

LABORATORY TESTING OF CUTTING STRENGTH PERFORMANCE OF PROTECTIVE GLOVES AGAINST MECHANICAL RISKS

FLORIN ADRIAN PĂUN¹, DAN GABOR², MIRELA RADU³, CĂTĂLIN
MIHAI POPA⁴, ANCA ALEXANDRA TĂZLĂUANU⁵

Abstract: In general, during work tasks, workers are exposed to risk factors, which requires the use of appropriate personal protective equipment in terms of ensuring protection. Protecting workers from risk factors requires that personal protective equipment meets certain constructive and safety requirements, which are very important for the level of protection to be provided.

This paper aims to identify both general and security requirements applicable to gloves that provide protection against mechanical hazards, as well as the applicable test methods, whose results allow their subsequent characterization from protection against risks that are present during the performance of work tasks perspective. The methodology for assessing gloves that provide protection against mechanical risks is described, in relation to the essential safety and health requirements applicable under Regulation 2016/425, as well as the innovative solutions for building the stand for determining the shear strength by cutting protective gloves.

Keywords: personal protective equipment, protective gloves, mechanical hazards, laboratory tests, explosive atmosphere.

1. INTRODUCTION

Protective gloves against mechanical hazards are part of the category of personal protective equipment, their role being to offer protection [1].

Protective gloves against mechanical hazards are part of the category of personal protective equipment, their role being to protect the worker against at least one of the mechanical hazards such as: abrasion, cutting and perforation.

¹ Ph.D. Eng., INCD-INSEMEX Petroșani, florin.paun@insemex.ro

² Ph.D. Eng., INCD-INSEMEX Petroșani, dan.gabor@insemex.ro

³ D. Eng., INCD-INSEMEX Petroșani, mirela.radu@insemex.ro

⁴ PhD. Student Eng. INCD INSEMEX Petroșani, mihai.popa@insemex.ro

⁵ Ec., INCD-INSEMEX Petroșani, anca.tazlauanu@insemex.ro

Given the role of personal protective equipment in ensuring the protection of workers against the risks present during the performance of work tasks, at national level, the aspects related to ensuring the best conditions in the work process, defense of life, bodily integrity and the health of employees and other persons participating in the work process, are regulated by the Law on safety and health at work no. 319/2006 and the Methodological Norms for the application of the provisions of this law [5].

According to the law on safety and health at work no. 319/2006 respectively of the Decision on the minimum safety and health requirements for the use by workers of personal protective equipment at work, personal protective equipment means any equipment intended to be worn or held by the worker to protect it against or several risks that could endanger his safety and health at work, as well as any additional elements or accessories designed for this purpose. The obligation to use personal protective equipment by workers, established by the Law on Safety and Health at Work no. 319/2006, makes the gloves for protection against mechanical risks to be used in all applications involving the presence of risk factors with mechanical action (abrasion, cutting and perforation) [4], [5].

In the context of above mentioned aspects, it should be noted that the mandatory use of personal protective equipment or gloves against mechanical hazards in all applications involves their use, including by workers in hazardous areas. In general, in industrial spaces where combustible / flammable substances are processed, handled and stored, they can occur under normal working conditions due to accidental processes or leaks, explosive mixtures of gases, vapors, mists or dusts and air [2].

In order to reduce the risk of explosion in these potentially explosive atmospheres, special protective equipment must be used in special construction for potentially explosive atmospheres, that do not produce or constitute sources of energy which could initiate an explosion.

This means that personal protective equipment and mechanical safety gloves, used in potentially explosive atmospheres, comply with the essential safety requirements regarding the danger of explosions by preventing (avoiding) intrinsic sources of ignition of explosive atmospheres, such as, for example, those of an electrostatic nature [3].

The essential health and safety requirements for personal protective equipment, both at national and European level, are governed by Regulation (EU) 2016/425 of the European Parliament and of the Council of 9 March 2016 on personal protective equipment and repealing Directive 89 / 686 / EEC [5].

