



Homeland
Security

Summary



The U.S. Department of Homeland Security, Preparedness Directorate, Office of Grants and Training (G&T) established the System Assessment and Validation for Emergency Responders (SAVER) Program to assist emergency responders in performing their duties. The mission of the SAVER Program is to

- Provide impartial, practitioner relevant, and operationally oriented assessments and validations of emergency responder equipment.
- Provide information that enables decision-makers and responders to better select, procure, use, and maintain emergency responder equipment.
- Assess and validate the performance of products within a system, as well as systems within systems.
- Provide information and feedback to the user community through a well-maintained, Web-based database.

The SAVER Program established and is supported by a network of technical agents who perform the actual assessment and validation activities. Further, SAVER focuses primarily on two main questions for the emergency responder community, "What equipment is available?" and "How does it perform?"

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Class 3 Personal Protective Equipment (PPE) Assessment Analysis Report Summary

A NFPA 1994 Class 3 personal protective equipment (PPE) ensemble includes a suit or garment with attached or separate gloves and footwear or booties with outer boots (certified as compliant with National Fire Protection Association [NFPA] 1994). The primary design feature of the ensemble is to minimize the inward leakage of liquids. The ensemble may be designed for use with a self-contained breathing apparatus (SCBA) or an air-purifying respirator (APR); however, the suit and component parts do not offer protection from gases, vapors, or aerosols. These ensembles, intended for use well after the release has occurred, are designed for the following purposes:

- worn to protect personnel when victims are ambulatory and symptomatic.
- worn in peripheral zones for decontamination, patient care, crowd control, and some clean-up.
- worn when exposure to liquids is expected to be incidental through contact with contaminated surfaces.



As a SAVER Program technical agent, the Center for Domestic Preparedness (CDP) has conducted an assessment of National Institute for Occupational Safety and Health (NIOSH) approved for chemical biological radiological nuclear (CBRN) Class 3 PPE.

A focus group was held in order to determine criteria by which to measure Class 3 PPE effectiveness, the scenario used in testing, and the products to be tested. In order to more effectively evaluate the components of a Class 3 PPE ensemble, the focus group decided to divide the ensemble into three sections when assessing the SAVER categories (capability, usability, affordability, deployability, maintainability). Those sections were suits, gloves, and boots.

The approach for selecting PPE for the assessment was patterned after the decision process followed by local jurisdictions procuring responder equipment. In the survey process, research of commercially available Class 3

ensembles was conducted. Factors deemed significant to local jurisdictions such as cost, material thickness and composition, component flexibility, availability and other factors were used to create a selection matrix for each of the PPE components. For example, costs of available suits ranged from \$10 to \$350, and suit material thicknesses ranged from 7 to 32 mils. Suits featured various options such as attached gloves, booties and hoods. Available boots differed more in their construction than in cost, and selections were based on functionality issues. Additionally, the types of available gloves had varying costs, construction, and characteristics. The matrix was then used to select components that were representative of a broad range of these and other factors.

After comparing the available PPE, six types of suits, three types of gloves, and two types of boots were selected for use in the Class 3 PPE assessment. All selected Class 3 PPE components are commercially available off-the-shelf and are pictured in tables 1, 2, and 3.

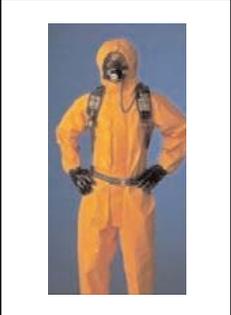
					
Tychem SL	Tychem ThermoPro	Tychem CPF3 HD	Tychem TK	Tychem LV	Tychem F
<ul style="list-style-type: none"> Elasticized face/wrists Attached booties No boot splash guards 	<ul style="list-style-type: none"> Elasticized wrists Drawstring face Elastic or attached gloves Attached booties No boot splash guards 	<ul style="list-style-type: none"> Elasticized face and wrists Attached booties No boot splash guards 	<ul style="list-style-type: none"> Elasticized face/wrists Attached booties No boot splash guards 	<ul style="list-style-type: none"> Elasticized face/wrists Attached booties No boot splash guards 	<ul style="list-style-type: none"> Elasticized face/wrists Attached booties No boot splash guards

Table 1. Selected Class 3 suits.

