(NASA-CR-161529) PROJECT FIRES. VOLUME 1: PROGRAM OVERVIEW AND SUMMARY, PHASE 1B Final Report (Grumman Aerospace Corp.) 49 p HC A03/MF A01 CSCL 06Q

N80-32098

Unclas G3/54 28587

NASA CONTRACTOR REPORT

NASA CR-161529

PROJECT FIRES, VOLUME 1: PROGRAM OVERVIEW AND SUMMARY PHASE 1B

By Fred J. Abeles
Grumman Aerospace Corporation
Advanced Development Department
Bethpage, New York 11714

Final Report

May 1980

Prepared for

NASA - Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

PREFACE

The Firefighters' Integrated Response Equipment System (FIRES) program was conducted by the Advanced Development Department of the Grumman Aerospace Corporation, under a contract jointly sponsored by the National Aeronautics and Space Administration (NASA) and the United States Fire Administration (USFA). The program consists of three phases. Phase 1A led to the preliminary design of a prototype system. Phase 1B the subject of this report consists of prototype development, fabrication, and laboratory testing. Phase 2 will proceed through field testing and evaluation of the prototypes, resulting in an economical, fully-acceptable ensemble and finalized specification.

Project FIRES is a systematic approach toward the development of improved protection for structural firefighters. The system protects against such hazards as heat, flame, smoke, toxic fumes, moisture, impact, penetration and electricity. It also affords improved firefighter performance through increased maneuverability, lighter burdens, and improved human engineering designs.

This report is presented in four volumes as follows:

- Volume 1 - Program Overview and Summary
- Volume 2 - Protective Ensemble Performance Standards (PEPS) "Goals for Firefighter Protection"
- Volume 3 - Prototype Protective Ensemble Design Development Report
- Volume 4 - Prototype Protective Ensemble Qualification Test Report

ABSTRACT

Title: Project FIRES Phase 1B Final Report

Author: Fred J. Abeles

Text:
(Keywords) Firefighters' Protective Clothing, Turnout Gear, Helmets, Faceshields, Turnout Coats and Pants, Gloves, Boots, Garment Testing, Advanced-Design Garments, Prototype Protective Garment

(Body) In Phase 1A overall performance requirements and evaluation methods for firefighters protective equipment were established and published as the Protective Ensemble Performance Standards (PEPS).

Current firefighters protective equipment was tested and evaluated against the PEPS requirements, and the preliminary design of a prototype protective ensemble was performed.

In Phase 1B the design of the prototype protective ensemble was finalized. Prototype ensembles were fabricated and then subjected to a series of qualification tests which were based upon the PEPS requirements.

Engineering drawings and purchase specifications were prepared for the new protective ensemble and are incorporated in Volume 3.

1

CONTENTS

1

TABLES

1 - SUMMARY

1.1 BACKGROUND

Always a hazardous profession, firefighting has grown more dangerous in recent years. Firefighters have sustained one of the highest in-the-line-of-duty death rates of any occupation. In 1977, there were 79 deaths per 100,000 professional firefighters. In addition to the high death rate, the injury rate is almost 50 percent. Overexertion, sprains and strains accounted for nearly a third of these injuries; burns, falls, cuts, toxic gas and injuries incurred during building collapse, accounted for the remainder.

In addition to the physical and psychological aspects of these injuries, the financial costs attributable to these accidents are staggering. The reported time lost in salaries plus associated costs, such as medical expenses, law suits, and time lost because of related paper work, etc., result in an estimated overall annual cost to municipal fire departments of between 10 and 20 percent of their budget.

The firefighter's primary defense against death or injury is his Life Protection System, which consists of his basic firefighting uniform, plus supplemental gear. The present system has been in use for years and is just not adequate in many aspects. Aside from not affording the necessary protection, the present full-up system is cumbersome, hot and heavy.

Steps have been taken previously by various corporations and governmental agencies aimed at short-range improvements in the self-contained air mask, turn-out coats, helmets and other equipment. These steps have generally proceeded independently and have not been considered part of an integrated system; and may, in the long run, have further complicated the problem of improving firefighter protection.

PROGRAM INITIATION

The need for improved firefighters protective clothing had been expressed by members of the fire service, as well as state and local technology transfer agents, and the members of the President's Commission on Fire Prevention and Control (America Burning).

Approximately one year after its formation in 1975 the United States Fire Administration (USFA) and the National Aeronautics and Space Administration (NASA) Technology Utilization Office entered into an interagency agreement to co-sponsor a program for the design, development, fabrication, field test and evaluation of improved firefighters personal protective clothing and equipment. There was, however, very little published data or validated reports on what specific problems were causing personal protective clothing and equipment related injuries and deaths.

The project team (USFA and NASA) decided that the most expeditious and efficient manner in which to identify problems and establish requirements was through the utilization of a User Requirements Committee (URC).

USER REQUIREMENTS COMMITTEE AND TECHNICAL ADVISORY GROUP

To ensure that the project was responsive to the needs of the fire service and aware of the most recent efforts in the area of protective equipment, a User Requirements Committee (URC) and a Technical Advisory Group (TAG) were established. The URC membership was established by soliciting recommendations from leaders in the fire service community so that all of the fire service community would be represented (fire chiefs, firefighters, volunteers, instructors, city managers and safety personnel). Selection was made to insure equal representation of the fire service as well as taking into consideration differences in geographic locations, environmental conditions, and different type firefighting situations. The TAG was comprised of representatives from the numerous organizations involved in or concerned with personal safety, or equipment and materials that are related to personal safety.

A complete listing of the membership of the advisory groups is presented in Tables 1 and 2.

PROGRAM GOALS

At an initial introductory meeting, held in early 1976 between members of the URC, the TAG and the project team, it was agreed that an integrated approach to the development of improved protective clothing should be taken as recommended by the Commission in America Burning. The project was called Project FIRES (Firefighters Integrated Response Equipment System). The overall goal of the program was to improve structural firefighter protection against hazards such as heat, flame, smoke, toxic fumes, moisture, impact, penetration and electricity and to allow for improved firefighter performance through increased maneuverability, lighter weight, and

TABLE 1 PROJECT FIRES USER REQUIREMENTS COMMITTEE

Louis DeChine
Safety Director
Miami Fire Department
1385 West 72nd Street
Hialeah, Florida 33014

Edward Durkin
Vice President, IAFF
5606 Old Middleton Road
Madison, Wisconsin 53705

William F. Foley
Chief Fire Marshal
Fire Department Headquarters
558 West DeKoven Street
Chicago, Illinois 60607

Jack Gannon
International Vice President
Cleveland Firefighters
10301 Lake Avenue #613
Cleveland, Ohio 44102

L. Robert Himes, Fire Chief
Forth Worth Fire Department
1000 Throckmorton Street
Fort Worth, Texas 76102

Tracy W. Howard, Supervisor
Budget and Management Office
Public Safety Analysis Section
414-14 Street, Annex II
Denver, Colorado 80202

Chief Warren E. Isman
Director
Montgomery County
Department of Fire and
Rescue Services
6100 Executive Boulevard
Rockville, Maryland 20852

John T. McLaughlin
Battalion Chief
City of New York Fire Department
Division of Training
Randalls Island
New York, New York 10036

Jim Minx
Oklahoma City Firefighters
Local 1524, IAFF
804 N.W. 6th
Oklahoma City, Oklahoma 73106

William Moore, Chief
Oakland Fire Department
1330 Grove Street
Oakland, California 94612

William J. Patterson
Fire Chief
Fire Department
County of Santa Barbara
Fire Administration Center
4410 Cathedral Oaks Road
Santa Barbara, California 93110

John L. Petersen
Volunteer Fire Council
49 East Downer Place
Suite 661
Aurora, Illinois 60505

Frank Smiley
City Manager
City of Newport News
2400 Washington Avenue
Newport News, Virginia 23607

Leo D. Stapleton
Deputy Fire Chief
Boston Fire Department
115 Southhampton Street
Boston, Massachusetts 02118

John L. Swindle, Chief
Fire Department Headquarters
1808 Seventh Avenue, South
Birmingham, Alabama 35203

Ralph Travis
IAFF, Local 112
1539 Beverly Boulevard
Los Angeles, California 90026

Jerry L. Weissinger
Director and Chief
Dayton Fire Department
300 North Main Street
Dayton, Ohio 45402

TABLE 2 PROJECT FIRES TECHNICAL ADVISORS

Louis Amabili
Pres. Int. Soc. of Fire Instructors
Delaware Fire Training Academy
RD-2, Box 166
Dover, Delaware 19901

Dr. Donald Campbell
NIOSH
944 Chestnut Ridge Road
Morgantown, West Virginia 26505

Edward V. Clougherty, Ph. D.
Fire Department Chemist
Boston Fire Department
115 Southampton
Boston, Massachusetts 02118

Richard Duffy
Department of Research
International Association of Firefighters
1750 New York Avenue N.W.
Washington, D.C. 20006

Donald D. Flinn, Gen. Mgr.
International Association of
Fire Chiefs
1329 18th St. N.W.
Washington, D.C. 20036

David Gratz
General Manager
IAFC Foundation
1329 18th Street, N.W.
Washington, D.C. 20036

Mr. John Krasny
National Bureau of Standards
Technology B-22
Washington, D.C. 20234

Abraham L. Lastnik
Department of the Army
U.S. Army - Natick Research and
Development Command
Natick, Massachusetts 01760

Robert D. Mahon, Chief
Protective Equipment Section
NIOSH
4676 Columbia Parkway
Cincinnati, Ohio 45266

Laurie Rosen
Department of the Army
U.S. Army-Natick Research and
Development Command
Natick, Massachusetts 01760

Thomas Seymour
Senior Program Engineer
Civil and Fire Protection Engineering
OSHA
Department of Labor, Room N 3463
Second and Constitution Avenues,
N.W.
Washington, D.C. 20210

Michael Smith
Department of Research
International Association of
Firefighters
1750 New York Avenue, N.W.
Washington, D.C. 20006

Bruce Teele
Fire Service Specialist
Public Protection Association
470 Atlantic Avenue
Boston, Massachusetts 02110

improved human engineering design. These improvements were to be provided at a reasonable cost and within a reasonable time frame. Using the systems approach, the program was to produce more meaningful results, because each piece of equipment would be considered part of a totally integrated system. Operational compatibility between the many functional elements that comprise the system would thereby be ensured. In addition, wherever possible, multiple functions would be combined into a single piece of equipment.

