

**SWATCH TEST RESULTS OF COMMERCIAL CHEMICAL  
PROTECTIVE BOOTS TO CHALLENGE  
BY CHEMICAL WARFARE AGENTS:  
EXECUTIVE SUMMARY**

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## **Executive Summary**

As part of the Domestic Preparedness Program, nine commercially available boot designs were tested to assess their capability to protect in a chemical warfare (CW) agent environment.

Swatches of material from each boot design were tested for resistance to permeation for Sarin (GB) and mustard (HD). From this data, the author calculated the estimated time it would take to permeate the boot with sufficient agent to cause physiological effects in a person wearing the boot. The tests are described and the calculated breakthrough times are presented.

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## **Preface**

The work described herein was authorized under the Expert Assistance (Equipment Test) Program for the U. S. Army Soldier and Biological Chemical Command (SBCCOM) Program Director for Domestic Preparedness.

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# SWATCH TEST RESULTS OF COMMERCIAL CHEMICAL PROTECTIVE BOOTS TO CHALLENGE BY CHEMICAL WARFARE AGENTS: EXECUTIVE SUMMARY

## 1. INTRODUCTION

In 1996, responding to Public Law 104–201 (Defense Against Weapons of Mass Destruction Act of 1996), the Department of Defense (DoD) formed the Domestic Preparedness Program. One of the objectives was to enhance federal, state, and local emergency and hazardous material (HAZMAT) response to nuclear, biological and chemical (NBC) terrorism incidents. In some cases, chemical protective boots may be required to enter a contaminated or potentially contaminated area. Limited data was available concerning the effectiveness of commercially available and commonly used chemical protective boots as protection against chemical warfare (CW) agents. Recognizing this need, the U.S. Army Soldier Biological and Chemical Command (SBCCOM) established a program to test some of the boot designs, using CW agents and test procedures developed for assessment of military-issue CW protective equipment. A detailed technical report was generated for each boot design tested, and a summary report was prepared that presented the essential results for all the boots in a single document. Because those reports are rather lengthy and technical, this report was prepared. This report is an overview of the results of the evaluation and is intended primarily for federal, state and local emergency and HAZMAT personnel as an aid in their evaluation (and possible modification) of current work rules regarding specific chemical protective boots currently in inventory and as an aid in future procurement of appropriate chemical protective boots.

The boot materials were tested in new, as-received condition. The effects of aging, temperature extremes, laundering, and other factors were beyond the scope of this test program. These tests addressed percutaneous (i.e. skin) protection only.

Each boot design was examined with swatch tests using test methodology taken from Test Operations Procedure (TOP) 8-2-501, Permeation and Penetration of Air-Permeable, Semipermeable and Impermeable Materials with Chemical Agents or Simulants (Swatch Testing). U.S. Army Dugway Proving Ground, UT. 3 March 1997, UNCLASSIFIED Report (AD A322329). In the swatch tests, sample swatches were cut from two pairs of each boot design, approximately midway up the side of each boot. These swatches were then exposed to liquid droplets of chemical agents Mustard (HD) and Sarin (GB), and the passage of agent vapor through them measured. Sarin is a non-persistent (volatile) nerve agent, and HD is a persistent blister agent.

## 2. LIQUID CHALLENGE/VAPOR PERMEATION TEST (SWATCH TEST)

For each boot design under test, twelve swatches (six to be tested with GB and six with HD) were taken from two pairs of boots. The swatches were placed in a test fixture and a predetermined ( $10 \text{ g/m}^2$ ) liquid agent challenge, GB or HD, was applied to the top surface of each swatch, and the fixture sealed. Periodically, over 24 hr, gas samples were taken from below the swatches. The amount of agent vapor that permeated the test swatch at each sampling time was measured using a highly sensitive, accurate, miniaturized gas chromatograph and sampling system known as MINICAMS™ (OI Analytical, CMS Field Products Group, Birmingham, AL).

The cumulative mass of agent vapor, which has permeated each of the swatches at each sampling time, divided by the area of the swatch, is defined as the permeation,  $M_f$ .

The permeation for each boot design tested was compared with other boot designs. Normally, continuous exposure to chemical agent would not exceed 8 hr (480 min) because of heat stress and fatigue, so the permeation, which occurs in the subsequent 16 hr, is of less interest.

An average cumulative permeation value ( $M_f$ ) for each boot design and agent combination was calculated by averaging the  $M_f$  values for the six swatches.

Mustard vapor can produce skin irritation (erythema) on the tops of the feet at a dosage (product of concentration and exposure time) of approximately 2357 mg-min/cm<sup>3</sup>. Sarin vapor can produce incapacitation at a dosage of approximately 8000 mg-min/m<sup>3</sup>. Threshold  $M_f$  values were calculated using these dosages. The threshold  $M_f$  for HD was 4714 ng/cm<sup>2</sup> and the threshold  $M_f$  for GB was 4159 ng/cm<sup>2</sup>. The breakthrough time was the time at which the average  $M_f$  reached the threshold  $M_f$ .

The breakthrough times from all the boot designs are collected and presented in Table 1.

Table 1. Swatch Test Results for Boots

Item	Breakthrough time, minutes	
	HD	GB
Dunlop Hevea Nailstep	654	805
Tingley Hazproof 82330	>1440	>1440
LaCrosse Commander 89612	1194	>1440
LaCrosse Monarch 87568	998	>1440
Bata Polymax 84076	785	>1440
Bata Hazmax 87012	1382	>1440
Bata Overbooties 97591	253	99
Servus Hazmat HZT 75107	443	>1440
LaCrosse Chemtrex 24228	268	>1440

### 3. CONCLUSIONS AND RECOMMENDATIONS

The test data reveals that the chemical protective boot designs tested can protect the wearers from liquid CW agents. Breakthrough times should not be interpreted as the time that a boot can be safely worn, either for HD or GB. Breakthrough times should only be used to compare boot materials.