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Mechanical tests on irradiated packaging materials

Eugen Bratu
IRASM Radiation Processing Center
Horia Hulubei National Institute of R&D
for Physics and Nuclear Engineering, Bucharest, Romania

General packaging materials

- Plastics (foil or injected)
- Rubber
- Paper
- Glass
- Metallic foils

Testing packages, Why for?

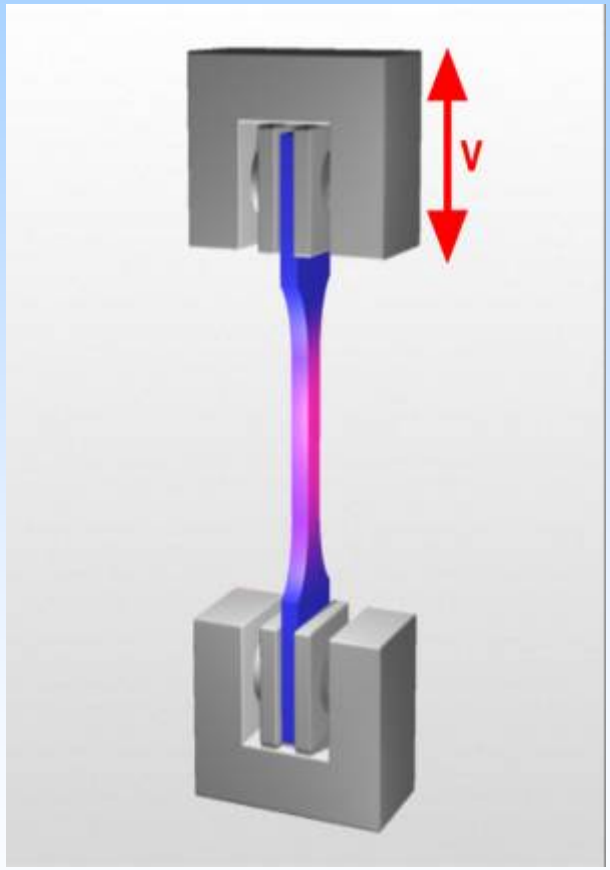
The aim for mechanical tests on irradiated packaging materials is to evaluate each package's ability to protect the product without defect or loss of content throughout the handling, distribution and storage environment.

Main mechanical tests

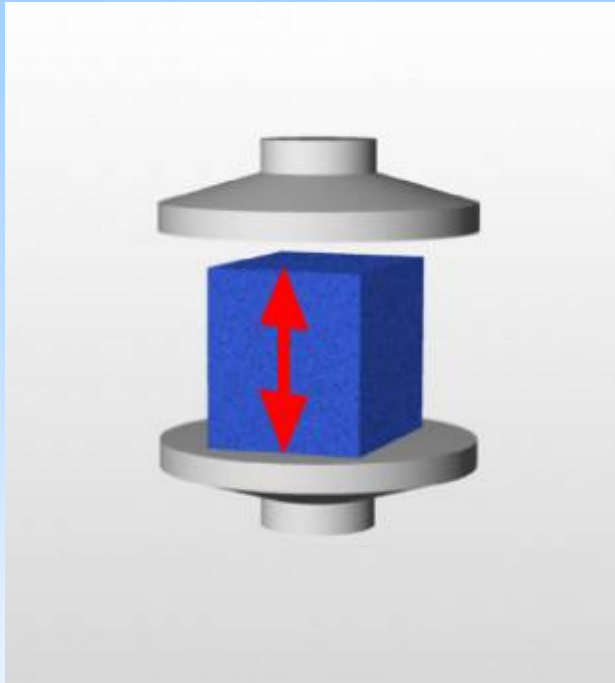
- Tensile
- Compression
- Tear
- Penetration
- Peeling
- Flexural behavior
- Resilience

Tensile test

- *Scope* Determination of :
  - tensile stress
  - tensile strain (elongation)
  - minimal break force
  - flow limit
- *Standards*
  - ISO 527-1;5 (plastics),
  - ISO 37 (rubber),
  - ISO 1798 (flexible cellular plastics)
  - ISO 3781 (wet paper)
  - ISO 1924 (dry paper)

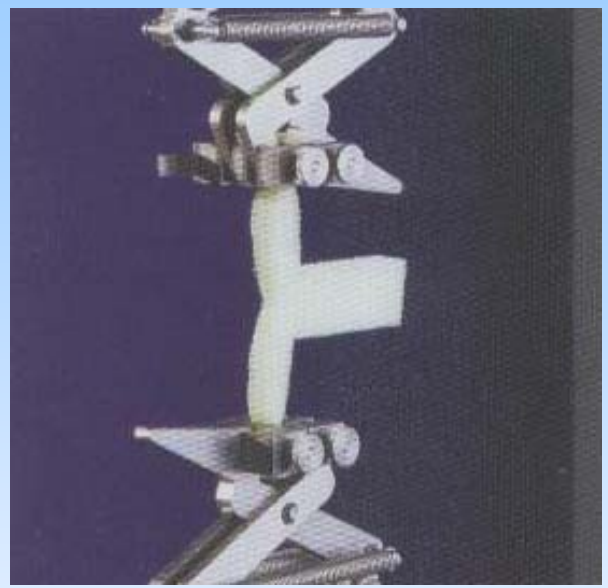


Compression test



- *Scope* Determination of :
  - compression stress
  - compression strain
  - compression flow limit
- *Standards*
  - ISO 3386 (flexible cellular plastics)
  - ISO 3035 (flat crush test for paper)
  - ISO 12048 (box crush test)