1.2 INTRODUCTION

This report documents Phase 1B of Project FIRES, a systematic approach toward the development of improved protection for structural firefighters. The system will protect against such hazards as heat, flame, smoke, toxic fumes, moisture, impact, penetration and electricity. It will also afford improved firefighter performance through increased maneuverability, lighter burdens, and improved human engineering designs. Phase 1A, which was completed in September 1977 led to the preliminary design of a prototype protection system. Phase 1B, the subject of this report, the development phase, consisted of the design, fabrication and qualification testing of a prototype protection system. Phase 2, the last phase of the program, comprises the field testing and evaluation of the system, resulting in an economical, fully acceptable ensemble and finalized specification.

1.3 TECHNICAL APPROACH

1.3.1 Phase 1A

The technical approach undertaken for the completion of Phase 1A consisted of four tasks. The first task was to establish firefighter protective requirements and prepare equipment performance criteria and standards. In this task, firefighters' protective needs were defined along with the test methods required to evaluate whether a particular piece of gear met these needs.

The second task was to evaluate existing turnout gear against performance criteria and standards developed in Task 1. Protective helmets, eyeshields, coats, pants, gloves and boots were procured and tested. Judgements were then made as to how well present equipment protects the wearers and what areas of existing gear require improvement.

The third task was the design and construction of a breadboard model of a Technology Demonstration Ensemble (TDE). The TDE is a firefighters' protection

system comprised primarily of the most advanced concepts, materials and equipment. Its purpose is to determine how close technology can come to fully meeting firefighters' protective needs when cost and availability are not a factor.

The fourth task was the preliminary design of a prototype protective ensemble. In this task, the lessons gained by the first three tasks were used to produce a preliminary design of an improved protection system which could be developed within the next two years and which could be marketed at prices not greater than 25% more than current equipment.

A more detailed discussion of the technical approach and results for Phase 1A are found in the five-volume Phase 1A final report for Project FIRES dated December 1978.

1.3.2 Phase 1B

The technical approach undertaken for the completion of Phase 1B consisted of four tasks. The first task was to finalize the design of the prototype protective ensemble. In this task Grumman worked closely with industry and the URC to finalize the technical details and the specific configuration of the prototype protective ensemble. The conclusion of this task was a critical design review at which time the finalized design was approved by the NASA, the USFA, the URC, and the TAG.

The second task was the fabrication of eight prototype protective ensembles; five were to be used for qualification testing and three were set aside for delivery to the NASA and the USFA. Three prototypes were constructed with outer shells fabricated out of a 50/50 blend of Kevlar and Nomex, while the outer shells of the remaining garments were constructed of polybenzimidazole (PBI). The ensembles were made in two configurations; a short jacketed bib pants version and a three-quarter coat regular pants version. Both ensembles are described in the brochure presented in the Appendix.

The third task was the performance of qualifcation tests on the individual prototype protective ensemble subsystems and the complete ensemble. The purpose of the tests were to determine how close the prototype comes to meeting the requirements of the Protective Ensemble Performance Standard (PEPS) and more importantly to determine the capabilities of the prototype.

The fourth task was the preparation of a purchase specification for the new protective ensemble. The specification which is to be used by members of the fire community was based upon the results of the qualification test performed on the prototype ensemble, thereby assuring a design which can be manufactured.

A more detailed discussion of the results of Phase 1B of the project is presented in Section 1.4 of this volume.

1.3.3 Phase 2

The technical approach planned for Phase 2 consists of four tasks. The first task will be the fabrication of field test protective ensembles. In this task, a representative group of fire departments will utilize the purchase specification developed in Phase 1B to procure equipment from equipment manufacturers.

The second task will be the field test and evaluation of the protective ensembles. The ensembles procurred in Task 1 will be subjected to the normal everyday use of current protective equipment. Data will be collected as to equipment performance.

In the third task, the information gathered during the field test will be incorporated into a revised edition of the purchase specification.

The fourth task will be to release the revised purchase specification to the firefighting community and industry.

1.4 RESULTS

A detailed report on the results of Phase 1B of Project FIRES is found in the remaining volumes, that comprise this report:

- Volume 2 - Protective Ensemble Performance Standards "Goals for Firefighter Protection"
- Volume 3 - Prototype Protective Ensemble Design Development Report
- Volume 4 - Prototype Protective Ensemble Qualification Test Report

The following paragraphs provide summaries of the content of each of the above four volumes:

1.4.1 Volume 2 - Protective Ensemble Performance Standards

Volume 2 of this report is the Protective Ensemble Performance Standards (PEPS), Revision E. This volume contains the latest set of performance requirements and test methods that were developed for a firefighters' protective system. It is based on actual firefighter needs and sound engineering judgment and not on the availability of materials and equipment. Wherever possible, the standard makes use of terminology used by firefighters and protective equipment manufacturers, because they are groups for whom the document has been prepared. However, an exception has been made in that the common terminology for protective equipment, helmet, face shield, coat, boot, and glove has been replaced by generic terminology as follows:

Head/ear protection

Face/eye protection

Torso/limbs protection

Hand/wrist protection

Foot/ankle protection.

This has been done to encourage the systems approach and the development of equipment that is functional rather than traditional.

Table 3 is a summary of the PEPS. Requirements for each of the generic groups are presented for criteria which fall into four categories: protection criteria, performance criteria, comfort criteria, and service criteria. It should be noted that the PEPS itself discusses test methods for each applicable criteria, but for the sake of brevity, these are not summarized in the table. The requirements have been stated wherever possible in terms of the actual environment faced by the working firefighter. Subsequently, they are translated into engineering terms where feasible. For example, the first line of Table 3, "head/ear impact protection," specifies that the level of protection should be provided "when hit by a brick falling four stores." In the body of the PEPS, this requirement is subsequently presented in engineering terms as "impact of 152 ft-lb."

TABLE 3 SUMMARY OF THE PROTECTIVE ENSEMBLE PERFORMANCE STANDARDS (SHEET 1 OF 6)

	Protection Criteria				
	Head/Ear	Face/Eye	Torso/Limbs	Hand/Wrist	Foot/Ankle
Impact	Limit head acceleration to Wayne State tolerances when hit by a brick falling 4 stories	Protector shall be serviceable after impact by brick	No bruises to firefighter's upper torso, elbows, and knees during falls	Protect back of hand against injury by falling slab of plaster	Protect toe from bruises caused by falling gas bottle or fire apparatus running over toe
Penetration	No injury from corner of brick falling 4 stories	No penetration by impacting nail	No puncture by nail	No penetration by nail	No nail penetration into sole of foot or side of arch
Cut	No cut damage by glass shards falling 4 stories	No cuts or scratches by sharp metal or grit	No cut damage by sharp metal edge	No cut through damage on palm side by sharp metal edge	No toe area cuts by saw blade; no instep cuts by falling glass; other areas not cut by metal edge
Flame	No ignition, burn, char, melt, etc. after exposure to flame	No ignition, burn, char, melt, etc., after exposure to flame	No ignition, burn char, melt, etc. after exposure to flame	No ignition, burn, char, melt, etc. after exposure to flame	No ignition, burn char, melt, etc. after exposure to flame

0505-007D

TABLE 3 SUMMARY OF THE PROTECTIVE ENSEMBLE PERFORMANCE STANDARDS (SHEET 2 OF 6)

Protection Criteria

	Head/Ear	Face/Eye	Torso/Limbs	Hand/Wrist	Foot/Ankle
Heat	• No distortion, meet all reqt's, & temps≤113°F in Class 1,2,3 • No irreversible injury in Class 4	• No distortion, meet all reqt's, & temp≤113°F in Class 1,2,3 • Remain intact, & no irreversible injury in Class 4	• Meet all reqt's. & temps≤113°F in Class 1, 2, 3. • No irreversible injury in Class 4 • Inside temps ≤ ≤113°F for conduction	• Meet all reqt's. & temps ≤ 113°F in Class 1,2,3. • No irreversible injury in Class 4 • Inside temps ≤113°F for conduction	• Meet all reqt's. & temps ≤113°F in Class 1,2,3. • No irreversible injury in Class 4 4 • Inside temps ≤ 113°F for conduction
Electricity	3 ma. max. leakage current at 2200 volts A.C.	3 ma. max. leakage current at 2200 volts A.C.	3 ma. max. leakage current at 2200 volts A.C.	3 ma. max. leakage current at 2200 volts A.C.	3 ma. max. leakage current at 2200 volts A.C.

