

SERIAL No. 40

Navy Department - Office of Research and Inventions

NAVAL RESEARCH LABORATORY  
WASHINGTON 20, D. C.

DECLASSIFIED: By authority of

DOD DIR 5200.9

Cite Authority

Date

1570

Entered by

NRL Code

CHEMISTRY DIVISION - PROTECTIVE CHEMISTRY SECTION

15 November 1945

CHAMBER TESTS WITH HUMAN SUBJECTS  
XVII. SUPPLEMENTARY TESTS OF  
CC-2 PROTECTIVE CLOTHING

By

FR-2688

W. H. Taylor, H. W. Carhart  
and J. H. Heinen, Lt. MC(S) USNR

Report No. P-2688

DECLASSIFIED by NRL Contract

Declassification Team

Date: 27 SEP 2016

Reviewer's name(s): H. DO, P. HANNA

Approved by:

Declassification authority: NAVY DECLASS  
GUIDE, 11 DEC 2012

W. C. Lanning - Head, Protective Chemistry Section

Dr. P. Borgstrom  
Superintendent,  
Chemistry Division

Commodore H. A. Schade, USN  
Director,  
Naval Research Laboratory

Preliminary Pages --- a - d  
Numbered Pages --- 18  
Tables --- 29  
Appendices --- 5  
Distribution List --- e


NRL Problem P-60

EHB

DECLASSIFIED

DISTRIBUTION STATEMENT A APPLIES  
Further distribution authorized by UNLIMITED only.

B  
Uncl



SERIAL No. **39**

Navy Department - Office of Research and Inventions

NAVAL RESEARCH LABORATORY  
WASHINGTON 20, D. C.

\* \* \*

CHEMISTRY DIVISION - PROTECTIVE CHEMISTRY SECTION

15 November 1945

CHAMBER TESTS WITH HUMAN SUBJECTS  
XVII. SUPPLEMENTARY TESTS OF  
CC-2 PROTECTIVE CLOTHING

By

W. H. Taylor, H. W. Carhart  
and J. H. Heinen, Lt.MC(S) USNR

Report No. P-2688

  
\* \* \*

Approved by:

W. C. Lanning - Head, Protective Chemistry Section

Dr. P. Borgstrom  
Superintendent,  
Chemistry Division

Commodore H. A. Schade, USN  
Director,  
Naval Research Laboratory

Preliminary Pages --- a - d  
Numbered Pages --- 18  
Tables --- 29  
Appendices --- 5  
Distribution List --- e

NRL Problem P-60  
EHB

DECLASSIFIED

-a-



## ABSTRACT

This report describes the results obtained in a number of supplementary chamber tests for the evaluation of the protection afforded by CC-2 impregnated clothing.

In supplementary tests of modifications of the aqueous CC-2 impregnation system, it was found that:

(a) Clothing impregnated by systems using methyl cellulose or Areskiene instead of PVA as emulsifying agent provides greater protection than standard aqueous process clothing.

(b) Impregnation of clothing by the CWS Foam Process does not result in an increase in protection as compared with the standard Navy process.

(c) Clothing impregnated by a simultaneous flame-proofing and CC-2 impregnating process provides protection comparable to or possibly superior to that afforded by standard aqueous process clothing.

Supplementary tests of CC-2 clothing "worn down" to the reimpregnation level showed that:

(a) The protection provided is proportional to both concentration of H vapor and time of exposure.

(b) A CT of approximately 1400 represents the maximum CT for which adequate protection is provided.

(c) The Field Set (Light Weight Simplified) is satisfactory for reimpregnation and that worn reimpregnated clothing provides the same degree of protection as that worn but not reimpregnated.

In tests of stored CC-2 clothing, it was found that:

(a) 2 months simulated tropical storage reduces the protection provided by standard aqueous process clothing by approximately 30%.

(b) 18 months to 2 years shipboard storage of

-b-

DECLASSIFIED

unstabilized solvent clothing reduces the protection by about 70%.

Tests of U. S. Marine Corps protective clothing showed that the protection afforded is comparable to that obtained with similar Navy protective clothing.

~~CONFIDENTIAL~~

-c-

DECLASSIFIED



# TABLE OF CONTENTS

<u>TEXT</u>	<u>Page No.</u>
ABSTRACT - - - - -	b - c
INTRODUCTION - - - - -	1
A. Authorization - - - - -	1
B. Statement of Problem - - - - -	1
C. Known Facts Bearing on Problem and Theoretical Considerations- - - - -	1
D. Previous Work Done at This Laboratory-	3
EXPERIMENTAL - - - - -	4
A. Procedure for Chamber Tests - - - - -	4
B. Supplementary Tests of Modified Aqueous CC-2 Impregnation Systems - - - - -	5
C. Supplementary Tests of Worn CC-2 Impregnated Clothing - - - - -	8
D. Tests of Stored CC-2 Impregnated Cloth- ing - - - - -	11
E. Tests of U. S. Marine Corps Protective Clothing - - - - -	12
SUMMARY AND CONCLUSIONS - - - - -	15
RECOMMENDATIONS - - - - -	17
ACKNOWLEDGMENT - - - - -	18
APPENDICES - 5	

DECLASSIFIED



## INTRODUCTION

### A. Authorization

1. This work was authorized under Project 547/41, "Maintenance, Bureau of Ships", dated 16 December 1940. The problems which were proposed for study were given in Bureau of Ships letter S-S77-2 (Dz), Serial 811 of 17 December, 1940.

### B. Statement of Problem.

2. The purpose of this report is to describe the results obtained in a number of supplementary chamber tests for the evaluation of the protection afforded by CC-2 impregnated clothing.

3. Included in the report are the results of supplementary tests on modified aqueous CC-2 impregnation systems and on worn CC-2 impregnated clothing. In addition, the data obtained in tests of stored CC-2 clothing and in tests of U. S. Marine Corps impregnated clothing are presented.

### C. Known Facts Bearing on Problem and Theoretical Considerations.

4. NRL Report No. P-2602, "Chamber Tests with Human Subjects XI", dated 18 August 1945, describes the results of chamber tests of a number of modified aqueous CC-2 impregnation systems. The modifications studied were binder modifications, stabilizer modifications, and modified methods of application.

5. In the present investigation, the following additional studies were made:

- (a) Study of emulsifying agent modifications.
- (b) Re-evaluation of the foam process.
- (c) Evaluation of flame-proof impregnated clothing.

6. NRL Report No. P-2597, "Chamber Tests with Human Subjects VIII", dated 5 September 1945, gives

DECLASSIFIED



results obtained in the chamber test evaluation of worn CC-2 impregnated clothing. Worn clothing of various types of impregnation (solvent, stabilized solvent, aqueous, and modified aqueous) from three wearing trials conducted by this Laboratory was tested.

7. The supplemental tests included in this investigation were concerned only with aqueous type CC-2 impregnated clothing from the second NRL wearing trial conducted at Camp Lejeune, N. C., in June - July, 1945. Studies were made of:

- (a) The effect of variation in concentration of H vapor and time of exposure.
- (b) Field Set (light weight simplified) reimpregnated clothing.

8. Many tests have been made during the past three years at this Laboratory, by the CWS and by NDRC investigators to determine and evaluate the storage characteristics of CC-2 impregnated clothing. These tests have been primarily concerned with the retention of CC-2 and retention of tensile strength during storage, and, as far as is known, no chamber tests have been conducted on stored clothing.