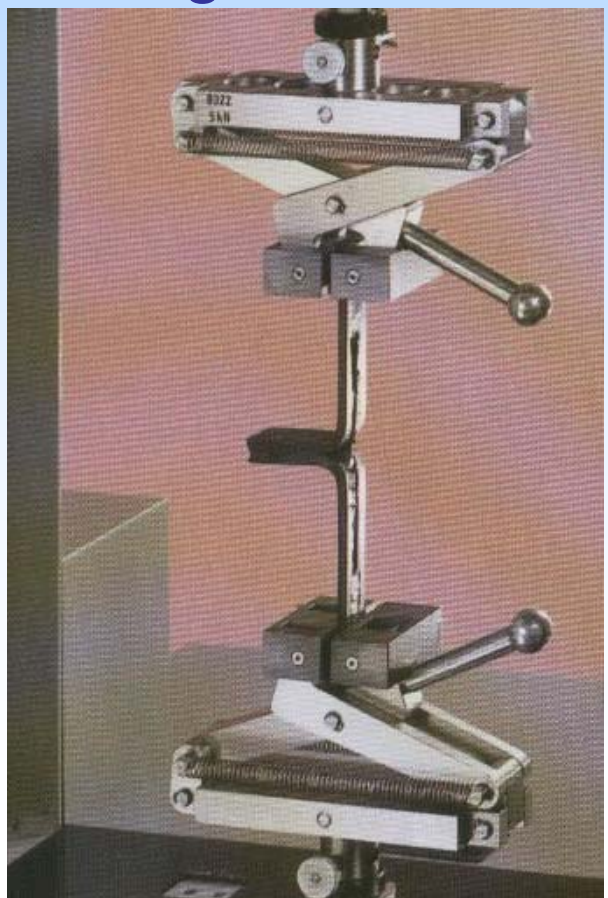
Tear test



- *Scope* Determination of :
  - tear stress
  - minimal tear force
  - strain before tearing
- *Standards*
  - ISO 34-1 (plastics)
  - ISO 1798 (flexible cellular plastics)
  - ISO 1974 (paper)
  - ISO 11897 (tear growth test)

Peeling test

- *Scope* Determination of welding, sealing or adhesive quality for plastic foils, rigid plastics, packaging paper and others, by measuring :
  - minimal peeling force
  - strain before tearing
  - tear limit on given force
- *Standards*
  - ISO 4578 (tape)
  - DIN 55543 seal strength (food packages foil-foil)
  - opening of sealed food packages (metal-plastic); customer specification



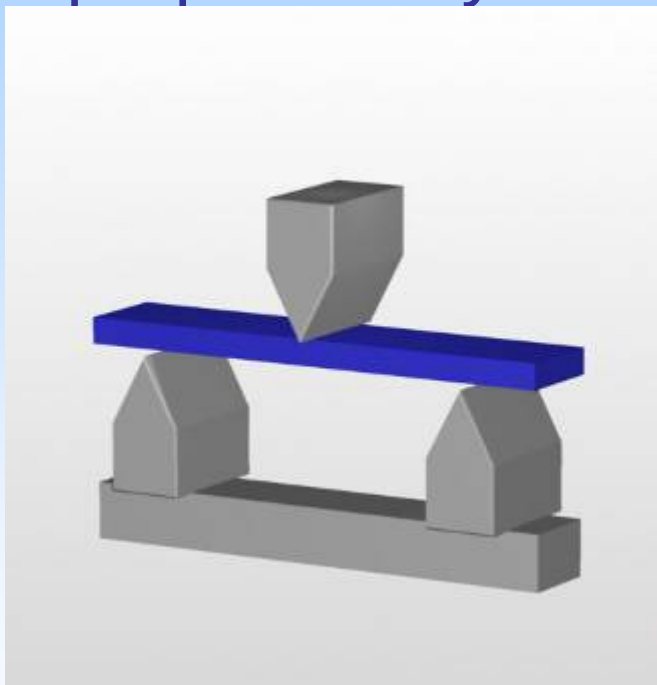
Penetration test

- *Scope:* Determination of puncture resistance by measuring
  - minimal penetration force
  - penetration stress
  - strain before puncture
- *Standards*
  - ISO 12236 (textile, plastics)
  - ISO 3036 (paper, card boxes)

Flexural test

- *Scope*: determination of flexural properties by measuring
  - flexural stress
  - deflection
  - maximal flexural stress

  before break
- *Standards*
  - ISO 178 (plastics)
  - ISO 14130 (carbon fiber composite)
  - ISO 5628 (Card boxes)



Resilience test

- *Scope* : Evaluating materials shock behavior by measuring
  - absorbed energy at break
- *Standards*
  - ISO 179-1;2 Charpy method
  - ISO 180 Izod method
  - ISO 8256 Tensile impact
  - ISO 6603-2 high speed impact

