



AEROSPACE INFORMATION REPORT

AIR1490™**REV. C**

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Superseding AIR1490B

(R) Environmental Degradation of Textiles

RATIONALE

AIR1490C has been updated to include new degradation results. The document has also been revised to the latest SAE standards format.

FOREWORD

The intent of this SAE Aerospace Information Report (AIR) is to make available information concerning the environmental degradation of textiles as used in unit load device (ULD) equipment common to the air cargo community.

1. SCOPE

1.1 Field of Application

Since cargo restraint devices made with textiles should have a predictable service life, there should be data available so that predictions can be made. This document compiles available information on textiles of the types used in air cargo restraint devices and reviews the degradation characteristics of each.

Textiles are used primarily in cargo restraint nets on air cargo pallets and nonstructural containers, restraint nets installed in cargo aircraft, and similar applications.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

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Documents
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2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

AS1131	Air and Air/Surface (Platform) Cargo Pallet Nets
AS1492	Interline Air Cargo Pallet Nets
AS5385	Cargo Restraint Straps - Design Criteria and Testing Methods
AS6554	Cargo Stopper Devices

2.1.2 U.S. Government Publications

A-A-55242	Webbing, Textile; Polyester, Low Elongation
MIL-W-4088	Webbing, Textile, Woven Nylon
MIL-W-27265	Webbing, Textile, Woven Nylon, Impregnated

2.1.3 ANSI Accredited Publications

Copies of these documents are available online at <http://webstore.ansi.org/>.

ISO 4115	Air Cargo Equipment - Air/Land Pallet Nets
ISO 4170	Air Cargo Equipment - Interline Pallet Nets
ISO 8647	Environmental Degradation of Textiles Used in Air Cargo Restraint Equipment
ISO 16049-1	Air Cargo Equipment - Restraint Straps - Part 1: Design Criteria and Testing Methods

2.1.4 IATA Publications

Available from International Air Transport Association, Publications Assistant, 800 Place Victoria, P.O. Box 113. Montreal, Quebec H4Z 1M1, Canada, Tel: 1-514-874-0202, www.iata.org.

IATA, Unit Load Devices (ULD) Regulations

2.2 Applicable References

- 2.2.1 Sunlight Exposure of Nylon Webbing, Technical Note WCRT 54-249; Wright Air Development Center, ARDC, United States Air Force, Wright-Patterson AFB, Ohio, December 1954
- 2.2.2 Comparative Chemical Resistance of Fibers, Bulletin X-48. E.I. DuPont de Nemours & Co., Textile Fibers Department, March 1956
- 2.2.3 Comparative Heat Resistance of Fibers, Bulletin X-56. E.I. DuPont de Nemours & Co., Textile Fibers Department, September 1956
- 2.2.4 Tensile Stress-Strain Properties of Fibers, Bulletin X-82. E.I. DuPont de Nemours & Co., Textile Fibers Department, May 1958
- 2.2.5 Light Resistance of Industrial Fiber Products, Bulletin X-189. E.I. DuPont de Nemours & Co., Textile Fibers Department, April 1964

- 2.2.6 A Contribution to the Research on the Aging of Textiles, Internal Report 1B152-75/15. German Research and Testing Institution for Aeronautics and Astronautics, Plastics Section, Braunschweig, West Germany, June 25, 1975
- 2.2.7 The Effects of Ultraviolet Light on Products Based on Fibers of Kevlar® 29 and Kevlar® 49 Aramid, Information Report C-29, E.I. DuPont de Nemours & Co., Textile Fibers Department, Wilmington, Del. USA 1977
- 2.2.8 Lifting Trials to Compare the Performances of Nylon & Polyester Braids & Webbing, Report BG 067, Bridport-Gundry, Ltd., Bridport, Dorset, England, May 1981
- 2.2.9 Material Strength Report, Report 35 -22996, Bruggeman & Brand, Wetter, Ruhr Germany, January 1986
- 2.2.10 Tensile Strength Degradation Results - 5 Year Outdoor Exposure Trials, Report MTR 08/109 2nd issue, AmSafe Bridport, The Court, Bridport, Dorset, DT6, 3QU, England, November 2008

3. TYPES OF DEGRADATION

Many factors can contribute to the degradation process. They are as follows:

- a. The natural environment factors of light and heat including ultraviolet exposure.
- b. The atmospheric pollution from industrial emissions.
- c. The exposure to various destructive chemicals.
- d. The washing powders and immersion in saltwater.

