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FINAL REPORT

FOR THE

EXPEDIENT PERSONNEL DECON PROCEDURE VALIDATION

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Section 1

Executive Summary

Background and Overall Objective

This project was conducted for and in conjunction with the Naval Special Warfare Development Group (NSWDG) specifically to address SOF shortfalls in personal decontamination procedures and equipment. The overall objective of this project was to develop and validate timely, rapid, lightweight and effective decontamination procedures and equipment that is easily integrated into SOF tactics. Several tactical guidelines were provided by NSWDG to help shape the specific objectives of the project. A summary of tactical guidelines, specific objectives and results follows.

Tactical Guidelines

Guideline 1: Decontamination of the force will occur at the closest permissive site to the target permitted by the tactical situation. In some missions, such as Maritime Interdiction Operations (MIO), decontamination will likely occur directly on the objective after it is secure.

Guideline 2: Timely and effective decontamination is critical to prevent CBR casualties. NSWDG anticipates the possibility of SOF contamination challenges that could be considerably higher than the standard 10gm/m2 that JSLIST Approved Material (JAM) is designed to protect against.

Guideline 3: CW break-through times on SOF Personal Protective Equipment (PPE) dictates the need to conduct decontamination at the soonest opportunity consistent with the tactical situation. CW break-through times are significantly reduced in the case of salt water exposed PPE, further heightening the importance of rapid decontamination

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Guideline 4: The nature of SOF operations in the NBC environment dictates that the use of a supporting force to conduct decontamination is often tactically infeasible. The SOF decontamination capability must reside completely within the force and be effective post mission for both healthy operators and casualties.

Guideline 5: Contamination control is a paramount. The reduction or elimination of the spreading of liquid or solid contamination off target and back to friendly forces, mission critical mobility platforms or forward staging bases is critical.

Guideline 6: The procedure and equipment should not produce undue logistical burden in terms of training, acquisition or maintenance.

Specific Objectives, Thresholds and Results

Objective 1
Develop a one-man portable, very lightweight system that does not displace an undue amount of the operator's combat load.

Threshold: Less than 20 pounds.

Results: A 17-pound system was developed. A single system can decontaminate 15-20 personnel.

Objective 2
The procedure must be effective against VGH, Bio and Alpha.

Threshold: Reduce contamination from levels above 10 gm/m2 to levels at least 100-fold less than the LD_{50} for VX, GA, GB, GD, GF and HD.

Results: Given an average challenge of 15 gm/m2, contamination was reduced to at least 100-fold less than the LD_{50} for VX, 500-fold less than the LD_{50} for GD, 300-fold less than the LD_{50} for GF, 10000-fold less than the LD_{50} for GA, and 17000-fold less than the LD_{50} for GB (2). This system would detect to a limit that was 10 fold above the first percutaneous symptoms for HD. It should be noted however, that the simulant system would detect 35,000-fold below the lethal dose of HD. Therefore contamination was reduced to at least these levels for HD. This system did not test the efficacy of the procedure using particulates.

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Approach: The project developed a procedure that is based on a "clean cut-out" of the protective ensemble. The decontaminant provides an added degree of safety and reduces off gassing of agent vapor, but is not required to achieve decontamination. An average challenge of 15gm/m2 of liquid chemical agent simulant (viscosity of G agent) was used for this testing. G viscosity was chosen since this is the worst case for agent permeation. A Tinopal simulant was specifically developed and it's concentration mathematically correlated to the lower limit of detection (LLD) for each agent (V, G, and H). The LLD of this simulant mathematically equates to at least 10-fold less than the LD_{50} for VX.

Objective 3
Conventional decontamination procedures are "wet" procedures. NSWDG preferred the development of a "dry" procedure to reduce weight and logistical burden.

Threshold: Identify dry decontaminants that are effective against VGH and biological agents.

Results: Sorbent Decon System (SDS) was down selected from fourteen candidates as the most appropriate decontaminant. SDS is proven against VGH, and is undergoing testing against biological agents. This objective is only partially achieved and is pending the outcome of the SDS biological tests. If SDS is not effective against biological agents, a

Calcium Hypochlorite decontaminant (wet) will continue to be used on biological agents.

Objective 4
The procedure should be simple, requiring minimal training or expertise to accomplish.

Threshold: The procedure can be taught to any level 1 NBC graduate in eight hours.

Results: All test subjects conducted eight hours of training, but demonstrated adequate proficiency in about four hours.

Objective 5
The procedure should be broadly applicable to a wide range of protective clothing types.

Threshold: The procedure must be effective for all JSLIST ensembles and MCPE.

Results: The procedure was tested against every conceivable configuration of PPE including litter born patients, and was proven effective.

Approach: PPE configurations were categorized as either one piece or two piece ensembles. Specific procedures were developed for each of these categories and tested against a wide variation of ensembles. This approach allows the broadest applicability to protective clothing types. Modified procedures were validated for litter born patients.

Objective 6
The decontamination station should require minimal space, be quickly set up and allow rapid processing of a SOF team.

Threshold: The station must be able to be set up in a typical shipboard space and be set up in less than 10 minutes. The amount of time that is required to process 32 operators using four kits in parallel must be less than 60 minutes.

Results: The station can be set up in under five minutes. The amount of time that is required to process 8 operators using a single kit ranged from 37 to 44 minutes depending on the ensemble and the proficiency of the cut-out team. It is postulated that 4 kits used in parallel for 32 operators would yield similar results.