Irradiated packaging materials

This presentation will analyze the result of mechanical test upon three kind of packaging materials:

- High quality paper (Xerox Business A4 80g/m^2 w=100μm ± 2μm)
- Low quality paper (common newspaper 47.5 g/m^2 w=86μm ± 5μm)
- Semi rigid polyethylene foil, dedicated to packaging (w=100μm ± 1.5μm)

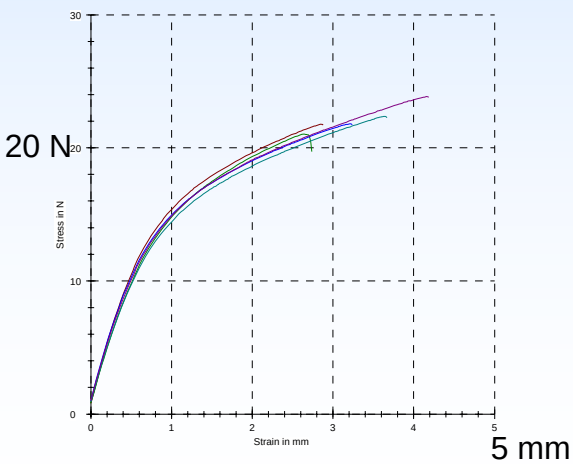
Performed mechanical tests

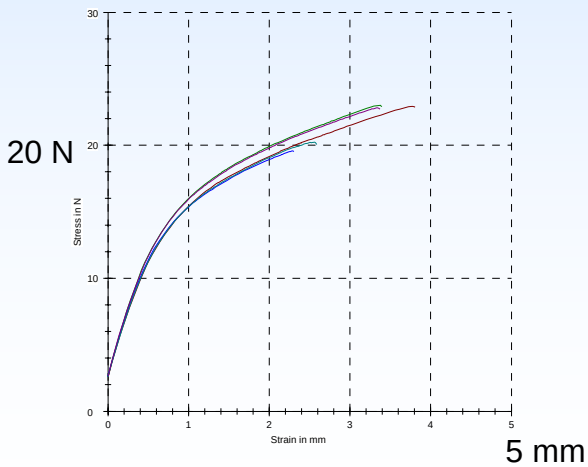
Experiments were conducted by choosing three types of representative mechanical tests on packaging materials:

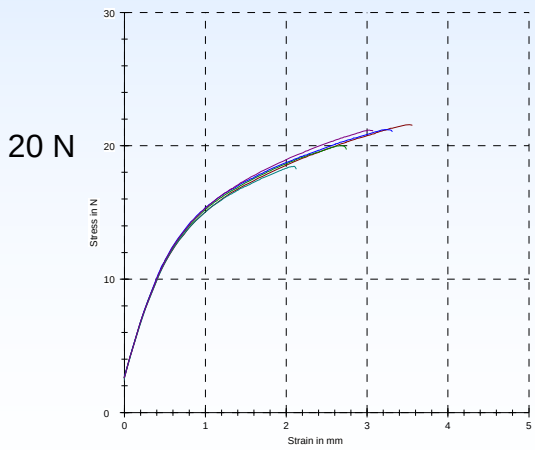
1. Tensile test
2. Tear test
3. Penetration test

Tensile test (high quality paper)

F_{max}= 22.17N (100%)	F_{max}=21.71N (97.93%)	F_{max}=20.48N (92.38%)
0 kGy	25 kGy	50 kGy

