

## PRODUCTION OF MULTIFUNCTIONAL FOOTWEAR FOR PRISON POLICE OFFICERS

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**ABSTRACT.** There is a close connection between the comfort in wearing footwear and the quality of this product. When we refer to the quality of footwear, we must start from the analysis of materials used to make the upper and lower shoe assembly, the analysis of how the joints between the different elements of the assembly behave and finally we must consider the behavior of the shoes as a whole. The footwear must create a climate where temperature, humidity, air circulation and their action on the foot, and on the whole body are correlated. Even at a rapid change of internal or external influences, the wearer must feel good. The so-called triple physiological agreement - temperature, humidity and air circulation - must be adaptable to various requirements during a working day such as: rest, movement, physical effort and climatic conditions. The design of a product is not only related to the aesthetic, artistic aspect, but more to its functionality and engineering (from the correct choice of materials, construction and technological concept, to prototyping). A good example in this regard is the design of multifunctional footwear, for soldiers and police officers. Therefore, designing the right footwear is a big challenge not only for designers, but also for engineers. The paper presents the way in which footwear as a component of the work uniform of prison police officers was made.

**KEY WORDS:** multifunctional footwear, materials, specifications

### DEZVOLTAREA ÎNCĂLȚĂMINTEI MULTIFUNCȚIONALE PENTRU POLIȚIȘTII DE PENITENCIARE

**REZUMAT.** Există o strânsă legătură între confortul pe care purtarea unui produs de încălțăminte îl conferă utilizatorului și calitatea acestui produs. Când ne referim la calitatea unui produs de încălțăminte trebuie să pornim de la analiza materialelor destinate confecționării ansamblului superior și inferior al încălțăminte, analiza modului în care se comportă îmbinările dintre diferitele elemente ale ansamblului și în final trebuie să avem în vedere comportarea produsului de încălțăminte în ansamblu. Încălțăminte trebuie să creeze un climat unde să fie corelate temperatura, umiditatea, circulația aerului și acțiunea lor asupra piciorului, respectiv a întregului organism. Chiar la o schimbare rapidă a influențelor interioare sau exterioare, purtătorul trebuie să se simtă bine. Așa numitul acord triplu fiziologic - temperatura, umiditatea și circulația aerului - trebuie să fie adaptabil cerințelor diverse din timpul unei zile de lucru cum ar fi: odihnă, mișcare, efort fizic și condițiile climatice. Proiectarea unui produs nu este legată doar de aspectul estetic, artistic, ci mai mult de funcționalitatea și ingineria sa (de la alegerea corectă a materialelor, construcției și conceptului tehnologic, până la prototipare). Un bun exemplu în acest sens este proiectarea încălțăminte multifuncționale, încălțăminte pentru soldați, polițiști. Prin urmare, proiectarea încălțăminte adecvate reprezintă o provocare mare nu numai pentru designeri, dar și pentru ingineri. Lucrarea prezintă modul în care a fost realizată încălțăminte din componența uniformei de serviciu a polițiștilor de penitenciare.

**CUVINTE CHEIE:** încălțăminte multifuncțională, materiale, specificații

### DÉVELOPPEMENT DE CHAUSSURES MULTIFONCTIONNELLES POUR DES AGENTS DE POLICE DES PRISONS

**RÉSUMÉ.** Il existe un lien étroit entre le confort des chaussures et la qualité de ce produit. Lorsque nous nous référons à la qualité des chaussures, nous devons partir de l'analyse des matériaux destinés à fabriquer l'ensemble supérieur et inférieur de la chaussure, l'analyse du comportement des combinaisons entre les différents éléments de l'ensemble et enfin nous devons considérer le comportement des chaussures dans son ensemble. Les chaussures doivent créer un climat où la température, l'humidité, la circulation de l'air et leur action sur le pied, et respectivement sur le corps entier sont corrélées. Même lors d'un changement rapide d'influences internes ou externes, le porteur doit se sentir bien. Le soi-disant triple accord physiologique - température, humidité et circulation de l'air - doit être adaptable à diverses exigences au cours d'une journée de travail telles que: repos, mouvement, effort physique et conditions climatiques. La conception d'un produit n'est pas seulement liée à l'aspect esthétique, artistique, mais plus à sa fonctionnalité et à son ingénierie (du choix correct des matériaux, de la construction et du concept technologique au prototypage). Un bon exemple à cet égard est la conception de chaussures multifonctionnelles pour les soldats et les agents de police. Par conséquent, la conception des chaussures appropriées est un grand défi non seulement pour les concepteurs, mais aussi pour les ingénieurs. Le document présente la façon dont les chaussures pour l'uniforme de service des agents de police des prisons ont été fabriquées.