0505-007D

TABLE 3 SUMMARY OF THE PROTECTIVE ENSEMBLE PERFORMANCE STANDARDS (SHEET 3 OF 6)

	Performance Criteria				
	Head/Ear	Face/Eye	Torso/Limbs	Hand/Wrist	Foot/Ankle
Hearing	Reduction ≤ 10% allowed	N/A	N/A	N/A	N/A
Coverage & Visibility	N/A	Eyes, nose, cheeks & face to be covered; ANSIZ87.1 optical reqt's	N/A	N/A	N/A
Mobility or Dexterity	N/A	N/A	Task to be done with energy expend. ≤10% greater than with street clothes alone; range of motion to be ≤95% of that with no subsystem	Ability to rotate knobs, and depress switches & manipulate objects	Ability to climb stairs with energy expenditures ≤10% greater than with street shoes
Grip and/or Traction	N/A	N/A	N/A	Ability to swing ax and pull on a halyard (wet or dry)	Same traction as Vibram-soled boots on dry surfaces; traction not to be less than 80% and 90%, respectively, of dry surface values

0505-007D

TABLE 3 SUMMARY OF THE PROTECTIVE ENSEMBLE PERFORMANCE STANDARDS (SHEET 4 OF 6)

Comfort Criteria

Function	Head/Ear	Face/Eye	Torso/Limbs	Hand/Wrist	Foot/Ankle
Cold Insulation	Protect from cold at low temp. (-10°F) for 30 min.	N/A	Protect from cold at low temp. (-10°F) for 30 min.	Maintain a minimum of 59°F skin temp. at low air temps (-10°F)	Prevent discomfort in deep snow and maintain inner surface temp ≥ 59°F
Heat Insulation	Hot day energy expenditures ≤ 1% greater than when in street clothes alone	N/A	Hot day energy expenditures ≤ 10% greater than when in street clothes alone	N/A	N/A
Liquid Penetration	Deflect falling liquids and not be affected by hot liquids	N/A	Inside of garment shall not get wet by hot water and sweat shall be allowed to evaporate	Protector shall withstand 4 psi water pressure, absorb sweat, & prevent water penetration at hand/arm interface	No water penetration in deep water (8 in.) and no water entry at foot/leg interface
Weight	30 ounces	6 ounces	5.5 lbs for the 95th percentile	4 ounces per hand	4 lbs total for the 95th percentile
Fit	Must fill all head shapes and sizes	Sizes to provide equal protection to all	Available in numerical sizes	Available in 3 sizes	Available in full & half sizes and range of widths
Retention	Remain on head during falls & impact with objects	N/A	N/A	Retained on hand during active use	N/A

0505-007D

TABLE 3 SUMMARY OF THE PROTECTIVE ENSEMBLE PERFORMANCE STANDARDS (SHEET 5 OF 6)

Service Criteria

Function	Head/Ear	Face/Eye	Torso/Limbs	Hand/Wrist	Foot/Ankle
Maintainability	Basic repairs in fire station	Basic repairs in fire station	Basic repairs in fire station	Basic repairs in fire station	Basic repairs except for soles & heels in fire station; use of standard tools, techniques for shop repairs
Reliability	Meet all performance requirements throughout service life	Meet all performance requirements throughout service life	Meet all performance requirements throughout service life	Meet all performance requirements throughout service life	Meet all performance requirements throughout service life
Durability	5 years service life	5 years service life except for lens which have 6 months	3 years service life	6 months service life	2 yrs service life
Don/Doff	Don in 5 seconds	Deployed in 2 seconds; stowed in 3 seconds	Don in 10 seconds	Don or doff within 5 seconds	Don within 8 seconds; rapid doffing
Dryability	After soaking, dryable within 6 hrs at room temp. 1 hr in oven	N/A	After soaking, dryable within 6 hrs at room temp. 1 hr in oven	After soaking, dryable within 3 hrs at room temp. 20 min in oven	After soaking, dryable within 6 hrs at room temp. 1 hr in oven
Recognizability	Light in color and have retroreflective surfaces	N/A	Retroreflective surfaces	Retroreflective back surfaces	Retroreflective surfaces

0505-007D

TABLE 3 SUMMARY OF THE PROTECTIVE ENSEMBLE PERFORMANCE STANDARDS (SHEET 6 OF 6)

Service Criteria (contd)

Function	Head/Ear	Face/Eye	Torso/Limbs	Hand/Wrist	Foot/Ankle
Acceptance	Protector shall be acceptable and promote usage	Protector shall be acceptable and promote usage	Protector shall be acceptable and promote usage	Protector shall be acceptable and promote usage	Protector shall be acceptable and promote usage
Compatibility	Compatible interfaces with Torso/limbs, Face/eye, Communication, Lighting & Breathing Systems.	Compatible interfaces with Head/ear and Comm. Systems; no interference with Breathing System	Compatible interfaces with all systems and subsystems; no exposed skin at wrists or ankles	Compatible interface with Torso/limbs subsystem and Lighting System; prevent entry of dirt & water into Hand/wrist area or Torso/limbs subsystem	Compatible interface with leg protector; watertight seal at interface
	No intereference with deployment, storage or use of tools, lights, or communication systems	No interference with deployment, storage or use of tools, lights, or communication systems	No interference with deployment, storage or use of tools, lights, or communication systems	No interference with deployment, storage or use of tools, lights, or communication systems	No interference with deployment, storage or use of tools, lights, or communication systems

0505-007D

1.4.2 Volume 3 - Prototype Protective Ensemble Design Development Report

Volume 3 of this report contains the information that was used in the Critical Design Review during Phase 1B. The report is divided into three parts as follows:

- Part I - Description of Prototype Protective Ensembles.

This section includes a description of each of the subsystems that make up the protective ensemble along with design selection rationale. An appendix with supporting technical data has also been provided.

- Part II - Engineering Drawings for Prototype Protective Ensemble

Included are a set of detailed engineering drawing which were used to fabricate the prototype protective ensemble described in Part I.

- Part III - Specifications for Prototype Protective Ensemble.

The specifications presented were developed using the requirements and test method of the Protective Ensemble Performance Standard (PEPS) as a guide. However, in those areas that could not be satisfied by the prototype ensemble, the specification conforms to the capabilities of the prototype rather than the requirements of the PEPS.

1.4.3 Volume 4 - Prototype Protective Ensemble Qualification Test Report

Volume 4 of this report contains the results of the evaluation of the prototype protection equipment developed during Phase 1B. Results are based upon tests that were either conducted during Phase 1A, Phase 2B or manufacturers data. Requirements used for the qualification tests were based upon and in most cases are the same as those requirements specified in Revision E of the PEPS. A summary of the test program is presented in Table 4. Included are brief descriptions of the requirements for the PEPS as well as the Qualification test, the test method, the test apparatus, and the results of the test.

1.4.4 Industry Briefings and Prototype Protective Ensemble Descriptive Brochure

A series of three industrial briefings were held at the conclusion of Phase 1B. The briefings were in Los Angeles, Ca, New Orleans, La, and New York, NY. The purpose of these briefings was to familiarize the firefighters protective equipment industry with the goals, status and future of the Project FIRES program. As part of the presentation, a brochure which describes the prototype protective ensemble was distributed. A copy of this brochure is included in the Appendix to this volume.

TABLE 4 PROJECT FIRES QUALIFICATION TEST PROGRAM SUMMARY (SHEET 1 of 16)

HEAD/EAR PROTECTION

TEST	REQUIREMENTS		TEST METHOD	TEST APPARATUS	RESULTS
	PEPS	QUALIFICATION			
IMPACT, APEX	BRICK FALLING 4 STORIES WITH IMPACT FORCE OF 152 ft lb/150g's TRANSMITTED	(PEPS)	SAME METHOD AS ANSI Z90.1 EXCEPT HEAD FORM/HELMET IS DROPPED FROM APPROPRIATE HEIGHT THAT GIVES 152 ft lb	ANSI Z90.1 SLED	PASS
IMPACT, SIDE	SAME AS ABOVE EXCEPT 152 ft lb/400g's • ABOVE TESTS TO BE RUN AT ROOM TEMP	101 ft lb/400 g	SAME AS ABOVE EXCEPT 101 ft lb	ANSI Z90.1 SLED	PASS
	• ABOVE TESTS TO BE RUN AFTER REACHING EQUILIBRIUM AT -23°C	SAME AS ABOVE	SAME AS ABOVE WITH THERMAL PRECONDITIONING	SAME AS ABOVE PLUS A CONDITIONING CHAMBER	PASS
	• ABOVE TESTS AFTER CLASS 2 & 3 HEAT	SAME AS ABOVE	SAME AS ABOVE WITH THERMAL PRECONDITIONING	SAME AS ABOVE PLUS A CONDITIONING CHAMBER	PASS
PENETRATION	CORNER OF A BRICK FALLING 4 STORIES WITH IMPACT FORCE OF 152 ft lb NO THROUGH PENETRATION	101 ft lb	SAME METHOD AS ANSI Z90.1 EXCEPT STRIKER IS DROPPED FROM APPROPRIATE HEIGHT THAT GIVES 101 ft lb	ANSI Z90 PUNCTURE TEST APPARATUS	PASS
	THE ABOVE TESTS ARE TO BE REPEATED FOR THE SAME 3 CONDITIONS AS FOR IMPACT TEST	SAME AS ABOVE	SAME AS ABOVE WITH THERMAL PRE-CONDITIONING AS REQUIRED	SAME AS ABOVE PLUS CONDITIONING CHAMBER	PASS

TABLE 4 PROJECT FIRES QUALIFICATION TEST PROGRAM SUMMARY (SHEET 2 of 16)

HEAD/EAR PROTECTION (CONT)

