

ASSESSMENT OF PROTECTIVE CLOTHING CONFORMITY WITH THE REQUIREMENTS OF PROTECTIVE CLOTHING STANDARDS

Srđan Z. Rutić^a, Predrag N. Stojisavljević^b

^a Serbian Armed Forces, Training Command, CBRN Centre, Kruševac, Republic of Serbia, e-mail: srdjan.rutic@gmail.com, ORCID iD: <http://orcid.org/0000-0001-5303-646X>

^b Serbian Armed Forces, Technical Test Center, Belgrade, Republic of Serbia, e-mail: pedjastojis@yahoo.com, ORCID iD: <http://orcid.org/0000-0002-1170-7912>

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Abstract:

Assessing the compliance of protective clothing is carried out in accordance with the prescribed methods, standards, procedures and criteria in competent laboratories. This paper presents the process of assessing the conformity of the characteristics of special clothing for the protection of the body of the insulating type in accordance with the general requirements of the protective clothing standard (SRPS EN 340: 2007 Protective Clothing, General Requirements). The results presented in the paper indicate that the concept of conformity assessment does not simply involve checking the basic characteristics of a product (purpose, functionality, etc.), but also checking characteristics that are at first glance "of lesser significance" and can influence the safe use of protective clothing.

Keywords: protective clothing, assessment of the compliance, general requirements.

Introduction

In order to improve the efficiency of product production and trade as well as to ensure the required product quality, the quality management concept based on the application of standards for quality control of products is applied worldwide. The concept of product quality testing is based on the process of assessing the conformity of the declared

characteristics of the product with the standard requirements. Product quality control is carried out through conformity assessment during the processes of: development, improvement, serial production, purchasing products from domestic or foreign markets, and others. Compliance evaluation is a complex process consisting of testing, controlling and certification (Brkljač, 2009). The focus in this paper is to demonstrate the process of assessing the conformity of the characteristics of special body protective clothing of the impermeable type with the requirements of the protective clothing standard (Institut za standardizaciju Srbije, 2007b) as well as to propose measures in order to improve the mentioned process of conformity assessment.

Special impermeable protective clothing

Impermeable protective clothing is used in case of the application of weapons of mass destruction (WMD), when carrying out the decontamination procedure, scrutinizing the contaminated terrain (area), operating on the contaminated ground (ConG) and in the contaminated atmosphere (ConA), when overcoming ConG as well as when carrying out activities that require a high level of protection of users from highly toxic chemicals (HTC), nuclear, radiological, chemical and biological (CBRN) contaminants.

CBRN protective clothing produced from impermeable materials is characterized by good protective properties against the HTC effects, but is physiologically unsuitable because it does not allow for air permeability. The use of such clothing causes heat load in the user, especially during intensive physical effort and in ambient conditions with temperatures over 25 ° C. Due to heat accumulation and heat load, the wearing time of protective garments is limited depending on environmental conditions (Karkalić, 2006).

Modern trends in the development of CBRN body protectors set high protection requirements. The latest generation CBRN protective clothing is made of neoprene, hepalone, viton or multilayer laminates. On the inside of these materials is, most often, a layer of butyl. Figures 1 to 4 show the construction of the latest generation of the impermeable materials manufactured by the German company MSA-Auer (Karkalić & Popović, 2004).

