FA-107/September 1991

Qualitatively Evaluating the Comfort, Fit, Function and Integrity of Chemical Protective Suit Ensembles

Federal Emergency Management Agency
United States Fire Administration

EVALUATION OF ASTM STANDARD F-1154

QUALITATIVELY EVALUATING THE COMFORT, FIT, FUNCTION AND INTEGRITY OF CHEMICAL PROTECTIVE SUIT ENSEMBLES

STEVE STORMENT, CHIEF

313 N. 9TH STREET

PHOENIX, AZ 85006

JAMES H. VEGHTE, Ph.D.

BIOTHERM, INC.

3045 RODENBECK DR.

BEAVERCREEK, OH 45341

FINAL REPORT,TASK 2

United States Fire Administration

Federal Emergency Management Agency

CONTRACT EMW-88-R-2755

PREFACE

This study was funded by the U.S. Fire Administration, Federal Emergency Management Agency (FEMA) under contract EMW-88-R-2755. This contract was monitored by Mr. Bob McCarthy of the U.S. Fire Administration, Emmitsburg, MD. My personal thanks to Chief Jan Dunbar, Sacramento Fire Department and the HAZMAT team members, for their participation in these evaluations.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

ABSTRACT

Experienced fire fighters with Hazardous Materials training participated in field tests using procedures described in ASTM F- 1154 to evaluate the fit and function of fully encapsulated and disposal type chemical protective ensembles. These evaluations were performed under various climatic conditions at the Sacramento, CA; Phoenix, AZ; Prince George's County, VA; and Del Ray Beach, FL Fire Departments. Initial trials at the first lest site in Sacramento showed that tasks described in either Procedure A and B of the ASTM standard were not rigorous enough by themselves to evaluate these ensembles so all the tasks (16) were combined and used to assess the physiologic responses of the fire fighters reported in Task 1 of this study. Based on these findings, a different suit integrity test was formulated and the disposable type chemical protective clothing was evaluated under field test conditions. This evaluation quickly identified several weak areas in the suits' construction and is reported in this study.

INTRODUCTION

The use of chemical protective clothing by fire fighters at chemical emergencies dates back to the early 1950's when fire fighting personnel used military styled garments lo control leaks in ammonia and chlorine systems. The use and application of these garments was not well understood and was generally confined to the larger, more well established fire departments. As the awareness of toxic exposure has increased in the fire service, the demand for durable, inexpensive chemical protective clothing has increased drastically. However, the manufacturing of such clothing has been very slow in developing as no regulatory standards existed that described the performance requirements for these garments..

Efforts to develop standards for chemical protective clothing began in 1978 with the formation of ASTM Committee F-23 on Protective Clothing. The committee represented by both clothing manufacturers and users perceived a strong need for standards which would allow consistent testing of protective clothing products. In the following years, ASTM succeeded in developing two standards for measuring clothing chemical resistance performance - permeation and penetration. Despite the development of these standards and the increase in end user understanding of clothing performance data, few products were tested in accordance with these standard test methods. Of those that were tested, inconsistent information was often provided or variations in the test procedures still left end users confused when attempting lo compare products. Efforts lo develop new ASTM standards were aimed at comprehensive standards that would result in consistent reporting of information by protective clothing manufacturers.

The need for comprehensive standards is also justified on the basis of existing clothing selection guideline. The U.S. Environmental Protection Agency (EPA) recommends various types of chemical protective clothing given a particular situation. Potential exposure situations are divided into four categories each requiring a different level of protection (see Table 1).

TABLE 1, EPA LEVELS OF PROTECTION

LEVEL	TYPE OF CLOTHING/EQUIPMENT	WHEN USED
A	Totally-Encapsulating Chemical Protective Suit Pressure demand SCBA or Supplied air respiratory with escape SCBA Chemical resistant gloves and boots	Severe respiratory skin, or eye hazards
B	Chemical Resistant coverall, one-or two-piece splash suit, gloves, and boots Pressure demand SCBA or supplied air respiratory with escape SCBA	Severe respiratory hazard, moderate skin hazard present

C	Chemical resistant coveralls, one or two-piece splash suit, gloves and boots Full face piece, air purifying canister equipped respiratory	Moderate respiratory or skin hazard present
D	Coverall, safety boots, safety glasses, and hard hat	No respiratory hazard, mild skin hazard present

While the EPA provides a description of the type of protective clothing that should be worn, it does not define the performance criteria for this protective clothing. Equally elusive are recommendations from other sources. The Department of Transportation Emergency Response Guidebook (Unknown author, 1987) simply recommends “chemical protective clothing...” for exposure to specified chemicals. Although much more extensive and still a good tool, “Guidelines for the Selection of Chemical Protective Clothing” (Schwope, 1987) recommend generic materials for specific chemicals but do not distinguish appropriate clothing designs or other relevent material properties for adequate protection. This reference does, however, provide a comprehensive list of considerations for selecting chemical protective suits. Therefore, the end user must depend on his or her own experience or knowledge lo adequately select chemical protective clothing and hope that sufficient information is provided for making those decisions.

Recently, ASTM has shifted its attention lo the formation of methods which can be used lo evaluate completed protective clothing items. In 1987, ASTM adopted F-1052, q Standard Practive for Pressure Testing of Gas-tight Totally Encapsulating Suits.” This standard can be employed by manufacturers as a quality control technique to determine protective suit integrity prior to shipment. It can also be employed in the field by the end users to periodically check the condition of suits upon receipt and following each use.

In accordance with ASTM F-1052, the suit is inflated lo a specified pressure and then the pressure drop is monitored over time (Figure 1,2 and 3). Only total-encapsulating suits or suits which can have all openings blocked can be tested in this manner. The minimum inflation pressure is 3 inches water (gauge) and the internal suit pressure is allowed lo drop 20% over three minutes to meet the “pass” criteria of the test. Exhalation valves, found in most vapor-protective suits for exhausting air from the wearer’s breathing apparatus, must be plugged before the test is performed.

