(2)

DURABILITY EVALUATION OF ASSAULT SNOWSHOES

NAVY CLOTHING AND TEXTILE RESEARCH FACILITY
NATICK, MASSACHUSETTS

NCTRF NO. 198

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	March 1993	Final

4. TITLE AND SUBTITLE

DURABILITY EVALUATION OF ASSAULT SNOWSHOES

5. FUNDING NUMBERS

62623M

6. AUTHOR(S)

Hall, Ronald

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Marine Corps Systems Command
(Attn: Capt Tillman)
Program Manager, Combat Systems Support
Quantico, VA 22134-5080

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

M9545092WRQ2AST
#M95450WR02

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for Public Release; Distribution Unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

Snowshoes selected by the Marine Corps were laboratory evaluated by the Navy Clothing and Textile Research Facility to ascertain durability/performance characteristics in support of the Soldier/Marine Enhancement Program. The snowshoes were obtained from three commercial manufacturers, incorporating distinct design and construction features. The three types evaluated included: (1) Atlas "Model 1022", (2) Redfeather "Goshawk" and (3) Tubbs "Katahdin". The components of the snowshoes (i.e., decking, framing, etc.) were subjected to a variety of physical tests to compare durability. A wear evaluation was also conducted by NCTRF laboratory personnel to ascertain comfort, wearability, and durability characteristics. Results of testing are somewhat inconclusive, due to lack of specific Marine Corps requirements. Each of the three snowshoes possessed positive and negative features, along with distinct design/construction characteristics which led to a difficult comparison between them. Based solely on the results of laboratory testing and not considering the cost factor , the Redfeather would be recommended.

14. SUBJECT TERMS	15. NUMBER OF PAGES
snowshoes; wearability; durability; laboratory evaluation	18
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UNLIMITED

This effort supports MCRDT&E Project (C2086) (Soldier/Marine Enhancement), (P.E. 62623M). The evaluation was conducted for:

Marine Corps Systems Command
(ATTN: Capt Tillman)
Program Manager, Combat Systems Support (SSC)
Quantico, VA 22134-5080

This effort was partly funded under Document #M9545092WRR2AST, Reference #M95450WR02 - Durability Evaluation of the Assault Snowshoe Prototype.

Durability Evaluation of Assault Snowshoes

I. DESCRIPTION of TEST ITEMS:

a. ATLAS SNOWSHOE

Mfgr: Atlas Snowshoe Company
2269 Chestnut Street
No. 868
San Francisco, CA 94123
Tel. (415) 703-0414

Model No.: 1022

Frame: 0.75" aluminum one piece tubing welded at tail
0.035" wall thickness

Decking: coated fabric riveted around the frame with double layer at heel area which is riveted and stitched

Hinge: 7/8"x3/32" thick rubber strap with double layer fabric reinforcement

Crampon: Non-removable crampons on sole and heel
(0.125" aluminum)

Color: Black decking with silver frame

Photo: See attachment (1) for front and rear view

b. REDFEATHER SNOWSHOE

Mfgr: Redfeather Design Inc.
332 West Main Street
Aspen, CO 81611
(303) 925-5333

Model: Goshawk

Frame: 0.75" anodized aluminum one piece tubing riveted at tail
0.035" wall thickness

Decking: HYPALON® coated fabric riveted around frame

Crampons: Removable 1/16" stainless steel

Hinge: 1-5/16"x1/8" thick rubber strap with double fabric reinforcement

Color: Black deck with gray frame

Photo: See attachment (1) for front and rear view

c. **TUBBS SNOWSHOES**

Mfgr: Tubbs Snowshoes
Stowe Canoe and Snowshoe Co., Inc.
P.O. Box 207
Stowe, VT 05672
Tel. (802) 253-7398

Model: Katahdin

Frame: 0.75" aluminium tubing, two piece design joined at the hinge (sleeved)

Decking: QUADEX® polymer material decking fastened to frame with lacing

Crampons: Removable 1/16" stainless steel

Hinge: Bindings swivel on metal bar

Color: Teal and purple decking with teal lacing and silver frame

Photo: See attachment (1) for front and rear view

II. RESULTS AND DISCUSSION:

Three snowshoes were received for laboratory evaluation, incorporating distinct design features and constructions. Due to these differences in design and type of materials used in the snowshoes, some test methods and numbers of specimens tested had to be modified. In some cases, it was not possible to perform the same tests on all snowshoes.

The snowshoes are identified as Atlas, Redfeather, and Tubbs. All snowshoes have aluminum frames but the Redfeather snowshoes were anodized. The Tubbs snowshoe uses a two piece frame design along with decking that attaches to the frame by lacing. The Atlas and Redfeather snowshoes decking is riveted to the snowshoe frame.