Objective 7
The equipment should be easily attainable, require little maintenance and be rugged.

Threshold: All materials must be available through the stock system or Commercial Off The Shelf (COTS) from US vendors. Maintenance must entail less than 8 man-hours per quarter per kit. All materials must survive typical SOF mission scenarios.

Results: All threshold objectives were achieved. Maintenance is estimated at less than 2 man-hours per quarter per kit.

Objective 8
Demonstrate the ability to achieve decontamination of contaminated casualties.

Threshold: Process casualties using a Raven Litter and Isolation Litter.

Results: Threshold objectives were achieved.

Conclusions:

1. All threshold objectives were met or exceeded with the exception of the efficacy of SDS against biological agents, the test results of which are pending.

2. NSWDG has determined the system and procedures have met the tactical guidelines.

3. The US Army West Desert Test Center validates and certifies that this procedure and equipment will achieve a reduction in contamination equivalent to 100-fold less than the LD_{50} for VX, GA, GB, GD, GF, and HD with a 95% degree of confidence for individuals when all of the conditions specified below are met:

One and two piece JSLIST ensembles and MCPE are worn and,
When the PPE is exhibiting no breakthrough of agent and,
Agent challenges do not exceed 15gm/m2 and,
When the procedure is conducted in accordance with the validated SOPs for one piece, two piece and litter borne cut-outs specified herein and,
When the procedure is accomplished with the validated equipment specified herein and,
When the procedure is conducted by operators and for operators who have undergone NBC level 1 training or equivalent and,
When the procedure is conducted by operators and for operators who have completed at least 4 hours of decontamination training from personnel who have previously qualified on this procedure and equipment under competent authority.
Characterization of break-through degradation on salt water exposed PPE and baseline non-salt water exposed PPE is documented in DTC Project Number 8-CO-160-000-046. This is a draft report containing preliminary test data on select PPE for NSWDG. Although further testing is required on additional NSWDG Maritime CBR Protective Ensembles (MCPE), sufficient proof exists on the degradation of microencapsulated carbon sphere technology by salt water to warrant consideration of time as a critical factor in SOF team decontamination. This is particularly true for protective materials that have been exposed to salt water, and then dried out, the greatest threat for which are the G agents.

Section 2

Introduction

This work was conducted as a subset validation project to DTC Test Directive 8-CO-160-000-046 (1). The objectives of this validation were to develop and prove that an expedient decontamination procedure would eliminate the possibility of cross contamination of personnel during physical removal of contaminated protective ensembles. This validation was designed to qualitatively measure cross contamination from a liquid challenge during a novel expedient decon procedure developed by NSWDG. Traditional decon methods are not suited to the mission needs of the SOF community based upon logistical burdens.

The scope of this study was limited to liquid challenge hazard because it represents the predominant source of cross contamination. This study does not take into account the effects of vapor off-gassing during cut-out procedures because it does not represent a source of cross contamination. While not eliminated, the vapor hazard is significantly mitigated by use of Sorbent decon and immediate isolation of contaminated articles. During the course of this study, the decontaminants used were not tested for their effectiveness against given agents. The project relied upon unpublished AMC test results that indicate these products inactivate or absorbed chemical warfare agents.

Of the six iterations of validation trials and eight iterations of procedure development (baseline studies), no incidence of liquid cross contamination due to procedure was noted. Early indications of lower back exposure to simulant following cut-out procedures (CPU/Gortex and Fris/CPU) were later attributed to the leeching of fluorescent dye (see explanation below) from the laundry tags attached to the CPU bottoms and tops. Therefore, of the 94 (46 for baseline, 48 for validation) individuals processed through NSWDGs cut-out procedure, the lack of cross contamination of simulant G agent served to validate both the one-piece and two-piece ensemble expedient personnel (ambulatory and non-ambulatory) decon procedure (described below) for a liquid challenge.

Materials and Methods

Tinopal Simulant Solution

The base simulant solution (G agent simulant) used for this study was a mixture consisting of 10% (w/v)of sucrose in distilled water. To this was added 0.06% Tinopal (w/v) (Tinopal-CBS, Tilley Chemical Company) as a fluorescent marker. This solution mimicked some of the physical properties of nerve agents (viscosity and droplet size) but did not mimic the liquid persistency of VX. However, it was demonstrated that even upon drying, the simulant portrayed a contact hazard and the ability to cross-contaminate upon touch. Therefore, this was an ideal solution for the determination of cross-contamination during expedient exfiltration of personnel.

Previous studies have indicated that a one pump spray (from a [DPG equipment] Tinopal spray bottle) consisted of approximately 1 cc of liquid that weighed 1 gram. Experimentation was conducted to determine the contamination density from one (one-pump) application. The solution was sprayed onto Whatman paper from a distance of 88

cm and the diameter of the spray pattern was measured. By calculating the area of the spray pattern, the density of contamination was determined. To increase accuracy and reliability, this experiment was completed with eight iterations. The simulant mixture was used to contaminate the individuals and equipment by spraying 20 pumps (to approximate 10gram/m^2 challenge) with a one quart pump spray bottle. To assess cross-contamination by cut-out procedure, the test participants were undressed and photographed under blacklight conditions to determine inherent fluorescence associated with lint, body hair, scars etc... Once individuals were suited up into the respective ensembles, they were exposed to Tinopal and again photographed under blacklight (see Figure 1 below). Following cut-out procedures, the individuals were photographed and assessed for Tinopal contamination due to the cut-out procedures.