9. It has been shown (NRL Report No. P-2597) that, in the case of worn CC-2 clothing, there is a reasonable correlation between loss of Cl+ and loss of protection. That such a correlation also exists in the case of stored clothing has been indicated by chemical leakage and capacity tests. However, it was considered desirable to substantiate this conclusion by means of chamber tests, and such tests have been conducted using CC-2 impregnated clothing which had been stored under the following conditions:

- (a) Simulated tropical storage (2 months at 45°C - 80% R.H.)
- (b) Shipboard storage.

10. The U. S. Marine Corps protective clothing consists of two types:

- (a) Two piece HBT fatigue clothing with



special hood - impregnated by the Field Set (M-1).

(b) Arnzen clothing impregnated by the solvent (TCE) +  $\text{CaCO}_3$  system.

11. Chamber tests were conducted using both of the above types of clothing to evaluate the degree of protection which might be expected in Service use and at the same time to compare the protective characteristics of this clothing with those of standard issue Navy protective clothing.

12. NRL Reports Nos. P-2597 and P-2602 include some chamber test data on Arnzen clothing reimpregnated by the Field Set (M-1) and on Arnzen clothing impregnated by means of the Field Set (LWS). NRL Report No. P-2603, "Chamber Tests with Human Subjects XII, Suit and Man 'Breaks' With CC-2 Impregnated Clothing", dated 31 August 1945 gives the results of chamber tests of Arnzen clothing impregnated with CC-2 by the solvent (TCE) and solvent +  $\text{ZnO}$  systems, but no previous tests have been carried out at this Laboratory on solvent +  $\text{CaCO}_3$  impregnated clothing.

D. Previous Work Done at This Laboratory.

13. This is the seventeenth of a series of reports on "Chamber Tests with Human Subjects" in which the results obtained in the evaluation of various protective devices against the effects of persistent chemical warfare agents are reported.

14. In addition to the NRL Chamber Test reports referred to above, the following NRL Reports present detailed information and data concerning some of the various types of CC-2 clothing studied in this investigation:

(a) NRL Report No. P-2000, "Progress Report on Protective Clothing", dated 20 February 1943.

(b) NRL Report No. P-2055, "Aqueous Impregnating Systems of Chlorinated Paraffin and Impregnite S-145", dated 12 May 1943.

(c) NRL Report No. P-2682, "Second Wearing Trial of Protective Clothing at Camp Lejeune, N. C.", dated 26 November 1945.

DECLASSIFIED



(d) NRL Report No. P-2690, "Study of Aresklene as Emulsifying Agent in Aqueous Process Impregnation of Clothing", dated 19 November 1945.

## EXPERIMENTAL

### A. Procedure for Chamber Tests

15. The operation of the NRL chamber as well as the general procedure for conducting chamber tests is described in detail in NRL Report No. P-2208, "Chamber Tests with Human Subjects I & II", dated 22 December 1943.

16. The chamber tests involved in the present investigation were conducted as 1-1/2 layer "man break" tests. In these tests, unless otherwise specified, each man exposed in the chamber was supplied with the following protective equipment:

(a) Navy diaphragm mask, Mark III or IV (with CC-2 impregnated sleeves on the hose connecting tubes.).

(b) CC-2 impregnated Arnsen suit.

(c) CC-2 impregnated rib knit shorts

(d) Standard Navy undershirt (skivvy shirt - unimpregnated)

(e) CC-2 impregnated cotton socks (2 pair)

(f) CC-2 impregnated elbow-length wool gloves.

(g) Overshoes (Arctics).

(h) Protective Ointment (S-330) for edge of face and neck.

17. The subjects were given successive daily exposures to H vapor in the chamber under the following conditions (unless otherwise specified):

(a) CT = 1200 (60 min.)

(b) Temperature =  $90^{\circ}\text{F} \pm 0.2^{\circ}\text{F}$ .

(c) Relative Humidity =  $65\% \pm 3\%$

(d) Wind Velocity = 2 - 2.5 m.p.h.

18. The clothing was worn by the subjects 1/2 hour after a chamber exposure. The men were examined

DECLASSIFIED



and read by the Medical Officer before each exposure, and each subject was withdrawn from the test when he had incurred a reading of E (intense erythema) or greater on any part of his body. The successive daily exposures were continued until all the men had "broken" i.e., reached a reading of E or greater. The average number of exposures tolerated was used as the basis for evaluating the protection given by the clothing.

B. Supplementary Tests of Modified Aqueous CC-2 Impregnation Systems.

19. The supplementary tests of modified aqueous CC-2 impregnation systems were tests of:

- (a) A methyl cellulose system
- (b) An Aresklene system
- (c) The Foam Process
- (d) A simultaneous flame-proofing and CC-2 impregnation system.

20. The first two systems (methyl cellulose and Aresklene) represent modifications of the emulsifying agent, used in the present standard aqueous formula:

CC-2 + 25% ZnO + 25% CP + 2.5% PVA + 9% dye.

In the methyl cellulose system the 2.5% PVA is replaced with 2.5% methyl cellulose, and in the Aresklene system the 2.5% PVA is replaced with 10% Aresklene.

21. Laboratory tests of clothing impregnated by these systems have shown that there is no significant difference in laundering resistance or storage and weathering stability as compared with clothing impregnated by the standard system. The methyl cellulose system was considered as representing an alternative method in case PVA becomes unavailable. However, the Aresklene system represents an improvement in the time required and ease of emulsification in the preparation of the aqueous impregnation bath. In addition, previous tests of clothing impregnated by the Field Set (LWS), which involves the use of Aresklene as the emulsifying agent, indicated an unusually high degree of protection as compared with the standard system, (10.6+ vs. 4.3 exposures tolerated - cf. NRL Report No. P-2602).

DECLASSIFIED



22. The "Foam Process" of impregnation represents a modification of the method of application. The details of the process and the proposed advantages have been described in NRL Report No. P-2602. The results of a preliminary chamber test conducted at this Laboratory were also presented in the above report. The data obtained were not in agreement with those reported by the CWS and therefore the present test represents a re-evaluation of the process using Arnzen clothing impregnated by the CWS at the Edgewood Arsenal M-2 plant.

23. The simultaneous flame-proofing and CC-2 impregnation system was designed, as the name indicates, to produce clothing which is resistant to both fire and H vapor. The formula used in this system was:

CC-2 + 100% CP + 100% ZnO + 4.2% PVA + 5% Duponol, and the clothing was impregnated by the "Foam Process" at the Edgewood Arsenal M-2 plant.

24. The data obtained in the chamber tests of clothing impregnated by these four modified aqueous impregnation systems are given in Table I. The detailed individual data for these tests are given in Tables VIII through XVII in Appendix II. These data include the readings of each subject at 24 and 48 hours after the last exposure, and in addition, summarized data showing "breaks" per day are presented.

Table I

Supplementary Tests of Modified Aqueous CC-2 Impregnation Systems

<u>Test Started</u>	<u>Impreg. System</u>	<u>No. of Men</u>	<u>No. of Breaks</u>	<u>Av. No. of Exposures Tolerated</u>
11/14/44	Methyl Cellulose	5	4	8.8+
9/27/45	" "	8	8	8.6
9/27/45	Aresklene	8	7	8.8+
9/27/45	Foam Process	8	8	6.1
10/15/45	Flame-Proof	6	3	8.0+
*11/14/44	Standard	8	8	4.4
** 9/27/45	"	8	7	6.1+

\* Concurrent Control Test for Methyl Cellulose Test on 11/14/44

\*\* Concurrent Control Test for Methyl Cellulose, Aresklene, and Foam Process Tests on 9/27/45.



25. From the data in the above table it may be seen that:

(a) In both tests of clothing impregnated by the methyl cellulose system greater protection was provided than was provided by the standard control clothing tested concurrently. The values obtained (8.8+ and 8.6 exposures tolerated) are also greater than the combined average value of 6.1+ for standard clothing (cf. NRL Report No. P-2602).

