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14. ABSTRACT
The U.S. Army Natick Research, Development and Engineering Center (Natick) is charged with the mission to continually improve the protective clothing systems and individual equipment for soldiers and marines in the field. For the past 10 years, we have relied on the use of state-of-the-art materials that resist penetration of water, while allowing moisture vapor to pass out through the garments. The use of such materials minimizes condensation of moisture that could create a conductive cold layer next to the skin, keeps the wearer dry, and reduces the potential for cold injuries.

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WATERPROOFING
COLD WEATHER
MOISTURE
INSULATION
STATE OF THE ART
COLD REGIONS
2GECWCS(SECOND GENERATION EXTENDED COLD WEATHER CLOTHING SYSTEM)

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WATERPROOF, BREATHABLE FABRICS FOR MILITARY CLOTHING SYSTEMS: AN INNOVATIVE APPROACH TO ACQUISITION

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The U. S. Army Natick Research, Development, and Engineering Center (Natick) is charged with the mission to continually improve the protective clothing systems and individual equipment for soldiers and marines in the field. For the past 10 years we have relied on the use of state-of- the-art materials that resist penetration of water, while allowing moisture vapor to pass out through the garments. The use of such materials minimizes condensation of moisture that could create a conductive cold layer next to the skin, keeps the wearer dry, and reduces the potential for cold injuries.

The first clothing system to use this "moisture management" principle was the highly successful, Extended Cold Weather Clothing System or ECWCS. Introduced to the Army in 1986, this system provides extreme cold weather protection to soldiers and marines operating in cold/wet and cold/dry conditions at ambient temperatures ranging from +40°F to -60°F. As highly successful as the system was, in nine subsequent years of use, it became evident that improvements needed to be made. The situations which lead to this decision included 1) a sole source supplier for the basic waterproof, breathable material, and 2) soldier and marine feedback from the field indicating increased use of the parka outside of the environmental envelope, i.e., higher temperatures and wetter conditions, effectively becoming the field coat of choice.

The United States Army Infantry School and the United States Marine Corps Systems Command proposed a joint Army/Marine Corps program to address these concerns and bring the ECWCS back to the state of the art. This new program is refered to as the Second Generation Extended Cold Weather Clothing System (2GECWCS).

While coordinating the requirements, we were presented with a number of challenges. First, there had been very limited success in interesting potential competitors to supply the basic material in previous alternate materials programs. Second, downsizing in the Government had led to limited internal prototyping and designing capabilities. Third, Government policy changes were driving us toward "performance specifications". Finally, in order to fit production into the supply pipeline without the need for bridge buys, we were given an 18 month timeframe to complete the program.

BUILDING THE PROGRAM

Obviously an intense innovative approach was required in order to meet these lofty goals. An acquisition strategy, collaboratively developed by the Project Manager, Soldier and Natick, was devised and was based in part on some techniques that were being considered in an on-going chemical protection program. The strategy was supported by industry and academia and encompassed 1) a nonabsolute material performance specification leading to a Qualified Materials List, 2) leveraging industry for materials and designs for the garments, 3) comparative testing of contractors' submissions in operational testing, and then 4) a production award to the successful design contractor.

MATERIALS SPECIFICATION

The materials requirements in the past have been perceived as being gold plated and only attainable by one manufacturer. Part of the strategy was to dispel that contention and to present a set of parameters that reflected the minimum requirements of the Government and were consistent with normal commercial practice. Materials scientists from Natick performed a complete review of the existing military specification and concentrated on the goals of attaining the best quality materials with the most reasonable requirements. An example of recommended changes are listed in Table I.

Table I. Example, Proposed New Requirement

CHARACTERISTIC	EXISTING REQUIREMENT	PROPOSED NEW 2GECWCS REQUIREMENT	TEST METHOD
Tearing Strength	Warp: 3.5 Kgf Filling: 3.2 Kgf	Warp: 3.0 Kgf Filling: 3.0 Kgf	ASTM D 2582[1]

RATIONALE:

Reason for Change: To accommodate state-of-the-art of coated and two layers laminate materials. Expand supply base.

Why 2GECWCS Requirement is correct: Based on good performance of Wet Weather Parka & Trouser in field service.

Each material requirement was reviewed for revision or for maintaining the status quo. When the recommendations were completed, Natick convened a technical review panel to scrub the recommendations to approve, disapprove, change, and finalize each individual fabric requirement. This panel consisted of members representing Natick, and the U. S. Navy Clothing and Textiles Research Facility, the Chief of the Defense

Personnel Support Center Quality Assurance Division, a representative of the Project Manager, Soldier, the former Chairman of the University of Massachusetts, Dartmouth Textile Sciences Department, and the Materials Testing Department Manager of a large east coast mail order and retail outerwear manufacturer. This distinguished panel analyzed and approved a sensible, attainable set of requirements that adequately described the needs of the Government in terms of best commercial practice for inclusion in the Request For Proposals for the 2GECWCS are contained at Appendix A.

PARKA AND TROUSER REQUIREMENTS

Concurrently, the U.S. Army Infantry School and the U.S. Marine Corps Systems Command approved and published the operational requirements for the parka and trouser[2,3]. These requirements were developed in a meeting at the Cold Regions Test Activity in Alaska by Army and Marine Corps experts who have worn and operated in the uniform, and who have spent considerable time in cold regions, training, and training others, in such specialties as military mountaineering, search and rescue, cold weather operations, and survival. These requirements are contained in Appendix B.

DOWN SELECTING THE CANDIDATES

Natick R, D, & E Center convened a Pre-Solicitation Conference and invited industry participation. Industry was encouraged to team, combining materials companies with end item manufacturers. In order to fairly and objectively evaluate proposals for the effort, a down selection plan that incorporated materials and end item prototype testing was developed by Natick's Behavioral Science personnel. They provided a downselection plan[4] that included identifying each services' requirements for the 2GECWCS, prioritizing the criteria for selection for each service, rating the performance of candidate systems on each criteria from test results, entering the ratings for each candidate into a decision model for comparing alternatives, and documenting the decision process and its methodology.

The development and preliminary structure of the decision model was established by review of the requirements documentation of the program, and was built using a software tool based on the Analytic Hierarchy Process[5]. The initial model involved two "decision trees", one for materials and one for the end items. These trees were modified based on input from user and developer inputs, and because the structures became almost identical, the trees were merged into one tree with the understanding that it would be used in two phases. Phase I would involve materials evaluation and selection using materials data and Phase II would evaluate design attributes, and ensemble characteristics. Data points would be taken from laboratory/chamber testing, developmental field testing, and operational field testing.

