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THERMAL MANNIKIN TESTING OF PROTOTYPE COMBAT VEHICLE CREWMAN COLD WEATHER JACKETS

by

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This report compares the thermal performance of two experimental flame-resistant (FR) battings (82% P84/18% polyester and 75% Curlon (r) /25% polyester) constructed into prototype combat vehicle crewman (CVC) cold weather jackets with the standard jacket, which uses Nomex(r) batting.

Prototype jackets were tested on a thermal mannikin along with the standard CVC cold weather jacket, both before and after laundering. The protype jackets containing these experimental battings exhibited comparable thermal properties to the standard and exhibited little, if any, weight reduction in the overall garment weight. It was recommended further work be done on the Curlon battings to improve their performance.

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PREFACE

This report compares the thermal performance of two experimental flame-resistant (FR) battings constructed into prototype combat vehicle crewman(CVC)cold weather jackets with the standard jacket, which uses Nomex® batting.

The two FR insulations - 82% P84®/18% polyester and 75% Curlon®/25% polyester - were determined to be the best candidates to replace the current Nomex batting based on extensive material testing conducted under the Flame-Resistant High efficiency Thermal Insulation portion of the Materials for Integrated Protection Program (IL16278AH98AAA00)[1].

Prototype jackets were tested on a thermal mannikin along with the standard CVC cold weather jacket both before and after laundering. This work was undertaken during the period of May 1995 to October 1995.

THERMAL MANNIKIN TESTING OF PROTOTYPE COMBAT VEHICLE CREWMAN (CVC) COLD WEATHER JACKETS

BACKGROUND

The Army currently has a flame-resistant (FR) requirement for their combat vehicle crewman (CVC) and aircrewman cold weather clothing. The batting used in these clothing systems is a needled Nomex® or Kynol™ (MIL-B-81813B; Batting, Aramid, or Novoloid Fiber, Quilted). This standard Nomex batting is a very dense batting weighing 3.8-4.8 oz/sq yd and it is not thermally efficient on a weight basis. Based on current technology, new fibers and processing techniques are available which should provide an improvement in the thermal and performance characteristics of the batting.

With this goal, the Army awarded a contract to Albany International Research Co. to engineer a FR batting modelled after Primaloft™ - a synthetic alternative to down.[2,3,4] Under this contract several battings were evaluated and a blend of 82% P84® (60% 1.5 denier P84 with water repellent (WR) finish, 22% 0.55 denier with WR finish) 18% polyester (4.0 denier binder fiber) was developed.[5] The performance characteristics of this batting along with several other battings - two of which were developed under a Navy contract [6,7] were evaluated to determine the most suitable replacement for the Nomex batting currently being used.

Two battings, the 82% P84/ 18% polyester and the 75% Curlon®/25% polyester blends were determined to be the best candidates[1] to replace the Nomex batting based on their performance characteristics and prototypes were made to test their overall end item performance.

PROTOTYPES

Prototype CVC cold weather jackets were constructed in the design and computerized pattern facility at the U.S. Army Natick Research, Development and Engineering Center (NRDEC). The 82% P84/18% polyester batting was quilted in-house to a Nomex pajama check fabric using a straight-line quilt pattern (as opposed to the dumbbell pattern called for in the specification). A 5" channel was used to correspond to the width of the dumbbell pattern. The 75% Curlon/25% polyester blend was received already quilted to a Nomex pajama check fabric in the dumbbell pattern.

Instead of constructing totally new prototype jackets, end

items were purchased, liners were removed and the prototype liners were substituted. The quilted P84/poly liners were sewn into six CVC cold weather jackets (3 medium, 3 large). The quilted 75 Curlon/25 poly liners were sewn into three (1 medium, 2 large) lightweight flyers jackets. Due to the limited quantity of CVC cold weather jackets available, lightweight flyers jackets were used. The sizing of the lightweight flyers jacket is comparable to the CVC jacket, the only difference between these jackets is that the flyers jacket does not have the retrieval strap opening with the hook and loop closure on the back yoke found on the CVC cold weather jacket.

