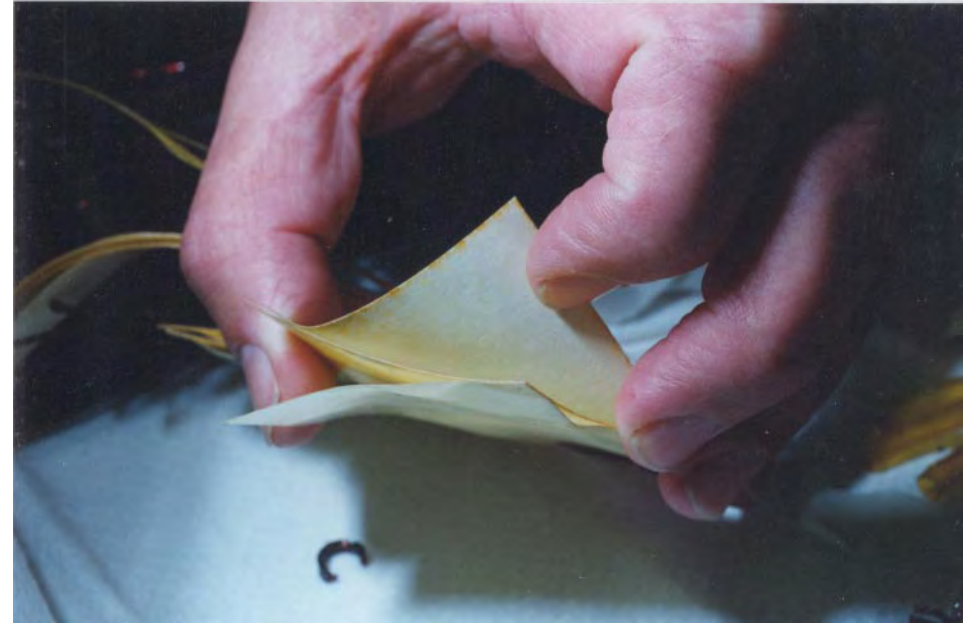
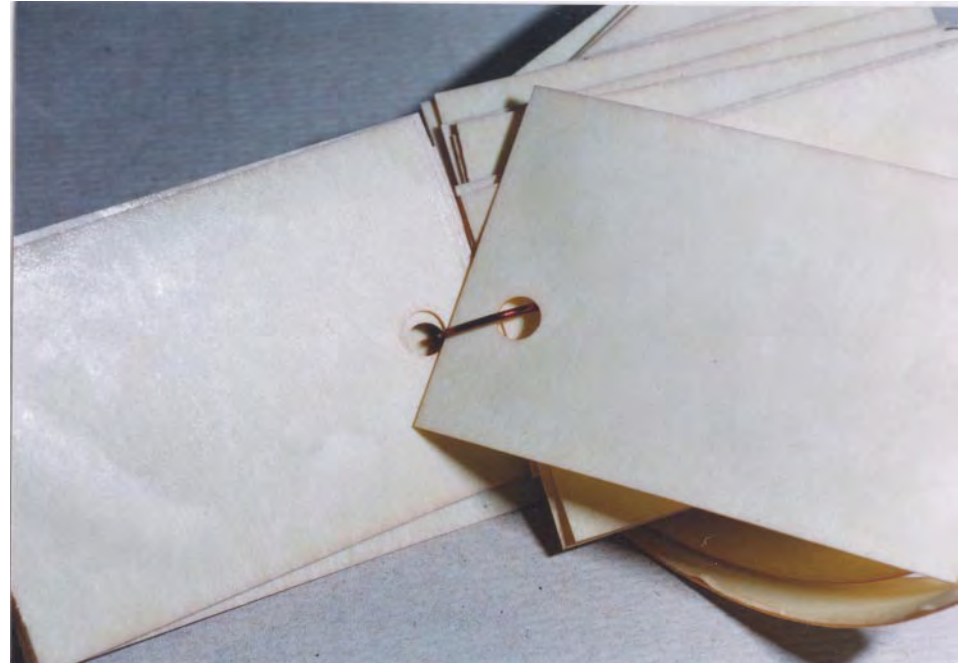
15. All Materials Except Motorettes.

R22/Mineral Oil 500 Hour plus R-407C/Polyolester 500 hour Exposure

16. All Materials Except Motorettes.









**PICTURES
SECTION 4**

**SHEET INSULATION
UNDER DRY
CONDITIONS**

SHEET INSULATION EXPOSED UNDER DRY CONDITIONS
R-22/MINERAL OIL TO R-407C/POLYOLESTER PICTURES

PICTURE

R22/Mineral Oil 500 Hour Exposure.

1. Nomex-Mylar-Nomex (NMN) Sheet Insulation, Blistered

R22/Mineral Oil 500 Hour plus R-407C/Polyolester 168 hour Exposure

2. Nomex-Mylar-Nomex (NMN) Sheet Insulation, Blistered
3. Nomex-Mylar-Nomex (NMN) Sheet Insulation, Blistered
4. Nomex-Mylar-Nomex (NMN) Sheet Insulation, Blistered