Also, ASTM proposed “Practices for Qualitatively Evaluating the Comfort, Fit, Function, and Integrity of Chemical Protective Suit Ensemble.” This standard was given the designation ASTM F23.50.05 and was promulgated as ASTM F-l 154 in 1988. The standard is intended to provide methods for qualitatively evaluating complete chemical protective ensembles. Like ASTM F-1052, it can be used either by manufacturers to assess suit designs or by users as a training or suit qualification test. The standard consists of 2 parts, which can be used singly or jointly to evaluate a particular protective suit ensemble. Procedure A of the standard is a manned exercise scenario designed to test garment seams and material strength or durability. Procedure B is a manned work task scenario intended lo determine human factor characteristics and the ability of the suited fire fighter to perform tasks representative of a typical work environment. Suit gas-tightness tests are performed before and after the manned exercise/work periods to ascertain changes in suit integrity as the result ensemble wear and use. Additionally, the standard addresses comfort and fit by measurement of wearer key size dimensions and their relation to suit or ensemble dimensions. Lastly, the standard includes a rating sheet that allow the lest subject to rate different areas of garment performance such as mobility, case of performing

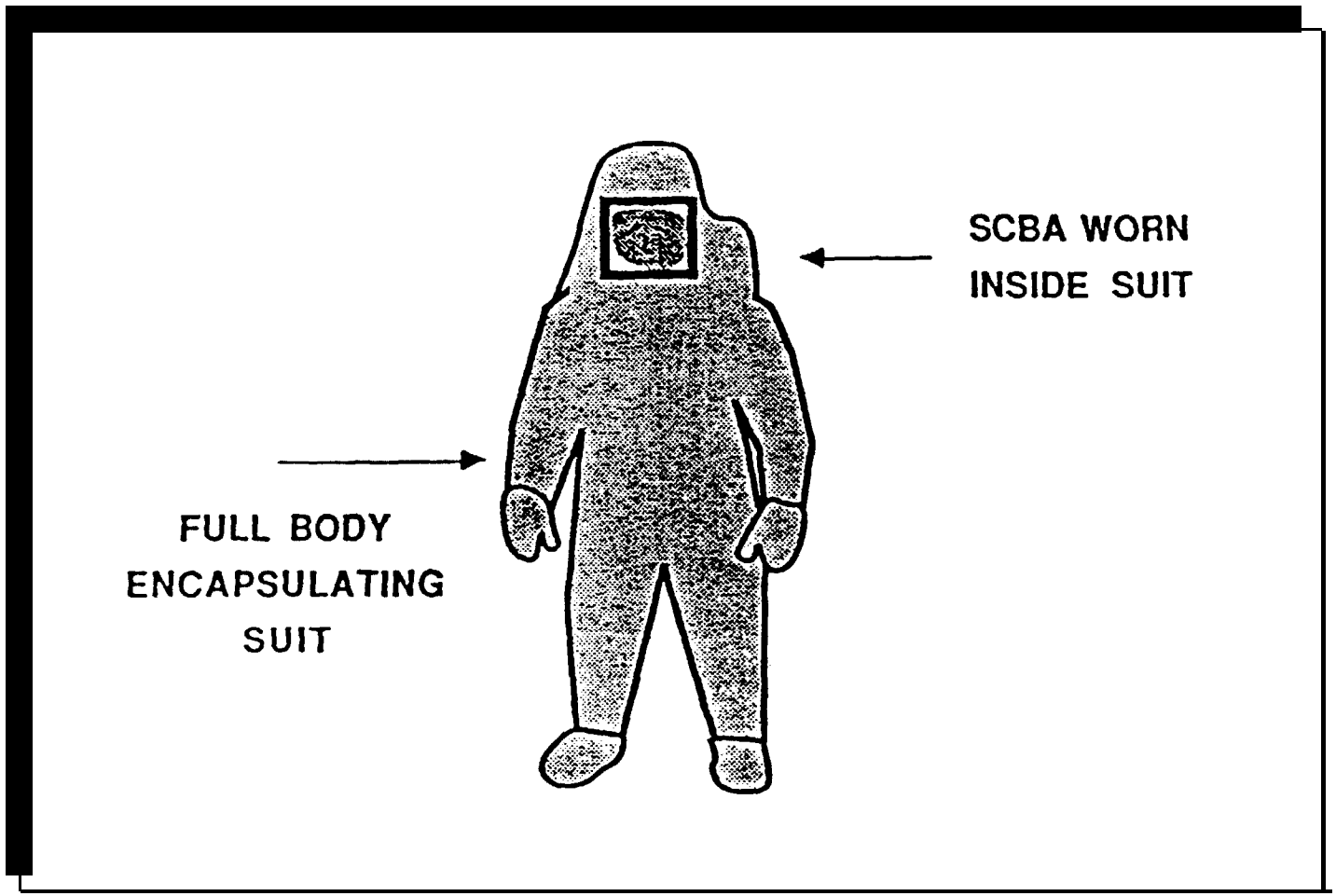

Figure 1: VAPOR - PROTECTIVE SUIT

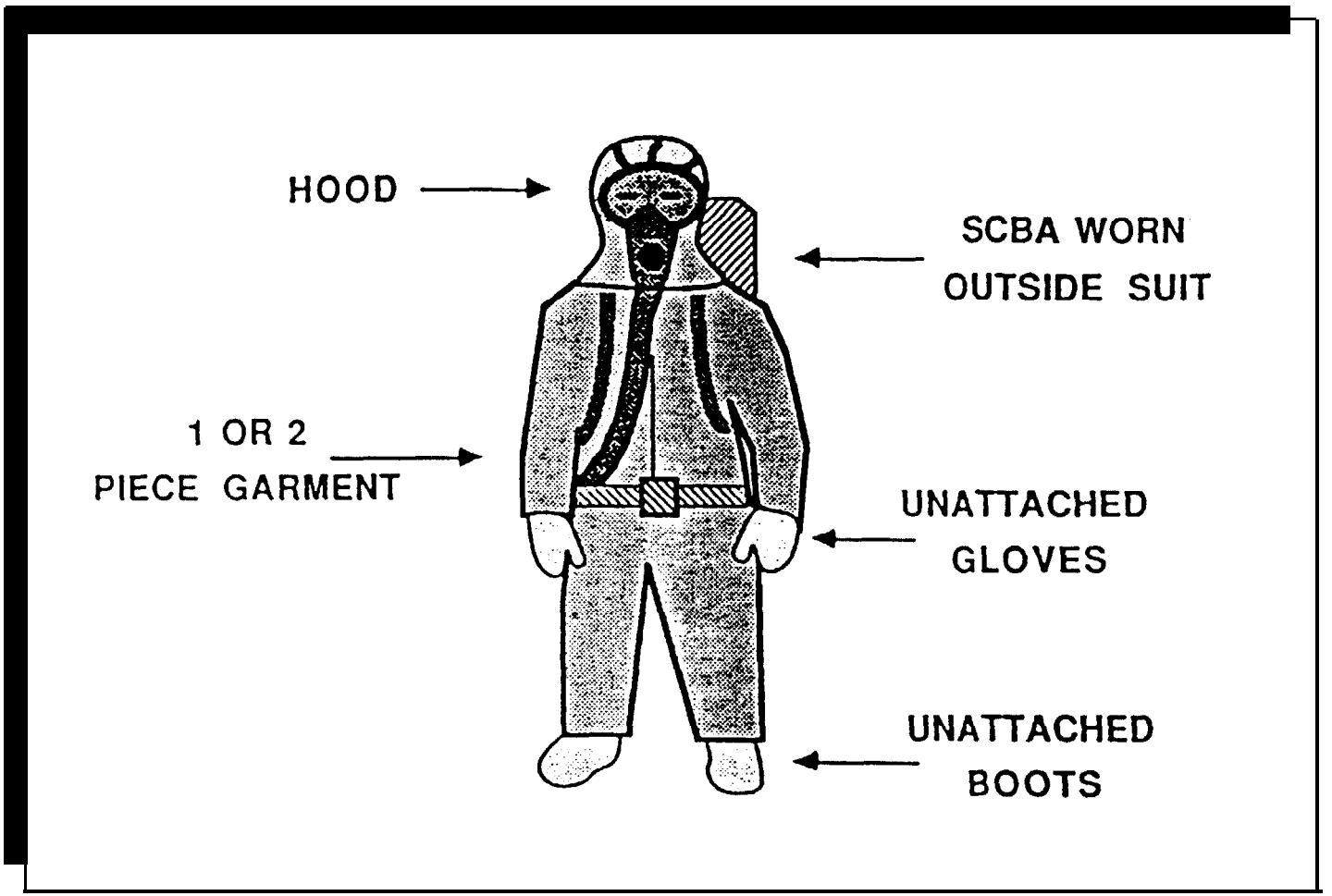

Figure 2: LIQUID SPLASH - PROTECTIVE SUIT

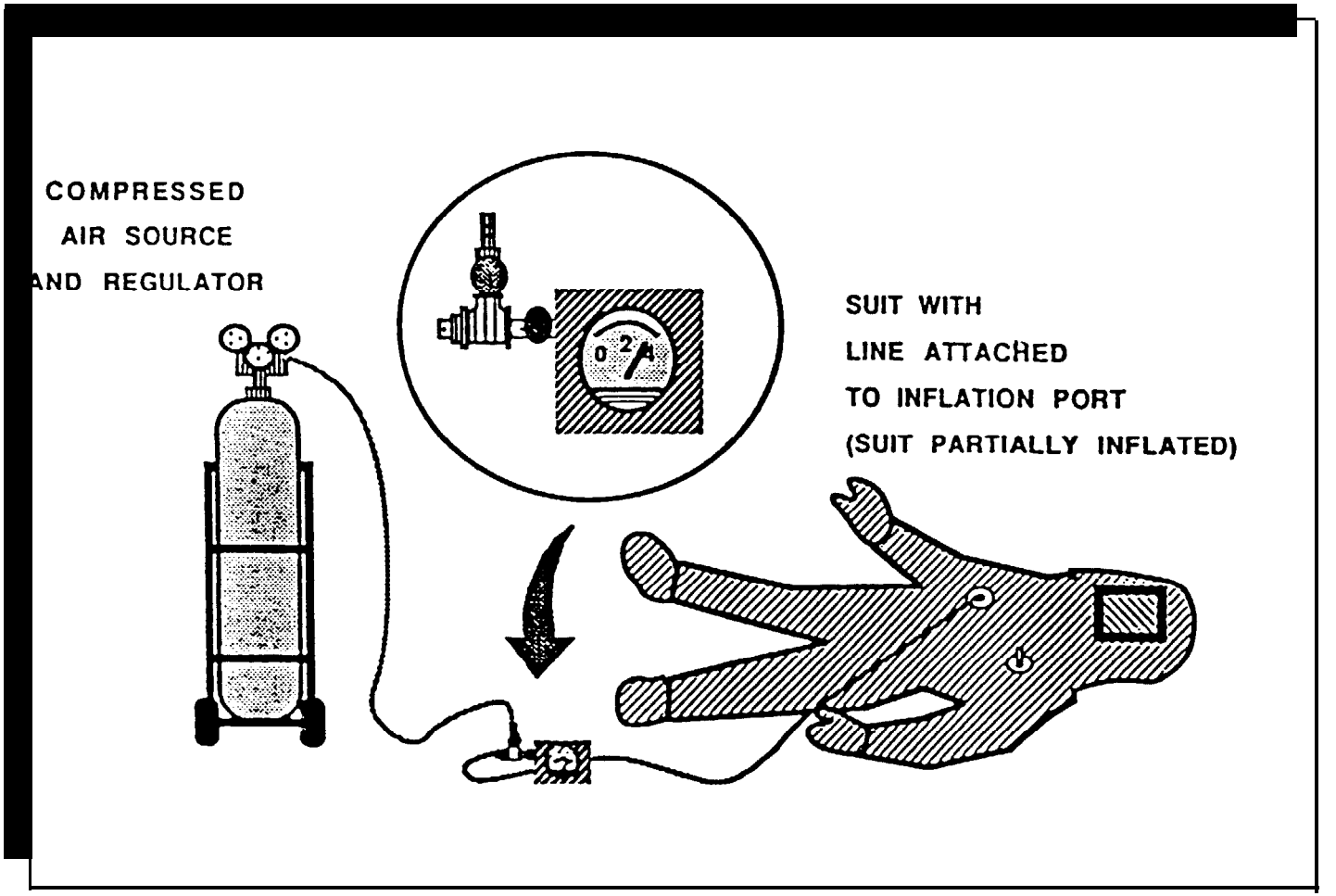

Figure 3: RECOMMENDED PRESSURE TEST APPARATUS AND TYPICAL TEST CONFIGURATION

specified functions, and relative comfort in particular suit regions.

With the advent of SARA Title III legislation, OSHA 29CFR Part 1910 for Hazardous Waste Operators and Emergency Responders, as well as NFPA 472 Standard for Professional Competence of Responders to Hazardous Materials Incidents and Recommended Practices for Responding to Hazardous Materials Incidents (NFPA 471), the fire service has started demanding durable and safe chemical protective clothing.