4. FACTORS INFLUENCING DEGRADATION (see 2.2.1, 2.2.2, 2.2.3, 2.2.4, and 2.2.5)

Natural and man-made fibers can be degraded by exposure to sunlight or to light rays from other sources. Industrial fiber products such as rope and webbing degrade at a much slower rate than fibers in yarn form; nevertheless, prolonged exposure can cause a loss in breaking strength, breaking elongation, and toughness. These properties are especially important in industrial fiber products.

4.1 Influence of Wavelength

Tests conducted by DuPont as well as experience show the primary cause for light degradation of fibers is ultraviolet rays with wavelengths between 290 millimicron and 400 millimicron. Radiation of shorter wavelengths, including gamma rays, damages fibers; however, this radiation is seldom encountered by fiber products. Radiation of longer wavelengths (that is, the visible and infrared rays), also damages some fibers, but this damage is minor compared to that from ultraviolet rays. Such radiation could, however, cause an increase in fiber temperature, which might result either in heat degradation or in accelerated ultraviolet degradation of the fiber.

The spectral distribution of the energy of the sun's radiation reaching the earth is about 5% in the ultraviolet region, 40% in the visible, and 55% in the infrared. These percentages vary with the seasons, time of day, atmospheric conditions, latitude, and altitude.

4.2 Influence of Other Factors

The deterioration of a fiber by sunlight or other radiation depends on a number of factors. A brief discussion of some of these factors follows:

4.2.1 Geographical Location of Exposure

Sunlight deterioration of fibers is more rapid at certain geographical locations than at others. This is due to differences in the duration and intensity of radiation in the particular wavelengths that damage fibers.

4.2.2 Time of Year When Exposed

The rate of sunlight deterioration of fibers also varies with the time of year of exposure. At most locations, deterioration is considerably more rapid in summer than in winter because of the relatively higher amount of ultraviolet radiation during the summer months.

4.2.3 Type of Exposure

Window glass filters out part of the ultraviolet rays from the sun; thus, the deterioration of fibers exposed behind glass is generally less rapid than that of fibers exposed outdoors. Fluorescent lamps having appreciable radiation in the ultraviolet range of wavelengths can cause deterioration of fibers, especially when unprotected fiber products are stored in close proximity to such lamps for long periods of time. Accelerated light deterioration tests are often made by exposing fiber products to radiation from carbon-arc lamps or xenon-arc lamps. Xenon arc lamps produce a spectral distribution much more closely resembling natural sunlight than do carbon-arc lamps. When interpreting the results of such tests it should be recognized that:

- a. The critical wavelengths differ for different fibers.
- b. The spectral distribution, temperature, and moisture conditions are likely to be quite different from those encountered in actual use of fiber products.

4.2.4 Size or Thickness of Fiber Structure

The light resistance of a single filament or single fiber increases with denier because less of the damaging radiation penetrates into the interior of the filament or fiber. This same principle applies to most cords and ropes since the outer fibers protect the inner fibers.

4.2.5 Materials Added in Fiber Manufacture

The amount of delustrant present in a fiber may greatly increase the rate of light deterioration. Bright fibers usually have better light resistance than semi-dull fibers which, in turn, usually have better resistance than dull fibers. Other pigments and additives incorporated in the polymer can be quite effective in improving the light and heat resistance of fibers.

4.2.6 Effect of Dyes, Finishes, and Other Agents

The effect of agents (coatings, dyes, finishes, etc.) applied to a fiber was not evaluated in the later Florida outdoor-exposure test; however, this effect is significant enough to warrant comment in the DuPont report (see 2.2.5).

The rate of deterioration of fibers may be affected appreciably by the presence of dyes; hence, this effect should be investigated whenever light durability is important. Dyes can have a positive, negative, or nearly-neutral effect on nylon strength retention under ultraviolet exposure - it depends on the specific characteristics of the dyestuff used. Some dyes adversely affect the light resistance to fibers. Others, including many of the "Capracyl" dyes and some of the "Pontamine" dyes, are very effective in increasing the light resistance of nylon 6-6. For instance, a 12.7 mm (1/2 inch) diameter rope of DuPont nylon dyed with 5% "Capracyl" yellow NW retained 80% of its original strength after 18 months of direct exposure to Florida sunlight and weather, while the same rope in the undyed state retained only 50% of its strength during exposure under exactly the same conditions.