R22/Mineral Oil 500 Hour plus R-407C/Polyolester 336 hour Exposure

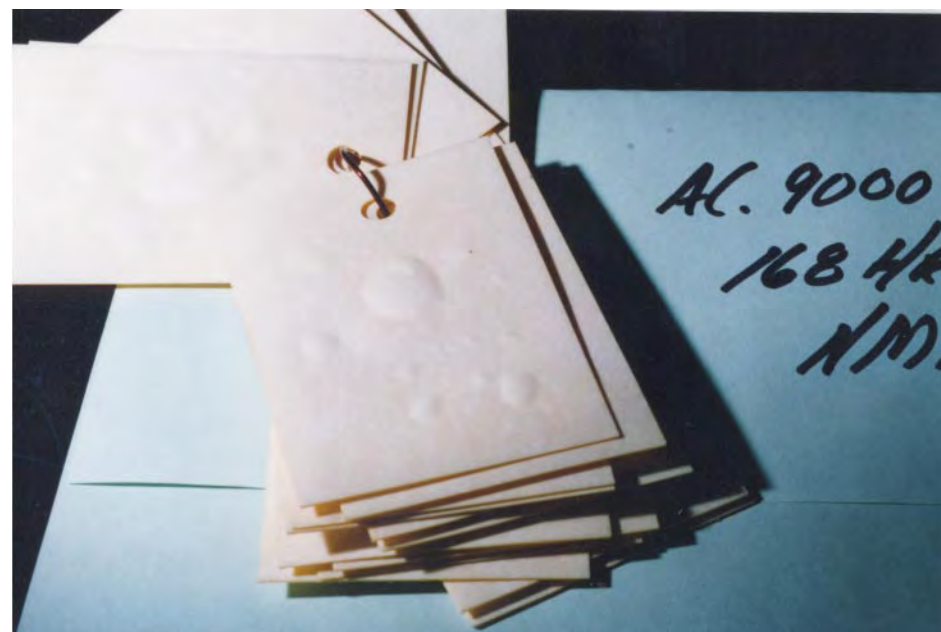
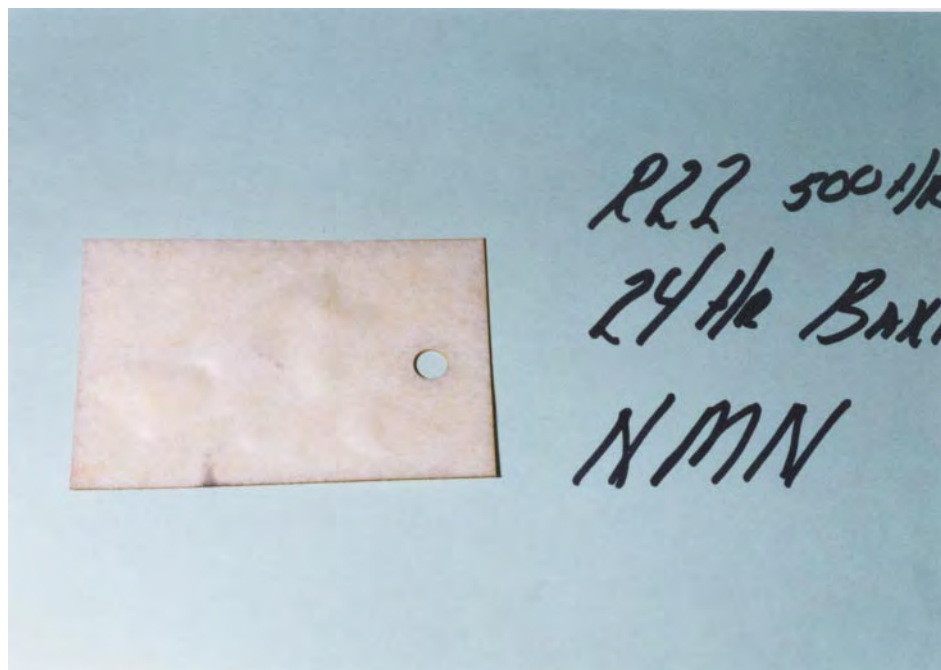
5. Nomex-Mylar-Nomex (NMN) Sheet Insulation, Blistered
6. Nomex Sheet Insulation, Blistered

