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ENVIRONMENTAL STABILITY TESTING OF A COATED, ELASTOMERIC DENTAL--ETC(U)
SEP 79 G J SHEMAKA, W W TENERO
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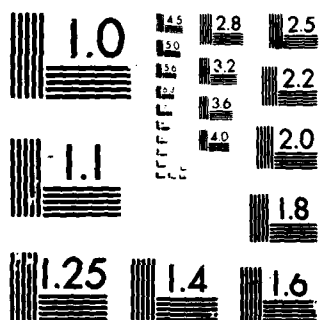
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REPORT #2

Environmental Stability Testing of a
Coated, Elastomeric Dental Ribbon

Final Report

Gary J. Shemaka
*William W. Tenero

Cooper Dental Products, Portland, Oregon
*Spring borne Industries, Enfield, Connecticut

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September, 1979

Supported by

U. S. ARMY MEDICAL RESEARCH AND DEVELOPMENT COMMAND
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Cooper Laboratories
110 E. Hanover Avenue
Cedar Knolls, New Jersey 07927

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) A coated, elastomeric dental ribbon developed by Dr. Paul Jaffe with Cooper Laboratories was taken through a series of physical tests at various environmental conditions to determine its suitability for military application. Tensile properties and Tensile Impact Strengths were determined at -40, 0, 73 and 120° Fahrenheit. Yield Strengths were 3730, 2170, 1130 and 1100 (p.s.i.) respectively. Break Strengths were 4150, 5030, 5260 and > 4500 (p.s.i.) respectively. Percent Elongations at breakage were 540, 640, 600 and > 700.			

(percent) respectively.) Modulus were 5.0, 0.18, 0.14 and 0.08 ($\times 10^5$ p.s.i.) respectively. The Tensile Impact Strengths were 180, 520, 580 and 720 (ft. -lbs./in.²) respectively.

The dental tape was placed in circulating air ovens at room temperature as a control, at 160°F with 90% relative humidity, at 194°F and 230°F for six and twelve weeks. After exposure, the specimens were removed and allowed to condition for a minimum of 40 hours at 73°F with 50% relative humidity. They were again tested for Tensile properties and Tensile Impact Strength. The Yield Strengths were 1130, 1630, 1830, 1380, 1390 and 2200 (p.s.i.) respectively. The Break Strengths were 5260, 4930, 3910, 2300, 1660 and 2700 (p.s.i.) respectively. The Percent Elongations at breakage were 600, 1060, 850, 790, 56 and 590 (percent) respectively. The Modulus were 0.14, 0.13, 0.14, 0.14, 0.13 and 0.71 ($\times 10^5$ p.s.i.) respectively. The Tensile Impact Strengths were 580, 331, 220, 500, 310 and 13 (ft. -lbs./in.²). Samples that were placed in the oven at 230°F for twelve weeks and samples at 266°F for 1, 3, 6 and 12 weeks were found too brittle to test.

No blocking was observed at -60, 73 and 160°F for a maximum of one month duration at 0.5 p.s.i. pressure. Little dimensional changes were noted at 160°F with 90% relative humidity, 194°F and 230°F, up to twelve weeks. Samples exposed at 266°F for six weeks were too brittle to be tested.

In conclusion, the coated elastomeric tape was found acceptable for use in a temperature range of 0 to 120°F. Due to high Modulus and low Tensile Impact Strength, the product will not function at -40°F. It was found suitable for storage at 194°F and 160°F with 90% relative humidity for twelve weeks. When stored at 230°F, the material proved too brittle for its intended use.

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Summary:

A coated, elastomeric dental ribbon developed by Dr. Paul Jaffe with Cooper Laboratories was taken through a series of physical tests at various environmental conditions to determine its suitability for military application. Tensile properties and Tensile Impact Strengths were determined at -40, 0, 73 and 120°Fahrenheit. Yield Strengths were 3730, 2170, 1130 and 1100 (p.s.i.) respectively. Break Strengths were 4150, 5030, 5260 and >4500 (p.s.i.) respectively. Percent Elongations at breakage were 540, 640, 600 and >700 (percent) respectively. Modulus were 5.0, 0.18, 0.14 and 0.08 (x 10 p.s.i.) respectively. The Tensile Impact Strengths were 180, 520, 580 and 720 (ft.-lbs./in.²) respectively.

The dental tape was placed in circulating air ovens at room temperature as a control, at 160°F with 90% relative humidity, at 194°F and 230°F for six and twelve weeks. After exposure, the specimens were removed and allowed to condition for a minimum of 40 hours at 73°F with 50% relative humidity. They were again tested for Tensile properties and Tensile Impact Strength. The Yield Strengths were 1130, 1630, 1830, 1380, 1390 and 2200 (p.s.i.) respectively. The Break Strengths were 5260, 4930, 3910, 2300, 1660 and 2700 (p.s.i.) respectively. The Percent Elongations at breakage were 600, 1060, 850, 790, 560 and 590 (percent) respectively. The Modulus were 0.14, 0.13, 0.14, 0.13 and 0.71 (x 10 p.s.i.) respectively. The Tensile Impact Strengths were 580, 331, 220, 500, 310 and 13 (ft.-lbs./in.²). Samples that were placed in the oven at 230°F for twelve weeks and samples at 266°F for 1, 3, 6 and 12 weeks were found too brittle to test.

No blocking was observed at -60, 73 and 160°F for a maximum of one month duration at 0.5 p.s.i. pressure. Little dimensional changes were noted at 160°F with 90% relative humidity, 194°F and 230°F, up to twelve weeks. Samples exposed at 266°F for six weeks were too brittle to be tested.

In conclusion, the coated elastomeric tape was found acceptable for use in a temperature range of 0 to 120°F. Due to high Modulus and low Tensile Impact Strength, the product will not function at -40°F. It was found suitable for storage at 194°F and 160°F with 90% relative humidity for twelve weeks. When stored at 230°F, the material proved too brittle for its intended use.

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Body of the Report:

Title: Environmental Stability Testing of a Coated, Elastomeric Ribbon

Objective:

To define and monitor the rate of degradation of various physical properties of a coated, elastomeric dental ribbon under several thermal and humidifying conditions. The physical properties investigated were Yield Strength, Break Strength, Percent Elongation at Breakage, Modulus, Tensile Impact Strength, Blocking Characteristics and Dimensional Changes.

Methods and Materials:

Cooper Laboratories supplied 500 coated Hytrel strips measuring 4 x 3/16 inches. Springborne Industries supplied the necessary conditioning chambers and instron units to perform the following tests:

- A. Tensile Properties at 120°F, 73°F, 0°F, and -40°F
A.S.T.M D882 and D759 Method A

Apparatus: Instron Tensile Tester TM
Grip Separation: 1.0 in. Str., 2.0 in. Mod.
Gauge Length: 1.0 in. Str., 2.0 in. Mod.
Crosshead Speed: 20.0 in./min. Str., 2.0 in./min. Mod.
Chart Speed: 5.0 in./min. Str., 20 in./min. Mod.
Load Range: 0-10 lbs. Str., 0-1 lb. Mod.