One Piece Cut-out Standard Operating Procedure

1. Remove Mk1 medical kits
2. Remove M291 and M295 and place at hot line
3. Full body 'buddy' decon (patting down) using M295
4. Proceed into first shuffle pit containing decontaminate. Decon feet/boots.
5. Proceed to second shuffle pit. While in pit, cut straps off hood, lossen neck cord. Cutter decon hands and cutting utensils. Roll hood from rear bottom and gather bottom into neck cord. Cutter decon hands and cutting utensils.
6. Cut wrist, waist, and ankle closures on PPE. Cutter decon hands and cutting utensils. Release cut boot closures. Cutter decon hands and cutting utensils.
7. Remove boots. Cutter decon hands and cutting utensils.
8. Cut back of PPE down one leg as far as possible. Cutter decon hands and cutting utensils. Cut down other leg from buttocks area. Cutter decon hands and cutting utensils.
9. Remove suit forward, stripping down and fold the suit into itself. Remove gloves with the garment. Cutter decon hands and cutting utensils.
10. (CPU removal) Cut down middle of back. Cutter decon hands and cutting utensils.
11. Extend arms forward and pull CPU top down arms folding CPU garment into itself. Cutter decon hands and cutting utensils.
12. Cut down outer side of each leg and have deconee step forward out of garment. Cutter decon hands and cutting utensils.
13. Strip of outer sock, then inner sock with deconee stepping directly onto safety pad (impregnated with decontaminate). Cutter decon hands and cutting utensils.
14. Proceed to mask drop area. Decon deconee's hands and remove mask by pulling crown tag on mask (utilizing breath hold technique with assisted mask removal). Cutter decon hands and cutting utensils.
15. Move to redress area, redress, move to exfil area.

Two piece Cut-out Standard Operating Procedure

1. Remove Mk1 medical kits
2. Remove M291 and M295 and place at hot line

3. Full body 'buddy' decon (patting down) using M295
4. Proceed into first shuffle pit containing decontaminate. Decon feet/boots.
5. Proceed to second shuffle pit. While in pit, cut straps off hood, lossen neck cord. Cutter decon hands and cutting utensils. Roll hood from rear bottom and gather bottom into neck cord. Cutter decon hands and cutting utensils.
6. Cut wrist, waist, and ankle closures on PPE. Cutter decon hands and cutting utensils.
7. Cut top rear center down back of garment. Cutter decon hands and cutting utensils.
8. Extend arms forward and pull top down arms folding garment into itself. Cutter decon hands and cutting utensils.
9. Cut down outer side of each leg and have deconee step forward out of garment. Cutter decon hands and cutting utensils.
10. Cut boot closures, cutter secure boot and deconee step forward out of boots. . Cutter decon hands and cutting utensils.
11. (CPU removal) (CPU removal) Cut down middle of back. Cutter decon hands and cutting utensils.
12. Extend arms forward and pull CPU top down arms folding CPU garment into itself. Cutter decon hands and cutting utensils.
13. Cut down outer side of each leg and have deconee step forward out of garment. Cutter decon hands and cutting utensils.
14. Strip of outer sock, then inner sock with deconee stepping directly onto safety pad (impregnated with decontaminate). Cutter decon hands and cutting utensils.
15. Proceed to mask drop area. Decon deconee's hands and remove mask by pulling crown tag on mask (utilizing breath hold technique with assisted mask removal). Cutter decon hands and cutting utensils.
16. Move to redress area, redress, move to exfil area.

Results

Tinopal Detection Limits

In an effort to define the operational meaning of "clean" using the Tinopal system, we completed a set of experiments to understand the limits of detection of the fluorescent dye. From this data and knowing the concentration of Tinopal in the solution and LD_{50} of each CW agent, it was possible to equate the Tinopal LLD (lower limits of detection) to a comparable CW agent contamination. This experiment had several inherent assumptions; 1) the Tinopal solution would act in a similar manner to the CW agents (the Tinopal solution was made so that the viscosity was similar to G agents). 2). Using the naked eye and UV lights (280nm wavelength) as the assay, variability will exist in this system (attempts were made to minimize the variation by doing 10-fold dilutions of the solution and using seven people to gauge the results).

The experimental design was to create 10-fold dilutions of the Tinopal solution (10% sucrose and 0.06% Tinopal) from 1 to 10^{-4} in 10% sucrose/water. A known volume (100µl) of these solutions were then applied to filter paper and assayed by the naked eye under the same black light system used in the baseline study. The highest dilution where a signal could be identified was determined as the LLD. A negative control (10%

sucrose/water) and a positive control (1x concentration of Tinopal solution) verified the validity of the assay system.

From this experiment, it was determined that the LLD was a 10^{-2} dilution of the Tinopal solution. Previous measurements determined that this would equate to approximately 1mg of liquid contamination. The LD_{50} for percutaneous application of VX is 10 mg/70 kg (50 mg/70kg GD, 30 mg/70kg GF, 1000mg/70kg GA, 1700mg/70kg GB (2). Therefore, in this system, the LLD of the Tinopal solution is approximately 10-fold less than the LD50 for a 70 kg person. Once again, it should be noted that this does not take into account the vapor hazard from CW agent contamination.