(b) Clothing impregnated by the Aresklene system gave greater protection than that impregnated by the standard system (8.8+ vs. 6.1+ exposures tolerated - both for concurrent standard and combined average).

(c) Previous results of tests of Foam Process clothing have been confirmed. In this test, as in the first test (NRL Report No. P-2602), there was no increase in protection as compared with standard clothing on the basis of the concurrent control test or the combined average value for standard clothing (6.1 vs. 6.1+).

(d) The simultaneous flame-proofing and CC-2 impregnating system produces clothing which in this test gave protection comparable to and possibly superior to that prepared by the standard system. No concurrent control test was conducted, but the value obtained for number of exposures tolerated (8.0+) is higher than the combined average value for standard clothing (6.1+).

This test is considered a preliminary test of this type of impregnated clothing and the results obtained should be evaluated with the realization that the Cl+ content of the clothing was abnormally high (0.75 mg.Cl+/cm.<sup>2</sup>). It is believed that the results of this chamber test should be confirmed and that other characteristics such as the Cl+ retention, reimpregnation build-up, etc., should be completely studied before any final conclusions can be drawn.

26. In general it may be said that all of the modifications studied in this series of tests, except the "Foam Process", appear to be advantageous with

DECLASSIFIED



regard to protective characteristics and should be given serious consideration in any future work on the preparation of CC-2 impregnated clothing.

C. Supplementary Tests of Worn CC-2 Impregnated Clothing.

27. The supplementary tests of worn CC-2 impregnated clothing consisted of the following tests of aqueous process CC-2 clothing from the second NRL wearing trial at Camp Lejeune, N. C., (June-July 1945):

(a) A study of the effect of variation in concentration of H vapor and time of exposure on clothing "worn down" to the reimpregnation value of 0.20 mg.Cl<sup>+</sup>/cm.<sup>2</sup>.

(b) A study of the protection afforded by worn Field Set (LWS) reimpregnated clothing.

28. The first of these studies was designed to determine if CT is a constant in the exposure of CC-2 clothing having a low Cl<sup>+</sup> content, and also to obtain an accurate measure of the absolute protection which is afforded by CC-2 clothing at the reimpregnation level.

29. The second study was carried out to secure a complete evaluation of the Field Set (LWS) and to obtain data for comparison with that obtained for worn Field Set (M-1) reimpregnated clothing (cf. NRL Report No. P-2597).

30. A complete description of the second NRL wearing trial at Camp Lejeune, N. C., is given in NRL Report No. P-2682. The test was carried out during the course of regular training activities in jungle warfare at Camp Lejeune. The mean temperature and relative humidity (0600 to 2000) for the six week period covered by the trial were 80°F and 81%, respectively. The conditions represented by the trial were considered quite severe and two weeks wear was sufficient to reduce the Cl<sup>+</sup> content to the reimpregnation level.

31. For the chamber tests to determine the effect of variation in concentration of H vapor and time of exposure, twenty-four suits, worn two weeks, and



whose Cl+ content\* averaged 0.17 mg./cm.<sup>2</sup>, were divided into 4 groups for "man break" tests under the following conditions:

- (a) CT 300 - 5 v H/l for 60 minutes.
- (b) CT 300 - 2.5 v H/l for 120 minutes.
- (c) CT 600 - 10 v H/l for 60 minutes.
- (d) CT 600 - 5 v H/l for 120 minutes.

32. The results of these chamber tests are shown in Table II. The detailed individual data are given in Tables XVIII through XXI and in Table XXIII in Appendix III.

\* Duplicate samples from the hood, elbow, shoulder, knee, seat, and crotch of each suit were analyzed by the iodometric titration method.

DECLASSIFIED



Table II

Supplementary Tests of Worn CC-2 Impregnated Clothing

Effect of Concentration of H Vapor and  
Time of Exposure

<u>Test</u> <u>Started</u>	<u>Conc. of H</u> <u>Vapor (γ/l.)</u>	<u>Time of</u> <u>Exp.(Min.)</u>	<u>CT of</u> <u>Exp.</u>	<u>No. of</u> <u>Men</u>	<u>No. of</u> <u>Breaks</u>	<u>Av.No.of</u> <u>Exposures</u> <u>Tolerated</u>	<u>Av. Total</u> <u>CT</u> <u>Tolerated</u>
9/17/45	5.0	60	300	6	6	4.0	1200
9/17/45	2.5	120	300	6	5	4.5+	1350+
9/17/45	10.0	60	600	6	5	2.0+	1200+
9/17/45	5.0	120	600	6	6	3.2	1920

Av. 1410+

33. The data shown in Table II indicate that in the case of worn CC-2 impregnated clothing having a Cl+ content at or near the reimpregnation level, the protection afforded is proportional to both concentration of H vapor and time of exposure, i.e., CT is a constant. For H vapor concentrations ranging from 2.5 to 10.0 γ H/l., and for times of exposure ranging from 60 to 120 min., a total average CT tolerated of 1410+ was obtained. This value, then, represents a measure of the maximum CT of exposure for which CC-2 clothing may be expected to provide adequate protection when the Cl+ content has been reduced to the reimpregnation level by wear under service conditions.

34. For the chamber test to study the protection afforded by worn Field Set (LWS) reimpregnated clothing, six suits which had been worn six weeks with reimpregnation every two weeks, and whose Cl+ content after the last two weeks wear averaged 0.15 mg./cm.<sup>2</sup>, were subjected to a "man break" chamber test at CT 600 (10 γ H/l for 60 min.). The data obtained in this test are presented in Table III. Individual data are shown in Tables XXII and XXIII in Appendix III.

DECLASSIFIED



Table III

Supplementary Tests of Worn CC-2 Impregnated Clothing  
Field Set (LWS) Reimpregnated Clothing

Test	Conc. of H	Time of	CT of	No. of	No. of	Av. No. of	Av. Total
Started Vapor ( $\gamma$ /l.)		Exp.(Min.)	Exp.	Men	Breaks	Exposures Tolerated	CT Tolerated
10/15/45	10.0	60	600	6	6	2.2	1320

35. The results of the test given in Table III show that the protection provided by worn Field Set reimpregnated clothing whose Cl+ content is at or near the reimpregnation level is comparable to that furnished by the type of clothing represented by the first part of this test (cf. Table II). An average total CT tolerated of 1320 was obtained as compared to an average of 1410+ from the data in Table II, or as compared to 1200+ for the same conditions of exposure.

D. Tests of Stored CC-2 Impregnated Clothing.

36. The tests of stored CC-2 impregnated clothing consisted of standard "man break" tests of:

(a) Standard aqueous process (25% CP) suits stored under simulated tropical conditions (45°C-80% R.H.) for 2 months.

(b) Unstabilized solvent process suits stored on shipboard under conditions ranging from temperate to semi-tropical and for periods of time ranging from 18 months to two years.

37. The data obtained in these tests are given in Table IV. (See also Tables XXIV through XXVI in Appendix IV.).

DECLASSIFIED



Table IV

Tests of Stored CC-2 Impregnated Clothing

<u>Test Started</u>	<u>Storage</u>	<u>mg.Cl+ /cm.<sup>2</sup></u> <u>Orig.</u>	<u>After Storage</u>	<u>No. of Men</u>	<u>No. of Breaks</u>	<u>Av.No. of Exposures Tolerated</u>
10/15/45	Tropical	0.82	0.74	6	6	4.2
10/15/45	Shipboard	0.35-0.40	0.19-0.31	6	6	2.3

38. To evaluate the data shown in Table IV in terms of loss of protection during storage, the values for average number of exposures tolerated may be compared with the combined average value for a number of tests of freshly impregnated clothing of the types used in this test. These combined average values have been reported in NRL Reports Nos. P-2602 and P-2603 and are:

- (a) 6.1+ av. exposures tolerated for standard aqueous (25% CP) system impregnated clothing.
- (b) 7.3+ av. exposures tolerated for unstabilized solvent system impregnated clothing (1 layer test).