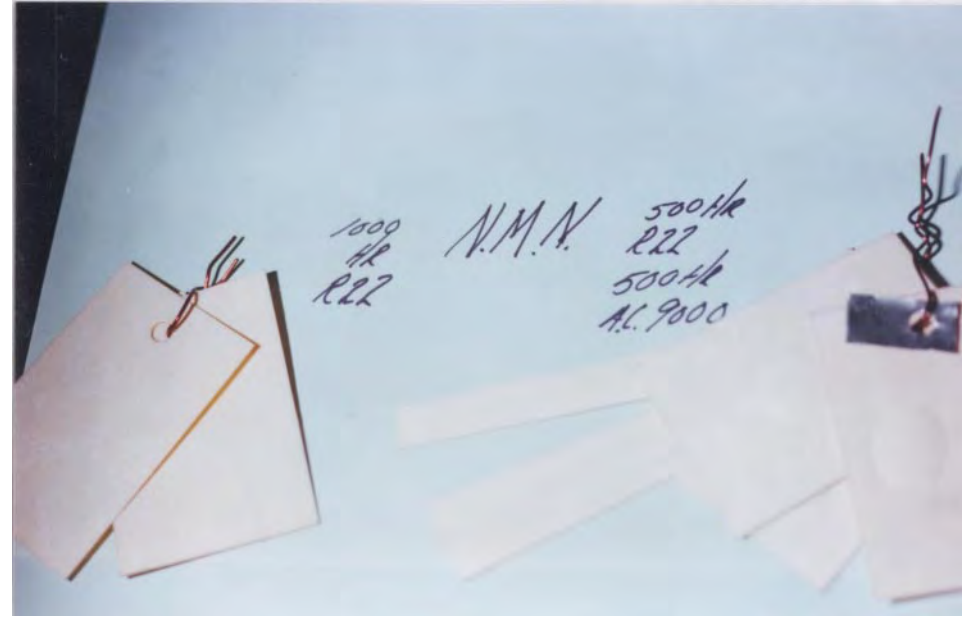
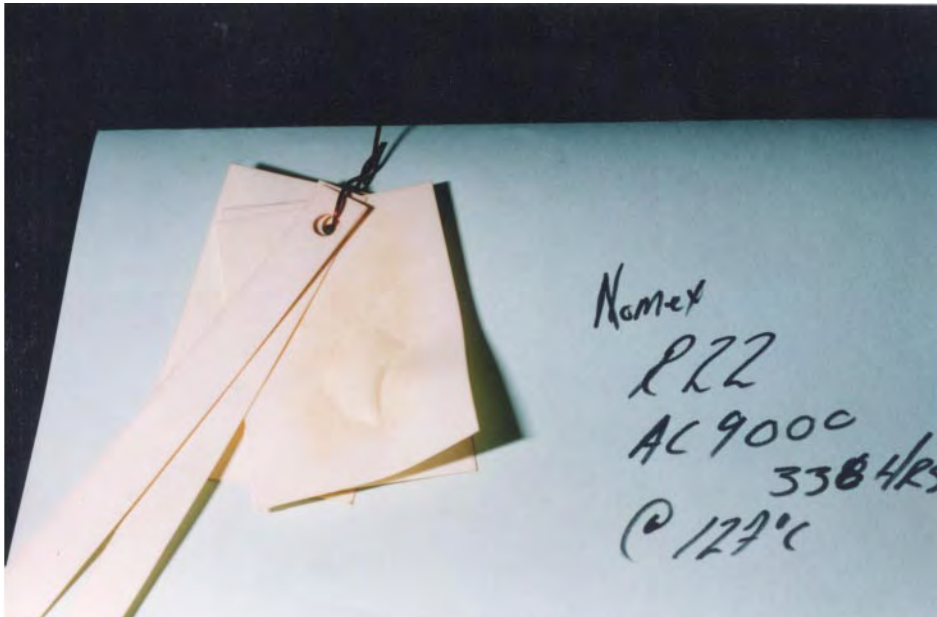
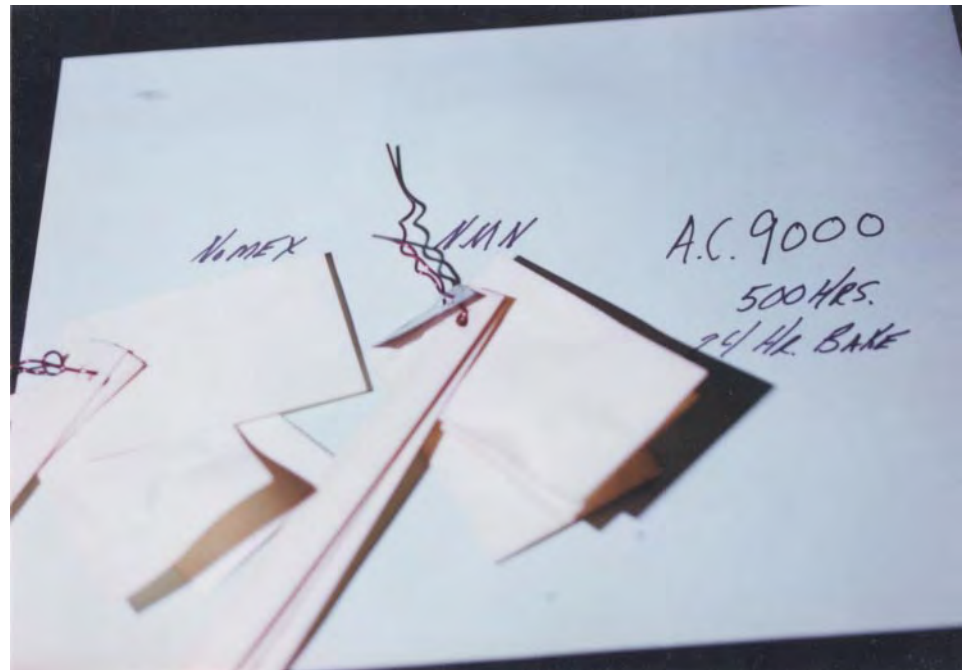
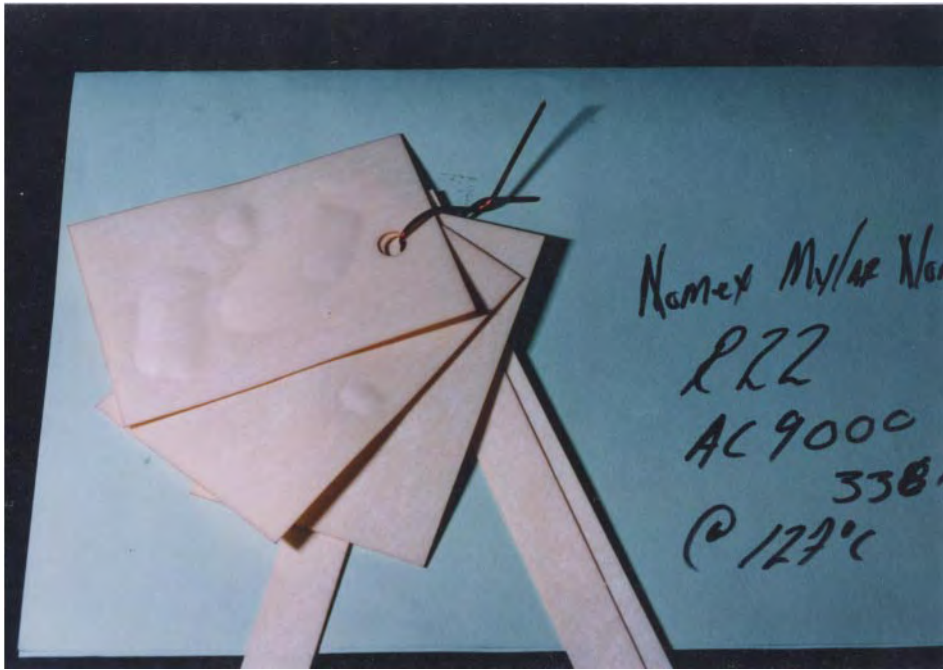
R22/Mineral Oil 500 Hour plus R-407C/Polyolester 500 hour Exposure