- B. Tensile Impact Strength at 120°F, 73°F, 0°F, and -40°F
A.S.T.M. D759 and D&R Spec

The strip specimens were tested for Tensile Impact Strength using a modified Baldwin Impact Tester. A specific fixture holds the specimen at 90° to the impact pendulum. A test gauge-length of 0.50 inches was used. The load capacity of the apparatus is 2 ft. -lbs.

- C. Degradation of Tensile Properties and Tensile Impact Strength when exposed at 194°F, 230°F, 266°F and 160°F at 90% Relative Humidity for six and twelve weeks.
A.S.T.M. D794 and E145

- D. Blocking Characteristics at 160°F, 73°F and -60°F
FTMS 101B method 3003 Procedure A

The specimens were tested dull side to dull side, shiny side to shiny side and dull side to shiny side. Periodically the specimens were checked for any sign of blocking by removing the 0.5 psi test load from the stack and pulling the sheets apart.

E. Dimensional changes when exposed at 194 F, 230 F, 266 F and 160 F at 90% Relative Humidity for six and twelve weeks. The widths were measured with a machinist's micrometer (to 0.001 inch) and the lengths were measured with a steel ruler (to 0.01 inch).

**Conditioning

Specimens tested at temperatures above and below room temperature were conditioned for a minimum of one hour at the test temperature. Aged specimens were conditioned for 40 hours at 73°F and 50% Relative Humidity prior to testing.

Results:A Tensile Properties at Various TemperaturesTable One: Yield Strength

<u>Test Temperature (F)</u>	<u>Averaged Yield Strength (PSI)</u>	<u>△ Percent from Control</u>
-40	3730	230
0	2170	92
73	1130	0
120	1100	-2.7

Table Two: Break Strength

<u>Test Temperature (F)</u>	<u>Averaged Break Strength (PSI)</u>	<u>△ Percent from Control</u>
-40	4150	-21.1
0	5030	-4.3
73	5260	0
120	>4500	N/A

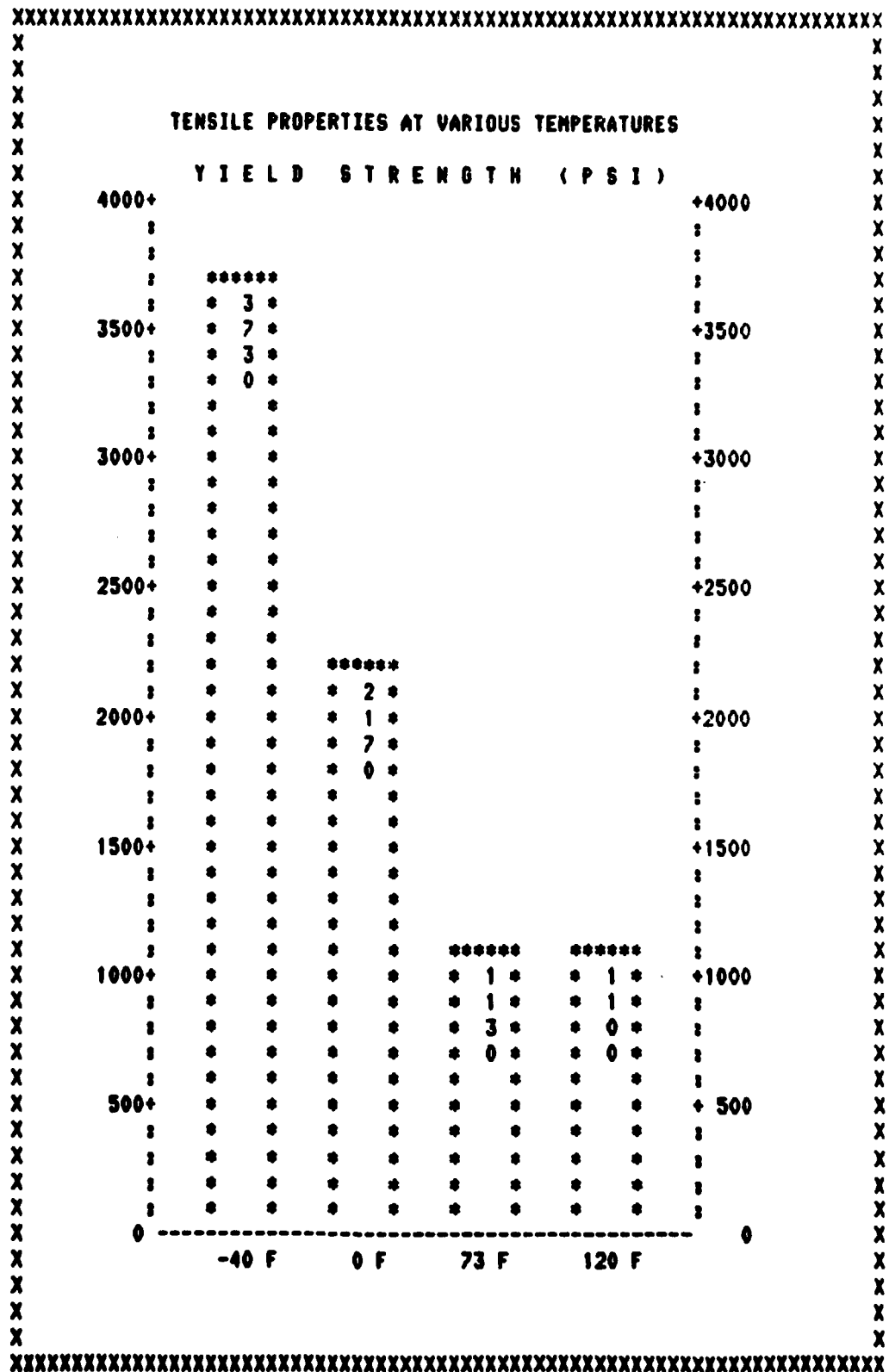
Table Three: Percent Elongation at Breakage

<u>Test Temperature (F)</u>	<u>Averaged % Elongation at Breakage (%)</u>	<u>△ Percent from Control</u>
-40	540	-10
0	640	6.7
73	600	0
120	>700	N/A