39. Comparison with the above values indicates that under the storage conditions as described, the "tropical storage" suits showed a decrease of 30% in protection and the "shipboard storage" suits showed a decrease of 70%.

E. Tests of U. S. Marine Corps CC-2 Impregnated Clothing.

40. The tests of U. S. Marine Corps protective clothing consisted of tests of 2 types:

- (a) Two piece HBT fatigue clothing with special detachable hoods - impregnated by the Field Set (M-1).
- (b) Arnsen clothing impregnated by the solvent + CaCO<sub>3</sub> system.

DECLASSIFIED



41. The chamber tests of the above clothing were conducted in the standard manner for 1-1/2 layer "man break" tests. However, no protective ointment was used on the neck and edge of the face since Marine directives do not provide for the issue of this item of protection.

42. The results of the chamber tests are given in Table V and in Tables XXVII through XXIX in Appendix V.

Table V

Tests of USMC CC-2 Protective Clothing

<u>Test Started</u>	<u>Type of Impreg. Clothing Method</u>	<u>No. of Men</u>	<u>No. of Breaks</u>	<u>Av.No. of Exps. Tolerated</u>
5/10/45	HBT Field Set(M-1)	13	13	5.0
5/10/45	Arnzen Solv.+CaCO <sub>3</sub>	7	7	8.3

43. For purposes of comparison, the following values for average number of exposures tolerated by subjects wearing similar Navy protective clothing are presented:

(a) Arnzen clothing impregnated by means of the aqueous (75% CP) system (Same formula as for Field Set M-1), gave a combined average value of 4.5+ exposures tolerated (cf. NRL Report No. P-2602).

(b) Aqueous process Arnzen impregnated clothing reimpregnated by means of the Field Set (M-1) provided protection for 4.0 chamber exposures (cf. NRL Report No. P-2597).


(c) Arnzen clothing impregnated by the stabilized (ZnO) solvent system gave a value of 6.7+ exposures tolerated for a 1 layer test. (cf. NRL Report No. P-2603).

44. It may be seen from the above data that the protective value of the USMC protective clothing compares very favorably with that exhibited by

DECLASSIFIED



similar Navy items, and it is considered that, from the protection standpoint, the USMC clothing is satisfactory for service use.

 - 14 -

DECLASSIFIED



## SUMMARY AND CONCLUSIONS

1. Supplementary chamber tests have been conducted at this Laboratory to obtain an evaluation of:

(a) some additional modifications of the aqueous CC-2 impregnation process.

(b) CC-2 impregnated clothing from the second NRL wearing trial at Camp Lejeune, N. C.

(c) stored CC-2 impregnated clothing.

(d) U. S. Marine Corps Protective Clothing.

2. In the tests of additional modifications of the aqueous CC-2 process it was found that:

(a) Substitution of 2.5% (on the CC-2) methyl cellulose or 10% Aresklene for the 2.5% PVA used as the emulsifying agent in the standard aqueous process resulted in an increase in the protective value of the clothing.

(b) The results obtained in the preliminary test of Arnzen clothing impregnated by the CWS Foam Process were corroborated. No increase in protection as compared with the standard process was observed in this second test of this type clothing.

(c) The simultaneous flame-proofing and CC-2 impregnating system provided clothing which gave protection comparable to or slightly superior to that prepared by the standard system.

3. The supplementary tests of worn CC-2 impregnated clothing showed that:

(a) The protection afforded by worn CC-2 clothing having a Cl+ content at or near the reimpregnation level is proportional to both concentration of H vapor and time of exposure, in the range studied.

(b) A CT of approximately 1400 represents the

DECLASSIFIED



maximum CT of exposure for which worn CC-2 clothing having a Cl+ content at or near the reimpregnation level may be expected to provide adequate protection.

(c) The protection afforded by worn Field Set (LWS) reimpregnated clothing having a Cl+ content at or near the reimpregnation level is comparable to that provided by worn, but not reimpregnated, clothing having the same Cl+ content.

4. The tests of stored CC-2 impregnated clothing produced the following results:

(a) Standard aqueous process (25% CP system) suits stored under simulated tropical conditions (45°C-80% RH) for 2 months showed a decrease of approximately 30% in protective value.

(b) Unstabilized solvent process suits stored on shipboard under conditions ranging from temperate to semi-tropical and for periods of time ranging from 18 months to 2 years showed a decrease of approximately 70% in protective value.

5. U. S. Marine Corps protective clothing consisting of two types: (a) Two piece HBT fatigue clothing with special detachable hoods - impregnated by the Field Set (M-1), and (b) Arnzen clothing impregnated by the solvent +  $\text{CaCO}_3$  system, provides protection which compares very favorably with that provided by similar Navy items.



## RECOMMENDATIONS

1. It is recommended that substitution of methyl cellulose or Aresklene for the PVA used as emulsifying agent in the standard aqueous CC-2 impregnation system be considered advantageous with regard to the protective characteristics of the resulting clothing, and that serious consideration be given these agents in any future work on the preparation of CC-2 impregnated clothing.

2. It is recommended that the CWS Foam Process of impregnation be considered of no advantage over the present standard Navy process with regard to the protective characteristics of the resulting clothing.

3. It is recommended that, pending further tests, the described simultaneous flame-proofing and CC-2 impregnating system be considered as giving protection comparable to that provided by the present standard system.

4. It is recommended that a CT of approximately 1400 be considered the maximum CT for which worn CC-2 clothing having a Cl+ content at or near the reimpregnation level may be expected to provide adequate protection.

5. It is recommended that the Field Set (LWS) be considered satisfactory for reimpregnation of worn CC-2 impregnated clothing.

6. It is recommended that the two types of U. S. Marine Corps protective clothing tested in this investigation be considered satisfactory for service use.

~~CONFIDENTIAL~~

- 17 -

DECLASSIFIED



## ACKNOWLEDGMENT

The following people have participated in conducting the experimental work involved in the tests described in this report:

### Medical Group

N. M. Clausen, Lt. (j.g.) (MC) USNR- Assistant Medical Officer.  
L. H. Wiggers, Jr., LT.(MC) USNR- Assistant Medical Officer.  
B. N. Stolp, Lt. USNR-Records and Clinical Laboratory Tests  
J. C. Conner, Jr. Lt. (j.g.) USNR- Volunteer Personnel  
H. W. McGrath, CBM - Volunteer Personnel  
C. F. Adams, Cox - Volunteer Personnel  
B. D. McCarthy, PhM 1/c- Clinical Laboratory Tests and Preparation of Subjects for Chamber  
J. B. Leary, PhM 2/c - " " " "  
B. Winter, PhM 2/c - " " " "  
F. J. Felker, CY - Secretarial

### Technical Group

R. E. Cunningham - Chamber Operation  
L. I. Jussila - Chamber Operation  
K. G. Williams, CSp(X) - Chamber Operation  
G. M. Gantz - Protective Clothing  
M. J. Curry, CSp(X) Protective Clothing  
H. R. Billica, CSp(X) - Protective Clothing  
A. M. Thomson - Protective Clothing  
F. C. Theile, CSp(X) - Preparation of H (TG)

The subjects participating in these tests were volunteer personnel from NTC, Bainbridge, Md.