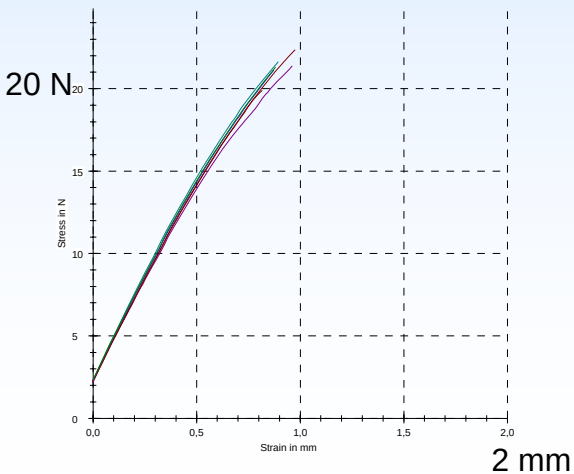


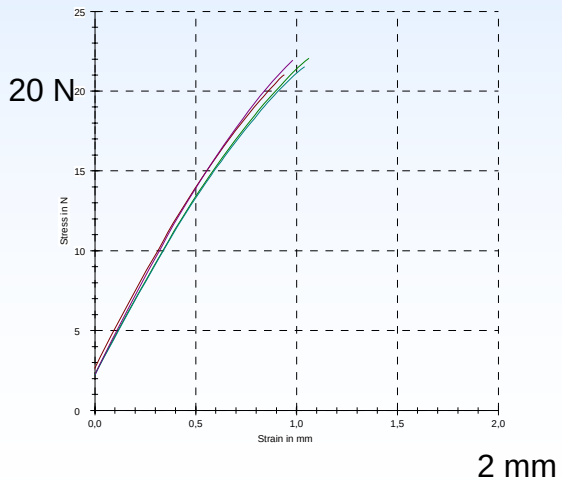


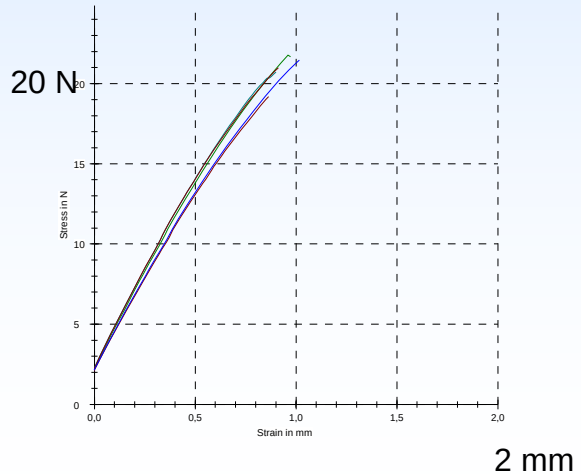


Tensile test (low quality paper)

F_{max}= 21.65N (100%)	F_{max}=21.29N (98.34%)	F_{max}=20.83N (96.21%)
0 kGy	25 kGy	50 kGy



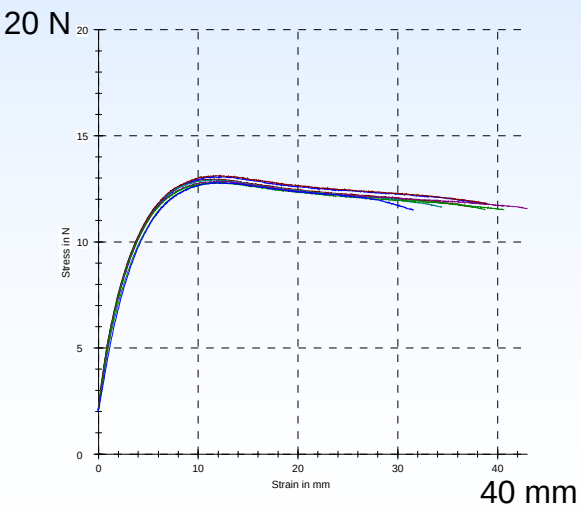




Tensile test (semi rigid plastic)

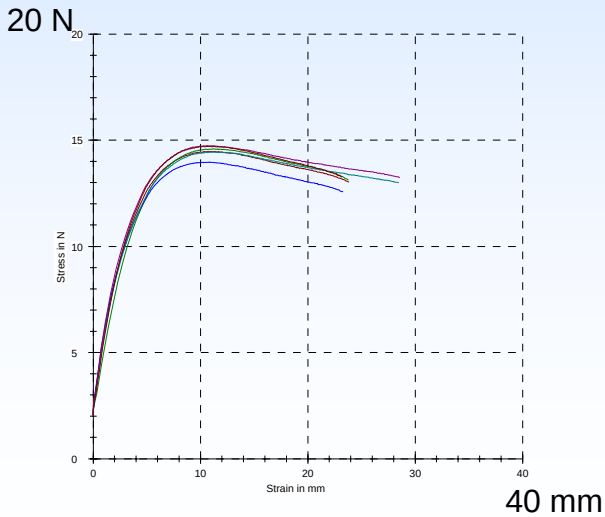
F_{max}= 12.91 N (100%)

0 kGy



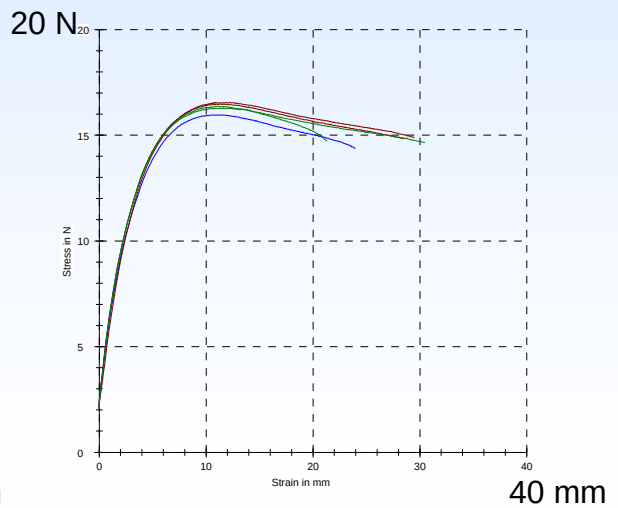
F_{max}= 14.48 N (112.16%)

25 kGy



F_{max}= 16.32 N (126.41%)

