

INFLUENCE OF BETA AND GAMMA RADIATION ON THE PROPERTIES OF NBC PROTECTIVE CLOTHING

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PPE Department

The PPE Department, located in Łódź, operates laboratories that enable comprehensive testing of the protective and performance characteristics of all types of PPE in accordance with EU requirements, addressing new hazards and evolving user needs.

The department consists of five specialized laboratories:

- Respiratory Protection Equipment Laboratory
- Head Protection and Fall Arrest Equipment Laboratory
- Protective Clothing Laboratory
- **Eye and Face Protection Laboratory**
- Hand and Foot Protection Laboratory





BACKGROUND OF THE STUDY

Preparation of guidelines on the durability and functionality of personal protective equipment which contributes to improving the safety of emergency services working in conditions of exposure to ionising radiation.

OBJECT OF STUDY IN THIS TASK

Polycarbonate sight glass

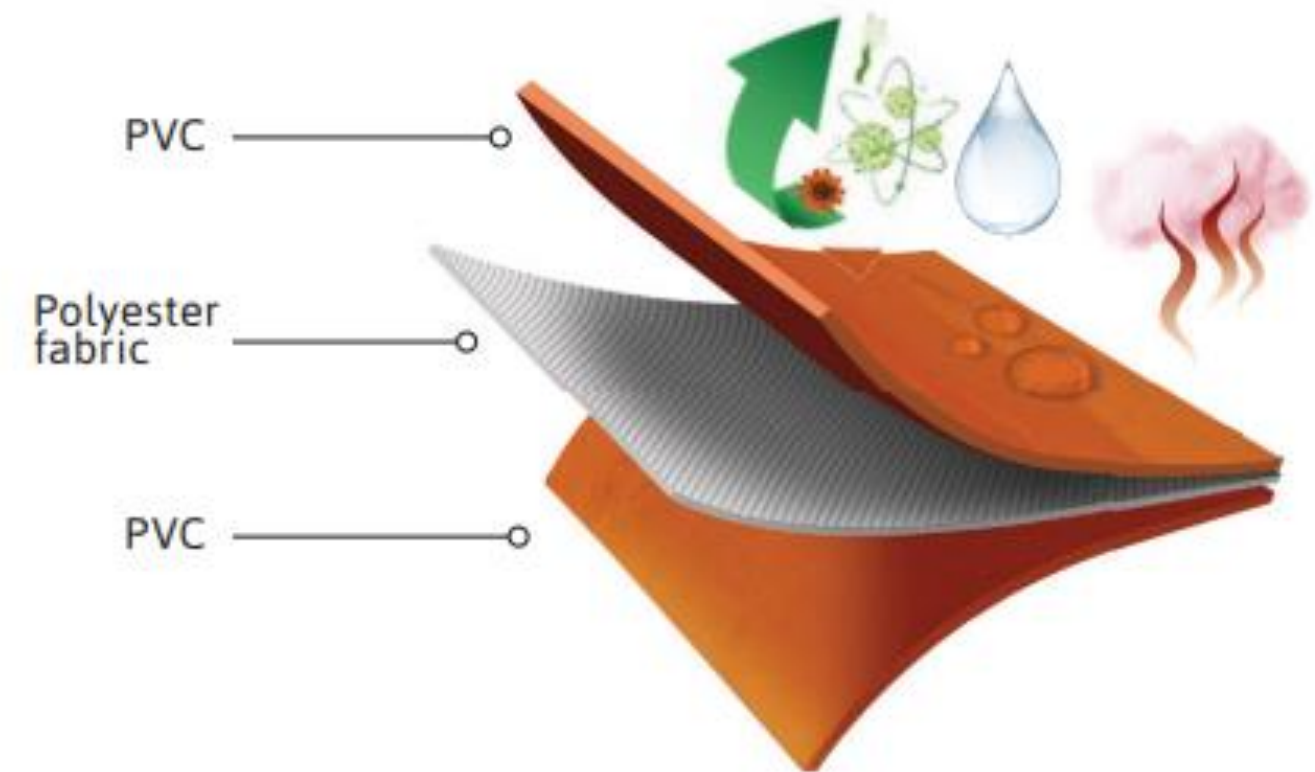


Butyl gloves

Polyester fabric coated with polyvinyl chloride full-rubber suit

Nitrile gloves

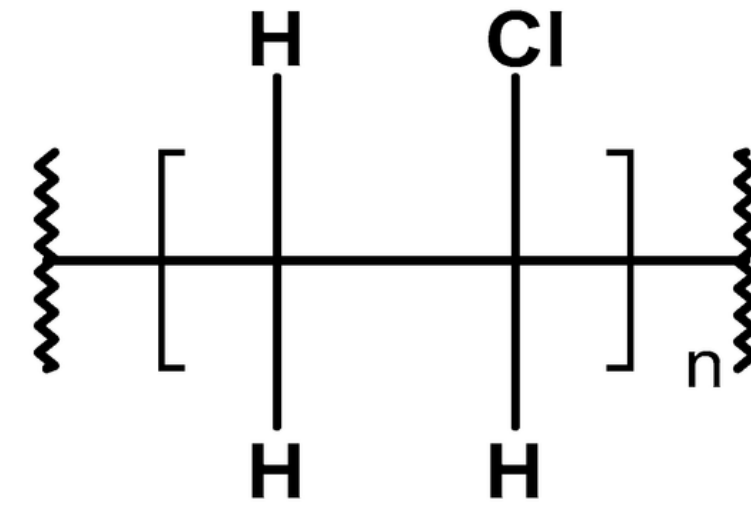
OBJECT OF STUDY



GAS-TIGHT FULL-RUBBER SUIT

- EN 943-1:2015-12 + A1:2019; TYPE 1a-B (protection against chemicals)
- EN 1073-2:2002; EN 14126:2003 (protection against radioactive contamination by solid particles)
- EN 1149-5:2008 (protection against infectious agents)

POLIVINYL CHLORIDE



PVC

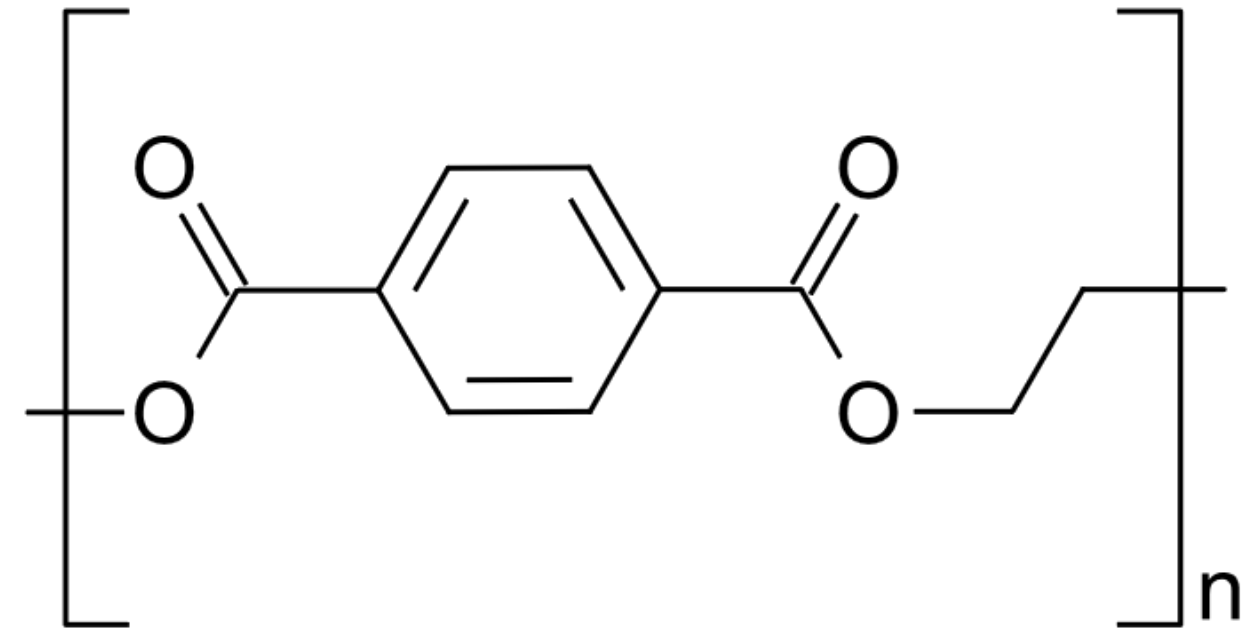
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- Thermoplastic polymer
- Good mechanical properties
- High-grade of resistance to chemical
- Anti-static properties (modified PVC)
- Elastic (additives of plasticiser)
- Self-extinguishing
- Inexpensive