DECLASSIFIED



## Appendix I

Table VI

Physiological Readings - Legend

<u>Symbol</u>	<u>Reaction</u>
E•	Moderate Erythema
E	Intense Erythema
E+	Papular Erythema
NPV	Numerous Pin-point Vesicles
V	Vesicle
NV	Numerous Vesicles

Readings of mild and questionable erythema are not included since they are not considered significant in tests of this nature ("man-break" tests).

DECLASSIFIED



Table VII

Body Areas - Legend

<u>Abbreviation</u>	<u>Area</u>	<u>Abbreviation</u>	<u>Area</u>
aaf	anterior axillary folds	le	legs
aar	anterior arms	lne	lateral neck
ab	abdomen	lth	lateral thorax
ale	anterior legs	lum	lumbar region
ane	anterior neck	paf	posterior axillary folds
ar	arms	par	posterior arms
ash	anterior shoulders	pen	penis
athi	anterior thighs	ple	posterior legs
ax	axillae	pne	posterior neck
bt	buttocks	pop	popliteal spaces
C <sub>7</sub>	7th cervical region	psh	posterior shoulders
cf	cubital fossae	pthi	posterior thighs
cl	clavicles	sc	scapulae
dh	dorsum of hands	scr	scrotum
dth	dorsal thorax	uab	upper abdomen
el	elbows	ulth	upper lateral thorax
fa	forearms	umar	upper medial arms
igf	intergluteal folds	umthi	upper medial thighs
il	iliac crest	ust	upper sternum
ing	inguinal region	uvth	upper ventral thorax
kn	knee	vth	ventral thorax
		wr	wrists

DECLASSIFIED



Appendix II

Detailed Physiological Data for Supplementary  
Tests on Modified Aqueous CC-2 Impregnation Systems

Table VIII

Test No. 1a - Methyl Cellulose System

Date Started: 11/14/44

No. of Exposures Tolerated	Readings (Hours after Last Exposure)	
	24	48
5	E psh,paf	E psh,paf E° cf,athi,kn,sc, dth,pthi,pop
5	E pthi,pop,ple E° psh,sc,dth	E pop E° athi,kn,psh,sc, dth,ple
8	E ax,cf E° kn,psh,sc, paf,pop	E ax,cf,psh,paf E° kn
12	E pop	E° ax,athi,kn,pop
14*	E° psh,sc	E° psh,sc,dth,par, pop

Av. 8.8+

\* Indicates, in this and subsequent tables, subject withdrawn from test for reasons other than a "break".

CONFIDENTIAL

DECLASSIFIED



Table IX

Test No. 1b - Methyl Cellulose System

Date Started: 9/27/45

No. of Exposures Tolerated	Readings (Hours after Last Exposure)	
	24	48
7	' E athi, kn, ale, pop ' E° psh, sc, dth, ' pthi, ple	' E athi, kn, ale, pop ' E° psh, sc, dth, pthi, ' ple
8	' E psh, sc, dth ' E° aar, cf, kn, par, ' el.	' E kn, ale, pop ) ' E° cf, athi, psh, ) 96 ' par, el, sc, ) Hrs. ' dth )
9	' E kn, ale, pop, ple ' E° athi, pthi	' E athi, kn, ale, ) 72 ' pthi, pop, ple ) Hrs.
12	' E pop ' E° athi, kn, ale, paf, ' psh, sc, dth, pthi, ' ple	' E pthi, pop, ple ' E° athi, kn, ale, psh, ' sc, dth
10	' E psh, sc, dth, pop ' E° athi, kn, ale, ' pthi, ple	' E athi, kn, ale, psh, ' sc, dth, pop ' E° par, el, pthi, ple
5	' E athi, kn, ale, ' pthi, pop, ple ' E° psh, par, el, sc, ' dth, lum	' E athi, kn, ale, psh, sc, ' dth, pthi, pop, ple ' E° aar, cf, par, el
9	' E kn, ale, pop ' E° cf, athi, psh, el, ' sc, pthi, ple	' E aar, cf, athi, ) 72 ' kn, ale, sc, pop ) Hrs.
9	' E athi, kn, ale ' E° cf, pthi, pop, ple	' E athi, kn, ale, ) 72 ' pthi, pop, ple ) Hrs.

Av. 8.6

DECLASSIFIED



Table X

Test No. 1c - Concurrent Control Test For

Methyl Cellulose System Test No. 1a

Low CP (25%) System

Date Started: 11/14/44

No. of Exposures Tolerated	Readings (Hours after Last Exposure)	
	24	48
3	' E par,ash,aaf,athi, ' kn,psh,sc,dth,paf ' E° ax,lth,cf,pthi, ' pop	' E uar,aaf,ash,psh,paf, ' sc,dth ' E° vth,thi,kn,pop
4	' E aar,cf,ax,psh, ' paf,sc,dth ' E° ash,aaf,athi,kn, ' ale,pop,par	' E ash,aaf,cf,ax,psh, ' sc,dth,pop
4	' E cf,psh,sc ' E° ash,athi,kn,dth, ' par,pop	' E ash,cf,aar,psh,sc, ' dth,paf, ' E° lth,par
4	' E cf,athi,kn,ale, ' psh,paf,pthi, ' pop,ple ' E° aar,ax,sc,dth	' E ash,aaf,ax,lth,cf, ' aar,athi,kn,paf,sc, ' pop ' E° par
4	' E cf,psh,paf,dth, ' sc,aar ' E° ash,athi,kn	' E aar,cf,psh,sc,dth ' E° ax,par
4	' E ash,cf,ax,athi, ' kn,psh,paf,sc ' E° par,pthi,pop, ' ple	' E ax,lth,cf,athi,ale, ' psh,sc,dth,pthi,pop ' E° par
4	' E ax,aaf,psh,paf, ' sc ' E° ash,vth,dth,aar	' E aaf,ax,psh,dth,paf, ' par,pop ' E° ash,kn,ale
8	' E ax,psh,sc,dth	' E ax,psh,sc,dth

Av. 4.4

DECLASSIFIED



Table XI

Test No. 1d - Concurrent Control Test for

Methyl Cellulose System Test No. 1b

Low CP (25%) System

Date Started: 9/27/45

No. of Exposures Tolerated	Readings (Hours after Last Exposure)	
	24	48
4	' E ash,aar,cf,athi, ' kn,ale,psh,sc ' E° el,dth,pthi, ' pop,ple	' No Readings (Sick Bay) ' ' '
12*	' No Readings E° or ' Greater	' No Readings E° or ' Greater
5	' E kn,ale,pthi, ' pop,ple ' E° athi	' E athi,kn,ale,pop, ' ple ' E° pthi
4	' E pop ' E° athi,kn,ale, ' pthi,ple	' E+ pop ' E athi,kn,ale,pthi, ' ple
10	' E pop ' E° aar,athi,kn, ' ale,psh,par, ' el,sc,dth,pthi, ' ple	' E kn,ale,psh,pop ' E° umar,athi,sc,dth, ' pthi,ple
4	' E athi,kn,ale,sc, ' pthi,pop,ple ' E° psh,dth	' E+ pop ' E athi,kn,ale,dth, ' pthi,ple ' E° ash,psh,sc
5	' E ale,pthi,pop,ple ' E° athi,kn,paf, ' psh,sc,dth	' E pop,ple ' E° athi,kn,ale,psh,sc, ' dth,pthi
5	' E athi,kn,ale,psh, ' pop ' E° sc,dth,pthi,ple	' E pop ' E° athi,kn,ale,psh,par, ' el,sc,dth,pthi,ple

