

WOODHEAD PUBLISHING IN TEXTILES



Military textiles

Edited by Eugene Wilusz



The Textile Institute

WP

Contents

<i>Contributor contact details</i>	<i>xi</i>
<i>Woodhead Publishing in Textiles</i>	<i>xv</i>
<i>Introduction</i>	<i>xxi</i>

Part I	General requirements for military textiles	1
1	Future soldier requirements: Dealing with complexity	3
	E. SPARKS, Cranfield University, UK	
1.1	Introduction	3
1.2	The current and future challenges faced by the soldier	5
1.3	Dynamic complexity: The impact of the human	9
1.4	Provision of capability and how to make trade-off decisions	11
1.5	Summary	14
1.6	References	15
2	Non-woven fabrics for military applications	17
	G. A. THOMAS, Auburn University, USA	
2.1	Introduction	17
2.2	Protective materials, devices and end-use requirements	23
2.3	Proper selection of fibers	26
2.4	Variations of fiber forms	29
2.5	Filament lay-up composites	39
2.6	Historical uses of non-woven ballistic-resistant fabrics	42
2.7	Methodologies for use of non-woven ballistic-resistant fabrics	43
2.8	Future directions for non-woven fabric applications	47
2.9	References	48

3	Mechanical failure criteria for textiles and textile damage resistance	50
	N. PAN, University of California, USA	
3.1	Introduction: Material resistance, strength and failure	50
3.2	Material strengths	51
3.3	The peculiarities of textile mechanics	54
3.4	Failure criteria for fabrics	56
3.5	Other forms of failure for fabrics and garments	62
3.6	Fabric and garment failure reduction	65
3.7	References	67
4	The sensory properties and comfort of military fabrics and clothing	71
	A. V. CARDELLO, US Army Natick Soldier Research, Development and Engineering Center, USA	
4.1	Introduction	71
4.2	The sensory and perceptual properties of fabrics and clothing	74
4.3	The comfort properties of fabrics and clothing	76
4.4	Cognitive influences on fabrics and clothing	81
4.5	Handfeel and comfort evaluations of military fabrics	82
4.6	Cognitive influences on fabric and clothing perception	94
4.7	The role of clothing comfort on military performance	100
4.8	Conclusions	103
4.9	Acknowledgment	103
4.10	References	103
5	Testing and analyzing comfort properties of textile materials for the military	107
	F. S. KILINC-BALCI and Y. ELMOGAHZY, Auburn University, USA	
5.1	Introduction	107
5.2	The multiplicity of characterization methodologies of comfort	108
5.3	The trade-off between protection and comfort	111
5.4	The comfort trilobite: Tactile, thermal, and psychological	111
5.5	Modeling the comfort phenomena: The ultimate challenge	123
5.6	Comfort and protection in military clothing	130
5.7	Multiple-layer systems	133
5.8	Future trends	133

5.9	References	135
5.10	Bibliography	136
6	Sweat management for military applications	137
	N. PAN, University of California, USA	
6.1	Introduction: Body/clothing/environment – the microclimate	137
6.2	Heat, moisture and interactions within the microclimate	140
6.3	Heat and moisture interactions in the microclimate	146
6.4	Sweat management for military apparel applications	149
6.5	Conclusions	154
6.6	References	155
7	Cold-weather clothing	158
	C. THWAITES, W. L. Gore and Associates UK Ltd, UK	
7.1	Introduction	158
7.2	Cold weather	159
7.3	Physiological responses to cold	159
7.4	Clothing design principles	162
7.5	Estimation of the clothing insulation required	165
7.6	Evaluation system for textiles and garments	167
7.7	Selection of clothing for cold weather	169
7.8	Sources of further information and advice	178
7.9	References	179
8	Designing military uniforms with high-tech materials	183
	C. A. GOMES, Foster-Miller, Inc., USA	
8.1	Introduction	183
8.2	Design process	184
8.3	Features of military uniforms	185
8.4	Physiological monitoring	185
8.5	Thermal management	186
8.6	Signature management	191
8.7	Chemical and biological defense management	194
8.8	Flame resistance	196
8.9	Environmental defense	196
8.10	Body armor	197
8.11	Future trends	198
8.12	Sources of further information and advice	201
8.13	References	202