In a similar experiment, the detection limit was determined by dropping undiluted Tinopal solutions of known volume on the Whatman paper. This test would eliminate the potential for the loss of visible signal due to dilution in the sugar water mix. However, the series of tests are limited by the accurate placement of a known volume. Therefore, the range for this test was undiluted Tinopal volumes of 100 µl, 10µl 1µl, 0.1µl. For a more accurate representation of the data, the experiment was run with eight replicates and included a sugar water negative control. The results from this series of tests showed that the Tinopal solution could be observed even at the lowest volume placed on the paper (equivalent to a 10-3 reduction of volume). This indicated that the LLD for the Tinopal solution was even 10 fold greater than determined from the previous experiment. Therefore, using the calculations above, the LLD for this taggant simulant is approximately 100-fold less than the LD50 of VX for a 70kg person. This same calculation was applied to the LD50's of other known agents (Table 1).

The first percutaneous symptoms for HD appear as erythema at 10µg/70Kg (the LD50 is 40-50mg/Kg which equates to 3500 mg/70 Kg person). Using these limits and the calculated LLD for the Tinopal solution, this system would detect to a limit that was 10 fold above the first percutaneous symptoms for HD. It should be noted however, that the simulant system would detect 35,000-fold below the lethal dose of HD.

Table 1. Lower Limits of detection of Tinopal solution.

LD50 on Skin			
Agent	Amount/70kg	Tinopal LLD (µl)	x-fold below LD50
GA	1000mg	0.1	10000
GB	1700 mg	0.1	17000
GD	50mg	0.1	500
GF	30mg	0.1	300
VX	10mg	0.1	100

Contamination Density

As described in the materials and methods, the density of the contamination was measured for this validation. The calculations determined that each spray pattern covered approximately 0.065 m^2 (σ = 0.0088, CV = 13.5%). From this it was calculated that at a distance of 88 cm (used in the validation) each spray resulted in a localized

contamination density of 15 grams/ m^2. When averaged over the approximate area of an individual (2 m^2), the average contamination density/individual was 10 grams/ m^2.

Figure 1. Tinopal spray patterm

Tinopal Inactivation

One critical aspect of this simulant system for use in determining the efficacy of a given procedure is the ability of the various decontaminates to inactivate or neutralize the fluorescent signal. The decontaminates used in this series of tests included: 5% sodium hypocholrite (household bleach), M295 resin and SDS resin (Sorbent Decon System). The decon solutions were used to test their effectiveness against both the wet and dried Tinopal solution. The Tinopal solution was applied to a variety of surfaces (hard porous, cloth material and skin) and treated with the decon material. From this analysis it was determined that the bleach and M295 neutralized the fluorescent signal in both a wet and dry simulant form. However, while the SDS neutralized the wet Tinopal solution rapidly, the neutralization was slowed when the Tinopal solution was allowed to dry. In this system, the SDS did minimize the transfer (cross-contamination) of the dried Tinopal solution and was useful for the validation studies conducted. DPG continues to analyze the effects of the various decontaminates on the physical properties of the different tinopal compounds and their relationship to the effects of the decontaminates on the various WMD agents.

Phase I: Baseline Study

The objectives of the baseline study were to utilize the existing decon solutions (hypochlorite – liquid decon) and refine 'proof of concept' and verify the reliability of the expedient decon exfiltration method. DPG and NSWDG personnel at NSWDG command conducted the original baseline study. This study (consisting of a liquid simulant challenge with fluorescent tag served to point out concerns with the decontamination cut-out procedure drafted by NSWDG. A follow-up developmental study (under similar conditions) was conducted the week of 17 June 1999 at WDTC,

DPG to further refine procedures. These proof of concept results were then applied to a phase II validation study conducted at WDTC, DPG the week of 8 August, 1999.

It should be noted that the selection of surrogates was to mimic one and two-piece protective ensembles for training and development of mechanical cut-out procedures. These surrogates were not selected for their (liquid) chemical protective qualities. For the baseline trials, liquid decontaminate (Sodium Hypochlorite), M295 and mechanical decontamination methods were employed. Of the 46 trials, there was one incidence of self cross contamination where an individual touched a clean body surface with a contaminated-gloved hand. No incidences of cross contamination due to procedure were observed. The successful development of these Phase I procedures provided the basis for validation in Phase II.

The ensembles and iterations used in the second baseline study are summarized in the following table.

Table 2. Proof of Concept (Baseline) Ensemble Constituents.

	Test #1	Test # 2	Test # 3	Test # 4	Test # 5	Test # 6	Test # 7 A/B
Ensemble	**Gortex**	***DBDU***	***Fris Suit***	***Dry Suit***	***JSLIST Type VII***	***DBDU***	**one (A) piece two (B) piece**
Running Shorts	X	X	X	X	X	X	X (A/B)
Smart (wool) socks							
Gortex Socks					X	X	X (A/B)
CPU Sock (smart wool Surrogate)	S	S	S	S	S	S	S (A/B)
CPU Bottom (therm underwear=Surrogate)	S	S	S	S		S	S (A)
CPU Top (therm underwear=Surogate)	S	S	S	S		S	S (A)
Gortex Bottom Saratoga=Surrogate	S						
Gortex Top Saratoga=Surrogate	S						
JSLIST Type VII					X		X (saratoga=surr)
DBDU Bottom		X				X	
DBDU Top		X				X	
FRIS			X				X (Dry Suit surr)
DRY Suit				X			
Boot of Choice	X	X	X		X	X	X (A/B)
Butyl Rubber Glove	X	X			X	X	
DUI Glove			X	X			
M45	X	X	X	X	X	X	X (A/B)