2. METHODOLOGY FOR ASSESSING PROTECTIVE GLOVES AGAINST MECHANICAL RISKS IN RELATION TO THE ESSENTIAL SAFETY AND APPLICABLE HEALTH REQUIREMENTS

2.1. Procedures for assessing the conformity of personal protective equipment with the requirements of Regulation (EU) 2016/425 for making available on the European market

LABORATORY TESTING OF CUTTING STRENGTH PERFORMANCE OF PROTECTIVE GLOVES AGAINST MECHANICAL RISKS

The main objectives of Regulation (EU) 2016/425 refers to:

-providing the essential safety and health requirements that personal protective equipment must meet, in order to maintain health and ensure the safety of potential users;

- ensuring the free movement of personal protective equipment throughout the European Union.

At the same time, Regulation (EU) 2016/425 also regulates the assessment procedures in relation to the essential safety and health requirements, applicable to the certification of personal protective equipment [6].

In order to certify personal protective equipment by third parties, the manufacturer is required to provide information in the technical documentation on the measures he has taken to ensure compliance of personal protective equipment with the applicable essential health and safety requirements.

If the manufacturer chooses to use harmonized European standards to ensure that personal protective equipment complies with Regulation (EU) 2016/425, he must be sure that these standards cover all the essential safety and health requirements applicable to his product under the foreseeable conditions for the intended use.

If harmonized European standards do not cover all the applicable essential health and safety requirements, it must, in addition to the application of these standards, ensure compliance with the essential health and safety requirements not covered by the use of other relevant technical specifications and other test methods.

In this context, it is important to note that personal protective equipment should be made available on the market and intended for use only if it complies with all applicable essential health and safety requirements.

According to Regulation (EU) 2016/425, the manufacturer is required to submit the model of personal protective equipment to one of the following certification procedures:

a) internal production control together with the EU declaration of conformity for category I PPE, in which case the manufacturer shall take all measures necessary to ensure that the manufacturing process and its monitoring ensure conformity of the PPE produced with the technical documentation and the applicable requirements of this Regulation.;

b) the EU-type examination, which is accompanied by the conformity to type based on internal production control and the EU declaration of conformity, for category II PPE, in which case the manufacturer shall take all measures necessary to ensure that the manufacturing process and its monitoring PPE products of the type described in the EU-type examination certificate and with the applicable requirements of Regulation (EU) 2016/425.

c) EU-type examination, which is accompanied by the manufacturer's choice of one of the procedures : conformity to type based on internal production control plus supervised product inspections at random intervals ; conformity to type based on quality assurance of the production process as well as by EU declaration of conformity for category III PPE, in which case the manufacturer shall take all measures necessary

to ensure that the manufacturing process and its monitoring ensure conformity of production and conformity of PPE produced with the type described in the EU-type examination certificate and with the applicable requirements of Regulation (EU) 2016/425. approved for the production, inspection of finished products and testing of the PPE concerned and subject to supervision.

After PPE certification, the manufacturer or his authorized representative might apply the CE conformity marking, attesting their conformity with all the provisions of Regulation (EU) 2016/425, including the certification procedures provided for in Art. 19. The European CE conformity marking consists of the initials "CE" and is subject to the general principles set out in Article 30 of Regulation (EC) No 1234/2007. 765/2008.

Where the notified body is involved in the production control phase, the European conformity marking shall be followed by the identification number of that body.