Currently, three minimal performance NFPA documents have been approved to address the flaws found in chemical protective garments: NFPA 1991 Standard on Vapor Protective Suits for Hazardous Chemical Emergencies; NFPA 1992 Standard on Liquid Splash Protective Suits for Hazardous Chemical Emergencies; and NFPA 1993 Support Function Protective Garments for Hazardous Chemical Operations. But even with these documents, no real task or real lime field evaluation adequately tests the integrity and function of the entire chemical protective suit ensemble,

A modification of Standard Pracitices for Qualitatively Evaluating the Comfort, Fit, Function, and Integrity of Chemical Protective Suit Ensembles (Procedure B), was used in this study lo determine its appropriateness for evaluating disposable-single use garments.

METHODS

The overall evaluation criteria required in ASTM F-1154 is shown in Table 2.

TABLE 2. ASTM F-1154 REQUIRED REPORT INFORMATION

1 . Descriptions and dimensions of the chemical protective suit and ensemble components.
2. Test subject body dimensions and body weight with underclothing.
3. Chemical protective suit ensemble weight, maximum width, maximum depth and any appropriate ensemble dimensions when worn
4. Environment conditions in which the testing was conducted.
5. Visual inspection and gas-tightness test results before and after manned testing.
6. Observations on the ability of the test subject to perform each exercise in Procedure A or each work task in Procedure B while wearing the protective ensemble.
7. Any other observations or relevant measurements made during the tests.

Initial tests at the first test site established neither Procedure A or B work tasks by themselves were sufficiently rigorous to achieve an adequate assessment of the Challenge fully encapsulated protective garment. Therefore, all tasks described in Procedure A and B were combined and evaluated in Task 1 of this study. During the initial stages of this contractural effort, an opportunity arose to assess the physical properlies of disposal type chemical protective clothing in the field. A set of test criteria was developed at the first test site, Sacramento, CA, and several clothing combinations were evaluated. Only this evaluation of these garments is reported under Task 2 of this study.