TEST METHODS

Thermal Mannikin Testing

Jackets utilizing the three different insulations discussed (Nomex, P84/poly, Curlon/poly) were submitted to the U.S. Navy Clothing and Textile Research Facility (NCTRF) for thermal mannikin testing both before and after laundering. Samples were tested in accordance with ASTM F 1291-90. The test environment was 21.1°C, 50% relative humidity and 1.0 m/s windspeed.

Three separate jackets containing each batting were tested on the mannikin. (Because there were only two jackets with the Curlon/polyester lining, one jacket was tested twice.) In addition to the jackets being tested, the mannikin wore the following items: a cold weather underwear shirt (50% Wool/50% Cotton - MIL-U-43262D;Undershirts, Cold Weather, Men's superseded by A-A-50383; Undershirt, Extreme Cold Weather, Man's and Woman's), a Nomex underwear drawer(MIL-D-85040B;Drawers and Undershirts, Flyers, Anti-Exposure, Aramid, High Temperature Resistant, CWU-43/P and CWU-44/P), CVC coveralls (MIL-C-44077B; Coveralls, Combat Vehicle Crewman's), the standard wool cushion sole sock (MIL-S-48L; Socks, Men's Cushion Sole, Stretch Type superseded by A-A-55079; Socks: Men's, Cushion Sole, Stretch Type), the standard leather combat boots (MIL-B-44152C; Boots, Combat; Mildew & Water Resistant, DMS), the CVC balaclava (MIL-H-44265A Hood, Combat Vehicle Crewmen's (balaclava)), and the mounted crewman cold/wet glove (developmental). Proper sizing was determined by the NCTRF tester and the project officer by fitting the mannikin before testing began. A size medium coverall and a size large jacket were tested

Weights

The samples were weighed before and after laundering using a Model 3830 NCI scale manufactured by the Worcester Scale Co.,Inc., to determine the overall weights of the sample and any weight changes as a result of laundering.

Laundering

After the jackets were tested on the thermal mannikin, they were laundered and retested. Laundering was conducted using the home laundering procedure that follows: two jackets per machine were laundered using a permanent press cycle and washed at 120 ± 5 ° F, rinsed at 80 ±5 °F , three times using American Textile Chemists and Colorists (AATCC) 124 detergent with optical brightener. Jackets were dried on a permanent press (med) cycle for approximately 40 minutes and a new fabric softener sheet was used for each drying cycle. This laundering was consistent with the laundering procedure specified for the aircrew battledress uniform liner and reflects the anticipated changes away from military laundering procedures to commercial test methods.

RESULTS AND DISCUSSIONS

As can be seen in Table 1, the prototype samples did not reduce the overall weight of the jacket. The P84/polyester sample exhibited almost the same weight as the standard before laundering, and while it did exhibit some weight loss in laundering the loss was minimal (1.8%). The size large Curlon/polyester sample exhibited a 8.3% increase in weight over the same size standard sample. Like the standard, the Curlon/polyester sample exhibited no weight change after washing.

Table 1: Total Jacket Weights (lbs)

	M1	M2	M3	Average	L1	L2	L3	Average
Standard (Nomex batting)								
Before Laundering	2.1	2.05	2.05	2.07	2.15	2.2	2.15	2.17
After Laundering	-	-	-	-	2.2	2.15	2.15	2.17
P84/Polyester batting								
Before Laundering	2.1	2	2.1	2.07	2.15	2.2	2.2	2.18
After Laundering	-	-	-	-	2.1	2.15	2.15	2.13
Curlon/Polyester Batting								
Before Laundering	2.25	-	-	2.25	2.35	2.35	-	2.35
After Laundering	-	-	-	-	2.35	2.35	-	2.35

M1,M2,M3 - Size Medium L1,L2, L3 - size Large

Considering the difference in the batting weights (see Table 2), it is not surprising that the jackets containing the Curlon/polyester batting were heavier than the standard CVC jacket. The Curlon/polyester jackets also seemed to produce a bulkier, stiffer garment.