Butyl Rubber Hood= MCU2P Surrogate	*S*	*S*	*S*	*S*	*S*	*S*	*X* (A/B)
Notes	8 personnel, including 2-man decon team with decon line close out	6 personnel	8 Personnel	Dry Suit (DUI)	8 personnel	8 personnel, 6 with 2-man decon team close out	Two runs-4 one-piece (A) using flight suit surrogate, 4 two-piece (B) using flight suit surrogate-hood removed

***S** denotes use of surrogate clothing item.*

Phase II: Validation of Procedures

Based upon results obtained from the developmental Phase I study, the validation study was conducted at WDTC, DPG the week of 8 August 1999. Prior to the timed validation results listed below was a period of training to orient the participants to the procedures. The average time of training per individual was 8 hours. Since there has not been an effort to optimize training efficiency to date, 8 hours represents the maximum period of time to master the procedures to these levels. The ensembles validated in Phase II constitute the Personal Protective Equipment currently employed by Special Operations Forces. The following table lists the constituents of the different ensembles used in the decontamination cut-out procedures.

Table 3. Ensemble Constituents of 'Contaminated' Personnel and (Cutter) Decon Personnel.

Ensemble	Gortex/CPU	Type VII	FRIS/CPU w/ tag	FRIS/CPU wo/tag	Dry Suit	Litter Decon	*Cutters*
Running Shorts	X	X	X	X	X	X	X
Smart (wool) socks	X	X	X	X	X		X
Gortex Socks	X	X			X	X	
CPU Sock						X	
CPU Bottom	X		X	X	X		
CPU Top	X		X	X	X		
Gortex Bottom	X						
Gortex Top	X						
JSLIST Type VII		X				X	
Saratoga			X	X			X
FRIS					X		
DRY Suit							
Flight Suit	X	X					
Adidas Boot							X
Other' Boot			X	X			
Vans	X	X	X	X		X	X
Butyl Rubber Glove					X		
CPU Glove	X	X	X	X	X	X	X
M45 Mask	X	X	X	X	X	X	

2nd Skin Hood	X	X	X	X	X	X	S
Butyl Rubber Hood							

Table 4. Results of 'CPU/GORTEX' Ensemble Cut-Out Procedure.

Personnel	Pre-exposure	Ensemble	Contamination	Time Through Line (min)
(10)	None	CPU / GORTEX / 2nd Skin Hood	Clean*	13
(16)	RT medial wrist	"	Clean*	ND
(2)	Charcoal on back	"	Clean*	ND
(8)	Frt. Shorts, Lft Rear,Dorsal Lft hand	"	Clean*	ND
(5)	Lft knee, Lft elbow	"	Clean	15
(3)	Tinea Rt abdom, Rt thigh	"	Clean	15
(15)	Rt thigh, Rt upper back	"	Clean	17
(12)	Rt foot	"	Clean	14
				Avg: 14.8 Min
Cutters				***Total Iteration Time: ND***
(7)	None	Flt. Suit/BR gloves/Sk/Bt/M45 w/BR Hood	Clean	
(13)	None	"	Clean	
(11)	None	"	Clean	
(6)	None	"	Clean	
			Decon Result (I.e. 'clean'):	
			w/o cutters 100%	
			w/ cutters 100%	

Clean* denotes contamination due to leeching of fluorescent dye for the laundry tags of the CPU garments (both situated at lower back). Initial contamination on the lower backs

of the noted individuals was later experimentally determined to be the result of the tags (see results below).

Figure 2 The following photo set (figure 2a through h) illustrates cut-out procedure using the two piece *GORTEX/CPU* ensemble worn by the test subjects.

A. APPLICATION OF TINOPAL

B. SHUFFLE PIT PROCEDURE

C. ROLLING/SECURING OF MASK HOOD

D. CUT-OUT OF OUTER GARMENT #1

E. CUT-OUT OF OUTER GARMENT #2

F. CUT-OUT OF OUTER GARMENT #3

G. CUT-OUT OF OUTER GARMENT #4

H. SDS MAT

Table 5. Results of 'Type VII' Ensemble Cut-Out Procedure.

Personnel	Pre-exposure	Ensemble	Contamination	Time Through Line (min)
(3)	none	TypeVII / 2nd Skin Hood	Clean	9
(7)	none	"	Clean	12
(6)	none	"	Clean	12
(12)	none	"	Clean	11
(1)	none	"	Clean	10
(8)	none	"	Clean	10
(2)	none	"	Clean	8
(4)	none	"	Clean	12
				Avg. 10.5 min
Cutters				*Total Iteration Time: 37 Min*
(5)	none	Flt. Suit/BR gloves/Sk/Bt/M45 w/BR Hood	Clean	
(11)	none	"	Clean	
(6)	none	"	Clean	
(2)	none	"	Clean	
			Decon Result (I.e. 'clean'): w/o cutters 100%	
			w/ cutters 100%	

Figure 3 The following photo set (Figure 3a through h) depicts *Type VII* ensemble two-piece cut-out procedures.

