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RADIATION HARDNESS OF POLYSULPHONE AND POLYCARBONATE ELEMENTS FOR LHC DETECTORS

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Abstract

In the TRT Inner Detector being developed for ATLAS, elements made from plastic materials are widely used. In order to meet necessary requirements of the construction, these materials should have a high radiation hardness. This work presents a study of mechanical features of polysulphone and polycarbonate in dependence on the radiation dose. The results of measurements have shown a weak dependence of mechanical properties of polysulphone and polycarbonate on the absorbed dose up to the value of 1 MGy. So, the products from these materials could be used to construct detectors at LHC, at least on the mechanical point of view.

1 Introduction.

The peculiarity of working conditions for the ATLAS experiment at LHC is a high level of radiation. In the construction of detectors for TRT on the base of thin film drift tubes [1], the elements made from plastic materials are widely used. These materials should possess enough mechanical hardness, it must be possible to glue them and to use moulding method in the production of the elements. Besides, they should preserve the required properties under electromagnetic and radiation fields during 10 years.

The purpose of this work was to study mechanical properties of polysulphone and polycarbonate at different stages of exposure.

2 Exposure Conditions at Reactor.

Rectangular samples having size of 118x10x4 mm produced from polysulphone and polycarbonate using, were divided into seven exposed and one control groups. The exposure of samples was performed at the set up for radiation research of the IBR-2 reactor, JINR [2]. The energy spectrum of fast neutrons of the IBR-2 reactor in the range of energies from 0,1-20 MeV with the mean energy of ~ 1 MeV corresponds to the neutron spectrum of the protons of LHC. The gamma spectrum besides the gamma radiation of the reactor itself, is significantly connected with gamma radiation after the capture of neutrons in the materials of the reactor shielding. It has a mean energy from 1,5 to 2 MeV and a high energy tail up to 9 MeV. The mixed neutron-gamma exposure of the samples was performed during ~300 hours and consisted of 7 cycles. After every cycle the groups were taken out from the exposure zone to study their mechanical properties. To measure the radiation rate of gammas in the mixed field of gamma-neutron radiation of the IBR-2 reactor, the thermoluminiscent detectors TLD-700 were used, and the total integral radiation rates were measured by alanin dosimeters from CERN. The maximum of the absorbed gamma-dose was 536 KGy at the simultaneous set of the fast neutron fluence of more than 10^{16} n/cm^2 that corresponds to the value of the absorbed dose of 474 KGy.

3 Methods for Testing Samples.

The samples from the exposed groups have undergone on deflection and Brinell hardness tests and then the obtained results were compared with those for the control group. Deflection tests were performed as the scheme given in Fig. 1 (3 point bending leak). According to the results of testing for every group, the dependences F = f (δ) were found to determine the modulus of elasticity, the yield limit and the ultimate strength.

Typical dependences for polysulphone and polycarbonate are shown in Fig. 2. As a result of measurements the dependences of the limit loading F_{max} and permissible loading at the level of 0,6 F_{max} (Fig. 3) were draw as well as the defection values (Fig. 4) corresponding to them on the exposed dose. The results of Brinell hardness tests for the same samples as a function of the absorbed dose are presented in Fig. 5. The study of radiation hardness of polysulphone and polycarbonate has shown that polysulphone practically preserves its mechanical properties: a reduction by ~ 10% of the value of the maximum deflection (Fig. 4) and an increase by ~ 15% of the Brinell hardness were found (Fig. 5). The reduction of the value of the maximum deflection for polycarbonate is about 25%. For small doses of radiation HB is decreasing slightly and next there is a small increase of HB at a large dose radiation. It is necessary to emphasize a strong dependence of the transparency of polycarbonate on the value of the absorbed dose. The control of the density of the exposed samples has shown its slight rise at the maximum exposure dose. The increase of the density at the maximum absorbed dose is ~ 0,25% relatively to the samples from the control group.

Conclusions

The performed research has shown a weak dependence of mechanical properties of the products from polysulphone and polycarbonate on the absorbed dose of radiation up to the value of 1 MGy. Strong influence of the radiation dose has been noticed on the optical properties of polycarbonate. The results of measurement have shown that the products from these materials can be widely used as construction elements for detectors at LHC, at least on the mechanical point of view.

