Plastic
Technologie
Service
Marketing- & Vertriebs GmbH

Hautschenmühle 3
D 91587 Adelshofen/Tauberzell
Fon +49 (0)9865-821
Fax +49 (0)9865-720
info@pts-marketing.de
www.pts-marketing.de

Uwe Stenglin

Crosslinking of "LIFE PARTS" with V-PTS-CREAMID PA6, PA6.6 MF/GF

Evaluation of UL-508 standard concerning

Industrial Control Equipment

THE STEP OUT OF THE NICHE

CROSSLINKING

of

molded parts, tubes and profiles

with

PA6, PA6.6, PA11, PA12 and PBT

What are Rays ?

- rays are carriers for energy
- the radiation of products cannot -for physical reasons- generate any radioactivity in the product
- irradiated products do not emit any radiation itself
- the properties of irradiated products are optimized by the energy input -chemical reactions will be caused
- this chemical reactions will cause crosslinking or degradation of polymers or sterilization

BGS

Generation of rays

Braun tube

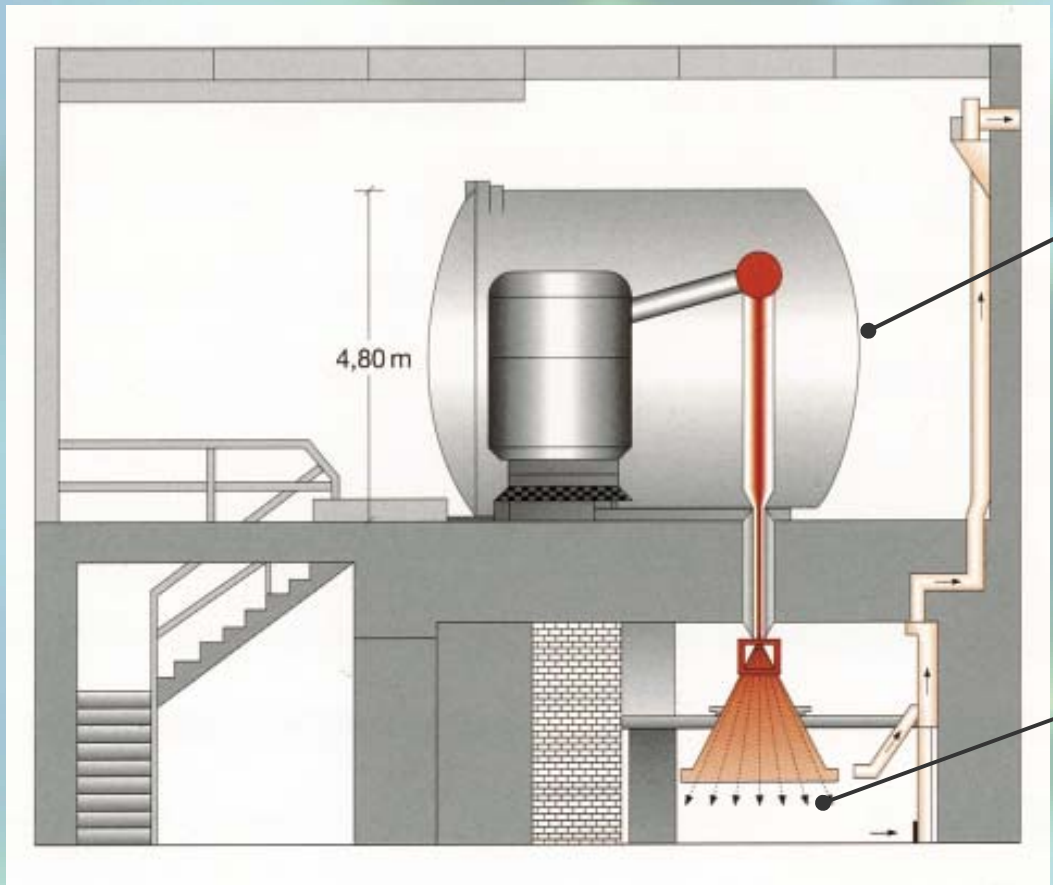
Accelerated electrons
(beta rays/ e-beams)
like: - TV-Sreens
- Röntgen rays

Gamma-Rays

Radioactive Material
(Co-60)