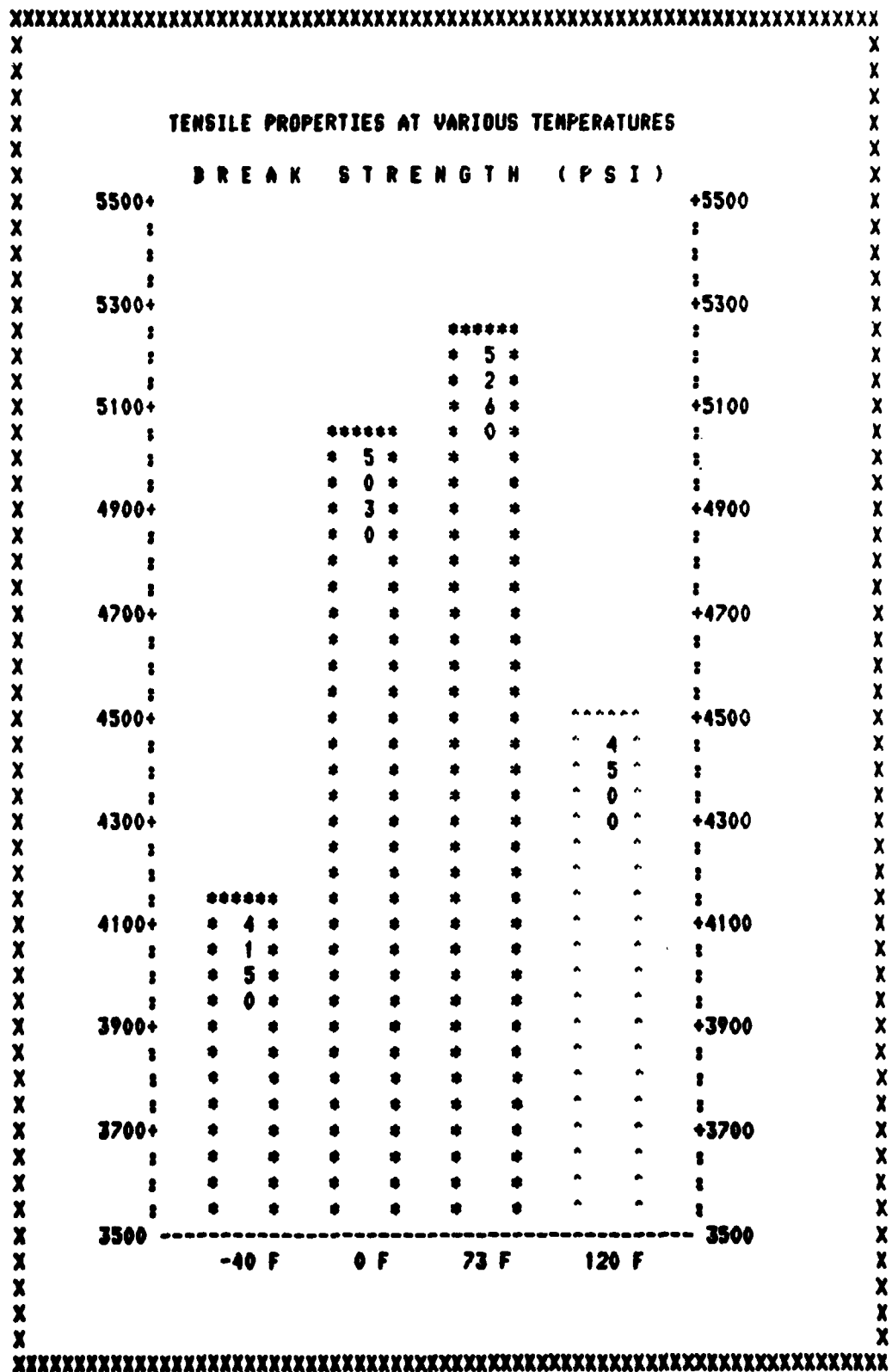
Table Four: Modulus

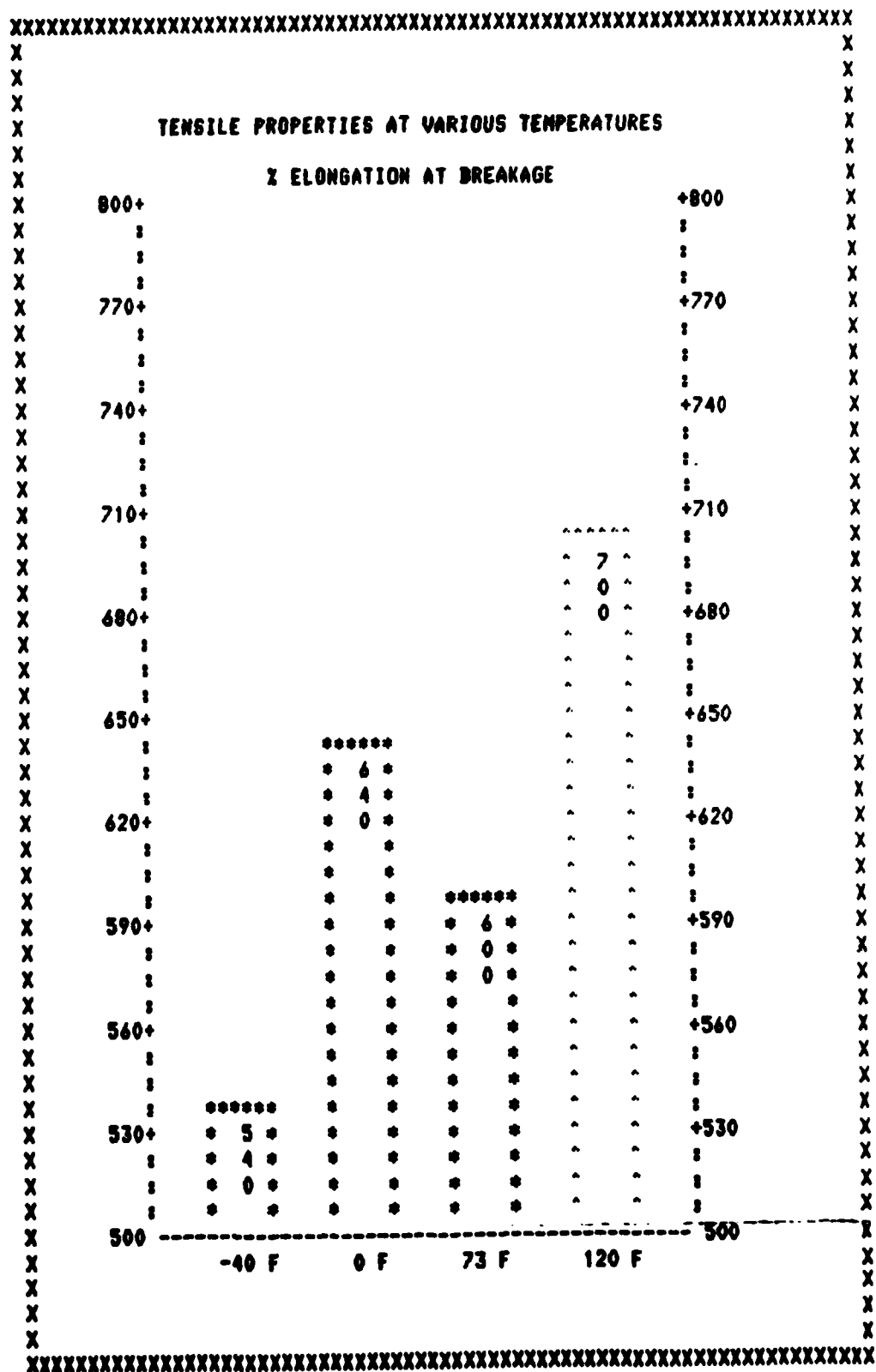
<u>Test Temperature (F)</u>	<u>Averaged Modulus (10⁵ p.s.i.)</u>	<u>△ Percent from Control</u>
-40	5.0	3471
0	.18	28.5
73	.14	0
120	.08	-42.9