Seven experienced fire service personnel in Sacramento, CA and Phoenix, AZ Fire Departments participated in this study. These members were all members of their Hazardous Materials Response Teams. They all had basic knowledge of use and application of chemical protective suit ensembles and had field experience with such garments. Each participant preformed the work tasks outlined in Procedure A and B of the ASTM F-1154 standard while dressed in a Gastight Level "A" Challenge garment . After each person had completed this task, they were informally polled as to degree of stress they felt these tasks placed on the garment. With this information, the following modified test protocol was developed to assess the physical qualities of these disposable single use garments (Table 3).

TABLE 3. DISPOSABLE CHEMICAL PROTECTIVE CLOTHING PHYSICAL TEST

1. Walk 100 feet on concrete. Stop and inspect bootees.

2. Sit down and stand up on concrete step. Inspect.

3. Bend down and pick up 20 lb. box four times. Inspect.

4. Walk up 2 flights of stairs. Inspect.

5. Remove overpak lid, put down, slide blue drum inside, tip up, secure lid, inspect.

6. Open and close overhead valve 2 times with left hand and 2 limes with right hand. Inspect.

7. Crawl on hands and knees 25 to 50 feet. Inspect.

8. Rub buttocks against concrete wall 10 times. Inspect.

Four different disposal type protective clothing suits were evaluated with several types of underlying clothing., These suit combinations are listed in Table 4. An SCBA was worn over each of the clothing configurations.

TABLE 4. CLOTHING CONFIGURATIONS

1. Charkate Model 20002 HRT
   a with station uniform and one piece coverall
   b. with station uniform and full turnouts

2. MSA Nuclear Coverall
   a. with station uniform and sweatshirt
   b. with station uniform and one piece coverall

3. Sawyer Tower Model RL 3103
   a. with station uniform
   b. with one piece coverall
   c. with station uniform and full turnouts

4. Sawyer Tower Model NF-4

with station uniform
b. with station uniform and one piece coverall
c. with station uniform and full turnouts

The following questionnaire was filled out by each subject evaluating the disposal proteclive clothing.