Part II	Protection	205
9	High-performance ballistic fibers	207
	T. TAM and A. BHATNAGAR, Honeywell International Inc., USA	
9.1	Introduction	207
9.2	Classical high-performance fibers	207
9.3	Rigid chain aromatic high-performance fibers	208
9.4	High-temperature performance fibers	209
9.5	High-performance thermoplastic fibers	210
9.6	Physical properties comparison	211
9.7	Requirements for high-performance fibers	211
9.8	Aramid fibers	213
9.9	Gel spinning of ultra-high molecular weight polyethylene (HMPE) fiber	219
9.10	Poly(<i>p</i> -phenylenebenzobisoxazole) (PBO) fiber	224
9.11	Sources of further information and advice	227
9.12	References	227
10	Ballistics testing of textile materials	229
	D. R. DUNN, H. P. White Laboratory, Inc., USA	
10.1	Introduction	229
10.2	Military usage of textiles	229
10.3	Armor testing	231
10.4	Ballistic limit (V50) testing	235
10.5	Residual velocity testing	237
10.6	Ballistic resistance testing	237
10.7	Blunt trauma (back-face deformation) testing	238
	Appendix 10.1: US military standards for armoring materials and commodities	240
	Appendix 10.2: Glossary	240
11	Chemical and biological protection	242
	Q. TRUONG and E. WILUSZ, US Army Natick Soldier Research, Development and Engineering Center, USA	
11.1	Introduction	242
11.2	Current chemical/biological (CB) protective clothing and individual equipment standards	246
11.3	Different types of protective materials	249
11.4	Proper protective material designs	253

11.5	Clothing system designs	256
11.6	Testing and evaluation of chemical/biological (CB) protective materials and clothing systems	258
11.7	Future trends	267
11.8	Acknowledgments	268
11.9	References	268
	Appendix 11.1: Chemical warfare agent characteristics	271
	Appendix 11.2: Selected biological agent characteristics	274
	Appendix 11.3: Protective gloves and shoes	277
	Appendix 11.4: Overgarment and other chemical protective clothing systems	278
	Appendix 11.5: Improved toxicological agent protective ensemble (ITAP), self-contained, toxic, environment protective outfit (STEPO) and other selected civilian emergency response clothing systems	279
	Appendix 11.6: Selected toxic industrial chemicals (TICs)	280
12	Self-decontaminating materials for chemical biological protective clothing	281
	G. SUN, University of California, USA and S. D. WORLEY and R. M. BROUGHTON Jr, Auburn University, USA	
12.1	Introduction	281
12.2	Self-decontaminating materials	282
12.3	Applications	284
12.4	Future trends	290
12.5	Summary	291
12.6	Acknowledgments	291
12.7	References	291
13	Camouflage fabrics for military protective clothing	293
	P. SUDHAKAR and N. GOBI, K. S. Rangasamy College of Technology, India and M. SENTHILKUMAR, PSG Polytechnic College, India	
13.1	Introduction	293
13.2	Methods for production of camouflage textiles	295
13.3	Chromic materials	296
13.4	Identification of chromophores	300
13.5	Synthesis of new polymers	301
13.6	Synthesis of monomeric and oligomeric chromophores	305
13.7	Conductive/conjugated polymers	305
13.8	Emissive polymers	312

13.9	Surface attachment of chromophores to conducting polymers	314
13.10	Processing of electrically conducting polymers	315
13.11	Assembling of gold nanoparticles	317
13.12	Conclusions	318
13.13	Acknowledgment	318
13.14	References	318
14	New developments in coatings and fibers for military applications	319
	P. SUDHAKAR, S. KRISHNARAMESH and D. BRIGHTLIVINGSTONE, K. S. Rangasamy College of Technology, India	
14.1	Introduction	319
14.2	Chemical agent resistant coatings	319
14.3	Influence of environmental regulations	321
14.4	Water-reducible, two-component polyurethane, chemical agent-resistant coating (CARC) topcoat	322
14.5	Contribution of binders and pigments	322
14.6	Functional garments for soldiers	323
14.7	New-generation fibers for military applications	324
14.8	Acknowledgment	324
14.9	References	325
14.10	Bibliography	325
15	Military fabrics for flame protection	326
	C. WINTERHALTER, US Army Natick Soldier Research, Development and Engineering Center, USA	
15.1	Introduction	326
15.2	Types of fabrics and their performance	327
15.3	Measuring flame and thermal performance	331
15.4	Clothing system configurations and their performance	332
15.5	Future trends	340
15.6	References	343
	<i>Index</i>	346