The final structure of the model (Table II) had three levels. Level one represents categories of criteria for MATERIALS FACTORS, HUMAN FACTORS, AND ACQUISITION FACTORS. The second level represents the main criteria under each

factor. The third level presents the sub-criteria which defines some of the second level criteria.

Table II. Combined Army/Marine Corps Requirement Weights

	Insulation		0.04690
	Repellency		.06350
	Moisture Perm		.05989
		Tearing	.00902
		Breaking	.00902
		Stiffness	.00902
Material	Durability	Abrasion	.00902
		POI /DEET	.00902
		Shrinkage	.00902
		Surface	.00902
		Weight	.02915
	Weight/Bulk	Bulk	.02786
	Colorfastness		.05051
	Camo/IR		.04402
		Mobility	.03448
	Performance	Flexibility	.02988
		Warmth	.03665
	Comfort	Feel	.01656
		Pockets	.01907

GOAL	Human Factors		Hood	.01907
			Linings	.00918
		Acceptability	Venting	.01052
			Style	.01052
			Noise	.00976
		Fit		.05537
			Weapons	.01587
			Clothing	.01664
		Compatibility	Load Bear Equip	.01626
			Vehicles	.01236
			Ease of Use	.02181
		Maintenance	Repair	.01782
			Laundering	.01969
			Material Cost	.01556
		Life Cycle Cost	Licenses	.01556
			Patents	.01556
			Contract	.01556
	Acquisition		Availability	.05362
			Production	.05433
			Shelf Life	.05577
			Disposal	.03598

Once the decision tree was finalized, a rating questionnaire (Figure 1.) was

administered to technical experts representing the material and combat developers, to rate the relative importance of first, the Level I categories, and then, Level II, and some of the Level III criteria.

When entered into the software program, the relative weights for each criterion were computed for each service. A combined weight for each criterion was also generated for use in the Phase I material selection.

A ratings scheme was established where test results for each criterion were converted to a descriptive rating of either Above Standard, Standard, or Below Standard, having a numerical value of 1.000, 0.667, or 0.333 respectively. In the case where there is a minimum value for Below Standard, a value below the minimum is considered a failure and scored as a zero. The conversion of laboratory chamber, developmental test and operational test is based either on user requirements or technical experts' judgement prior to the testing phase or on a statistical comparison with test values of the baseline or standard system (Table III).

The rating value on the particular criterion for a given offered system is then multiplied by the user's weight of importance for that criterion. The final score for the candidate system is the sum of the rating values times weights across all criteria. The candidate systems are then ranked according to the totals based on this weighted model (Table IV).

Table III. Material Requirements Ratings

WATER PROOFNESS & REPELLENCY	Water Permeability (AATCC #127)	Initial After Flex , 70 F After cold Flex, -40 F After Synthetic Perspiration After DEET After diesel After Weapons Lubricant After seam tape	STD BLW STD	Pass (10 minutes) Pass (5 minutes)
	Hydrostatic Resistance (ASTM D 3393)	Initial After Strength of coating After abrasion After DEET After diesel After weapons lubricant After high humidity	STD BLW STD	Pass (40 psi) Pass (30 psi)
	Spray Rating (AATCC #22)		ABV STD STD BLW STD	100, 100, 90 90, 90, 80 80, 80, 70
	Resistance to Organic Liquids (AATCC #118)		ABV STD STD BLW STD	> 5 launderings = 5 launderings 3-4 launderings

Table III. (Con't)

DURABILITY	Tearing Strength (ASTM D 2582)	ABV STD	>3.3X3.3
		STD	3.0X3.0-3.3X3.3
		BLW STD	>2.6X2.6
	Breaking Strength (ASTM D 5034)	ABV STD	>150X120
		STD	135X100-150X120
		BLW STD	>100X100
	Shrinkage (AATCC # (96)	ABV STD	<2.5X2.0
		STD	=4.0X2.0
		BLW STD	>4.0X2.0
	Physical Surface Appearance Change (Proc. "E")	STD	Pass
		BLW STD	Fail
WEIGHT/BULK	Weight (ASTM D 3776)	ABV STD	<5.0
		STD	5.0-6.0
		BLW STD	>6.0
	Stiffness FED-STD-191 TM 5204)	ABV STD	<9.0
		STD	9.0-10.0
		BLW STD	10.1-12.0
	Bulk	ABV STD	
		STD	Rating
		BLW STD	

Table III. (Con't)