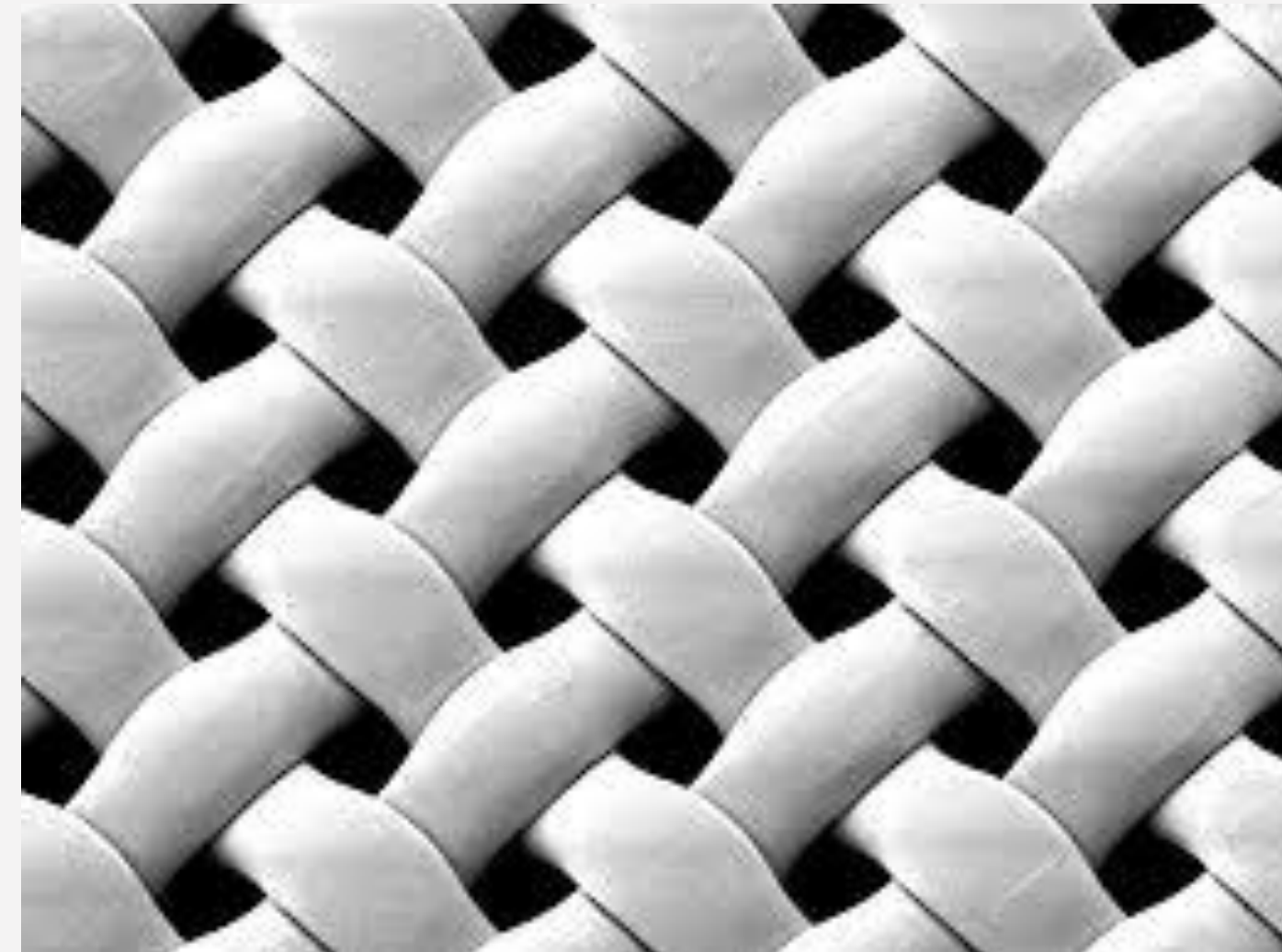
POLYESTER FABRIC



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- Thermoplastic polymer
- Good mechanical properties (strong and durable)
- Hydrophobic
- Lightweight



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METHODOLOGY

1. PREPARATION

The samples were irradiated with beta and gamma rays

2. CARRYING OUT TESTS

Samples before and after irradiation were examined for:

- tear resistance,
- chemical degradation resistance and puncture resistance,
- blade resistance test,
- microstructure.





BETA RADIATION

The material was exposed to accelerated electron beam radiation in a linear accelerator Elektronika ELU-6. The irradiation was carried out using an electron beam with an energy of 6 MeV, a pulse frequency of 20 Hz, and a pulse duration of 4 μ s.