QUESTIONNAIRE

FRONT

HOOD

1. Duct Tape?
2. Primary Material?
3. Seams?

TORSO

CROTCH

1. Seam Ripout?
   Primary Material Rip?

ZIPPER

1. Failure (pulls apart)?
   Seam Ripout?

ARMPITS

1. Seam Ripout?
2. Primary Material Rips?

LEGS

BOOTEES

1. Any Sign of Abrasion/Rips, Etc.?
2. Seam Ripout'?

GLOVES

1. Material Rips?
2. Where Are Rips?

BACK

1. SCBA Stress Rips?
2. Primary Material Rips?
3. Seam Rips?

RESULTS

The disposal type chemical protective clothing was visually inspected after performing the various work tasks described in Table 3. The results of this inspection are outlined in the following data sheets. If there is no obvious damage, that question item is left blank. Table 5 lists the results of this performance evaluation of these garments.

TABLE 5. CLOTHING PERFORMANCE

1. Charkate Model 20002 HRT		
a. with station uniform and one piece coverall	Failed	Ballooned, Excessive Abrasion
b. with station uniform and full turnouts	Failed	Rips, Excessive Abrasion, Glove failed water test
2. MSA Nuclear Coverall		
a. with station uniform and sweatshirt	Failed	Holes, Excessive Abrasion
b. with station uniform and one piece coverall	Failed	Seam failures, Excessive Some Abrasion
3. Sawyer Tower Model RL 3103		
a with station uniform	Passed	Hole caused by Name Tag
b. with one piece coverall	Passed	Abrasion
c. with station uniform and full turnouts	Passed	Abrasion
4. Sawyer Tower Model NF-4		
a. with station uniform	Failed	Seam Failure
b. with station uniform and one piece coverall	Failed	Seam failures, holes
C. with station uniform and full turnouts	Failed	Seam failures

TASK 2
NON-EMERGENCY SPLASH SUIT
QUESTIONNAIRE

SUBJECT NUMBER: 22 DATE: 12/13/89 CITY : Sacremento, Ca
HEIGHT: 5'6" WEIGHT: 140 lbs
CLOTHING: Charkate Model 20002 HRT XL. shorts. T-shirt. station uniform. 1 piece coverall, leather boots inside suit. MSA-2200 over suit nitrile rubber gloves.

FRONT

HOOD — DUCT TAPE?

PRIMARY MATERIAL?

SEAMS?

TORSO/CROTCH: SEAM RIPOUT? None.

PRIMARY MATERIAL RIP? None.

TORSO/ZIPPER: FAILURE (PULLS APART)?

SEAM RIPOUT? None.

TORSO/ARMPITS: SEAM RIPOUT? Just starting to separate after #5.

PRIMARY MATERIAL RIPOUT? None.

LEGS/BOOTEES: ANY SIGN OF ABRASION/RIPS, ETC? Left foot saranex is abrading after#1.
SEAM RIPOUT?

GLOVES: MATERIAL RIPS? Passed water pressure test.

WHERE ARE RIPS? None.

BACK:

SUIT: SCBA STRESS RIPS? None.

PRIMARY RIPS? None.

SEAM RIPS? None.

COMMENTS

"Never worn a splash suit before. Tears too easy."

QUESTIONNAIRE

SUBJECT NUMBER: 21 DATE: 12 / 13/ 8 9 CITY: SACRAMENTO.CA
HEIGHT: 5' 11" WEIGHT: 220 lbs
CLOTHING: Charkate Model 20002 HRT (zipper in back) Shorts. T-shirt. station uniform. leather boots inside suit. MSA-2200 worn over suit. nitrile rubbergloves duct taped

FRONT

HOOD:

DUCT TAPE? Yes. Stitching stressed. Stitching to chest coming apart.

PRIMARY MATERIAL? Saranex/Tyvek

SEAMS? Folded and stitched

TORSO/CROTCH: SEAM RIPOUT? More ripping after task #3, more again after #4.

PRIMARY MATERIAL RIP? After tests, rip in crotch extended down leg, now is 1

TORSO/ZIPPER: FAILURE (PULLS APART)? No.

SEAM RIPOUT? No.

TORSO/ARMPITS: SEAM RIPOUT? Very slight evidence of stitching stress in right armpit. Still good after task #6.
PRIMARY MATERIAL RIPOUT?

LEGS/BOOTEES: ANY SIGN OF ABRASION/RIPS, ETC? More abrasion on seam after #4. Hole at After #7, knees slightly abraded, left toe is out.
SEAM RIPOUT?

GLOVES: MATERIAL RIPS? Passed water pressure test.

WHERE ARE RIPS? None.

BACK:

SUIT: SCBA STRESS RIPS? No.

PRIMARY RIPS? No.

SEAM RIPS? No.

COMMENTS:

"This suit felt the same as the splash suit we presently use. I felt that the suit didn't provide a safe cover for my body. In the beginning of the test the suit ripped down both legs."
Suit ballooned up immediately when attempting to sit down. Then could not gel up.

TASK 2
NON-EMERGENCY SPLASH SUIT
QUESTIONNAIRE

SUBJECT NUMBER: 23 DATE: 12/13/89 CITY: SACRAMENTO,CA
HEIGHT: 5'7" WEIGHT: 165 lbs
CLOTHING: Charkate 20002 HRT XL. shorts. T-shirt. station uniform. bunker coat/pants. leather boots inside suit. MSA-2200 SCBA, nitrile rub gloves

FRONT

HOOD: DUCT TAPE?

PRIMARY MATERIAL?

SEAMS? 1" rip at seam on left side at #7.

TORSO/CROTCH: SEAM RIPOUT? None.

PRIMARY MATERIAL RIP? None.

TORSO/ZIPPER: FAILURE (PULLS APART)? Twisted at #4 and started to unzip just below chin..
SEAM RIPOUT? None.

TORSO/ARMPITS: SEAM RIPOUT? Front seam coming apart after #2. Seam coming apart both sides after #2.
PRIMARY MATERIAL RIPOUT?