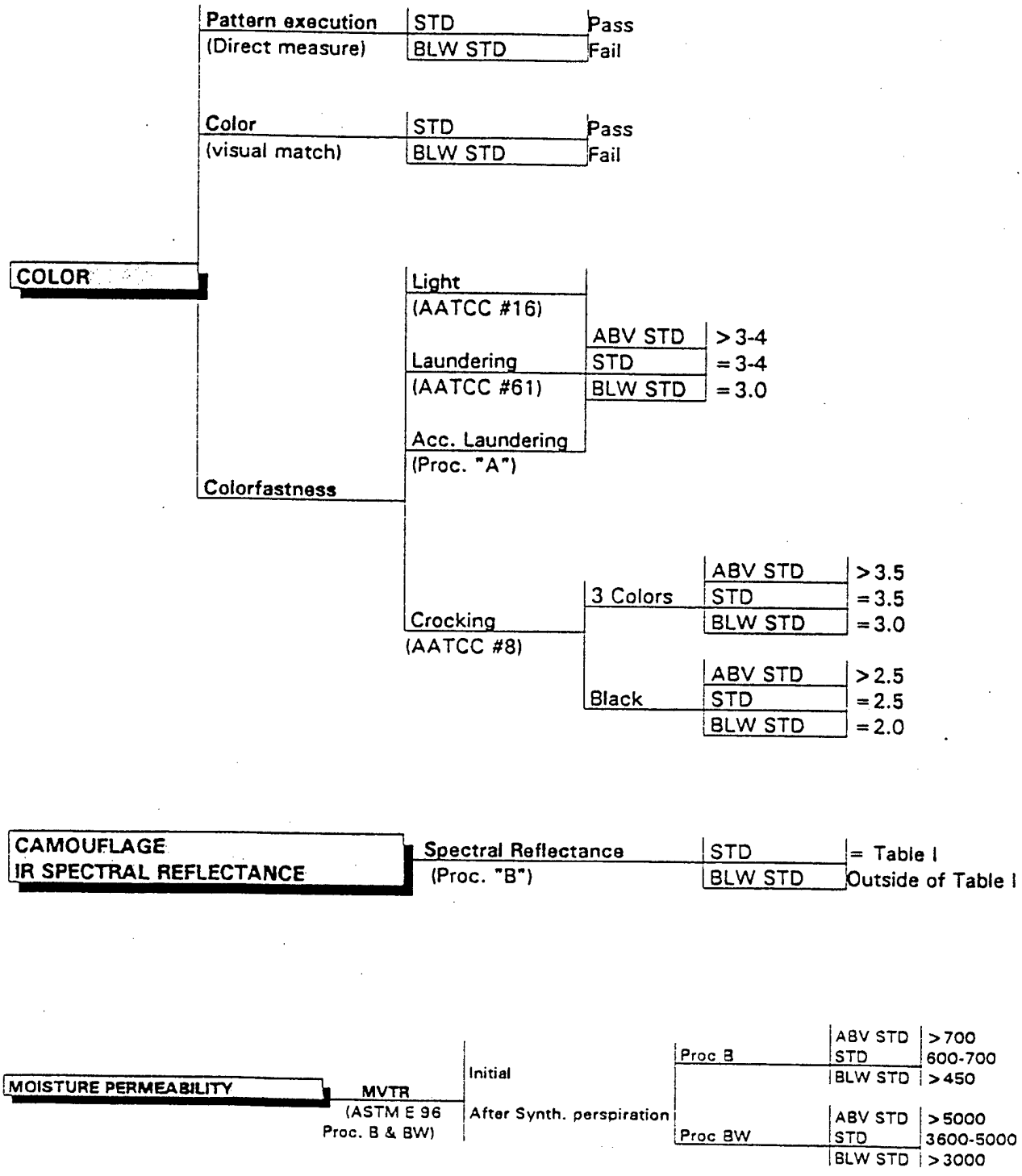

Table IV. Weighted Model Ranking Chart

Combined wts.		2GECWCS		STD:	0.70966	
Army/Marines		Ext Cold Wthr Clothg System		MAX:	1.00000	
		ABV STD =	A	SCORE:	0.71937	FINAL
		STD =	S		COMBINED	
		BLW STD =	B			
		FAILURE =	F	SCORE	WEIGHT	FINAL
CONTRACTOR:				SCORE	WEIGHT	FINAL
MATL	INSULAT	——— ——— >	S	0.667	0.04690	0.03128
	REPEL'CY		>	0.792	0.06350	0.05028
		WATER PERM	>	1.000		
		INITIAL	S	1.000		
		AFT FLEX70F	S	1.000		
		AFT COLDFLEX	S	1.000		
		AFT SYN PERSP	S	1.000		
		AFT DEET	S	1.000		
		AFT DIESEL	S	1.000		
		AFT WPN LUBE	S	1.000		
		AFT MOT.OIL	S	1.000		
		AFT JP-8	S	1.000		
		AFT SEAM TAPE	S	1.000		
		HYDR.REST. FAILURE	>	0.833		
		INITIAL	S	1.000		
		AFT STR COAT	S	1.000		
		AFT ABRASION	S	1.000		
		AFT DEET	B	0.500		
		AFT DIESEL	S	1.000		
		AFT WPN LUBE	F	0.000		
		AFT MOT.OIL	S	1.000		
		AFT JP-8	S	1.000		
		AFT HUMIDITY	S	1.000		
		SPRAY RATNG ———>	S	0.667		
		ORGNC REST ———>	S	0.667		
	MOISTPRM		>	0.834	0.05989	0.04992
	(MVTR)	INITIAL	>	0.834		
		PROC. B	A	1.000		
		PROC. BW	S	0.667		
		AFT SYN PERSP	>	0.834		
		PROC. B	A	1.000		
		PROC. BW	S	0.667		
	DURABILI	TEARING ———>	A	1.000	0.00902	0.00902
		BREAKING ———>	S	0.667	0.00902	0.00602
		STIFFNES ———>	A	1.000	0.00902	0.00902
		ABRASION ———>	S	1.000	0.00902	0.00902
		POL/DEET ———>	F	0.000	0.00902	0.00000
		SHRINKAG ———>	B	0.333	0.00902	0.00300
		SURFACE ———>	S	1.000	0.00902	0.00902
	WT./BULK	WEIGHT ———>	S	0.567	0.02915	0.01944
		BULK ———>	S	0.567	0.02786	0.01858
	COLOR:		>	1.000	0.05051	0.05051
	PATTERN	——— ———>	S	1.000		
	COLOR	——— ———>	S	1.000		
	COLORFAST:		>	1.000		
		LIGHT ———>	A	1.000		
		LAUDER ———>	A	1.000		
		ACC ALUNDER ———>	A	1.000		
		CROCKING:	>	1.000		
		3 COLOR ———>	A	1.000		
		BLACK ———>	A	1.000		
	CAMO PR	——— ———	S	1.000	0.04402	0.04402

Weighted Model Ranking Chart (con't)

HF	PERFORM	MOBILITY	——>	S	0.667	0.03448	0.02300
		FLEXIBIL	——>	S	0.667	0.02088	0.01393
	COMFORT	WARMTH	——>	S	0.667	0.03665	0.02445
		FEEL	——>	S	0.667	0.01656	0.01105
	ACCEPT	POCKETS	——>	S	0.667	0.01097	0.00732
		HOOD	——>	S	0.667	0.01097	0.00732
		LININGS	——>	S	0.667	0.00918	0.00612
		VENTS	——>	S	0.667	0.01052	0.00702
		STYLE	——>	S	0.667	0.00829	0.00553
		NOISE	——>	S	0.667	0.00976	0.00651
	FIT	———	——>	S	0.667	0.05537	0.03693
	COMPATBL	WEAPONS	——>	S	0.667	0.01587	0.01059
		CLOTHING	——>	S	0.667	0.01664	0.01110
		LOAD_EQP	——>	S	0.667	0.01626	0.01085
		VEHICLES	——>	S	0.667	0.01236	0.00824
	MAINTAIN	EASE USE	——>	S	0.667	0.02181	0.01455
		REPAIR	——>	S	0.667	0.01782	0.01189
		LAUNDER	——>	S	0.667	0.01969	0.01313
ACQ	LIFECOST	MAT.COST	——>	S	0.667	0.01556	0.01038
		LICENSES	——>	S	0.667	0.01556	0.01038
		PATENTS	——>	S	0.667	0.01556	0.01038
		CONTRACT	——>	S	0.667	0.01556	0.01038
	AVAILABL	———	——>	S	0.667	0.05362	0.03575
	PRODUCTN	———	——>	S	0.667	0.05433	0.03623
	SHELF	———	——>	S	0.667	0.05577	0.03720
	DISPOSE	———	——>	S	0.667	0.03598	0.02400

Figure 1. Example Questionnaire

EXTENDED COLD WEATHER CLOTHING SYSTEM
FACTOR RATING QUESTIONNAIRE

1. RATE the IMPORTANCE of the following two categories of SELECTION FACTORS when considering materials for ECWCS (use the rating scale below):

IMPORTANT:
Make sure no two characteristics have the same exact rating! Use intermediate decimal values like 3.6 if needed.

