

R.A. BAILEY

HEADQUARTERS QUARTERMASTER RESEARCH & ENGINEERING COMMAND, US ARMY
Quartermaster Research & Engineering Center
Natick, Massachusetts

C-1,290

TEXTILE, CLOTHING & FOOTWEAR DIVISION

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HISTORY OF WORLD WAR II
DEVELOPMENT OF JUNGLE WARFARE UNIFORM

by

Dr. David Bruce Dill

Approved: Theodore L. Bailey, Chief
Clothing Branch

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UNIFORMS



FORWORD

The emergence of a number of new uncommitted nations in underdeveloped tropical areas and the crises in South East Asia and the Congo have led to an increased interest in jungle warfare and associated clothing and equipment. The research background, which led to the adoption of the present standard clothing for jungle warfare, is largely unavailable to those now in positions of decision. The paper that follows was prepared by Lt. Col. David Bruce Dill, a medical officer serving with the Quartermaster Corps as the Chief of the Analysis and Test Group of the Research and Development Branch in OQMG during World War II. Dr. Dill's paper summarizes all the World War II research which led to the adoption of the present standard tropical or jungle warfare uniform. This uniform, Shirt, Man's, Cotton/Poplin, OG 107, and Trousers, Man's, Cotton/Poplin, OG 107, (Formerly Jacket and Trousers, Lightweight) is currently under the monetary allowance although it was originally adopted as a functional combat uniform parallel to the cold-wet, cold-dry original issue of combat clothing.

While the uniform under question can undoubtedly be improved in the future, it represents the best that is available today for hot climate limited warfare.

Dr. Dill's paper is reproduced here to make available the research background of the poplin uniform and also to serve as source material for future development.

THE COMBAT UNIFORM

Soldiers fighting in tropical theatres have no uniform specially designed for them. In contrast with the highly specialized clothing provided the combat soldier in extreme cold and in temperate climates, he wears the two-piece "fatigue" suit in the tropics--a suit used only for fatigue duties in other theatres. In the early days of tropical warfare special attention was given to the need for protective coloration, but after trial of a camouflage pattern in both one-piece and two-piece HBT garments, trousers and jackets in O.D. #7 were finally adopted. The emphasis on a camouflage design diverted attention from the many other important military characteristics of clothing worn by the soldier who must fight in rain, high temperatures and high humidities. Sometimes he is crawling through the grass, brush, thorns or mud of the jungle. Frequently he is subject to bites of creeping and crawling insects with resulting infections and disease. He is provided with a headnet, gloves and insect repellent to keep mosquitoes away from his face and hands, jungle boots to make easier the jungle trails, a machete to cut his way and a prized Jungle Medical Kit with which to treat his wounds. Still his uniform is not especially adapted to his needs.

Eventually a new idea was born and after many vicissitudes reached the flowering stage. The checkered history of this project illuminates the paths one often follows in military developments. The story is told here hoping that it will be a useful guide to those charged with research and development whether in or out of the QMC.

Faults of the HBT Uniform

Because of the hazards of scratches from thorns, of bites from insects and of burns, all combat soldiers must keep their bodies covered, even though it is uncomfortable to do so. When our first observer, Capt. Robert L. Woodbury, returned from the Buna campaign in May 1943, he brought with him tales of the extreme fatigue suffered by men fighting in humid heat. Since then these tales have multiplied: if a soldier experienced in tropical combat complains about his equipment, his clothing will be near the head of the list: he thinks it is hot, heavy, slow to dry, quick to get dirty, hard to wash, subject to snagging: he dislikes the metal tack-on buttons, the gas flaps, the pockets, the poor fit and the poor design (Exhibits 1 and 2). "The present HBT type uniform is universally disliked by troops in this theater. The principal complaints are poor fitting and heavy weight. They are exceedingly hot for wear in this theater."

Study of an Experimental Tropical Uniform

The Quartermaster in the Southwest Pacific Area, attentive to such complaints, evolved many experimental uniforms, varied in design and fabric. Capt. Woodbury brought back one of these for study. It was a two-piece suit made of closely-woven, light-weight Byrd Cloth (known to the British as Grenfell Cloth). The highlights of developments from that time until late 1944 are presented in Exhibit 3. Certain phases of the development will be singled out for attention, namely:

- Physiological studies
- Mosquito protection
- Vesicant gas protection
- Theater tests
- Board test
- Design

Physiological Studies

When the Byrd cloth uniform was proposed, critics raised the objection that such a tightly woven fabric would be hot. They pointed out that a loose weave had been sought in HBT with the need for coolness in mind. The hypothesis upon which this objection was based was tested in Florida by a party from Military Planning Division, headed by Major Ronald M. Ferry. Various fabrics were used and it was established that the closely-woven fabrics were at least not hotter than heavier, porous fabrics. All soldiers who wore the test garments thought that those made of poplin were cooler, lighter, quicker to dry and more protective against mosquitoes than HBT. Soldiers given their choice wore poplin, choosing it over Byrd cloth because the seams of the latter garments ripped. It is significant that the principal results of that first study of the tropical uniform have not

been challenged. The subjective reactions of soldiers in this Florida test, living and working for several days under sub-tropical conditions, coupled with physiological observations, convinced some that the uniform should be standardized. It was decided, however, to make more tests, both of wearing qualities and of heat load, the latter to be carried out in a physiological laboratory. Research and Development Branch assigned the responsibility for these latter tests to Dr. Sid Robinson of Indiana University, Special Consultant to the QMC, working under the auspices of the Committee on Medical Research, OSRD.

Robinson's series of reports, summarized in Exhibit 4, began 7 December 1943. In his first report it was concluded that the heat stress of acclimatized subjects working under simulated tropical conditions

increases with: thickness of fabric
weight of fabric
weight of water required to wet the fabric
length of time required to dry the fabric

decreases with: amount of ventilation provided through apertures
percent of body exposed

Poplin and Byrd cloth were measurably cooler than HBT--10% cooler as judged by sweat rate.

Tests by Robinson continued and he joined forces with Dr. Lyman Fourt during the summer of 1944 to prove conclusively that heat stress is independent of tightness of weave within broad limits of air permeability and air movement.* This proved non-valid the early thinking that guided the development of the moderately permeable HBT: there is no merit physiologically in such a characteristic.

Late in 1944 the QMC Climatic Research Laboratory began evaluating various fabrics proposed for tropical uniforms (Exhibit 5). Robinson's conclusions that heat stress is higher in HBT than in lightweight closely-woven fabrics such as poplin have been confirmed. Even where there are no measurable differences in heat stress, there may be decided soldier preferences. Curiously enough, there was decided preference for Uniform Twill, Khaki, over the same fabric in OD #7. Poplin proved to be one of the favorite fabrics.

* Dr. Fourt presented his physical findings 2 August 1944, at a conference on the "Principles of Environmental Protection" held under the auspices of the Climatology and Environmental Protection Section, Research and Development Branch, Military Planning Division, Office of the Quartermaster General:

Mosquito Protection

The hazard of mosquito-borne diseases was deeply impressed on soldiers by the high incidence of malaria in the early New Guinea campaigns. The inadequacy of protective measures led to intensive studies by all responsible agencies. The first study of the degree of protection afforded by various types of fabrics used in clothing was made in 1943 by the QMC Florida party mentioned above. Byrd cloth and poplin gave almost perfect protection, uniform twill was nearly as good while HBT gave practically no protection. Following this pioneering test, laboratory observations have continued by the Bureau of Entomology and Plant Quarantine at Orlando, Florida and at Beltsville, Maryland. Field studies have been conducted under the auspices of the Panama Mobile Force, Caribbean Defense Command, and by the Quartermaster Board (Test No. 1450) in Florida in 1944. Finally there have been several reports from theaters of operation in the tropics. References are given in Exhibit 6, together with a summary of findings. The outstanding conclusions are:

Some species of mosquitoes bite through HBT easily.

Some species of mosquitoes can bite through poplin occasionally, but few ever bite through the more closely-woven Byrd cloth or the newly developed Oxford cloth.

In the light of concurrent physiological tests, the mosquito protection of the clothed part of the body afforded by light-weight, closely-woven fabrics does not involve a sacrifice of comfort, but rather a gain.

Protection Against Vesicant Gases

It is an accepted military characteristic of combat clothing that at least one layer be capable of impregnation with chemical agents and that when so impregnated it protects against vesicant gases. This characteristic is in accord with War Department policy. The degree of protection that can be offered depends on the nature of the fabric--both weight and strength of material--on the efficiency of closures and on the stability of the impregnated fabric during storage.

The greater the weight of a given fabric, the greater the quantity of impregnate held and the longer the useful period of protection against vesicant agents. On this score HBT is preferred, since per unit of surface it is about one-third heavier than poplin. This does not exclude poplin from consideration, however, since overloading with impregnate is possible, and in addition poplin may offer compensatory advantages. For example, a possible advantage of poplin (so far not studied) is that its low air permea-

bility may make it more protective than HBT in wind.

The strength of material and the garment's life under combat conditions are of major importance in determining its usefulness in carrying impregnate. A garment that offers perfect protection when intact fails if it is subject to rips and tears. In this respect poplin garments are more resistant to snagging and wear longer than HBT. (Details will follow.)

The efficiency of closures in protective garments requires the use of flaps or other devices that prevent the direct access of gas to the skin. The flap added to the jacket closure is not popular with soldiers and it is commonly torn out because it is inconvenient and makes the garment hotter. Also the tack-on buttons needed to attach the hood are objected to and removed. These facts mean that many soldiers, when first subjected to gas attack, would have to discard clothing so mutilated and rely on new clothing kept in reserve. If it is possible therefore, to use a fabric and design that is acceptable to the soldier without mutilation and also to make easily available to his company commander a field-impregnation outfit, there would be a better chance of protecting him against a surprise gas attack than is now the case. The poplin uniform in improved design would gain this end. In any case, the faulty design of the HBT protective devices should be corrected.

The stability of impregnated clothing is an acute problem since according to present policy, a stock of such clothing must be held in reserve in every theater--at least one outfit per man. In the tropics such clothing has had a useful life of not over nine months although it is being lengthened by specially selecting the fabric for such garments. On this score poplin has rated poorly as judged by laboratory tests and it is the present view of Chemical Warfare Service, (CWS), that poplin, while suitable for field impregnation, is unsuited for storage impregnation. So long as this view holds, if poplin garments are standardized, a stock of impregnated HBT Garments made of specially selected fabric must be kept in reserve in case of gas attacks.

