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

EXTILE, CLOTHING & FOOTWEAR DIVISION

Clothing Branch Series
Report No. 7

THE DEVELOPMENT OF A LIMITED PROTECTION COVERALL FOR ROCKET FUEL HANDLERS

by

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Project Reference:
7-79-05-012

September 1958

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NOTE: All illustrations follow text.

1. Introduction

Items of protective clothing are developed to allow human operators to perform certain tasks while minimizing hazards to life, health, and limb. In the past, attempts to safeguard the industrial worker's health and safety have been pretty sporadic and haphazard. However, great strides have been made and industrial safety has grown into a well-founded and well-organized effort. This development logically followed the introduction of many new and potentially dangerous types of industrial operations and products.

In spite of the progress made in the development of safety products and clothing, many of these items are not suitable for military use. There are several reasons why this is the case. One of the most important of these reasons is the difference in military and commercial use concept. While in an industrial situation most operations can be performed under rather favorable conditions, in a military situation this is quite often not the case due to variable location, environment, or enemy action. Furthermore, it is frequently not possible for a soldier to wear a protective item designed for one particular type of hazard since his protective gear should be part of a system that provides protection against many different types of military hazards that are imminent.

In the case of protection for rocket fuel handling crews, a fairly typical development cycle can be noticed. In the absence of a specially designed military protective ensemble, fueling crews were initially issued commercially available protective clothing. This clothing did not appear satisfactory but, at the time, was the best solution available. QM technologists initiated development to produce a more satisfactory item. The objectives were to develop an ensemble that provided a high level of protection and could be used over the whole range of environmental conditions under which the Army expects to operate.

However, experiments showed that with ensembles providing a high level of protection, the functional capability of the soldiers was seriously reduced by impairment of body movement, vision, dexterity, and by heat stress. It was noticed that, in some instances, no or incomplete protective clothing was worn when hazardous operations were performed. These protective ensembles met with low user acceptance, partly because of the impairment of the soldiers' functionability mentioned above, and partly because soldiers believed that they were grossly overprotected.

During the fall of 1956, it was decided to conduct an operational study of fuel handling operations to determine more accurately which hazards were involved in the fueling and defueling process. 1/ The results of the extensive Human

1/"Operational Analysis of Protective Clothing for Guided Missile Propellant Handlers." Research Study PB-12, QM R&E Command, July, 1957.

Engineering Study have been instrumental in the formulation of the concept of Limited and Full protection clothing, as agreed upon at the D/A meeting as military requirements for protection of rocket fuel handlers, held at Natick on 9 October 1957.

This concept requires an ensemble providing a high level of protection for wear only during certain very hazardous operations. The concept further requires a limited protection ensemble for use during the more routine and less hazardous part of the fueling and defueling operations.

This report relates the development of the limited protection coverall for rocket fuel handlers as developed on the basis of the requirements formulated at the 9 October 1957 meeting at Natick, Massachusetts.

2. Analysis of the Problem

In this discussion, Protective clothing is defined as any garment or device worn by or attached to an operator for the purpose of providing suitable and adequate protection against a potential hazard in his immediate working environment.

Suitable and adequate are the key words in the above definition. Obviously, adequacy refers to the level of protection. Experience has shown the importance of providing the correct level of protection. If too little protection is provided, the purpose of protective clothing is defeated. Yet, if the level of protection is above what is required, job performance may be lowered and secondary safety hazards introduced. Determining the actual hazards involved in the performance of an operation is the first necessary step.

Suitability refers not only to job performance and functionability but also to user acceptance, cost, availability, durability, and many other factors. Each of these factors is of great importance since failure to consider even one of them may result in negating the benefits of an otherwise excellent solution.

Accurate information as to the nature of the hazard involved in fueling and defueling Nike and Corporal missiles has been obtained during the Human Engineering Research study of fueling operations. These studies not only determined types of operations which involved a relatively high exposure risk, but also the source and directive of the most likely spills and splashes. Furthermore, it was possible to make a prediction as to the frequency of occurrence of spills and splashes, based upon the observed frequencies of spills.

In general, the basic method of providing protection consists of placing something between the operator and the hazard (or the potential hazard). This "something" could be:

1. Distance.
2. A neutralizing agent.
3. A physical barrier.

The method of distance (remote controls) does not appear feasible in the case of fueling missiles. Neither does it seem feasible to utilize the mechanism of a neutralizing agent. The remaining possibility then is the physical barrier, or a combination of 1, 2, or 3.

In analyzing the various possible applications of the barrier principle, it can be noted that from a standpoint of design, there are three basic approaches:

a. A shield between the operator and the hazard source.

b. A capsule, completely encasing the operator, thus providing "full" protection (but also limiting the freedom of the operator).

c. A shield or capsule surrounding the source of danger.