SLIGHTLY IMPORTANT			MODERATELY IMPORTANT			EXTREMELY IMPORTANT		
1	2	3	4	5	6	7	8	9

RATING

_____ MATERIAL FACTORS (weight durability, insulation, degradation, camouflage, static electricity, water repellency)

_____ ACQUISITION FACTORS (shelf life, repairability, disposability, material costs, producibility, material availability, licensing costs, patent costs)

Rationale for ratings:

_____
_____
_____
_____
_____
_____

CONFIDENCE LEVEL:
Indicate your level of CONFIDENCE in your ratings above (circle number):

NOT CONFIDENT		SLIGHTLY CONFIDENT		MODERATELY CONFIDENT		EXTREMELY CONFIDENT		
0	1	2	3	4	5	6	7	8	9

TESTING METHODOLOGY

The Natick Acquisition Center solicited industry for proposals to meet the Government needs. Contractor teams were requested to provide Government Certified Laboratory Test Reports on the submitted fabrics, yardage for verification testing, sample designs for parkas and / or trousers representing their interpretation of the design requirements of the two services, and reports indicating past performance history, past quality history, past delivery history, and indication of the ability to perform the manufacture of technically difficult specialty garments.

The data from the Government Certified Laboratory Reports was entered into the decision tree. Any test in the tree that did not specifically relate to the evaluation of the fabric remained constant for all candidates, thereby obtaining a score for the fabric only. This provided a basis to evaluate candidate fabrics against the standard where a manufacturer need not absolutely meet all requirements, but could qualify based on the weighted importance of criterion versus criterion. For example, a fabric may perform above standard against a criterion that is highly weighted and perform below standard for a factor that is not as important to the user. The resultant weighted score will qualify the material since the total score would exceed the total Standard score. Fabrics which scored equal to or above the standard were qualified to be used to manufacture test items.

A Technical Evaluation Team evaluated nine proposals based on the contractors' submissions of materials, designs, past quality performance, past delivery performance, manufacturing capability, and item cost and producibility. Three contractors qualified to make four candidate parka and trouser sets. The candidates included three new parka and trouser designs and two new fabrics as well as the standard basic shell fabric. All three provided a tariff of two hundred parkas and two hundred trousers for test.

These parkas and trousers will be tested by two independent Government test agencies, the Test and Evaluation Command (TECOM), and the Test and Experimentation Command (TEXCOM). TECOM will address all pertinent developmental issues while TEXCOM will address operational issues. Three test sites have been chosen to provide the full range of environmental conditions required of the parka and trousers. The Cold Regions Test Activity, an agency assigned to TECOM will conduct a combined developmental/operational test at Ft Greely, Alaska to assess the environmental protection in extreme cold/dry conditions. Historically, the test activity experiences temperatures as low as -60° F during the months of January and February. Forty degrees below zero is common during this time. Marines will test at the United States Marine Corps Mountain Warfare Training Center in the Sierra Nevada Mountains at Bridgeport, California. This Center traditionally experiences temperatures in the -10° to -20° F with very heavy snowfall. Following the training at the Center, the test marines will deploy for an operational exercise in Norway. United Stated Army soldiers will test

at Ft Lewis, WA to assess the ability to protect in cold/wet conditions. This facility normally experiences temperate, but very wet conditions.

Data gathered from these field tests will be added to the materials data and run through the downselect model. The designs for the parka and trouser assessed as the best overall and most advantageous to the Government will be awarded Production Test Quantities to produce up to 30,000 parkas and trousers for the initial fielding. The successful contractor(s) will also deliver specifications for their product to be used by the Defense Personnel Support Center to contract for follow on supply procurement.

CONCLUSION

The 2GECWCS Parka and Trouser Program is one of the first to venture into the concept of integrated acquisition. The program aims to integrate improved new items into the supply system through sound planning up front, minimizing inventories of residual assets, and cutting the time frame that it takes to develop and deliver quality state of the art protective clothing and equipment to soldiers and marines. As the services continue to "right size", it only makes sense to rely on the expertise of American Industry to provide the best for our soldiers, sailor, airmen and marines.

REFERENCES

1/ American Society for Testing Materials, Annual Book of Standards, 1994, Test Method D2582, Test Method for Puncture Propogation Tear Resistance of Plastic Film and Thin Sheeting, Vol. 08.02, pp 76-79.

2/ U. S. Army Infantry School and Center, Operational Requirements Document for a Second Generation Extended Cold Weather Clothing System Parka and Trousers, 2 November 1993, and amended 30 November 1993

3/ U. S. Marine Corps Systems Command, Operational Requirements Document for Cold Weather Clothing and Equipment, no date

4/ Sampson, J., Second Generation Extended Cold Weather Clothing System (2GECWCS) Downselection Plan, 23 December, 1993

5/ Saaty, T. L., Multicriteria Decision Making - The Analytic Hierarchy Process, RWS Publications, Pittsburgh, PA, 1992.

Appendix A

2GECWCS MATERIAL REQUIREMENTS

CHARACTERISTICS	2GECWCS REQUIREMENTS	TEST METHODS
Weight	6.0 oz/sq yd max.	American Society for Testing Materials (ASTM) D 3776[1]
Color	4 color Woodland Camouflage Pattern	Visual-match standard sample
Colorfastness to Light	Equal to or better than "3-4" American Association of Textile Chemists and Colorists (AATCC) Gray Scale for Color Change[2] rating after 40 hours.	AATCC #61[3], option "A"
Colorfastness to Laundering	Equal to or better than "3-4" AATCC Gray Scale for Color Change[2] rating (4 cycles)	AATCC #61[3], option 1A & Army detergent
Colorfastness to Accelerated Laundering. (Black Only)	Equal to or better than "3-4" on AATCC Gray Scale[2] rating.	Test procedure "A"
Colorfastness to Crocking	4 Colors: Equal to or better than "3.5" AATCC Chromatic Transference Scale[4] Rating.	AATCC #8[5]
Pattern Execution	Equal to standard sample. Repeat on 27.25" +1.25", -2.5" warp.	Direct linear measure
Spectral Reflectance	See Table	Test procedure "B"
Breaking Strength (WxF)	Warp = 135 lbs, min. Filling = 100 lbs, min	ASTM D 5034[6]
Tearing Strength (WxF)	W = 3.0 kgf, min F = 3.0 kgf, min	ASTM D #2582[7]