TEST	REQUIREMENTS		TEST METHOD	TEST APPARATUS	RESULTS
	PEPS	QUALIFICATION			
CUT	GLASS FALLING 4 STORIES WITH AN IMPACT FORCE OF 39 ft lb, PROTECTOR NOT CUT THROUGH	(PEPS)	SAME METHOD AS ANSI Z41.1	ANSI Z41.1 IMPACT TESTER ADAPTED WITH SPECIAL CUTTING EDGE	CUT TESTS WERE NOT PERFORMED BECAUSE PENETRATION REQUIREMENTS ARE MORE SEVERE
	THE ABOVE TESTS ARE TO BE REPEATED FOR THE SAME 3 CONDITIONS AS FOR IMPACT TEST	(PEPS)	SAME AS ABOVE WITH THERMAL PRECONDITIONING AS REQUIRED	SAME AS ABOVE PLUS CONDITIONING CHAMBERS	
FLAME	NOT BURN, CHAR, IGNITE, AFTER 5 SEC EXPOSURE TO A 1200°F FLAME	(PEPS)	BUNSEN BURNER FLAME DIRECTED AT HELMET	BUNSEN BURNER	PASS
HEAT	UNDERGO COMBINATION OF RADIANT & CONVECTIVE HEAT CONDITIONS (CLASS 1, 2 & 3 IN PEPS)	(PEPS)	HELMET INSTRUMENTED & PLACED IN CONDITIONING CHAMBER	SPECIALLY INSTRUMENTED OVEN	PASS
ELECTRICITY	LIMIT CURRENT FLOW TO <3 ma WITH A 2200 VAC POTENTIAL	(PEPS)	ANSI Z89.1	ANSI Z89.1	PASS
	THE ABOVE TESTS ARE TO BE REPEATED FOR THE SAME CONDITIONS AS FOR THE IMPACT TEST	(PEPS)			
HEARING	NOT TO ATTENUATE BY MORE THAN 10%	(PEPS)	ANSI Z24.22	ANSI Z24.22	NOT REQUIRED

TABLE 4 PROJECT FIRES QUALIFICATION TEST PROGRAM SUMMARY (SHEET 3 of 16)

HEAD/EAR PROTECTION (CONT)

TEST	REQUIREMENTS		TEST METHOD	TEST APPARATUS	RESULTS
	PEPS	QUALIFICATION			
HEAT INSULATION	NOT TO INCREASE ENERGY EXPENDITURES BY MORE THAN 1%	(PEPS)	GRUMMAN STEP TEST	STEP TEST EQUIPMENT PLUS ENVIRONMENTAL CHAMBER	PASS
WATER PENETRATION	DEFLECT WATER FROM AN OVERHEAD SPRINKLER	(PEPS)	HELMET WORN BY SUBJECT	MULTIPLE SPRINKLER HEADS	PASS
WEIGHT	SYSTEM SHALL WEIGH LESS THAN 30 oz	33 OZ. MAX	WEIGHING	BALANCE	PASS
FIT	FULL RANGE OF SIZES	(PEPS)	VISUAL EXAMINATION ANSI Z89.3	TAPE MEASURE ANSI Z89.3	PASS
RETENTION	NO INJURY WHEN BRIM IS IMPACTED WITH 152 ft lb	(PEPS)	SAME METHOD AS ANSI Z90.1 BUT IMPACT IS ON THE BRIM	ANSI Z90.1 SLED	NOT TESTED TEST; APPARATUS NOT AVAILABLE
MAINTAINABILITY	CAPABLE OF BEING PERFORMED IN FIRE HOUSE	(PEPS)	FIELD EVALUATION	FIELD	TO BE EVALUATED IN FIELD TEST
RELIABILITY	(PEPS)	(PEPS)	FIELD EVALUATION		TO BE EVALUATED IN FIELD TEST
DONNING/ DOFFING	BE ABLE TO DON IN 5 sec	(PEPS)	TIMING OF SUBJECTS		PASS
RECOGNIZABILITY	VISUAL RECOGNITION BY SUBJECT AT 200 ft	(PEPS)	VISUAL RECOGNITION IN SIMULATED CONDITIONS		PASS
DRYABILITY	DRY IN AN OVEN AT 200° AFTER 1 hr	(PEPS)	WET & PLACE IN OVEN FOR 1 HR	OVEN & BALANCE	PASS
ACCEPTANCE	ACCEPTABLE TO FIRE SERVICE	(PEPS)	FIELD EVALUATION		TO BE EVALUATED IN FIELD TEST
COMPATABILITY	(PEPS)	(PEPS)	OBSERVATION	SYSTEM TEST	PASS

1/1-18

TABLE 4 PROJECT FIRES QUALIFICATION TEST PROGRAM SUMMARY (SHEET 4 of 16)

FACE/EYE PROTECTION

TEST	REQUIREMENTS		TEST METHOD	TEST APPARATUS	RESULTS
	PEPS	QUALIFICATION			
IMPACT	BRICK FALLING 4 STORIES WITH IMPACT ENERGY OF 152 ft lb • NO SHATTERING OR SPALLING	REDUCED ENERGY OF 101 ft lb	SAME METHOD AS ANSI Z90.0. EYE SHIELD IS MOUNTED ON HELMET	ANSI Z90.1 SLED	DOES NOT PASS. DEVELOPMENT WORK CURRENTLY UNDERWAY TO IMPROVE PRODUCT
	THE ABOVE TEST IS TO BE RUN AT				
	• ROOM TEMP	SAME AS ABOVE	SAME AS ABOVE		
	• AFTER REACHING EQUILIBRIUM AT -23°F	SAME AS ABOVE	SAME AS ABOVE WITH THERMAL PRECONDITIONING	SAME AS ABOVE PLUS A CONDITIONING CHAMBER	
	• AFTER CLASS 2 & 3 HEAT	CONDITIONING FOR CLASS 3 HEAT IS REDUCED TO 1 MIN AT 485°F	SAME AS ABOVE WITH THERMAL PRECONDITIONING	SAME AS ABOVE PLUS A CONDITIONING CHAMBER	
PENETRATION	4 PENNY NAIL IMPACTING WITH AN ENERGY OF 10 ft lb	(PEPS)	ANSI Z90.1 EXCEPT STRIKER ADAPTED FOR 4 PENNY NAIL & HEIGHT ADJUSTED AS NECESSARY	ANSI Z90.1 PUNCTURE TEST, MODIFIED	SAME AS IMPACT
CUT	SURFACE NOT CUT OR SCRATCHED BY A METAL BLIND	(PEPS)	DRAW METAL BLIND ACROSS THE PROTECTOR	METAL BLIND	PASS
SCRATCH	NOT SCRATCHED AFTER RUBBED WITH SAND	(PEPS)	RUB OIL SAND & OIL MIXTURE OVER PROTECTOR	50-50 OIL & SAND MIXTURE	PASS
FLAME	NOT BURN, CHAR, IGNITE, AFTER 5 SEC EXPOSURE TO A 1200°F FLAME	(PEPS)	BUNSEN BURNER FLAME DIRECTED AT PROTECTOR	BUNSEN BURNER	PASS

TABLE 4 PROJECT FIRES QUALIFICATION TEST PROGRAM SUMMARY (SHEET 5 of 16)

FACE/EYE PROTECTION (CONT)

TEST	REQUIREMENTS		TEST METHOD	TEST APPARATUS	RESULTS
	PEPS	QUALIFICATION			
HEAT	UNDERGO A COMBINATION OF RADIANT & CONVECTIVE HEAT CONDITIONS, (CLASS 1, 2, & 3 IN PEPS); NO DISTORTION) NO FACIAL CONTACT POINT TEMPERATURE >113°F	SAME AS PEPS	SUBSYSTEM PLACED IN CONDITIONING CHAMBER	INSTRUMENTED OVEN	NOT TESTED IMPROVED; PRODUCT CURRENTLY UNDER DEVELOPMENT
ELECTRICITY	LIMIT CURRENT FLOW TO < 3 ma WITH A 2200 VAC POTENTIAL	(PEPS)	ANSI Z89.1	ANSI Z89.1	VERIFIED
COVERAGE	SHALL COVER EYES, NOSE, CHEEKS & UPPER LIP	(PEPS)	INSPECTION	VOLUNTEER SUBJECTS	PASS
VISIBILITY	MEET OPTICAL PERFORMANCE OF ANSI Z87.1	(PEPS)	ANSI Z87.1	ANSI Z87.1	PASS
FOG PREVENTION	PREVENT THE FORMATION OF FOG OR CONDENSATION	(PEPS)	TEST SUBJECT EXERCISING AT ATMOSPHERIC CHAMBER	ENVIRONMENTAL CHAMBER	PASS
WATER PENETRATION	DEFLECT WATER FROM AN OVERHEAD SPRINKLER	(PEPS)	FACE/EYE SHIELD PLUS HELMET WORN BY SUBJECT & SUBJECTED TO SHOWER	MULTIPLE SPRINKLER HEADS	PASS
WEIGHT	SHALL WEIGHT LESS THAN 6 oz INCLUDING ATTACHMENT HARDWARE	(PEPS)	WEIGHING	BALANCE	NOT TESTED IMPROVED; PRODUCT CURRENTLY UNDER DEVELOPMENT

TABLE 4 PROJECT FIRES QUALIFICATION TEST PROGRAM SUMMARY (SHEET 6 of 16)

FACE/EYE PROTECTION (CONT)

TEST	REQUIREMENTS		TEST METHOD	TEST APPARATUS	RESULTS
	PEPS	QUALIFICATION			
FIT	SHALL BE ADJUSTABLE OR PROVIDED IN MULTIPLE SIZES SO AS TO PROVIDE ADEQUATE PROTECTION FOR ALL	(PEPS)	VISUAL EXAMINATION	TAPE MEASURE	PASS
MAINTAINBILITY	CAPABLE OF BEING PERFORMED IN THE FIRE HOUSE	(PEPS)	VISUAL EXAMINATION		TO BE EVALUATED IN FIELD TEST
RELIABILITY DURABILITY	REPLACEABLE LENS TO LAST 6 MONTHS	(PEPS)	FIELD EVALUATION		TO BE EVALUATED IN FIELD TEST
DONNING/ DOFFING	DEPLOYED IN < 2 sec & STOWED IN < 3 sec	(PEPS)	TIMING OF SUBJECTS	STOPWATCH	PASS
ACCEPTANCE	ACCEPTABLE TO FIRE SERVICE	(PEPS)	FIELD EVALUATION		TO BE EVALUATED IN FIELD TEST
COMPATIBILITY	MUST BE COMPATIBLE WITH VARIOUS SYSTEMS & SUBSYSTEMS	(PEPS)	VISUAL INSPECTION	SYSTEM TEST	PASS
IMPACT	SHOULDERS & BACK TO BE PROTECTED FROM AN IMPACT ENERGY OF 43 ft lb. THE KNEES & ELBOWS SHALL ALSO BE PROTECTED	PROVIDE PROTECTION	NOT REQUIRED		MEETING THE PEPS WOULD RESULT IN UNACCEPTABLE DECREASE IN MOBILITY