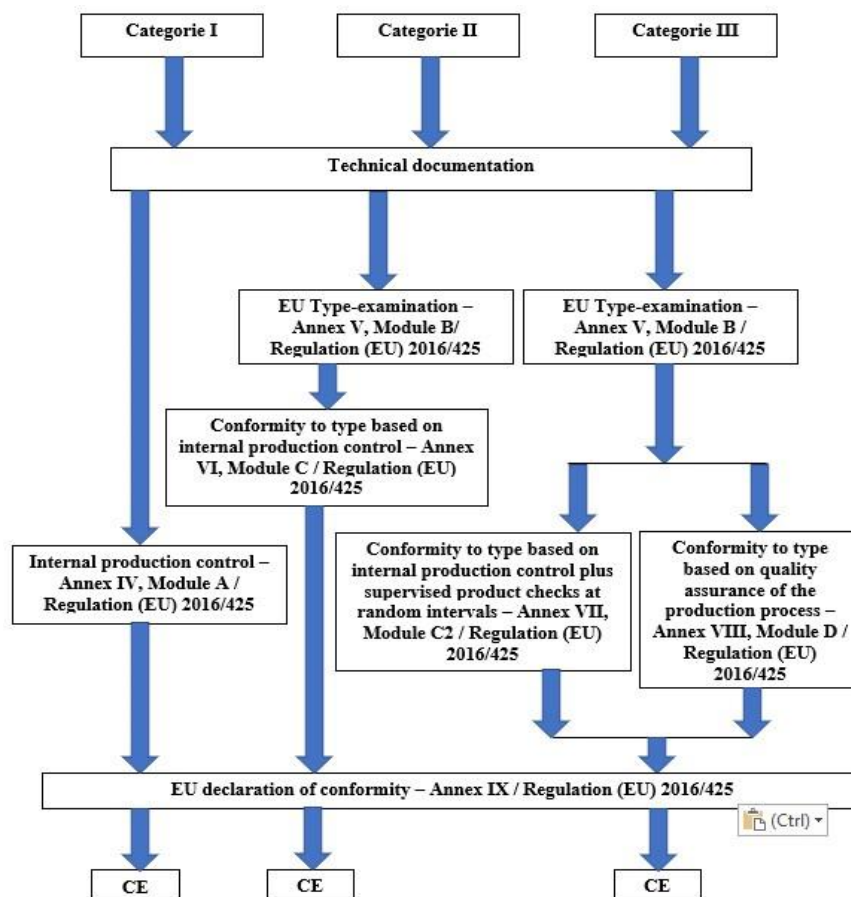


Fig.1. Conformity assessment procedures for personal protective equipment according to Regulation (EU) 2016/425

LABORATORY TESTING OF CUTTING STRENGTH PERFORMANCE OF PROTECTIVE
GLOVES AGAINST MECHANICAL RISKS

2.2. General and specific requirements for protective gloves

In accordance with the standard EN ISO 21420: 2020 "Protective gloves. General requirements and test methods ", protective gloves must meet a number of general requirements in order to ensure protection against risk factors related to the ergonomics and construction of gloves, the resistance of constituent materials to water penetration, their safety, comfort and effectiveness, plus the marking and information provided by the manufacturer applicable to all protective gloves [7].

From the point of view of design and construction, protective gloves must be designed and constructed in such a way as to ensure the highest possible level of protection under the foreseeable conditions of use for which they are intended, the user being able to perform normally when exposed to hazards.

If required, protective gloves should be designed to minimize wear and / or tear. If the protective gloves contain seams, their material and strength must be such that the overall performance does not decrease significantly.

The constituent materials of the gloves must have a certain resistance to water penetration expressed by one of the performance levels given in the table 1:

Table 1. The performance levels given

Performance level	Penetration time minutes
1	30
2	60
3	120
4	180

Protective gloves must also be designed to provide protection without harming the user when used in accordance with the manufacturer's instructions.

The constituent materials of the protective gloves, the degradation products, the built-in substances, the seams, the edges and in particular the parts which come into direct contact with the user, must not harm his health and hygiene.

Regarding the size and dimensions of the hand, two main measures are considered, namely the circumference of the hand and the length of the hand (distance from the joint of the hand to the tip of the middle finger). The size of the protective gloves is determined by the size of the gloves they are wearing. However, the actual dimensions of the gloves must be determined by the manufacturer, taking into account the behavior of the glove material and the intended use.

The dexterity of protective gloves is very important. It is recommended that a protective glove be as dexterous as possible for the intended use. The dexterity of a protective glove depends on many factors, such as the thickness of the glove material, its flexibility and deformability.

Also, if necessary, protective gloves should have a water vapor permeability of at least 5 mg / (cm²h) . When the protective characteristics of the glove reduce or

exclude water vapor permeability, the glove should be designed to minimize the effects of perspiration.

In addition to these general requirements, gloves for protection against mechanical hazards must meet a number of safety requirements relating to abrasion resistance, shear strength, tear strength and puncture resistance.

3. TEST METHOD FOR DETERMINING CUTTING STRENGTH BY CUTTING MECHANICAL RISK PROTECTIVE GLOVES

The test method for blade cut resistance determination for protective gloves is provided in SR EN 388+A1:2019 „Protective gloves against mechanical risks”.

The test method consists in cutting test samples with a device having a circular blade, moving with an alternate motion under a specified load. Thus, the test sample is submitted to a number of cutting cycles, subsequently recorded and the blade cut resistance index is then calculated.