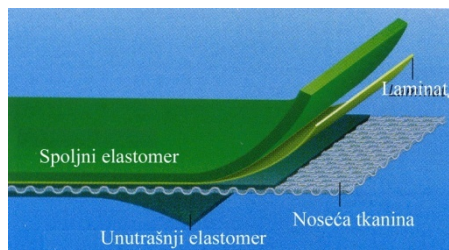


Figure 1 – Composite material Vautex Elite

Рис. 1 – Композиционный материал Vautex Elite

Слика 1 – Композитни материјал Vautex Elite

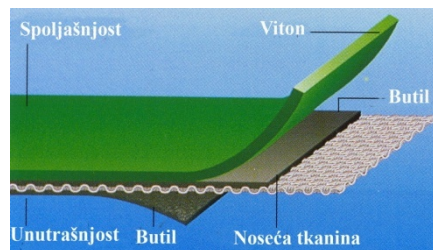


Figure 2 – Composite material Vautex SL

Рис. 2 – Композиционный материал Vautex SL

Слика 2 – Композитни материјал Vautex SL

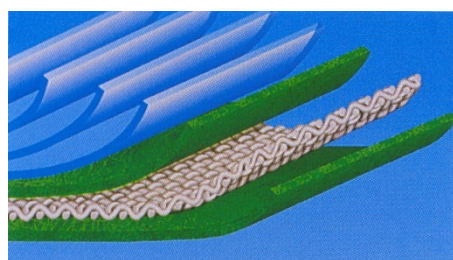


Figure 3 – Composite material Champion Super

Рис. 3 – Композиционный материал Champion Super

Слика 3 – Композитни материјал Champion Super

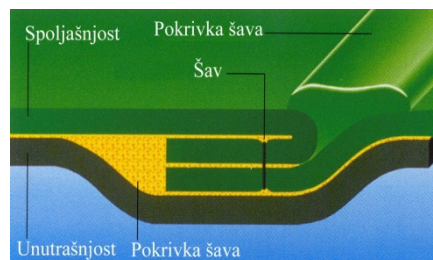


Figure 4 – Seam construction in Vautex

Рис. 4 – Конструкција шва на Vautex

Слика 4 – Конструкција шва код Vautex-a

For the needs of the NBC specialized units during the 1980s, an M3 two-piece protective suit was developed and later modernised and replaced with a one-piece M5 model (Figure 5).

The M5 suit (KZ-M5) is intended to protect the user's body from CBRN contaminants, the thermal radiation pulse of a nuclear explosion (TINE) and a flammable napalm mixture flame. The corporation "Trayal" from Krusevac (hereinafter referred to as manufacturer) is the KZ-M5 manufacturer.



Figure 5 – M5 protective suit in use in the SAF CBRN units
Рис. 5 – Защитный костюм М5, используемый войсками РХБЗ ВСРС
Слика 5 – Заштитни комбинезон М5 на употреби у јединицама АБХ службе ВС

According to the product quality regulation (Vojnotehnički institut, 1985), the manufacturer defined the following characteristics of the KZ-M5:

- camouflage properties in the visible and infrared spectrum;
- the protection against highly toxic chemicals (HTC) at a temperature of 36 ± 1 ° C is at least 150 min, and after five-fold contamination and decontamination it is at least 105 min;
- in case of the thermal radiation pulse of a nuclear explosion (TINE), with the energy of 67 J / cm^2 for the duration of 3.51 s, the suit does not burn, and after the cessation of the TINE effect, there is no glowing phenomenon;
- in contact with napalm mixture drops, the material of the protective suit resists to their penetration for at least 10 s, and upon the cessation of napalm mixture effects it has a self-extinguishing property;
- it retains protective, physical and exploitation properties at temperatures from -30 ° C to $+ 50$ ° C;

- it is easily taken off and put on;
- it allows execution of tasks in real conditions of use;
- suit material is safe to use;
- the geometric characteristics of the suit are defined in the manufacturer technical documentation;
- the basic maintenance is possible within the competence of the suit user;
- the weight of the suit does not exceed 3 kg
- It is made in three sizes.

The M5 protective suit consists of a jacket, trousers and a hood connected in one piece of clothing. The suit opens/closes on the front right side of the body by a patented zipper which is impermeable to liquids, gases and vapors. The KZ-M5 design allows it to be tightened around the waist as well as to achieve permeation by adjusting sleeves and trousers legs. The M5 suit is made of synthetic rubberized fabric covered with rubber mixtures of butyl and hypalone on both sides.

In order to create safe working conditions and eliminate heat stress, according to the valid rules of CBRN equipment use and depending on ambient temperature, the time standards for the use of this CBRN protective suit are defined (Table 1).