TABLE 4 PROJECT FIRES QUALIFICATION TEST PROGRAM SUMMARY (SHEET 7 of 16)

TORSO/LIMB PROTECTION

TEST	REQUIREMENTS		TEST METHOD	TEST APPARATUS	RESULTS
	PEPS	QUALIFICATION			
PENETRATION	NOT TO BE PUNCTURED BY A 4 PENNY NAIL WITH A FORCE OF 22 lb	(PEPS)	4 PENNY NAIL MOUNTED IN FIXTURE FORCES AGAINST SAMPLE UNTIL PUNCTURE	GRUMMAN TEST FIXTURE	PASS
CUT	NOT TO BE CUT THROUGH BY A FORCE OF 22 lb	(PEPS)	NIOSH TEST METHOD	NIOSH TEST APPARATUS	PASS
FLAME	NOT BURN, CHAR, IGNITE, ETC, AFTER A 5 sec EXPOSURE TO A 1200°F FLAME	(PEPS)	BUNSEN BURNER FLAME DIRECTED AT SAMPLE	BUNSEN BURNER	PASS
HEAT (RADIANT & CONVECTIVE)	UNDERGO A COMBINATION OF RADIANT & CONVECTIVE HEAT CONDITIONS (CLASS 1, 2, & 3 IN PEPS)	(PEPS)	SUBSYSTEM MOUNTED ON AN INSTRUMENTED MANIKIN & TESTED IN AN ENVIRONMENTAL CHAMBER	INSTRUMENTED MANIKIN & ENVIRONMENTAL	PASS
HEAT (CONDUCTIVE)	SHALL BE ABLE TO KNEEL ON 250°F FOR 5 min INSIDE TEMP <113°F	(PEPS)	INSTRUMENTED MANIKIN IN SUBSYSTEM IS PRESSED AGAINST HOT PLATE SURFACE	INSTRUMENTED MANIKIN & HOT PLATE	PASS
	TEST REPEATED AFTER WETTING WITH 180°F WATER		SAME AS ABOVE	SAME AS ABOVE	PASS
MOBILITY	SHALL BE ABLE TO CLIMB, REACH, RUN	(PEPS)	STEP TEST	GRUMMAN STEP TEST	PASS
COLD INSULATION	SHALL KEEP THE FIRE FIGHTER > 64°F WHEN EXPOSED TO COLD	(PEPS)	VOLUNTEER WEARING SYSTEM WITH WINDCHILL OF -58°F	VOLUNTEER	PASS

TABLE 4 PROJECT FIRES QUALIFICATION TEST PROGRAM SUMMARY (SHEET 8 of 16)

TORSO/LIMB PROTECTION (CONT)

TEST	REQUIREMENTS		TEST METHOD	TEST APPARATUS	RESULTS
	PEPS	QUALIFICATION			
HEAT INSULATION	NOT TO INCREASE ENERGY EXPENDITURE BY MORE THAN 10%	(PEPS)	PROJECT FIRES STEP TEST	STEP TEST EQUIPMENT	PASS
WATER PENETRATION	NOT WET ON THE INSIDE WHEN SHOWERED FROM AN OVERHEAD SPRINKLER SUBSYSTEM SHALL NOT ABSORB MORE THAN 5% WATER	(PEPS)	ENTIRE SYSTEM MOUNTED ON A VOLUNTEER SUBJECTED TO SHOWER. WEIGHT BEFORE & AFTER	SHOWER & A SCALE	PASS PASS
WEIGHT	SUBSYSTEM SHALL WEIGH LESS THAN 5 lb FOR 95TH PERCENTILE	SUBSYSTEM SHALL WEIGH LESS THAN 6.5 lb FOR 95TH PERCENTILE	WEIGH SUBSYSTEM	SCALE	PASS
FIT	SUBSYSTEM TO BE PROVIDED IN NUMERICAL SIZES	(PEPS)	VISUAL EXAMINATION		PASS
MAINTAINABILITY	CAPABLE OF BEING PERFORMED IN THE FIRE HOUSE	(PEPS)	VISUAL EXAMINATION		PHASE 2
RELIABILITY/ DURABILITY	SUBSYSTEM TO LAST 3 YEARS	(PEPS)	FIELD EVALUATION		TO BE EVALUATED IN FIELD TEST
DONNING/ DOFFING	CAPABLE OF BEING DONNED OR DOFFED 10 SEC	20 SECONDS	TIMING OF SUBJECTS	STOPWATCH	PASS

TABLE 4 PROJECT FIRES QUALIFICATION TEST PROGRAM SUMMARY (SHEET 9 of 16)

TORSO/LIMB PROTECTION (CONT)

TEST	REQUIREMENTS		TEST METHOD	TEST APPARATUS	RESULTS
	PEPS	QUALIFICATION			
REC-OGNIZ-ABILITY	VISUAL RECOGNITION BY SUBJECT AT 200 FT	(PEPS)	VISUAL RECOGNITION IN SIMULATED CONDITIONS		PASS
DRY-ABILITY	DRY FOR ONE HOUR AT 200°F AFTER WATER PENETRATION TEST	(PEPS)	AFTER WATER PENETRATION TEST, PLACE IN OVEN	OVEN & SCALES	PASS
ACCEP-TANCE	ACCEPTABLE TO FIRE SERVICE	(PEPS)	FIELD EVALUATION		TO BE EVALU-ATED IN FIELD TEST
COMPAT-IBILITY	MUST BE COM-PATIBLE WITH VARIOUS SYS-TEMS AND SUB-SYSTEMS	(PEPS)	VISUAL EVALUATION	SYSTEM TEST	PASS
PENETRA-TION	NOT TO BE PUNCTURED BY A 4 PENNY NAIL WITH A FORCE OF 99 lb	FORCE REDUCED TO 45 lb	PROJECT FIRES PUNCTURE TEST	PUNCTURE TEST APPARATUS	PASS
CUT	NOT TO BE CUT THROUGH BY A SHARP EDGE WITH A FORCE OF 99 lb	FORCE REDUCED TO 22 lb	NIOSH TEST METHOD	NIOSH TEST APPARATUS	PASS
FLAME	NOT BURN, CHAR, IGNITE, AFTER A 5 SEC EXPOSURE TO A 1200°F FLAME	(PEPS)	BUNSEN BURNER FLAME DIRECTED AT SAMPLE	BUNSEN BURNER	PASS

TABLE 4 PROJECT FIRES QUALIFICATION TEST PROGRAM SUMMARY (SHEET 10 of 16)

HAND/WRIST PROTECTION

TEST	REQUIREMENTS		TEST METHOD	TEST APPARATUS	RESULTS
	PEPS	QUALIFICATION			
HEAT (RADIANT & CONVECTIVE)	UNDERGO A COMBINATION OF RADIANT & CONVECTIVE HEAT CONDITIONS (CLASS 1, 2, & 3 IN PEPS) INSIDE TEMP <113°F	(PEPS)	SUBSYSTEM MOUNTED ON INSTRUMENTED MANIKIN & TESTED IN AN ENVIRONMENTAL CHAMBER	INSTRUMENTED MANIKIN AND ENVIRONMENTAL CHAMBER	PASS
	• TEST REPEATED AFTER WET WITH WATER	(PEPS)	SAME AS ABOVE	SAME AS ABOVE	PASS
HEAT (CONDUCTIVE)	SHALL BE ABLE TO HOLD 950°F OBJECT FOR 5 SEC, INSIDE TEMP <113°F	(PEPS)	SUBSYSTEM MOUNTED ON INSTRUMENTED HANDFORM THEN PRESSED AGAINST HOT SURFACE	INSTRUMENTED HANDFORM & HOT PLATE	PASS
	• TEST REPEATED AFTER WET WITH WATER	(PEPS)	SAME AS ABOVE	SAME AS ABOVE	PASS
GRIP	CAPABLE OF GRIPPING WITH 85% OF BARE-HANDED GRIP	(PEPS)	GRUMMAN GRIP TEST	GRUMMAN TEST APPARATUS	PASS
COLD INSULATION	SHALL KEEP THE HANDS >59°F WHEN EXPOSED TO COLD	(PEPS)	VOLUNTEER WEARING GLOVES WITH WINDCHILL OF -58°F	VOLUNTEER	PASS
WATER	NOT ALLOW WATER TO ENTER FREELY AT THE WRIST	(PEPS)	MOUNT SUBSYSTEM ON HAND IMMERSE FOR 30 SECONDS	VOLUNTEER	PASS (COATED GLOVE)
	NOT ABSORB MORE THAN 5% WATER AFTER IMMERSION	(PEPS)	WEIGHT BEFORE & AFTER THE PREVIOUS TEST		PASS COATED GLOVE)

TABLE 4 PROJECT FIRES QUALIFICATION TEST PROGRAM SUMMARY (SHEET 11 of 16)

HAND/WRIST PROTECTION (CONT)