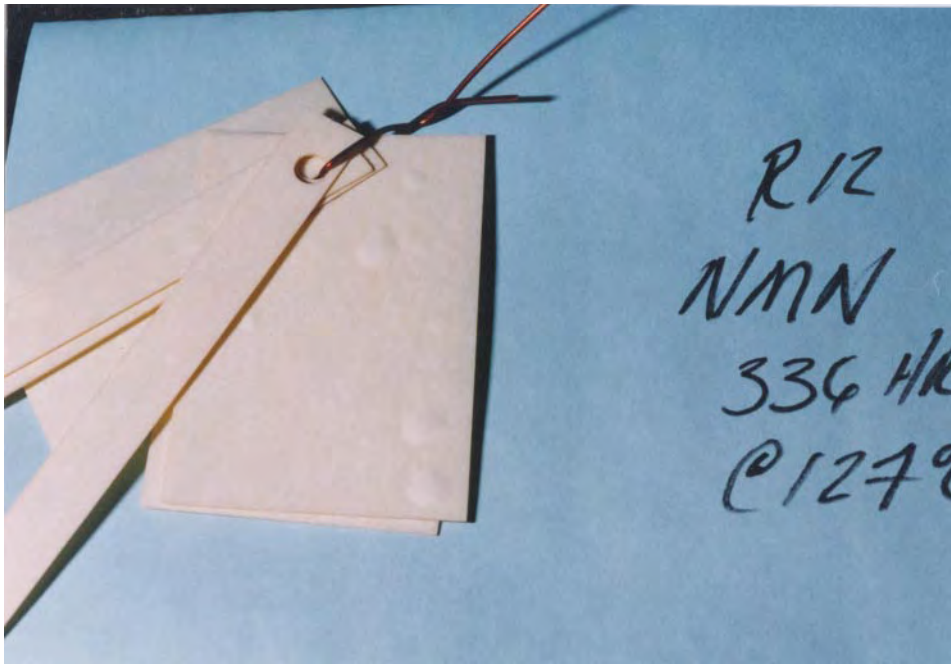
7. Nomex-Mylar-Nomex (NMN) Sheet Insulation, Blistered
8. Nomex-Mylar-Nomex (NMN) Sheet Insulation, Blistered, Compared to 1000 Hour Exposure to R-22/Mineral Oil.

R-12/MINERAL OIL, 500 HOURS TO R-134A/POLYOLESTER

1. Nomex-Mylar-Nomex (NMN), R-134a 336 Hours, Blistered
2. Nomex, R-134a 336 Hours, Blistered
3. Nomex-Mylar-Nomex (NMN), R-134a 500 Hours, Blistered







PICTURES SECTION 5

**R-502/Mineral Oil to
R-404A/Polyolester**

R-502/MINERAL OIL TO R-404A/POLYOLESTER PICTURES

PICTURE

R502/Mineral Oil 500 Hour Exposure.

1. Bomb 1: Motorettes, Tapes, Tie Cords and Lead Wires
2. Bomb 2: Helical Coils and Three Sheet Insulations
3. Bomb 3: Helical Coils and Three Sheet Insulations
4. Bomb 4: Twisted Pairs
5. Bomb 5: Motorettes, Varnish Disks, and Sleeving
6. Nomex Sheet Insulation, Blistered
7. Nomex Sheet Insulation, Blistered, Close-up
8. Nomex-Mylar-Nomex (NMN), Blistered
9. Nomex-Mica, Blistered

R502/Mineral Oil 1000 Hour Exposure.

10. All Materials Except Motorettes

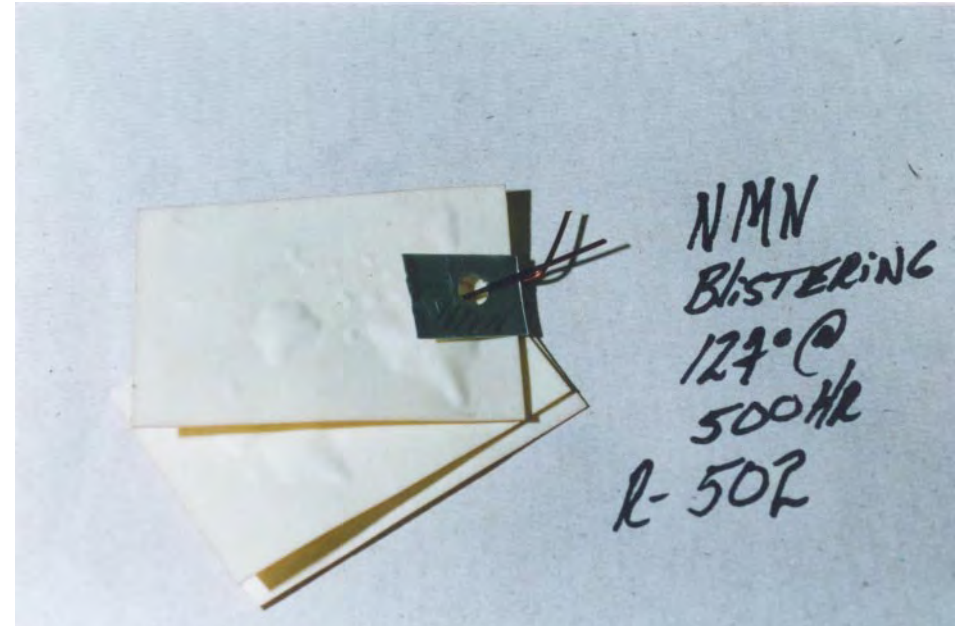
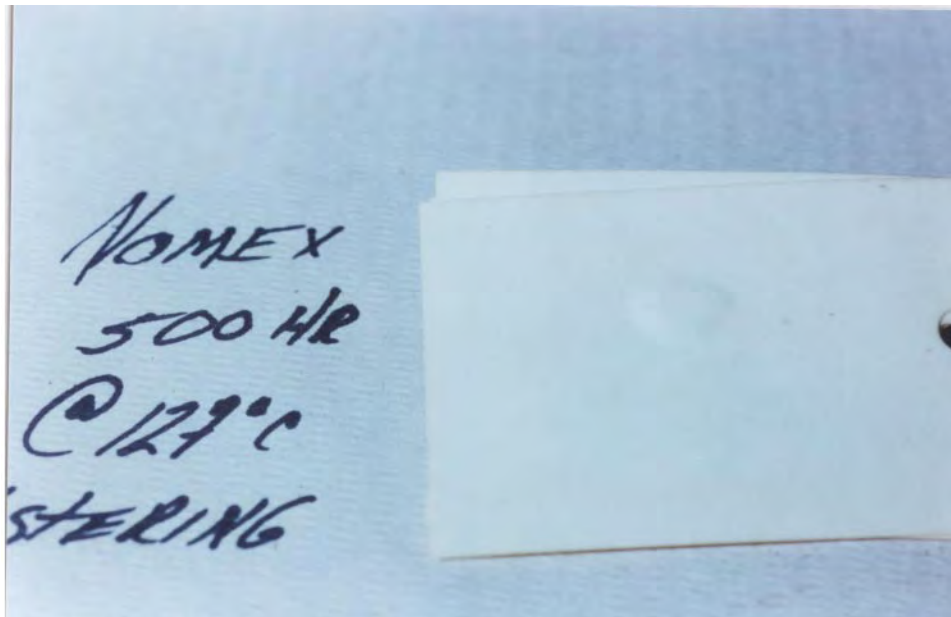
R502/Mineral Oil 500 Hour plus R-404A/Polyolester 336 hour Exposure