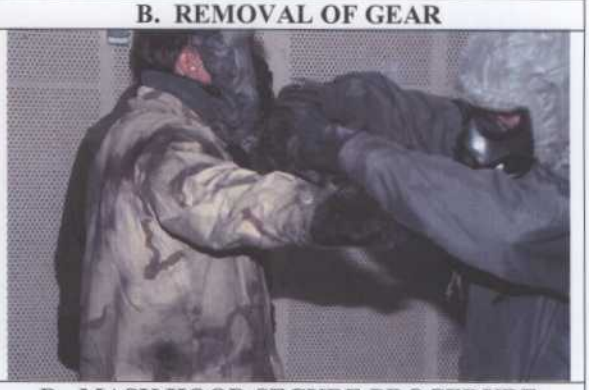
A. APPLICATION OF TINOPAL	B. REMOVAL OF GEAR
	
C. MASK HOOD ROLL	D. MASK HOOD SECURE PROCEDURE
	
E. OUTER GARMENT CUT-OUT #1	F. OUTER GARMENT CUT-OUT #2
	
G. OUTER GARMENT CUT-OUT #3	H. SDS MAT

Table 6. Results of 'FRIS/CPU [w/tag]" Ensemble Cut-Out Procedure.

Personnel	Pre-exposure	Ensemble	Contamination	Time Through Line (min)
Mummert (2)	None	FRIS/CPU [with tag] / 2nd Skin Hood	clean	12
Gehosky (3)	None	"	Clean	11
Wilkens (1)	None	"	Clean	12
Harty (8)	None	"	Clean	10
Voight (5)	None	"	Clean	11
Swanson (16)	None	"	Clean*	12
Peterson (17)	None	"	Clean	12
Maddocks (12)	None	"	Clean*	11
				Avg. 11.4 Min
Cutters				***Total Iteration Time: 44 Min***
(a)	None	Flt. Suit/BR gloves/Sk/Bt/M45 w/BR Hood	Clean	NA
(b)	None	"	Clean	NA
(c)	None	"	Clean	NA
(d)	None	"	Clean	NA
			Decon Result (i.e. 'clean'): w/o cutters 75%	
			w/ cutters 83%	

Clean* denotes contamination as a result of CPU tag leeching.

Figure 4 The following photo set (figure 4a –f) depicts *FRIS/CPU with tag* ensemble one piece cut-out.

A. TINOPAL APPLICATION

B. M295 APPLICATION

C. M295 APPLICATION

D. CUTTING OF BOOT STRAP

E. OUTER GARMENT CUT-OUT #1

F. OUTER GARMENT REMOVAL

Previously, 'contamination' was noted on several individual's lower back following cut-out of the Gortex/CPU ensemble. That phenomenon was again noted with the FRIS/CPU ensemble cut-out. It was determined that the FRIS suit, alone, was impervious to the liquid simulant under passive and 'under pressure' challenges. The same challenges were earlier presented for the Gortex material. Results from the passive and 'under pressure' challenges of this material proved to be inconclusive, but suggest that bleed through of simulant under the demonstrated loads (operator gear) was unlikely. Due to these data, a separate qualitative experiment was conducted to determine if the fluorescent dye contained within the laundry tags from the CPU garments were leeching onto the test participant's backs via perspiration. CPU laundry tags were cleanly removed (without skin contact) from previously unworn garments and placed in either 200 mls of double distilled water or in (pH 7.0) Phosphate Buffered Saline (PBS) at ambient (75° F) temperature. Tags were incubated in water or saline for 30 minutes and then removed. The water and saline were then observed under standard black light conditions to qualitatively determine if fluorescent dye had leeched from the tags. Incubation of the tags in water did not induce leeching. Incubation of the tags in PBS (sweat surrogate) produced considerable leeching of dye. To confirm that the CPU tag dyes were the cause of 'contamination' of the test participants, the garments that had tags removed were then used for the following iteration (FRIS/CPU without tags). As predicted, individuals exposed to similar simulant levels and outfitted with similar gear (as with FRIS/CPU with tags) did not have evidence of cross contamination or penetration of simulant through their protective (FRIS/CPU) ensemble.

Table 7. Results of 'FRIS/CPU [wo/tag]' Ensemble Cut-Out Procedure.

Personnel	Pre-exposure	Ensemble	Contamination	Time Through Line (min)
(16)	None	Fris/CPU [without tag] / 2nd skin hood	Clean	11
(12)	None	"	Clean	12
(5)	None	"	Clean	9
(8)	None	"	Clean	10
(1)	None	"	Clean	12
(6)	None	"	Clean	13
(17)	None	"	Clean	11
(2)	None	"	Clean	9
				Avg. 10.9 Min
Cutters				*Total Iteration Time: 40 Min*
(5)	None	Flt. Suit/BR gloves/Sk/Bt/M45 w/BR Hood	Clean	
(11)	None	"	Clean	
(6)	None	"	Clean	
	None	"	Clean	

Decon Result (i.e. 'clean'):
w/o cutters 100%
w/ cutters 100%

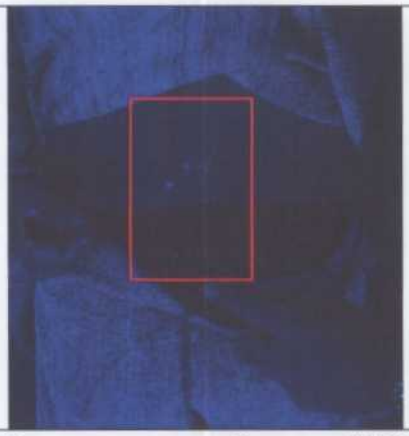
Figure 5 The following photo set (Figure 5a-f) depicts the FRIS/CPU without tag one piece ensemble cut-out. This iteration was inserted into the validation study to verify that the "contamination" detected on the lower backs of some test participants was due to the leeching of fluorescent dye from the laundry tags of the CPU garments.