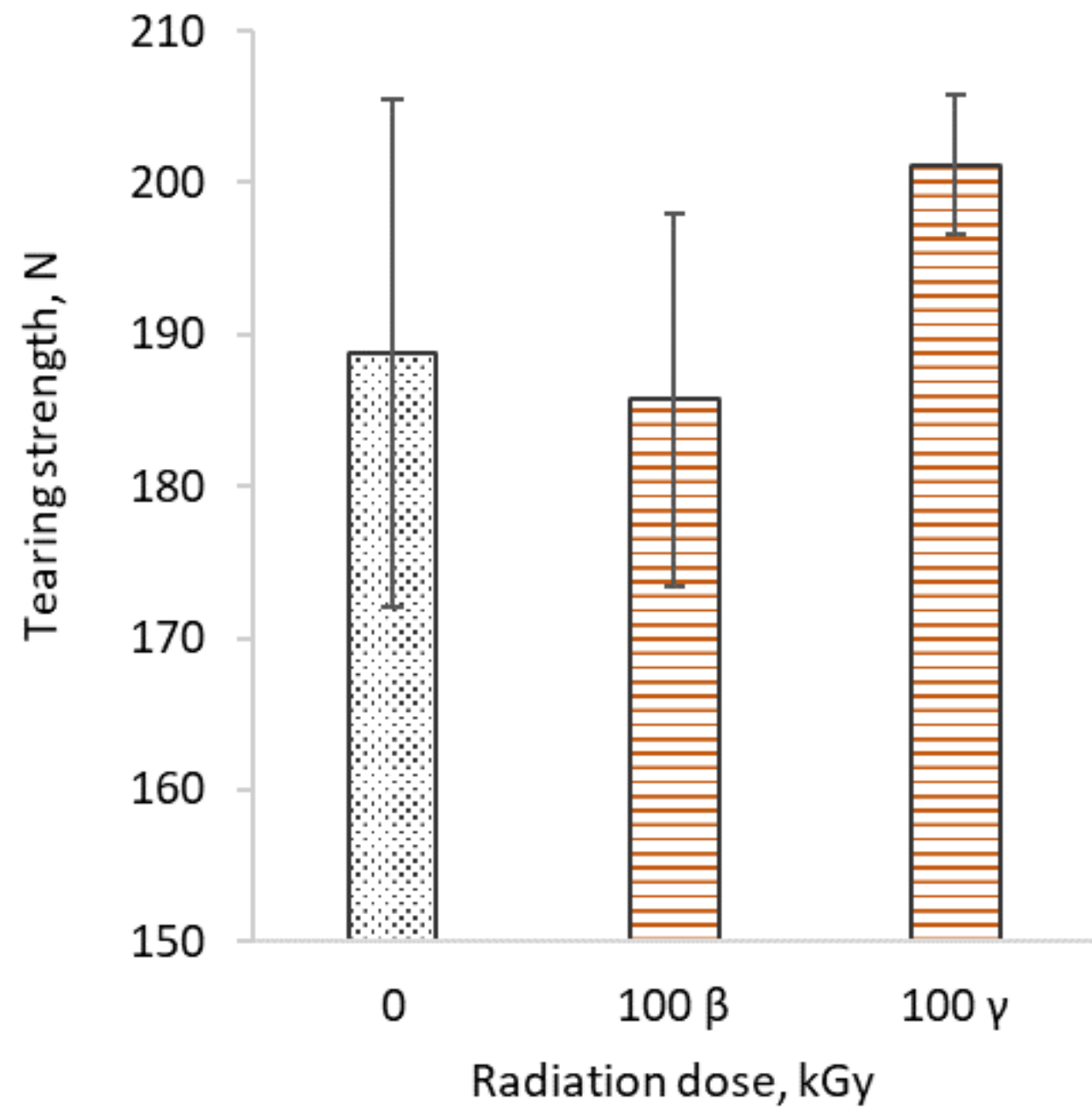


GAMMA RADIATION

To simulate gamma radiation exposure were used isotope ${}^{60}\text{Co}$, which has a half-life of 5.272 years and an average photon energy of 1.25 MeV. The radiation source was a metallic sinter enclosed in sealed, double-walled capsules made of acid-resistant steel, placed in a frame container surrounded by a concrete shield.