The Atlas snowshoe has a non-removable crampon design while both Redfeather and Tubbs utilize removable crampons which screw into a base plate. The Atlas crampons are aluminum, while the Redfeather and Tubbs are stainless steel.

The snowshoes are all designed to be worn on either the right or left foot, depending on what side the wearer prefers to have the bindings close.

As shown in Section II (paragraphs a and b), based on overall weight of a pair from each supplier, the Redfeather snowshoes, including crampons, are the lightest. The Tubbs snowshoes are the heaviest in overall weight. The deck materials range in weight from 39.2 to 45.4 oz/yd^2, with Redfeather having the lightest material and Tubbs, the heaviest.

Both Atlas and Redfeather deck materials have similar thicknesses, but the Tubbs deck is approximately 25% thicker than the other snowshoes [see Section II (paragraph c)].

Section II (paragraph d) discusses the decking of the snowshoes. The Atlas snowshoe is an unidentified coated fabric which in cross-section is equally coated on both sides of the material. The Redfeather decking is also a coated fabric, which is identified as Hypalon® and is visually thicker on one side of the fabric substrate compared to the other. The Tubbs snowshoe decking is identified as "QUADEX"® polymer, a solid plastic.

Abrasion testing (Section II, paragraph e) was conducted on the deck materials based on 5000 cycles using a double head rotary abrader with non-resilient, vitrified wheels with medium abrasive properties normally used for rubber, coated fabrics, and plastics. A 500 gram total load was applied during test. A change in thickness was measured initially and after completion of the 5000 cycles. The Tubbs decking had the least amount of material removed, while Atlas and Redfeather lost 8.5% of their coating.

Abrasion resistance of the decking materials (Section II, paragraph f) was determined using the folding bar #14 of the Stoll abrader. The test was conducted for a specified number of cycles (5000) and subsequently until destruction of the test specimens. The Tubbs material could not be tested because it is too stiff to insert into the test apparatus. The Redfeather decking was tested with both sides facing the cutting edge of the folding bar due to the asymmetrical coating. The thicker side of the Redfeather decking was twice as resistant to abrasion as the thin side. The Atlas decking results were equivalent to the thin side of the coating on the Redfeather decking.

Deflection and Permanent Set testing (Section II, paragraph g) was conducted by placing the snowshoe frame on 4"x4" wood supports over the test table. The heel section was tested with a thirty pound load on a 2"x3" loading block, while the hinge and center section had a two hundred pound load on an 8"x3" loading block. Three measurements were taken between the deck and the top of the test table at the heel section and at the hinge of the snowshoe in the following configurations:

Measurement #1 - with no weight on the snowshoe

Measurement #2 - with weight after one minute

Measurement #3 - after weight has been removed

Deflection was determined by subtracting measurement #2 from measurement #1. Permanent set was determined by subtracting measurement #3 from measurement #1. Atlas snowshoes exhibited the greatest deflection at the heel and hinge, followed by Redfeather and Tubbs. There was no permanent set of the heel areas of any snowshoes, but the Redfeather hinge exhibited 1/4 inch permanent set and both Atlas and Tubbs 1/8 inch.

Cold Temperature testing (Section II, paragraph i) was conducted at -40°F after a four hour exposure time. The test specimens were rolled with a ten pound steel roller and visually examined for any cracking, peeling or flaking of the coating or polymer. In addition, the test specimens were folded and rolled flat, which created crease lines in the Tubbs specimen. The general observation during cold testing was that the decking on all snowshoes became stiff, while straps and lacing remained flexible. The Atlas hook and pile fastener was difficult to remove. The Atlas heel strap pad became very stiff. This may cause a problem if boots or shoes are put on when very cold. Walking would cause it to lose its stiffness which would cause the bindings to loosen.

Tear strength (Section II, paragraph j) was performed on Atlas and Redfeather only. The Tubbs material was not tested because it stretches and does not tear. Both Atlas and Redfeather decking materials exceed the capacity of the heavy duty test equipment. Consequently, both materials are considered to possess outstanding tear resistance.

All the snowshoe materials, with the exception of the aluminum frames, were subjected to 80 hours of accelerated weathering (Section II, paragraph k). The components were visually examined for any change in color or fading. All snowshoes were acceptable after 80 hours of exposure.

Puncture resistance was conducted using the American National Standard Institute (ANSI) test method for resistance to upper penetration for footwear (see Section II, paragraph l). The test jig was modified to have the penetrometer exert its pressure from the bottom of the crosshead of the tensile testing apparatus operating at 20 inches per minute. Three punctures were made in each test specimen and three specimens from each snowshoe were tested. The Tubbs decking material had the greatest puncture resistance. See attachment (2) for views of penetrometer.