The present War Department policy on storage impregnation should be reviewed.

The following questions are raised:

What is the record of availability of durable, non-deteriorated, impregnated garments to task forces in tropical theaters?

Are there field-evaluated methods that enable CWS officers to determine the stage of deterioration that renders a garment unserviceable?

The principle of on-the-spot impregnation, or of impregnating in a staging area, has been validated by experience with DMP impregnation for protection against the scrub typhus mite. Therefore, why not abandon the present wasteful and burdensome maintenance of stored impregnated clothing and rely solely on field impregnation?

Theater Tests

Jungle combat uniforms have been tested by four widely separated infantry divisions involved in light to heavy combat activity. The weather, terrain, and locations where those tests were made are described in Exhibit 7. The summary of test results (Exhibit 8) proves that a lightweight, closely woven strong fabric is superior in every important respect to the present HBT uniform. Specifically it is superior on the following counts:

- Durability - wears longer
- Heat load - is cooler
- Dirt penetration - stays cleaner
- Water absorption - absorbs less water
- Launderability - is easier to wash
- Drying time - dries faster
- Mosquito protection

There is one point that deserves special attention, - durability. It is noteworthy that the two organizations that gave the garments a long wear test, rated them equal or better than HBT. After four months' use the 37th Infantry Division concluded, "There was no noticeable difference in durability between this type uniform and HBT's."

The 7th Infantry Division tested poplin and uniform twill throughout the early four months of the Leyte operation. The report states:

"88% of those issued 8.2 twill say their trousers were either slightly worn or show no wear. 86% of those issued poplin say the same thing--therefore the fabrics are very nearly equally durable in battle."

In an earlier radio report, indorsed by Division and Corps Commanders, it was stated that poplin does not tear as easily as HBT--that poplin uniforms outlast HBT uniforms. (S-2482 and S-3511)

In the light of theater experience the combat efficiency of the soldier fighting in hot climates would be improved by giving him a poplin uniform.*

Board Tests

Preliminary to the theater tests, the Quartermaster Board in November 1944, initiated a wear test of the proposed uniform. In the Board report (Test No. 1343), submitted in April 1944, it was concluded that:

1. "Based on the QMB scoring system, after 10 trips over the combat course the amount of fabric deterioration in HBT trousers is approximately 33% less than....in poplin...."
2. By the same token, "after 15 trips...deterioration in the HBT jackets is approximately 24% less than....in poplin...."

The Quartermaster Board was requested to carry out a comprehensive field test of tropical uniforms of various fabrics (OQMG Test 1450, Florida) and arrangements were made with AGF for a somewhat parallel test by infantry troops (OQMG Test 293, Infantry Board, Ft. Benning, Ga.). The results of these two tests are summarized in Exhibit 9. Some conclusions reached by the Board differed considerably from those reached by combat troops; reference to this will be made below.

Design of the Tropical Uniform

It was one purpose of the various tests of the tropical uniform to evolve a design which best contributes to combat efficiency and which still conforms to other required military characteristics. Opinions expressed by combat troops were remarkable in their agreement. The design of the test uniforms is shown in Exhibit 10 and the final design, based on theater recommendations, is given in Exhibit 11.

* While the theaters tested only poplin and uniform twill, it is likely, as judged by other tests, that Byrd cloth or 6.5 oz. oxford cloth might have proved as acceptable as poplin.

Critique of Board Tests of the Tropical Uniform

No other recently developed Quartermaster item has had as extensive tests at home and overseas as has the tropical uniform. Hence a comparison of conclusions reached by the test agencies throws light on the validity of their techniques. In certain respects the Boards and combat troops agree - for example:

Poplin is preferred for the jacket.
Poplin is equal or superior to HBT in coolness.
Dirt doesn't penetrate poplin; it is easier to wash than HBT.
Poplin is lighter in weight and dries faster.

In some respects combat troops disagree with conclusions reached in Board tests - for example:

Troops prefer poplin for trousers and say it wears as well as HBT. The first Quartermaster Board test, over the combat course, showed poplin up poorly; the later field test rated it satisfactory. Infantry Board recommended uniform twill for trousers; poplin trousers ripped, especially in the crotch.

Troops like slash pockets; the Quartermaster Board recommends eliminating them.

Troops recommend eliminating cargo pockets but Quartermaster and Infantry Boards recommend retaining them.

Troops object to tack-on buttons; Boards accept them.

The above differences in opinion can be accounted for by two basic assumptions:

Board tests of wearing quality of combat clothing may be faulty.

Board opinions on design of combat clothing may be unrealistic.

The conclusion reached by the Quartermaster Board in Test No. 1343, that poplin trousers did not wear as well as HBT, strongly influenced future planning. Uniforms sent overseas for test included uniform twill as well as poplin trousers. Even in February 1945, a reverberation of the year-old Quartermaster Board Test came from the Southwest Pacific. The USAFFE Board in Report No. 206, 8 February 1945* in a strong indorsement of the tropical uniform based on the report of their observer's visit to the 41st and 7th Divisions, added the following comment:

"The uniform according to controlled tests, has a life of 75% that of HBT. Although this would necessitate the shipment of more uniforms in a given length of time, the reduction in weight and bulk would make additional shipping space unnecessary.

* The full reference is:

USAFFE Board Report No. 206, 8 February 1945, file 319.25
T/O SWPA: theater file 334 (11 December 1944) FEED: Subj:
QM Information. The Quartermaster representative on the
USAFFE Board, Col. Gardner, was on duty in the OQMG during
April 1944 and was familiar with results of the Quarter-
master Board test. This is no doubt the "controlled test"
to which reference is made.

"In analyzing the need for this new uniform, more weight should be given to views of the soldiers than to those who have never worn the HBT fatigues. It is recommended that the new uniform replace the HBT in spite of the longer life of the HBT fatigue uniform."

This critique of Board tests of clothing is not intended as a sweeping criticism of testing methods. It does indicate, however, that the Quartermaster Board combat course and the combat experiences simulated by the Quartermaster and Infantry Boards are not representative of conditions under which our tropical wars are being waged. If they were representative, closer agreement should have been reached on wearing qualities and on details of design.

Conclusions

The present HBT uniform is not well adapted for combat in hot climates and is unpopular with troops, on account of its faulty sizing, poor design and heavy fabric.

For combat in hot climates a uniform made of lightweight, closely woven strong fabric such as poplin is superior to the HBT uniform and proved very popular with combat troops for the following reasons:

It has less tendency to snag, and wears longer in combat.
It is cooler.
Dirt has less tendency to penetrate it.
It is easier to wash.
It is quicker to dry and therefore more comfortable to wear while sleeping.

It is lighter in weight, wet and dry, and therefore less fatiguing.

It offers better protection against mosquitoes.

It has an improved design.

Poplin garments are suitable for impregnation in the field for protection against vesicant gases. If poplin proves unsuitable for storage after impregnation, either this scheme can be abandoned or special HBT garments can be channeled for this use, as at present.

The proposed design and fabric are superior to the present two-piece HBT for combat troops not only in the jungle but in any hot climate. It is proposed, therefore, that the design of the two-piece HBT uniform be improved at once, as outlined in Exhibit II, and that the fabric be adopted as rapidly as production facilities permit.

Tests carried out by Boards do not necessarily lead to the same conclusion as those carried out by combat troops.

Recommendations

That the present design of the two-piece HBT uniform be improved as outlined in Exhibit II.

That as soon as production facilities permit, a change-over to poplin or similar fabric be made and that such uniforms to be channeled to combat troops in hot climates.

That testing techniques used by our Boards be subjected to critical review in the light of accumulated war experiences and revised where at fault.

Table I

Soldier Opinion in Southwest Pacific Area of Items Carried or Worn in Combat

Morotai, Nov. 1944

Ten Most Valued Items

Ten Most Frequent Complaints

42 Officers and EM of 155th Inf. Regt.

Weapons	30	Jungle Pack too large and heavy	16
Canteen	17	Leggings	6
Ammunition	15	Steel Helmet	5
First Aid Packet	14	Carrying Machete	4
Jungle Medical Kit	12	Pockets too deep in HBT Jackets and	
Poncho	8	Trousers	3
Light Wool Socks	5	HBT too bulky and uncomfortable	3
Good Shoes	5	Rations too bulky for extended patrols	3
Side Arms	5	Side arms too stiff; chafe side of hips	3
Jungle or Trench		Cartridge belt, M1 rifle, cuts into hips	2
Knife	5		

99 Officers and EM of 167th Inf. Regt.

Weapons	82	Jungle Pack too large and heavy	42
Ammunition	42	Leggings	28
Jungle Medical Kit	37	Steel Helmet	26
Canteen	37	Field Uniform when off duty	
Rations	25	(leggings and shirt)	20
Poncho	21	Food	13
Steel Helmet	17	Clothes don't fit	9
First Aid Packet	15	Fatigue uniforms too heavy	8
Two Canteens	10	Carrying unnecessary clothing	6
Jungle or Trench		Pockets too deep in HBT Jackets and	
Knife	10	Trousers	5
		Carrying rifle on work details	5

EXHIBIT I

Table II

Soldier Opinion in Pacific Ocean Area of Items Carried or Worn in Combat

Palau Islands, Nov. 1944

Ten Most Valued Items

Ten Most Frequent Complaints

138 Officers and EM of 321st Regt.

Weapons	51	Jungle Pack too heavy	30
Canteen	49	Haversack	16
Poncho	33	Fatigues	14
Jungle Medical Kit	27	Leggings	14
Shoes	22	Cartridge Belt replaced by pistol belt	6
Steel Helmet	18	Unnecessary items	6
Cushion Sole Socks	15	Shelter half	5
Entrenching Tool	12	Eliminate pack	5
Knife	11	Poncho	4
Ammunition	11	Baggy pockets	4

117 Officers and EM of 322nd Regt.

Canteen	58	Jungle Pack too heavy	23
Jungle Medical Kit	44	Gas Mask	15
Weapons	30	Clothing too heavy	13
Poncho	17	Fatigues	12
Entrenching Tool	17	Unnecessary items	12
Knife	14	Leggings	7
Ammunition	12	Eliminate Pack	7
Rations	12	Baggy pockets	5
First Aid Packet	9	Cartridge Belt replaced by pistol belt	5
Steel Helmet	8	Excess ammunition	5