BGS

Generation of rays



Tank with SF6

Scanner

3.0MeV-Electron-accelerater

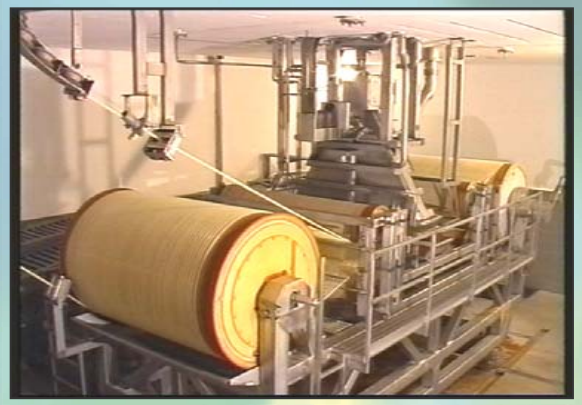
BGS

Principle of a gamma radiation plant

Conveyersystems for
Cartonage and single pieces

Palett-systems

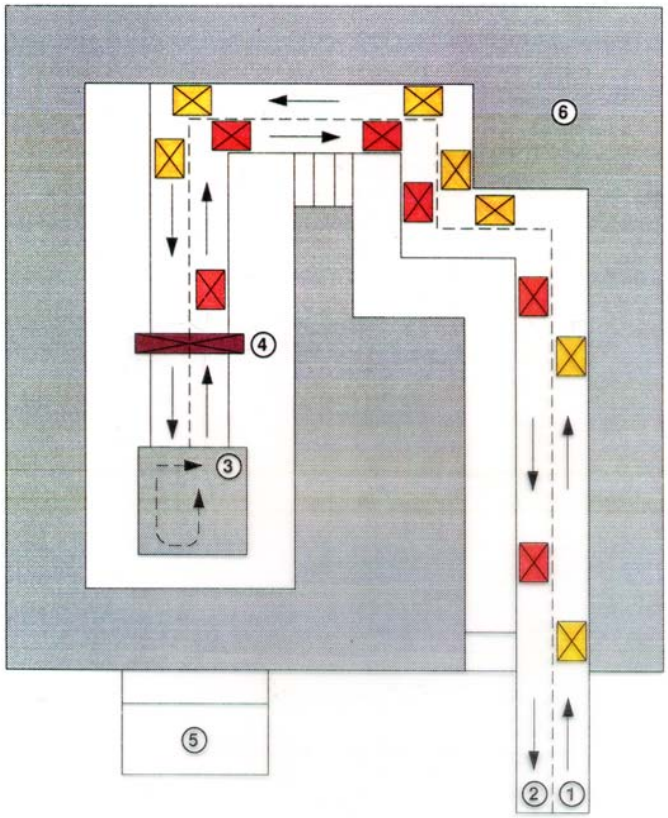
Handlingsystem for Material on reels



Casset systems for Tubes,
pieces and Cartons

BGS

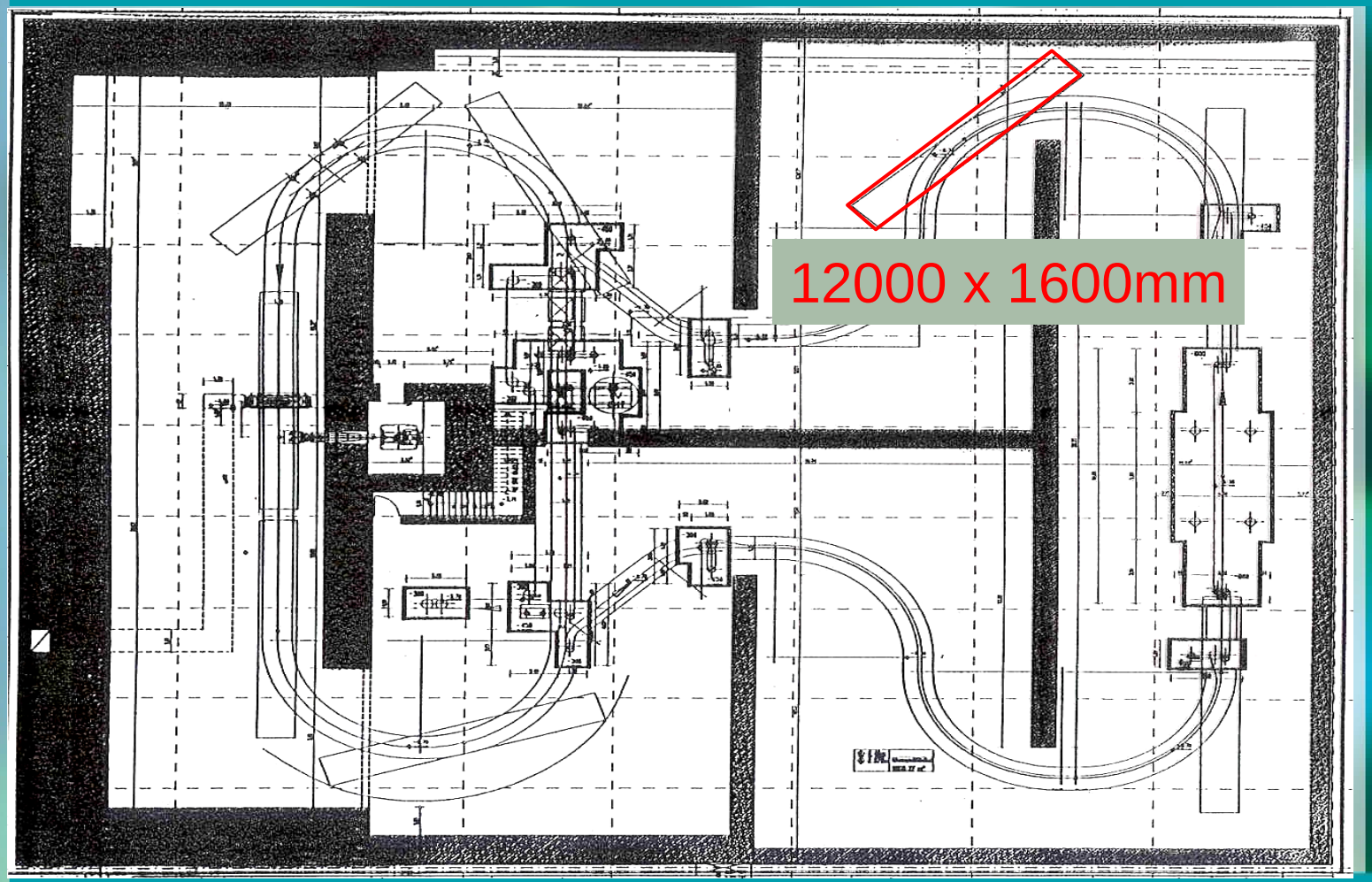
Beltsystem for Cartons



1.) Rollenband-Fördersystem Produktaufgabe
2.) Produktentnahme
3.) Wender bzw. Übersetzvorrichtung
4.) Austritt Elektronenstrahl (Scanner)
5.) Steuer- und Messwarte
6.) Bestrahlungsbunker