When break strength (Section II, paragraph m) was determined for all snowshoes, the directionality of the decking fabric was not able to be determined (the specimens could be from the machine, cross or bias direction). This fact is apparent when reviewing the individual values for each decking material and seeing the variability within the test results. The test specimens were the dumbbell shaped (Die "C"). Comparatively the Tubbs and Atlas had similar test value averages, while the Redfeather results were significantly lower.

For break strength/elongation determination after flexing (Section II, paragraph n), the decking material test specimens were cut along the bias. The specimens were flexed on the 3M flex tester which provides a rotating

type of flexing movement and were flexed for 1000 cycles. Only the Atlas and Redfeather decking materials were tested. The Tubbs decking was not tested because of the stiffness of the material. There was no significant change in strength or elongation of the Atlas or Redfeather decking after flexing.

Elongation (Section II, paragraph o) was also determined on the decking test specimens from break strength. Elongation was greatest on the Tubbs decking followed by Atlas and Redfeather.

Break strength/elongation (Section II, paragraph p) of the Tubbs decking/lacing was tested, the Atlas and Redfeather design did not incorporate decking with lacing. The specimens consisted of the edges of the decking where the lacing holes were centered, cut into samples large enough to be held by the grips of the tensile testing machine. The lacing was secured in the other grip of the apparatus and the jaws were separated at twelve inches per minute. Six sets of decking/lacing were tested. Two of the sets exhibited lacing failures. The other failures occurred when the decking was ripped by the lacing. On average, it took about 125 pounds of force for a failure to occur with elongation greater than 700%.

The aluminum framing was tested for resistance to compression (Section II, paragraph q), using a tensile tester operating in compression mode. Two inch pieces of the frames were placed on the compression cell and compressed at 20 inches per minute to the point of complete flattening. The Redfeather frame withstood the greatest compression load, while the Tubbs exhibited failures at less than 400 pounds.

Impact and compression resistance testing was also performed on the frames, using the Impact Testing device described in ANSI Standard for Protective Footwear No. 1.4.5.1. (see Section II, paragraph r). The drop heights of 3", 6", and 12" resulted in equivalent loads of 12.5, 25, and 50 ft-lbs, respectively. As expected, as the ft-lbs increased, the amount of deformation to the aluminum frame also increased. In most cases, the Tubbs sustained slightly greater deformation in comparison to the other snowshoes.

Stiffness (TM 5202 - Section II, paragraph s and t) was conducted on Atlas and Redfeather decking for bending moment, using the 0.155 pound moment weights. Stiffness (TM 5206) was also conducted on the Atlas and Redfeather decking materials. The Redfeather material, due to its asymmetrical coating, was tested face up and face down on the test apparatus. Tubbs decking could not be tested due to rigidity. Both materials tested were found to possess similar stiffness.

Wear Evaluation:

The snowshoes were wear tested for a distance of one mile. The surfaces consisted of approximately 1/5 mile of asphalt paving and approximately 4/5 mile of unpaved road consisting of gravel, rocks, damp ground, and sand. Jogging was performed with each snowshoe for approximately 200 feet over the same surface to test for comfort and control of the snowshoe. See attachment (3) for pictures of snowshoes after wear.

Atlas: The crampons were removed for the wear test. Bindings were fairly easy to don and doff. The snowshoe was comfortable and easy to control while walking and jogging. The tail of the frame had worn flat spots. The decking around the tail had worn through at the edges. The material under the hinge had worn through. This material would normally be protected by the crampon. The t-nuts on the hinge rusted.

Redfeather: The bindings were very easy to don and doff. The snowshoe was comfortable and easy to control while walking and jogging. The tail of the frame had worn flat spots. The decking around the frame on one snowshoe had some abrasions at the tail, heel, and side.

Tubbs: The bindings were more difficult to don than the other snowshoes. The snowshoes were comfortable, but harder to control than the other snowshoes, due to the more flexible hinge. The lacing around the frame of the tail area was worn to the point of breaking. When the lacing breaks, the decking will separate from the frame.

III. CONCLUSIONS:

The three types of snowshoes should provide a satisfactory performance on snow, but other factors should be taken into account.

The Tubbs snowshoe is probably more conducive to recreational use. It has stiff bindings which make it bulky and more difficult to pack. The frame is covered by lacing which causes any friction applied to the snowshoe to be directed to the lacing. If the lacing breaks, it would cause the ultimate failure of the snowshoe.

The Atlas and Redfeather snowshoes both can be packed flat for easy carrying. The Atlas also has a strap to hold the two shoes together. The strap has a pocket to cover the points of the crampon.

It was not determined whether removable or permanent crampons would be better, but with the Atlas snowshoe, they cannot be removed.