PREPARATION

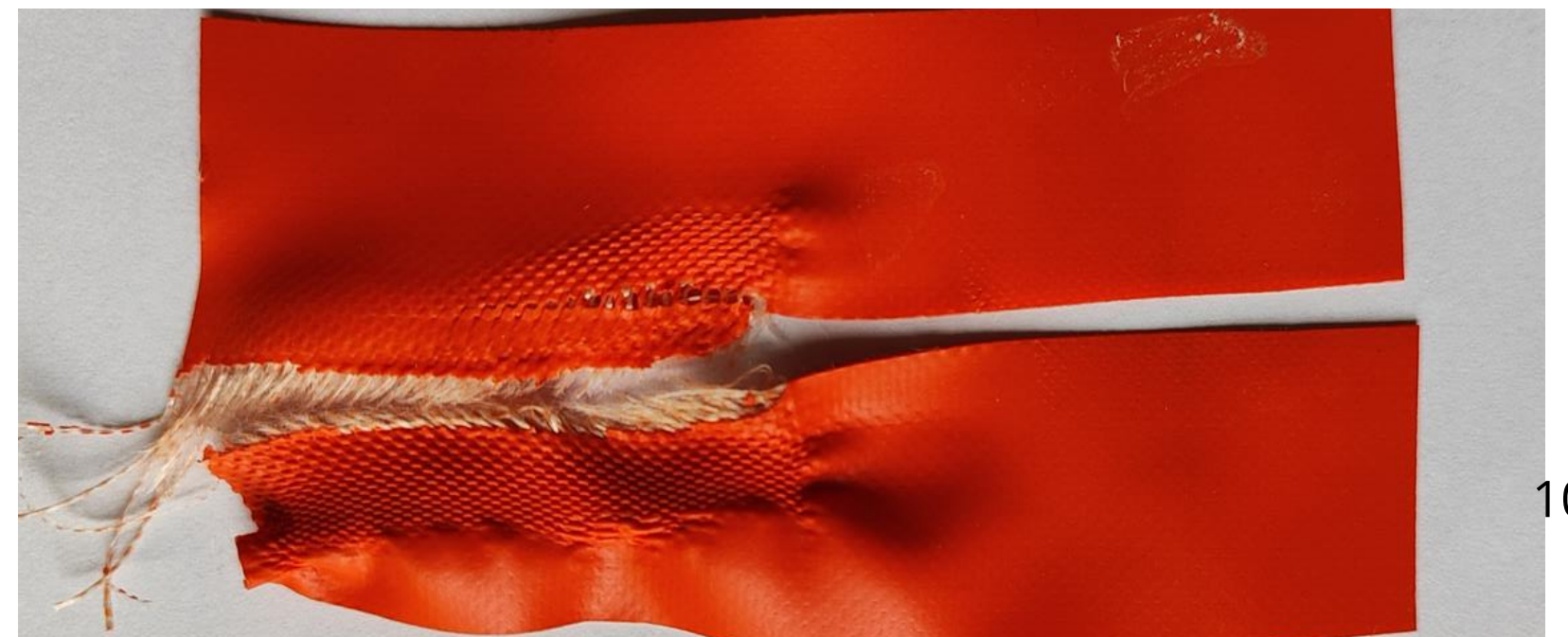
Samples absorbed a dose of 100 kGy of beta and gamma radiation



TEAR RESISTANCE

The samples that were tested were in the “pant shape”

The jaw rate was 100 ± 10 mm/min and the jaw spacing was at least 10 mm.



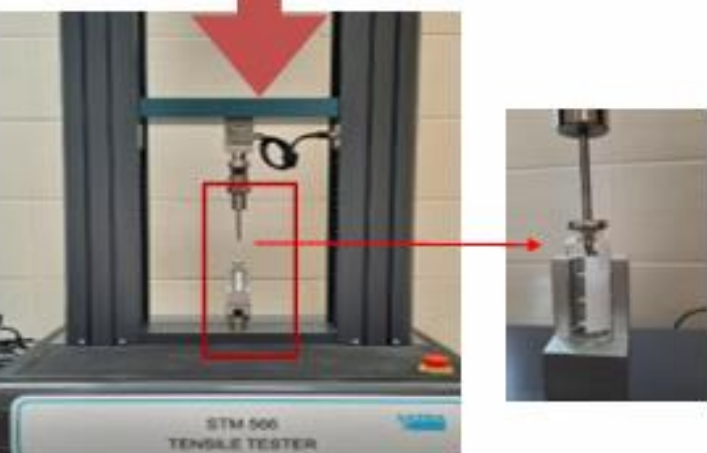
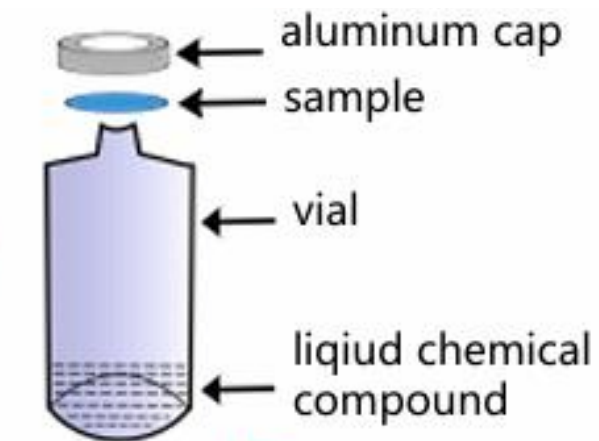
■ CHEMICAL DEGRADATION RESISTANCE AND PUNCTURE RESISTANCE