References

1. CERN/LHCC/97-17, ATLAS TDR-5, 30 April 1997,Volume 2.
2. V.V. Golikov et al., JINR, Dubna, P13-96-403, 1996.

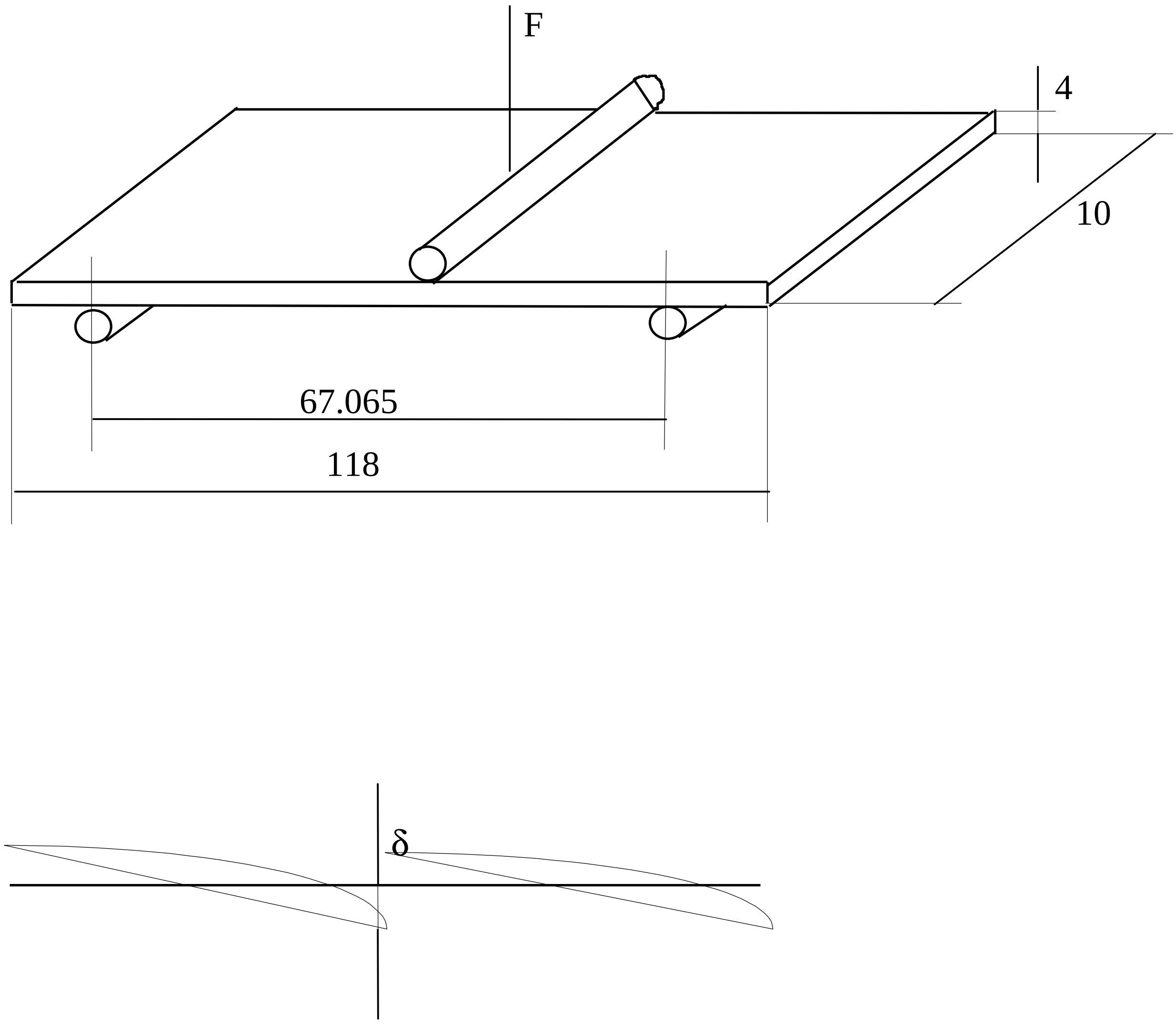
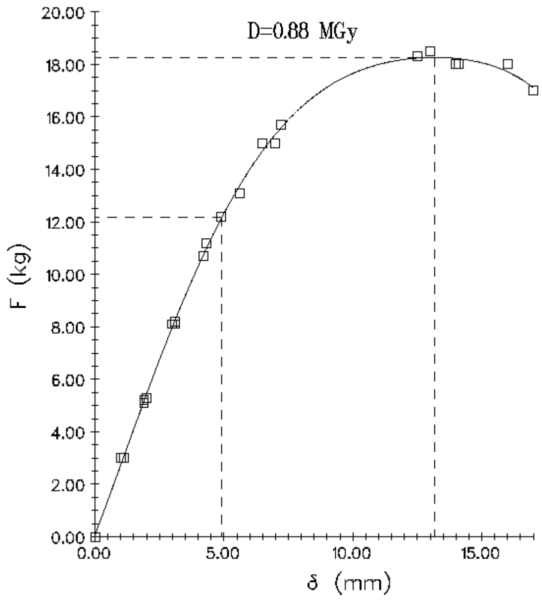


Figure 1: Scheme of deflection tests stand.