EXHIBIT II

EXHIBIT 3

The Tropical Uniform: Chronological Record

1. The pre-war development of HBT at the Philadelphia Quartermaster Depot emphasized the importance of three considerations: strength, porosity and procurability.
2. Lt. Woodbury returned from the Southwest Pacific Area (SWPA) about 15 May 1943, bringing with him a Grenfell cloth tropical uniform developed by the U. S. Quartermaster in Australia.
3. On 2 June 1943 the one-piece camouflage jungle suit was declared limited standard, following many complaints from the field that it was too hot and that its lack of opening was a serious handicap. At this time, Trousers and Jacket, HBT, Camouflage were standardized to replace the one piece garment.
4. Radio from 6th Army, SWPA, dated 27 July 1943, stated that preliminary tests indicated the superiority of Grenfell cloth to HBT for lightness, minimum water absorption and ease of field laundering. Durability test for field use were recommended, with a view to adoption of the new fabric if satisfactory. Requested 2-piece HBT O.D. #7, until Grenfell suits of the same color could be made available.
5. The uniform brought from Australia by Lt. Woodbury (Para. 2) was submitted to the Philadelphia Quartermaster Depot for analysis. PQD reported 24 August that the material was water-repellent and that it was similar to Byrd Cloth, the American counterpart of Grenfell cloth. Reactions of PQD and of this Office were at first negative on theoretical grounds; it was believed that a fabric with low air permeability, even though lightweight, would be unsuitable for tropical uniforms. Practical tests were nevertheless planned.
6. On 8 September 1943, OQMG wrote asking the 6th Army, SWPA, to furnish details of the Grenfell cloth uniform and the tests which had proved it cooler than HBT (Para. 4).
7. A field test was carried out in Florida, 15-29 September 1943, by representatives of the Military Planning Division. Results were as follows:
 - a. Poplin and Byrd cloth uniforms were more comfortable than HBT and 8.2 oz. Army Twill (felt cooler, weighed less dry, absorbed less water and dried more quickly). Byrd cloth tore badly at the seams whereas poplin did not.

b. Byrd cloth offered the best protection against mosquitoes but both poplin and 8.2 oz. twill were far superior to HBT.

c. Taking all factors into consideration, poplin was the first choice for uniforms. When men were not engaged in testing, they preferred to wear poplin or Byrd cloth.

8. Serious doubts remained as to the wear qualities of such lightweight fabrics as Byrd cloth and poplin. During October, the QM Board was called upon to submit a test plan; this was done 29 October.

9. On 12 October 1943, the Office of the Surgeon General was asked to transmit to the National Medical Research Institute a request for tests of mosquito protection afforded by the various fabrics under consideration. In indorsing this request, the OSG recommended on 19 October that parallel tests be carried out at Gorgas Memorial Laboratory in Panama and the Bureau of Entomology at Orlando, Florida, and that 1000 shirts and 1000 trousers of poplin, "which at present holds favor in mosquito impervious qualities", be sent to malaria units in the SWPA and SPA for test. Action on this indorsement was withheld pending the results of the proposed QMB Test. Unfortunately these were long delayed. (See Para. 23).

10. A jungle clothing meeting of Research & Development Branch, Military Planning Division, 13 October 1943, agreed to recommend the immediate adoption of poplin for the jungle uniform.

11. In answer to OQMG's September letter (Para. 6), SWP wrote on 15 October that one uniform had been tested in New Guinea for two months under rainy, humid, and hot conditions. The comparative lightness of the Grenfell cloth made it vastly more comfortable than other uniforms. "The material is considered sufficiently tough to withstand normal abusive use incidental to field service." Results of a test of 45 uniforms would follow (See Para. 16).

12. A memo prepared by members of Military Planning Division was sent to General Gregory on 23 October 1943. It gave the results of the Florida expedition, pointed out the advantages of Byrd cloth and poplin for jungle uniforms, and in view of the shortage of Byrd cloth, recommended that: (1) poplin be introduced immediately for field trials; (2) 1500 poplin uniforms be sent by air to the South Pacific for evaluation of comfort, durability, and mosquito protection.

13. Report from Dr. Robinson, University of Indiana, 7 December 1943: Heat stress measured by sweat rate in simulated jungle conditions (high temperature and R.H., still air) with acclimatized subjects increases with:

Thickness of fabric
Weight of fabric
Weight of water required to wet fabric
Length of time required to dry fabric

It decreases with:

Amount of ventilation provided
Percent of body exposed

Amount of sweating with different fabrics:

No clothing except for shoes, socks, athletic support	100%
Nylon, 3 oz.	144
Nylon, 5 oz.	152
Byrd cloth	159
Poplin	164
British Cellular weave	169
8.2 oz. Uniform Twill	172
HBT	181

14. A wear test over a combat course was initiated at the QM Board on 20 November 1943 to determine the relative durability of HBT, poplin, and Byrd cloth (OQMG Test 1343). A preliminary report dated 28 December 1943 indicated that poplin and Byrd cloth wore about 2/3 as well as HBT.

The final report was not ready until 14 April 1944. It showed that fabric deterioration was greatest in Byrd cloth, next in poplin and least in HBT. Jackets wore about 1/2 longer than trousers of the same material.

15. A jungle clothing meeting of 31 December recommended the use of 8.2 Uniform Twill for trousers because:

- a. Durability was thought to be about that of HBT.
- b. Mosquito protection was about that of poplin.
- c. Heat load was no greater than that of HBT.
- d. Material was more readily available than poplin or Byrd Cloth.

16. The report from SWP on the 45 Grenfell cloth uniforms (Para. 11), dated 10 January 1944, reported that the garments had been tested in New Guinea under extremely hot, humid, and rainy conditions. Tests

were continued for two months, though not under combat. Advantages of Grenfell cloth were (1) greater comfort to wearer due to lightness in weight; (2) quicker drying after laundering or exposure to rainfall. Disadvantages were that it did not give sufficient warmth at night unless a knit shirt was worn under the uniform.

17. A prospectus prepared by the QM Board, supporting the need for changing from HBT to a more comfortable and more mosquito-proof textile, was submitted to AGF and approved informally by them. At the same time, General Simmons and other officers of OSG indorsed the jungle clothing prospectus and agreed that the proposed change in fabric should be made at the earliest practicable moment.

18. Tests under actual jungle conditions were conducted by Major Kearny in Panama during February and March 1944 and participated in by Medical and Sanitary Corps officers. These tests showed a marked superiority of Byrd cloth over HBT from the standpoint of coolness, comfort, quickness of drying, and mosquito protection. Adequate comparisons of Byrd cloth and poplin were not made. Uniform Twill trousers were too heavy and binding at the crotch when wet with sweat.

19. Conferences held with AGF and with Col. H. P. Reeder resulted in a letter from Military Planning Division to ASF Hq., 29 February 1944, presenting all facts then known and requesting a test of the proposed uniform by ground force troops in tropical theaters. It was stated that QMCTC would be presented with a recommendation that poplin jackets and 8.2 oz. Uniform Twill trousers be used for combat troops in jungle areas.

20. Verbal objections were raised to this request by ASF Hq. because of doubts as to CWS protection and availability of material. The letter was nevertheless indorsed to AGF. Instead of an indorsement, AGF proposed 15 April that 1000 garments be sent to each of three tropical theaters. On 15 May 1944, ASF indorsed tests of jungle combat clothing in the South Pacific, Southwest Pacific and China-Burma-India Theaters of Operation by AGF technical observers and representatives of malaria survey units in those areas. These uniforms were accordingly procured. At the same time ASF made the reservation that no action be taken without assurance that the uniform in question could be procured in quantity without disrupting existing Army clothing and equipment manufacture. (See Exhibit 8, Theater Tests of Tropical Clothing)

21. Early in 1944 Dr. William Mann visited the South Pacific on a special War Department mission. He wore an experimental poplin uniform and discussed its merits with experienced infantry officers and men in that theater. Their verbal indorsement was hearty, and was followed

by a radio from the CG, SPA, dated 30 March 1944, requesting that experimental two-piece uniforms, 200 each of poplin and Uniform Twill, be sent to the theater for evaluation. The uniforms were accordingly dispatched by fast freight on 5 May. (See Exhibit 8, Theater Tests.)

22. Trousers and Jacket, HBT, Camouflage were declared limited standard 30 March 1944 since the camouflage pattern was considered undesirable. At the same time, the present uniform was standardized: two-piece HBT Trousers and Jacket, O.D. #7. There have been many favorable field reports of these garments. The chief objection to them has been heat load and heavy weight, especially when wet.

23. The answer to OSG indorsement of 19 October 1943 (Para. 9) was sent by OQMG to CG, ASF, on 24 April 1944. This letter stated that action had been withheld pending completion of extensive field tests in the zone of the Interior, and recommended that the request of the OSG for the shipment of garments to the Theater Commander be approved.

24. During May, an officer in AGF received an enthusiastic report of poplin uniforms from an officer who had worn his in Bougainville on all-day patrol. It was one of 20 uniforms issued to officers and enlisted men, to whom they "seemed much too good to be items of issue." The officer's suit was wet with water or sweat most of the days, was rarely taken off, yet dried during the nights and wore well. The material worked fine as a water repellent. The design was excellent. Uniform Twill trousers were too heavy and too hot. The poplin trousers were so popular that the twill trousers were not worn much.

25. Capt. Orr, a QM Combat Observer, wrote 22 May 1944: "When brand new, the (poplin) uniform was quite hot. Repeated launderings finally made wearing of the suit bearable. It is believed possible that a water repellent treatment was applied to the poplin uniforms inasmuch as they shed water when new. The tightness of the weave was looked upon as somewhat of a detriment."

This letter from Capt. Orr was followed by a radio from MacArthur to ASF, 26 June, which advised against procurement of proposed tropical uniforms (poplin) and recommended, both for combat and rear areas, 8.2 oz. twill shirts with HBT trousers, differing somewhat in design from the poplin uniforms. The radio stated that two types of jacket (poplin and twill) for combat and rear troops, would only confuse the supply situation. Poplin was not believed sufficiently durable, was far too hot, and glued to sweaty skin. "Do not believe extra mosquito protection afforded by poplin necessary; "comfort (i.e. coolness) is the chief functional requirement...."Two of the uniforms requested, plus two of the type proposed by OQMG, were air mailed to Orr 22 June.