				
Viton Gloves	Nitrile Gloves	Butyl Gloves	ONGUARD Hazmax Boots	Tingley HazProof Boots
<ul style="list-style-type: none"> Resistant to aromatic solvents such as benzene, toluene and xylene Resistant to chloroform, formaldehyde & pentane Some types include two-tone wear indicator Multilayered Protects from acetone & toluene Used for military applications 	<ul style="list-style-type: none"> Resists most solvents, acids, animal fats and alcohols Resists abrasions, cuts, tears, and punctures Suggested for chemical processing, acid cleaning, food processing, metal machining, plating, automotive assembly, agriculture, and maintenance 	<ul style="list-style-type: none"> Have high permeation resistance to gas & water vapors Resist common acids & alcohols Suggested for use with dioxane, ketones, acetone, esters, aldehydes, alcohols and most organic acids or caustics 	<ul style="list-style-type: none"> Steel safety toes and soles Kick off lug Molded one piece without seams Height cut-down rings 	<ul style="list-style-type: none"> Steel safety toes and soles Kick off lug Oversized to cover extra suit fabric Stretch fastener closure system

Table 2. Selected glove types.

Table 3. Selected boots.

The scenario for this assessment was taken from the Homeland Security Council (HSC) Planning Scenarios associated with the Universal Task List (UTL). For the purposes of this assessment, the scenario used was Scenario 7, Chemical Attack - Nerve Agent, and the activities performed were consistent with operational objectives that would exist in the event a nerve agent attack actually occurred.

Class 3 PPE Assessment Results

The Class 3 PPE were rated according to the SAVER categories of usability, affordability, deployability, maintainability, and capability. The category results for the Class 3 PPE ensemble are provided in tables 4, 5, and 6. Class 3 PPE scoring by category, a discussion of evaluator comments, and equipment differences as they apply to individual criteria are included in the following sections.

The following synopses are the compilations of evaluator opinions and observations during the assessment.

Class 3 PPE	Composite	Capability Score	Usability Score	Affordability Score	Deployability Score	Maintainability Score
Tychem CPF3HD	74.2	79.3	73.1	63.4	78.9	62.0
Tychem F	73.1	78.8	70.0	64.9	77.3	63.0
Tychem SL	69.7	72.6	66.6	64.1	77.3	62.0
Tychem LV	68.2	73.1	64.3	64.9	69.7	63.0
Tychem ThermoPro	66.4	72.1	67.4	54.2	68.7	50.0
Tychem TK150	64.3	64.1	65.1	62.6	65.4	62.0

Table 4. Suit assessment results.

Glove Type	Composite	Capability Score	Usability Score	Affordability Score	Deployability Score	Maintainability Score
Nitrile	71.6	69.2	74.7	69.1	74.9	60.3
Butyl	66.3	59.7	68.6	69.1	74.0	58.7
Viton	65.8	64.8	62.5	67.7	71.9	58.7

Table 5. Glove assessment results.

Boot Type	Composite	Capability Score	Usability Score	Affordability Score	Deployability Score	Maintainability Score
Tingley	68.1	80.7	76.1	50.0	68.8	46.2
ONGUARD	65.0	66.7	68.4	66.7	61.9	60.1

Table 6. Boot assessment results.

Suit Evaluator Comments

Capability

While evaluators expressed confidence in the protection capability of all six suits, they commented that the draw-string and elasticized openings of all the suits failed to provide adequate seals without taping. These openings

were not taped during the assessment and evaluators experienced exposed skin at these points throughout the assessment. However, in order to evaluate the suits without using remedial techniques, a decision was made not to tape. As a result, evaluators recommended taping all six Class 3 PPE suits to ensure responder safety during future assessments and/or operations.

With all of the suits, evaluators expressed frustration with the excess bootie material, which made the HazMat

boots hard to don and uncomfortable to wear. Real world environments could necessitate having different sized boots for different PPE class ensembles. The hood size/shape on each of the suits would not accommodate a protective helmet and the Tychem TK150 was too bulky and rigid to allow a helmet to be worn over it.

Protective storage cases should be used for suits that are stored in the trunk of a vehicle.

Usability

Due to difficulty in grasping closure flaps, evaluators recommended that pull tabs should be provided on the closure tape to assist responders who are wearing gloves. Evaluators commented that the white Tychem SL would be easily seen during low light conditions, but the brown Tychem LV would be difficult to see under such conditions.

Affordability

The Tychem CPF3HD, Tychem F, and Tychem LV suits were reasonably priced. The Tychem ThermoPro was not considered as cost effective as other suits due to its initial cost and shorter shelf life.