Graph One:

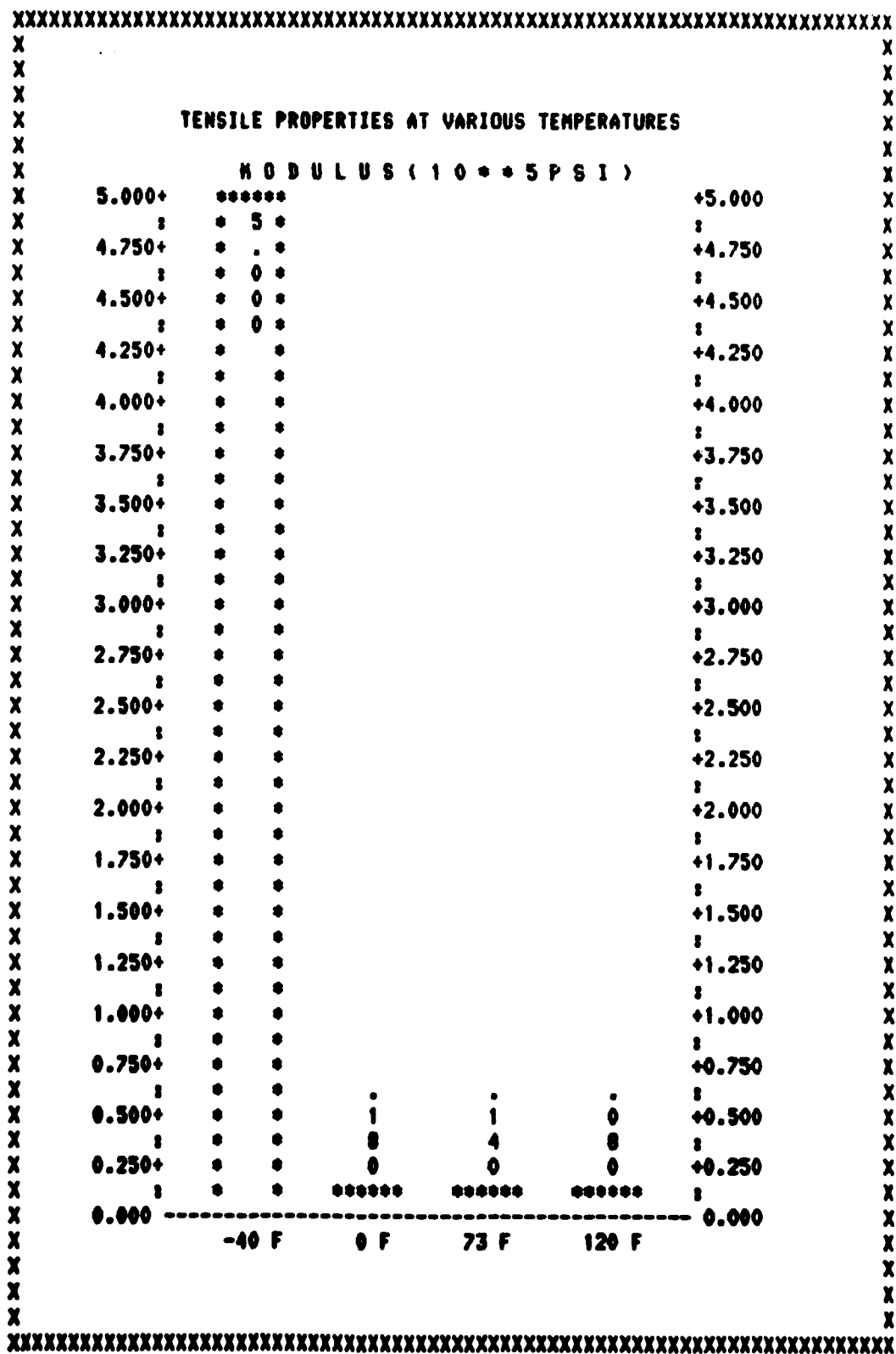


Graph Two:



Graph Three:

Graph Four:

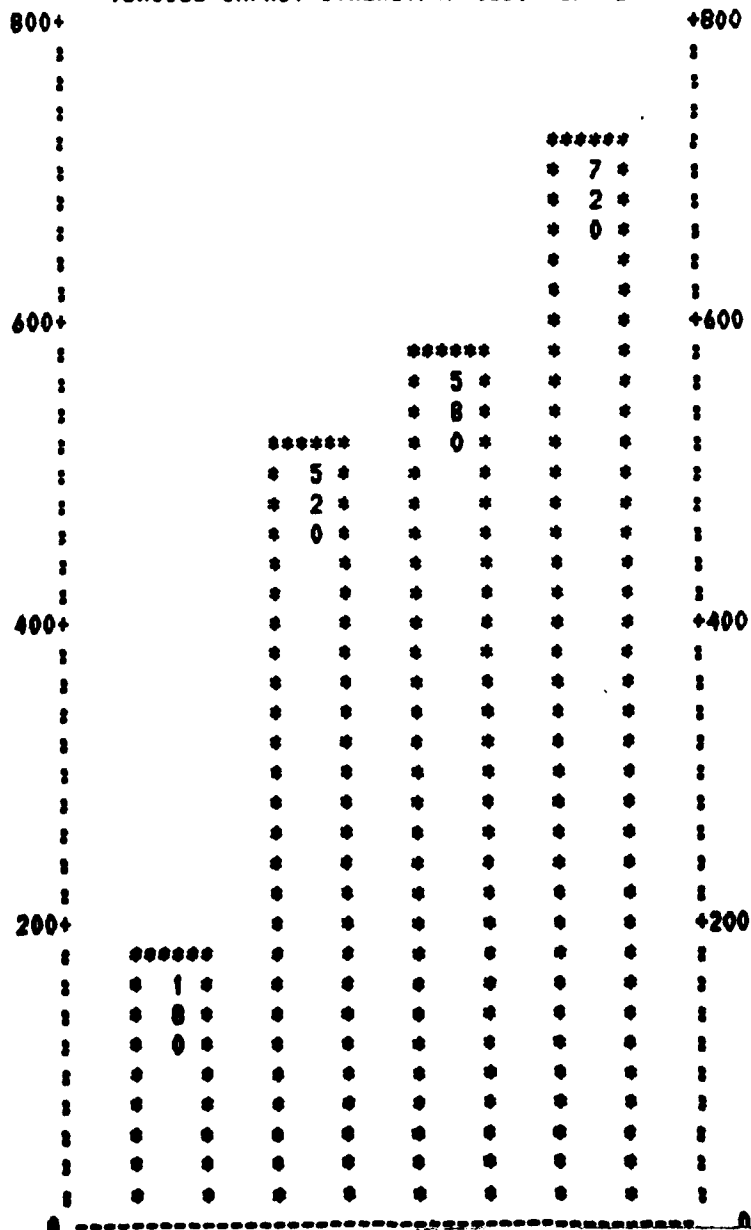


B Tensile Impact Tests at Various TemperaturesTable Five: Tensile Impact Strength

<u>Test Temperature (F)</u>	<u>Averaged Tensile Impact Strength (ft.-lbs./in.²)</u>	<u>△ Percent from Control</u>
-40	180	-68.9
0	520	-10.3
73	580	0
120	720	24.1

Graph Five

TENSILE IMPACT TEST AT VARIOUS TEMPERATURES

TENSILE IMPACT STRENGTH (FT. LBS./IN.²)

Results:C Tensile Properties at Various Thermal and Moisture ExposuresTable Six: Yield Strength

<u>Exposure Conditions</u>	<u>Averaged Yield Strength (PSI)</u>	<u>△ Percent from Control</u>
Control	1130	0
160°F, 90% R.H., 6 wks	1630	44.2
12 wks	1830	61.9
194°F 6 wks	1380	22.1
12 wks	1390	23.0
230°F 6 wks	2200	94.7
12 wks	Too brittle to test	
266°F 1 wk	Too brittle to test	
3 wks	Too brittle to test	
6 wks	Too brittle to test	
12 wks	Too brittle to test	

Table Seven: Break Strength

<u>Exposure Conditions</u>	<u>Averaged Break Strength (PSI)</u>	<u>△ Percent from Control</u>
Control	5260	0
160°F, 90% R.H., 6 wks	4930	-6.3
12 wks	3910	-25.7
194°F 6 wks	2300	-56.3
12 wks	1660	-68.4
230°F 6 wks	2700	-48.7
12 wks	Too brittle to test	
266°F 1 wk	Too brittle to test	
3 wks	Too brittle to test	
6 wks	Too brittle to test	
12 wks	Too brittle to test	

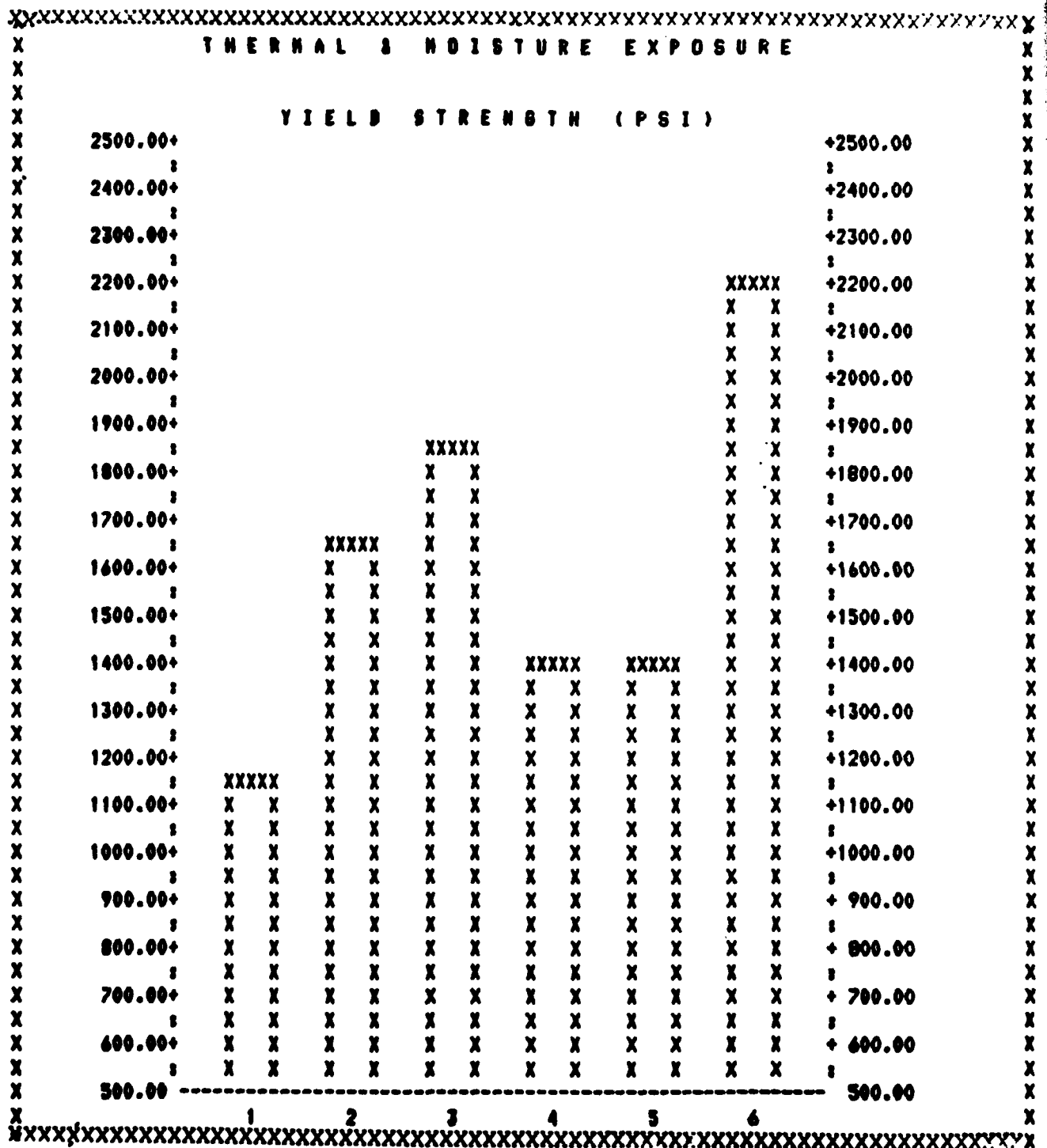
Results:C Tensile Properties at Various Thermal and Moisture ExposuresTable Eight: Percent Elongation at Breakage