5. CONCLUSIONS BY THE WRIGHT AIR DEVELOPMENT CENTER ON "SUNLIGHT EXPOSURE TEST OF NYLON WEBBING" - TEST CONDUCTED DECEMBER 1954 (see 2.2.1)

- 5.1 Olive drab color webbing has better ultraviolet resistance than natural colored webbing.
- 5.2 Strength retention of olive drab resin-treated webbing was superior to that of olive drab untreated webbing.
- 5.3 Resin-treated natural color webbing and natural color untreated webbing lost approximately the same amount of strength
- 5.4 Latex-treated, olive drab color webbing lost more breaking strength at most exposure times than resin-treated olive drab color webbing.

6. OUTDOOR EXPOSURE TEST - 1975 TO 1976

6.1 The samples of webbing and thread used in the tests were representative samples of materials used in the construction of cargo nets, tie-down straps, and barrier nets.

6.2 Exposure Conditions

6.2.1 Geographical Location

United States of America, Torrance, CA.

6.2.2 Season of Year

May 22, 1975 to August 22, 1976 (15 months).

6.2.3 Type of Exposure

Out-of-doors in direct sunlight. No attempt was made to measure radiation. Torrance, CA, is a light industrial complex which emits an indeterminate amount of pollutants into the atmosphere. Although near the Los Angeles County smog area, Torrance is relatively free from noticeable smog because of prevailing sea breezes.

6.2.4 Exposure Period

Continuous exposure 24 hours per day for a period of 15 months. One rope exposure test was, however, for 12 months.

6.2.5 Weather Conditions

A stochastic analysis of the weather conditions was made from U.S. Department of Commerce weather summaries for the Los Angeles-Long Beach area. About 95% of the days were overcast in the mornings until approximately 11:00 a.m. About 4% of the days experienced rain, and about 7% of the days were mostly or completely overcast.

6.3 Test Condition

6.3.1 A broad sampling of commercially available webbing and thread were used in this test. A total of 29 different webbings and three thread samples were included. All specimens were suspended vertically and faced due north when mounted on the exposure stand.

6.3.2 No weights were attached to the ends of each specimen.

6.3.3 Breaking strength of the specimens was determined at 21 °C (70 °F) 65% relative humidity using a 27272 kg (60000 lbf) tensile tester.

6.3.4 Percent strength retained after exposure was calculated from the breaking strength of the unexposed specimens.

6.4 Analysis of Test Results

The percent of original breaking strength retained by the specimens after exposure is a measure of the outdoor durability of the test items.

Data for percent strength retained is tabulated in Tables 1, 2, and 3. The progressive rates of strength loss are shown in graphs in Figures 1 through 5.

6.4.1 Color

Generally, the most weather resistant webbings are those dyed with darker colors such as olive drab.

6.4.2 Weave

Webbings and the rope in the heavier strength ranges were also much more weather resistant. This can be explained by the webbing weave patterns, which hide many fibers from direct exposure. As an example, some heavy webbings have a stiffer weave with parallel strength members buried under a top and bottom warp. This type of weave weakens less than a plain weave where strength members weave from top to bottom and are directly exposed to sunlight.

6.4.3 Material

Generally, the polyesters retained their strength far better than nylon. The exception was the 4000 pound capacity nylon rope.