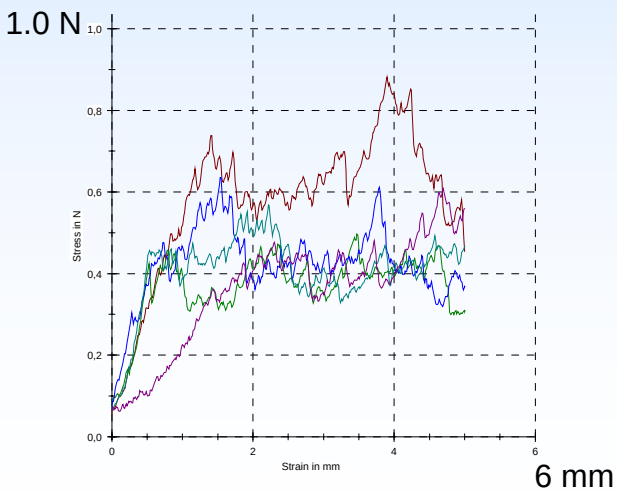
50 kGy



Tear test (high quality paper)

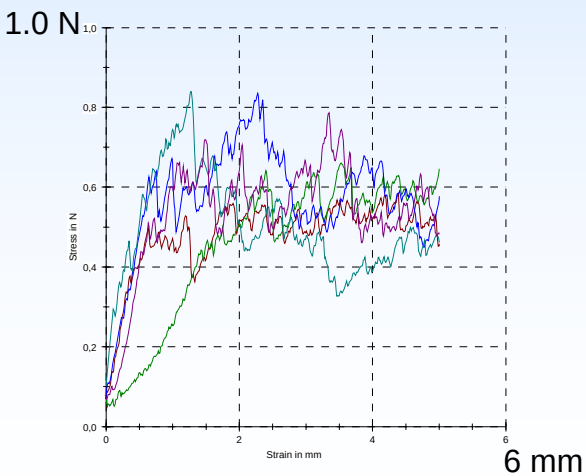
F_{max}= 0.74N (100%)

0 kGy



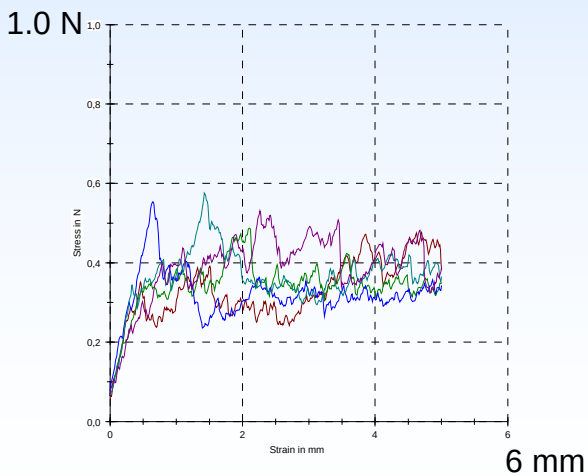
F_{max}= 0.64N (86.49%)

25 kGy



F_{max}= 0.52N (70.27%)

50 kGy



Tear test (low quality paper)

F_{max}= 0.31 N (100%)

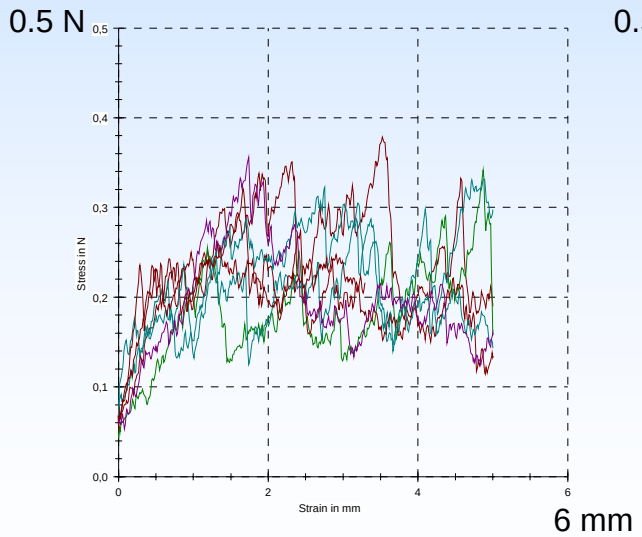
F_{max}= 0.27 N (87.10%)

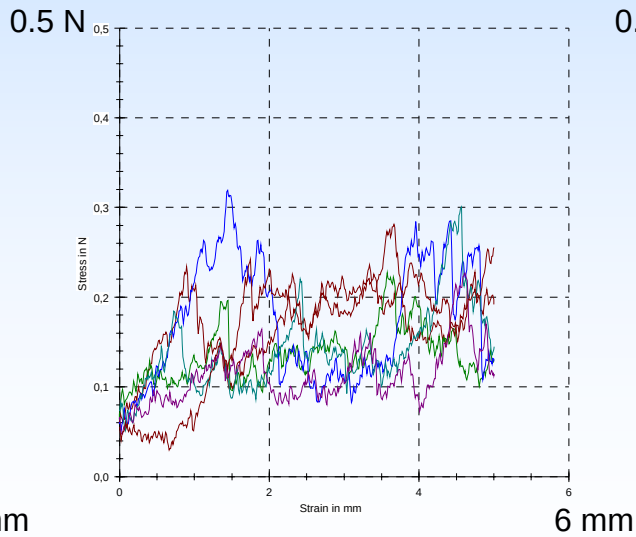
F_{max}= 0.25 N (80.65%)