**MOTS CLÉS :** chaussures multifonctionnelles, matériaux, spécifications

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**INTRODUCTION**

Footwear protects human feet against harsh conditions, such as cold or hot environments, wet surfaces, etc. Over time, there have been many changes in design, materials and technologies used, all of these in order to meet the needs of end users, from fashion to comfort and protection. That is why, today, there are a lot of types of footwear on the market, each with its own specific characteristics, e.g. sports shoes, trekking/hiking shoes, summer shoes, safety shoes, work shoes, etc. A special type of footwear is for soldiers and police officers, which is used in different environmental conditions (for cold and/or hot weather).

Military footwear has to fulfill many specific requirements, from maintaining and

improving mobility to maximizing protection and eliminating or minimizing the risk to the wearer (protection against ballistics, low temperatures, heat, degradation of human perspiration or microbiological agents, insects and snake bites etc.). Therefore, designing proper military footwear represents a major challenge not only for designers, but also for engineers.

When developing new products, considerable efforts must be made in designing the process, from the correct choice of materials, construction type and technological concept, to prototypes and consumer preferences (Figure 1) [1]. Only in this way the new product will be designed and functionalized according to the needs and requirements of the end user.

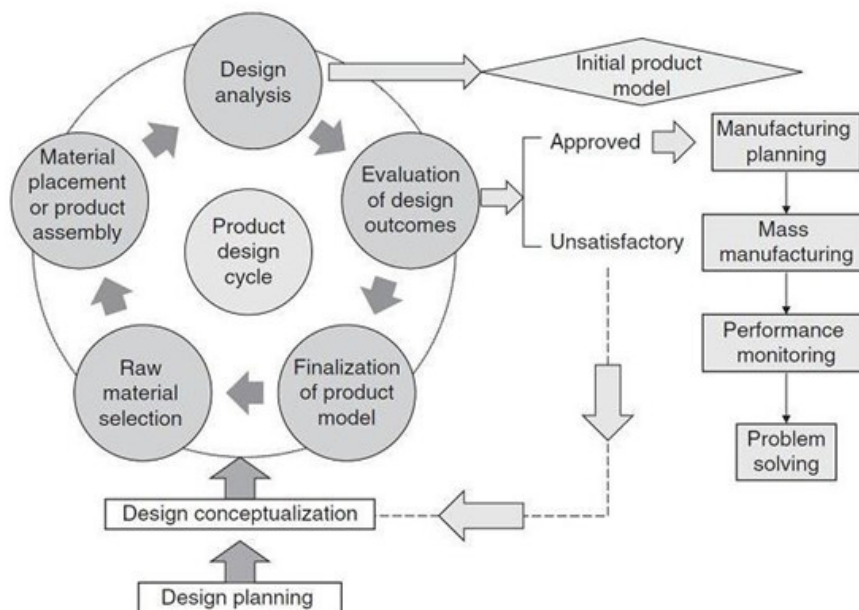


Figure 1. Product design concept

The process of designing specific products (for example, protective clothing or footwear) includes the entire design activity for the development of new products with high technological content, from the initial idea and the first project concept to the feasibility analysis, taking into account the materials to be tested during design, prototyping and manufacturing [2]. Designing specific products means balancing design requirements with function, performance, protection and comfort [3, 4]. This paper presents the development

of boots for hot and cold climatic conditions, specifically for the work uniform of police officers working in prisons.

**EXPERIMENTAL**

The purpose of the study is to develop multifunctional footwear for prison police officers, which can be worn in different climatic conditions, both during hot and cold weather. According to the common product design cycle (Figure 1), the design analysis, the material

selection, the product assembly mode, the evaluation of the design results, the prototyping, the prototype testing in real environment and the prototype corrections were performed according to the preferences and recommendations of the end user. As a result of such an integrated and iterative process of product development, a multifunctional product is developed for hot and cold weather conditions.

## RESULTS AND DISCUSSIONS

As a result of a survey on functionality, ergonomics, comfort, protection, shape, weight, etc. conducted among the end users the sketch of the boots that are part of the work uniform was made (Figure 2).