A. CUTTING OF HOOD STRAP

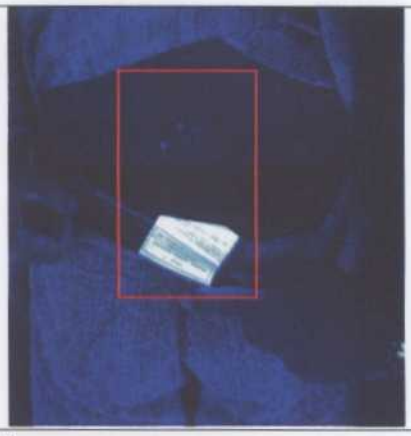
B. CUTTING OF FRIS

C. TOP DOWN CUT OF UPPER CPU

D. TOP DOWN CUT OF LOWER CPU



E. "CONTAMINATION" FROM CPU TAG



F. FLUORESCENT PROPERTIES OF TAG

Table 8. Results of 'DRY Suit' Ensemble Cut-Out Procedure.

Personnel	Pre-exposure	Ensemble	Contamination	Time Through Line (min)
Wilkins	None	Dry Suit/CPU [w/o tags]	Clean	14
Woods	None	"	Clean	15
Mummert	None	"	Clean	13
Peterson	None	"	Clean	11
Swanson	None	"	Clean	12
Traber	None	"	Clean	12
Harty	None	"	Clean	13
Voight	None	"	Clean	11
				Avg. 12.6 Min
Cutters				***Total Iteration Time: 41 Min***
#1	None	Flt. Suit/BR gloves/Sk/Bt/M45 w/BR Hood	Clean	
#2	None	"	Clean	
#3	None	"	Clean	
#4	None	"	Clean	

Decon Result (i.e. 'clean'):
w/o cutters 100%
w/ cutters 100%

Figure 6 The following photo set (Figure 6a-g) depicts the Dry Suit one piece ensemble cut-out.

A. TINOPAL APPLICATION

B. CUTTING OF HOOD STRAP

C. ROLLING OF HOOD

D. SECURING OF HOOD

E. TOP DOWN CUT OF DRY SUIT

F. DRY SUIT REMOVAL "STEPPING OUT."

G. SDS MAT

Table 9. Results of 'Litter Decon' Cut-Out Procedure.

Personnel	Pre-exposure	*Ensemble	Contamination	Time Through Line (min)	Decon (cutter) Team
Carter	None	JSLIST	Clean	16	A
McDonald	None	"	Clean	13	A
Woods	None	"	Clean	18	B
Peterson	None	"	Clean	20	B
Carter	None	"	Clean	12	A
McDonald	None	"	Clean	12	A
Woods	None	"	Clean	13	B
Peterson	None	"	Clean	13	B
				Avg. 14.6 Min	
Decon Team A	Cutter Team A			No Iteration Times Taken	
Wilkins	None	Flt. Suit/BR gloves/Sk/Bt/M 45 w/BR Hood	Clean		
Harty	None	"	Clean		
Sasnicki	None	"	Clean		
Mummert	None	"	Clean		
Decon Team B	Cutter Team B				
Swanson	None	Flt. Suit/BR gloves/Sk/Bt/M 45 w/BR Hood	Clean		
Voight	None	"	Clean		
Nettleton	None	"	Clean		
Maddocks	None	"	Clean		
			Decon Result (i.e. 'clean'): w/o cutters 100%		
			w/ cutters 100%		

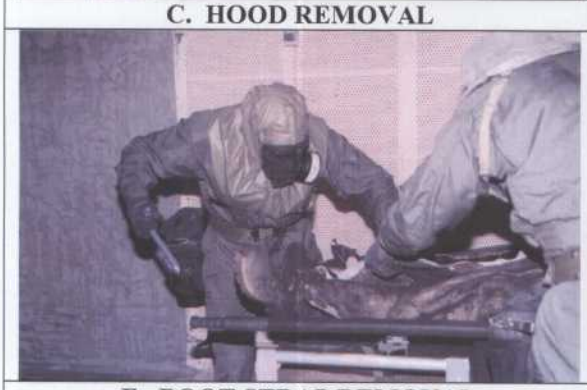
Figure 7. The following photo set (Figure 7a-g) depicts the Litter Decon cut out.

A. TINOPAL APPLICATION

B. M295 APPLICATION

C. HOOD REMOVAL

D. OUTER GARMENT REMOVAL



E. BOOT STRAP REMOVAL

F. TROUSER REMOVAL

G. REMOVAL OF CPU

Discussion

These procedures proved to eliminate liquid cross contamination during clothing (decon) removal. This study did not attempt to prove minimization of adverse effects of liquid off-gassing (vapor hazard). To ascertain whether these procedures provide complete protection to the individual during the decon process, individuals would have to be: 1) exposed to a liquid challenge simulant with low vapor pressure that is proven to be absorbed/neutralized by one of the dry decon technologies carried by NSWDG, and 2) monitored for both liquid and vapor exposure during the procedures. The assumption was made during this study that the decon technologies used would neutralize the agent and minimize off gassing.

An additional consideration that must be addressed is the possibility of off-gassing from the dropped equipment. It is assumed that the PPE will be contaminated during the cutting procedure and will off-gas throughout the period of decontamination. With the possibility of frequent wind shifts this would be an issue. Also, enclosed areas with minimal air circulation would only serve to increase the concentration of hazardous vapors within a given area. These issues may be minimized by the utilization of decon solutions/powders in the PPE drop areas (equipment bags or mask drop bags). Obviously, airflow, direction and the length of the decon line can be altered to minimize these effects.