Polysulphone



Polycarbonate

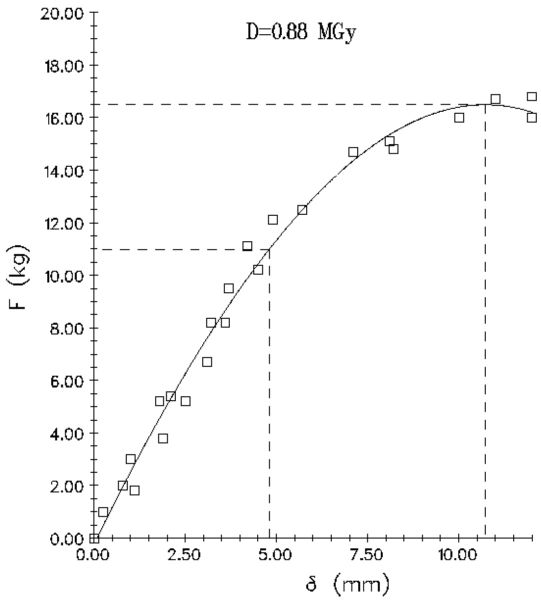
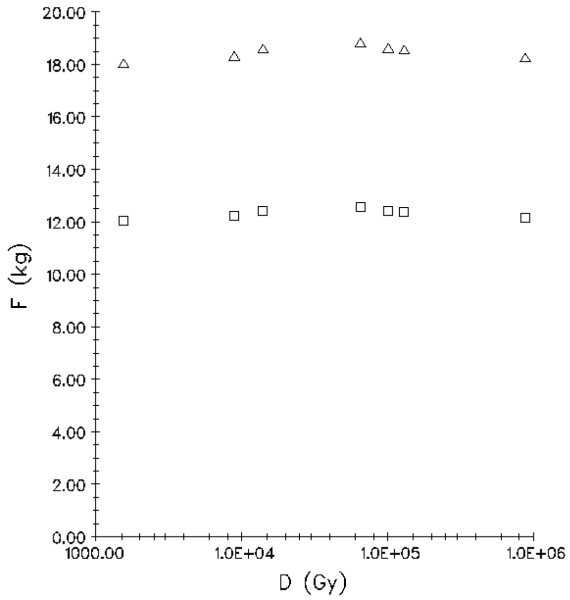


Figure 2:Typical dependences of maximum deflection on loading.

Polysulphone



Polycarbonate

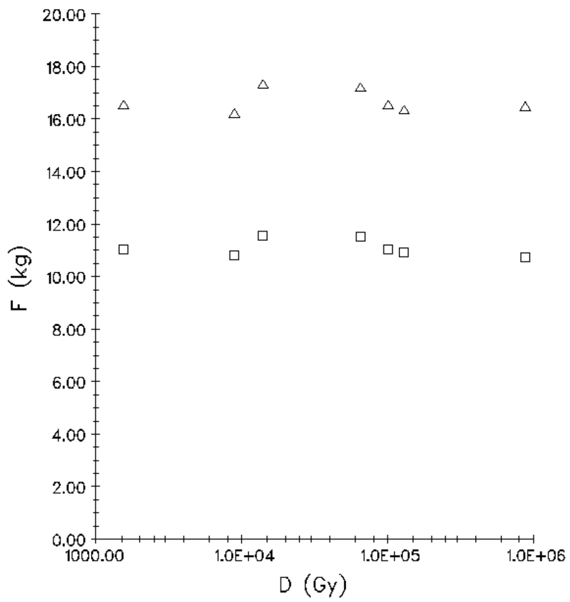
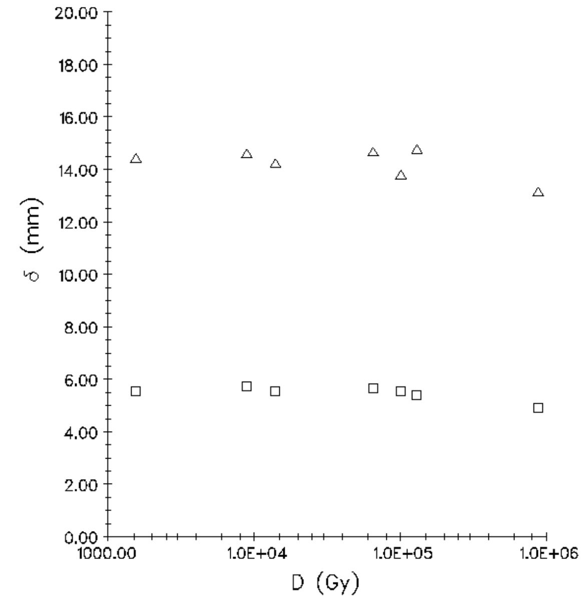