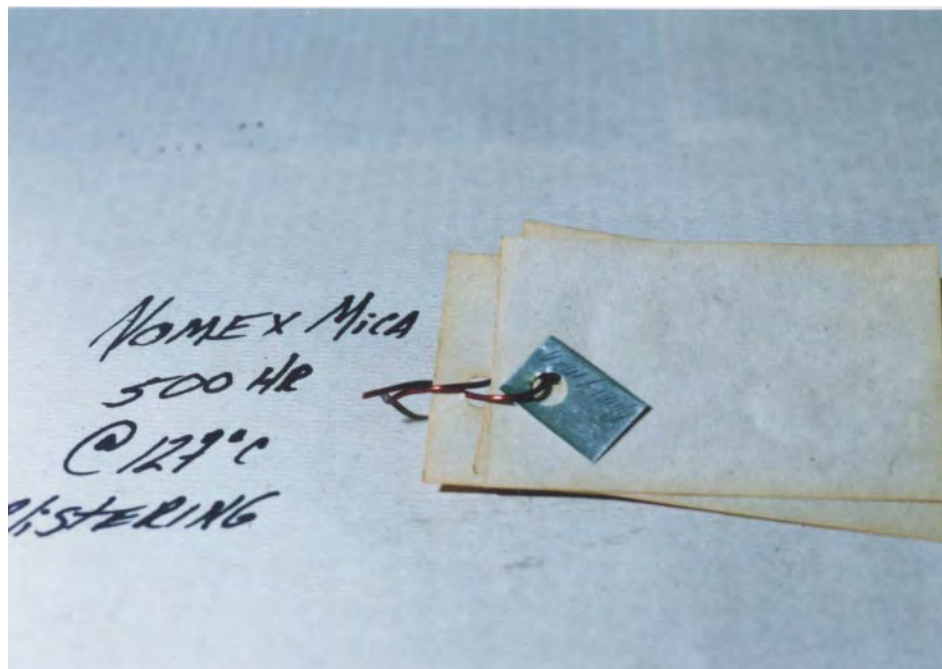
11. All Materials Except Motorettes.
12. Nomex, Blistered
13. Nomex, Blistered, Side View
14. Nomex-Mylar-Nomex, Delaminated
15. Nomex-Mylar-Nomex, Delaminated, Close View

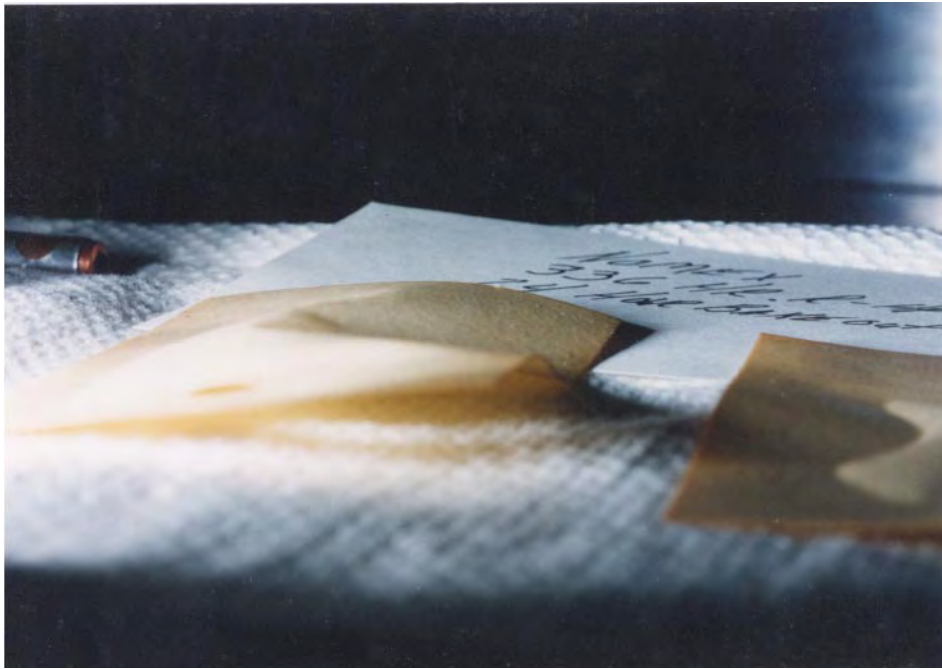
R502/Mineral Oil 500 Hour plus R-404A/Polyolester 500 hour Exposure

16. All Materials Except Motorettes.









PICTURES SECTION 6

**R-11/Mineral Oil to
R-123/Mineral Oil**

R-11/MINERAL OIL TO R-123/MINERAL OIL PICTURES

PICTURE

R11/Mineral Oil 500 Hour plus R-123/Mineral Oil, 168 hour Exposure

1. All Materials Except Motorettes
2. Permacel Tape
3. Motorettes, Showing Blistering of the Varnish on Steel.

Note: Varnish blistering was not observed with additional exposures to R-123.