<u>Exposure Condition</u>	<u>Elongation at Breakage</u>	<u>Δ Percent from Control</u>
Control	600	0
160°F, 90% R.H., 6 wks	1060	76.7
12 wks	850	41.7
194°F 6 wks	790	31.7
12 wks	560	-6.7
230°F 6 wks	590	1.7
12 wks	Too brittle to test	
266°F 1 wk	Too brittle to test	
3 wks	Too brittle to test	
6 wks	Too brittle to test	
12 wks	Too brittle to test	

Table Nine: Modulus

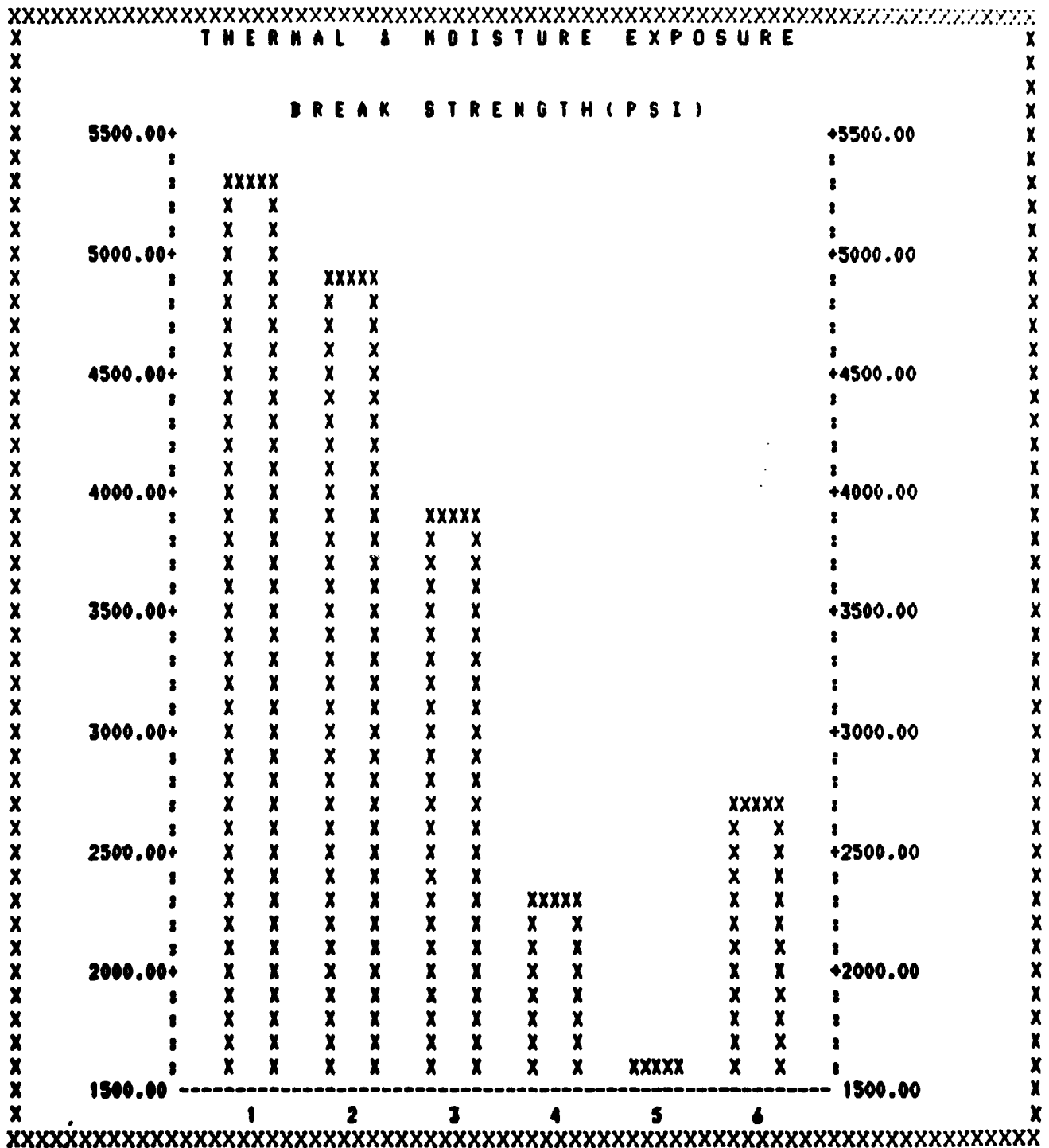
<u>Exposure Condition</u>	<u>Averaged Modulus</u>	<u>Δ Percent from Control</u>
Control	0.14	0
160°F, 90% R.H., 6 wks	0.13	-7.1
12 wks	0.14	0
194°F 6 wks	0.14	0
12 wks	0.13	-7.1
230°F 6 wks	0.71	407.1
12 wks	Too brittle to test	
266°F 1 wk	Too brittle to test	
3 wks	Too brittle to test	
6 wks	Too brittle to test	
12 wks	Too brittle to test	