Av. 6.1+

DECLASSIFIED



Table XII

Test No. 1e - Aresklene System

Date Started: 9/27/45

No. of Exposures Tolerated	Readings (Hours after Last Exposure)	
	24	48
11	' E kn,paf,pop ' E° athi,ale,psh, ' sc,pthi,ple	' E athi,kn,ale,paf,par,pop ' E° aar,pthi,ple
9	' E pthi,pop ' E° ash,aar,cf, ' psh,sc,ple	' E umar,paf,psh,pop) ' E° cf,aar,athi,kn,) 72 ' ale,par,el,sc, )Hrs. ' pthi,ple )
9	' E cf ' E° ash,psh,par, ' el,sc,pop	' E cf ) ' E° aar,athi,kn,ale,) 72 ' psh,sc,pop )Hrs.
12*	' E° aar,cf,athi, ' kn,ale,psh,el, ' sc,dth	' E° aar,cf,athi,kn,ale, ' paf,psh,sc,dth
10	' E kn,ale,pop ' E° athi,psh,sc, ' dth,pthi,ple	' E athi,kn,ale,psh,pop ' E° ash,cf,sc,dth,pthi, ' ple
7	' E kn,ale,pop ' E° athi,psh,sc, ' dth,pthi,ple	' E athi,kn,ale,pthi,pop, ' ple ' E° psh,sc,dth
7	' E cf ' E° athi,kn,ale, ' psh,par,el,sc, ' dth,pthi,pop, ' ple	' E cf ' E° athi,kn,ale,psh,sc, ' dth,pop
5	' E psh ' E° par,el,sc,dth	' E psh,sc ' E° aar,cf,kn,par,el,dth

Av. 8.8+

DECLASSIFIED



Table XIII

Test No. 1f - Concurrent Control Test For

Aresklene System Test No. 1e

Low CP (25%) System

Date Started: 9/27/45

This test was conducted concurrently with Test Nos. 1b and 1e (Tables IX and XII). The data are presented in Table XI as Test No. 1d. The average number of exposures tolerated was 6.1+ (7/8 men "broken").

**SECRET**

DECLASSIFIED



Table XIV

Test No. 1g - Foam Process

Date Started: 9/27/45

No. of Exposures Tolerated	Readings (Hours after Last Exposure)	
	24	48
8	' E psh,sc ' E° par,el,dth ' ' '	' E umar,cf,paf,psh, ) ' sc,pop ) 96 ' E° athi,kn,ale,dth, ) Hrs. ' pthi,ple ) '
5	' E pop ' E° psh,par,el, ' sc,dth,pthi, ' ple '	' E dth,pop ' E° psh,par,el,sc,dth, ' pthi,ple '
7	' E athi,kn,ale, ' pthi,pop ' E° cf,ax,psh,par, ' el,sc,dth,ple '	' E athi,kn,ale,pthi,pop, ' ple ' E° aar,cf,psh,par,el,sc,dth ' '
5	' E psh,sc,dth ' E° cf,athi,kn, ' ale,par,el '	' E paf,psh,sc,dth ' E° cf '
9	' E kn,ale,paf, ' psh,sc,pop ' E° cf,lth,athi, ' par,el,dth, ' pthi,ple '	' E ash,umar,aar,cf, ) ' athi,kn,ale,paf, ) ' psh,sc,pop ) 72 ' E° lth,vth,par,el, ) Hrs. ' dth,pthi,ple ) '
5	' E psh,sc,dth,pop ' E° athi,kn,ale, ' pthi,ple '	' E° psh,par,el,sc,dth,pop ' '
5	' E pthi,pop,ple ' E° athi,kn,ale, ' el '	' E athi,kn,ale,pthi,pop,ple ' E° ale '
5	' E ash,athi,kn, ' ale,paf,psh ' E° aar,cf,par,el, ' sc,dth,pthi, ' pop,ple '	' E ash,psh ' E° aar,cf,athi,kn,ale,par, ' el,sc,dth,pthi,pop,ple ' '

Av. 6.1

DECLASSIFIED



Table XV

Test No. 1h - Concurrent Control Test

for Foam Process Test No. 1g

Low CP (25%) System

Date Started: 9/27/45

This test was conducted concurrently with Tests Nos. 1b, 1e, and 1g (Tables IX, XII, and XIV). The data are presented in Table XI as Test No. 1d. The average number of exposures tolerated was 6.1+ (7/8 men "broken").

CONFIDENTIAL

DECLASSIFIED



Table XVI

Test No. 11 - Flame Proof Impregnated Clothing

Date Started: 10/15/45

No. of Exposures Tolerated	Readings (Hours after Last Exposure)	
	24	48
3	E psh E° ash,aar,cf,el, dth	E psh E° ash,aar,cf,athi,kn, ale,el,sc,dth
12*	No Readings	E° cf,pthi,pop, ) 72 ple ) Hrs.
12*	No Readings	No Readings E° or ) 72 Greater ) Hrs.
12*	No Readings	No Readings E° or ) 72 Greater ) Hrs.
10	E aar,cf,kn,ale, lum E° ash,lth,vth, athi,psh,par, el,sc,dth, pthi,pop,ple	E ash,cf,lum E° lth,vth,athi,kn,ale, psh,par,el,sc,dth, pthi,pop,ple
3	E paf,psh E° aar,el,sc,dth	E paf,psh E° sc,dth

Av. 8.0+

DECLASSIFIED



Table XVII

Supplementary Tests on Modified Aqueous CC-2 Impregnation  
Systems - Break/Day

Date Started	Impreg. System	No. of Men	1	2	3	4	5	6	7	8	9	10	11	12	13	14	No. of Breaks	Av. Exp. Tolerated
11/14/44	Methyl Cellulose	5					2			1				1		1*	4	8.8+
9/27/45	Methyl Cellulose	8					1		1	1	3	1		1			8	8.6
9/27/45	Aresklene	8					1		2		2	1	1	1*			7	8.8+
9/27/45	Foam	8					5		1	1	1						8	6.1
10/15/45	Flame-Proof	6			2							1		3*			3	9.0+
** 11/14/44	Standard	8			1	6				1							8	4.4
*** 9/27/45	Standard	8				3	3					1		1*			7	6.1+

\* Subject withdrawn from test for reasons other than a "break".

\*\* Concurrent Control Test for Methyl Cellulose System Test on 11/14/44.

\*\*\* Concurrent Control Test for Methyl Cellulose, Aresklene, and Foam Process Tests on 9/27/45.

DECLASSIFIED



Appendix III

Detailed Physiological Data for  
Supplementary Tests on Worn GC-2 Impregnated Clothing

Table XVIII

Test No. 2a - CT = 300 (60 min.)

Date Started: 9/17/45

No. of Exposures Tolerated	Readings (Hours after Last Exposure)	
	24	48
3	' E psh,sc ' E° ash,dth	' E psh,sc,dth ' E° cf,athi,kn,par,el
5	' E psh,dth,lum ' E° ash,kn,par, el,sc	' E psh,sc,dth ) 72 ' E° ash,kn,par,el ) Hrs.
5	' E sc,dth ' E° cf,kn,psh,pop	' E ash,psh,sc,dth,) lum,pop ) 72 ' E° aar,cf,kn,par,) Hrs. el )
3	' E psh,sc,dth ' E° ash,aar,cf, kn,par,el, C7	' E ash,aar,cf,psh,sc,dth ' E° athi,kn,ale
4	' E psh,sc,dth ' E° ash,cf	' E ash,umar,cf,aaf,) ax,psh,sc,dth, ) pop,lth,paf ) 96 ' E° aar,kn,par,el, ) Hrs. dth )
4	' E psh,sc,dth ' E° ash,aar	' E psh,sc ) ' E° ash,kn,ale,dth, ) 96 lum,pop ) Hrs.