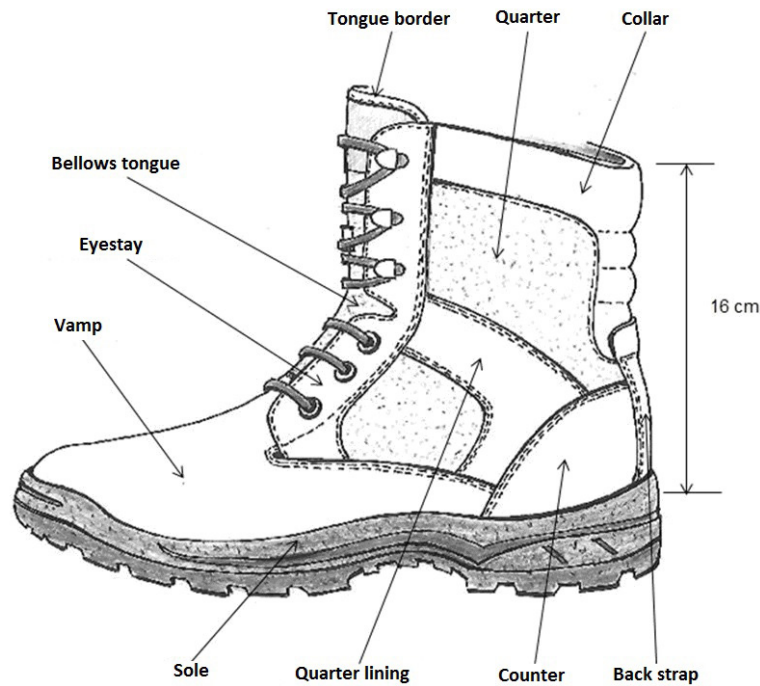


Figure 2. Sketch of the boots used as part of work uniform

Because there are many different component parts that make up the product, it is very important to choose the right materials that meet all end-user requirements regarding tensile strength, flexural strength, hardness, abrasion, etc., while ensuring adequate comfort for the wearer, both in hot and cold environments. In addition, the materials for all 70 component parts must be able to be combined together, ensuring aesthetic and functional value, as well as comfort.

Thus, the shoe uppers are made of natural black bovine leather (vamp, counter, back strap, collar, quarter lining, eyestay, eyestay lining), but also of textile material (quarters and tongue). Both leather and textile material are chemically waterproofed.

The upper leather must be waterproof, with a thickness of 1.8 to 2 mm, so that it can

meet the parameters related to tear strength and load resistance. These parameters influence the quality, strength, elasticity and plasticity during the manufacturing process and on the final product - the boots. Also, according to environmental standards, the chromium content should be undetectable. Other parameters (water permeability, water absorption, water vapor permeability) are closely related to foot comfort when wearing boots.

The textile material for uppers is a Cordura-type fabric and must be resistant to water penetration.

The inner linings are made of pig basan (counter lining), but also of textile material (quarter lining, vamp and tongue). The linings are stitched in a zig zag pattern and the seams are heat sealed.

The intermediate linings are made of a thermo-adhesive textile material (vamp reinforcement and quarter reinforcement), a self-adhesive material (eyestay) and a self-adhesive sponge (intermediate collar lining and intermediate tongue lining).

The sole is bicomponent (rubber + polyurethane), directly injected into the double density system. The outer layer has a high density which ensures increased wear resistance. The inner layer has a lower average density than the outer layer, which ensures an elasticity that takes over the mechanical shocks and allows an efficient distribution of body weight. The outsole has a non-slip appearance with regular shapes

on the outer surface. No bumps or irregularities are allowed on the visible side of the sole.

The locking system is stitching with eyelets and a black cotton lace.

The boots are made using the injection system (shoes with soles directly injected on the uppers).

No metallic elements are allowed in the boots, in order not to elicit a false alarm during antiterrorist and specialized control, when accessing the penitentiary.

Table 1 presents the characteristics of the materials used to make the boots as part of the work uniform of prison police officers.