Table 1 - Ultraviolet and corrosive atmosphere tests

Webbing Description	Color	Control Sample Strength lbf (kg)	Strength in lbf (kg) after 450 Days Exposure	% Retention
Type 25 nylon resin treated	White	4540 (2064)	2000 (909)	44
Type 25 nylon resin treated	Olive	5120 (2327)	2800 (1273)	54
Type 25 nylon resin treated	Drab	5320 (2418)	2400 (1091)	45
Type 25 nylon resin treated	Blue	5100 (2318)	1960 (891)	38
Type 25 nylon resin treated	Red	4940 (2245)	2690 (1223)	54
Polyester Type 25 resin treated	Black	4700 (2136)	2860 (1300)	60
Polyester Type 25 resin treated	Blue	4700 (2136)	2500 (1136)	53
Polyester Type 25 resin treated	White	4500 (2045)	3080 (1400)	68
Type 17 nylon resin treated	Olive	3600 (1636)	1180 (536)	32
Type 17 nylon resin treated	Drab	3600 (1636)	1940 (882)	54
Type 17 nylon resin treated	Red	3130 (1423)	1230 (559)	39
Type 17 nylon resin treated	Black	3300 (1500)	1200 (555)	37
Type 17 nylon resin treated	Blue	3560 (1618)	1060 (482)	29
Polyester resin treated (spec)	White	3260 (1482)	1240 (564)	38
Polyester resin treated (spec)	Blue	2760 (1255)	1940 (882)	70
Polyester resin treated (spec)	Pink	2920 (1327)	1600 (727)	55
Nylon Type 18 resin treated	Olive	7040 (3200)	3300 (1500)	47
Nylon Type 18 resin treated	Drab	7000 (3182)	2000 (909)	28
Nylon Type 18 resin treated	White			

Table 2 - Ultraviolet and corrosive atmosphere tests

Webbing Description	Color	Control Sample Strength lbf (kg)	Strength in lbf (kg) after 450 Days Exposure	% Retention
Type 13 resin treated	Red	7800 (3545)	2700 (1227)	34
Type 13 nylon not treated	White	8440 (3836)	2220 (1009)	26
Type 13 nylon resin treated	Blue	8120 (3691)	3340 (1518)	41
Type 13 nylon resin treated	Olive	8360	4200	50
	Drab	(3800)	(1909)	
Polyester 6500 lb not treated rating	Red	6730 (3059)	4620 (2100)	68
Type 19 nylon resin treated	White	11240 (5109)	5900 (2682)	52
Type 19 nylon resin treated	Olive	11600	6800	58
	Drab	(5273)	(3091)	
Type 26 nylon not treated	White	15500 (7045)	5400 (2455)	35
X-581 nylon not treated	White	18700 (8500)	8040 (3655)	43
Polyester, Type 5 not treated	White	10640 (4836)	7500 (3409)	70
Polyester, Type 6 not treated	White	18600 (8455)	12500 (5682)	67
Bridport Gundry	Yellow	2600 (1182)	1500 (682)	58
Nylon braided rope				
Bridport Gundry	Yellow	4000	3000	75
Nylon braided rope		(1818)	(1364)	

Table 3 - Ultraviolet and corrosive atmosphere tests thread tests

Description of Thread	Color	Control Sample Strength lbf (kg) ¹	Strength in lbf after 450 Days Exposure ¹	% Retention
Number 3 cord nylon	White	3390 (1541)	1560 ² (709)	46
Number 3 cord nylon	Olive	3790 (1723)	2160 ³ (982)	57
Number 3 cord polyester	White	3160 (1436)	1920 ³ (873)	60

¹72 stitch sewing pattern 3/4 inch (19 mm) square²Thread failure³Webbing failure at stitching