Table 1 – Time standards for wearing the protective suit depending on the ambient temperature (Vojnotehnički institut, 2016)

Таблица 1 – Предельно допустимое время ношения защитного костюма в зависимости от температуры окружающей среды (Vojnotehnički institut, 2016)
Табела 1 – Временске норме ношења заштитног комбинезона у зависности од амбијенталне температуре (Vojnotehnički institut, 2016)

Outdoor temperature	Allowed operating time in the protective position
+30 °C and more	15 to 20 min
+25 °C to +30 °C	to 30 min
+20 °C to +25 °C	40 to 50 min
+15 °C to 20 °C	1.5 to 2 h
under + 15 °C	3 to 4 h

The exposure time at 30 ° C is limited to 15 to 20 minutes, which is often insufficient for the realization of missions and tasks in the

contaminated environment. This can be a serious problem, given that in some cases, due to potentially high levels of danger or specific types of contamination, the impermeable protective suit cannot be replaced by a filtering suit which is characterized by a better physiological suitability.

The protective clothing standards

Standard SRPS EN 340: 2007 Protective Clothing prescribes the general requirements regarding the performance of protective clothing related to: ergonomics, harmlessness, size determination, durability, aging, compatibility and marking. The specified performances are prescribed as follows:

- ergonomics (anthropometric characteristics of protective clothing, biomechanical interaction between protective clothing and the human body, thermal interaction between protective clothing and the human body, interactions between protective clothing and all human senses as well as skin),
- harmlessness (protective clothing must not adversely affect the health of the user; the protective clothing material must be chemically suitable; the material must not release substances that are toxic or harmful; the material must not be degraded to release substances that are carcinogenic, mutagenic or causing allergic reactions in users; the material should be selected to reduce the environmental impact of the production and destruction of protective clothing),
- the determination of the size (protective clothing must have a size designation based on body dimensions; the measurement procedure and the size designation must comply with the applicable standards (Institut za standardizaciju Srbije, 2007c), (Institut za standardizaciju Srbije, 2007d), (Institut za standardizaciju Srbije, 2015) or relevant Serbian standards that are identical with international standards; proportions and protective clothing measures should reflect the needs of the user together with the clothing worn under protective clothing),
- construction (it must enable: correct fitting of protective clothing on the user; protective clothing remaining in place during the intended period of use; adjusting protective clothing to the morphology of the user; arm and knee bending at ease; it must ensure: that there are no uncovered parts of the body considering expected movements; that the garment can be removed easily; and that the overlapping of the jacket and the trousers is adequate),

- comfort (protective clothing must not: have rough, sharp or hard surfaces that injure the user, be so tight that it prevents the flow of blood, be so loose or heavy to interfere with movements),
- aging (harmful effects of its color, changes in size due to cleaning, changes in marking legibility after cleaning),
- compatibility with other personal protection equipment,
- marking (general marking: text in the official languages of the destination country, labeling on the product or labels fixed to the product to be visible and legible permanently for the intended number of cleaning procedures, special designations: name, product type designation, size designation, European standard number, pictograms and performance levels, maintenance labels, notes if it is disposable clothing), and
- information provided by the manufacturer along with protective clothing (how it is donned and removed, proper use to reduce the risk of injury, usage restrictions (e.g. temperature range), cleaning instructions (temperature, drying process, PH value, mechanical cleaning), instructions regarding repair, instructions on how to identify product aging, details of defects in use (reduction of the field of vision, heat shock risk).

Conformity evaluation

Conformity evaluation¹ is an indication that the specific requirements relating to the product², process, system, person are met.

Assessing the compliance of body protection equipment is a set of three functions that satisfy the need or requirement to show that the specified requirements are met. According to SRPS ISO / IEC 17000: 2007 Standard (Institut za standardizaciju Srbije, 2007a), the following three basic functions are recognized:

- selection,
- determination, and
- review and decision-making.

¹ Standard SRPS ISO / IEC 17000: 2007 Evaluation of compliance - vocabulary and general principles (Institut za standardizaciju Srbije, 2007a).

² The product includes the assets and components of the weaponry and military equipment, the quality of which is defined by the regulation on product quality, standard, specification of characteristics and similar technical documents (Internal document of the quality management system, Technical Center of Reference, 2015).

The selection function includes planning, programming and preparatory activities for the collection or production of all information and inputs necessary for the transition to the next function or the determination function.

The determination function covers the activities being undertaken in order to obtain complete information as to whether the conformity of an assessed product or its sample meets specified requirements, which includes examination, control, etc.

