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Overseas Experimentation: Method, Review, Interest and Feedback to Improve New Concepts of Protective Clothing

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Summary

The NATO military forces could be engaged under NBC threat in various climatic conditions which could expose them to warm temperature. Under hot climate, the soldiers, particularly when they wear full IPE (MOPP4), have to face an important physical and thermal load which decreases their operational capacity. A multi disciplinary team under joint Army Staff had developed a complete technical laboratory and field testing process in order to evaluate both the burden provided by the NBC IPE and the loss of capacity of the unit in operation.

This process is based on laboratory testing of the main technical parameters of suits, the measure of loss of individual physiological capacity for human subjects on tread mill, the measure of loss of manual dexterity, the measure of loss of visual field and sighting, the measure of loss of voice transmission and understanding and on field testing on overseas sites conducted with skilled military units on typical operational scenarios.

On the field, tactical scenarios are based on fighting missions of platoon infantry (Land forces) and on air rescue and search mission (Air force). The main recorded parameters used to determine the global loss of operational capacity are the followings : capacity to perform the mission, compared time to complete a mission under both level of protection, hydration needs, and thermal storage. Additionally, elementary tasks and firing exercises are achieved in order to quantify the impact of NBC protective suits on current battlefield actions. Only the methodological aspects of this full measurement process linked to physical and temperature burden are described in the paper.

Actual field trials under extreme climatic conditions are complementary with laboratory tests in order to get a concrete and realistic evaluation of the loss of operational capacity of military units that could be engaged overseas under NBC threat.

Introduction

The Nato military forces could be engaged under NBC threat in extremely warm climatic conditions. In this case the soldiers, particularly when they wear full IPE (MOPP4), have to face an important physical and thermal load that decreases their operational capacity.

A multi disciplinary team under joint Army Staff, (ie the medical service CRSSA, the technical section of the Army STAT and the main board armament DGA/CEB) has developed a complete technical laboratory and field testing process in order to evaluate both the burden provided by the NBC IPE and the loss of capacity of the unit in operation. These trials are fully integrated in a complete gradual and increasing program.

Only the methodological aspects of this full measurement process linked to physiological and temperature burden are described in the paper.

Method

This process is based on laboratory and field experiment :

- laboratory testing of technical parameters of suits, the main of them are the following ones :
 - isolation factor of suits using a instrumented thermal manikin,
 - air permeability and water porosity,
 - protection factor against toxic.
- laboratory testing of physiological parameters on voluntary subjects :
 - the loss of individual physical capacity of human subjects on trade mill,
 - the increase of skin, core temperatures and thermal storage,
 - the loss of manual dexterity and sensitivity,
 - the loss of visual field and sighting,
 - the loss of voice transmission and understanding,

The aim of this evaluation method is to compare the assigned task with the realised one, performed by the subject in different situations. For the NBC matter, we are used to compare a situation considered as a reference or blank (MOPP 0, battle dress) with the situation in full IPE (MOPP 4).

Required data

* Assigned task --> maximum score (Max Sc)
--> time :

It could be :

T_{ref}	{	- the necessary duration to perform the task, - a reference time defined and imposed by the expert,
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* Realised task --> score achieved by the subject,
--> time achieved by the subject to perform the task,

Abbreviation

Score achieved by the subject : Sc subject
Time : T subject

Definition of performance parameters

*** Quality coefficient Cq**

This coefficient expresses the quality of the realised task compared with the assigned task.

$$C_q = \frac{\text{Sc subject}}{\text{Max Sc}}$$

In the case of a multiple or complex task, depending upon several coefficients, we quantify, as far as possible, each of them separately and then we multiply all those elementary coefficients.

* Efficiency coefficient Ceff

This coefficient introduces the time factor in the realisation of tasks.

$$C_{eff} = \frac{C_q \times T_{ref}}{T_{subj}}$$

- If $C_q = 1$, it is not possible to quantify the score so :

$$C_{eff} = \frac{T_{ref}}{T_{subj}}$$

- If the task execution time is imposed, so

$$C_{eff} = C_q$$

NB : - during the execution of a task included a range of elementary acts, the training and the familiarization will conduct to an increase of the quality and efficiency coefficients. After this step, the low dispersion of these coefficients around an average result indicates accommodation of the subject. Then the tiredness begins and is linked with a gradual decrease of these same coefficients.
 - In the case of an intensification of the task, linked with an excess workload of the subject, this will often conduct to a failure in the evolution of these coefficients.