Table 2: Batting Physical Properties and Clo Values

Material	Thickness (in)	Bulk Density	Weight	Clo	Clo/
	0.002 psi	(lb/cu ft)	(oz/sq yd)	Intrinsic	oz/sq yd
Standard - Nomex	(unquilted)				
Unlaundered*	0.29	1.28	4.46	1.34	0.3
Laundered*	0.23	1.36	3.65	1.11	0.3
Standard - Nomex (QR)	(quilting removed)				
Unlaundered	0.27	1.31	4.25	1.33	0.31
Laundered	0.2	1.82	4.35	1.12	0.26
P84/Poly	(unquilted)				
Unlaundered	0.89	0.35	3.71	3.63	0.98
Laundered	0.5	0.62	3.73	2.42	0.65
75% Curlon/ 25% Poly	(quilting removed)				
Unlaundered	0.88	0.67	7.03	4.41	0.63
Laundered*	0.58	0.99	6.87	3.13	0.46

Data average of three samples unless otherwise specified
*Data average of two samples

Overall, all three jackets demonstrated comparable clo values both before and after laundering with neither prototype offering any significant improvement in thermal properties over the standard jacket. (See Table 3.) Generally, a 10% change in clo value is considered significant.

Table 3: Thermal Mannikin Testing of Jackets

	Before Launder			After Launder		
	Total Clo	Torso Clo	Arm Clo	Total Clo	Torso Clo	Arm Clo
Standard (Nomex batting)	1.93	2.92	2.57	1.97	3.02	2.74
P84/Poly batting	1.97	3.08	2.79	2.00	3.15	2.87
Curlon/Polyester batting	1.98	3.07	2.94	1.99	3.08	2.96

Data average of three samples

CONCLUSIONS

There was not a significant improvement in the thermal performance of the end item when the standard Nomex batting was substituted with the prototype liners containing the experimental FR battings and little/if any weight reduction in the garment was experienced. The prototype jackets containing the experimental battings - (82% P84/18% polyester or 75% Curlon/25% polyester)- exhibit thermal properties comparable to the standard.

RECOMMENDATIONS

Because there is no price advantage to using these experimental battings, no further work will be done at this time. The Curlon/polyester blend does show potential as a possible replacement for the Nomex batting. Development of a Curlon blend in a lower-weight range should be explored as finer denier Curlon fibers are available which could decrease the batting weight by 15 - 35% and should increase the thermal performance of the item while providing equal to or better flammability properties than the Nomex batting at a comparable or lower price.

References

1. Auerbach, M., Evaluation of Flame-Resistant Battings, Technical Report Natick/TR-96/033, July 1996. AD A311 762

2. Dent, R.W., Donovan, J.G., Skelton,J. and Fossey, S., Development of Synthetic Down Alternatives, Technical Report Natick/TR-86/021L, Phase I, April 1984. AD B101 043L

3. Dent, R.W., Donovan, J.G., Skelton, J. and Fossey, S., Development of Synthetic Down Alternatives Phase II, Technical Report Natick/TR-87/004L, January 1986. AD B113 116L

4. Donovan, J.G., Pilot Line Development of High Performance Thermal Insulation, Technical Report Natick/TR-89/041L, September 1989. AD B139 693

5. Donovan, J.G., Development of Flame-Resistant, High Efficiency Thermal Insulation, Technical Report Natick/TR-95/013, January 1995. AD 291 136

6. Shanley, L.A., Aircrew Personal Protective Clothing for Use in Extreme Cold Weather, Phase I Report DI-MGMT-80555, Contract No. N62269-91-C-0220, unpublished report, Naval Air Warfare Center, Warminister, PA. August 20, 1991 - July 20, 1992.

7. Slaten, B.L., Shanley, L.A., Broughton, R. and Baginski, M. Thermal Properties of Novel Carbon Fiber Battings. Auburn University Report, 308B Spindle Hall, Auburn, Alabama, undated.

Military Specifications:
Specifications are available from:
Standardization Document Order Desk
700 Robbins Avenue, Building 4D
Philadelphia, PA 19111 - 5094

ASTM Test Method
ASTM Standard Test Method for Measuring the Thermal Insulation of Clothing Using a Heated Manikin,Volume 11.03, ASTM, 1916 Race Street, Philadelphia, PA, 1994.