The function of the review is to verify the suitability, adequacy and effectiveness of the selection and determination activities, as well as the results of these activities, in order to prove the fulfillment of the specified requirements for the conformity of the assessed product. The review is the final phase of checking, before deciding whether it is reliably demonstrated that the product conformity assessment meets the specified requirements, which results in the confirmation of compliance and a statement that the fulfillment of specified requirements exists. If the fulfillment of the specified requirements has not been shown, it indicates that it is not compliant.

Conformity assessment of the protective clothing standards requirements

After the activities have been carried out in accordance with the selection function, the analysis is carried out within the framework of the determination function. Testing is carried out through laboratory tests and tests in real conditions of use.

Examination of the personal protective equipment in real conditions is carried out by the SAF center in cooperation with the end user (unit, organizational unit from the SAF) and the medical institution (MMA, etc.). As part of this activity, the personal protective equipment testing is carried out in accordance with the requirements of the applicable standard for protective clothing - SRPS EN 340 Protective Clothing, General Requirements.

Testing in real operational conditions is realized in different meteorological conditions, with and without load (combat equipment) and generally implies the following activities:

- Proper donning, removing and packing protective clothing,
- checking the functionality and compatibility of protective clothing with other personal protective equipment and other personal equipment,

- checking the convenience of wear and endurance in the execution of specific tasks and the implementation of different procedures; and
- possibility of care and maintenance of protective clothing (basic and periodic care, washing, drying, ironing).

The number of persons engaged in the study is defined during the testing planning process and in accordance with the purpose of the product itself, the development phase of the product (prototype, zero series, etc.), the amount of samples, etc.

In order to make more complete and more objective assessment of the characteristics of protective clothing, physically fit and psychophysically prepared individuals of different sexes and body types and build are selected. Before the start of the examination, a medical examination of the examinees is carried out.

Also, before the start of the test, the following procedures are done: checking of the size, design characteristics and comfort of the protective clothing. Checking is performed with respondents through donning and removing, performing basic actions and procedures (squatting, raising arms up, etc.), checking body mass, etc.

The aggravating factors in the selection of respondents are:

- a minimum of 100 participants are required for complete statistical data processing and evaluation of the protective clothing from the aspect of ergonomics, comfort, and compatibility. The number of respondents is most often determined by the number of samples of protective garments;
- group packaging of protective garments contain three sizes (small, medium, large) packed in a ratio of 1: 3: 1. Body height is the basic factor in the distribution of samples for testing purposes. For this reason, there is a possibility for respondents to get unsuitable samples in terms of other design factors (shoulder width, sleeve length, waist circumference, etc.);
- the current regulations for the use of protective clothing do not specify a specific type of clothes worn under the KZ-M5; and
- ensuring the engagement of the same group of respondents during the examination process, especially when the tests last over a period of 10 working days. A change in the engagement of respondents may affect the validity and objectivity of the product assessment.

The duration of testing in real operating conditions depends on several factors (the request of the tester, the product purpose, the phase of product development, the season, etc.) and is determined by the test plan. During the examination, the test center, in cooperation with the medical institution, monitors the course of the examination and records the information on the protective clothing that is examined. All information is registered in various forms of records (recording in specially prepared notepads and records, taking photos of the observed changes, recording the stream of activities with a video camera). After completing the examination process, respondents fill out the questionnaire. The questions from the questionnaire are formed in accordance with the requirements for checking the characteristics specified in the standard for protective clothing SRPS EN 340 and in accordance with the information recorded in the mentioned records.

Results presentation

During 2015, KZ-M5 samples were tested in the SAF Testing centre. As part of the testing in real operational use, the conformity assessment was carried out according to the requirements of Standard SRPS EN 340 Protective Clothing, General Requirements. In the final examination of KZ-M5 samples, 23 respondents from the SAF CBRN Service unit participated: 22 professional soldiers and one non-commissioned officer. Out of that number, 3 respondents were female, accounting for 13% of the total number of respondents which is the average representation of women in units of the Serbian Armed Forces. The average age of the respondents was 32 years. The average time spent serving in the SAF was about 7 years. The respondents were psycho-physically prepared for the participation in the testing. During the distribution of KZ-M5 suits to the respondents, it was noticed that the respondents of a medium build were the most present. It was not possible to adequately provide for the respondents of small and large body height. Figure 6 shows the respondent who got the KZ-M5 with the size markings "V" (large) based on his body height. It is evident that there is no appropriate fitting of protective clothing on the user and that there are uncovered parts of the body due to expected movements.