Av. 4.0

DECLASSIFIED



Table XIX

Test No. 2b - CT = 300 (120 min.)

Date Started: 9/17/45

No. of Exposures Tolerated	Readings (Hours after Last Exposure)	
	24	48
3	' E psh,sc,dth ' E° ash,cf,athi,kn, ' ale,par,el,pthi ' pop,ple	' E ash,psh,sc,dth ' E° aar,cf,athi,kn,ale, ' par,el,pthi,pop, ' ple
5*	' E° cf,psh,par,el, ' sc,pop	' E psh,sc ) ' E° ash,aar,cf,athi, ) 72 ' kn,dth,pop,par,el)Hrs,
4	' E ash,psh,sc ' E° aar,cf,dth	' E+ athi,ale,pthi,ple) ' E kn,psh,par,sc,pop ) 96 ' E° aar,cf,lth,el,dth)Hrs.
5	' E psh,sc ' E° dth	' E ash,aar,paf,psh, ) ' sc,dth ) 72 ' E° cf,par,el,pop )Hrs.
5	' E psh,sc ' E° ash,aar,cf,aaf, ' par,el,dth	' E ash,aar,paf,psh,sc)72 ' E° par,dth )Hrs.
5	' E psh ' E° ash,cf,kn,par, ' el,sc,dth,pop	' E° ash,psh,par,el,) 72 ' sc,dth )Hrs.

Av. 4.5+

DECLASSIFIED



Table XX

Test No. 2c - CT = 600 (60 min.)

Date Started: 9/17/45

No. of Exposures Tolerated	Readings (Hours after Last Exposure)	
	24	48
2	' E ash,paf,psh ' E° sc,dth ' '	' E ash,psh,sc,dth ' E° aar,cf,lth,vth,kn,par, el,pop ' '
2	' E aar,cf,paf, psh,par,sc ' E° ash,dth ' '	' E ash,aar,cf,paf,psh, par,sc,dth,pthi,pop, ple ' E° lth,athi,kn,ale ' '
2	' E ash,aar,cf,vth, athi,kn,ale,paf, psh,par,el,sc, dth,pthi,pop, ple ' '	' E ash,aar,cf,vth,athi, kn,ale,paf,psh,par, el,sc,dth,pthi,pop,ple ' E° lth ' '
2*	' E° ash,psh,sc ' '	' E ash,psh,sc ' E° aar,cf,athi,kn,dth ' '
2	' E psh ' E° ash,par,el, sc,dth ' '	' E psh,sc,dth ' E° ash ' '
2	' E psh,sc,dth ' E° ash,par,el ' '	' E ash,psh,sc,dth ' E° aar,cf,athi,kn,ale, par,el,pthi,pop,ple ' '

Av. 2.0+

DECLASSIFIED



Table XXI

Test No. 2d - CT = 600 (120 min.)

Date Started: 9/17/45

No. of Exposures Tolerated	Readings (Hours after Last Exposure)	
	24	48
3	'E ash,paf,psh,sc,dth 'E° aar,cf,ax,athi,kn, ' pthi,pop ' '	' E ash,aar,aaf,ax,athi, ' kn,paf,psh,sc,dth, ' pop ' E° pthi,ple '
3	'E paf,psh,sc 'E° dth,pop '	' E paf,psh,sc,dth ' E° ash,aar,cf '
3	'E ash,paf,psh,sc 'E° aar,cf,kn,par, ' el,dth '	' E ash,paf,psh,sc,dth ' E° aar,cf,athi,kn, ' ale,pop '
3	'E ash,psh,sc 'E° cf,par,el,C <sub>7</sub> , ' dth '	' E ash,psh,sc ' E° aar,cf,athi,kn,ale, ' C <sub>7</sub> ,dth,pthi,pop '
3	'E psh,sc,dth 'E° ash,cf,par,el '	' E psh,sc,dth ' E° ash '
4	'E kn,ale,pthi,pop, ' ple 'E° aar,cf,athi,paf, ' psh,sc,dth ' '	' E ash,umar,aar,cf,) ) ' ulth,athi,kn, ) ' ale,paf,psh,par,) 96 ' sc,dth,pthi,pop,) Hrs. ' ple ) '

Av. 3.2

DECLASSIFIED



Table XXII

Test No. 2e - Field Set (Light Weight Simplified)

Reimpregnated Clothing

Date Started: 10/15/45

No. of Exposures Tolerated	Readings (Hours after Last Exposure)	
	24	48
3	' E ash,psh,sc	' E ash,psh,sc,dth
	' E° el,dth	' E° el
	'	'
3	' E aar,sc,dth	' E aar,dth
	'	' E° ash
	'	'
2	' E ash,psh,sc,dth	' E psh,sc,dth
	'	' E° ash
	'	'
3	' E paf,psh,sc	' E paf,psh,sc
	'	'
	'	'
1	' E psh,sc	' E psh,sc,dth
	' E° ple	' E° ash,cf
	'	'
1	' E ash,psh,sc	' E ash,psh,sc
	' E° dth	' E° kn,el,dth
	'	'

Av. 2.2

CONFIDENTIAL

DECLASSIFIED



Table XXIII

Supplementary Tests on Worn CC-2 Impregnated Clothing  
Breaks/Day

Date Started	Type of Clothing	Conc. H ( $\frac{g}{l.}$ )	Time of Exp. (Min.)	CT of Exp.	No. of Men	No. of Breaks on Day No. -					No. of Breaks	Av. Exp. Tol.	Av. Total CT Tolerated
						1	2	3	4	5			
9/17/45	Worn 2 Wks.	5.0	60	300	6		2	2	2		6	4.0	1200
9/17/45	" " "	2.5	120	300	6		1	1	3,1*		5	4.5+	1350+
9/17/45	" " "	10.0	60	600	6		5,1*				5	2.0+	1200+
9/17/45	" " "	5.0	120	600	6		5	1			6	3.2	1920
10/15/45	Reimp. by Field Set (LWS) and Worn Two Weeks.	10.0	60	600	6	2	1	3			6	2.2	1320

\*Subject withdrawn from test for reasons other than a "break".

DECLASSIFIED



Appendix IV

Detailed Physiological Data for  
Tests on Stored CC-2 Impregnated Clothing

Table XXIV

Test No. 3a - Simulated Tropical Storage (2 mo.)

Date Started: 10/15/45

No. of Exposures Tolerated	Readings (Hours after Last Exposure)	
	24	48
7	' E pop ' E° pthi,ple	' E pthi,pop,ple ' E° psh,sc,dth
4	' E paf,psh,sc,dth ' E° pop	' E° sc ) 96 hrs.
3	' E cf,psh ' E° ash,aar,el,sc, ' dth,pop	' E cf,psh,sc,dth ' E° ash,aar,kn,el, ' C7,pop
4	' E lth,psh,sc,dth ' E° ash	' E° ash,lth,psh,par,) 96 ' el,sc,dth )Hrs.
3	' E psh,sc ' E° ash,el,dth, ' pthi,pop,ple	' E psh,sc,dth ' E° ash,cf,el,pthi, ' pop,ple
4	' E psh,sc,dth ' E° ash	' E° psh,sc,dth) 96 Hrs.