CHARACTERISTIC	2GECWCS REQUIREMENTS	TEST METHODS
Moisture Vapor Transmission Rate (MVTR). Cond 1 Proc. B & Proc BW Cond 2 Proc. B or Proc. BW	 600 g/m sq/24hrs, min 3600 g/m sq/24hrs, min 600 g/m sq/24hrs, min 3600 g/m sq/24hrs, min	 ASTM E 96[8], Procedure B 1/ & BW 2/ ASTM E 96[8], Procedure B 1/ & BW 2/
MVTR, After Synthetic Perspiration Cond 1 Proc. B & Proc BW Cond 2 Proc. B & Proc BW	 600 g/m sq/24 hrs, min 3600 g/m sq/24hrs, min 600 g/m sq/24hrs, min 3600 g/m sq/24hrs, min	 Test procedure "C" & ASTM E 96[8], Procedure B 1/ & BW 2/ Test procedure "C" & ASTM E 96[8], Procedure B 1/ & BW 2/
Hydrostatic Resistance (HR) - Initial	No leakage (40 psi)	ASTM D 3393[9]
HR, After Strength of Coating	No leakage (40 psi)	FED-STD-191 #5972[10] 4/ & ASTM D 3393[9]
HR, After Abrasion, (Face and Back)	No leakage (40 psi)	AATCC #119[11] 1/ & ASTM D 3393[6]

CHARACTERISTIC	2GECWCS REQUIREMENTS	TEST METHODS
HR, After Exposure to DEET Initial Exposure After Laundering	 No leakage (40 psi) No leakage (40 psi) (1 cycle)	 Test procedure "D" & ASTM D 3393[9] Test procedure "D" & "F" and ASTM D 3393[9]
HR, After Exposure to Diesel Initial Exposure After Laundering	 No leakage (40 psi) No leakage (40 psi) (1 cycle)	 Test procedure "D" & ASTM D 3393[9] Test procedure "D" & "F" and ASTM D 3393[9]
HR, After Exposure to Weapons Lubricant Initial Exposure After Laundering	 No leakage (40 psi) No leakage (40 psi) (1 cycle)	 Test procedure "D" & ASTM D 3393[9] Test procedure "D" & "F" and ASTM D 3393[9]
Hydrostatic Resistance After High Humidity	No leakage (40 psi)	Test procedure "J" & ASTM D 3393[9]
Stiffness	10.0 cm - maximum	FED-STD-191 #5204[12]
Water Permeability Initial	No leakage (50 cm/10 minutes)	AATCC #127[13] 6/
Water Permeability After Flex, 70°F (Warp & Filling)	No leakage 50 cm/10 minutes)	Test procedure "G" & AATCC #127[13] 6/

CHARACTERISTIC	2GECWCS REQUIREMENTS	TEST METHODS
Water Permeability After Synthetic Perspiration		Test procedure "C" & AATCC #127[13] 6/
Initial Exposure	No leakage (50 cm/10 minutes)	Test procedure "C" & "F" and AATCC #127[13] 6/
After Laundering	No leakage (50 cm/10 minutes) (1 cycle)	
Water Permeability After Cold Flex,		Test procedure "H" & AATCC #127[13] 6/
-40°F - Warp & Filling	No leakage (50 cm/10 minutes)	
Water Permeability After DEET		Test procedure "D" & AATCC #127[13] 6/
Initial Exposure	No leakage (50 cm/10 minutes)	Test procedure "D" & "F" and AATCC #127[13] 6/
After Laundering	No leakage (50 cm/10 minutes) (1 cycle)	
Water Permeability After Diesel		Test procedure "D" & AATCC #127[13] 6/
Initial Exposure	No leakage (50 cm/10 minutes)	Test procedure "D" & "F" and AATCC #127[13] 6/
After Laundering	No leakage (50 cm/10 minutes) (1 cycle)	

CHARACTERISTIC	2GECWCS REQUIREMENTS	TEST METHODS
WP, After Weapons Lubricant Initial Exposure After Laundering	 No leakage (50 cm/10 minutes) No leakage (50 cm/10 minutes) (1 cycle)	 Test procedure "D" & AATCC #127[13] 6/ Test procedure "D" & "F" and AATCC #127[13] 6/
Spray Rating After Laundering	 Equal to or better than 90,90,80 after 5 laundering	 Test procedure "F" & AATCC #22[14]
Resistance to Organic Liquids After Laundering	 No wetting by n-tetradecane after 5 laundering	 Test procedure "F" & AATCC #118[15]
Physical Surface Appearance Changes After Laundering	No changes in physical surface appearance after 20 laundering	Test procedure "E"
Dimensional Stability, Warp x Filling	Warp - 4.0% (max.) Filling - 2.0% (max.)	FED-STD-191 #5552[16]
Water Permeability After Seam Tape	No leakage (50 cm/10 minutes)	Test procedure "K"

1/ The back side of the test cloth shall face the water, the free stream air velocity shall be 550 ± 50 FPM as measured 2 inches above the fabric specimen. The air flow shall be measured at least 2 inches from any other surface. The test shall be run for 24 hours and weight measurements shall be taken at only the start and completion of the test. At the start of the 24 hour test period, the air gap between the water surface and the back of the specimen shall be 3/4 ± 1/16 inch. Five initial and three after synthetic perspiration specimens shall be tested.

2/ The back side of the test cloth shall face the water. The free stream air velocity shall be 550 ± 50 FPM as measured 2 inches below the fabric specimen. The air flow shall be
measured at least 2 inches from any other surface. The test shall be run for 2 hours and weight measurements shall be taken at only the start and completion of the test. Five specimens shall be tested. The specimen shall be sealed in any manner which prevents wicking and/or leaking of water out of the cup.

3/ The water pressure shall be applied to the face side of the test cloth.

4/ Except that the specimens shall be stretched at 20 pounds.

5/ The abrasion test shall be conducted in multidirectional mode using the face side of the test cloth as the abradant. A load of 6 pounds shall be applied to the abradant. The test shall be completed at 10,000 cycles.

6/ The water permeability shall be measured as specified in Method 5516[17] of FED-STD-191, except that the face side of the test cloth shall contact the water. The hydrostatic head shall be 50 centimeters and shall be held for 5 minutes. The report shall include only measurement of the appearance of water drops. Leakage is defined as the appearance of water any place within the 4-1/2 inch diameter test area. The test may be performed using any device which tests the same specimen area at the equivalent pressure. In cases of dispute, the apparatus described in Method 5516[17] of FED-STD-191 shall be used.