26. Colonel Bolton, a British Officer, stated in June that laboratory tests carried out in England had compared Grenfell cloth with British cellular weave in terms of comfort under simulated tropical conditions. Contrary to the previously held hypotheses, Grenfell cloth proved the more comfortable. Col. Bolton brought to this country a tropical uniform made of utility gabardine, somewhat similar to Grenfell cloth, which was adopted by the British as a tropical combat uniform.

27. An informal report from Capt. Stern and Mr. Nilsson who wore tropical garments (one poplin and one Byrd cloth) on a 3-day march at Ft. Benning in June, stated that they were cool and felt comfortable. During the period the temperature reached 103; there was one thunder shower and two hours heavy rain. Both tropical uniforms gave almost perfect protection against mosquitoes, in marked contrast to HBT worn by other participants in the test.

28. Colonel Booth, AGF, returned from a 6-week tour in SWPA, reported on 7 July that poplin jackets and both poplin and Uniform Twill trousers were enthusiastically received. He found the jacket lightweight and cool. It was given a 3 to 4 hour work-out in a PT boat but did not soak through in spite of thorough splashing. The design of the trousers, including shape of packets, was very good.

29. The following is extracted from letter 4 September 1944, from Col. C. T. Davis, Infantry (CBI) to Colonel Doriot:

"Ref. the new Jungle Uniform, I wonder if this is the same sample given me in Panama by Major Kearny. He described the material as "Byrd Cloth." It is ideal in every way except that, being so tightly woven, it is practically air-tight. It is therefore, very hot. I have worn it myself many times and can personally testify. Unless your new suit is different, am afraid the jungle troops will reject it. In case the new suit is different from Kearny's, would like to see it. Is Leonard bringing samples?"

30. Lt. Col. Renn's report from the Pacific (1 Oct.): The two-piece HBT uniform is used throughout the SWPA for combat only; cotton khaki is worn for all other duty. Gen. Kryger was quoted as saying that HBT and khaki's are entirely satisfactory and to forget about anything else: a lighter weight uniform is not necessary. However, Col. Renn added, tests of 1000 poplin uniforms are being continued in SWPA in order to secure information for future reference. Shorts were seen only at Canton Island (ATC personnel). The O.D. #7 fades and washes out a good deal from clothing as well as other cotton items. This is not a matter of concern since we have air superiority. Efforts at camouflage have largely been abandoned.

31. Action was taken 10 October by QMCTC to standardize women's duty uniforms for SWPA in accordance with specific requests from that theater. Material: 6 oz. twill shirting and 8.2 oz. twill slacks. The cable stated that the Chief Surgeon does not approve wearing skirts or poplin waists in mosquito areas and that the material requested meets mosquito protective requirements. (A cable from R&D ASF, had stated earlier that 6 oz. cotton khaki is unsatisfactory to the OSG for mosquito protection.) Color: Khaki. It was stated that camouflage is unnecessary and that khaki is preferred for appearance and health protection. Protective flaps were requested, but in view of recent action to remove them from men's khaki uniforms, G4 (Lt. Col McDowell) decided at the meeting that they should also be removed from women's khakis without referring the question to the theater for reconsideration.

The subjects, acclimatized to heat, wore test clothing while working on a treadmill in a simulated tropical environment, the conditions being:

Temperature 87° F.
 Relative Humidity 80%
 Air Movement 1/4 mph

The heat load was evaluated by measurements of heart rate, skin temperature and rate of sweating. A standard procedure was followed whereby on one occasion, two subjects walked together, one wearing standard, one wearing test uniform; and on a second occasion the same subjects exchanged uniforms and repeated the walk.

Conclusions reached were:

HT should be replaced by cooler clothing such as rayon, poplin or Gyd fabric.
 No difference was found between the heat load imposed by water repellent (WR) and non-water repellent (non-WR) treatments.

Report No. 2, 21 December 1943: Field tests of jungle clothing.

This summarizes observations made by Dr. Robinson while a member of the Military Planning group which studied tropical clothing in the Everglades of Florida, September 1943.

Summary: "The rates of sweating of men wearing the various suits indicate that HT is somewhat hotter than the other fabrics... The men felt that the fabric, Gyd cloth and poplin, were cooler than the thicker fabrics. This was despite the fact that Gyd cloth and poplin are slightly woven fabrics with low air permeability, while HT and British cellular weave are much more permeable."

EXHIBIT 4

Physiological Studies of Tropical Uniforms

By Dr. Sid Robinson and Associates

These investigations were carried out in the Department of Physiology, Indiana University Medical School, Bloomington, Indiana. They were supported by the Committee on Medical Research, OSRD.

Report No. 1, 7 December 1943: Physiological Studies of Clothing for Men Working in Humid Heat.

The subjects, acclimatized to heat, wore test clothing while walking on a treadmill in a simulated tropical environment, the conditions being:

Temperature	87° F.
Relative Humidity	80%
Air Movement	1/4 mph

The heat load was evaluated by measurements of heart rate, skin temperature and rate of sweating. A standard procedure was followed whereby on one occasion, two subjects walked together, one wearing standard, one wearing test uniforms; and on a second occasion the same subjects exchanged uniforms and repeated the walk.

Conclusions reached were:

HBT should be replaced by cooler clothing such as nylon, poplin or Byrd cloth.

No difference was found between the heat load imposed by water repellent (WRT) and non-water repellent. (non WRT) treatments.

Report No. 2, 31 December 1943: Field Tests of Jungle Clothing.

This summarizes observations made by Dr. Robinson while a member of the Military Planning party which studied tropical clothing in the Everglades of Florida, September 1943.

Summary: "The rates of sweating of men wearing the various suits indicate that HBT is somewhat hotter than the other fabrics...The men felt that the thin fabrics, Byrd cloth and poplin, were cooler than the thicker fabrics. This was despite the fact that Byrd cloth and poplin are tightly woven fabrics with low air permeability, while HBT and British cellular weave are much more permeable."

Report No. 5, 15 February 1944: Physiological Studies of Clothing for Men Working in Hot Environments.

This study concerns the effects on men working in a hot environment, of impregnating their clothing with CC2 (for protection against vesicant gases). DMP (dimethyl phthalate, for protection against insects, particularly mites) and WRT (chemicals that make clothing water repellent). None of these impregnations, including WRT, had any effect on the heat load of the test garments.

Report No. 6, 18 February 1944: Studies of Nylon and Cotton Clothing for Men Working in Humid Heat.

A 3 oz. nylon suit was compared with a 3 oz. cotton suit. It was concluded that the suits wore equally cool. It was suggested that a decision be reached regarding minimal thickness and weight of cotton fabrics which can meet Army requirements for durability.

Report No. 7, 15 March 1944: Summary of Results Thus Far Obtained.

Under simulated jungle conditions, the coolness of clothing is related as follows:

Directly to: thinness of cloth
amount of ventilation through apertures
percent of the body surface exposed
Inversely to: weight of the suit
amount of water required to wet the suit
length of time required to dry the suit.

Water repellency of clothing was found to be of great advantage to men exposed to cold rains; it did not significantly affect evaporative cooling.

Report No. 9, 17 May 1944: Suggested Plan for Field Test of Water Repellent Clothing.

Clothing which dries quickly is a great advantage in any wet climate. "It is necessary to carry out extensive field studies in order to know all possible advantages and disadvantages of water repellent clothing." A test procedure was recommended for field tests both in cold rainy weather and in hot rainy weather.

Report No. 11, May 1944: Studies of the Physiological Effects of Solar Radiation.

Clothing such as uniform twill shirts and trousers worn when sitting in the hot sun reduces the heat load below its value when sitting nude; whereas in moderate to hard work, wearing only shorts and a helmet involves less heat load than when the man is fully clothed.

Report No. 12, 14 May 1944: Effects of Hot Environments on Man.

It was the purpose of these 182 experiments to determine the physiological effect on men of variations in air temperature and humidity up to the limits of human tolerance. The effects of clothing and of work on man's response to his environment were determined in conditions ranging from cool to very hot with both low and high humidities. An environmental physiological index was derived, based on heart rate, skin temperature, rectal temperature and rate of sweating.

Report No. 16, 4 November 1944: Physiological Methods of Testing Hot Weather Clothing.

This described physiological methods developed by Dr. Sid Robinson and his associates in testing hot weather clothing. The laboratory is described as well as the types of activity employed and the physiological measurements that have proved most significant.

Report No. 17, 10 November 1944: Methods for Use in Field Tests of Hot Weather Clothing.

This puts in accessible form the fruit of a year's experience in the laboratory and in the field by Dr. Robinson and his associates.

Report No. 18, 20 December 1944: Physiological Comparisons of Hot Weather Clothing.

Uniforms tested were made in the standard 2-piece HBT design of the following fabrics:

- Shirley (Cloth, Cotton, Wind-resistant, Oxford, 6.5 oz.)
HBT
- Uniform Twill, 8.2 oz. OD #7
- Uniform Twill, 8.2 oz. Khaki
- Uniform Twill, 6 oz. OD #7
- Poplin (Cloth, Cotton, Wind-resistant, Poplin)
- Seersucker

In addition, the effects of wearing the Brynje vest under the uniform were studied.

Laboratory studies showed no difference between heat stress imposed by oxford, poplin, and 6 oz. uniform twill. They were all cooler than the 8.2 oz. uniform twill and they were also cooler than seersucker. The British type Brynje vest increased the heat load of men working under jungle conditions, both as determined by laboratory experiments and by field tests. Field studies were carried out on the effects of heat stress on OD #7 and Khaki color, with men working in the sun. The Khaki colored uniform was somewhat cooler than the green uniform.

Report No. 19, 12 January 1945: Comparison of the Resistances of Poplin and HBT Jungle Uniforms to Rapid Bodily Movements.

The resistance to rapid bodily movements imposed by HBT and by poplin uniforms was determined by timing cross-country runners wearing such uniforms. The runners made better time when they wore poplin and were unanimous in agreeing that it offered less drag on their legs.

Report No. 20, 13 January 1945: The Effects of Air Movement and Air Permeability of Clothing on Working Men.