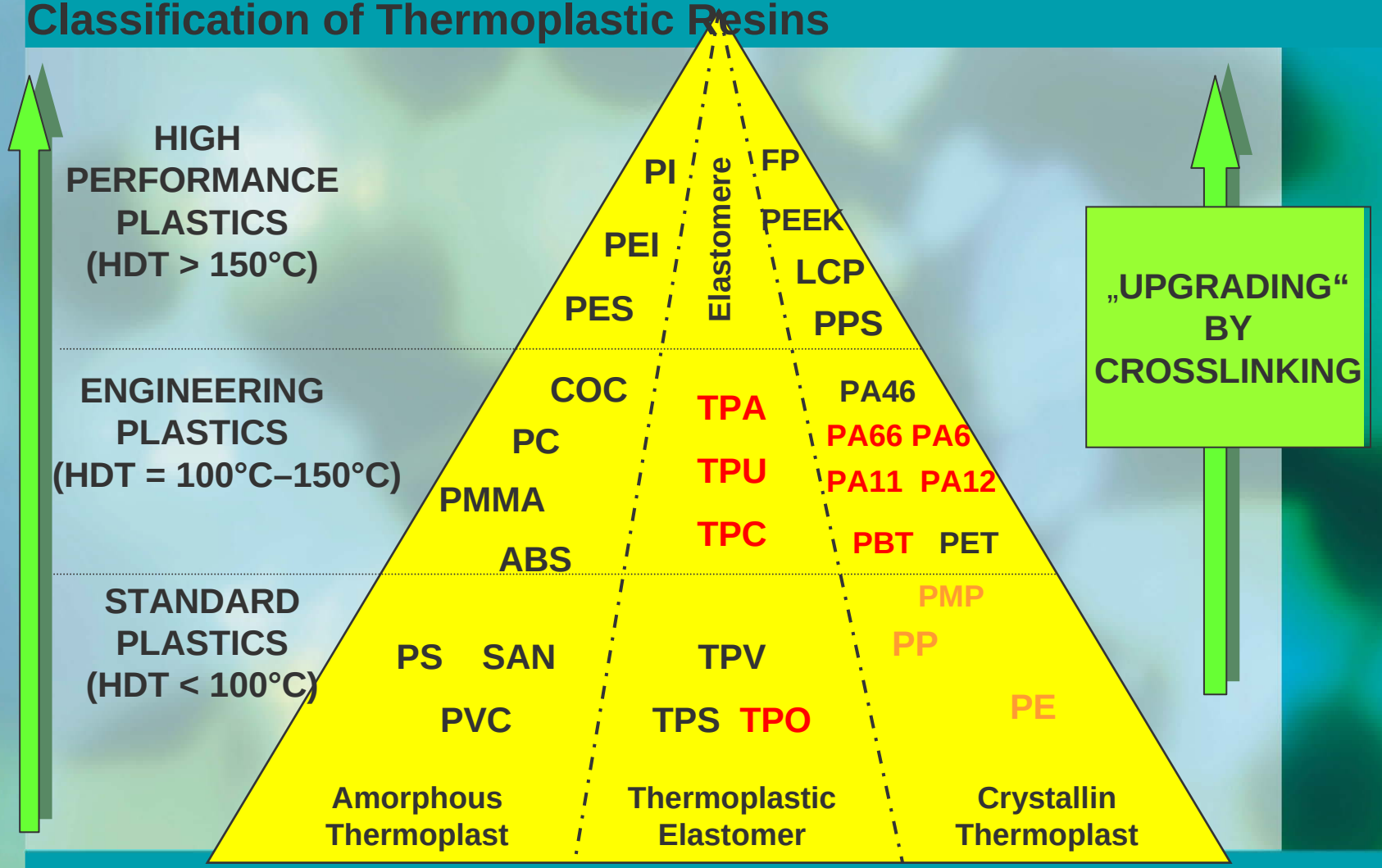
BGS

Conveyor system for cartons and bulk products
Handling system for tumbled goods



BGS

Classification of Thermoplastic Resins



Improvement of ....
(thermoplastic resins)

.... mechanical Properties

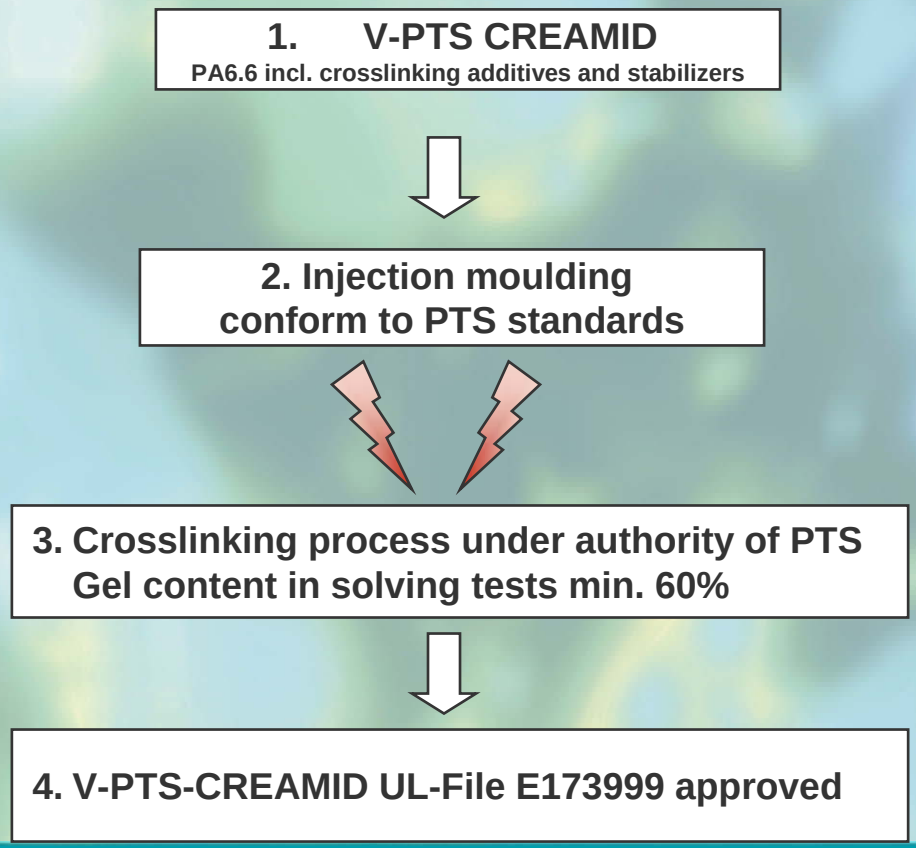
.... thermal Properties

.... chemical Properties

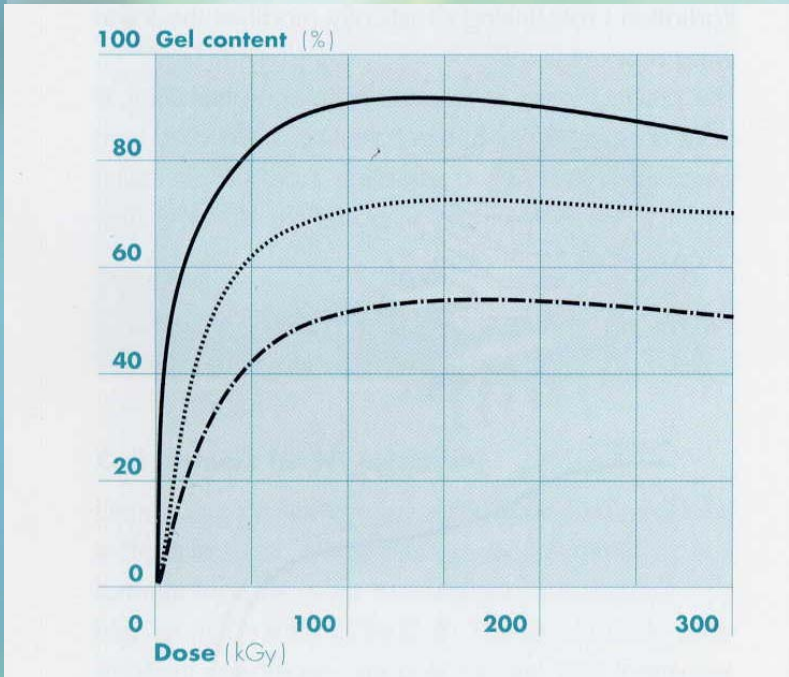
.... electrical Properties

.... tribological Properties

UL 94 - Proceeding for V-PTS-CREAMID (crosslinked)