TEST PROCEDURES

A - Accelerated laundering test. The test procedure shall be in accordance with FED-STD-191 test method 5614[18], except the following deviations shall apply: Five (5) specimens containing predominantly Black print, each 4-1/2 inches by 3 inches, shall be cut from the test fabric and then folded in half, with the face side out, to form a bag 2-1/4 by 3 inches. Machine stitch the open edges together (seam allowance no more than 1/4 inch) to form a bag leaving an opening (approximately one inch in length). Through the opening add 35 stainless steel spheres. Close the bag by stapling or stitching. Place the bag in a stainless steel cylinder (one bag per cylinder) without the color transfer cloth, add 50 ml of P-D-245[19], Type II detergent solution (0.5 percent by weight detergent solution) and loo stainless steel spheres and close tightly. Place the stainless steel cylinder in a preheated Launder-Ometer set at a water bath temperature of 160° ± 5° F. Agitate cylinder for one (1) hour maintaining a constant temperature. At the end of the laundering cycle, remove the bag from cylinder and rinse each bag thoroughly in a beaker, in running tap water at 100° ± 5° F for five (5) minutes with occasional stirring or hand squeezing. Remove excess water by squeezing in hand (not extracting) and then dry bag in automatic tumble dryer set on permanent press cycle, 150°-160° F for fifteen

(15) minutes (more than one bag can be dried together). If the bag breaks open to release the contained spheres at any time during the test, the test shall be considered invalid and another bag specimen shall be prepared and tested. Remove all spheres from the bag and evaluate each face of the bag without pressing or ironing the bag. Each face of the laundered bag shall be compared to the original sample (unlaundered) in accordance with AATCC Evaluation Procedure 1 for evaluation of Gray Scale for Color Change[2] and the rating shall be based on the portion of the Black print exhibiting the most color loss. The lower of the two ratings of each bag shall be recorded as the result for the bag. Failure of any of the five (5) bags to meet the required rating, shall be considered a test failure.

B - Spectral reflectance test. Reflectance data shall be obtained from 600 to 860 nm relative to a barium sulfate standard, the preferred white reference standard. Other reference white standards may be used provided they are calibrated to an absolute white; e.g., Halon, magnesium oxide or vitolite tile. The spectral bandwidth at 860 nm shall be less than 26 nm. Reflectance measurements shall be made using either the monochromatic or polychromatic mode of operation of a spectrophotometer. When the polychromatic mode is used, the spectrophotometer shall operate with the specimen diffusely illuminated with the full emission of a source that simulates either CIE Source A^{20} or CIE Source $D65^{20}$. Each shade of the pattern shall be measured as a single layer of cloth backed with six layers of outer shell material of the same shade. Readings will be taken on a minimum of two different areas and the data averaged. The specimen shall be viewed at an angle no greater than 10 degrees from normal with specular component included. Photometric accuracy shall be within 2 nm. The standard aperture size used in the color IR reflectance values falling outside the limits at four or more of the wavelengths specified in Table A-1 shall be considered a test failure.

Table A-1. Spectral Reflectance Requirements

Wavelength	Reflectance Values (percent)					
	Black 357		Light Green 354		Dark Green 355 and Brown 356	
Nanometers	Min	Max	Min	Max	Min	Max
600			8	20	3	13
620			8	20	3	13
640			8	20	3	13
660			8	20	3	13
680			8	36	3	22
700		20	14	60	6	46
720		30	26	78	20	60
740		33	40	90	30	80
760		33	50	92	32	88
780		34	55	92	32	90
800		34	55	92	32	90
820		35	55	92	32	90
840		35	55	92	32	90
860		35	55	92	32	90

C - Water permeability and moisture vapor transmission rate after perspiration test. The specimen, 8 inches by 8 inches, shall be cut and exposed to synthetic perspiration as follows: The synthetic perspiration solution shall be made up in a 500 ml glass beaker by combining 3.0 grams sodium chloride, 1.0 gram trypticase soy broth powder, 1.0 gram normal propyl propionate, and 0.5 gram of liquid lecithin. Add 500 ml of distilled water, add a magnetic stirring bar, and cover the beaker. Place the beaker on a combination hot plate/magnetic stirrer apparatus. While stirring, heat the solution to 500° C until all ingredients are dissolved. While stirring, cool the solution to 350° C, remove cover, and dispense immediately with a pipette or other suitable measuring device. Dispense 2 ml of perspiration solution at 350° C onto the center of an 8 inch by 8 inch by 1/4 inch glass plate. Place the specimen on the glass plate with the knit side facing the glass. Dispense an additional 2 ml of the synthetic perspiration solution onto the center of the specimen. Place an 8 inch by 8 inch by 1/4 inch glass plate on top of the specimen with a 4 pound weight positioned in the center. After 16 hours, remove the specimen (do not rinse) and air dry the specimen before testing. Test the specimen for water permeability or moisture vapor transmission rate, as applicable.

D - Hydrostatic Resistance after exposure to petroleum, oils, and lubricants test. The specimen, 8 inches by 8 inches, shall be laid flat, face side up, on a glass plate, 8

inches by 8 inches by 1/4 inch. Three drops of the test liquid (i.e., DEET, diesel) shall be applied to the center of the specimen. A glass plate of the same dimensions shall be placed on the specimen and a four (4) pound weight placed in the center of the glass plate of the assembly. After 16 hours, remove the specimen and test immediately for hydrostatic resistance or water permeability, as applicable.

E - Physical surface appearance laundering test. Place 2 + 0.2 pounds of the finished, test cloth and, if needed, ballast in an automatic washing machine set on permanent press cycle, high water level and warm (100° + 10° F, -0° F) wash temperature. Each sample unit, 48 inches in length by full width, shall be cut in half across the width of the fabric. one half of the sample unit (24 inches) will be laundered and the other half retained for final evaluation (unlaundered). Place 0.5 ounces (14 grams) of detergent conforming to Type II of P-D-245[19] into the washer. The duration of each laundering cycle shall be 30 + 5 minutes. After laundering, place sample and ballast in an automatic tumble dryer set on permanent press cycle, 150°-160° F, and dry for approximately 15 minutes. Conduct 20 laundering and drying cycles. After each drying cycle, examine both sides of the cloth for changes in physical surface appearance. Sample shall show no changes in physical surface appearance when compared to the unlaundered sample. The laundering equipment, washer and dryer, shall be in accordance with AATCC test method #135[21].