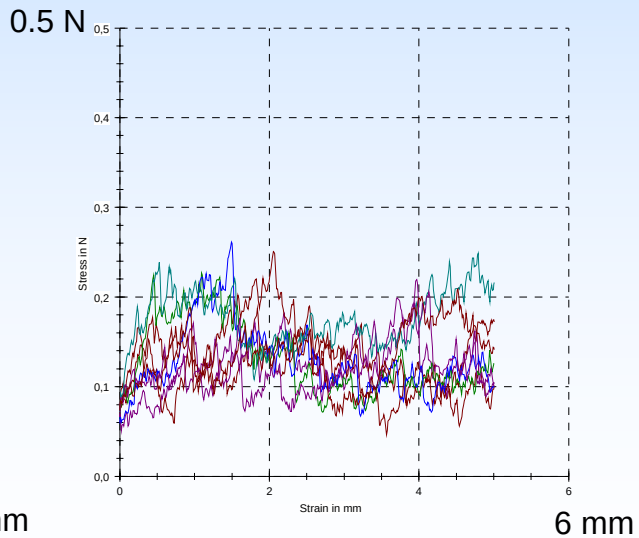
0 kGy

25 kGy

50 kGy







Tear test (semi rigid plastic)

F_{max}= 8.94N (100%)

F_{max}=9.09N (101.68%)

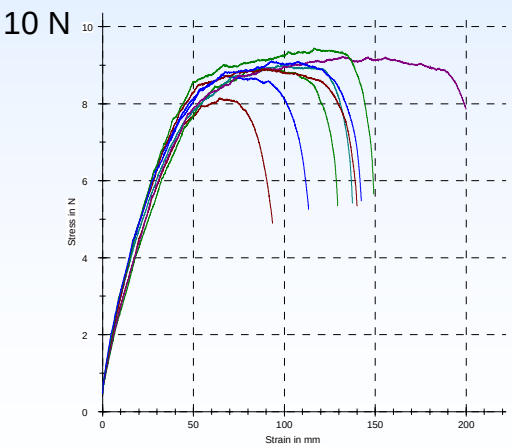
F_{max}=9.72N (108.72%)

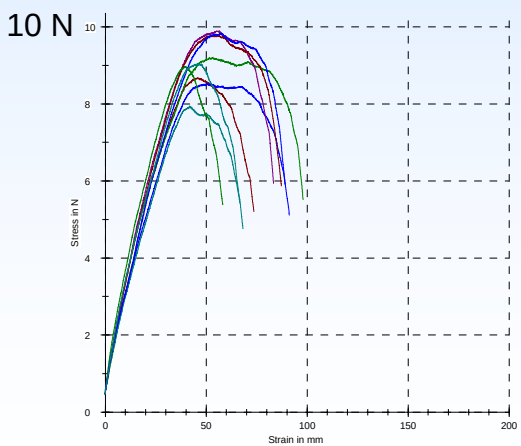
0 kGy

25 kGy

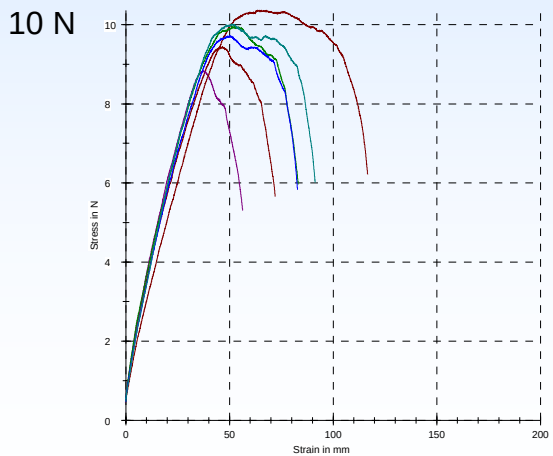
50 kGy

200mm





200mm



200mm

Penetration test (HQ paper)

F_{max}= 23.68 N (100%)

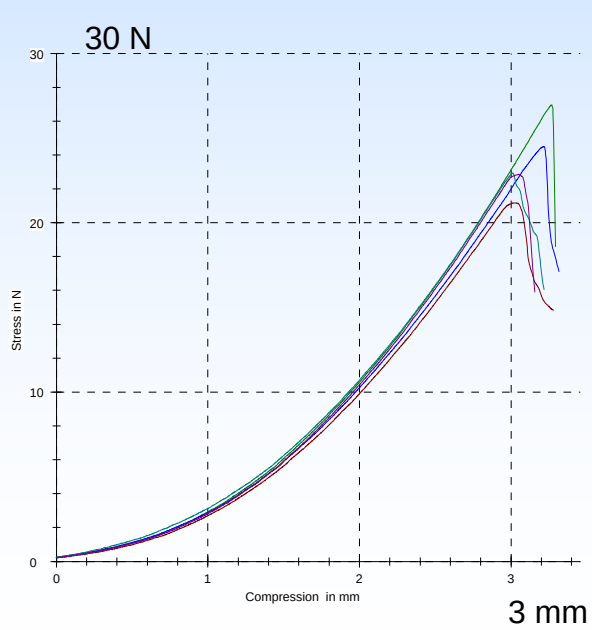
F_{max}=19.74 N (83.36%)