The design of the procedures and success of the associated training for these procedures is reflected in the consistency of time required (when comparing all iterations) for each man to be successfully cut-out, regardless of ensemble. These times were determined by marking time from the first crewman's step into the decon line until the last man removed his mask. There was significant improvement (from 14.8 +/- 1.5 to 10.5 +/- 1.5 minutes) in the time required to perform a two-piece cut-out procedure (comparison of times required from Gortex/CPU to Type VII cut-out, respectively).

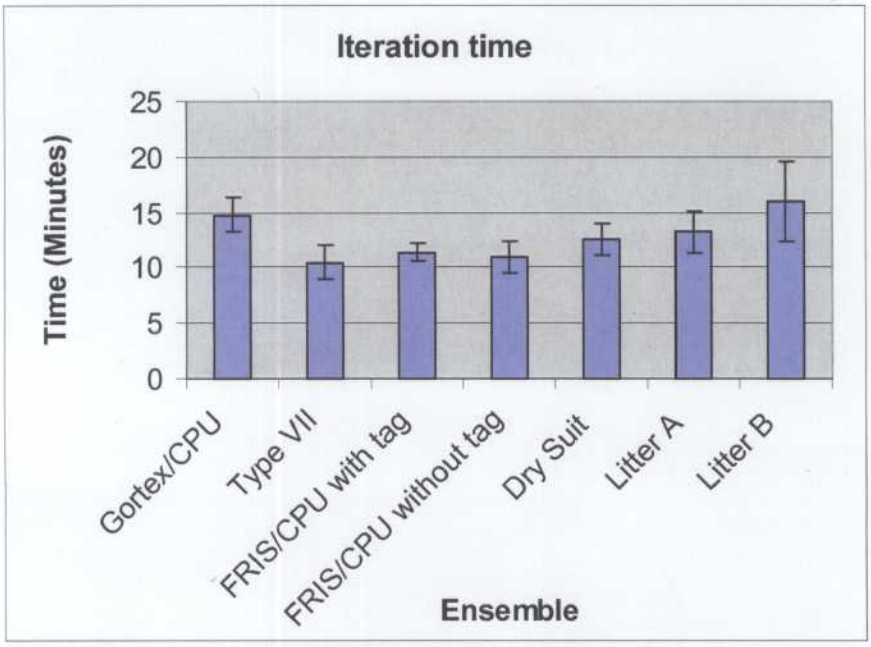


Figure 8. Per-man iteration times for all ensembles.

One-piece procedures were consistent (ranging from 10.9 to 12.6 minutes, 11.6-minute average). Litter decon cut-out procedures utilized two distinct cutter teams (A and B). Each team (alternating 2 procedures at a time between A and B) performed a total of four cut-out procedures. Teams A and B displayed significant improvement (11% and 32%, respectively) in the #3 and #4 iteration times (as compared to #1 and #2 iteration times) required to extricate the patient from his protective gear. Iteration times for 8 man teams were consistent as well, ranging from 37 minutes to 44 minutes. In the case of repeating the FRIS/CPU ensemble (with CPU laundry tags to a without CPU tag status) cut-out, the team iteration time was reduced by 10%, representing an example of the minimal training required to raise the confidence and efficiency rate in the procedure. The results presented in this report suggest that the NSWDG cut-out standard operating procedures allow a valid technique in expedient removal of contaminated clothing (regardless of ensemble) from an individual, while preventing any liquid cross-contamination and further harm to the individual.

Appendices

APPENDIX A. REFERENCES

1. Memorandum, NSWDG issued a request for testing, U.S. Army Dugway Proving Ground (DPG), Utah, 30 April 1999, Project III, IV and V, Test Resource Management Systems (TRMS) No. 08-CO-160-000-046.

2. U.S. Army Medical Research Institute of Chemical Defense (USAMRICD) "Medical Management of Chemical Casualties Handbook".

APPENDIX B. ABBREVIATIONS

AMC – Army Materiel Command

Avg - Average

Bio – Biological

BR – butyl rubber

Bt - Boot

CBR – chemical/biological/radiological

cm - Centimeter

COTS – Commercial off-the-shelf

CPU – chemical protective undergarment

CV – Coefficient of variation

CW – Chemical Warfare

DTC – Defensive Test Command

DPG – U.S. Army Dugway Proving Ground

F - Fahrenheit

Flt – Flight

FRIS – Fire resistant insertion suit

Frt - Front

GB – sarin

GD – soman

GF – Cyclohexyl Methyl phosphonofluoridate

HD – distilled mustard

Kg - Kilogram

JAM – JSLIST-approved material

JSLIST – Joint Services Lightweight Integrated Suit Technology

LD50 – Lethal dose for 50% of the population

Lft - Left

LLD – Lower limits of detection

MCPE – Maritime chemical protective ensemble

M - Meter

μg - Microgram

Mg – Milligram

Mk1 – Mark 1 antidote kits

Min – Minutes

NBC – Nuclear biological chemical

ND – Not determined

NSWDG – Naval Special Warfare Development Group

PBS – Phosphate buffered saline

PPE – Personal protective equipment

Rt - Right

SDS – Sorbent decon system

σ – Standard deviation

Sk – Sock

SOF – Special operations forces

TECOM – U.S. Army Test and Evaluation Command

Therm – Thermal

US – United States

UV - Ultraviolet

VX – a persistent nerve agent

WDTC – West Desert Test Center

WMD – Weapons of mass destruction

APPENDIX C. DISTRIBUTION LIST

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