Varying the air permeability of clothing between the limits of 12 and 40 units (defined as $\text{ft}^3/\text{ft}^2/\text{min.}$ at a pressure of 0.5" of water) makes no consistent difference in the heat load, nor does it alter to any important degree the proportion of heat dissipated by the avenues of radiation, convection and evaporation. Changes in air movement, within the limits of 5 to 184 m./min. (0.2 to 7 mph.) produced the same effects, regardless of air permeability within the above stated limits.

EXHIBIT 5

Jungle Uniforms: Test No. 80
QMC Climatic Research Laboratory
Lawrence, Massachusetts

Phase I: Physiological Heat Load: Report 1-2 December 1944

Basic conditions were established:

Temperature	90° F. ± 1°
Relative Humidity	85% ± 2%
Wind Velocity	1.5 mph

Eight to ten acclimatized soldiers spend 3 hours a day, five days a week, in this environment. The middle hour is spent in paired tests, walking on a treadmill at 3.5 mph., the other two as the subject pleases (avoiding exercise). At the end of the hour's exercise, measurements are made of rectal temperature, pulse rate, sweat loss and amount of perspiration absorbed by the test garments. Each subject evaluates the garments worn in regard to coolness, drag, skin sensation and overall preference. Basic clothing was determined as:

Drawers, Cotton, Shorts
Socks, Wool, Cushion Sole
Boots, Jungle

The conclusion was reached that if adequate precautions are taken in regard to control of conditions and subjects, reproducible data regarding physiological heat load may be obtained.

Phase II: Thickness, Wet and Dry: Report 11 December 1944

Thick fabrics (approx. 0.30" new and dry, .024" old and wet)

HBT: 8.2 oz uniform twill (WRT, non-WRT and Khaki color)

Medium fabrics (approx. .022" new and dry, .018" old and wet)

Nylon-filled poplin; 6.5 oz. oxford;* 6 oz. khaki twill; 5 oz. poplin (Both WRT and non-WRT)

Thin fabric: Nylon twill, about 0.13" thick.

WRT apparently has little effect on the thickness of a fabric. As a general rule, weight of a fabric is correlated with thickness, an exception being 6.5 oz. oxford which was thinner than other 5 and 6 oz. fabrics. Old, wet fabrics are generally thinner than new, dry ones.

* This fabric is described as 7 oz. oxford in the CRL reports. Since this test was set up (CRL No. 80) the designation of 6.5 oz. oxford has been agreed on. Its full official designation is: Cloth, Cotton, Wind-Resistant Oxford, 6.5 oz.

Phase III: Physiological Heat Load: Report 15-16 December 1944

A uniform made of 6 oz. uniform twill, khaki, imposed a smaller heat load than HBT, and was preferred to HBT by the subjects.

A uniform made of nylon twill imposed less heat load than 6 oz. uniform twill, but most subjects nevertheless preferred the latter garments.

Phase IV: Physiological Heat Load: Report 26-27 December 1944

The Marine camouflage suit (Fortisan yarn, mesh fabric) imposes significantly less heat load than the Marine Suit. Utility (HBT), but there was no decided preference for it.

The camouflage suit imposes less heat load than one of nylon twill, yet the subjects expressed a 7.1 preference for the latter.

Phase V: Physiological Heat Load: Report 5-6 January 1945

There is no significant difference in heat loads imposed by uniforms made of 5 oz. poplin and of nylon-filled poplin. Subjects nevertheless expressed a decided preference (8.1) for the 5 oz. poplin.

There is no significant difference in heat loads imposed by nylon-filled poplin and 6.5 oz. oxford. However, eight of the ten subjects preferred the former. The other two subjects considered the uniforms equal.

Phase VI: Physiological Heat Load: Report 12-13 January 1945

There is no significant difference in the heat loads of uniforms made of nylon-filled poplin and 6 oz. uniform twill (khaki). However, there was unanimous preference for the uniform twill.

Uniforms made of 6 oz. uniform twill and 6.5 oz. oxford impose approximately the same physiological heat load; nevertheless all subjects preferred the uniform twill.

Phase VII: Drying Rates: Report 17-18 January 1945

Other conditions being equal, the time required to dry test uniforms is determined by the amount of moisture absorbed by each of the

garments. At the end of seven hours in the Jungle Chamber, the amount of water residual in each uniform, in ascending order, is as follows:

Nylon)	
6.5 oz. oxford)	Almost dry
Nylon-filled poplin)	
5 oz. poplin)	
5 oz. poplin, WRT)	
8.2 oz. twill, WRT)	
6 oz. uniform twill, khaki)	
8.2 oz. uniform twill, khaki)	
8.2 oz. uniform twill, OD)	
HBT)	

Phase VIII: Measurements of Skin Temperature by Means of a Radiation Thermopile: Report 24-25 January 1945

A rise in skin temperature generally follows onset of exposure of resting acclimatized subjects to a jungle environment. During the first few minutes after beginning exercise, a fall in skin temperature is noted. Skin temperature measurements may be useful as an adjunct to other measurements in determining the heat load imposed by different uniforms.

Phase IX: Physiological Heat Load: Report 30-31 January 1945

Poplin, 5 oz., WRT was compared with poplin, 5 oz., non-WRT. Before laundering, the non-WRT uniform imposed 7% less heat load, as indicated by the higher sweat rate of the men wearing the WRT garments. All subjects preferred the non-WRT garments. After one laundering, there was a 2% mean difference in heat load in favor of treated garments, and at the same time their subjective rating improved.

Though one laundering equalized the heat load of the WRT uniform, its property of absorbing less water than the untreated uniform was not eliminated; moisture uptake for each fabric was not altered by washing.

Phase X: Physiological Heat Load: Report 14-15 February 1945

There was no significant difference in heat loads imposed by a uniform made of uniform twill, 8.2 oz. OD, non-WRT and one of the same fabric in khaki color. The latter was preferred, however, by all but one soldier who rated the garments equal.

Tests were not done in daylight, therefore, there was no effect on heat load from solar radiation.

HBT imposes a somewhat greater heat load than 8.2 uniform twill, khaki, non-WRT; the latter was preferred by all but one soldier who rated the garments equal.

Phase XI: Dragometer Measurements: Report 23-24 February 1945

Since the comfort of a uniform is associated with amount of "drag" it produces, a device for measuring this factor was assembled. The rank order of fabrics, from least drag to most drag, is as follows:

- 6.5 oz. oxford
- Nylon-filled poplin
- 6 oz. uniform twill, khaki
- Nylon twill
- 5 oz. poplin, non-WRT
- 8.2 oz. uniform twill, khaki
- 8.2 oz. uniform twill, non-WRT
- HBT
- 5 oz. poplin WRT
- 8.2 oz uniform twill, OD, WRT

There was fairly close correspondence between objective values and subjective reactions obtained during earlier experiments. It was concluded that materials with WRT have a greater amount of drag than untreated materials.

During February and March 1944, two field tests in jungle areas were carried out by the Panama Mobile Force under Major G. H. Kearny, with the assistance of Medical and Sanitation Officers. The first test, lasting two weeks, was a comparison of uniforms made of bird cloth, poplin-twill (poplin jacket, uniform jacket trousers) and HBT worn by 150 men marching and maneuvering in the worst jungle areas that could be located. It was found that bird cloth was superior to the other fabrics in degree of mosquito protection as well as in most other physical characteristics. However, it did not wear quite as well as the other garments.

This test was followed by a second, 18 to 22 March, in which 30 officers and EM wore bird cloth and HBT uniforms. Men engaged in simulated jungle combat in an area of jungle with sufficient density of mosquitoes to provide a severe test of clothing. Results reported by Major G. H. Tackett, MC, are as follows:

<u>Avg. Bites per Man</u>	<u>Fabric</u>
121.0	HBT
5.2	Bird Cloth

EXHIBIT 6

Protection Against Mosquitoes Afforded by Fabrics

A. Field Tests

1. The first evidence that closely woven fabrics are far superior to HBT for mosquito protection was obtained during the Florida field test in September 1943. This indicated that mosquito protection is directly correlated with tightness of weave of a fabric: dry poplin and Byrd cloth gave almost perfect protection, with uniform twill almost as good, while the more porous fabrics, HBT and British cellular weave, gave practically no protection. Relative biting rates through three fabrics are recorded.

<u>Fabric</u>	<u>No. of Bites</u>
HBT	25
Uniform Twill	4 or 5
Poplin	1 or 2

British cellular weave was not included in this test since earlier results had shown that it was no deterrent to mosquitoes; and Byrd cloth, although it was an excellent mosquito barrier, was ruled out because the seams ripped, due, it was later found, to faulty stitching.

2. During February and March 1944, two field tests in jungle areas were carried out by the Panama Mobile Force under Major C. H. Kearny, with the assistance of Medical and Sanitation Officers. The first test, lasting two weeks, was a comparison of uniforms made of Byrd cloth, poplin-twill (poplin jacket, uniform twill trousers) and HBT worn by 120 men marching and maneuvering in the worst jungle areas that could be located. It was found that Byrd cloth was superior to the other fabrics in degree of mosquito protection as well as in most other physical characteristics. However, it did not wear quite as well as the other garments.

This test was followed by a second, 18 to 25 March, in which 36 officers and EM wore Byrd cloth and HBT uniforms. Men engaged in simulated jungle combat in an area of jungle with sufficient density of mosquitoes to provide a severe test of clothing. Results reported by Major O. H. Tackett, MC, are as follows:

<u>Fabric</u>	<u>Avg. Bites per Man</u>
HBT	121.0
Byrd Cloth	2.2

Although the test group was provided with poplin jackets and uniform twill trousers, no test of them is reported. The twill was ruled out because, in comparison with Byrd Cloth, it was too uncomfortable when wet with water or sweat.

3. A test of tropical uniforms was conducted by the Infantry Board, Fort Benning, Ga., (OQMG Test No. 293) during the summer of 1944. One aspect of the test was the determination of mosquito protection afforded by the experimental garments. Fifteen men sat for 1½ hours in a swampy area infested with mosquitoes, their jackets drawn tight across their shoulders. They were examined for mosquito bites before and after the test. Results were as follows:

<u>Fabric</u>	<u>Subjects</u>	<u>No. of Bites</u>	<u>Bites per Man</u>
HBT	4	76	19
Poplin, WRT	5	2	.4
Poplin, non-WRT	6	4	.7
Uniform twill (trousers)	3	0	.0

It was observed by the Test Officer that mosquitoes would light on HBT and within a few seconds bite the wearer. However, after lighting on the poplin jackets they would try to force their proboscis through the material four or five times with no success, finally flying away.