Gel content as a function of the radiation dose (β)



6% BETALINK IC/W 65 PA6 ———

4% BETALINK IC/W 65 PA6 ·····

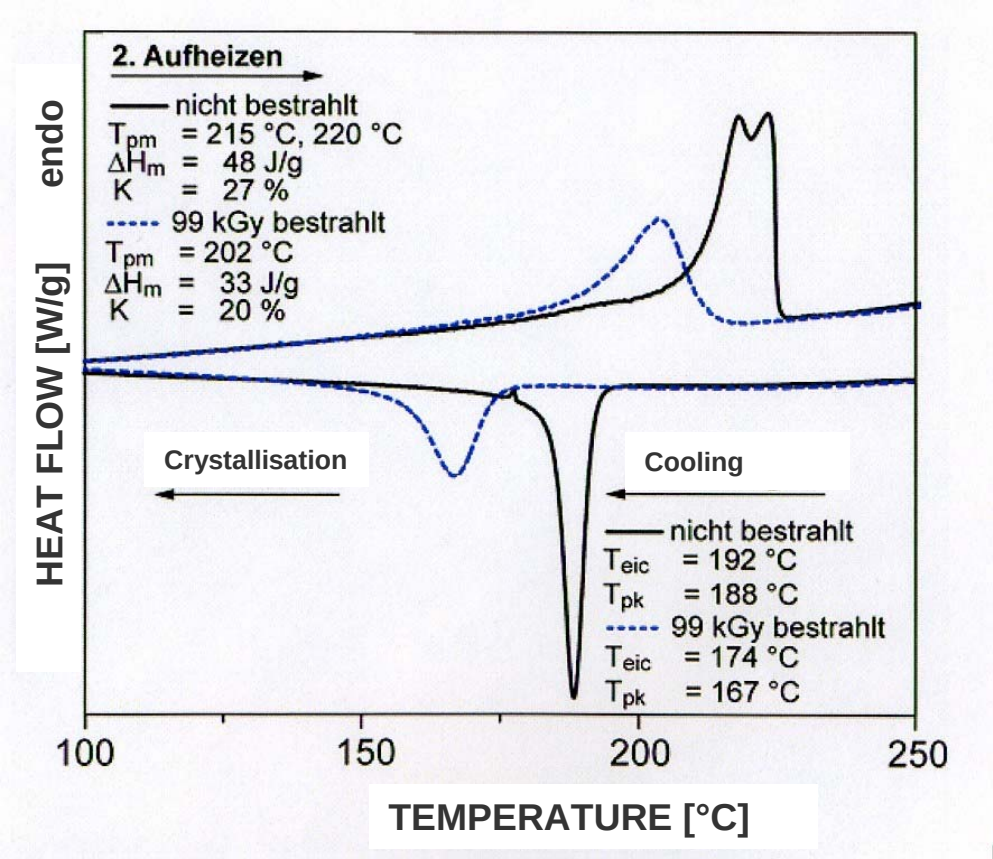
3% BETALINK IC/W 65 PA6 – · – · –

Control of Heat Distorsion Temperature for crosslinked parts by soldering test

Part: PA 6 GF30
Soldering pin: Ø 1mm, weight: 1000g, Temperature: 350°C

BGS

Thermal Analysis (Differential Scanning Calorimetry) of PA6



The crystallinity is disturbed by the crosslinked areas. The result is a lower crystallisation temperature and reduction of heat content!

The trend-setting test in the year 1987

Not crosslinked **crosslinked**

Parameter:

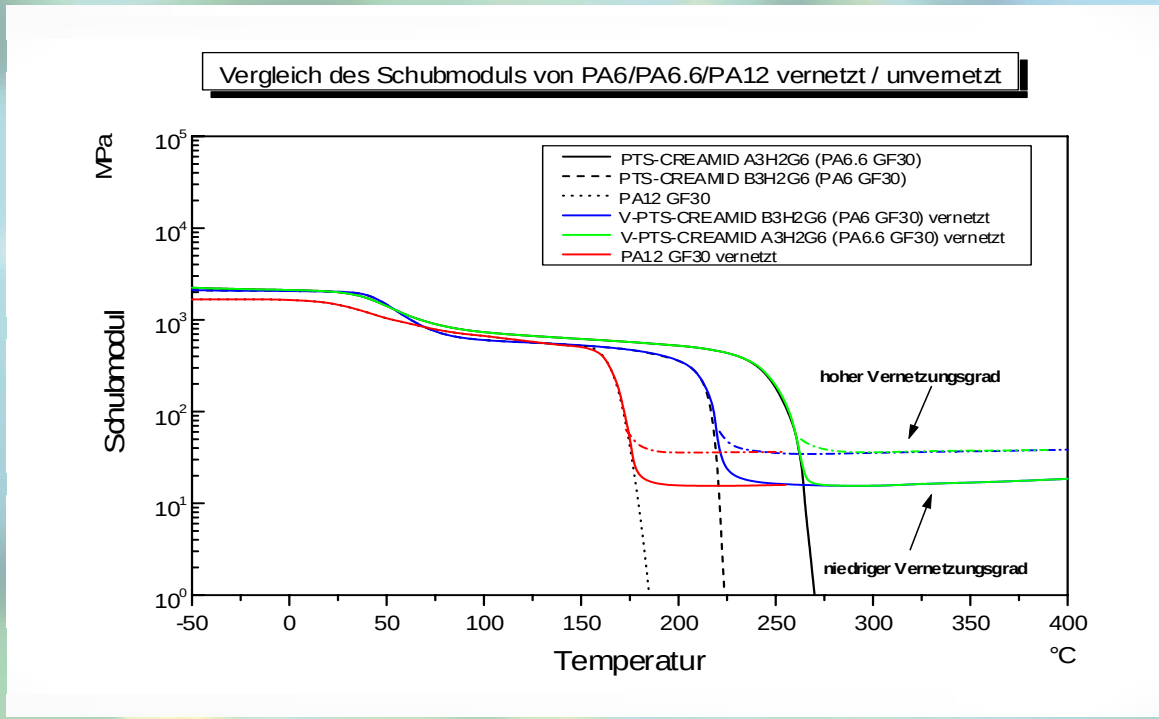
Time: **15 min**

Temperature: **270°C**

Crosslinking of PA11 and PA12

This resins are situated between Technical Thermoplastics and Thermoplastic Elastomers.