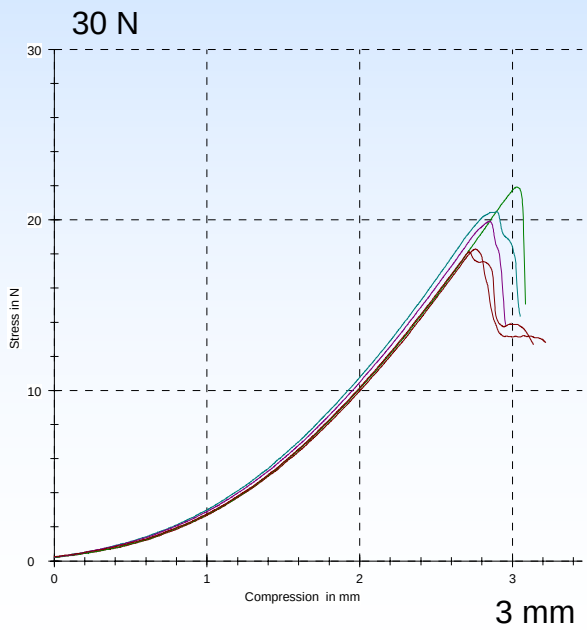
F_{max}= 16.54 N (69.85%)

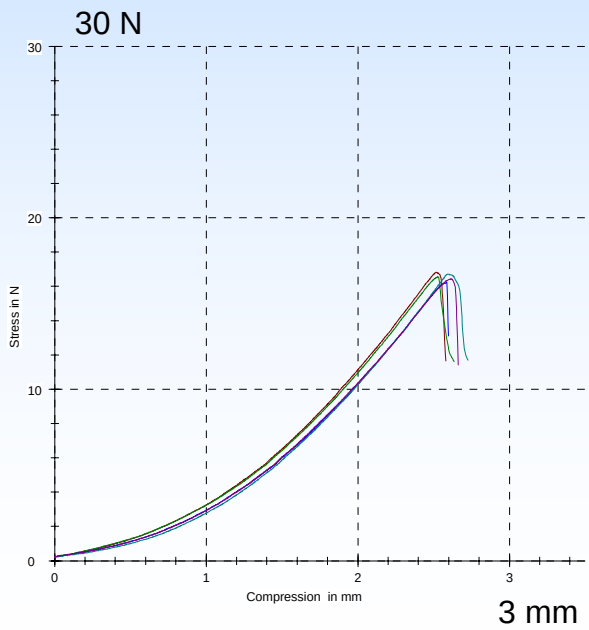
0 kGy

25 kGy

50 kGy



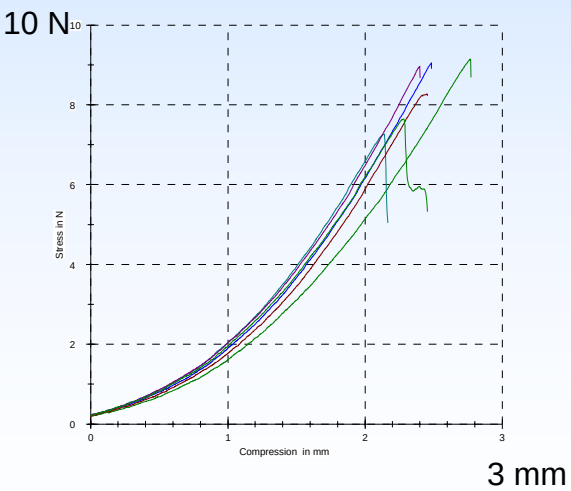




Penetration test (LQ paper)

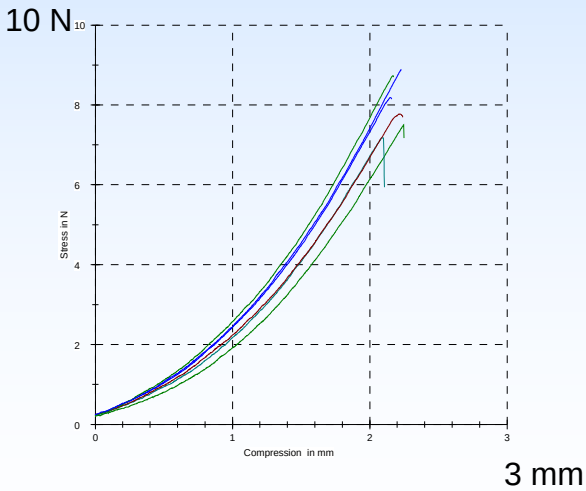
F_{max}= 8.38 N (100%)