TEST	REQUIREMENTS		TEST METHOD	TEST APPARATUS	RESULTS
	PEPS	QUALIFICATION			
WEIGHT	SUBSYSTEM SHALL WEIGH LESS THAN 8 OZ/PAIR FOR 95TH PERCENTILE	(PEPS)	WEIGH SUBSYSTEM	BALANCE	PASS
FIT	AT LEAST 3 SIZES TO FIT 5TH-95TH PERCENTILE	(PEPS)	VISUAL EXAMINATION	HANDFORM LASTS	PASS
MAIN-TAIN-ABILITY	CAPABLE OF BEING PER-FORMED IN FIRE HOUSE	(PEPS)	VISUAL EXAMINATION		TO BE EVALU-ATED IN FIELD TEST
RELIA-BILITY/ DURA-BILITY	SUBSYSTEM TO LAST 6 MONTHS	(PEPS)	FIELD EVALUATION		TO BE EVALU-ATED IN FIELD TEST
DEXTER-ITY	PERFORM A STANDARD-IZED TEST WITHIN AL-LOTTED TIME	(PEPS)	BENNET DEXTERITY TEST	BENNET TESTER	PASS
DONNING	CAPABLE OF BEING DONNED IN 5 SEC	10 SEC	TIMING OF SUBJECTS	STOPWATCH	PASS
DRYABIL-ITY	DRY IN AN OVEN AT 230°F AFTER 20 MIN	(PEPS)	AFTER WATER IMMERSION ON HANDFORM, PLACE IN OVEN	OVEN & SCALES HANDFORM	PASS
ACCEP-TANCE	ACCEPTABLE TO FIRE SERVICE	(PEPS)	FIELD EVALUATION		TO BE EVALU-ATED IN FIELD TEST
COMPAT-IBILITY	MUST BE COM-PATIBLE WITH TORSO/LIMBS PROTECTION SUBSYSTEMS	(PEPS)	VISUAL EXAMINATION	SYSTEM TEST	PASS

TABLE 4 PROJECT FIRES QUALIFICATION TEST PROGRAM SUMMARY (SHEET 12 of 16)

FOOT/ANKLE PROTECTION

TEST	REQUIREMENTS		TEST METHOD	TEST APPARATUS	RESULTS
	PEPS	QUALIFICATION			
IMPACT	TOE NOT BRUISED BY AN IMPACT OF 110 ft lb	(PEPS)	ANZI Z41.1-1967 (R1972) MODIFIED TO IMPACT FORCE OF 110 ft lb	ANSI Z41.1-1967 (R1972)	PASS
	INSTEP NOT BRUISED BY AN IMPACT OF 40 ft lb	(PEPS)	ANSI Z41.2-1976 MODIFIED TO IMPACT FORCE OF 40 ft lb	ANSI Z41.2-1976	PASS
COMPRES-SION	ABLE TO TAKE A COMPRESSIVE FORCE OF 3000 lb WITH NO IN-JURY	2200 lb	ANSI Z41.1	ANSI Z41.1	PASS
PENETRA-TION	SHALL BE ABLE TO STEP ON 4 PENNY NAIL • BOTTOM OF FOOT • ARCH & SIDE WITH NO PENETRATION	(PEPS)	ANSI Z41.5-1977 ARCH & SIDE TESTING USE GRUMMAN PUNCTURE TEST	ANSI Z41.5-1977 GRUMMAN PUNCTURE TEST APPARATUS	PASS PASS
CUT	TOE NOT CUT THRU BY A POWER SAW IN 5 SEC	(PEPS)	APPLY POWER SAW TO TOE	POWER SAW	PASS
	REMAINDER NOT CUT THRU BY A SHARP EDGE WITH A FORCE OF 22 lb	(PEPS)	NIOSH TEST METHOD	NIOSH CUT TEST APPA-RATUS	PASS
FLAME	NO BURN, CHAR IGNITE, AFTER A 5 SEC EXPOSURE TO A 1200°F FLAME	(PEPS)	BUNSEN BURNER FLAME DIRECTED AT SAMPLE	BUNSEN BURNER	PASS

TABLE 4 PROJECT FIRES QUALIFICATION TEST PROGRAM SUMMARY (SHEET 13 of 16)

FOOT/ANKLE PROTECTION (CONT)

TEST	REQUIREMENTS		TEST METHOD	TEST APPARATUS	RESULTS
	PEPS	QUALIFICATION			
HEAT (RADIANT & CONVECTIVE)	UNDERGO A COMBINATION OF RADIANT & CONVECTIVE HEAT CONDITIONS (PEPS CLASS 1, 2, & 3) INSIDE TEMP < 113°F	(PEPS)	SUBSYSTEM MOUNTED ON INSTRUMENTED & TESTED IN AN ENVIRONMENTAL CHAMBER	INSTRUMENTED & ENVIRONMENTAL CHAMBER	PASS
	• TEST REPEATED AFTER WET WITH WATER	(PEPS)	SAME AS ABOVE	SAME AS ABOVE	PASS
HEAT (CONDUCTIVE)	SHALL BE ABLE TO STAND ON A 250°F SURFACE FOR 10 MIN INSIDE TEMP <113°F	(PEPS)	SUBSYSTEM MOUNTED ON INSTRUMENTED FOOTFORM, THEN PRESSED AGAINST HOT PLATE	INSTRUMENTED FORM & HOT PLATE	PASS
	TEST REPEATED AFTER WET WITH WATER	(PEPS)	SAME AS ABOVE	SAME AS ABOVE	PASS
	SHALL BE ABLE TO STAND IN 180°F WATER FOR 10 MIN	(PEPS)	SUBSYSTEM MOUNTED ON AN INSTRUMENTED FOOTFORM IMMERSED IN 180°F WATER	SAME AS ABOVE	PASS
ELECTRICITY	LIMIT CURRENT FLOW TO 0-3 MA WITH A 2200 VOLT AC POTENTIAL BOTH WET & DRY	(PEPS)	ANSI Z41.4 1976	ANSI Z41.4 1976	PASS
MOBILITY	ABLE TO CLIMB STAIRS AT EXPENDITURE 110% OF STREET SHOES	(PEPS)	GRUMMAN STEP TEST	GRUMMAN STEP TEST	PASS

TABLE 4 PROJECT FIRES QUALIFICATION TEST PROGRAM SUMMARY (SHEET 14 of 16)

FOOT/ANKLE PROTECTION (CONT)

TEST	REQUIREMENTS		TEST METHOD	TEST APPARATUS	RESULTS
	PEPS	QUALIFICATION			
TRAC-TION	PROVIDE TRACTION ON DRY SUR-FACE, WET SURFACE, & ICY SURFACE	(PEPS)	PROJECT FIRES METHOD	HORIZONTAL SPRING FORCE GAGE	PASS
COLD INSUL-ATION	SHALL BE ABLE TO REMAIN IN SNOW FOR 30 MIN. TEMP IN-SIDE TO REMAIN 59°F	(PEPS)	SUBSYSTEM WORN BY VOLUNTEER IN AN ICEWATER BATH	VOLUNTEER	PASS
WATER PENETRA-TION	SHALL BE ABLE TO STAND IN 8 IN. WATER FOR 30 MIN WITHOUT WATER ENTRY	(PEPS)	SUBSYSTEM ON FOOTFORM IMMERSED IN TANK	WATER TANK & FOOTFORM	PASS
WEIGHT	SUBSYSTEM SHALL WEIGH LESS THAN 4 lb/PAIR FOR THE 95th PER-CENTILE	(PEPS)	WEIGH SUBSYSTEM	BALANCE	PASS
FIT	SHALL BE AVAIL-ABLE IN SAME COMMON RANGES AS STREET SHOES	(PEPS)	MEASUREMENTS USING SUBJECTS & FOOT LASTS	FOOT LASTS	PRES-ENTLY AVAIL-ABLE IN WHOLE SIZES; FITS ALL
SUPPORT	SYSTEM SHALL INCORPORATE A LADDER SHANK & AN OPTIONAL ARCH SUPPORT	(PEPS)	INSPECTION		PASS

TABLE 4 PROJECT FIRES QUALIFICATION TEST PROGRAM SUMMARY (SHEET 15 of 16)

FOOT/ANKLE PROTECTION (CONT)

TEST	REQUIREMENTS		TEST METHOD	TEST APPARATUS	RESULTS
	PEPS	QUALIFICATION			
MAINTAINABILITY	SHALL BE CAPABLE OF BEING PERFORMED IN THE FIRE HOUSE	(PEPS)	VISUAL EXAMINATION		TO BE EVALUATED IN FIELD TEST
RELIABILITY/ DURABILITY	SUBSYSTEM TO LAST 2 YEARS	(PEPS)	FIELD EVALUATION		TO BE EVALUATED IN FIELD TEST
DONNING/ DOFFING	CAPABLE OF BEING DONNED OR DOFFED IN 8 SEC	DONNED IN 15 SEC DOFFED IN 20 SEC	TIMING OF SUBJECTS	STOPWATCH	PASS
RECOGNIZABILITY	VISUAL RECOGNITION BY SUBJECT AT 200 ft	(PEPS)	VISUAL RECOGNITION IN SIMULATED CONDITION		PASS
DRYABILITY	DRY IN AN OVEN AT 200°F AFTER 1 HR	(PEPS)	AFTER WATER IMMERSION ON FOOTFORM, PLACE IN OVEN	OVEN, FOOTFORM & SCALES	PASS
ACCEPTANCE	ACCEPTABLE TO FIRE SERVICE	(PFPS)	FIELD EVALUATION		TO BE EVALUATED IN FIELD TEST
COMPATIBILITY	MUST BE COMPATIBLE WITH TORSO/LIMBS PROTECTION SUBSYSTEM	(PEPS)	VISUAL EXAMINATION		PASS

TABLE 4 PROJECT FIRES QUALIFICATION TEST PROGRAM SUMMARY (SHEET 16 of 16)