LEGS/BOOTEES: ANY SIGN OF ABRASION/RIPS, ETC? Material is already on bottom after #l (left). Hole in right heel at #4, toe abraded at #4, seam failure on Left at #4, multiple holes in heel at #4.Hole in instep at #5.
SEAM RIP OUT? Slight abrasion on knees, toes good.

GLOVES: MATERIAL RIPS? Right glove failed water pressure test at thumb.

WHERE ARE RIPS?

BACK:

SUIT: SCBA STRESS RIPS? None.

PRIMARY RIPS? None.

SEAM RIPS? None.

COMMENTS:

This was the second lime I've used the Charkate suit. This time as with the first, it fell cool with lots of room (good range of motion). No problems with compleing the work assignments. The gloves seemed lo be loose, making it somewhat difficult to use small hand tools.

TASK 2
NON-EMERGENCY SPLASH SUIT
QUESTIONNAIRE

SUBJECT NUMBER: 24 DATE: 12 / 14/ 89 CITY: SACRAMENTO, CA
HEIGHT: 6'0" WEIGHT: 190 lbs
CLOTHING: MSA Nuclear Coverall (medium). shorts. T-shirt. station uniform. sweat shirt. rubber boots/no bootees. MSA 2200 worn outside suit nitrile rubber gloves

FRONT

HOOD: DUCT TAPE? Yes. Facepiece, gloves, Rubber boots-hood could not be sealed under chin, portion of neck exposed.
PRIMARY MATERIAL? Very thin(4 mil?). PVC(?) unsupported.

SEAMS? All heat sealed, no stitching, one fold.

TORSO/CROTCH: SEAM RIPOUT? No.

PRIMARY MATERIAL RIP? Pinhole in seat after lest #2. 1" abraded hole at right hip at conclusion of test.

TORSO/ZIPPER: FAILURE (PULLS APART)? None.

SEAM RIPOUT? None.

TORSO/ARMPITS: SEAM RIPOUT?None.

PRIMARY MATERIAL RIPOUT? None.

LEGS/BOOTEES: ANY SIGN OF ABRASION/RIPS, ETC? 1" holes in both knees. Both cuffs ripped easily around pants legs when duct tape was removed.
SEAM RIPOUT? Hole in upper leg at Test 8. Holes in both knees al Test 7.

GLOVES: MATERIAL RIPS? None,

WHERE ARE RIPS? None.

BACK:

SUIT: SCBA STRESS RIPS? Very visible signs of rubbing, no damage.

PRIMARY RIPS? None.

SEAM RIPS? None.

COMMENTS:

TASK 2
NON-EMERGENCY SPLASH SUIT
QUESTIONNAIRE

SUBJECT NUMBER: 25 DATE: 12/14/89 CITY: SCRAMENTO,CA
HEIGHT: 6' 1" WEIGHT: 200 lbs
CLOTHING: MSA Nuclear Coverall T-shirt. shorts. station uniform. suit. rubber boots. MSA-2200 worn outside suit. nitrile rubber gloves

FRONT

HOOD:

DUCT TAPE? Facepiece, gloves, rubber boots.

PRIMARY MATERIAL? Very thin (4 mil?) PVC(?) unsupported.

SEAMS? All heat sealed, no stitching, no fold.

TORSO/CROTCH:

SEAM RIPOUT? 11" ripout on test #7.

PRIMARY MATERIAL RIP? Front waist torn, possibly from SCBA.

TORSO/ZIPPER:

FAILURE (PULLS APART)?

SEAM RIPOUT?

TORSO/ARMPITS:

SEAM RIPOUT'? After #5, seam failure under left arm. (1.5 " hole).

PRIMARY MATERIAL RIPOUT?

LEGS/BOOTEES;

ANY SIGN OF ABRASION/RIPS, ETC?

SEAM RIPOUT? Complete failure upper leg at test #8. Abrassion to both knees at test #7.

GLOVES:

MATERIAL RIPS?

WHERE ARE RIPS?

BACK:

SUIT:

SCBA STRESS RIPS?

PRIMARY RIPS? Seat developed 2.5 " tear on first pass in test #8, in center of butt.

SEAM RIPS?

COMMENTS:

None.

TASK 2
NON-EMERGENCY SPLASH SUIT
QUESTIONNAIRE

SUBJECT NUMBER: 26 DATE: 1 2/14/89 CITY: SACRAMENTO.CA
HEIGHT: 5'9" WEIGHT: 160 lbs
CLOTHING: MSA Nuclear Coverall (XL). T-shirt. shorts station uniform. jump suit. rubber boots. MSA-2200 worn outside suit. nitrile rubber gloves.

FRONT

HOOD: DUCT TAPE? Facepiece, gloves, rubber boots.

PRIMARY MATERIAL? Very thin (4 mil?) PVC(?) unsupported.

SEAMS? All heat sealed, no stitching, no fold.

TORSO/CROTCH: SEAM RIPOUT? Has rip on right side, hip level, unknown cause-possibly while still in package.
PRIMARY MATERIAL RIP?

TORSO/ZIPPER: FAILURE (PULLS APART)?

SEAM RIPOUT?

TORSO/ARMPITS: SEAM RIPOUT?

PRIMARY MATERIAL RIPOUT? "V" tear over chest possibly caused by buckle on SCBA strap. 1" tear at left hip bone-unknown when occurred.

LEGS/BOOTEES: ANY SIGN OF ABRASION/RIPS, ETC? left cuff frayed and ripped at heel. Right knee, wide area of abrasion, no tears. Left knee, heavy abrasion, tiny holes. Above and below knee also shows heavy abrasion.
SEAM RIPOUT?

GLOVES: MATERIAL RIPS? None.

WHERE ARE RIPS? None.

BACK:

SUIT: SCBA STRESS RIPS? None.

PRIMARY RIPS? None.

SEAM RIPS? None.

COMMENTS:

None.