Table 1: Characteristics of materials used to make the boots for prison police officers

No.	Material	Size (mm)	Nature of material	Use
1.	Natural bovine black leather, smooth grain, chemically waterproofed	1.8-2 (thickness)	Bovine leather	Vamp, counter, back strap, collar
2.	Natural bovine black leather, smooth grain, chemically waterproofed	1.2-1.4 (thickness)	Bovine leather	Quarter lining, eyestay, eyestay lining
3.	Double layer Cordura waterproof fabric	3 (thickness)	Synthetic	Quarters
4.	Simple Cordura waterproof fabric	0.5 (thickness)	Synthetic	Bellows tongue
5.	Textile material doubled with polyurethane foam	1.6 (thickness)	Synthetic	Inner lining for quarters, vamp and tongue
6.	Self-adhesive sponge	8 (thickness)	Synthetic	Intermediate lining for collar
7.	Self-adhesive sponge	6 (thickness)	Synthetic	Intermediate lining for tongue
8.	Thermoadhesive fabric	0.4-0.5 (thickness)	Cotton	Reinforcement for vamp and quarters
9.	Self-adhesive reinforcement	0.4-0.5 (thickness)	Non-woven textile	Reinforcement for eyelets
10.	Cotton strap	12 (width)	Cotton	Tongue border
11.	Self-adhesive strap	10 (width)	Synthetic	Sealing the stitches
12.	Thermoadhesive reinforcement	1.7 (thickness)	Thermoplastic material	Toe-cap
13.	Thermoadhesive reinforcement	2 (thickness)	Thermoplastic material	Rigid counter
14.	Tubular cotton laces	1300 (length)	Cotton	Lacing
15.	Expanded EVA doubled with textile material, preformed	2.2 (thickness)	EVA + synthetic	Insole cover
16.	Synthetic thread	30/3 Nm 40/3 Nm	Synthetic	Sewing uppers and linings
17.	Black round eyelets	∅ 5 mm	Plastic / composite material with high hardness	Lacing, 12 pcs/pair

18.	Hooks for lacing	Plastic / composite material with high hardness	Lacing, 12 pcs/pair
19.	Adhesives	Manual solution	Upper gluing
20.	Injected sole	Rubber + Polyurethane	Sole
21.	Colourless wax		Finishing
22.	Dye for upper retouching		Retouches

Table 2 presents the requirements that the finished product must be met by materials used for the boots and

Table 2: Physical-mechanical parameters required for the materials and the finished product

Specifications	Standard	U/M	Imposed values
<b>Leather</b>			
Tensile strength	SR EN ISO 3376:2012	N/mm <sup>2</sup>	min. 24
Water resistance of flexible leather - absorption after 3h - amount of water passed through the leather	SR EN ISO 5403-1:2012	% g/h	max. 45 max. 2.5
Water vapour permeability	SR EN ISO 14268:2013	mg/cm <sup>2</sup> h	min. 0.8
Flexural strength	SR EN ISO 5402-1:2012	cycles	250000
<b>Sole</b>			
Hardness - outer layer - inner layer	SR ISO 7619-1:2011	°ShA	70±5 60±5
Abrasion strength	SR EN 12770:2002	mm <sup>3</sup>	max. 250
Flexural strength	SR EN ISO 17707:2005	cycles	100000
<b>Material for quarters</b>			
Resistance to water penetration	SR EN 811:2018	mm col. water	min. 10000
<b>Bellows tongue material</b>			
Moisture resistance (Spray-test)	SR EN ISO 4920:2013	note	min. 4
<b>Lining</b>			
Tear strength	SR EN ISO 13937-3:2002	N	min. 20
Abrasion strength	SR EN ISO 12947-2:2017	no. of cycles	min. 25000
<b>Finished product</b>			
Leather upper and sole peel resistance	SR EN ISO 17708:2004	N/mm	min. 4

In accordance with the specified materials and the chosen technology, the prototypes were made and offered to the volunteers for real field tests in hot and cold environment. The feedback was positive from almost all users, which meant that all their requests and expectations were met, although some suggested that the size of the boots could be better adjusted to the type of foot (narrower, wider, etc.). Based on these results, the final shape of the multifunctional

boots for hot and cold weather conditions (Figure 3) was established. They will be standard equipment for prison police officers, as they are comfortable and durable boots.



Figure 3. Multifunctional footwear for hot and cold weather

## CONCLUSIONS

The production of a type of footwear that can be worn even in hot and cold weather conditions, intended for use during service by the penitentiary police officers, proved to be possible by the multifunctional design of a new product, made through the interdisciplinary team work of engineers and designers, in accordance with the requirements and suggestions of end users.

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