PROTOTYPE PROTECTIVE ENSEMBLE

TEST	REQUIREMENTS		TEST METHOD	TEST APPARATUS	RESULTS
	PEPS	QUALIFICATION			
WATER PENETRATION	DEFLECT WATER FROM OVERHEAD SPRINKLER	(PEPS)	VOLUNTEERS SUBJECTED TO SPRINKLER SHOWER	SPRINKLERED TEST BUILDING	PASS
MOBILITY	ENERGY INCREASE OF 21% MAXIMUM	(PEPS)	GRUMMAN TEST METHODS	GRUMMAN STEP TEST	PASS
COMPATIBILITY	MUST BE COMPATIBLE WITH VARIOUS SYSTEMS AND SUBSYSTEMS	(PEPS)	SEARCH-AND-RESCUE TRAINING EXERCISE	SMOKE HOUSE	PASS
FLASHOVER	CLASS 4 HEAT: 1500°F, 4.2 WATTS/cm^2 10 SEC	(PEPS)	EXPOSURE TO FLASHOVER	FLASHOVER CHAMBER	PASS
COLD INSULATION	PERFORM NORMAL DUTIES WITH WINDCHILL OF -58°F	(PEPS)	VOLUNTEER WEARING ENSEMBLE	VOLUNTEER	PASS

APPENDIX

introduction

Jointly sponsored by the United States Fire Administration and the National Aeronautics and Space Administration, the Firefighters Integrated Response Equipment System (FIRES) project has been conducted by the Grumman Aerospace Corporation. Project FIRES is to develop improved structural firefighter protection against heat, flame, smoke, toxic fumes, moisture, impact, penetration, and electricity. Firefighter performance is to be improved by increased maneuverability, lighter weight, and superior human engineering design. These improvements are to be made available to the firefighting community at a cost which does not depart significantly from that of current equipment and in an acceptable design. Including senior fire service personnel representing all sections of the country, a User Requirements Committee (URC) and a Technical Advisory Group (TAG) were established to ensure this acceptance by the fire service.

Developed with the aid of the URC and TAG, the ensemble improves protection characteristics and also reduces weight by 40 percent. When combined with proper design and materials selection, the weight reduction provides an energy savings of about 25 percent and allows for increased maneuverability and improved performance. With all these improvements, the protective ensemble costs only 30 percent more than current systems.

COMPARISON OF PROTOTYPE AND CURRENT ENSEMBLES

HAZARD	PROTECTION		AREAS IMPROVED*
	CURRENT	PROTOTYPE	
IMPACT	< 10 FT-LB AT 250°F	150 FT-LB AT 485°F	HEAD/EAR
PENETRATION	< 10 FT-LB AT 250°F	100 FT-LB AT 485°F	HEAD/EAR
	10 - 20 LB	400 LB	FOOT/ANKLE (ARCH)
	25 LB	50 LB	HAND/WRIST
HEAT (RAD, CONV)	SAGS AT 300°F < 5 MIN HEAD > 100°F	> 5 MIN AT 485°F HEAD < 100°F	HEAD/EAR
	EXPOSED AREAS	FULL COVERAGE	TORSO/LIMB (NECK, WRIST)
HEAT (COND)	250°F < 2 MIN	250°F > 5 MIN	TORSO/LIMB (KNEES, ELBOWS
CUT	< 20 LB	> 20 LB	HAND/WRIST
	< 1 LB	> 4 LB	FACE/EYE
SCRATCH	< 1 LB	> 4 LB	FACE/EYE
WATER	EXPOSED AREAS	FULL COVERAGE	TORSO/LIMB (NECK) HAND/WRIST (WRIST)

**FOR THOSE AREAS NOT LISTED, PROTECTION IS AT LEAST EQUAL TO CURRENT*

ACHIEVED INCREASED PROTECTION

WEIGHT ESTIMATE

SUBSYSTEM	CURRENT WT,LB	PROTOTYPE WEIGHT, LB
HEAD/EAR	2.0	1.9
FACE/EYE	0.4	0.5
TORSO/LIMB	10.0	6.5
HAND/WRIST	0.4	0.4
FOOT/ANKLE	8.5	3.4
TOTAL	21.3	12.7

ACHIEVED 40% WT REDUCTION

COST ESTIMATE

SUBSYSTEM	CURRENT COST	PROTOTYPE COST
HEAD/EAR	$ 45	$ 70
FACE/EYE	10	25
TORSO/LIMB	230	275*
HAND/WRIST	23	23
FOOT/ANKLE	50	75
TOTAL	$358	$468

*SHELL 50/50 KEVLAR/NOMEX

COST INCREASE HELD TO 30%

PERFORMANCE ESTIMATE

METABOLIC EVALUATION OF VARIOUS CONFIGURATIONS*

	SYSTEM		
	STREET CLOTHES	CURRENT 3/4 TURNOUT COAT HIP BOOTS PULLED UP	PROTOTYPE 2 PIECE SHORT JACK-BIB PANTS SHORT LIGHTWEIGHT BOOT
VAPOR BARRIER	NONE	NEOPRENE	GORE-TEX
PROTECTIVE EQUIP WEIGHT - LB	NONE	17	12.7
*METABOLIC RATE - %	100	140	106

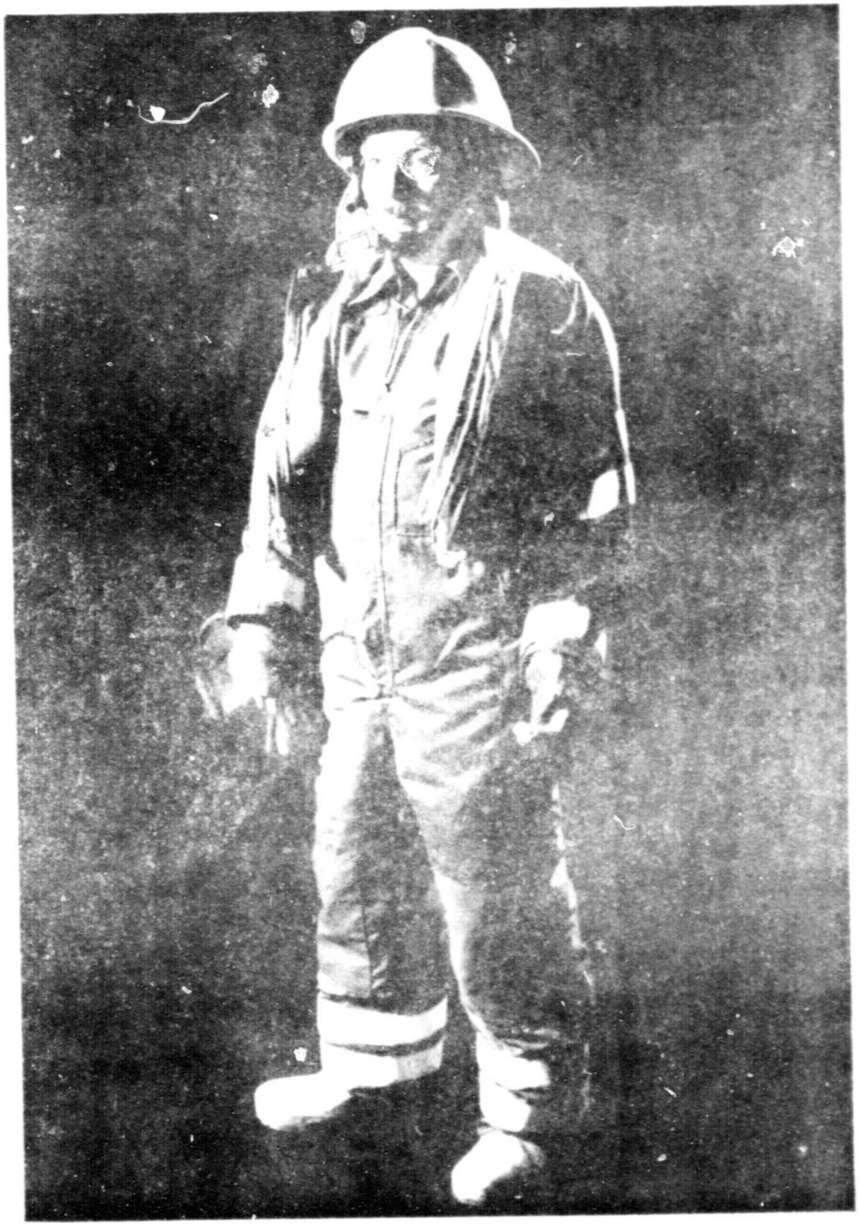
*BASED ON A 1 MINUTE STRESS TEST

ACHIEVED IMPROVED PERFORMANCE

garment

The protective garment system is the major component of the firefighter's protective ensemble and consists of the following subsystems.

- Head/ear protection subsystem
- Face/eye protection subsystem
- Torso/limb protection subsystem
- Hand/wrist protection subsystem
- Foot/ankle protective subsystem.



head/ear

The prototype head/ear protection subsystem has a helmet and a detachable inner liner or hood. Attached to the torso/limb protection subsystem, the hood prevents debris or water from reaching the neck area. The front peak of the helmet keeps debris and water away from the face area, eliminating the need for a front brim, and protects the face/eye shield when retracted.

A combination of special foam insulation and advanced composite materials similar to those used in military aircraft will protect the firefighter at much higher temperatures and impact forces than current counterparts.

The head/ear protection subsystem materials are as follows:

Outer shell:
0.090 to 0.125 inches thick, composed of 15 ounces of high temperature epoxy resin reinforced with one layer of glass and one layer of Kevlar

Liner:
Approximately 8 ounces of polyurethane heat-resistant foam approximately 3/4 inch thick

Retention straps and ancillary hardware:
All straps and nonmetallics will be made of flame-resistant materials such as Nomex, treated cotton, etc. All metal hardware will be rust resistant. Approximate weight is 8 ounces.