The Redfeather snowshoe is lighter, but is approximately 3-1/2" longer than the Atlas. This causes any abrasion to be applied to the metal tail, whereas on the Atlas snowshoe, the abrasion is applied on the decking material wrapped around the frame.

The Redfeather had the simplest bindings with fewer straps and buckles and still held firmly.

IV. RECOMMENDATION:

Based on the results of laboratory testing and not involving the cost factor the Redfeather would be recommended.

APPENDIX A

TEST DATA

TEST DATA

a. Overall Weight:

Atlas - 3 lbs per pair with crampons

Redfeather - 2.5 lbs per pair (add 0.25 lb with 2 crampons)

Tubbs - 3 lbs per pair (add .38 lb with 2 crampons)

b. Decking Weight: TM 5041 FED-STD-191A

Atlas - 3.5378 3.5731 3.7496 3.5594 5.6174
= Av 3.6075 gramsx45.72/4 = 41.2 oz/yd²

Redfeather - 3.5089 3.3886 3.4580 3.3908 3.4217
= Av 3.4336 gramsx45.72/4 = 39.2 oz/yd²

Tubbs - 4.0164 3.9552 3.9313 4.0312 3.9756
= Av 3.9819 gramsx45.72/4 = 45.4 oz/yd²

c. Thickness of Deck Material: TM 5030 FED-STD-191A

Atlas - 0.047"

Redfeather - 0.047"

Tubbs - 0.061"

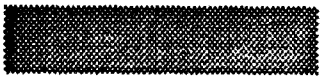
d. Cross-section of Deck Material:

Atlas  coating is equal on both sides of fabric

Redfeather

 coating is heavier on one side of fabric

Tubbs

 solid plastic sheet

e. Abrasion Resistance: TM 5306 FED-STD-191A

The decking material was subjected to 5000 cycles on the Taber Abraser with 250 grams of weight on each wheel. Abradant type = Calibrade H-18

	Thickness Original	Thickness After Abrasion	% Material Removed
Atlas	0.047"	0.043"	8.5
Redfeather	0.047"	0.043"	8.5
Tubbs	0.061"	0.059"	3.3

f. Abrasion Resistance of Decking, TM 5300, FED-STD-191A

Atlas: at 5000 cycles, the test specimen was abraded through rubber to fabric

End point of test = 16030 cycles when specimen was abraded through rubber and fabric to bottom layer of rubber

Redfeather: at 5000 cycles, the rubber surface was slightly abraded (worn smooth)

End point of test = 11,825 cycles when specimen was abraded through the rubber layer and 28,838 cycles abraded through thick rubber layer

g. Deflection and Permanent Set Test

See Discussion section of this report for test parameters.

Results of Deflection/Permanent Set:

	(1) No weight	(2) Weight in Place	(3) Weight Removed
Atlas:			
Heel	4"	3-3/8"	4"
Hinge	4-3/8"	2-7/8"	4-1/4"
Redfeather:			
Heel	3-3/4"	3-3/8"	3-3/4"
Hinge	3-3/4"	2-3/4"	3-1/2"
Tubbs:			
Heel	3-7/8"	3-3/4"	3-7/8"
Hinge	3-1/4"	2-3/4"	3-1/8"

	Deflection (1) - (2)	Permanent Set (1) - (3)
Atlas:		
Heel	5/8"	0"
Hinge	1-1/2"	1/8"
Redfeather:		
Heel	3/8"	0"
Hinge	1"	1/4"
Tubbs:		
Heel	1/8"	0"
Hinge	1/2"	1/8"

h. Resistance to Low Temperatures, TM 5874 FED-STD-191A

The snowshoe was placed in the cold chamber along with separate test specimens of decking which was creased with the 10 lb metal roller at -40°F, the material was also rolled flat after being folded. Visual observation of the crease lines for cracking, peeling or flaking of the coating/laminate was performed.

TEST RESULTS

	10 lb roller	rolled flat
Atlas	no cracking	no cracking
Redfeather	no cracking	no cracking
Tubbs	no cracking	permanent crease lines

i. Effects of Low Temperatures Test

The entire snowshoe was placed in a climatically controlled chamber at -40°F for 4 hours and visually and manually manipulated for any changes

Atlas:

The decking became stiff. Strapping and laces exhibited no change. The hook and pile fastener became difficult to remove. The heel strap pad became stiff.

Redfeather:

The decking became stiff. Strapping and laces exhibited no change. The toe bindings became stiff.