4. An important aspect of the Florida field test in the summer of 1944 (OQMG Test No. 1450) was the determination of protection afforded by various fabrics to extremely high mosquito populations. Species were largely Aedes, the vicious marsh mosquito. Tests were conducted at two sites, at the second of which the mosquito population was exceptionally dense. The number of mosquito landings on a given area of a man's back, and the number of successful bites through a uniform, were used in determining the relative merits of standard and test garments. Results at the highest biting rate were as follows:

<u>Fabric</u>	<u>No. of Man Exposures</u>	<u>% of Men Bitten</u>	<u>Av. Bites per Man Exposure</u>	<u>Bites per 100 landings</u>
Nylon-filled poplin	24	29.2	3	.2
Byrd cloth	23	56.5	5	.2
Nylon, twill, 5 oz., #2837A	26	73.0	8	.5
Oxford (jo cloth), 6.5 oz.	23	65.2	7	.6
Poplin, 5 oz. WRT	12	100.0	42	6.0
Poplin, 5 oz. non-WRT	12	91.7	52	8.2
Twill, 8.2 oz. OD #7	11	90.9	85	8.3
HBT	4	100.0	110	14.8

(Exposure periods adjusted to an hourly basis)

On the basis of tests at both sites, with differing mosquito biting rates, fabrics were grouped as follows, on the basis of bites per 100 landings:

	<u>Site I</u>	<u>Site II</u>
Fabrics affording good protection	Byrd cloth Oxford	Byrd cloth Oxford Nylon-filled poplin* Nylon*
Fabrics affording medium protection	Poplin, 5 oz. 8.2 oz twill	Poplin, 5 oz. 8.2 oz. twill Poplin, WRT*
Fabrics affording poor protection	HBT	HBT

* (Garments not tested at Site I)

5. The U. S. Army Second Arctic Mosquito Test Expedition, under the leadership of Dr. H. H. Stage, was conducted during the summer of 1944. Although its primary purpose was the determination of the period of repellency afforded by liquids and creams, tests of protection of fabrics were also made. Subjects sat in a mosquito-infested area with their jackets drawn tightly across the shoulders as in the 1943 Florida test. Results were as follows:

<u>Fabric</u>	<u>Bites in one hour</u> <u>(average of 20 men)</u>
Blue Denim	1.1
Serge, OD	79.
Flannel, OD	21.
Poplin	3.
Byrd Cloth	0.
Poplin impreg. with 6:2:2:	.1
Serge impreg. with 1:1:1:	.2
Bare back	293.

6. As a consequence of a visit by Dr. Mann to SPA on a special War Department mission, the CG, SPA, asked that 400 uniforms--200 each of poplin and uniform twill--be sent to the theater for evaluation. These were worn on Bougainville by soldiers of the 37th Inf. Div. The mosquitoes aspect of the test was conducted by the local Malaria Survey Unit. Since no Anopheles were present in the area, two cage tests were made, using newly-hatched laboratory mosquitoes of this species. Results were negative, in that no mosquitoes bit through any fabric, test or standard.

In addition, 24 paired field trials were conducted, with the following results:

Clothing Used	Poplin (New)		Heavy (new)* (8.2 Twill)		HBT (old)		Khaki**	
	wet	dry	wet	dry	wet	dry	wet	dry
Attempted Bites in Field	1953	1143	904	957	862	1005	979	1144
Actual Bites in Field	0	1	0	1	0	4	2	1

* Washed in boiling water prior to the tests

** Assumed to be Trousers, 8.2 oz. Twill, Khaki and Shirt, Twill, Khaki, weight unknown.

These tests were made in partially cleared jungle areas that had the most adult mosquitoes. The weekly oiling was suspended in order to conduct the experiment. No Anopheles adults were found that attempted to bite through any of the clothing. Gloves and headnets were worn, but repellents were not used.

7. The mosquito protective aspect of jungle clothing was obscured by a radio sent by the CG, SWPA, in late June 1944, in which it was stated: "Do not believe extra mosquito protection afforded by poplin cloth necessary." It was about this time that the SGO released figures showing that malaria cases in New Guinea had been reduced 95% and it was therefore understandable that the SWPA attitude toward mosquito protection should be influenced by the decline both in malaria incidence and in mosquito populations. However, the Military Planning Division held to the belief that mosquito protection was important, not only in new areas into which our troops would penetrate without benefit of previous measures to kill adult and larvae mosquitoes, but also for protection against biting by pest mosquitoes--a direct health and morale factor.

8. One thousand uniforms were sent to each of three theaters--SWPA, CPA (later POA) and CBI (later BI)--in June and July 1944 for tests indorsed by AGF and ASF, the mosquito aspect of the test in each case to be conducted under the supervision of malaria terms operating in those theaters. All jackets were made of poplin, but half the trousers were of poplin and half of uniform twill. Reports of these tests have been received and are summarized in Exhibit 8. In none of them was mosquito protection an important consideration. Indeed, in the Burma-India theater there were no mosquitoes, the test having been conducted during the cold season. In POA (Leyte) mosquitoes were scarce; and in SWPA (Biak) artificial methods of testing had to be adopted since the free-flying mosquito biting rate was too low to give any evaluation of the protection afforded by different fabrics. In addition, all uniforms

worn on Biak, standard as well as test, were impregnated with DMP which is one of the effective agents for preventing mosquito bites.

POA: Leyte

Mosquitoes were not a serious pest during most of the operation and there was no malaria on the island. When questioned as to their opinions of the mosquito protection afforded by standard and experimental garments, men replied as follows:

Poplin affords best protection	180	82.6%	of those answering
Poplin and 8.2 twill the same	3	1.4	"
8.2 Twill best protection	7	3.2	"
HBT best protection	12	5.5	"
All afford equal protection	16	7.3	"
No answer	5		

SWPA: Biak

Sixty-one thirty-minute tests were conducted, using 3-5 men in each test. Mosquitoes of various species were allowed to hatch in a cage 12' x 6' x 8', screened to increase darkness within the cage, since a dim light increased mosquito activity. Record was made of attachments (minimum of five seconds) and bites. Test subjects wore standard and test uniforms, both treated (with DMP) and untreated. No headnets, gloves, or other repellents were used.

Results: Out of a total of 13,107 attachments, there were only 17 successful bites, as follows:

HBT (2 yrs. old)	7
HBT (old)	3
8.2 oz. khaki twill (old)	6
Poplin	1

Impregnation of uniforms with a solution of DMP appeared to be very effective in repelling mosquitoes. In one series, where there were 1068 attachments, only 4 of the total were on impregnated clothing.

B. Laboratory Tests

1. Following the report of the 1943 Florida test (Part A-1, page 25), the Naval Medical Research Institute, Bethesda, Maryland, was asked by the QMG to carry out laboratory tests of mosquito biting rates through the five fabrics employed in the field test. Results were reported on 3 December 1943 in Project X-258, by Lts. (jg) C. S. Wilson and D. R. Mathieson, Materials were made into closed sleeves which fitted snugly

over the forearm and were stretched taut over the knuckles. These were inserted into cages of laboratory-reared Aedes aegypti plus a few Anopheles albopictus. At the beginning of each test, the normal biting rate was established by counting the bites on an unprotected arm; and at the conclusion of each test of fabric the bare arm was again inserted "because mosquitoes lose interest if they are unable to bite."

Fabrics were tested dry for a total of 35 minutes, and wet for 5 minutes, with the following results:

Fabric	Dry Tests		Wet Tests	
	Arm	Knuckles	Arm	Knuckles
Byrd cloth	0	0	*	*
8.2 oz. Uniform Twill	0	*	***	*
HBT	0	*	0	***
Poplin	*	**	**	***
Brit, Cellular Weave	****	****	****	****

* Less than 1.5 bites per 5 minutes exposure

** 1.5 to 2.9 bites

*** 3.0 to 4.9 bites

**** 5 bites or over

It was concluded that Byrd cloth was definitely best and British cellular weave poorest. HBT and uniform twill were both good, with little choice between them. Poplin was poor. (Note: This is the only test, field or laboratory, in which poplin ranks below HBT in degree of mosquito protection afforded.)

2. The Bureau of Entomology, Dept. of Agriculture, at Orlando, Florida, has done extensive testing of fabrics. Mosquito protection afforded by tightly woven fabrics was shown to be far superior to that of loosely woven ones. Laboratory results showed that Byrd cloth seemed to offer perfect protection against bites (0%); poplin and 8.2 oz. uniform twill were very satisfactory (0-1%); while HBT was very unsatisfactory (9-14%).

3. The responsibility for the fabric testing phase of mosquito protection was assigned in July 1944 to the Belville, Maryland Research Center, U. S. Dept. of Agriculture, Bureau of Entomology & Plant Quarantine. Laboratory-reared mosquitoes, Aedes and Anopheles, are kept in a 10" cubical cage. For test purposes the cage is brought into a warm, humid dimly-lighted room. After ascertaining that a specified minimal mosquito activity obtains (at least 10 landings in 30 seconds on an area of bare arm 1" x 3"), mosquitoes are given the opportunity to bite through a similar area of cloth wrapped tightly, but not stretched, around the subject's arm. Three tests are run on each fabric, tests in each case being related to a control fabric, 8.2 oz. OD uniform twill. The numbers of attempts and successes are used to determine the percentage of successful bites.