Safety developments in other fields have made use of all three approaches and demonstrated advantages and disadvantages.

Examples of the first approach ("shield") are a welder's face shield and goggles, a windshield on a motor cycle, an umbrella, etc. The advantages these applications have in common is that they do not interfere very much with the functionability of the operator. However, the level of protection provided is usually fairly low or limited to a small area.

Examples of the capsule approach are the full protection rocket fuel handlers ensemble T 57-9 and the Air Force "space suit." Both do provide high levels of protection but they have the serious disadvantage of interfering with sensory and motor performance.

An example of the third approach is the wire encasing of moving parts of machinery in factories.

The concept of adequacy, as used in the definition of protective clothing, requires that not only shall the interference with sensory and motor function be minimal, but the protective ensemble must be acceptable to the operators.

Acceptability is influenced, of course, by many factors. However, a major source of item rejection is often "comfort." The comfort aspect of many protective ensembles, when worn under hot environmental conditions, is of paramount importance. Under extreme conditions, the heat stress imposed by protective clothing interfering with physiological mechanisms can actually cause operators to become ineffective or even casualties.

In addition to seeking approaches to providing suitable and effective protection, the military designer has to keep in mind that whatever he comes up with must be a minimum of sizes. This is necessary not only because of logistical reasons but because it is impossible to offer a soldier in the field a leisure choice from a large tariff of sizes. Incorrectly fitting items are in most cases a direct limitation on the ability to perform a job properly and safely.

On the basis of the above analysis, it was decided to attempt to continue the advantages of the "shield" approach, with the advantages of the capsule approach, while minimizing the disadvantages of both.

3. The Design of the Limited Protection Ensemble

The limited protection suit is a one-piece "apron-type" coverall which fully covers the front and sides of the wearer but leaves a full length strip in back open for ventilation. The item is donned in the same fashion as a surgeon's apron. Figures 1, 2, 3, and 4 illustrate some of the features of the ensemble.

Five elastic straps with two snap button adjustments are provided in the back. The system of having the closure in the back and having adjustment features has several distinct advantages:

(1) The coverall fits almost all sizes of men.

(2) The coverall interferes very little with body movements; it "gives" when the operator bends, kneels, or reaches.

(3) The donning and doffing of the coverall is extremely simple. No zippers are utilized, and, consequently, none can get stuck.

The sleeves of the coverall are fitted with a set of plastic rings, similar to those on the full protection ensemble, to make a perfect seal with the plastic rings fitted on the (standard) protective gloves.

A limited protection hood has been designed for wear with the coverall. The hood consists of a double-layered plastic face shield attached to an adjustable headband. Attached to the face shield is a long bib in front with a strap around the chest to keep the bib in place. The back of the head is left partially open to provide for ventilation. The hood is compatible with devices for respiratory protection.

In view of the findings that standard rubber footgear provides adequate protection, the decision has been made that no special footgear is required for wear with these protective ensembles.

4. Fabrication and Testing of Limited Protective Ensembles

Eighty limited protective ensembles, in one size, have been procured for test and evaluation. Half of these were fabricated from a fabric coated with a modified butyl compound (22809 U. S. Rubber) weighing 16.0 oz. per yard. The others were made from a fabric coated with a butyl vistanex compound (Hodgman) weighing only 9.0 oz. per yard.

These coveralls have been evaluated during the winterization check-out of the Redstone missile at Eglin AFB during March, 1958, and during a user test conducted at Ft. Bliss during May, 1958.

The results of both tests indicate that the limited protection coverall met with a high user acceptance. The Redstone winterization test at Eglin did point to the need for a larger size coverall for use under cold weather operations. The adjustment features provided did not permit the regular size coverall to be worn by men wearing the full cold weather ensemble.

The user test at Ft. Bliss indicated that, for wear under extremely hot conditions, the limited protection coverall was significantly more comfortable than any of the previously used ensembles. The subjects reported practically no interference with work performance.

It is expected that, on the basis of the favorable results obtained, the limited coverall will be recommended for type classification in FY 1959.

5. Conclusions

The account of the development effort of the limited protection ensemble has again stressed the importance of following an orderly and logical approach. In order to design a suitable end item, the designer must know in detail what the item is supposed to do and the conditions under which the item is to be used. Such knowledge can frequently only be gained by a thorough operational analysis, and such analysis should take place before any development work has started. These conditions were fulfilled in the development described in this report, and, consequently, a highly satisfactory end item can be made available to the user in an extremely short development time.

Figure 1. Front View of Limited Protection Ensemble, showing general design features. M-9 face mask of respiratory protective device is attached to harness supporting back-carried cannister.

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Figure 3. Side View of Limited Protection Ensemble, showing excellent field of vision afforded by Face piece.

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