Crosslinkable Compounds for the production of tubes are now available!

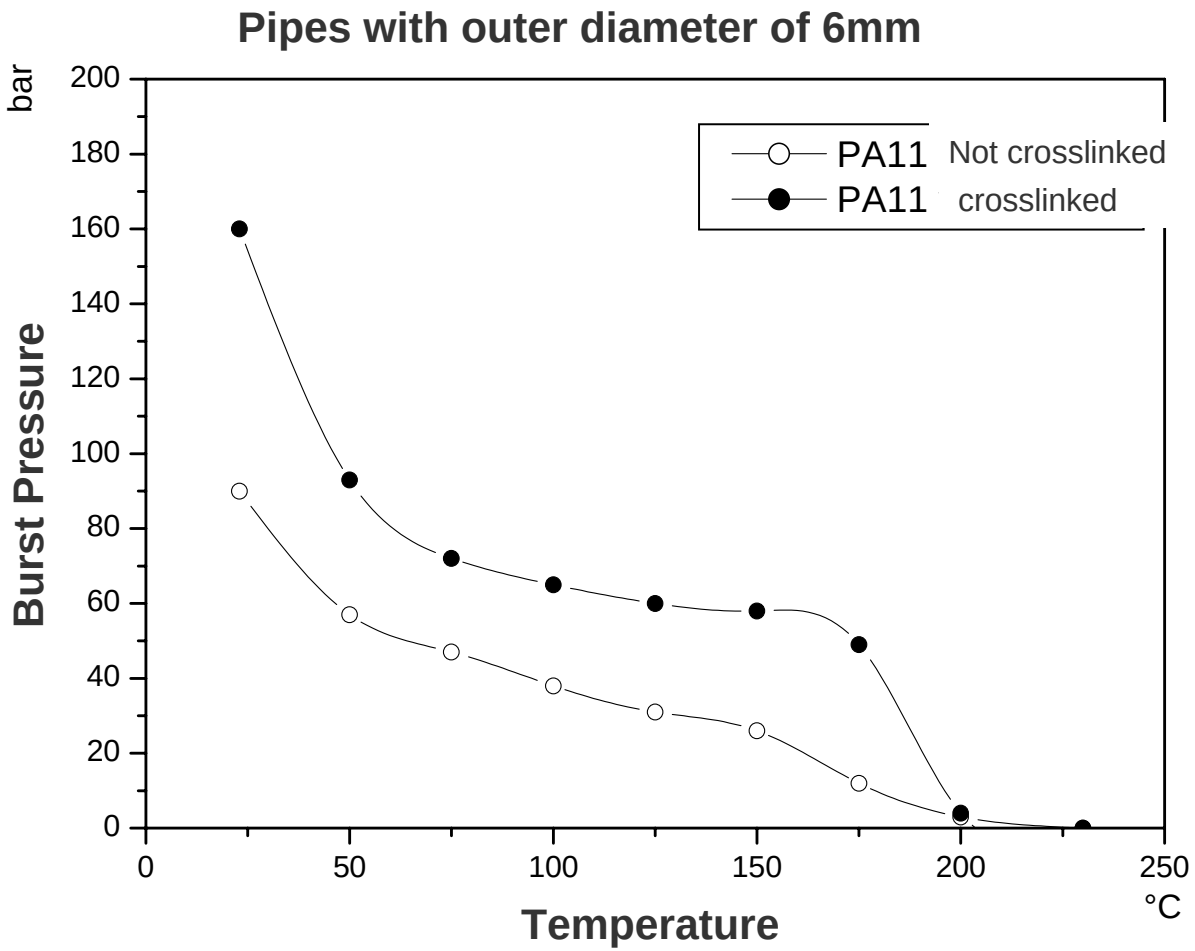


Burst pressure (Mpa) of tubes (8mm*6mm) at different temperatures

Temperature 23°C	Burst pressure not XL	Burst pressure XL	gain
AESN P202T6L	28	33,7	20,4
AESN P40 TL	25	32,8	31,2
BESN P20 TL	28	38,6	37,9
BESN P40 TL	24	28,8	20
Temperature 130°C	**Burst pressure not XL**	**Burst pressure XL**	**gain**
AESN P202T6L	7,5	9	20
AESN P40 TL	7	9,2	31,4
BESN P20 TL	9	12,3	36,7
BESN P40 TL	7,5	10,3	37,3
Temperature 160°C	**Burst pressure not XL**	**Burst pressure XL**	**gain**
AESN P202T6L	0	5,3	>>
AESN P40 TL	0	3,8	>>
BESN P20 TL	0	6,6	>>
BESN P40 TL	0	5,6	>>

Best results at 20% content of plasticizer:

Higher burst pressure of about 40% !



Crosslinking of PA11 and PA12

Crosslinked PA11 and PA12 (RILSAN-based) has no thermoplastic behaviour after the irradiation process.

As a result following properties are characterizing the products:

1.) no surface melting at short thermal peaks above the former melting point

2.) moulded parts and tubes show a Memory-effect

3.) tremendous reduction of thermo fixing times

4.) better dimensional stability of thermo fixed tubes

5.) improvement of the pull-off force of pressed-on tubes

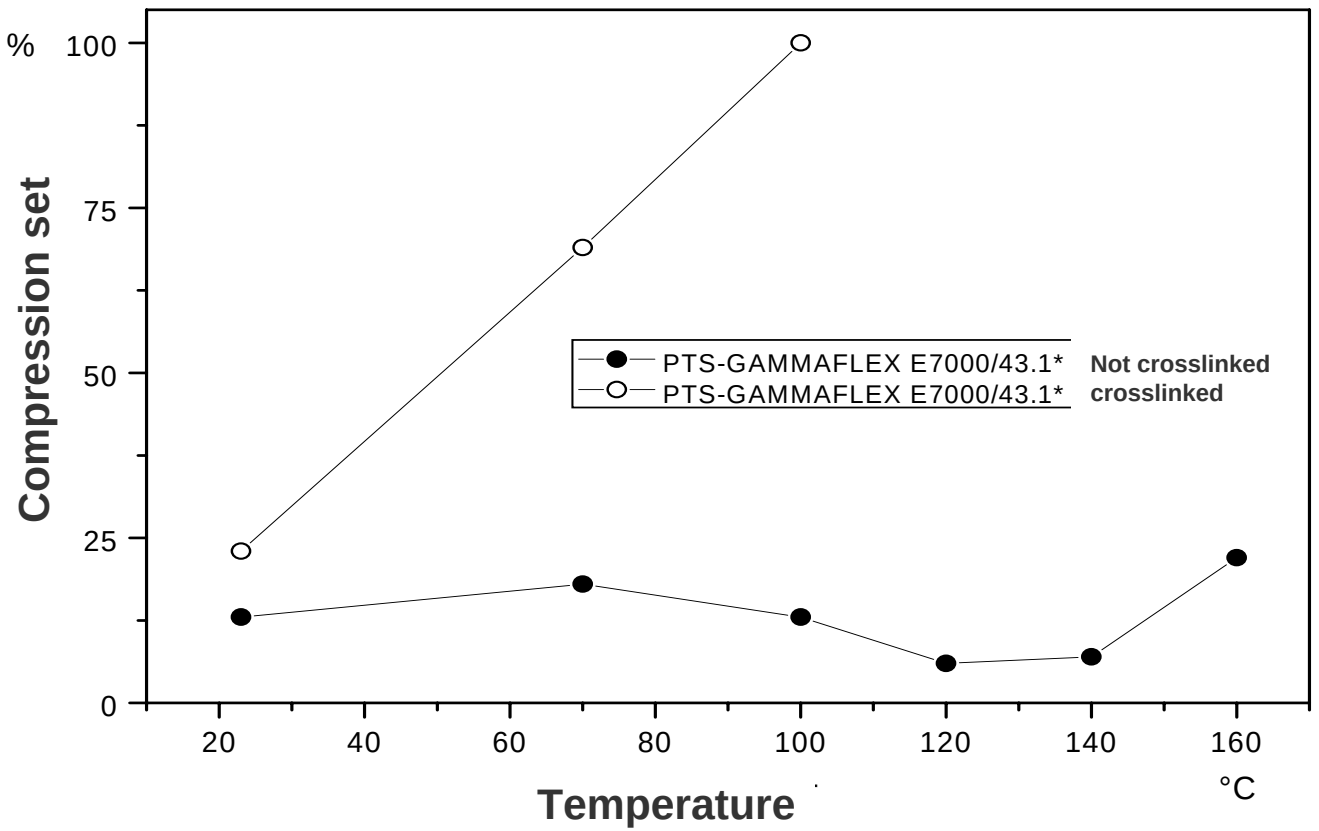
6.) significantly lower creep behaviour

7.) massive improvement of chemical resistance

Technical Applications - Fuel Lines And Hot Water Tubing

Radiation cross-linked fuel lines and hot water tubing, radiation cross-linked electrical insulation