EXPOSURE TO CHEMICAL SUBSTANCES

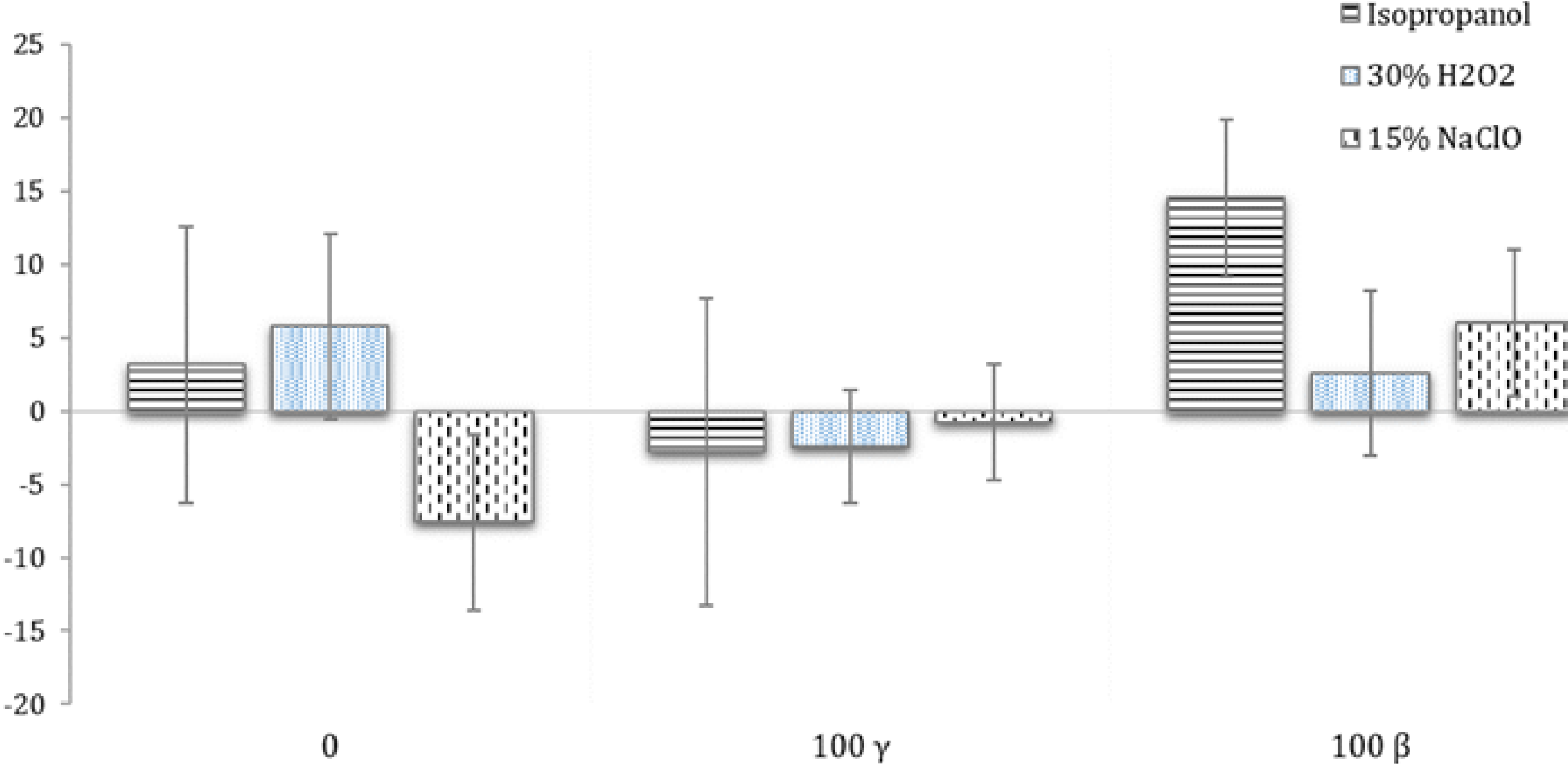
MECHANICAL TESTING – PUNCTURE FORCE MEASUREMENT

- Samples were placed in tightly sealed vials.
- They were exposed to liquid substances for 1 hour.
- This setup prevented the influence of climatic fluctuations.

- Puncture force was measured on both control and chemically exposed samples.
- Testing was performed at a constant speed of 100 mm/min.
- The maximum force value was recorded for each sample.
- Percentage differences between reference and degraded samples were calculated.



RESULTS OF CHEMICAL DEGRADATION RESISTANCE AND PUNCTURE RESISTANCE



The largest degradation percentage value was obtained by the 100 β sample, which was treated with isopropanol relative to the result for the non-irradiated sample.