Some 40 tests have been run on various untreated and impregnated samples. The results on fabrics which have been used in other tests are as follows:

<u>Fabric</u>		<u>% Biting Success</u>
<u>Control:</u> Cloth, Cotton, Uniform Twill, 8.2 oz. OD	Stdn.	0.20%
Cloth, Cotton, Wind Resistant Oxford, Type I, 6.5 oz. (Case, Sleeping Bag: recommended for Tropical Uniform)	Stdn.	0.04%
Cloth, Cotton, Wind Resistant (Byrd Cloth) (Specified for Mosquito Gloves)	Stdn.	0.04%
Cloth, Nylon, Twill, Calendered, #3S37A (CRL test: Florida 1944 field test)	Exper.	0.12%
Cloth, Cotton, Uniform Twill, 8.2 oz. Khaki (Khaki trousers)	Stdn.	0.50%
Cloth, Cotton, Wind Resistant (Poplin), O.D. (Linings, Jacket, Field, M-1943)	Stdn.	0.60%
Cloth, Cotton, Uniform Twill, 6 oz., Khaki (Khaki shirting)	Stdn.	1.27%
Cloth, Cotton, HBT, OD (Army one-piece and two-piece fatigue uniforms)	Stdn.	2.05%

4. In response to a wire from OSG, 1 May 1944, to CG, Panama Canal Dept., laboratory studies were conducted over a period of several weeks to determine the degree of mosquito protection afforded by HBT and Byrd cloth. Two types of tests were run:

- a. Arm tests: One arm, covered with closely fitting fabric was introduced into a cage containing Aedes mosquitoes. The bare arm of the same subject introduced into another cage in which there were mosquitoes of similar breeds and ages, served as control.
- b. Room tests: The subject entered a mosquito-proofed room containing laboratory-reared mosquitoes. All openings of the uniform were carefully taped, and special care was taken to protect hands, ankles and face. At the conclusion of the test, mosquitoes were killed with pyrethrum aerosol, identified, and those counted which contained blood.

A report was rendered by a Board of Officers, 7 August 1944. Conclusions of the Board were:

- a. Byrd cloth is highly impenetrable to the bites of unfed laboratory-reared mosquitoes.
- b. Byrd cloth affords protection far in excess of that given by HBT.
- c. Laboratory results should be checked by field trials.

5. Under the auspices of Lt. B. V. Travis, USNR, the U.S. Naval Medical Research Unit #2 in cooperation with the U.S. Dept of Agriculture, Bureau of Entomology and Plant Quarantine, conducted cage tests on Guadalcanal to determine whether Anopheles punctulatus bites through clothing. Results were reported in Tropical Diseases Report #31, 13 September 1944. The fabric to be tested was stretched over the hand and exposed for 5 minutes in a cage of mosquitoes. From 50 to 100 mosquitoes were attempting to bite at all times, but it was not possible to determine the exact number of bites received. It was concluded that this species of mosquito can bite through regulation GI clothing, when it is stretched tightly against the skin. The degree of protection afforded by uniform materials, from best to least, is roughly as follows:

8.2 oz. Uniform Twill, Khaki	-	only rare bites
HBT	-	numerous bites
6 oz. Uniform Twill, Khaki	-	numerous bites

EXHIBIT 7

Weather and Working Conditions in Theater Tests

Combat organizations and conditions in brief were as follows:

<u>Test No.</u>	<u>Location</u>	<u>Organization</u>	<u>Rainfall</u>	<u>Sunshine</u>	<u>Temperatures</u>	
					<u>Day</u>	<u>Night</u>
293	Bougainville	37th Inf. Div.	Heavy	Little	Hot	Cool
309A	Leyte	7th Inf. Div.	Very Heavy	Very Little	Hot	Cool
309B	North Burma	124th Cav. Regt.	None	Much	Pleasant	Very cool
309C	Biak	41st Inf. Div.	Heavy	Moderate	Hot	Cool

Details of weather and of working conditions follow:-

QQMG Test 293, 37th Inf. Div., Bougainville

This test was carried out from 1 July through October 1944. Weather reports from the nearby AAF Station, Piva air strip, show for the months of July and August the temperatures ranging from 69° to 90°F and averaging 79°F. On 15 days out of 62 there was no more than a trace of rain. The monthly rainfalls were 18 and 13 inches respectively which were somewhat above average. In other words, the weather was rainy, humid and hot in the day, very humid and cool at night.

Troops taking part in the test were from Infantry, Ordnance, QM, Signal and Engineer units, all of the 37th Inf. Div. This Division was engaged in patrol activity during the four months of the test.

QQMG Test 309A, 7th Inf. Div., Leyte

This test began on Leyte, 20 October 1944 and continued until early February. Some test garments were worn the entire time and most of them were worn for seven or more weeks except in the case of casualties. The men were engaged in combat throughout the period of the test.

Weather records made near the Tacloban air strip (where it was drier than in the areas where the 7th Div. fought), show minimum temperatures, usually between 70° and 75°F. The lowest temperature over a period of nearly four months was 67°F and the highest, 97°F. The mean temperature was generally between 80° and 85°F. Rainfall was heavy, exceeding 2" per 24 hours on several occasions and on one occasion reaching 5.15" in 24 hours.

The terrain of Leyte consists of steep mountains which rise abruptly from level rice paddies and other cultivated fields. These fields are now partly overgrown but were originally used for sweet potatoes, corn, bananas, and hemp. There are numerous small shallow rivers and near the sea, where there was not much fighting, extensive swamps. The valley soil is mucky volcanic earth with the water table 6 to 10 inches below the surface. The soil of the mountains is dark red and of volcanic origin, still containing many small sharp-edged rocks. The mountains are covered with typical rain forest and there it rains 5 to 6 times a day the year around. Mountains are continually shrouded in clouds. Trails are tortuous, muddy and slippery.

OQMG Test 309B, 124th Cav. Regt. Sp., North Burma

There was no precipitation and little wind during the six weeks of the test. Days were sunny, not very humid and pleasantly warm with maximum temperatures of 80° to 85°F. Only men working in the sun in mid-day found it hot. Nights were humid and cool with temperatures as low as 48°F.

During the first month, the men were in simulated combat, creeping, crawling, firing, marching, patrolling and living in the jungle. The remaining two or three weeks were spent in actual combat. Only one suit of clothing was in the hands of each man during the combat phase.

Terrain included mud, bogs, sand, gravel, rocks, firm soil, and streams. The men were shaded by dense trees 75% of the time and in grass, often difficult to penetrate, the rest of the time.

OQMG Test 309C, 41st Inf. Div., Biak

Temperatures during the 37-day test period ranged from 94° to 68° F, the mean maximum and minimum temperatures being 90.2° and 73.8°F respectively. The daily rainfall varied from 0 to 1.81 inches, the average being 0.28 inch. There was no rain during one day in three, as compared with one in four on Bougainville. There was some sunshine nearly every day. The relative humidity was usually within the limits of 60% to 85% except when it rained.

The troops of this Division were engaged in combat patrols and fatigue duties. Many were in the sun since the camp and dock area were largely cleared of trees.

Biak is a low, coral island with few streams, with wooded coral cliffs but less mud, sand and swamp than is found in many other areas in the Southwest Pacific.

EXHIBIT 8

THEATER TESTS OF JUNGLE COMBAT UNIFORMS

	<u>37th Inf. Div.</u> <u>(CQMG Test 293, Bougainville)</u>	<u>7th Inf. Div.</u> <u>(CQMG Test 309A)</u>	<u>124th Cavalry Regt. (Sp.)</u> <u>(CQMG Test 309B)</u>	<u>41st Inf. Div.</u> <u>(CQMG Test 3090)</u>
1. Garments Tested	Jacket, poplin*, non-WRT* Jacket, uniform twill* Trousers, poplin, non-WRT* Trousers, uniform twill	Jacket, poplin*, WRT* Trousers, poplin, WRT* Trousers, uniform twill*	Jacket, poplin*, WRT Trousers, " " Trousers, uniform twill*	Jacket, poplin*, WRT Trousers, poplin, WRT Trousers, uniform twill*
2. Fabric	Poplin preferred to HBT* and uniform twill. Better "feel" smoother and softer than HBT. Recommended for jacket and trousers.	Poplin preferred to HBT and uniform twill. Recommended for jacket and trousers.	Almost 100% of men prefer test garments to HBT. Garments look better, are more comfortable and "creep" less than HBT. Preference for poplin and uniform twill about 50-50.	Poplin preferred to HBT and uniform twill. Recommended for jacket and trousers.
3. Durability	Poplin satisfactory for both jacket and trousers. Poplin equal to HBT and uniform twill in 4 months' wear under combat conditions.	Poplin jacket and trousers outwear HBT. After four months' intermittent wear, 93% jackets and 86% poplin trousers showed little or no wear.	Sufficiently durable after 6 weeks' wear in combat training. Test clothing does not snag or tear as much in undergrowth as HBT. Some stitching failure.	Poplin satisfactory for both jacket and trousers in one month test. Test continuing.
4. Heat Load	Poplin cooler than HBT and uniform twill.	Poplin cooler than HBT and uniform twill, particularly after laundering.	Test garments cooler than HBT. Perspiration absorption poor until garments were washed 2-3 times.	Poplin cooler than HBT and uniform twill; became cooler with laundering.
5. Dirt Penetration	No comment	Notably less with poplin than with HBT. Mud dries on poplin and can be brushed off, whereas it becomes embedded in HBT.	No comment.	Notably less with poplin than with HBT, hence less washing required.

Exhibit 8 (cont)

	<u>37th Inf. Div. (OQMG Test 293, Bougainville)</u>	<u>7th Inf. Div. (OQMG Test 309A)</u>	<u>124th Cavalry Regt. (Sp.) (OQMG Test 309B)</u>	<u>41st Inf. Div. (OQMG Test 309C)</u>
6. Water Absorption	Differs little from HBT and Uniform Twill. No recommendation on WRT.	Less than that of HBT and uniform twill. Recommend that WRT be eliminated.	More water resistant than HBT. Lighter than HBT when wet or dry. (Note: True only of poplin.)	Less than that of HBT and uniform twill. Recommended that WRT be eliminated
7. Launderability	Satisfactory: washed 20 times using GI soap, scrub brushes, sometimes boiling water.	Poplin easier to wash than HBT or uniform twill. Washed an average of 14 times, usually by natives.	Hard to get clothing wet enough to wash for first 2-3 washings. Laundered in streams by pounding on flat surface.	Washed only 2-3 times, using GI soap and sometimes boiling water. Test continuing.
8. Drying time	Poplin superior to HBT and uniform twill.	Poplin dries rapidly; superior to HBT or uniform twill.	Much faster drying than HBT. (Note: True only of poplin.)	Poplin far superior to HBT; this characteristic of first importance.
9. Mosquito Protection	Excellent for all fabrics, including HBT.	Few mosquitoes seen, but 82% of the men favored poplin to HBT for mosquito protection.	No comment, No mosquitoes at this time of year.	Excellent for all fabrics, including HBT. All uniforms impregnated with dimethyl phthalate.
10. Jacket Design				
a. Shoulder Loops	Eliminate	Eliminate	Eliminate	Eliminate
b. Neck Buttons	Eliminate	No comment	No comment	Eliminate
c. CWS flap	Eliminate	Sew back	Liked by some for added warmth (weather cool to cold)	Eliminate
d. Pockets	No comment	Satisfactory. Add pencil slot to left pocket and enclose pistol cover.	Satisfactory	Add pencil slot; remove pleat
e. Sleeve Design	No comment	Redesign gusset	Eliminate cuff gusset or redesign.	Simplify cuff closure.
f. Jacket Length	No comment	20% of jackets too long.	No comment	Shorten jacket one inch.
g. Side vents	No comment	Retain	Liked	No comment
h. Button Type	Use bone or plastic sewed-on buttons rather than metal tack-on buttons.	Use sewed-on buttons	Use plastic buttons with thread eyes counter sunk.	Use strong sewed-on buttons.