Graph Six

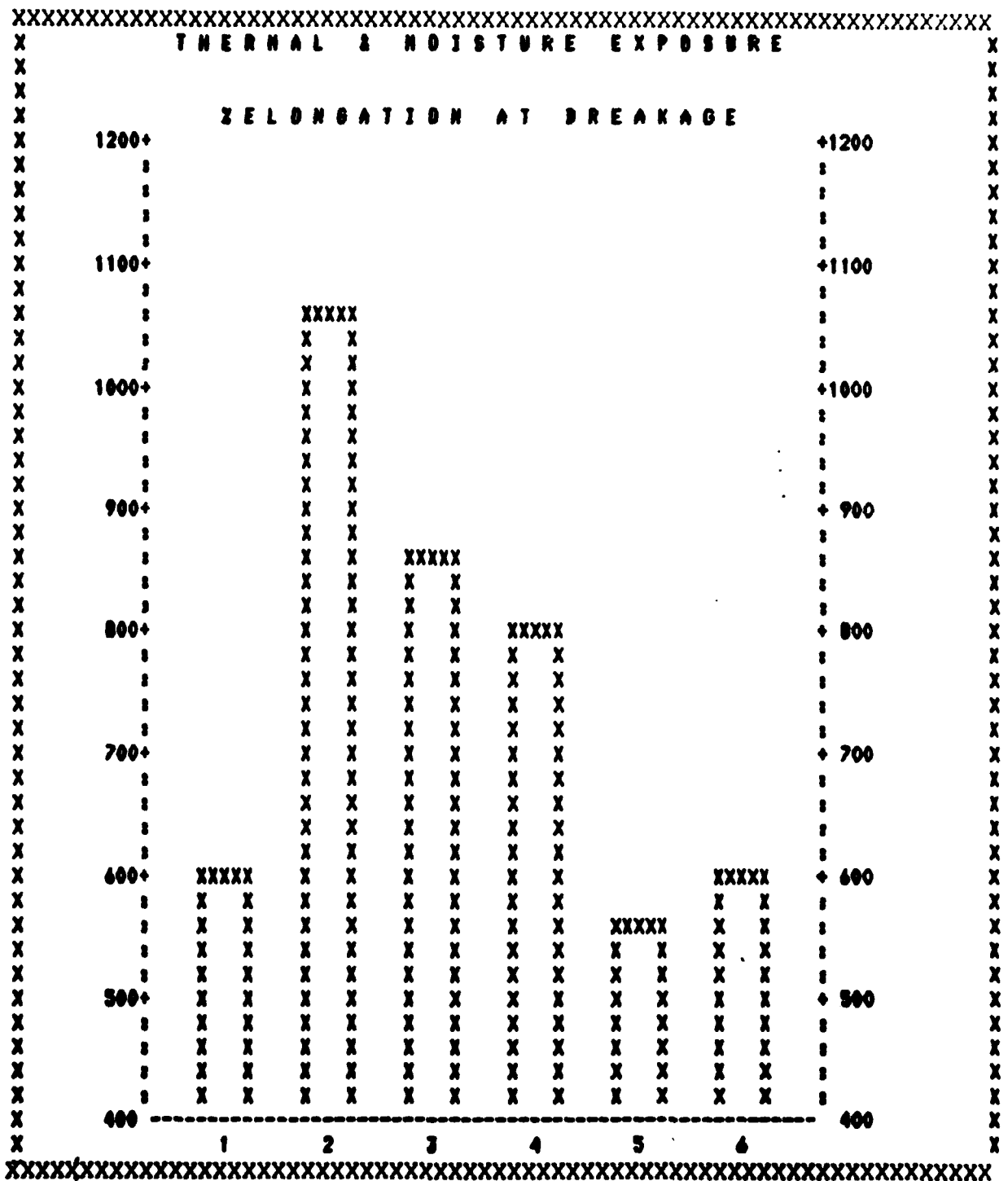


Bar	Exposure Condition	Value
1	Control	1130
2	160°F, 90% R.H., 6 wks	1630
3	12 wks	1830
4	194°F 6 wks	1380
5	12 wks	1390
6	230°F 6 wks	2200

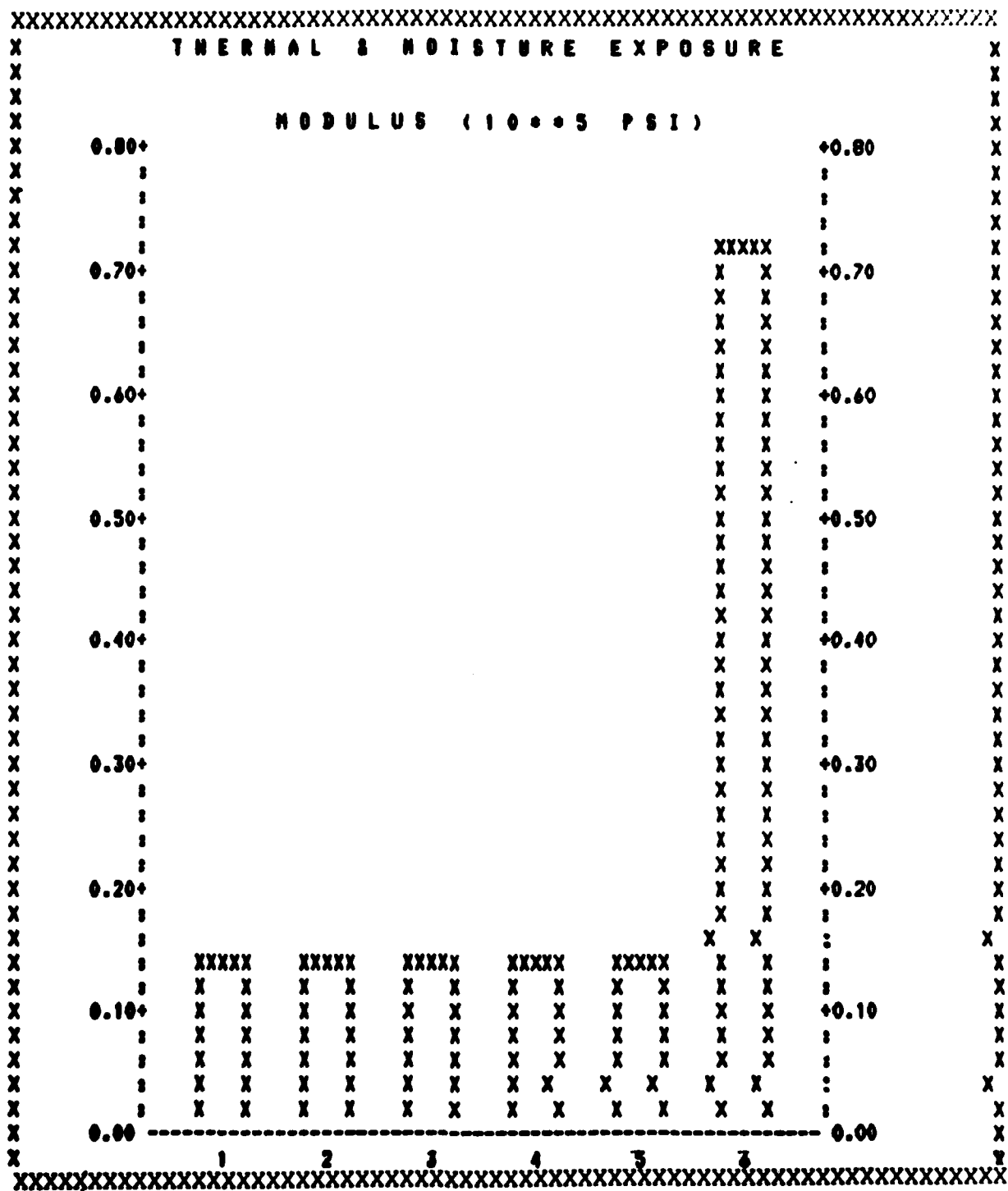
Graph Seven



<u>Bar</u>	<u>Exposure Condition</u>	<u>Value</u>
1	Control	5250
2	160°F, 90% R.H., 6 wks	4930
3	12 wks	3910
4	194°F 6 wks	2300
5	12 wks	1600
6	230°F 6 wks	2700

Graph EightBarExposure ConditionValue1
2
3
4
5
6Control
160°F, 90% R.H., 6 wks
12 wks
194°F
6 wks
12 wks
230°F
6 wks600
1060
950
7250
560
590