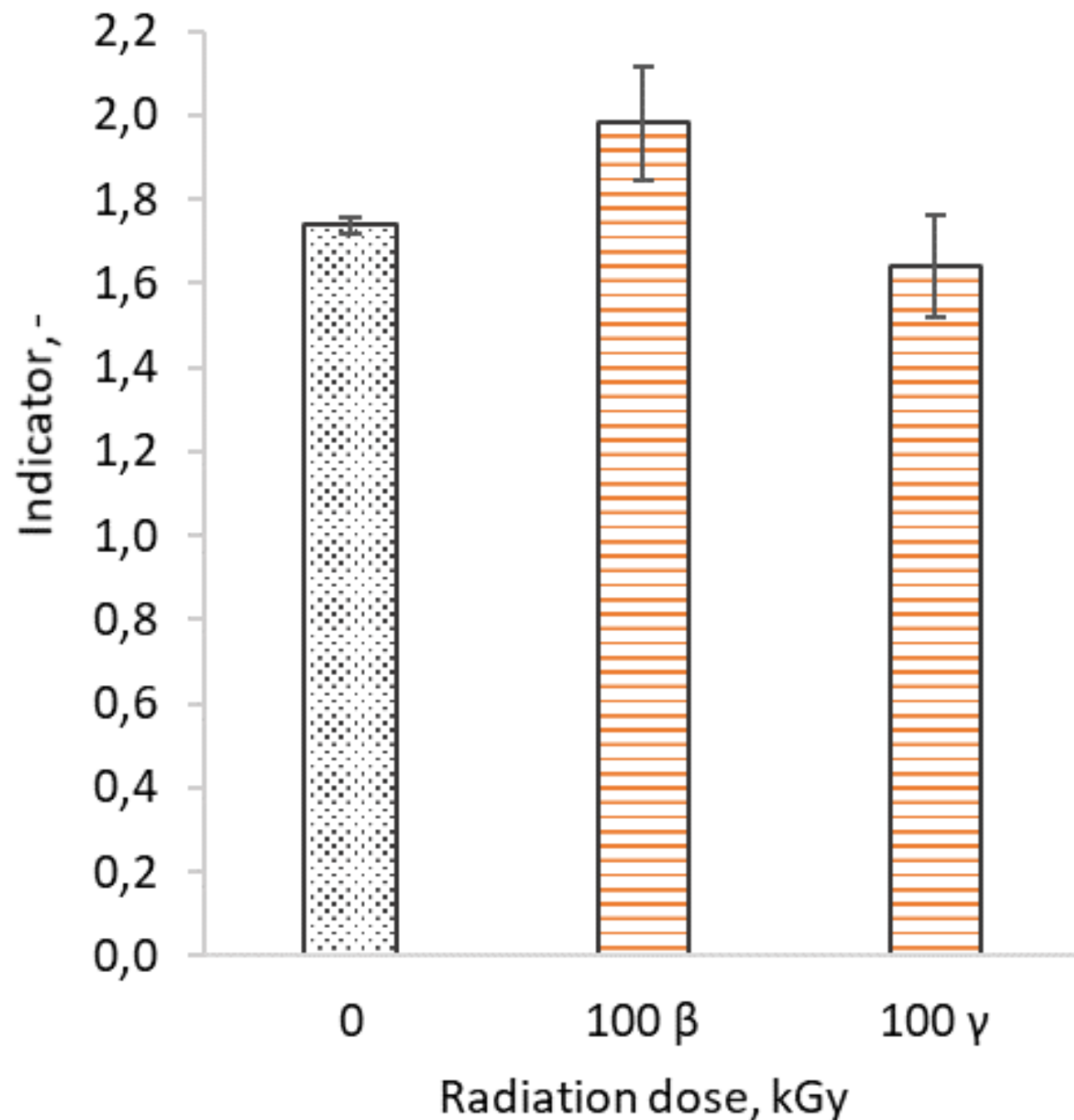
The reference sample, which was treated with sodium hypochlorite, had the lowest degradation value.

Negative values indicate the possibility of cross-linking processes occurring, which is observed for samples that were treated with gamma radiation