PTS-GAMMAFLEX E7000/43.1*800

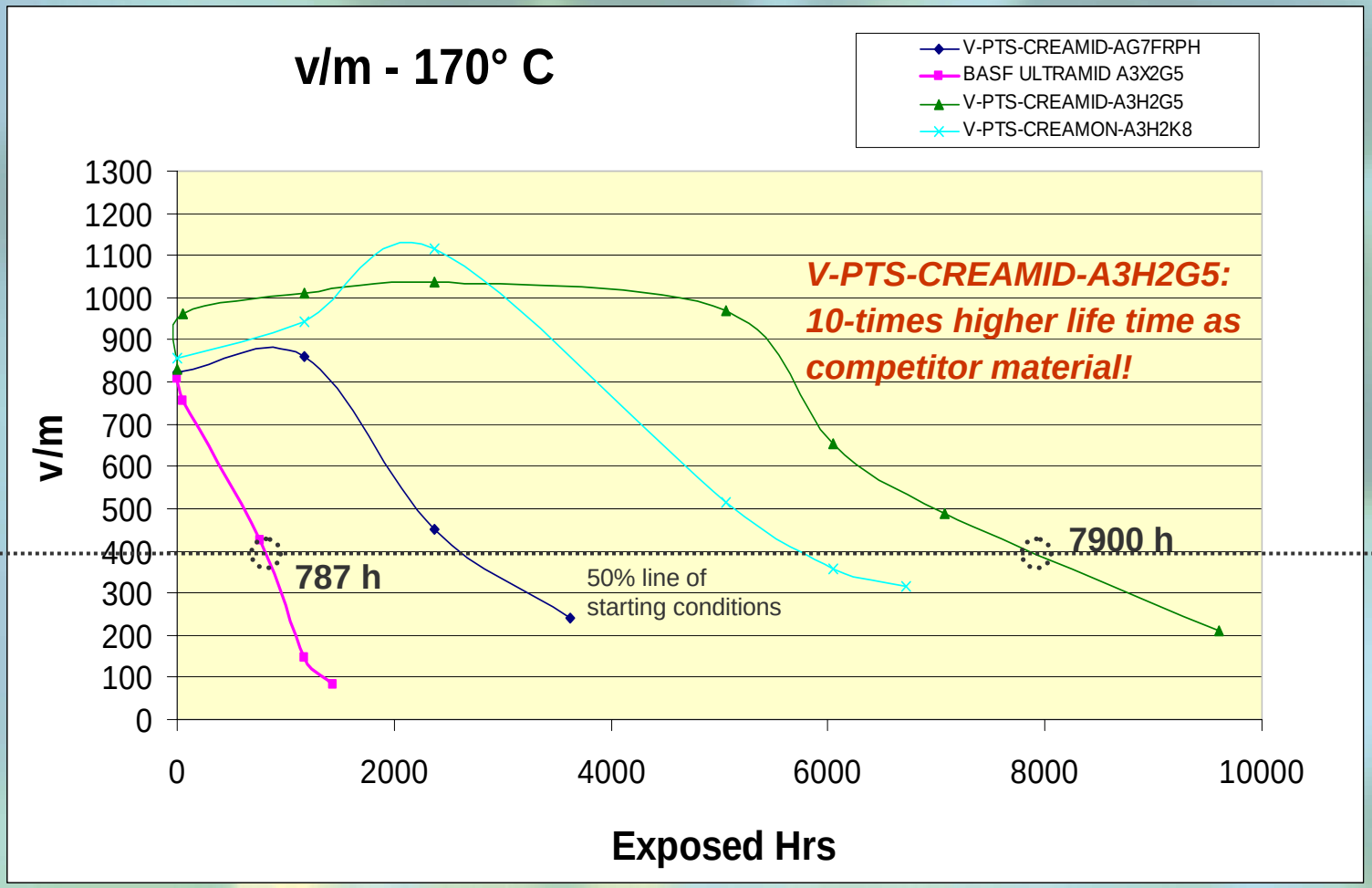


Simultaneous crosslinking of PA6.6 GF and TPE-X

PTS-GAMMAFLEX

TPE-X

Insulation properties in comparison to Ultramid A3X2G5

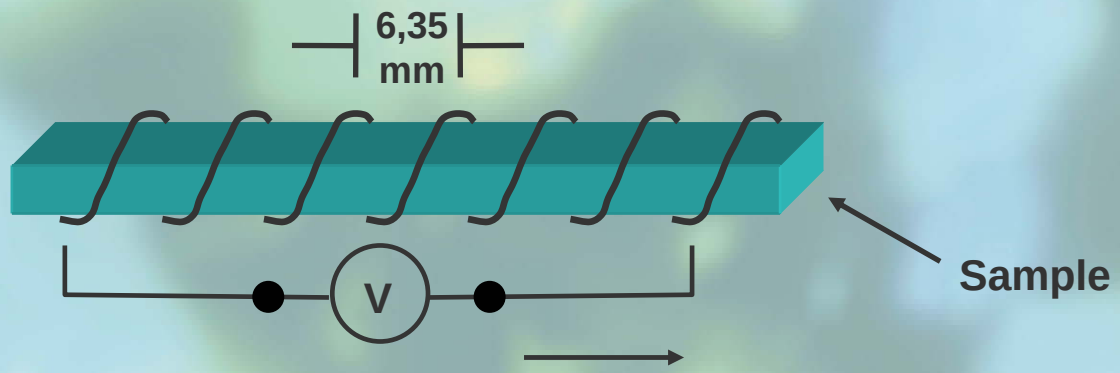


Advantages of crosslinked V-PTS-Creamid

- Very strong increase of ageing behaviour (RTI-elec.)
- RTI (elec.): 150°C in case of V-PTS-CREAMID-GF and MF
- RTI (elec.): 140°C in case of V-PTS-CREAMID-FRPH...(red phosphor)
- RTI (elec.): 115°C in case of ULTRAMID-A3X2G5
- No melting of contacts at T > 258°C
- Extreme low flammability (HWI = 0-1), UL can be done without flame retardant
- Best quality of contact, because material is free of phosphor and halogens
- No limitation in colouring
- Low density of flue gas and low toxicity in fire emergency

- **Successful unleaded soldering technology at temperatures of 280°C. Replacement of LCP and thermosets in many cases.**
- **High temperature soldering at 450-500°C / 0,5 s feasible**
- **Price reduction of 30% with V-PTS Creamid in comparison to thermosets**
- **Reduction of claims (melted relay carriers down to 0)**
- **No claims caused by thermoset tails (contamination between contacts)**
- **Increase of abrasion resistance**
- **Higher thermal load possible (RTIelectric = 150°C)**
- **Best contact quality (no red phosphorous or halogens)**
- **excellent HWI of 0-1 (*H*ot *W*ire *I*gnition Index)**

Test equipment for HWI (schematic):