Tubbs:

The decking became stiff. Strapping and laces exhibited no change. The test temperature appeared to have no effect on the bindings.

j. Tear Strength, ASTM D1424

Tested Atlas and Redfeather decking materials only. Unable to tear these materials, tear strength exceeds the capacity of the test apparatus.

k. Resistance to Accelerated Weathering, TM 5804

Atlas: 80 hrs - no fading or change in color

Redfeather: 80 hrs - no fading or change in color

Tubbs: 80 hrs - no fading or change in color

All materials from the snowshoes were placed in weatherometer except for the aluminum frame.

l. Upper Penetration Resistance, para. 4-4.3 Standard for Protective Footwear for Structural Firefighters

Decking material was tested. Penetrometer speed was 20 inches/minute

Atlas:

10.6 9.2 10.8 11.2 11.2 11.6 11.6 11.4 12.0 = Av 11.1 lbs

Redfeather:

11.9 12.0 11.6 13.0 13.4 13.2 12.2 11.8 12.0 = Av 12.3 lbs

Tubbs:

27.5 26.5 26.5 27.0 27.5 27.0 25.5 25.5 25.5 = Av 26.5 lbs

m. Break Strength of Decking material, TM 4111, FED-STD-601

-testing performed using a one inch gauge length with dumbbell shaped test specimens (Die "C")

Atlas: 122 44 70 44 128 = Av 81.6 lbs

Redfeather: 13 15 15 17 16 = Av 15.2 lbs

Tubbs: 97 96 86 58 96 = Av 86.6 lbs

n. Break Strength After Flexing, TM 5102, FED-STD-191A

with flexing on the 3M Flex Tester for 1000 cycles. Test specimens of 1"x6" decking material were cut along the bias.

Unflexed:

	Break Strength (lbs)	Elongation (%)
Atlas:	331	229
Redfeather:	297	260

After Flex (1000 cycles):

	Break Strength (lbs)	Elongation (%)
Atlas:	337	233
Redfeather:	232	255

o. Elongation at Break of Decking, TM 4121, FED-STD-601

Atlas: 60.0 63.5 62.0 49.5 67.5 = Av 60.5%

Redfeather: 17.5 20.5 27.0 26.0 19.0 = Av 22.9%

Tubbs: 900 851 885 447 926 = Av 801.8%

p. Break Strength (bindings and components), TM 5102, FED-STD-191A

The Atlas, Redfeather, and Tubbs binding assemblies were tested for breaking strength of the webbing. All binding straps exceeded 750 pounds of tension with no break.

The Tubbs snowshoe deck and lacing was also tested for break strength. See Discussion section of this report for description and test methodology.

Results:

Trial	Break Strength (lbs)	Elongation (%)
1	116	714
2	120	918
3	123	1056
4	103	824
5	122	895
6	134	975

Lacing broke on trials #2 and #6

q. *Resistance to Compression (aluminum framing)*

- Two inch long pieces of the aluminum frame were compressed at 20"/minute to the point of deformation

Atlas: 580 600 700 590 740 = Av 642 lbs

Redfeather: 850 920 1000 810 650 = Av 846 lbs

Tubbs: 370 370 400 370 380 = Av 378 lbs

r. Impact/Compression Testing, American National Standard for Personal Protection - Protective Footwear (aluminum framing)

Drop Height 3"/12.5 ft-lbs:

	Original Thickness	After Impact Thickness	Deformation
Atlas	0.750"	0.525"	0.225"
	Original Thickness	After Impact Thickness	Deformation
Redfeather	0.750"	0.500"	0.250"
Tubbs	0.750"	0.460"	0.290"

Drop Height 6"/25 ft-lbs:

Atlas	0.750"	0.305"	0.445"
Redfeather	0.750"	0.312"	0.438"
Tubbs	0.750"	0.297"	0.453"

Drop Height 12"/50 ft-lbs:

Atlas	0.750"	0.095"	0.655"
Redfeather	0.750"	0.100"	0.650"
Tubbs	0.750"	0.095"	0.655"