F - Spray Rating and Resistance to Organic Liquids test. Procedure E except for the sample size and the evaluation for physical surface appearance shall be used to launder samples for one (1) cycle prior to testing for spray rating and resistance to organic liquids and to launder synthetic perspiration, DEET, diesel, weapons lubricant, motor oil and JP-8 contaminated samples for one (1) cycle prior to testing for hydrostatic resistance and water permeability, as applicable.

G - Water Permeability after flex (700° F) test. One specimen, eight (8) inches by twelve (12) inches, shall be cut from the sample unit with the eight (8) inch dimension in the indicated direction (warp or filling as applicable). The specimen shall be conditioned and flexed as specified in Method 2017[22] of FED-STD-101 except the specimen shall not be aged, the short edges shall not be heat sealed or otherwise joined, and the specimen shall be flexed for 1500 cycles. Two six (6) inch by eight (8) inch specimens shall be cut from the eight (8) inch by twelve (12) inch flexed specimen and tested for water permeability.

H - Water permeability after cold flex test. The water permeability after cold flex test shall be as specified in procedure G except that the eight (8) inch by twelve (12) inch specimen shall be mounted on the flex test apparatus, placed in a test chamber at the specified temperature for one hour, and then flexed in the test chamber at the specified temperature. At the end of the flexing cycle, the specimen shall be removed from the test chamber and conditioned prior to testing for water permeability.

J - High humidity test. Three (3) specimens, four (4) inches by four (4) inches, shall be

tested and shall be laid flat, back side up on a supporting plate and the assembly placed in a desiccator containing water in the lower portion. The water level shall be approximately one (1) inch below the specimens. The lid of the desiccator shall be put in place and the desiccator placed in a circulating air oven having a temperature of 160° F ± 2° F for a period of seven (7) days. At the end of the aging period, each specimen shall be removed from the desiccator and tested immediately in accordance with ASTM D-3393 with the water pressure being applied to the face side of the material.

K - Water permeability after seam tape. A square sample of material, 24 inches by 24 inches, shall be cut with one diagonal of the specimen parallel to the warp direction of the material. The square sample shall then be cut in half to form two (2) rectangular pieces of dimensions 12 inches by 24 inches. The two (2) rectangular pieces shall be superimposed with face sides together and then seamed along one, 24-inch long dimension. The bias seam (relative to the fabric) shall be constructed as a Type SSa-1 seam[23] using a Type 301 stitch[24], size B thread of V-T-285[25], 10 to 13 stitches per inch and a 1/4 (max.) seam allowance. The seam shall then be seam taped with a suitable seam tape compatible with the material. The seam tape shall be one (1) inch (± 1/16 inch) wide and shall be applied over the sewn seam on the back side of the material as one continuous piece. The taped, seamed test sample shall be cooled for a minimum of one (1) hour prior to further testing. The test sample shall be laundered for five (5) cycles in accordance with Test Procedure E and then visually examined for any sign of tape lifting, curling, bubbling, puckering or separation along the tape edges or tape width (the occurrence of any of these visual defects shall be considered a test failure). Three (3) test samples shall be prepared and evaluated. Two (2), eight (8) inch by eight (8) inch, test specimens (maximum) shall be cut from the center 16 inch square area of each test sample; the seam taped seam shall be centered in each test specimen. Five (5) test specimens shall then be tested for water permeability in accordance with AATCC #127[13] 6/ with the seam centered in the test area and using a 50 centimeter hydrostatic pressure head held for a period of 10 minutes.

REFERENCES

1/ American Society for Testing Materials, Annual Book of Standards, 1994, Test Method D3776, Standard Test Method for Mass per Unit Area (Weight) of Woven Fabrics, Vol. 07.02, pp 89-92.

2/ Technical Manual of the American Association of Textile Chemists and Colorists, Test Method AATCC Evaluation Procedure 1, Gray Scale for Color Change, pp 348-349.

3/ Technical Manual of the American Association of Textile Chemists and Colorists, Test Method #61, Colorfastness to Laundering, Home and Commercial: Accelerated, pp 94-97.

4/ Technical Manual of the American Association of Textile Chemists and Colorists, Test Method AATCC Evaluation Procedure 3, AATCC Chromatic Transference Scale, pp 352-352.

5/ Technical Manual of the American Association of Textile Chemists and Colorists, Test Method #8, Colorfastness to Crocking: AATCC Crockmeter Method, Vol. 69, pp 23-25.

6/ American Society for Testing Materials, Annual Book of Standards, 1994, Test Method D5034, Standard Test Method for Breaking Force and Elongation of Textile Fabrics (Grab Test), Vol. 07.02, pp 704-710.

7/ American Society for Testing Materials, Annual Book of Standards, 1994, Test Method D2582, Test Method for Puncture Propagation Tear Resistance of Plastic Film and Thin Sheeting, Vol. 08.02, pp 76-79.

8/ American Society for Testing Materials, Annual Book of Standards, 1994, Test Method E96, Test Method for Water Vapor Transmission of Materials, Vol. 04.06, pp 696-703.

9/ American Society for Testing Materials, Annual Book of Standards, 1994 Test Method, D3393, Specification for Coated Fabrics - Waterproofness, Vol. 09.02, pp 128-129.

10/ FED STD 191, Federal Standard for Textile Test Methods, Test Method #5972, Strength of Coating; Water Resistance Method.

11/ Technical Manual of the American Association of Textile Chemists and Colorists, Test Method #119, Colorfastness to Flat Abrasion (Frosting): Screen Wire Method, pp 199-201.

12/ FED STD 191, Federal Standard for Textile Test Methods, Test Method #5204, Stiffness of Cloth, Directional, Self Weighted, Cantilever method.

13/ Technical Manual of the American Association of Textile Chemists and Colorists, Test Method #127, Water Resistance: Hydrostatic Resistance Test, pp 216-217.

14/ Technical Manual of the American Association of Textile Chemists and Colorists, Test Method #22, Water Repellency: Spray Test, pp 70-71.

15/ Technical Manual of the American Association of Textile Chemists and Colorists, Test Method #118, Oil Repellency: Hydrocarbon Resistance Test, pp 196-198.

16/ FED STD 191, Federal Standard for Textile Test Methods, Test Method #5552, Shrinkage in Laundering; Cloth other than Cotton and Linen.

17/ FED STD 191, Federal Standard for Textile Test Methods, Test Method #5516, Water Resistance of Cloth, Water Permeability, Hydrostatic Pressure Method.

18/ FED STD 191, Federal Standard for Textile Test Methods, Test Method #5614, Colorfastness to Laundering of Wool, Silk, Rayon, and Other Textile Materials, Launder-Ometer method.