0 kGy	100 kGy β	100 kGy γ
130,66 \pm 4,38	135,23 \pm 2,27	146,65 \pm 3,14

Puncture resistance

BLADE RESISTANCE TEST



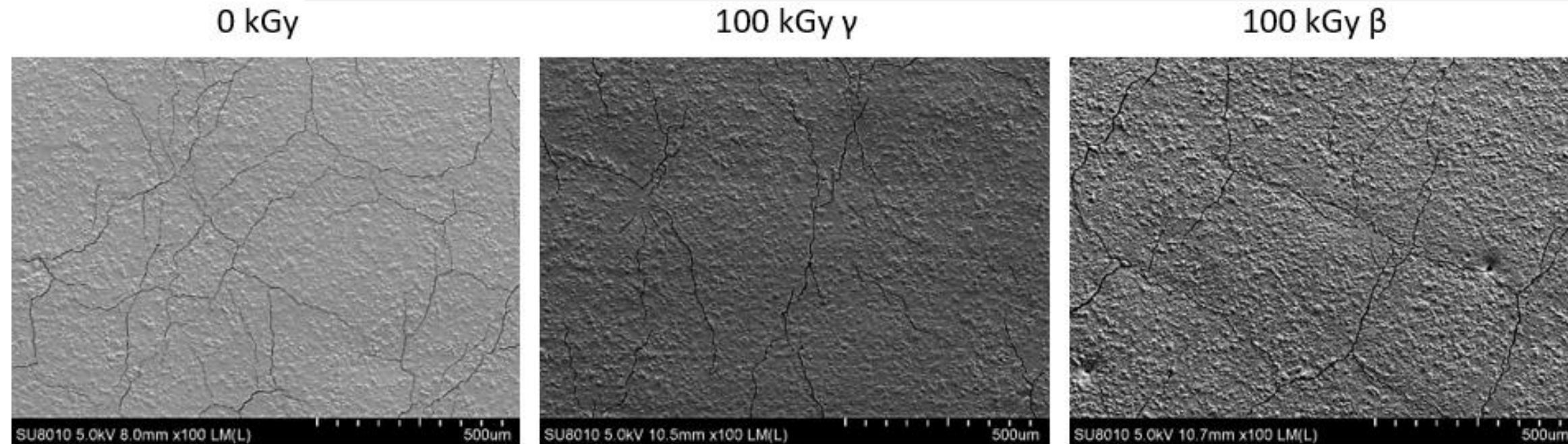
The test samples consisted of a strip with a width of (60 ± 6) mm and a length of (100 ± 10) mm, cut at an angle.

The material under test was placed in the holder, and a blade arm was lowered, then the number of cycles (blade rotations) at which the sample was cut through (T) was recorded.

A significant increase in the index value was observed for the sample that was exposed to beta radiation. The higher the index, the more cut-resistant the material is and the better it protects the suit wearer.

MICROSTRUCTURE

Surface cracking was observed for both irradiated and non-irradiated samples
Cracks in the surface of the material appear deeper after irradiation.



The surface microstructure of the examined visors was analyzed based on images taken using a scanning electron microscope SU-8010 (Hitachi, Hitachi-shi, Japan) with an electron acceleration voltage of 5 kV and a Lower InLens (L) detector.



- Exposure to beta radiation caused a deterioration in cut and tear resistance, suggesting that degradation processes were occurring in the samples.
- Gamma radiation improved chemical degradation resistance and puncture resistance.
- Microstructure analysis indicated significant changes in the surface of the tested material.

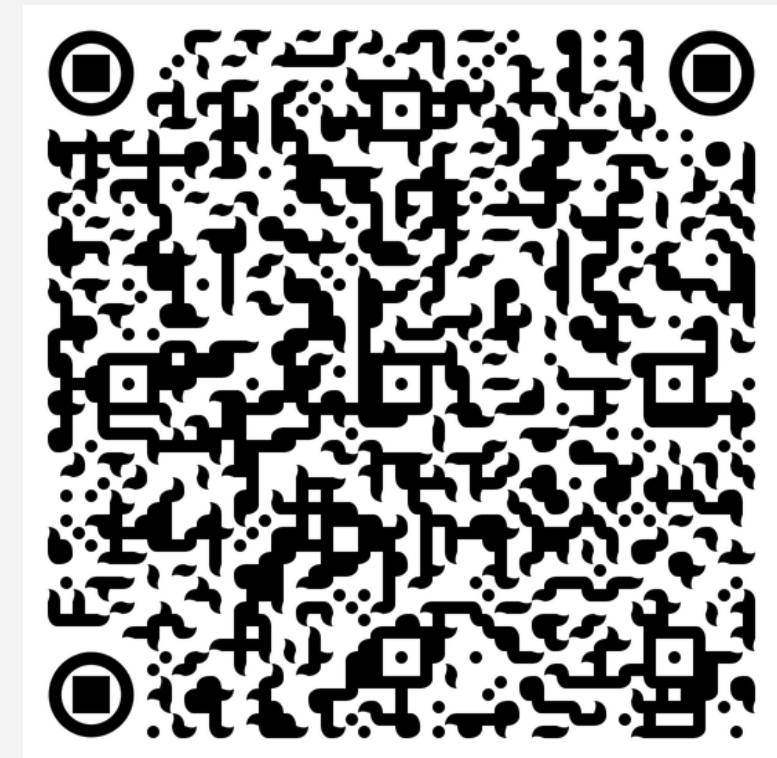
CONCLUSION

This task was completed on the basis of results of research carried out within the scope of the 6th stage of the National Programme “Governmental Programme for Improvement of Safety and Working Conditions”, funded by state services of the Ministry of Family, Labour and Social Policy.

task no.: 1.ZS.07

Entitled: “Influence of ionising radiation on PPE durability”),

The Central Institute for Labour Protection – National Research Institute is the Programme’s main co-ordinator.



**THANK YOU
FOR YOUR
ATTENTION**