s. Stiffness of Decking Material, TM 5202, FED-STD-191A

Atlas: 44 45 45 = Av 44.7x0.155/100 = 0.070 in-lbs

Redfeather: 51 65 55 = Av 57.0x0.155/100 = 0.090 in-lbs

Tubbs: can not be tested

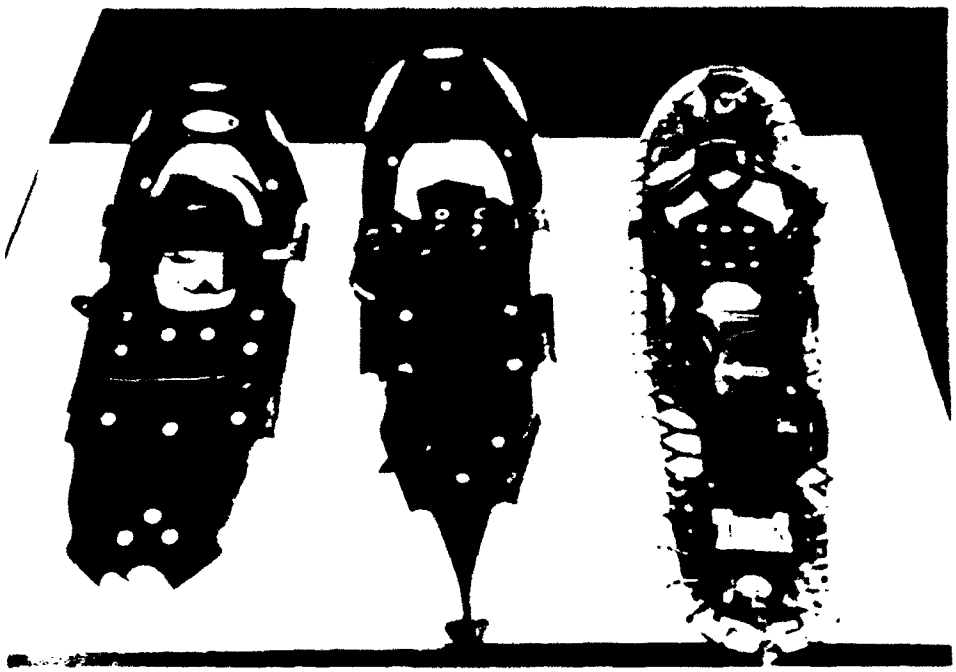
t. Stiffness of Decking Material, TM 5206, FED-STD-191A

Atlas: 4 4 4 = Av $(4/2)^3$x41.2x.482x10^{-4}
= 158.9x10^{-4} in-lbs

Redfeather: 4.9 4.2 4.6 3.4 3.6 3.5 = Av $(4.03)^3$
x39.2x.482x10^{-4} = 154.9x10^{-4} in-lbs