Figure 6 – Reduced arm mobility at the elbow (Tehnički opitni centar, 2015)
 Рис. 6 – Ограниченная подвижность рук в области локтевого сустава (Техниčki opitni centar, 2015)
 Слика 6 – Смањена покретљивост руку у пределу лакта (Техниčki opitni centar, 2015)

After obtaining the garments based on the size criterion, the respondents were informed on the operational use, the planned activities, as well as the procedures regarding safety and health protection measures.

Data collection was carried out in accordance with the guidelines given in (Institut za standardizaciju Srbije, 2007b) and based on the observations recorded during the test process. During the use of the KZ-M5, respondents made their observations on the change in the material of the product, the way and the possibilities of use in the performance of the assigned tasks, basic maintenance options and other observations (wearing time, effects on increased sweating, etc.). All changes to the material of the protective clothing observed during the examination were recorded in the photo and video format.

Filling out the questionnaires was completed at the end of the examination. The respondents expressed their opinion through the questionnaire on:

- the possibility of carrying out the basic actions with the equipment (walking, sitting, getting up, suit donning and removing, etc.),

- physiological suitability in field conditions (mobility of the body when wearing KZ-M5, increased sweating during physical activity, etc.),
- allergic reactions to the materials,
- possibility of executing specific tasks within the planned activities (training),
- characteristics according to SRPS EN 340 (construction, comfort, aging, marking and instructions for use and maintenance delivered with the product), and
- compatibility of this product with other equipment for personal CBRN protection.

The material safety testing was carried out by monitoring the occurrence of allergic reactions and presenting the observations of the subjects. When assessing harmlessness, there is also a possibility of proving the presence of substances in the KZ-M5 materials that can cause allergic reactions to the user. In this case, a special group of respondents is engaged and the examination is conducted according to the program and the consent of the medical institution for conducting such type of examination. In addition, the manufacturer of the product is obliged to document the safety of the use of the product (the harmlessness of the protective clothing material to the user's health and the environment).

The results of the test have confirmed the prescribed time standards for wearing the KZ-M5 depending on the air temperature (Table 1). Part of the results from the processed questionnaires in accordance with the requirements of SRPS EN 340 is shown in Table 2.

Table 2 – Results after analysing the questionnaires in accordance with the requirements of EN 340 Protective Clothing, General Requirements

Таблица 2 – Результаты опросников, обработанных в соответствии с требованиями SRPS EN 340 Защитная одежда, Общие требования

Табела 2 – Резултати након обраде анкетних листова у складу са захтевима SRPS EN 340 – Заштитна одећа, Општи захтеви

Question from the questionnaire	Respondents' answers in%	
	YES	NO
Is the KZ-M5 comfortable?	83	17
Is it possible to take off / put on the KZ-M5 without difficulty?	96	4
Can you sit with the KZ-M5 without difficulty?	70	30

Question from the questionnaire	Respondents' answers in%	
	YES	NO
Can you stand with the KZ-M5 without difficulty?	96	4
Can you raise both arms above the head without difficulty wearing the KZ-M5?	78	22
Can you walk and climb ladders, stairs, etc. without difficulty, wearing the KZ-M5?	57	17 (26 percent of respondents did not carry out this action)
Is the KZ-M5 compatible with the protective mask M2 and M3 and with protective gloves M5?	100	-
Wearing the KZ-M5, can you carry out specific tasks with CBRN service assets and equipment?	83	17
Can you bend down wearing the KZ-M5 and take a small object (e.g. a pencil) without difficulties?	74	26
Do you have difficulties entering / exiting the vehicle (special purpose vehicles, transport vehicles, etc.)?	17	83
Is the tightness between protective gloves and the KZ-M5 jeopardized?	39	61
Is the tightness between protective boots and the KZ-M5 jeopardized?	22	78
Is the tear of the KZ-M5 material noticeable as well as the splitting of materials along the seams?	61	39

Based on the results from the completed questionnaires, the following was concluded:

- conformity assessment of the protective clothing has been carried out in accordance with the characteristics of SRPS EN 340 (ergonomics, construction, comfort, aging, marking and application of the instructions for use and maintenance) and the defined test plan;
- the engaged SAF unit has made it possible to objectively evaluate the product from the aspect of its application in real operating conditions;
- correction in the KZ-M5 is required in order to improve the design and comfort of the KZ-M5;
- special attention must be paid to the quality requirements for compatibility and selection of size numbers. In addition to the basic three sizes, it is necessary to create a larger range of KZ-M5 sizes for users of both sexes, and

- the use of the KZ-M5 in real conditions indicates the need to consider and create a special type of garments worn under the KZ-M5.