Deployability

Some type of protective case would be needed for any of the suits once issued. The Tychem LV zipper was easily caught in the suit material while donning the PPE. Potentially, this could cause delays for responders donning the suit at an emergency scene. The lack of a pull tab for the tape strip on the Tychem SL slowed suit donning, and the drawstring of the Tychem ThermoPro was difficult to fasten without assistance. The need for taping the suits was stressed with the Tychem ThermoPro because it had shorter sleeves.

Maintainability

Evaluators made the following maintainability comments:

- Suits should be checked on an annual basis for routine maintenance.
- Vapor-resistant cases would provide adequate protection for the suit and allow the suit to be stored in the patrol vehicle trunk.
- Suit warranties are difficult to read and understand for all of the suits except the Tychem ThermoPro and Tychem TK150.

Suit Conclusions

When the suits are properly taped, evaluators concluded that they will provide adequate protection during an incident response. Evaluator scores for all six suits fell within a ten point range. However, an analysis of the scores and evaluator comments indicate that the “best” suits for the job depend upon the responder’s field of discipline and the activities to be performed. This view is supported by the following observations:

- HazMat responders seemed to favor thicker, heavier suits such as the Tychem LV, Tychem ThermoPro, and Tychem TK150.
- EMS and law enforcement seemed to favor thinner, lighter, more flexible suits such as the Tychem F and Tychem SL.

As a result, the medium weight Tychem CPF3HD was ranked highest by the evaluators based on comments and scoring. These findings led to the conclusion that suit selection at the local level will likely depend on the responder discipline and the degree of flexibility and dexterity required in the response operation.

Evaluators expressed a lack of confidence in the elastic and drawstring hood and wrist openings and zipper closures. Taping of the openings is currently not a requirement, but evaluators felt that responders would be better

protected if taping protocols were adopted for all Class 3 PPE suits. Evaluators from all represented disciplines recommended taping the wrist and face openings as well as the zipper closure and boot interface.

Another factor which inhibited responder wear of the Class 3 ensembles was the excessive bootie material found in all but the Tychem ThermoPro suit. Excess suit material made donning boots more difficult and took additional time. Due to the booties, evaluators required larger boot sizes than recommended. Once donned, the larger boots were uncomfortable and difficult to walk in. Jurisdictions which plan to use multiple types of suits with the same boots will find it necessary to take the bootie size of all the suits into consideration when determining boot sizes. Otherwise, multiple pairs of boots for each responder could be required—increasing PPE procurement, storage, and maintenance costs.

Glove Evaluator Comments

Table 7 provides a comparison of evaluator comments on key glove selection considerations from all five SAVER categories. Details of these comments by category are included in the following sections.

Glove Type	Nitrile	Butyl	Viton
No Taping Required			
Adequate Dexterity	X		
Adequate Gauntlet	X	X	
Not Sticky or Slippery	X		
Good Fit	X		
Durable	X	X	X

Table 7. Glove Comments.

Capability

In order to provide adequate protection for responders, each of the suits needed to be taped to the gloves. The ThermoPro suit and Viton glove combination made taping even more necessary. Other comments on the Viton gloves included:

- Provided the least dexterity of the three glove types.
- Small objects could not be picked up.
- The gloves were too short which left skin exposed.
- The inside glove surface made it difficult for the evaluators to keep the glove from slipping off their hands.

Usability

Although the gloves were sufficiently durable and cut resistant for the assessment tasks, evaluators favored the dexterity of the nitrile gloves over the other two glove types. The proportions of the butyl gloves, especially the fingers, created dexterity problems. The butyl and nitrile gloves were not well proportioned, and the gauntlets were too short. There was some difficulty with the grip of the outside and slippage of the inside of the butyl and Viton gloves. The butyl gloves began to stick together at the end of the second evolution. The gloves required taping to prevent any liquid from entering the glove and suit during decontamination. All three gloves can be worn inside/outside of the suit, but the evaluators recommended the gloves should be taped either way.

Affordability

Evaluators did not provide comments for the following criteria: volume discounts, order lead time/availability, and model replacement. Also, the two criteria that were not observable by the evaluators during the assessment were shelf life and price-by-sizes.

Deployability

All three types of gloves were easily donned without assistance; however, it was difficult to obtain a good fit with the Viton and nitrile gloves. The nature and requirements of an emergency situation would determine whether or not gloves would be taped during deployment.

Maintainability

Evaluators did not provide any comments concerning the following criteria: storage environment requirements, ease of cleaning/storage, and maintenance required. There was not any shelf life or warranty information included from the manufacturer which resulted in no comments.