Comparison of two situations

By using the performances coefficients of the subject in two different levels (MOPPO, MOPP4), it will be possible to compute the performance degradation and the operational efficiency loss.

* Degradation rate T_d

It is calculated by using the two quality coefficients measured in the execution of the task in two different situations (full protection and battle dress).

$$T_d = \frac{(1 - C_q \text{ IPE})}{C_q \text{ Ref}} \times 100$$

* Efficiency loss L_{eff}

It is computed by using the two efficiency coefficients measured in the execution of the task in two different situations (full protection and battle dress). It takes into account the modification of the execution time of the task.

$$L_{eff} = \frac{(1 - C_{eff} \text{ IPE})}{C_{eff} \text{ Ref}} \times 100$$

NB : - If some of these results are more than 100 %, it generally indicates a training or a familiarization of the subject.
 - In some particular case, these results can be linked with particular tasks where the full protection does not affect the speed or the quality of the task execution.
 - Moreover, the full protection can induce the subjects to differently perform the task than in battle dress or than included in the trial protocol.

Field trial review

The purpose of this kind of investigation is to evaluate in a hot country the effects and security limits of the wearing of different light NBC protective combat suits during various physical activities. Many field trials have been performed in Djibouti and French Guyana to study the activity of protected infantry soldiers.

- Moisture and very hot desertic climate (Djibouti)

1987: Feasibility study on field and checking out of the monitoring quality to ensure safety

1990: 1st overseas qualification on the field of the French NBC combat clothing (TOM).

1993: Comparative study of NBC clothing, influence of sweat on the protection efficiency.
Long-lasting stays in the desert (36 hours). 1st studies of dehydration effects.

1997 : Definition and use of reference scenarios, validation of a method to quantify the performances of an infantry fighting group.

- Hot and highly moist tropical climate

1998 : Evaluation of protective equipment in collaboration with DMO-DSO (Singapore)

1999 : Measurement of the efficiency of an infantry motorised platoon through 4 different scenarios (French Guyana).

Field testing on overseas sites are conducted with skilled military units on typical operational scenarios. On the field, tactical scenarios are based on platoon infantry fighting missions (Land forces) and on air rescue and search mission (Air force).

The main recorded parameters used to determine the loss of operational capacity are the following ones :

- capacity to perform the mission with residual capabilities,
- compared time between the same mission fulfilled in both level of protection,
- hydration needs which influence the maximal duration of mission and logistic supports,
- thermal storage which undermine the physiological limits of personal.

Additionally, elementary tasks and firing exercises are achieved in order to quantify the impact of NBC protective suits on current battlefield actions using the same computing method.

Local meteorology measurements

Records of micro-climate (Brüel & Kjaer device) are performed during all trials, as close to action as possible. They show the existence of the great variability during the day :

- the dry and wet temperatures of air,
- the humidity, linked to the solar load,
- the radiant charge depending on the position of the sun in relation to the horizon and the reflective nature of the ground, temporary modified by the possible presence of clouds,
- the wind speed,
- the possible temporary or long-lasting rains.

Physiological monitoring and safety

The same safety limits have been used in laboratory and during field trials (F_{cmax} 180 bpm, T_{re} 38.5°C) without any incident. However this type of exercise needs a real time monitoring of heart frequency (ie Polar system) and body temperatures (HTM 8000 data logger) of all voluntary people.

Interest and feedback

This test allows to know the real limitations of the wearing of protective NBC equipment in realistic conditions close to the battlefield and with variable climatic conditions. It also allows to know the loss of performances of typical combat group using protective equipment.

On the field, we measure real safety limits by wearing the whole NBC protective equipment. Moreover we notify and appreciate problems linked to the comprehension of communication, the dehydration, the vision, the manual dexterity (4, 5) and those linked to the mobility. In these conditions, rehydration is fundamental (6, 7) but the gas mask constitutes a potential constraint for drinking.

CONCLUSION

Actual field trials under extreme climatic conditions are complementary to laboratory tests in order to get a concrete and realistic evaluation of the loss of operational capacity of military units that could be engaged overseas under NBC threat.

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