19/ Federal Specification P-D-245, Detergent, General Purpose, Laundry and Hand Washing (Granular)

20/ Publication CIE No. 15 (E-1.3.1 1971), Colorimetry, Bureau Central de la CIE, Paris 1971; Supplement 1, 1972; Available from U. S. National Committee, CIE National Bureau of Standards, Washington, D. C. 20234

21/ Technical Manual of the American Association of Textile Chemists and Colorists, Test Method #135, Dimensional Changes in Automatic Home Laundering of Woven and Knit Fabrics, pp 233-235.

22/ FED STD 101, Federal Standard for , Test Method #2017, Flexing Procedure for Barrier Materials

23/ FED STD 751, Federal Standard for Stitches, Seams, and Stitching, Seam Type Ssa-1.

24/ FED STD 751, Federal Standard for Stitches, Seams, and Stitching, Stitch Type 301.

25/ Federal Specification V-T-285, Thread, Polyester.

Appendix B

2GECWCS PARKA AND TROUSER REQUIREMENTS

REQUIREMENT[1,2]	ARMY[1]	MARINE CORP[2]
Environmental Protection	Provide wet and cold environmental protection at temperature ranges down to -60 deg F. Environmental Protection Range using current ECWCS under garments.	Function in a wet/cold and dry/cold environment in the temperature range of +40 deg F to -25 deg F. Maximum protection from snow and rain. Maintain or enhance the current cold weather protection of the user.
Waterproofness	Water resistant ('83 SNCIE[3]) Provide waterproof front and underarm vent closures. (ORD[1])	Waterproof in design. Maintain MVTR
Compressed bulk	Latest materials technology (less bulky than current ECWCS Parka)	Achieve at least a 15% compressed bulk reduction (25%0 desired) when compared to the current standard item. (system)
Weight	= < the standard system	Achieve at least a 15% weight reduction (25% desired when compared to the current standard item. (system)
Lower Cargo Pockets, Pockets	Must be compatible/usable while wearing LBE/ITLBV	Pockets (generic) must be accessible while wearing LBE. Exterior pockets (generic) must be oriented to allow natural anatomic entry of hands.
Hood	Rolled and stowed, compatible with a fur ruff	Stowable hood
Hung Lining	Investigate Elimination	Investigate Elimination

REQUIREMENT	ARMY	MARINE CORPS
Snow Skirt	Retain	Retain
Field durability See Note 3 of COIC	=> current parka or provide for 120 days field life, whichever is the more restrictive criterion	Minimum service life of 120 days under combat conditions
Comply with applicable health, safety, and HFE design requirements	Yes (ORD[1]). Materials not harmful to skin and do not constitute a flame thermal hazard ('83 SNCIE[3]).	Yes, = < current standard system
ILS	To be supported in the same manner as existing like systems. No additional burdens on the support system. No training strategy or devices required. '83 SNCIE[3] states "Require no user maintenance other than normal care, cleaning, or replacement of damaged components, Repairable by using unit"	Require no user maintenance other than normal care and cleaning
MANPRINT	Shall present no significant MANPRINT issues	Shall present no significant MANPRINT issues.
Fit	5th% female to 95th% male Soldier	5th% female to 95% male Marine
Concept	Use as a layering system with ventilation openings. Function Homogeneously with other items of combat clothing and equipment. Function as the protective layer of ECWCS.	Use as a layering system with ventilation openings. Function Homogeneously with other items of combat clothing and equipment. Function as the protective layer of ECWCS.
Don/Doff	Easily donned and doffed ("83 SNCIE[3])	Easily donned and doffed

REQUIREMENT	ARMY	MARINE CORPS
Shelf life	5 year shelf life ('83 SNCIE[3])	Minimum shelf life of 5 years
Resistant to mold and mildew	Yes ('83 SN-CIE[3])	Yes
Resistant to POL's	Yes, when practical	Yes, when practical
Launderable	= to or better than current standard	SHIPBOARD
Ventilation (Heat Burden Reduction)	provide ease of use for underarm ventilation, reduce heat burden, and be compatible when used with LBE	provide ease of use for underarm ventilation, reduce heat burden, and be compatible when used with LBE
Special pockets		Waterproof interior "map pocket
Trousers		Trousers must have external pockets. They shall accommodate either suspenders or a belt.
Drying	Quick Drying	Quick Drying
Camouflage	Compatible with approved camouflage patterns. Possess maximum IR signature reduction. ('83 SNCIE[3])	Compatible with approved camouflage patterns. Possess maximum IR signature reduction. ('83 SNCIE)
Semi-permanently attached name tape	Yes	Yes
Compatible with current NBC ensemble	Yes ('83 SNCIE[3])	Yes
Compatibility	Compatible with components/subsystems of IIFSP ('83 SNCIE[3]). Compatible with the developmental Modular Field Pack if ready.	Compatible with components/subsystems of IIFSP. Compatible with the developmental Modular Field Pack if ready.

REFERENCES

1/ U. S. Army Infantry School and Center, Operational Requirements Document for a Second Generation Extended Cold Weather Clothing System Parka and Trousers, 2 November 1993, and amended 30 November 1993

2/ U. S. Marine Corps Systems Command, Operational Requirements Document for Cold Weather Clothing and Equipment, no date

3/ United States Army Infantry School, Statement of Need, Clothing and Individual Equipment for an Extended Cold Weather Clothing System, 1983

ACRONYMS

2GECWCS - Second Generation Extended Cold Weather Clothing System
AATCC - American Association of Textile Chemists and Colorists
ABV STD - Above Standard
ASTM - American Society for Testing and Material
BLW STD - Below Standard
^{o}C - degrees Celsius
CIE - Commission International De l'Eclairage
DEET - Diethyltoluamide
ECWCS - Extended Cold Weather Clothing System
^{o}F - degrees Fahrenheit
FED STD - Federal Standard
FPM - Feet Per Minute
HR - Hydrostatic Resistance
ILS - Integrated Logistics Support
ITLBV - Individual Tactical Load Bearing Vest
KGF - Kilograms of Force
LBE - Load Bearing Equipment
MANPRINT - Manpower and Personnel Integration
MVTR - Moisture Vapor Transmission Rate
NBC - Nuclear, Biological, Chemical
NRDEC - Natick Research, Development, and Engineering Center
ORD - Operational Requirements Document
POL - Petroleums, Oils, and Lubricants
PSI - Pounds per Square Inch
STD - Standard
TECOM - Test and Evaluation Command
TEXCOM - Test and Experimentation Command
WP - Water Permeability