Glove Conclusions

Evaluator comments showed that all three glove types should provide adequate protection for first responders in the scenarios portrayed in the assessment. However, the primary factor in determining the “best” glove for the job will be the type of chemical involved. Secondary considerations will be fit, dexterity, and comfort factors, as well as the type of response activity to be performed. An analysis of the scores and evaluator comments appeared to support this thesis. The following evaluator findings should give significant insight on the secondary glove selection considerations:

- The nitrile gloves rated highest in all five SAVER categories.
- Longer gauntlet lengths are preferred for all glove types.
- Taping gloves to the suit is needed to prevent skin exposure, to aid in dexterity and to keep suit sleeves from riding up over the gloves.

Boot Evaluator Comments

Capability

Evaluators did not provide any comments concerning the following criteria: storage environment requirements, ease of cleaning/storage, and maintenance required. There was not any shelf life or warranty information included from the manufacturer which resulted in no comments for these criteria also.

No feedback was provided by the evaluators for puncture resistant criterion. Because of excess suit bootie material, the recommended boot sizes could not be worn. The boots were very tight with the Tychem LV suit, but the same boot was comfortable with the Tychem ThermoPro. This issue should be noted if jurisdictions plan on using the same boots with different suits. Even after size adjustments, evaluators removed ONGUARD boot insoles to accommodate the suit. The ONGUARD lacked an interior lining to provide insulation during cold weather, and they were too stiff and rigid to allow needed flexibility. The recommended storage temperatures of -32° to 100° Fahrenheit for the ONGUARD boots would prevent storage of the boots in response vehicles due to heat extremes. The Tingley boots did not include any storage temperature information and were not scored in this criterion. The boots were not worn in a variety of temperatures and most evaluators responded “undecided” to this criterion.

Usability

Some evaluators decided to shorten the ONGUARD boot height using the height cutdown rings to accommodate the booties. In order to get the boots to fit, they noted the boot had to be cut to a height lower than they preferred. The Tingley’s expandable shaft was preferred over the pull-on style ONGUARD boot. However, the evaluators wanted the Tingley boot’s elastic closure system to fit tighter.

Both types of boots should be taped to seal the area around the calf. Evaluators discovered a defective boot when they unpacked the ONGUARD boots. The material covering the steel toe inside the boot had released from the toe and formed a bubble in the boot toe. The boot was not wearable which resulted in the staff obtaining a replacement boot from the Logistics Department. The elastic closure bands of the Tingley boots tended to open and/or fall off. The ONGUARD boots did not have any closures.

When donning the ONGUARD boots, the suit bootie material became bunched and evaluators had to use a plastic grocery bag to aid in donning. It was noted that these boots were not very flexible and pull grips were needed to aid in donning. The evaluators felt as though a flock lining was needed to ease donning and doffing.

The soles of both types of boots provided adequate traction on the dry and wet assessment lane surfaces. Also, the evaluators did not experience any tripping, discomfort, or walking problems due to the heel height of either boot type. Evaluators removed the ONGUARD boot insole to accommodate suit bootie material. No feedback on insole comfort or durability of either boot type was given. Some of the evaluators reported that the Tingley boots were heavy and noted this could add to fatigue if the boots were worn for extended periods of time.

Affordability

No shelf life information was provided with the Tingley boots, and the ONGUARD boot shelf life was defined by the manufacturer as “no known maximum storage life.” Neither boot manufacturer provided information which would indicate the effects of extended storage on the protection level of the boots.

Deployability

Appropriate boot size varied from suit to suit depending upon the size of the suit booties. While this caused diffi-

culties for some, the expandable shaft made the Tingleys much easier to don and doff during the lane evolutions. Properly sized ONGUARD boots were extremely difficult to pull over some suits. The manufacturer literature should be followed concerning the inspection of boots for cuts, tears, or rips before each use. The boot storage location should be free of sharp objects during transport. The evaluators wanted information concerning folding, crimping, or bending the boots, and neither boot manufacturer provided such information.

Maintainability

No specific information was provided by the boot manufacturers for the following:

- Storage or cleaning information.
- Effects of extended storage (i.e., damage or deterioration to the boot).
- Shelf life, storage condition, and temperature storage information.

The only warranty information provided with the Tingley boots was a small card attached to the boots. It stated “Manufacturer disclaims all warranties, expressed, or implied.” No warranty information was provided with the ONGUARD boots.