R11/Mineral Oil 500 Hour plus R-123/Mineral Oil, 500 hour Exposure

4. All Materials Except Motorettes.



PICTURES SECTION 7

**R-11/Mineral Oil to
R-245ca/Polyolester**

R-11/MINERAL OIL TO R-245ca/POLYOLESTER PICTURES

PICTURE

R11/Mineral Oil 500 Hour Exposure.

1. All Materials
2. Nomex-Mylar-Nomex (NMN). Blistered
3. Magnet Wire
4. Oil Sample
5. Motorettes.

R11/Mineral Oil 1000 Hour Exposure.

6. All Materials Except Motorettes
7. Nomex-Mylar-Nomex (NMN), Blistered

R11/Mineral Oil 500 Hour plus R-245ca/Polyolester 168 hour Exposure

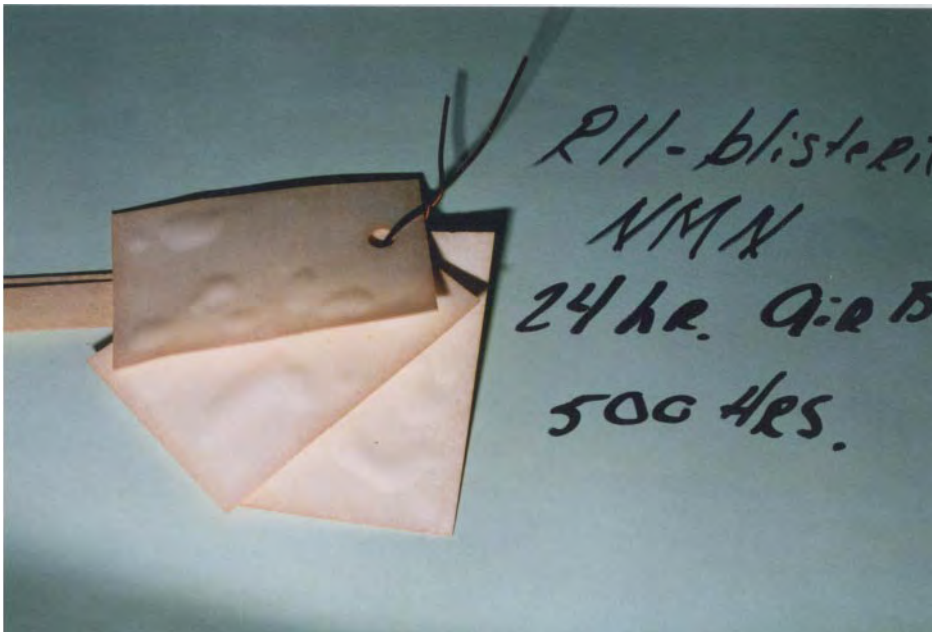
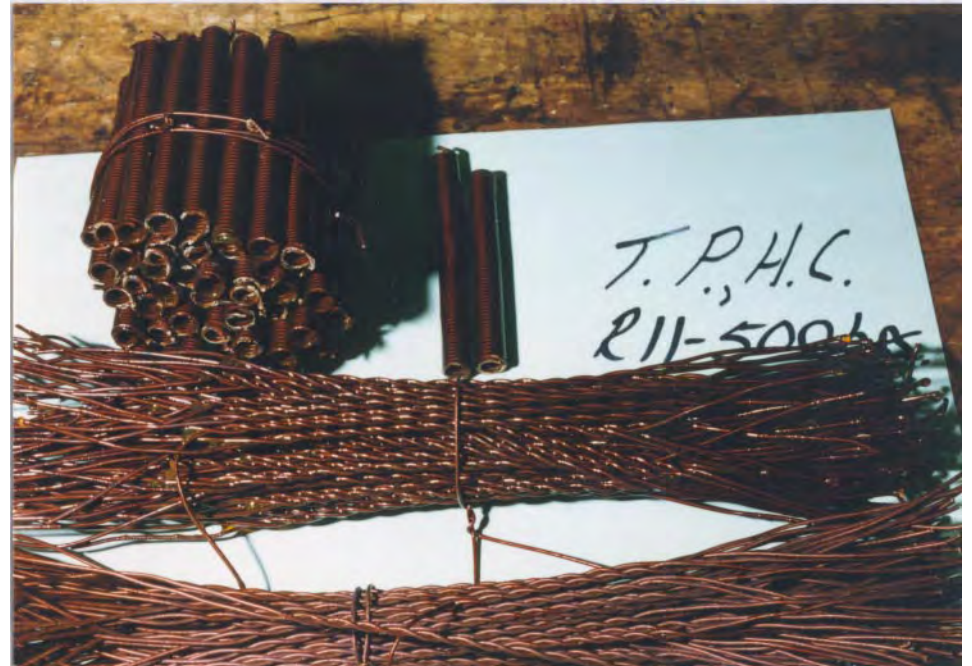
8. All Materials Except Motorettes
9. Nomex-Mylar-Nomex (NMN), Blistered