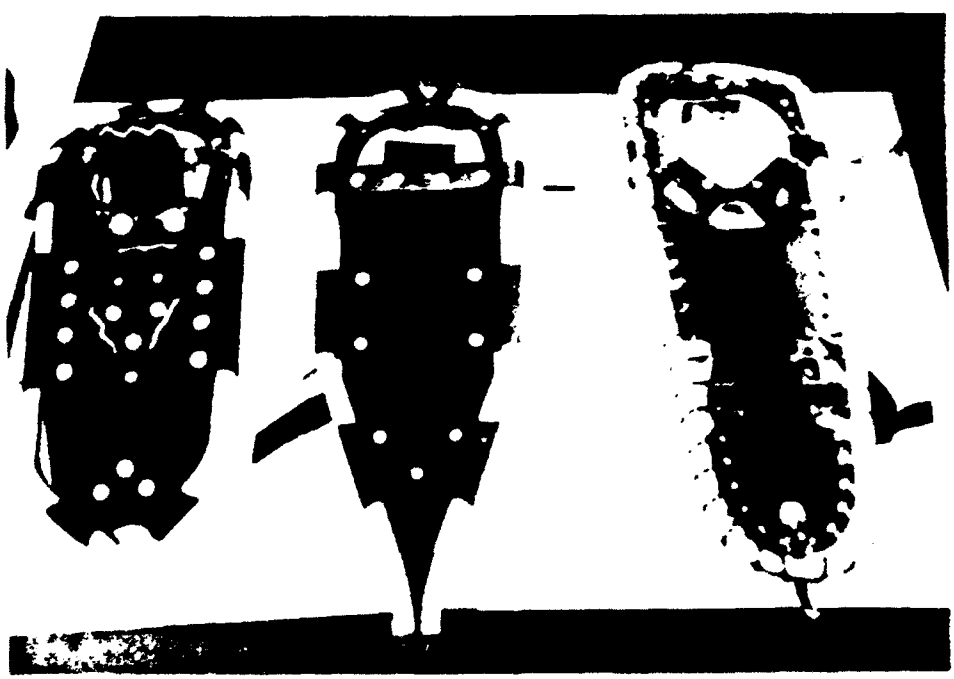
Tubbs: can not be tested

FRONT VIEW



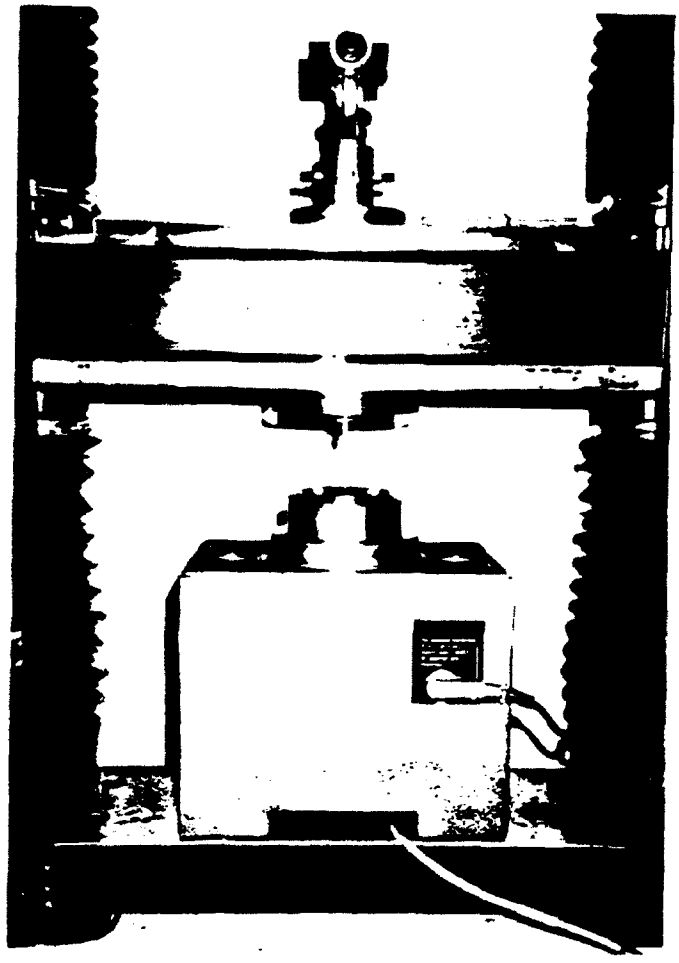
ATLAS SNOWSHOE | REDFEATHER SNOWSHOE | TUBBS SNOWSHOE

REAR VIEW



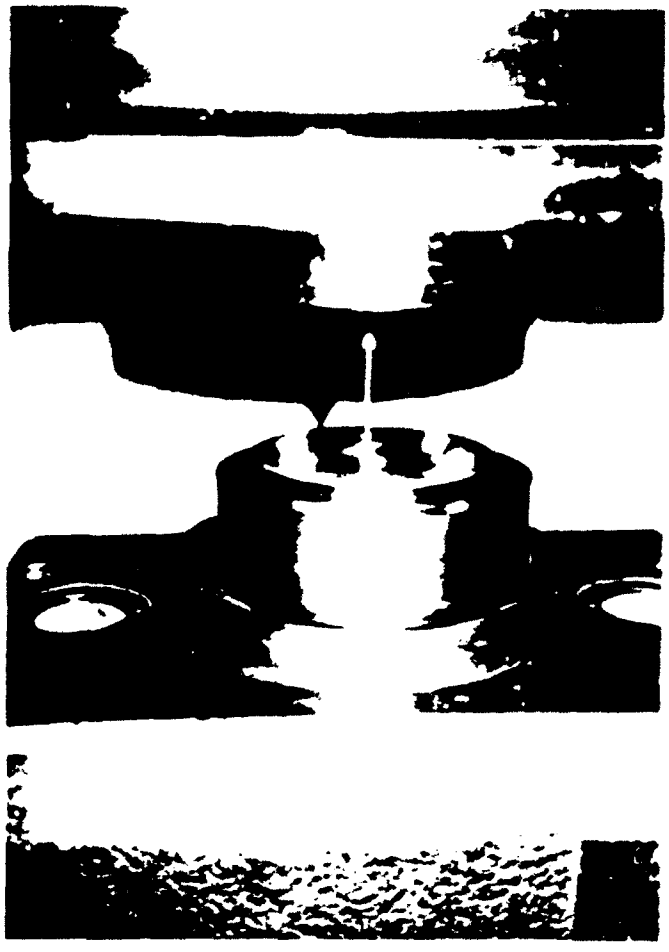
ATTACHMENT (1)