Figure 3: Dependence of the limit and permissible loading on radiation dose.

Polysulphone



Polycarbonate

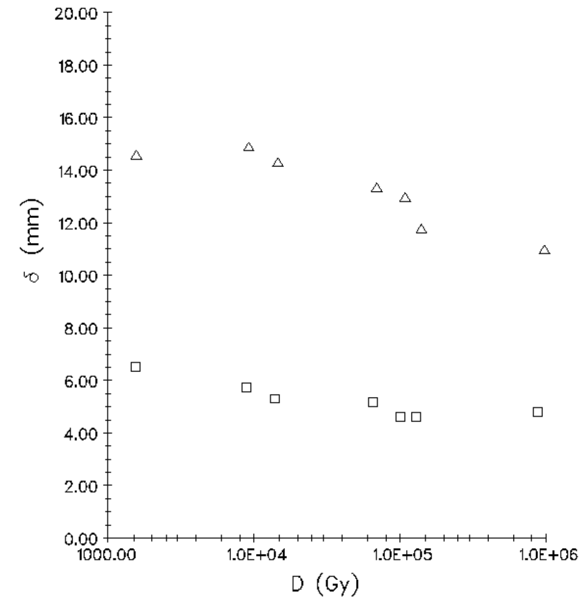
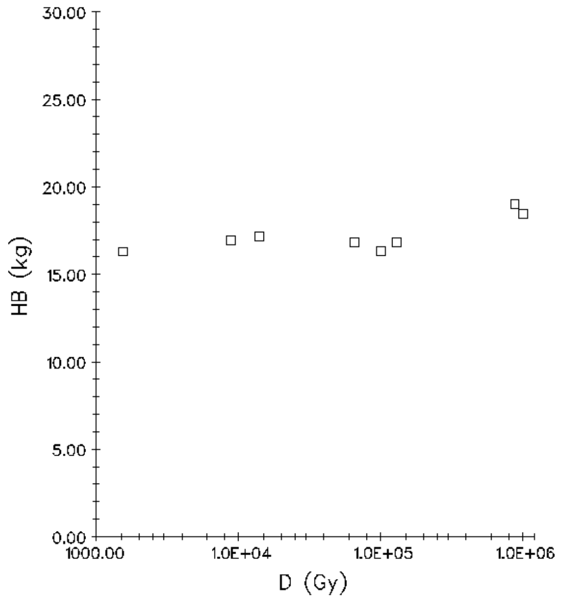


Figure 4: Dependence of the maximum deflection value on the absorbed dose: (Δ) – at $F = F_{max.}$, (□) – at $F=0,6\ F_{max.}$.

Polysulphone



Polycarbonate

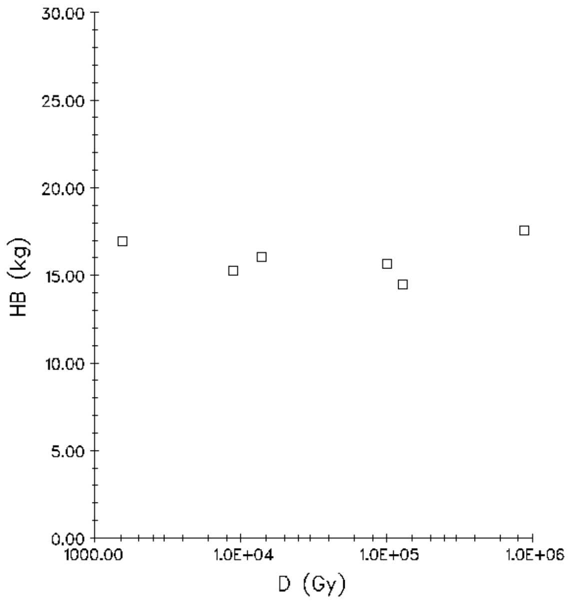


Figure 5: Dependence of Brinell hardness for polysulphone and polycarbonate on the absorbed dose value.