Av. 4.2

DECLASSIFIED



Table XXV

Test No. 3b - Shipboard Storage

Date Started: 10/15/45

No. of Exposures Tolerated	Readings (Hours after Last Exposure)	
	24	48
4	'E psh,sc,dth,lum 'E° kn,el,C <sub>7</sub> ,pthi, ' pop,ple	' E psh,sc,dth ) ' E° par,el,pthi,) 96 ' pop,ple )Hrs.
2	'E sc 'E° ash,paf,psh, ' dth,pop,ple	' E sc ' E° ash,aar,cf,psh,dth, ' pop,ple
2	'E psh 'E° ash,cf,vth, ' athi,kn,ale,el, ' sc,dth	' E athi,kn,psh,pop ' E° cf,ale,el,C <sub>7</sub> ,sc,dth, ' pthi,ple
2	'E lum 'E° psh,sc,dth	' E lum ' E° psh,sc,dth
3	'E psh,sc 'E° ash,el,dth,pop	' E psh,sc ' E° cf,el,dth,pop
1	'E psh,sc,dth 'E° ash	' E psh,sc,dth,C <sub>7</sub> ' E° ash

Av. 2,3

DECLASSIFIED



Table XXVI

Tests on Stored CC-2 Impregnated Clothing

Breaks/Day

Date Started	Type of Clothing	Type of Storage	No. of Men	No. of Men Broken on Day No.-							No. of Breaks	Av. Exp. Tolerated
				1	2	3	4	5	6	7		
10/15/45	Standard Aqueous	Tropical	6			2	3			1	6	4.2
10/15/45	Unstabilized Solvent	Shipboard	6	1	3	1	1				6	2.3

DECLASSIFIED



Appendix V

Detailed Physiological Data For  
Tests on Marine Corps GC-2 Impregnated Clothing

Table XXVII

Test No. 4a - Field Set (M-1) Impregnation

Date Started: 5/10/45

No. of Exposures Tolerated	Readings (Hours after Last Exposure)	
	24	48
5	' E ax,cl,ane ' E° aar,aaf,uvth,uab, ' kn,paf,psh,C7,sc, ' dth,ust	' E cl,aaf,ax,ulth, ) ' uvth,paf,uab,sc, ) 96 ' dth,pop,ust ) Hrs. ' E° cf,kn,ale,psh, ) ' C7,pthi )
2	' E cf,dth,ane,ust ' E° aar,kn,paf,psh, ' par,el,sc,lne,pne	' E cl,aar,cf,paf,psh,sc, ' dth,ane,ust ' E° umar,ax,lth,uvth,kn, ' par,el,C7,lne,pne
7	' E umthi ' E° psh,C7,sc,dth, ' pop,ane,lne,ust, ' pne	' E umthi,pthi,pop ' E° athi,kn,ale,psh,par, ' el,sc,dth,ple,ane, ' lne,ust,pne
5	' E psh,sc,dth ' E° cf,ax,lth,vth,ab, ' athi,kn,ale,paf, ' pop,lne,ane,ust, ' pne	' E cf,ax,kn,paf,psh,sc, ' dth ' E° ulth,vth,ab,athi,ale, ' C7,pop,pne,lne,ane, ' ust
6	' E dth ' E° kn,psh,sc,pthi, ' pop,ple,ane,lne, ' pne	' E dth,pne ' E° athi,kn,ale,psh,el, ' sc,pthi,pop,ple,ane, ' lne,ust
6	' E kn,sc,dth,pop ' E° umar,cf,ax,ulth, ' uab,athi,ale,psh, ' el,pthi,ple,pne, ' lne,ane,ust	' E athi,kn,ale,sc,dth, ' pthi,pop ' E° umar,aar,cf,ulth,ab, ' paf,psh,ple,ane,lne, ' ust,pne

(Continued on next page)

DECLASSIFIED



Table XXVII (Cont'd.)

No. of Exposures Tolerated	Readings (Hours after Last Exposure)	
	24	48
4	'E aar,cf,umthi,athi, ' kn,ale,paf,psh,el, ' sc,dth,pthi,pop, ' ple 'E° par,C7,ane,lne,ust'	' E aar,cf,athi,kn,ale, ' paf,psh,el,sc,dth, ' pthi,pop,ple ' E° uab,par,C7
6	'E paf,psh,C7,sc,dth 'E° cf,ax,lth,uab,kn, ' el,ane,lne,ust, ' pne	' E cl,psh,C7,sc,dth,pne ' E° aar,cf,ax,lth,uab, ' kn,ale,paf,el,pthi, ' pop,ple,ane,lne,ust
6	'E cl,paf,psh,C7,sc, ' dth,ane,lne,pne,ust 'E° athi,kn,ale	' E cl,paf,psh,sc,dth,pne, ' ust,lne,ane ' E° aar,cf,athi,kn,ale, ' C7,pthi,pop,ple
2	'E ax,psh,sc,dth 'E° par,el,C7,ane, ' lne,ust,pne	' E ax,psh,sc,dth,ane,lne, ' pne,ust ' E° kn,par,el,C7
9	'NV psh,umar 'E° kn,paf,ane,lne, ' pne,ust	' NV umar,psh ' E ust ' E° kn,pop,ane,lne
3	'E cl,ane,ust 'E° uvth,psh,C7,sc, ' dth,pne,lne	' E cl,uvth,ane,ust ' E° paf,psh,C7,sc,dth, ' lne,pne
4	'E ane,ust,pne,lne 'E° psh,el,C7,sc,dth	' E ane,lne,ust,pne,psh, ' sc,C7,dth ' E° cf,uab,kn,el

Av. 5.0

 L

DECLASSIFIED



Table XXVIII

Test No. 4b - Stabilized Solvent (CaCO<sub>3</sub>) Impregnation

Date Started: 5/10/45

No. of Exposures Tolerated	Readings (Hours after Last Exposure)	
	24	48
12	V cf,fa E° ash,umar,aar,kn, paf,psh,el,sc, dth,ane,lne,ust, pne	NV dh,wr V fa E cf,paf,psh,el,sc,ane, ust,lne E° ash,aar,aaf,kn,dth, pthi,pop,ple,pne
8	E ane,lne E° ust,kn,pne	E ane,lne E° ust,cl,pne
6	E paf,psh,sc E° ane,ust,pne, el,dth	E ane,pne,paf,psh,sc,dth E° ust,lne,cl,umar,kn
4	E ane,ust,lne E° kn,pne,psh,sc, dth	E ane,ust,lne,cl E° aar,cf,kn,pne,psh,par, el,sc,dth,pop,ple
12	NV kn E° ane,ust,lne,pne, psh,el,sc,dth	NV kn E° ane,ust,lne,pne,psh, el,sc,dth
7	E ane,ust E° lne,ash,kn,pne, paf,psh,sc,dth	E ane,ust,lne E° ash,athi,kn,ale,pne, paf,psh,sc,dth,pop
9	NV aar E° ane,ust,lne,scr, kn,pne,psh,el, C7,sc,dth	NV aar E cf E° ane,lne,ust,kn,pne, psh,sc,dth

Av. 8.3

DECLASSIFIED

Table XXIX

Tests on U. S. Marine Corps Impregnated Clothing

Breaks/Day

Date Started	Type of Clothing	No. of Men	1	2	3	4	5	6	7	8	9	10	11	12	No. of Breaks	Av. Exp. Tolerated
5/10/45	HBT-Field Set (M-1) Impreg.	13		2	1	2	2	4	1		1				13	5.0
5/10/45	Arnzen-Solv. + CaCO <sub>3</sub> Impreg.	7				1		1	1	1	1			2	7	8.3

DECLASSIFIED



Distribution

Bu Ships	17
Bu Med	2
OR&I	2
CO, Naval Unit, E. A.	1
CWS, Tech. Div.	4
CWS, Med. Div.	1
CWS, Med. Div. EA	1
NDRC (Dr. W. Reeve)	4
NRC, Wash. D. C.	2

DECLASSIFIED