Conclusion

Assessing the compliance of the protective clothing in accordance with the requirements of the standard requires a complex approach. The example in this paper only confirms that the application of standards in the process of conformity assessment is an indispensable and necessary activity. In the complete process of protective clothing development, the participation of the end user is necessary.

Complex and comprehensive research of the body cooling system conducted within the research project of the Ministry of Defense of the RS (Jovanović, 2013) indicates that the use of cooling systems can reduce the user's sweating intensity, which contributes to preventing dehydration and improving the physical performance of soldiers when wearing CBRN protective equipment.

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ОЦЕНКА СООТВЕТСТВИЯ ЗАЩИТНЫХ КОСТЮМОВ ТРЕБОВАНИЯМ СТАНДАРТОВ ДЛЯ ЗАЩИТНОЙ ОДЕЖДЫ

Срджан З. Рутич^а, Предраг Н. Стоисавлевич^б

^а Вооружённые Силы Республики Сербия, Штаб по обучению,
Центр РХБЗ, г. Крушевац, Республика Сербия

^б Вооружённые Силы Республики Сербия, Опытно-экспериментальный
технический центр, г. Белград, Республика Сербия

ОБЛАСТЬ: химические технологии
ВИД СТАТЬИ: профессиональная статья
ЯЗЫК СТАТЬИ: английский

Резюме

Оценка соответствия защитных костюмов требованиям стандартов для защитной одежды проводится согласно предписанным методам, стандартам, нормам и критериям в соответствующих лабораториях. В настоящей работе представлен процесс оценивания соответствия свойств специальной защитной одежды изолирующего типа общим требованиям стандарта для защитной одежды (SRPS EN 340:2007 *Защитная одежда, Общие требования*). Результаты, представленные в данной работе, свидетельствуют о том, что понятие «оценивание соответствия» включает не только проверку основных свойств защитной одежды (назначение, функциональность и пр.), но и проверку свойств, которые на первый взгляд могут показаться не столь значительными, но которые в тесной связи с безопасностью использования средств ВВТ.

Ключевые слова: защитная одежда, оценка соответствия, общие требования.

ОЦЕЊИВАЊЕ УСАГЛАШЕНОСТИ СРЕДСТАВА ЗА ЗАШТИТУ ТЕЛА У СКЛАДУ СА ЗАХТЕВИМА СТАНДАРДА ЗА ЗАШТИТНУ ОДЕЋУ

Срђан З. Рутић^а, Предраг Н. Стојисављевић^б

^а Војска Србије, Команда за обуку, Центар АБХО,
Крушевац, Република Србија

^б Војска Србије, Технички опитни центар,
Београд, Република Србија

ОБЛАСТ: хемијске технологије
ВРСТА ЧЛАНКА: стручни чланак
ЈЕЗИК ЧЛАНКА: енглески

Сажетак:

Оцењивање усаглашености средства за заштиту тела изводи се по прописаним методама, стандардима, поступцима и критеријумима у компетентним лабораторијама. У раду је приказан процес оцењивања усаглашености карактеристика специјалних средстава за заштиту тела изолирајућег типа у складу са општим захтевима стандарда за заштитну одећу (SRPS EN 340:2007 – Заштитна одећа, Општи захтеви). Резултати приказани у раду указују на то да се под појмом оцењивања усаглашености не подразумева само провера основних карактеристика средства НВО (намена, функционалност и др.) већ и провера карактеристика које су на први поглед „мањег значаја”, а могу утицати на безбедну примену средства НВО.

Кључне речи: заштитна одећа, оцењивање усаглашености, општи захтеви.

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