TASK 2
NON-EMERGENCY SPLASH SUIT
QUESTIONNAIRE

SUBJECT NUMBER: 21 DATE: 12/ 13/89 CITY:SACRAMENTO, CA
HEIGHT: 5'11" WEIGHT: 220 Ibs
CLOTHING: Sawyer Tower Model RL 3103 (PVC green). T-shirt. shorts. station uniform. leather boots duct-taped. MSA-2200 worn outside suit nitrile rubber gloves.

FRONT

HOOD:	DUCT TAPE? Yes.
	PRIMARY MATERIAL? PVC/glass.
	SEAMS? Stitched, taped, sealed
TORSO/CROTCH:	SEAM RIPOUT? None torso hole Test #3.
	PRIMARY MATERIAL RIP?None.
TORSO/ZIPPER:	FAILURE (PULLS APART)?No.
	SEAM RIPOUT? None.
TORSO/ARMPITS:	SEAM RIPOUT? None.
	PRIMARY MATERIAL RIPOUT? Pinhole noticed on right chest on Test #3. Probably from name tag corner on station uniform.
LEGS/BOOTEES:	ANY SIGN OF ABRASION/RIPS, ETC? No.
	SEAM RIPOUT? Knees-no abrasion, but possibly some ground in grit. Be a good candidate for a permeation test.
GLOVES:	MATERIAL RIPS? None.
	WHERE ARE RIPS? None.

BACK:

SUIT:	SCBA STRESS RIPS? None.
	PRIMARY RIPS? None.
	SEAM RIPS? None.

COMMENTS:

"This suit compared to the Charkate was in my opinion far superior in the construction and comfort. I felt very secure in this suit."

TASK 2
NON-EMERGENCY SPLASH SUIT
QUESTIONNAIRE

SUBJECT NUMBER: 23 DATE: 12/13/89 CITY: SACRAMENTO, CA
HEIGHT: 5'7" WEIGHT: 165 lbs
CLOTHING: Sawyer Tower Model RL-3103 (PVC areen) XL. T-shirt. shorts. coveralls leather boots. MSA-2200 worn outside suit. nitrile rubber cloves.

FRONT

HOOD: DUCT TAPE? Yes, separation at mask at #3, progressed at #6.

PRIMARY MATERIAL? PVC

SEAMS? Stitched, taped, sealed.

TORSO/CR0TCH: SEAM RIPOUT?No

PRIMARY MATERIAL RIP? No.

TORSO/ZIPPER: FAILURE (PULLS APART)? No.

SEAM RIPOUT? None.

TORSO/ARMPITS: SEAM RIPOUT? None.

PRIMARY MATERIAL RIPOUT? None.

LEGS/BOOTEES: ANY SIGN OF ABRASION/RIPS, ETC? Knees-no abrasion but ground in grit.
SEAM RIPOUT?

GLOVES: MATERIAL RIPS? None.

WHERE ARE RIPS? None.

BACK:

SUIT; SCBA STRESS RIPS? No, but some evidence of rubbing of back frame.

PRIMARY RIPS? Considerable evidence of SCBA rubbing all around waist at waist strap, but no suit failure.
SEAM RIPS? None.

COMMENTS:

"This was the first time I used the Sawyer Tower suit. I was a bit too warm during the work assignments even with cool outside temperalure. Range of motion was tight. Glove fit was good. Glove material although thick presented no problems using small fools or picking up objects.

TASK 2
NON-EMERGENCY SPLASH SUIT
QUESTIONNAIRE

SUBJECT NUMBER: 27 DATE: 12/l 3/89 CITY: SACRAMENTO.CA
HEIGHT: 5' IO" WEIGHT: 190 Ibs
CLOTHING: Sawyer Tower Model RL 3103 (PVC areen XL). T-shirt. shorts.station uniform bunker coat/pants. leather boots. MSA-2200 worn outside suit nitrile rubber gloves

FRONT

HOOD: DUCT TAPE? Yes, separated at facepiece at #4.

PRIMARY MATERIAL? PVC, gloves PVC.

SEAMS? Stitched, taped, sealed.

TORSO/CROTCH: SEAM RIPOUT'? No.

PRIMARY MATERIAL RIP?

TORSO/ZIPPER: FAILURE (PULLS APART)? No.

SEAM RIPOUT? No.

TORSO/ARMPITS: SEAM RIPOUT? None.

PRIMARY MATERIAL RIPOUT? None.

LEGS/BOOTEES: ANY SIGN OF ABRASION/RIPS, ETC? Knees: no abrasion, but obvious scuffing, some ground in dirt, candidate for permeation lest.
SEAM RIPOUT? No.

GLOVES: MATERIAL RIPS? None.

WHERE ARE RIPS? None.

BACK:

SUIT: SCBA STRESS RIPS? Considerable evidence of SCBA rubbing around waist from waist strap.
PRIMARY RIPS? At rear-left pocket (of turnout) several scuffmarks and possibly pin hiles thruough material due to tools carried in pocket at #2 and #5.
SEAM RIPS? Seat shows major wear on set, PVC abraded off lo sub-strate material.

COMMENTS:
"This is the fourth lime I've worn one of these suits. Movement restricted my ability to reach the valve or even the top of my head. The suit fit tight in the armpits The suit was tight in the knees and thighs in the silting and squatting positions. While wearing full turnouts it weemed to gel very hot in this suit. Restricted head movement-left and right-up and down. Gloves fit very loose."

NON-EMERGENCY SPLASH SUIT QUESTIONNAIRE

SUBJECT NUMBER: 28 DATE: 12/ 13/88 CITY: SACRAMENTO.CA
HEIGHT: 5'8" WEIGHT: 165 lbs
CLOTHING: Sawyer Tower Model NF-4, XXL Station uniform. shorts. T-shirt. turnouts. rubber boots. MSA-2200 worn over suit, nitrile rubber gloves.

FRONT

HOOD: DUCT TAPE?

PRIMARY MATERIAL? PVC?

SEAMS?

TORSO/CROTCH: SEAM RIPOUT? Crotch completely blown.