PENETROMETER DEVICE



PENETROMETER IN TENSILE
TESTING APPARTUS

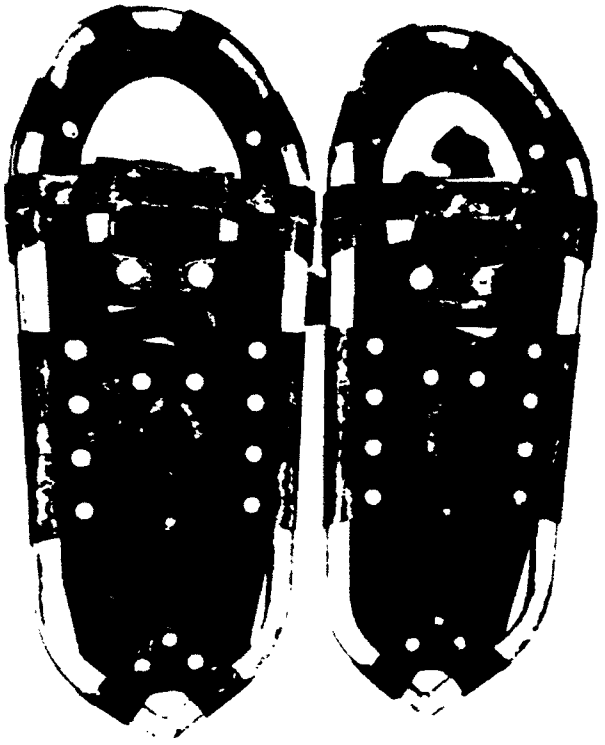
CLOSE UP VIEW



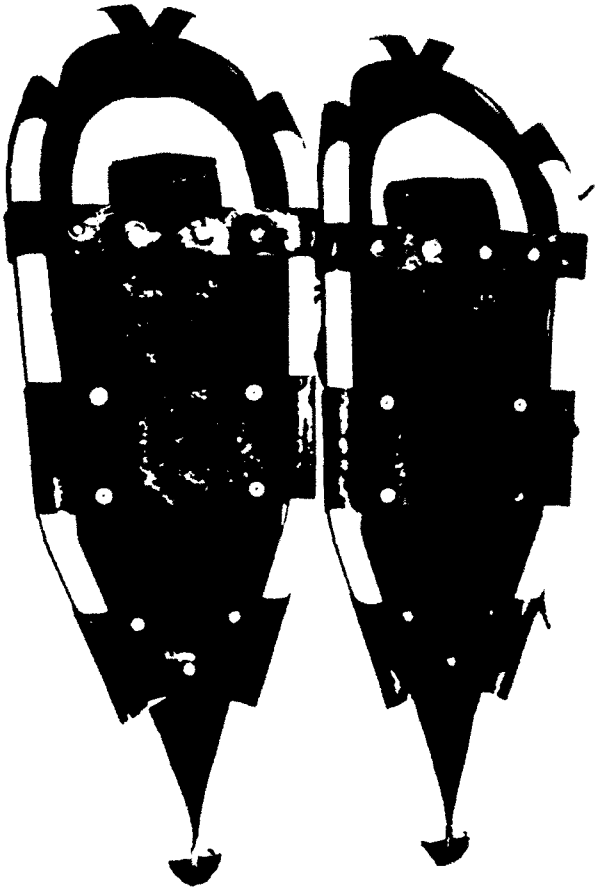
ATTACHMENT (2)

WEAR TEST PHOTOGRAPHS

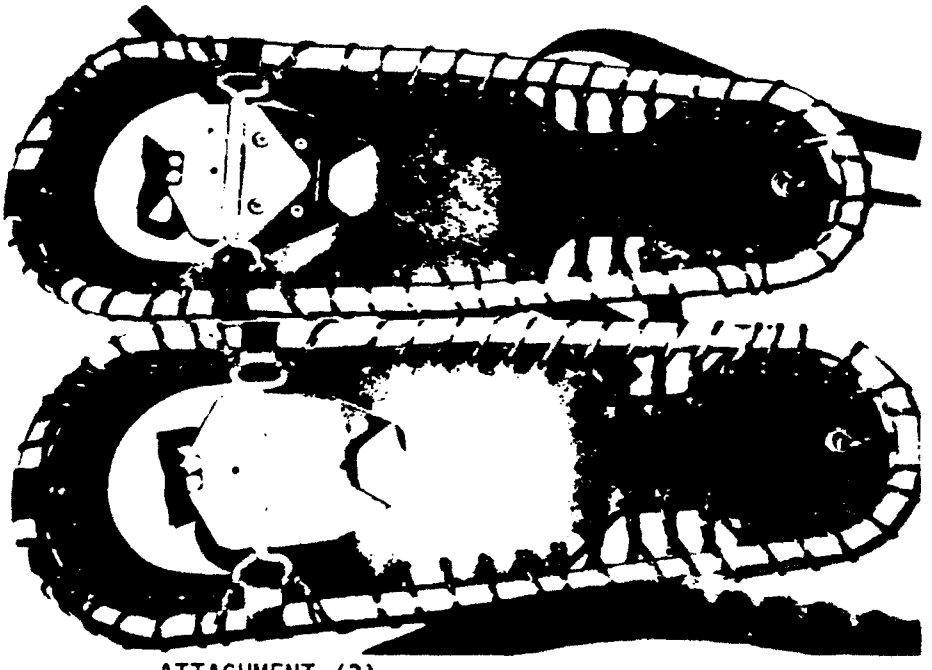
ATLAS SNOWSHOES



REDFEATHER SNOWSHOES



TUBBS SNOWSHOES



ATTACHMENT (3)