Total weight: 31 ounces

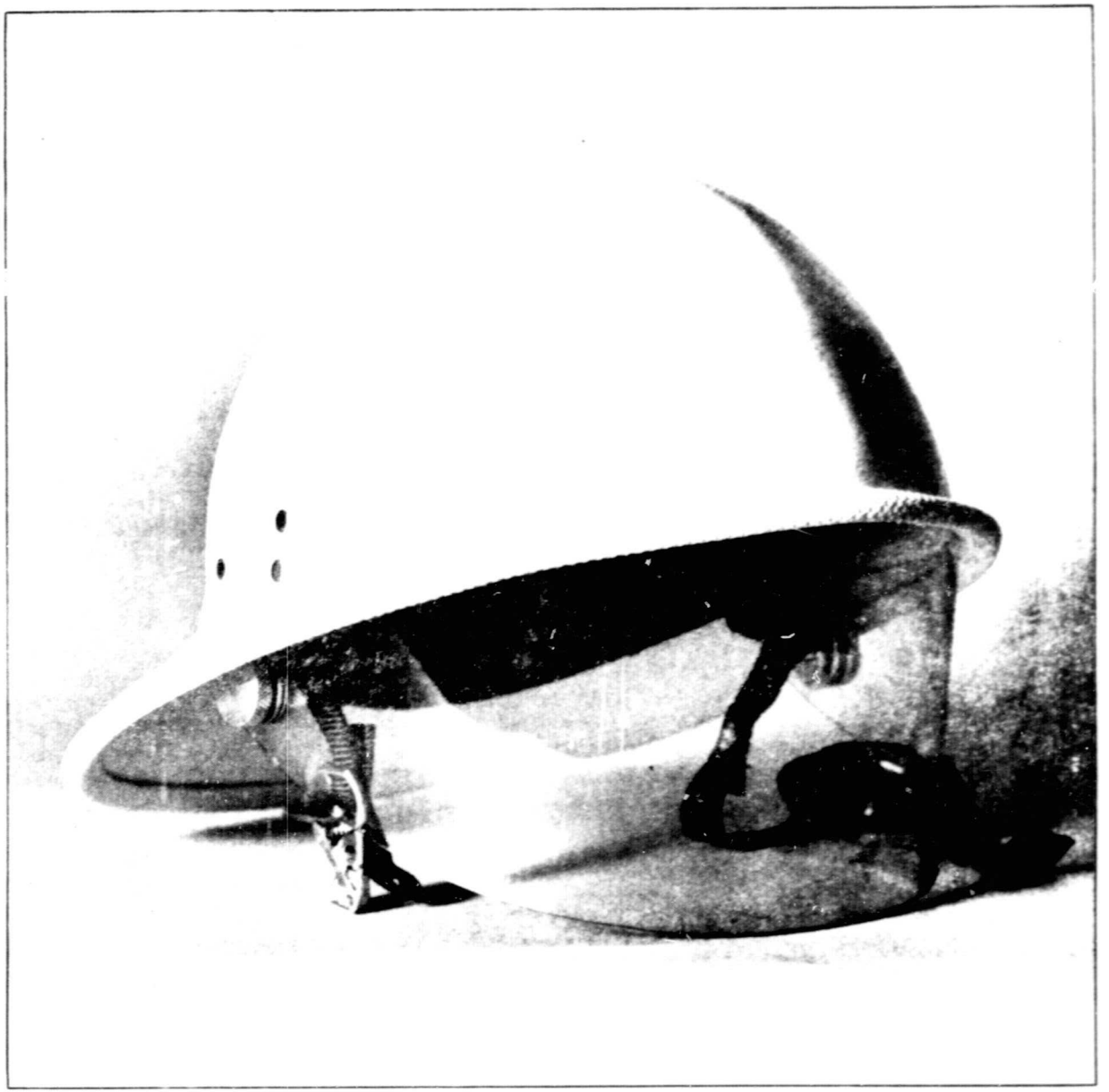
Retail price: $70.00

face/eye

The prototype face/eye protection subsystem has a full face piece that covers the eyes, nose, and cheeks down to the upper lip. When not in use, the protector is stowed inside the helmet so that it will be shielded. Generally good for impact, current polycarbonate face shields are poor under high heat conditions and offer little or no abrasion or scratch resistance. The prototype face/eye protector is fabricated of a high-temperature, impact-resistant glass that is laminated to a high-impact resistant, high-temperature resistant thermoplastic (polyethersulfone). This combination provides an outer surface that affords the scratch and abrasion protection of glass along with the high temperature and high impact resistance of a thermoplastic.

The face/eye protector specifications are as follows:

Material:	Chemtempered glass backed with polyethersulfone
Thickness:	1/16 to 1/8 inch
Weight:	8 ounces
Retail price:	$25.00



torso/limb

Two configurations make up the torso/limb protection subsystem. One assembly has a short jacket and bib pants and the other consists of a longer coat and turnout pants without a bib. Detachable hoods for the jacket and coat are used in conjunction with the head/ear protector. Detachable wristlets fit over the palms. To work in conjunction with the foot/ankle protection subsystem, the pant legs have an adjustable seal on the trousers.

Completely covering the torso/limb area, this subsystem does not depend on the garment worn beneath it. This makes it possible for the same system to be worn by either paid or volunteer firefighters. The torso/limb subsystem clearly illustrates the integrated systems approach. In addition to protecting the torso and limbs, this subsystem interfaces with other protective subsystems. The hood works in conjunction with the head/ear protection subsystem; the wristlet covers the palm and mates with the hand/wrist protection subsystem; and the boots, which can be directly attached, serve as the foot/ankle protection subsystem. With these advantages, the torso/limb protection subsystem provides as much protection, and in some cases more, than current turnout systems and weighs only about half as much.

Padding at the knees and elbows provides added impact protection. The padding, however, is limited so as not to reduce mobility. An outer shell of Polybenzimidazole (PBI), or 50/50 intimate blend of Nomex and Kevlar, enhances flame and heat protection. Both fabrics are new materials developed for military use. Because the weight reduction cuts energy expenditures, the firefighter can operate more comfortably and efficiently. A special material, Gore-Tex, helps to reduce metabolic heat buildup. Gore-Tex does not allow liquids to pass through, but does allow air and water vapor to pass through. In the new system, evaporation and cooling can occur when the firefighter perspires. The current system restricts evaporation and causes heat buildup.

The torso/limb protection subsystem materials are as follows:

Outer shell:
Polybenzimidazole or a Kevlar and Nomex 50/50 intimate blend, 7.5 ounces/yd^2

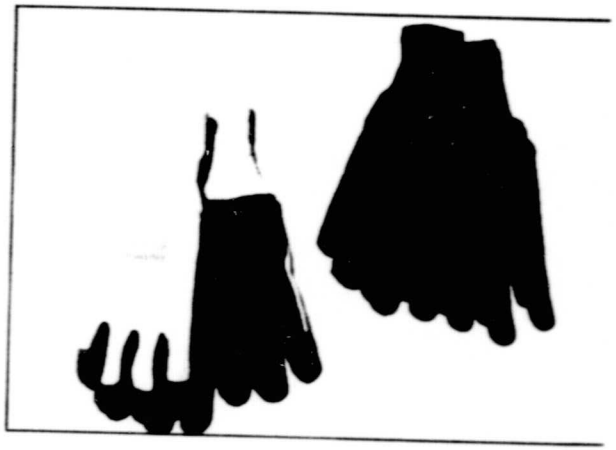
Water barrier:
Gore-Tex bonded to Nomex pajama check, 3.5 ounces/yd^2

Thermal liner:
Nomex quilt, 7.5 ounces/yd^2 (summer)
Nomex quilt, 10.1 ounces/yd^2 (winter)

Total weight:
6.5 lb

Retail price:
$275.00 (outer shell 50/50 Kevlar/Nomex)
$325.00 (outer shell PBI)

hand/wrist



An outer glove or shell is worn in conjunction with a wristlet that is attached to the torso/limb protection subsystem. In addition to providing added heat, puncture, and cut protection, the wristlet prevents debris and water from entering the sleeve and also protects the wrist from flame. Positioned in the process of donning the torso/limb protector, the wristlet has no fingers to prevent any hindrance to rapid donning. Once the torso/limb protector is in place, the glove shells are pulled on.

The glove shells come in two versions. One assembly is a latex dipped waterproof glove; the other assembly includes a nonwaterproof leather-palmed glove. The components are listed below:

Wristlet

Outer shell:	Blend of 50/50 Kevlar/Nomex
Water barrier:	Gore-Tex on cotton jersey
Pulse & palm:	Kevlar felt

Dipped glove

Body:	High temperature latex dipped on cotton jersey over Kevlar felt
Cuff:	Knit Kevlar
Total weight:	6.5 ounces

Leather palm

Body:	Knit Kevlar and Kevlar felt with aluminized mylar inner layer
Palm side:	High-temperature leather facing
Total weight:	7.5 ounces
Retail price:	$23

foot/ankle

An 11-inch high molded polyurethane boot has an optional pants seal to keep out water. The boots are exceptionally light, weighing less than 4 pounds for size 12 compared with 10.6 pounds for current size 12 footgear. Providing better fit and more comfort, this boot also offers greater heat and arch penetration protection.

The foot/ankle subsystem is constructed of the following materials:

Outer skin:	High-temperature, flame-retardant polyurethane skin sprayed on Nomex fabric layer
Insulation layer:	Flame-retardant polyurethane foam
Inner skin:	Nylon jersey fabric plus polyurethane
Protective features:	Steel toecap, steel midsole, aluminum arch protector
Total weight:	3.4 lb
Retail price:	$75.00

☆U.S. GOVERNMENT PRINTING OFFICE: 1980—640-247/96 REGION NO. 4