PRIMARY MATERIAL RIP? buttocks abraded.

TORSO/ZIPPER: FAILURE (PULLS APART)?

SEAM RIPOUT?

TORSO/ARMPITS: SEAM RIPOUT?

PRIMARY MATERIAL RIPOUT?

LEGS/BOOTEES; ANY SIGN OF ABRASION/RIPS, ETC'? left cuff area abraded.

SEAM RIPOUT?

GLOVES: MATERIAL RIPS?

WHERE ARE RIPS?

BACK:

SUIT: SCBA STRESS RIPS?

PRIMARY RIPS?

SEAM RIPS?

COMMENTS:

Material abraded through after test #8.

TASK 2

NON-EMERGENCY SPLASH SUIT QUESTIONNAIRE

SUBJECT NUMBER: 29 DATE: 12/13/89 CITY: SACRAMENTO.CA
HEIGHT: 6'0" WEIGHT: 208 lbs
CLOTHING: Sawyer Tower Model NF-4 XXL Station uniform. shorts T-shirt. Nomex jump suit. rubber boots. MSA-2200 worn over suit. nitrile rubber gloves

FRONT

HOOD: DUCT TAPE?

PRIMARY MATERIAL? PVC?

SEAMS?

TORSO/CROTCH: SEAM RIPOUT? Hole in left hip. Hole in crotch.

PRIMARY MATERIAL RIP? buttocks abraded.

TORSO/ZIPPER: FAILURE (PULLS APART)?

SEAM RIPOUT?

TORSO/ARMPITS: SEAM RIPOUT?

PRIMARY MATERIAL RIPOUT?

LEGS/BOOTEES: ANY SIGN OF ABRASION/RIPS, ETC? Hole in right knee.

SEAM RIPOUT? Entire rear

GLOVES: MATERIAL RIPS?

WHERE ARE RIPS?

BACK:

SUIT: SCBA STRESS RIPS?

PRIMARY RIPS?

SEAM RIPS?

COMMENTS:

Entire rear abraded through after lest #8.

TASK 2
NON-EMERGENCY SPLASH SUIT
QUESTIONNAIRE

SUBJECT NUMBER: 28 DATE: 12/13/89 CITY: SACRAMENTO.CA
HEIGHT: 5'8" WEIGHT: 165 lbs
CLOTHING: Sawyer Tower Model NF-4. XXL. Station uniform. shorts. T-shirt. turnouts. rubber boots, MSA-2200 worn over suit, nitrile rubber gloves.

FRONT

HOOD: DUCT TAPE?

PRIMARY MATERIAL? PVC?

SEAMS?

TORSO/CROTCH: SEAM RIPOUT? Crotch completely blown.

PRIMARY MATERIAL RIP? buttocks abraded.

TORSO/ZIPPER: FAILURE (PULLS APART)?

SEAM RIPOUT?

TORSO/ARMPITS; SEAM RIPOUT?

PRIMARY MATERIAL RIPOUT?

LEGS/BOOTEES; ANY SIGN OF ABRASION/RIPS, ETC? left cuff area abraded.

SEAM RIPOUT?

GLOVES: MATERIAL RIPS?

WHERE ARE RIPS?

BACK:

SUIT: SCBA STRESS RIPS?

PRIMARY RIPS?

SEAM RIPS?

COMMENTS:

Entire rear abraded through after lest #8.

DISCUSSION

The results of this test evaluation quickly identified various deficiencies for the suits. Table 5 lists the problems with each suit after performing the test criteria described in Table 3. Some suits like the Sawyer Tower Model NF-4 do not pass the tests criteria without major seam failures. Sizing is especially critical when complete turnouts are worn underneath. If the suit is too tight, stress on the seams/materials is increased and can lead to seam failure as seen with the Charkate and Sawyer Tower Model NF-4 protective garments. Abrasion is another problem due either to crawling, rubbing against walls or SCBA harness. This abrasion resulted in many holes or removal of the primary protective layer of the clothing.

RECOMMENDATIONS / CONCLUSIONS

This new testing procedure quickly evaluated the strength and durability of disposable type chemical protective garment material and seams. This lack of performance could lead to garments being used in situations of high risk and failures.

In order to belter serve the Fire Service and Hazardous Waste Handlers, it is recommended that this test criteria, be evaluated further and considered for adoption by ASTM.

REFERENCES

Annual Book of ASTM Standards. 1989. F-1154. Practices for Qualitatively Evaluating the Comfort, Fit, Function and Integrity of Chemical Protective Suit Ensembles. Section 15, Vol. 15.07 Philadelphia, PA.

ASTM-STP-1037. 1989. Chemical Protective Clothing Performance in Chemical Emergency Response [Eds], J.L. Perkins and J. O. Stull. Philadelphia, PA.

Federal Register - Part III
Department of Labor Occupational Safety and Health Administration. 29 CFR Part 1910, Hazardous Waste Operations and Emergency Response: Final Rule March 6, 1989

National Fire Protection Assoiciation
Henry F. Marlin, Editor; Hazardous Materials Response Handbook with The Complete Text of NFPA 471 and NFPA 472

NFPA 1991, Vapor-protective Suits for Hazardous Chemical Emergencies. 1990 Edition. Quincy, MA.

NFPA-1992, Liquid Splash-Protective Suits for Hazardous Chemical Emergencies. 1990 Edition. Quincy, MA.

NFPA-1993, Support Function Protective Garments for Hazardous Chemical Operations. 1990 Edition. Quincy, MA.

Schwope, A.D., P.O. Costa, J. 0. Jackson, J.O. Stull and D. J. Weilzman. 1987. Guidelines for the Selection of
Chemical Protective Clothing. American Conference of Governmental Industrial Hygienists. Cincinnati, OH.

Unknown author. 1987. Department of Transportation, Emergency Response Guidebook. Washington, DC.

☆ U.S.GOVERNMENT PRINTING OFFICE:1991-526-655/40890