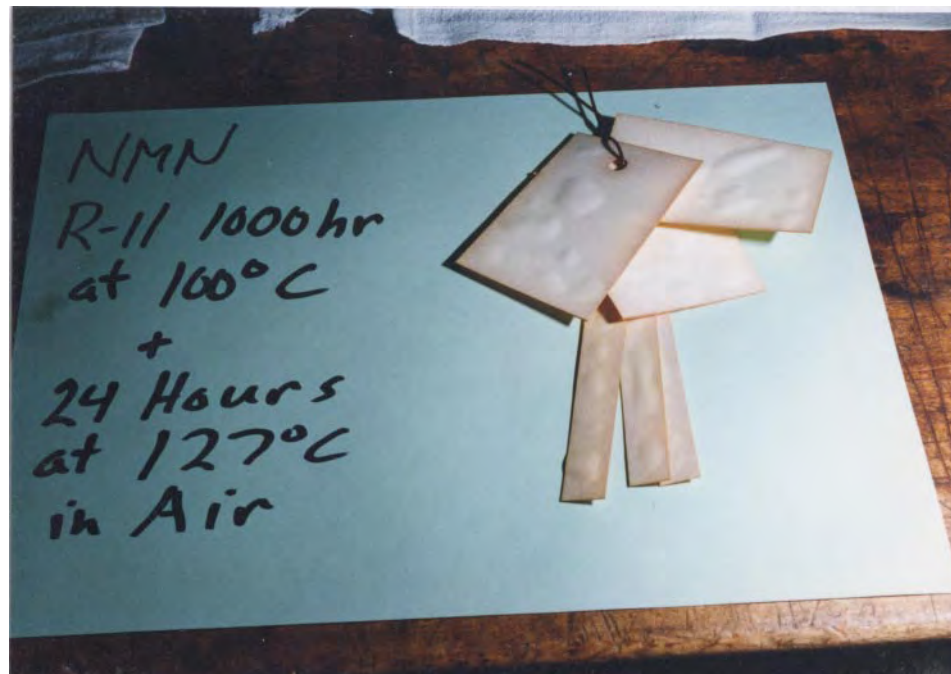
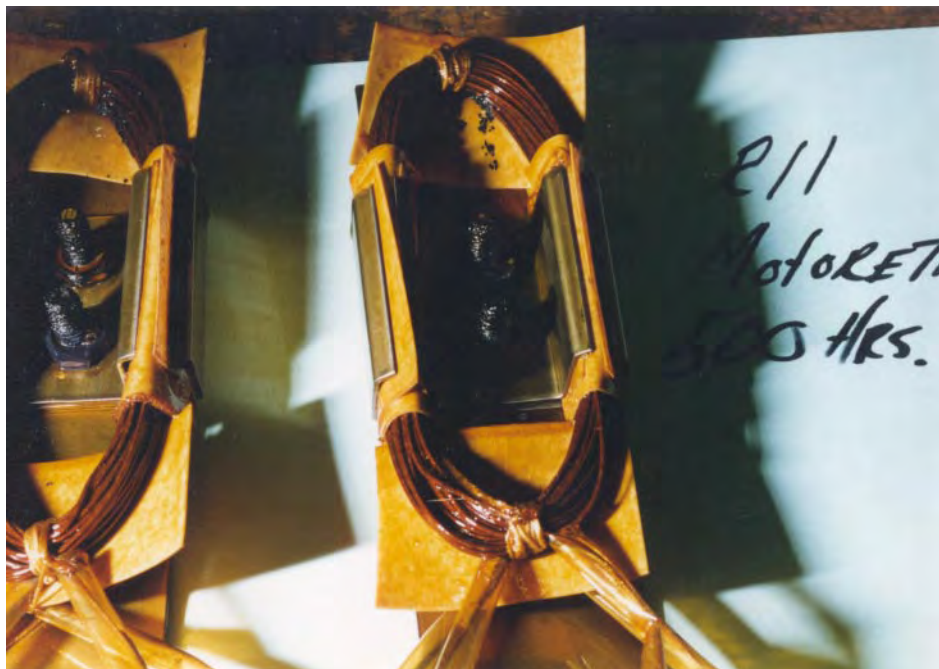
R11/Mineral Oil 500 Hour plus R-245ca/Polyolester 336 hour Exposure