Graph Nine

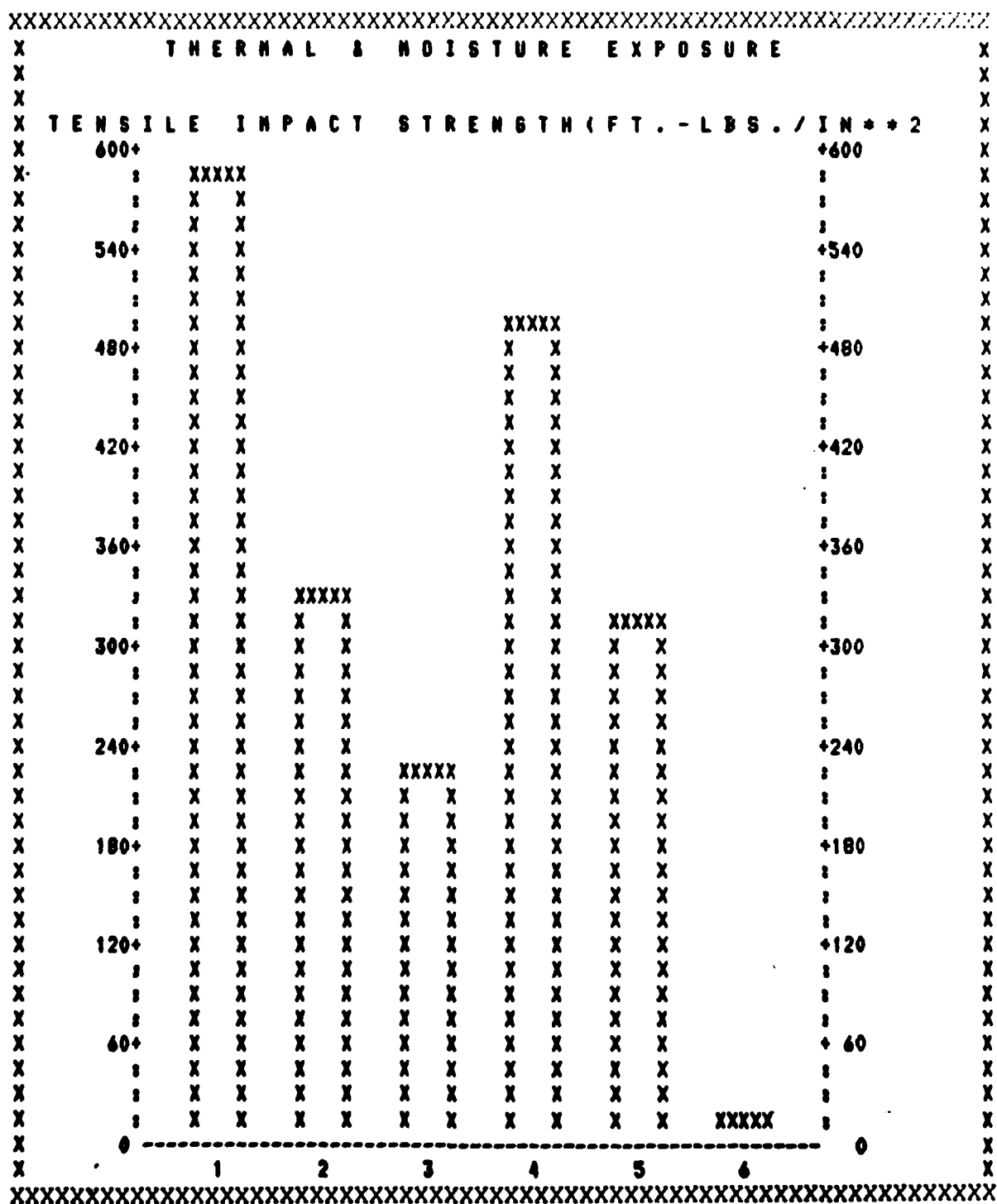
BarExposure ConditionValue1
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6Control
160°F, 90% R.H., 6 wks
12 wks
194°F
12 wks
230°F
6 wks0.14
0.13
0.14
0.14
0.13
0.71

Results:D Tensile Impact Test at Various Thermal & Moisture ExposuresTable Ten: Tensile Impact Strength

<u>Exposure Condition</u>	<u>Averaged Tensile Impact Strength (ft.-lbs./in²)</u>	<u>Δ Percent from Control</u>
Control	580	0
160°F, 90% R.H., 6 wks	331	-42.9
12 wks	220	-62.1
194°F 6 wks	500	-13.8
12 wks	310	-46.6
230°F 6 wks	13	-97.8
12 wks	Too brittle to test	
266°F 1 wk	Too brittle to test	
3 wks	Too brittle to test	
6 wks	Too brittle to test	
12 wks	Too brittle to test	

E Blocking Characteristics at Various TemperaturesTable Eleven

<u>Test Conditions</u>	<u>Test Results</u>
-60°F	
after 1 day	no blocking
after 1 week	no blocking
after 1 month	no blocking
73°F	
after 1 day	no blocking
after 1 week	no blocking
after 1 month	no blocking
160°F	
after 1 day	no blocking
after 1 week	no blocking
after 1 month	no blocking

Graph TenBarExposure ConditionValue

1	Control	580
2	160°F, 90% R.H., 6 wks	331
3	12 wks	220
4	194°F	500
5	12 wks	310
6	230°F	13

Results:F Dimensional Changes at Various ConditionsTable Eleven

<u>Exposure Conditions</u>	<u>Δ Percent Length</u>	<u>Δ Percent Width</u>
160°F, 90% R.H., 6 wks	0.0	+0.1
194°F 6 wks	+0.3	-0.3
12 wks	+0.2	-0.6
230°F 6 wks	+0.2	-0.9
12 wks	+0.04	-0.9
266°F 1 wk	-0.2	+0.2
3 wks	-0.2	-0.5
6 wks	Too brittle to test	
12 wks	Too brittle to test	

Discussion:

The regular use of dental floss to remove interproximal plaque accumulation is an important factor in controlling dental disease. The dental tape studied in this project was felt to have several positive benefits in a mobile military environment.

To assure its stability under hostile environmental conditions, the coated elastomer ribbon was subjected to various thermal conditions. It was found acceptable for use in a temperature range of 0 to 120°F. Due to high Modulus and low Tensile Impact Strength, the product will not function at -40°F. Break Strength and Percent Elongation at breakage could not be accurately determined at 120°F due to limitation of the machinery used in the study.

The coated, elastomeric dental ribbon was found suitable for storage at 194 F and 160°F with 90% relative humidity for 12 weeks. Heat aging characteristics may be improved by the incorporation of an antioxidant upon extrusion of the tape.

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