This blade cut resistance index represents one of the safety parameters of the protective gloves, showing their resistance to cutting by blade. The protective gloves fulfilling this requirement are considered to be adequate from a blade cut resistance standpoint.

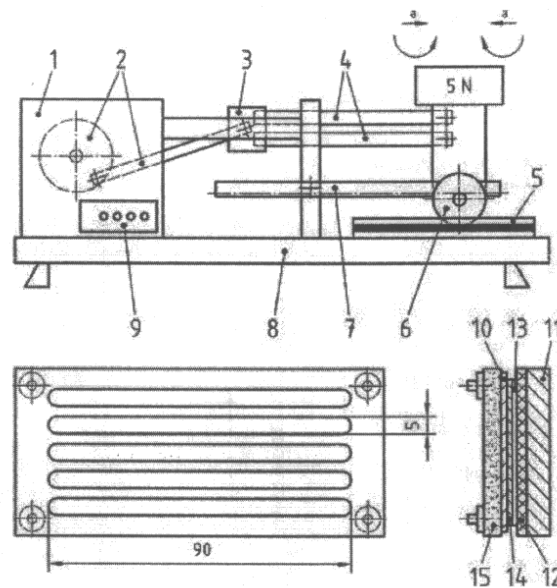


Fig.2. Schematic diagram of the test stand

Legend:

- | | |
|---|-------------------------|
| 1 – motor casing and electronic detection | 9 – counter |
| 2 – driving wheel and rod | 10 – test sample |
| 3 – sliding system | 11 – insulating support |

LABORATORY TESTING OF CUTTING STRENGTH PERFORMANCE OF PROTECTIVE GLOVES AGAINST MECHANICAL RISKS

- | | |
|--------------------|----------------------------|
| 4 – connecting rod | 12 – conductive rubber |
| 5 – sample support | 13 – Aluminum foil |
| 6 – circular blade | 14 – filter paper |
| 7 – cogged rail | 15 – upper part |
| 8 – support plate | a – blade alternate motion |

The apparatus required for carrying out the test consists in the following:

- a testing machine, moving horizontally, alternative, a rotating circular blade.
The stroke is 50mm and the blade fully rotates in a sense opposed to the motion sense.
The maximum circumferential velocity is 10 cm/s;

- a weight pressing the blade with a force of $(5 \pm 0,05)$ N;
- the circular blade having the diameter of $(45 \pm 0,5)$ mm, thickness of $(3 \pm 0,5)$ mm and a cutting angle between 30° and 35° , made of wolfram steel having a Vickers hardness between 740 and 800;
- a conductive rubber support (hardness 80 ± 3 DIDC);
- a frame to hold the test sample;
- an automatic cut detection system;
- a cycle number counter, adjusted for tenths of cycles.

The test method for determining the shear strength of cut-resistant protective gloves shall be performed using the test stand shown in figure 3.



Fig.3. Test stand for determination of blade cut resistance of protective gloves

4. LABORATORY TESTS FOR DETERMINING BLADE CUTTING STRENGTH BY CUTTING MECHANICAL RISK PROTECTIVE GLOVES

In order to determine the shear strength, which is one of the essential protective performance of gloves against mechanical hazards, a series of laboratory tests have been carried out by applying the test method and using the stand test,

previously presented. The laboratory tests were performed according to the requirements of the standard SR EN 388 + A1: 2019, on samples taken from several varieties of gloves for protection against mechanical risks, within the INSEMEX-GLI laboratory, laboratory accredited according to the requirements of the standard SR EN ISO / IEC 17025 : 2018.

The laboratory tests were mainly aimed at determining the shear strength of the samples taken from the gloves against mechanical hazards, the accuracy of the results obtained, the repeatability and reproductibility of the tests and last but not least the identification of factors influencing the quality of the test results. The results obtained on the test samples, as a result of the determination of the shear strength of the gloves for protection against mechanical hazards, are presented in the table below:

Table 2. The determination of the shear strength of the gloves for protection against mechanical hazards

Test sample	Sampling area	Temperature and relative humidity	Test number	Index value, i	Average index value, i	Performance level
A(split cowhide)	palm	20 °C and 63 %	1	2,61	2,62	Level 2
			2	2,50		
			3	2,66		
			4	2,65		
			5	2,71		
B (split cowhide)			1	1,21	1,29	Level 1
			2	1,34		
			3	1,27		
			4	1,45		
			5	1,20		

From the results obtained, shown in the table above, it can be seen that although the test samples were conditioned and tested under the same conditions of temperature and relative humidity, the level of performance is different.