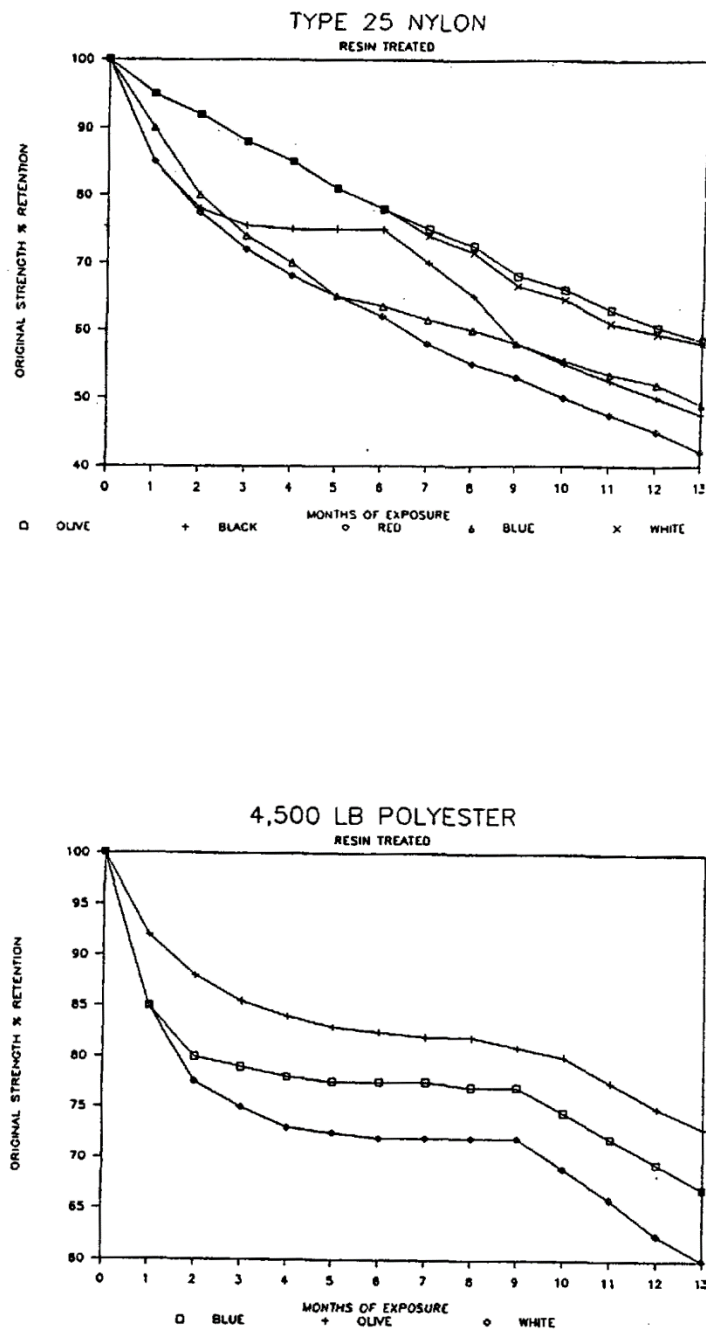


Figure 1

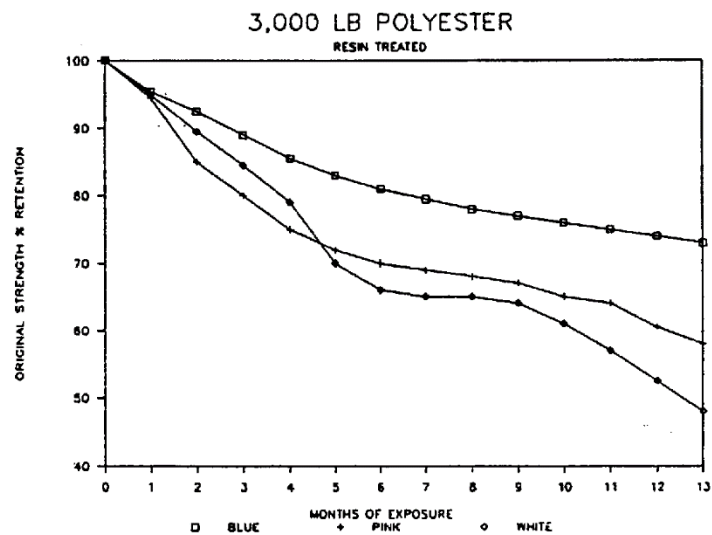
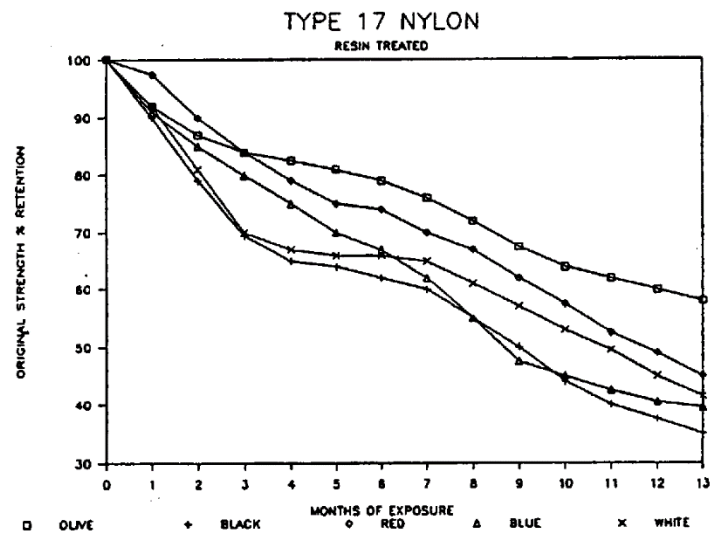


Figure 2