Exhibit 8 (cont)

	<u>37th Inf. Div.</u> <u>(OQMG Test 293, Bougainville)</u>	<u>7th Inf. Div.</u> <u>(OQMG Test 309A)</u>	<u>124th Cavalry Regt. (Sp.)</u> <u>(OQMG Test 309B)</u>	<u>41st Inf. Div.</u> <u>(OQMG Test 309C)</u>
11. Trouser Design				
a. Suspender Buttons	Eliminate	Eliminate	Eliminate	Eliminate
b. CWS fly	Eliminate	No comment.	See 10c	Eliminate
c. Watch pocket	No comment.	Retain	No comment	Retain
d. Slash pockets	Retain	Retain	Satisfactory	Retain
e. Cargo pockets	Eliminate	Eliminate	Location and design debatable.	Eliminate
f. Hip pockets	Add at least one	"Many want them"	No comment	Add two
g. Drawstring Closure	Retain	Retain	Retain	Retain
h. Button type	See 10h	See 10h	See 10h	See 10h
12. Sizing	No comment	Reduce sizing one size.	Many sleeves 1½ - 2" too long. 180/870 uniforms were too large to fit personnel.	Develop accurate tariff or use USAFFE tariff.
13. Basis of Issue	No comment	Theater recommends immediate standardization. Issue in place of all HBT in tropics, with priority given to infantry combat troops.	No comment	Either 3 per individual or 2 per individual plus cotton khaki uniform.**

* Note:

Official nomenclatures are as follows:

Cloth, Cotton, Wind Resistant, Poplin
 Cloth, Cotton, Wind Resistant, Byrd Cloth
 Cloth, Cotton, Wind Resistant, Oxford 6.5 oz.
 Cloth, Cotton, Uniform Twill, 8.2 oz.
 Cloth, Cotton, Herringbone Twill
 Water Repellent Treatment

Terminology in this report:

Poplin
 Byrd Cloth
 Oxford
 Uniform Twill
 HBT
 WRT

** The khaki uniform consists of: Jacket, Cloth, Cotton, Uniform Twill, 6 oz. khaki
 Trousers, Cloth, Cotton, Uniform Twill, 8.2 oz., khaki

Exhibit 9

Quartermaster Board and Infantry Board Tests of Tropical Uniforms

	<u>Quartermaster Board</u> (OQMG Test 1450, Florida)	<u>Infantry Board</u> (OQMG Test 293, Infantry Board, Ft. Benning, Ga.)
1. Garments Tested	Jackets and trousers, poplin, *WRT* and non-WRT Jackets and trousers, uniform twill* Jackets and trousers, Byrd cloth* Jackets and trousers, nylon-filled poplin Jackets and trousers, nylon Jackets and trousers, Oxford*	Jackets and trousers, poplin,* WRT* and non-WRT Trousers, uniform twill.
2. Fabric	All closely woven lightweight fabrics preferred to HBT and uniform twill. Recommended (other than nylon): Byrd cloth, Oxford.	WRT poplin recommended for jacket, uniform twill for trousers.
3. Durability	Satisfactory in 42-day test: Byrd cloth, oxford, poplin, HBT	Uniform twill recommended for trousers; poplin OK for jackets.
4. Heat load	All closely woven, lightweight fabrics cooler than HBT and uniform twill. Included are poplin, WRT and non-WRT, Byrd cloth, oxford.	No differences noted by measurement of sweat rate; all soldiers preferred poplin to HBT.
5. Dirt Penetration	No comment	Mud and dirt can be brushed off poplin easily after the uniform dries.
6. Water absorption	WRT poplin absorbed less water than non-WRT poplin or oxford. All absorbed much less than HBT and uniform twill. No recommendation on WRT.	WRT poplin the lightest uniform when exposed to rain and perspiration. Non-WRT poplin absorbs much less water than HBT or uniform twill. WRT recommended.
7. Launderability	Shrinkage negligible in hand laundering and slight in mobile unit laundering. No comment on ease of washing.	Shrinkage was slight in all fabrics. Poplin uniforms were easy to wash.
8. Drying Time	Lightweight fabrics dry rapidly as compared with HBT and uniform twill.	WRT poplin dried in half the time required for non-WRT poplin after both were submerged in water for one hour. Rate of drying proportional to water content.

Exhibit 9 (cont)

Quartermaster Board
(OCMG Test 1450, Florida)

9. Mosquito Protection Byrd cloth, oxford excellent; poplin good; uniform twill and HBT poor.
10. Design of Jacket
- a. Shoulder loops Retain
 - b. Neck buttons No comment
 - c. CWS flap Retain, but tack down
 - d. Pockets No comment except as noted in lld.
 - e. Sleeve design Replace with plain or raglan sleeves, with button-holed spun nylon drawstring in tunneled closure at wrists.
 - f. Jacket length No comment
 - g. Button type No comment
11. Design of Trousers
- a. Suspended buttons Replace by suspender buttonholes, placing buttons on suspenders,
 - b. CWS fly Retain
 - c. Crotch No comment
 - d. Watch pocket Eliminate; add waterproof insert pocket inside left jacket pocket.
 - e. Slash pockets Eliminate
 - f. Cargo pockets Retain but strengthen
 - g. Hip pockets Add right hip pocket.
 - h. Drawstring closure Retain but use nylon drawstring
 - i. Button type No comment
12. Sizing All garments too large by one tariff size.
13. Basis of Issue No comment

Infantry Board
(OCMG Test 293, Infantry Board, Ft. Benning, Ga.)

Poplin and uniform twill excellent, HBT Poor.

"Serve no purpose"
No comment
No comment
Jacket pockets were large enough.
Jacket cuffs are bulky.

No comment
No comment

Eliminate
No comment
Should be looser and reinforced.
No comment

Retain
Retain
No comment
Replace with flap and button
No comment

No comment

No comment

*For official nomenclatures, see Exhibit 8, page 38.

EXHIBIT 10

Design of HBT Uniform Compared with that of Uniforms Used In
Tropical Tests

HBT Uniform

Jacket, HBT, Special, PQD #45D,
12 March 1943

Trousers, Special, HBT, PQD #420
10 March 1943

Uniform used in OQMG Tests 309A,
309B, 309C (Pacific and IB Theaters)

JACKET

- | | |
|---|---|
| a. Two-ply convertible collar | a. Single ply convertible collar |
| b. No shoulder loops | b. Shoulder loops |
| c. CWS double texture flap | c. CWS single texture flap |
| d. 6-button front | d. 5-button front |
| e. Two patch pockets, 7" x 9", with
button-through straight flap | e. Two shirt-type pleated pockets, 6"
x 7½", beveled corners, with con-
cealed buttons under pointed flap. |
| f. Sleeve without gussets, and cuffs
adjustable to two positions by
means of two buttonholes and one
button. | f. Gusseted shirt-type cuffs adjustable
to two positions by means of two
buttons and one buttonhole; tuck in
or out skirt. |
| g. No slimmed trunk | g. Slimmed trunk |
| h. No vents | h. 5-inch side vents overlapping ½". |
| i. Either sewed-on composition buttons
or tack-on metal buttons | i. Half with composition sewed-on
buttons; half with metal tack-on
buttons |

TROUSERS

- | | |
|--|---|
| a. 7 belt loops, 5/16" wide | a. 7 belt loops, 3/4" wide |
| b. No suspender buttons | b. Two suspender buttons |
| c. 5-button CWS fly, double texture | c. Same |
| d. No watch pocket | d. Watch pocket inside waistband on
right side |
| e. No slash pockets | e. Two full slash-type pockets above
cargo pockets |
| f. Two outside patch cargo pockets
across side seam, 8-8½" wide by
9 e/4" long, set 7" below waist | f. Same |
| g. Button-through straight flaps | g. Concealed buttons under straight flaps |
| h. No ankle closure | h. Tunneled draw cord inside hem of cuff |
| i. Either sewed-on composition buttons
or tack-on metal buttons | i. Half with composition sewed-on buttons;
half with metal tack-on buttons |

EXHIBIT 11

Final Recommendations on Design

Jacket

- | | |
|-------------------|---|
| a. Shoulder Loops | Eliminate |
| b. Neck buttons | Use aluminum or melamine formaldehyde
sewed-on buttons, 24 ligne, with thread
eyes counter sunk |
| c. CWS flap | Retain but tack down |
| d. Pockets | Use shirt type with concealed buttons and
pencil slot in left pocket |
| e. Sleeve design | Simplify |
| f. Side vents | Retain |
| g. Button type | See b. |

Trousers

- | | |
|-----------------------|--------------------------|
| a. Suspender buttons | Eliminate |
| b. CWS fly | Retain |
| c. Crotch | Reinforce or make looser |
| d. Watch pocket | Use khaki trousers type |
| e. Slash pockets | Use khaki trousers type |
| f. Cargo pockets | Eliminate |
| g. Hip pockets | |
| h. Drawstring closure | Retain |
| i. Button type | See b. Jacket. |

Some new features of garment design, not commented upon in theater tests, are assumed to have been satisfactory and should be retained. These include the 3/4" belt loops on the trousers and the following features on the jacket:

- a. Single-ply convertible collar
- b. Single-texture CWS flap
- c. 5-button front
- d. Slimmed trunk