Boot Conclusions

Like other evaluated PPE components, chemical protection is the primary factor in boot selection. Evaluator comments indicate that both assessed boots should provide adequate chemical protection for first responders in the scenarios portrayed in the assessment. Other boot selection factors include fit, comfort, closure method, and height. The assessment revealed several key factors which determine the “best” boot to purchase:

- Boots should be tested with the suit or suits to be used in the PPE ensemble to determine correct size, fit, and comfort.

- The elastic strap closure of the Tingley boots may be preferred for donning, but it may not provide a snug enough fit for some responders.
- The additional height of the ONGUARD boots may be unusable since it must accommodate more suit material.

reports dealing with the Class 3 PPE assessment project. The QuickLook charts for the Class 3 PPE assessment are also available on the SAVER Web site (see figure 1, 2, and 3). The QuickLook charts offer responders a mechanism to select equipment items based on characteristics that are of most importance to their department. Using the QuickLook charts, responders can emphasize and de-emphasize five categories to fully refine their search for equipment items.

Class 3 PPE Conclusions

The full Class 3 PPE assessment analysis report can be found on the SAVER Web site along with other CDP

Product	COMPOSITE	ASTRO-DABILITY	CAPABILITY	DEPLOYABILITY	MAINTAINABILITY	USABILITY	Features
 RKB Nitrile Gloves	★	★	★	★	★	★	<ul style="list-style-type: none"> • Resists most solvents, acids, animal fats and alcohols • Resists abrasions, cuts, tears, and punctures • Suggested for chemical processing, acid cleaning, food processing, metal machining, plating, automotive assembly, agriculture, and maintenance
 RKB Butyl Gloves	★	★	★	★	★	★	<ul style="list-style-type: none"> • Have high permeation resistance to gas & water vapors • Resist common acids & alcohols • Suggested for use with dioxane, ketones, acetone, esters, aldehydes, alcohols and most organic acids or caustics
 RKB Viton Gloves	★	★	★	★	★	★	<ul style="list-style-type: none"> • Resistant to aromatic solvents such as benzene, toluene and xylene • Resistant to chloroform, formaldehyde & pentane • Some types include two-tone wear indicator • Multilayered • Protects from acetone & toluene • Used for military applications

Figure 1. The Class 3 PPE Glove SAVER Quicklook chart is available on the SAVER Web site.

Product	COMPOSITE	ASTRO-DABILITY	CAPABILITY	DEPLOYABILITY	MAINTAINABILITY	USABILITY	Features
 RKB Tingley HazProof Boots	★	★	★	★	★	★	<ul style="list-style-type: none"> • Steel safety toes and soles • Kick off lug • Oversized to cover extra suit fabric • Stretch fastener closure system
 RKB ONGUARD Hazmax Boots	★	★	★	★	★	★	<ul style="list-style-type: none"> • Steel safety toes and soles • Kick off lug • Molded one piece without seams • Height cut-down rings

Figure 2. The Class 3 PPE Boot SAVER Quicklook chart is available on the SAVER Web site.

SAVER is sponsored by the U.S. Department of Homeland Security, Preparedness Directorate, Office of Grants and Training.

For more information on the Class 3 PPE project, please see the SAVER Web site or contact the SAVER Program Support Office.

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Product		COMPOSITE	AFFORDABILITY	CAPABILITY	DEPLOYABILITY	MAINTAINABILITY	USABILITY	Features
	 Tychem CPF3 HD	★	★	★	★	★	★	<ul style="list-style-type: none"> Elasticized face and wrists Drawstring face Elastic or attached gloves Attached booties No boot splash guards
	 Tychem F	★	★	★	★	★	★	<ul style="list-style-type: none"> Elasticized face and wrists Drawstring face Elastic or attached gloves Attached booties No boot splash guards
	 Tychem SL	★	★	★	★	★	★	<ul style="list-style-type: none"> Elasticized face/wrists Attached booties No boot splash guards
	 Tychem LV	★	★	★	★	★	★	<ul style="list-style-type: none"> Elasticized face and wrists Drawstring face Elastic or attached gloves Attached booties No boot splash guards
	 Tychem ThermoPro	★	★	★	★	★	★	<ul style="list-style-type: none"> Elasticized wrists Drawstring face Elastic or attached gloves Attached booties No boot splash guards
	 Tychem TK	★	★	★	★	★	★	<ul style="list-style-type: none"> Elasticized face and wrists Drawstring face Elastic or attached gloves Attached booties No boot splash guards

Figure 3. The Class 3 PPE SAVER Quicklook chart is available on the SAVER Web site.