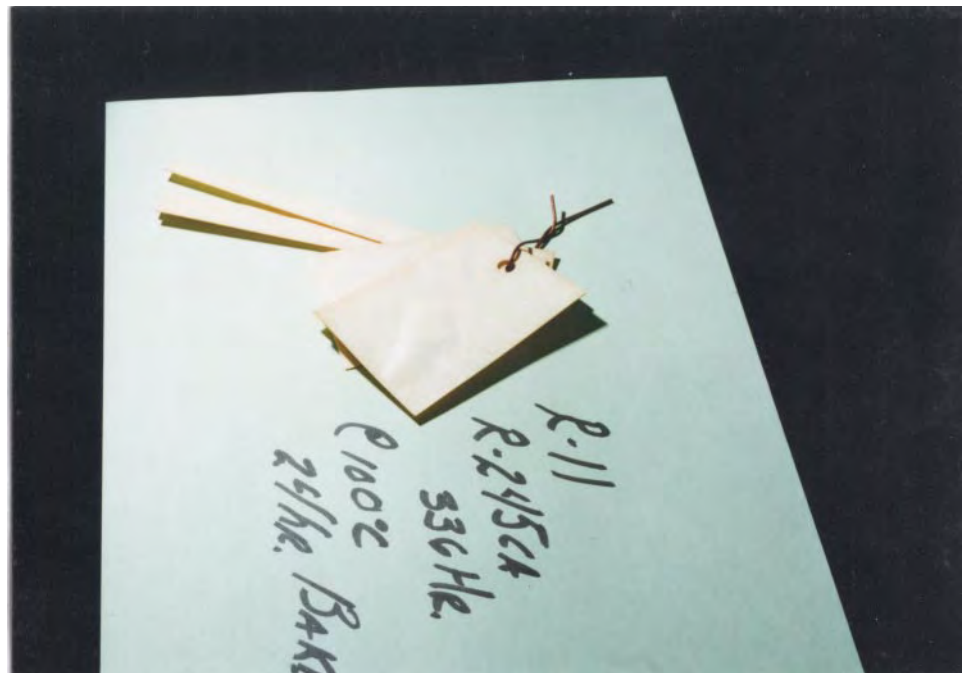
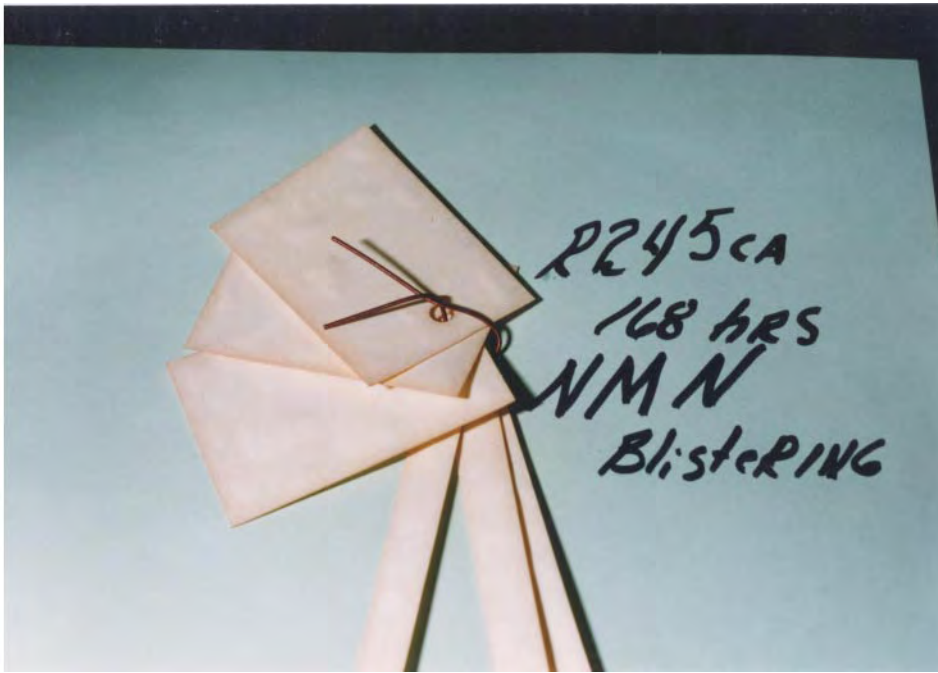
10. All Materials Except Motorettes.
11. Nomex-Mylar-Nomex (NMN), Blistered

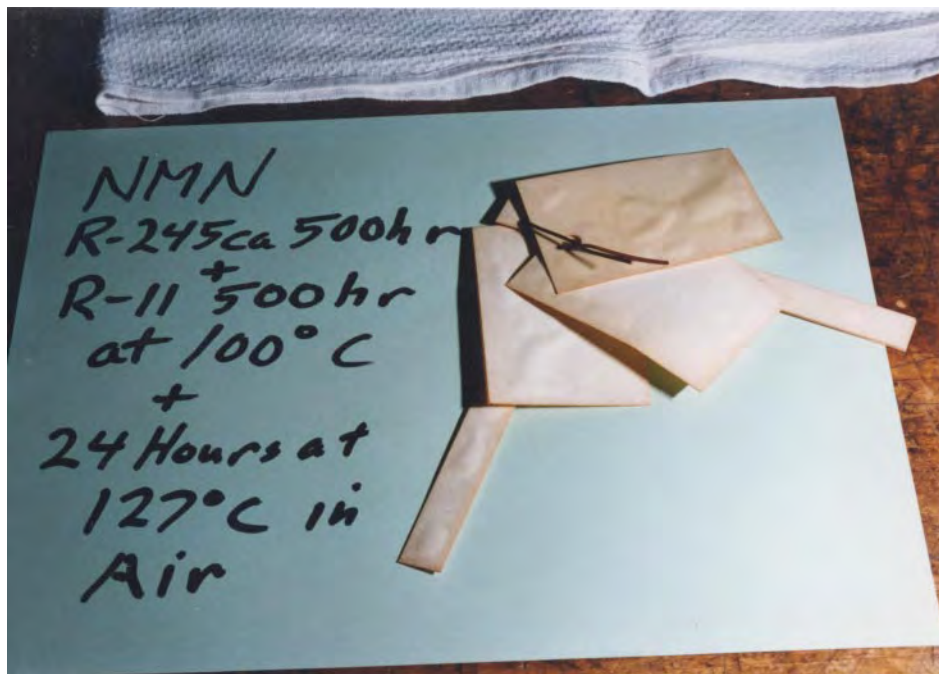
R11/Mineral Oil 500 Hour plus R-245ca/Polyolester 500 hour Exposure

12. All Materials Except Motorettes.
13. Nomex-Mylar-Nomex (NMN), Blistered
14. Motorettes









PICTURES SECTION 8

**R-123/Mineral Oil to
R-245ca/Polyolester**

R-123/MINERAL OIL TO R-245ca/POLYOLESTER PICTURES

PICTURE

R123/Mineral Oil 500 Hour Exposure.

1. Sheet Insulation, Sleeving, Tapes, Tie Cords and Lead Wires
2. Magnet Wire
3. Motorettes.

R123/Mineral Oil 1000 Hour Exposure.

4. All Materials Except Motorettes
5. Nomex-Mylar-Nomex (NMN), Blistered

R123/Mineral Oil 500 Hour plus R-245ca/Polyolester 168 hour Exposure

6. All Materials Except Motorettes
7. Nomex-Mylar-Nomex (NMN), Blistered

R123/Mineral Oil 500 Hour plus R-245ca/Polyolester 336 hour Exposure

8. All Materials Except Motorettes.
9. Nomex-Mylar-Nomex (NMN), Blistered

R123/Mineral Oil 500 Hour plus R-245ca/Polyolester 500 hour Exposure

10. All Materials Except Motorettes.
11. Nomex-Mylar-Nomex (NMN), Blistered
12. Distillation Apparatus to Recover low Pressure Refrigerants.