If the tests on the two test samples (A and B) were performed in the same way, according to the requirements of the standard SR EN 388 + A1: 2019, it can be seen that the level of performance is different, so that the difference is due test sample material [8].

Although the material of both test specimens under test was bovine skin splinters, the samples being taken from different assemblies of gloves for protection against mechanical risks, led to a different level of performance.

Therefore, the performance level of gloves against mechanical hazards is mainly influenced by the material of which these gloves are made, while the conditioning and test conditions do not affect the results obtained, provided that the tests are performed and meet the requirements of SR. EN 388 + A1: 2019 [8].

At the same time, based on the results obtained and presented in the paper as well as other results obtained from the determination of shear strength on different

LABORATORY TESTING OF CUTTING STRENGTH PERFORMANCE OF PROTECTIVE GLOVES AGAINST MECHANICAL RISKS

types of gloves for protection against mechanical risks, it can be stated that in compliance with the test requirements of SR EN 388+ A1: 2019, both the test method and the test stand used, allow to obtain comparable results which leads us to ensure the repeatability and reproducibility of the tests performed.

5. CONCLUSIONS

Gloves that provide protection against mechanical hazards must comply with the applicable essential health and safety requirements in order to ensure a high level of protection of the user during the performance of work tasks.

Laboratory testing of their properties with a role in ensuring protection against risk factors is particularly important and at the same time necessary to establish the compliance of mechanical risk protection gloves with the applicable essential health and safety requirements.

Testing gloves against mechanical hazards for certification is particularly important given the risk of mechanical aggression and the risk of explosion that exists and must be minimized, in order to ensure the safety of life and health of workers.

Test methods ensure the repeatability and reproducibility of tests in various test laboratories, which is of particular importance as it provides a real basis for comparing the results of tests performed in European accredited laboratories in order to properly assess compliance with essential safety requirements. .

In order to have a basis for comparison, tests must be performed with well-defined test methods that take into account the influencing factors and that can ensure adequate repeatability and reproducibility.

In order to obtain results as accurate and as close as possible to the real ones, it is necessary to apply standardized test methods, respectively to perform the tests in an accredited laboratory according to the requirements of the SR EN ISO / IEC 17025: 2018 standard.

REFERENCES

- [1]. **Păun F.A.**, *Proiect Program NUCLEU „Tehnologie inovativă pentru testarea performanțelor specifice echipamentelor pentru protecția mâinii”*, 2014-2015.
- [2]. **Păun F.A.**, s.a., *Innovative technology for testing of protective gloves specific performances*, 7th INTERNATIONAL CONFERENCE ON MANUFACTURING SCIENCE AND EDUCATION, MSE 2015, 3 - 5 Iunie 2015, Sibiu, România.
- [3]. **Păun F.A.**, s.a., *Innovative technology for determination of blade cut resistance of protective gloves*, The International Conference TexTeh VII “CREATING THE FUTURE OF TEXTILES” Proceedings, ISSN 2068-9101, Vol.7, October 22 - 23, 2015, Bucharest, Romania.
- [4]. **Hotărârea de Guvern nr. 1048/09.08.2006** privind cerințele minime de securitate și sănătate pentru utilizarea de către lucrători a echipamentelor individuale de protecție la locuri de muncă;

[5]. **Hotărârea de Guvern nr. 1058/09.08.2006** privind cerințele minime pentru îmbunătățirea securității și protecției sănătății lucrătorilor care pot fi expuși unui potențial risc datorat atmosferelor explozive.

[6]. **Regulamentul (UE) 2016/425** al Parlamentului European și al Consiliului din 9 martie 2016 privind echipamente individuale de protecție și de abrogare a Directivei 89/686/CEE a Consiliului.

[7]. *** **EN ISO 21420:2020** Mănuși de protecție. Cerințe generale și metode de încercare.

[8]. *** **SR EN 388+A1:2019** Mănuși de protecție împotriva riscurilor mecanice.