0 kGy



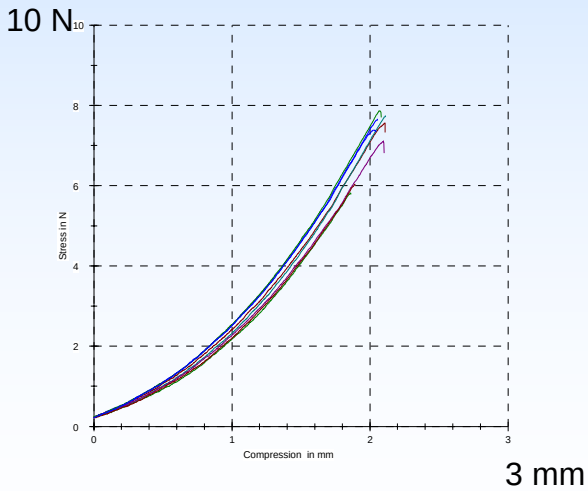
F_{max}= 8.04 N (96.40%)

25 kGy



F_{max}= 7.14 N (85.61%)

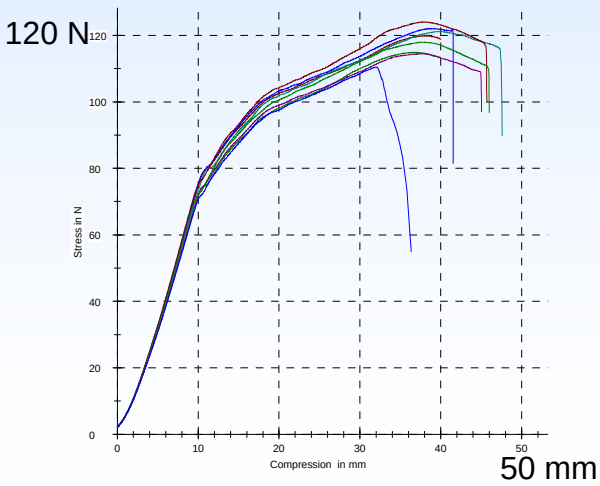
50 kGy



Penetration test (semi rigid plastic)

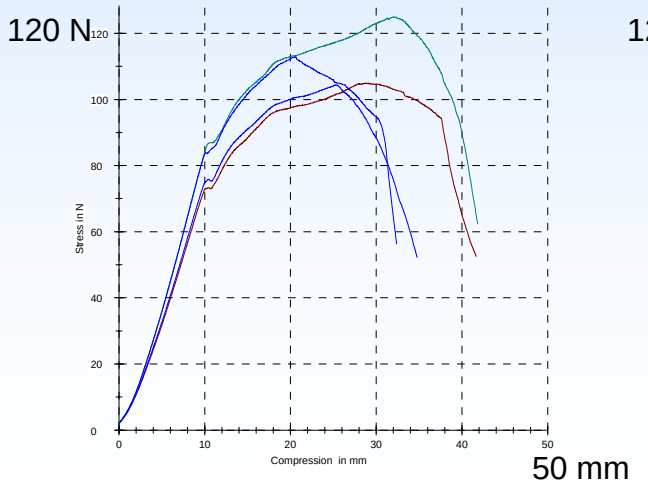
F_{max}= 118.16N (100%)

0 kGy



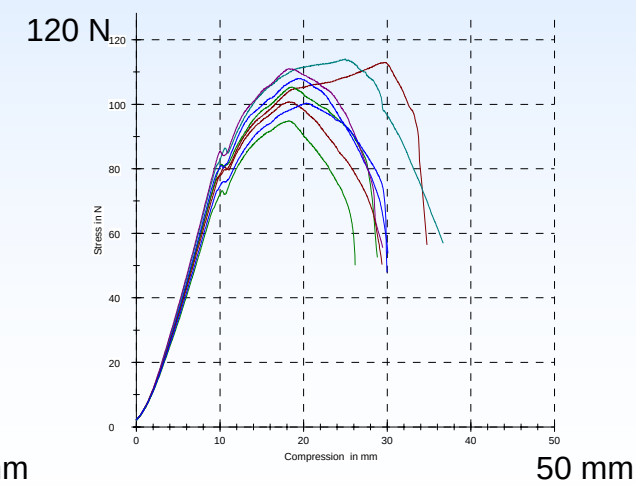
F_{max}= 111.78N (94,60%)

25 kGy



F_{max}= 105.93N (89.65%)

50 kGy



Results

No	Type of test	Material	Maximal breakdown force in (%) at different doses		
			0 kGy	25kGy	50kGy
1	Tensile	HQ paper	100	97.93	92.38
2	Tensile	LQ paper	100	98.34	96.21
3	Tensile	PE foil	100	112.16	126.41
4	Tear	HQ paper	100	86.49	70.27
5	Tear	LQ paper	100	87.10	80.65
6	Tear	PE foil	100	101.68	108.72
7	Penetration	HQ paper	100	83.36	69.85
8	Penetration	LQ paper	100	96.40	85.61
9	Penetration	PE foil	100	94.60	89.65

Conclusions

- Paper is continuously degrading at absorbed doses over sterilization level (25 kGy).
- Loss of mechanical properties are not significant at sterilization level, but became important in case of re-sterilization (50 kGy)
- High Quality paper is more affected than Low Quality paper.
- PE is loosing flexibility, becoming more rigid by increasing absorbed doses.
- In case of PE re-sterilization, loss of mechanical properties are not so obvious as paper (see penetration test)
- Materials must be specially tested for absorbed doses over 25kGy

June 2007 , BRAN

Thank You

and

enjoy the rest of the Workshop