ARCON PROJECT

PHYSICO – MECHANICAL TESTS ON THE MATERIALS FROM THE TREATED ARCHIVES

Catalina Mihaela Talasman, Argentina Radu, Daniela Manea, Maricica Burlacu

Research Department SC CEPROHART SA, Braila, ROMANIA
Experimental program
Within the experimental program were irradiated with various Gamma radiation doses different paper samples naturally or artificially aged.

The papers were analyzed in order to assess the effect of the Gamma radiations on the physico-mechanical properties that influence the papers’ durability.

- Import copy paper manufactured in July 2009 HXI 1 (0 ÷ 200 kGy)
- Import copy paper manufactured in November 2009 HXI 2 (0 ÷ 25 kGy)
- CEPROHART copy paper manufactured in November 2009 HXCPH (0 ÷ 25 kGy)
- Naturally aged paper (RSR Official Monitor / 01.08.1968) (0 ÷ 13,7±0,8 kGy)
- Whatman paper manufactured in 2010 ICHR (0 ÷ 13,7±0,8 kGy)
- Business copy paper 80 g/m² manufactured in 2010 (0 ÷ 13,7±0,8 kGy)
Evolution of tearing resistance mN at various radiation doses

Evolution of bursting strength kPa at various radiation doses

Evolution of breaking length m. L/T at various radiation doses
Evolution of folding endurance no. L/T at various radiation doses

Evolution of whiteness % at various radiation doses

Evolution of bursting strength kPa at various radiation doses
From the analysis of the determined characteristics we could conclude that

**Import copy paper**

- The most affected are the physico-mechanical characteristics
- The doses of 25 kGy comparatively with higher doses of gamma radiation are less destructive. The breaking length, breaking load, tearing resistance, bursting strength decrease significantly (10,1 ÷ 23,9 %) and the folding endurance decrease drastically (62,5% in comparison with the initial value).
- The doses of 25 kGy Gamma radiations affects in a small measure the optical characteristics of the irradiated paper (whiteness decrease with 4,6%)
- The effects of the 12,5 kGy Gamma radiations doses are negligible on the optical characteristics (whiteness decrease only with 2.7%)
- The doses of 6,25 kGy Gamma radiations have a diminished effect on the physico-mechanical characteristics of the papers. The bursting strength decrease only with 1.4% and the tearing resistance with 3.6%, but the influence on the folding endurance is significant (34%).
- The effects of the 6,25 kGy Gamma radiations doses are negligible on the optical characteristics (whiteness decrease only with 1,76%)
- In the further test we will correlate the radiation doses with the contamination degree of the documents in order to mitigate the negative effect on the initial values of the paper’s physico-mechanical characteristics.
CEPROHART copy paper

- The most affected are the physico-mechanical characteristics
- The doses of 25 kGy comparatively with higher doses of gamma radiation are less destructive. The breaking length, breaking load, tearing resistance, bursting strength decrease significantly (11.3 ÷ 22.9 %) and the folding endurance decrease significantly with 33.3% in comparison with the initial value.
- The doses of 25 kGy Gamma radiations affects in a very small degree the optical characteristics of the irradiated paper (whiteness decrease with 5.5%)
- The doses of 12.5 kGy have significant effects only on the folding endurance (the decrease is of 23.8% comparatively with the initial value) while the tearing resistance decrease with 20.5%
- The effects of the 12.5 kGy Gamma radiations doses are negligible on the optical characteristics (whiteness decrease only with 4.7 %). The whiteness of the CEPROHART paper decrease more because comprise a higher percent of cellulose fibres
- The Gamma radiation doses have a small effect on the physico-mechanical characteristics even negligible for the bursting strength (1.4%), but with a significant influence on the folding endurance (a decrease with 19%).
- The effects of the 6.25 kGy Gamma radiations doses are negligible on the optical characteristics
- In the further tests we will correlate the radiation doses with the contamination degree of the documents in order to mitigate the negative effect on the initial values of the paper’s physico-mechanical characteristics.
The next experimentations consists of irradiation of 3 paper grades samples at various Gamma radiation doses as follows:

<table>
<thead>
<tr>
<th>Radiation doses</th>
<th>Paper grades</th>
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| 0 kGy           | 1.RSR OM PI 105-107 pg 889-904  
|                 | 2.Business copy paper 80g/m²  
|                 | 3.Whatman ICHR |
| 1,7±0,1 kGy     | 1.RSR OM PI 105-107 pg 905-920  
|                 | 2.Business copy paper 80g/m²  
|                 | 3.Whatman ICHR |
| 4,2±0,2 kGy     | 1.RSR OM PI 105-107 pg 921-936  
|                 | 2.Business copy paper 80g/m²  
|                 | 3.Whatman ICHR |
| 5,9±0,4 kGy     | 1.RSR OM PI 105-107 pg 937-952  
|                 | 2.Business copy paper 80g/m²  
|                 | 3.Whatman ICHR |
| 9,9±0,6 kGy     | 1.RSR OM PI 105-107 pg 953-996  
|                 | 2.Business copy paper 80g/m²  
|                 | 3.Whatman ICHR |
| 13,7±0,8 kGy    | 1.RSR OM PI 105-107 pg 969-984  
|                 | 2.Business copy paper 80g/m²  
|                 | 3.Whatman ICHR |
Evolution of tearing resistance at various radiation doses

Evolution of Cobb60 size test at various radiation doses

Folding endurance no. evolution at various radiation doses

Breaking length m, evolution at various radiation doses
Cobb$_{60}$ size test evolution $g/m^2$ at various radiation doses

Folding endurance evolution, no at various radiation doses
For all the doses of Gamma radiations used within the tests the breaking length increases. The increase could not be attributed to the positive effect of Gamma radiation but to the lack of uniformity of the analyzed paper qualities. It seems that the blank represents the paper sample with the most reduced values of the physico-mechanical characteristics.

Tearing and bursting resistance decreased but without to could be correlated with the radiation doses. Their evolution is influenced by the analyzed paper quality.

Opacity decreased with a very small percent at all the used Gamma radiation doses (0.4÷0.77%).

Whiteness decreases only with 2.7÷6% and represents a positive signal that the optical characteristics of paper are maintained after the irradiation process. The documents could be still read easily and after the irradiation.

The radiation doses are reduced and slightly affects the irradiated paper characteristics.

In the further test we will correlate the radiation doses with the contamination degree of the documents in order to mitigate the negative effect on the initial values of the paper’s physico-mechanical characteristics.
The last set of determinations consists of a comparative consideration of two paper grades: Whatman (ICHR) and a Business copy paper (XEROX paper) of 80 g/m².

We analyzed them comparatively in order to study the effect of the additives and fillers on the evolution of the physico–mechanical characteristics of the irradiated papers at various Gamma radiation doses.

**Business copy paper 80 g/m²**

- The radiation doses had either a positive effect on the breaking length with a small increase of the value (only at 1.7 kGy and 4.2 kGy) or a small decrease of the value at other radiation doses used within the experiments.

- At all the used radiation doses the opacity decreased comparatively with the initial value (5.52% ± 5.95%).

- The most affected characteristics by the ageing and irradiation processes are the mechanical characteristics and not the optical ones.
The whiteness decreasing for all the radiation doses is a minor phenomenon (1.5 ÷ 5.8 %) and could be controlled taking into account the contamination degree of the documents.

The bursting resistance decrease constantly in the range 6.6 ÷ 14.9% reasonable to assure a good durability.

At all used radiation doses the Cobb size test increased gradually in a range of 5.7 ÷ 15.35% illustrating a negative influence.

The decrease of the folding endurance is situated in a wide range of values respectively 3.7 ÷ 51.9% allowing us to analyze carefully the used radiation dose and to correlate it with the contamination degree and the composition of the document.
Whatman ICHR paper

✓ The used radiation doses had a positive effect on the breaking length leading to increases within the range 2,4÷11,5%

✓ At all the used radiation doses the opacity increased comparatively with the initial value within the range 0,04÷2,9% confirming us the different behavior of the cotton cellulosic fibers comparatively with the paper complex

✓ The phenomenon of whiteness decreasing is registered for all the used radiation doses but is minor (0,5÷6,2 %) and could be controlled taking into account the contamination degree of the documents

✓ The tearing resistance increase for all the radiation doses (7,7÷30,4%) and could be a positive signal for the behavior of the papers with cotton cellulose fibers in composition irradiated with Gamma radiations.
The evolution of the Cobb size test was random the values registering an increase at some radiation doses and an decrease for others. The increases and decreases of the initial value could not be correlated with the radiation doses without a replica of the experiments in order to verify their consistency.

The values of the folding endurance are situated in a small range allowing us to conclude that the radiation effect is not harmful on cotton cellulose fibres. We could run some tests radiation doses > 13.7 kGy in order to simulate the utilization of Gamma radiation for documents with high contamination degree.

We will run some experiments at higher radiation doses trying to simulate the effect of the radiations on paper support documents with a superior contamination degree.