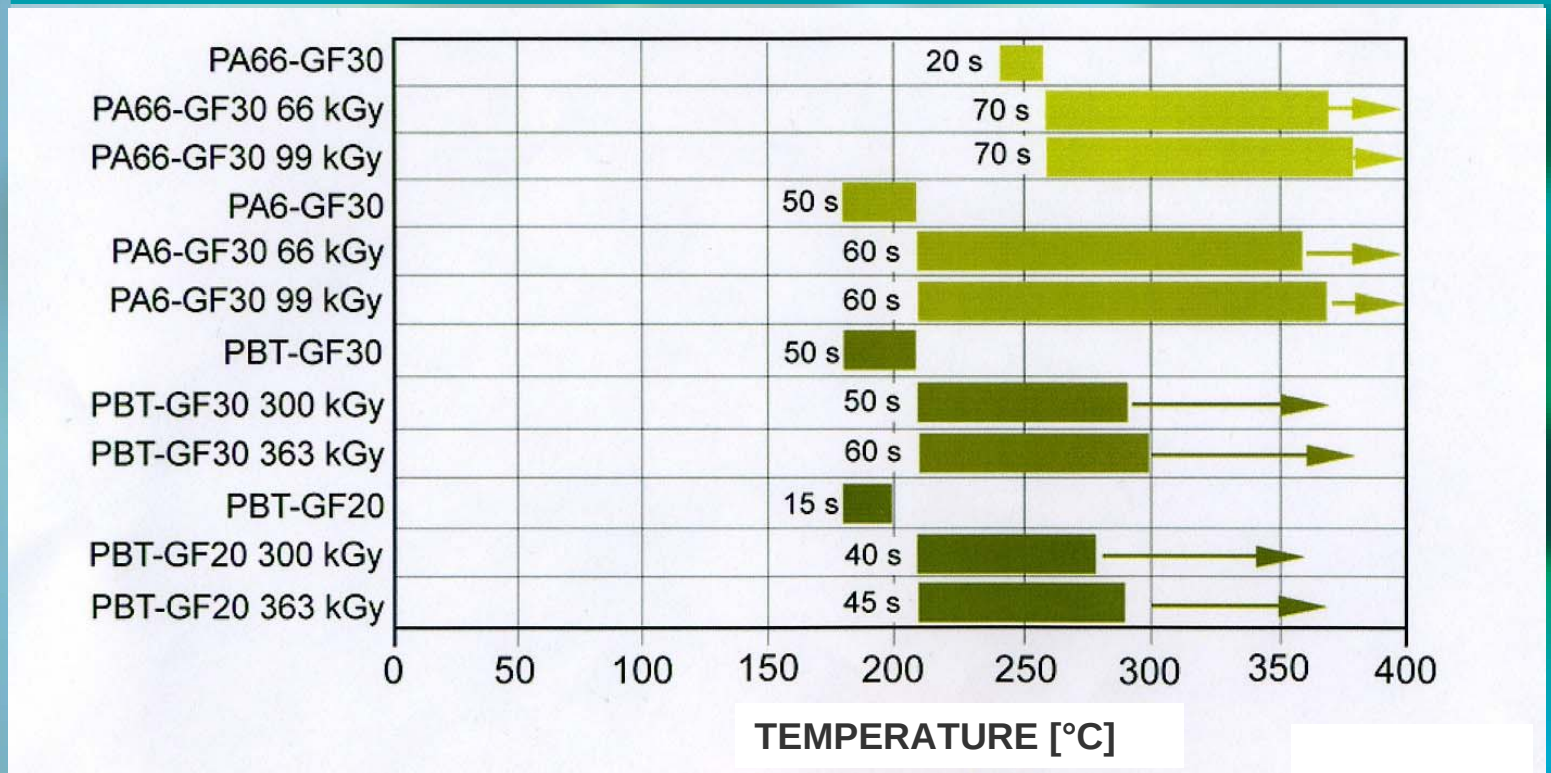


Power supply: 0,26 W/mm

HWI (Hot Wire Ignition – UL-746A) in accordance to ASTM D 3874-88

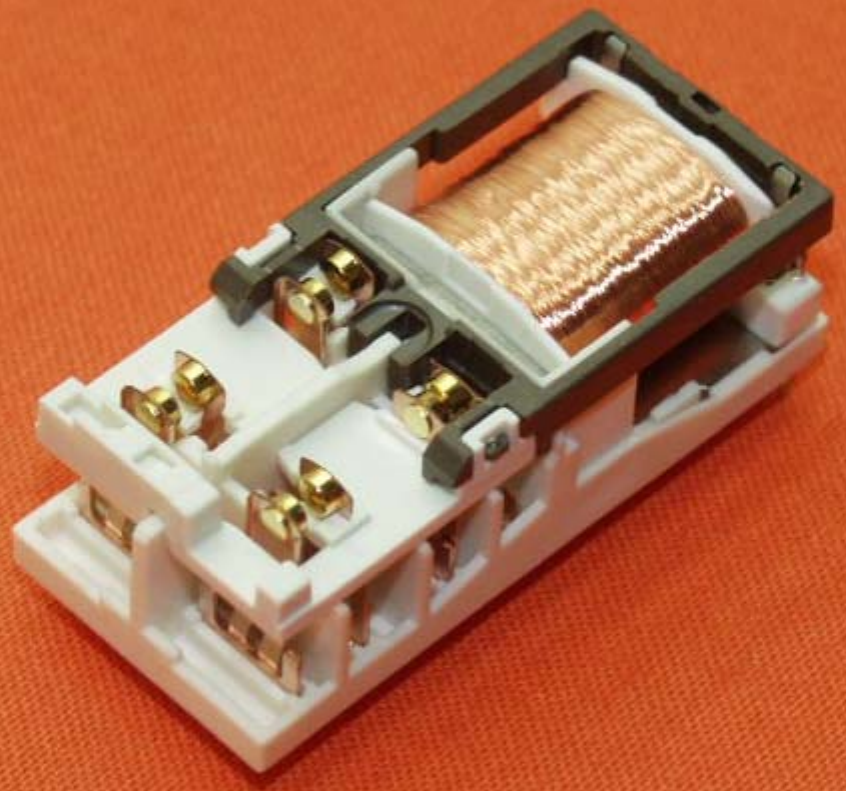
Goal: Performance level for resistance against ignition of plastic materials caused by an electrical heated wire. The time for ignition defines the PLC value.

Ignition time IT [s]	PLC (performance level category)
120 ≤ IT	0
60 ≤ IT < 120	1
30 ≤ IT < 60	2
15 ≤ IT < 30	3
7 ≤ IT < 15	4
0 ≤ IT < 7	5



Improvement of short time thermal application limit

V-PTS-CREAMID-A3H2G7



PA66-GF 35

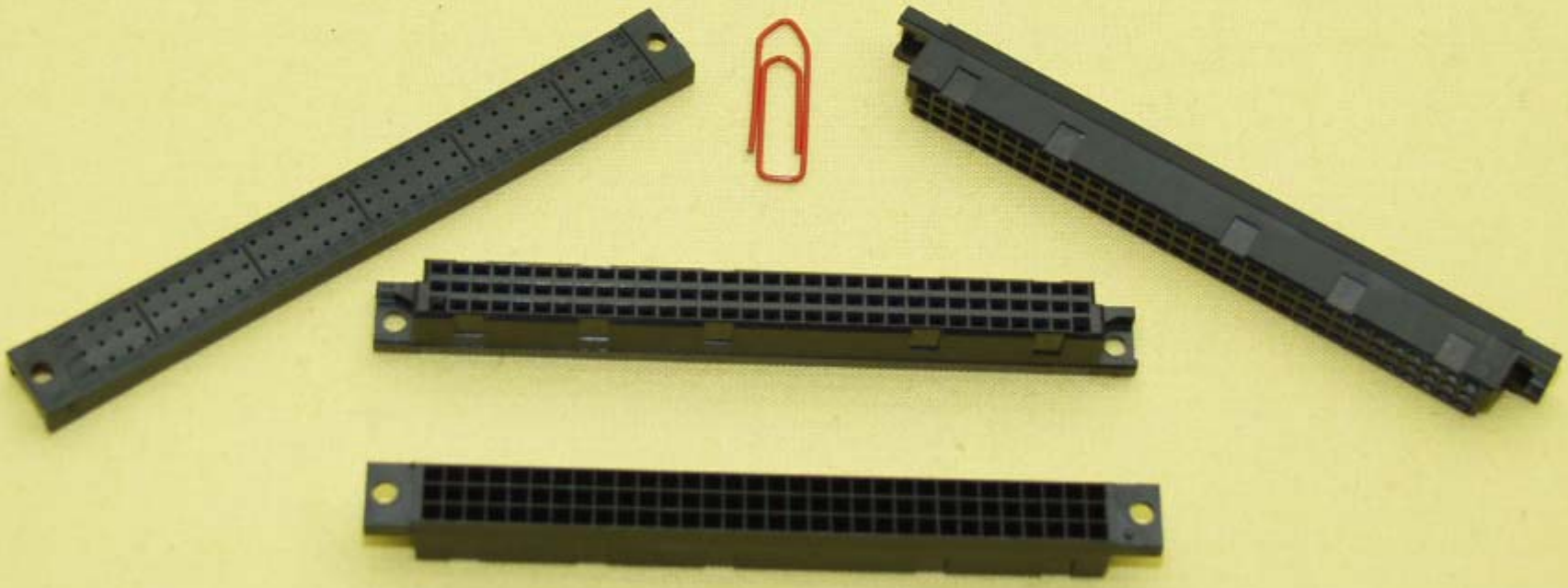
Crosslinked with 100 KGy

V-PTS-CREAMON-A3H2K8 for low warpage housing

PA66-MF 40

Crosslinked with 100 KGy

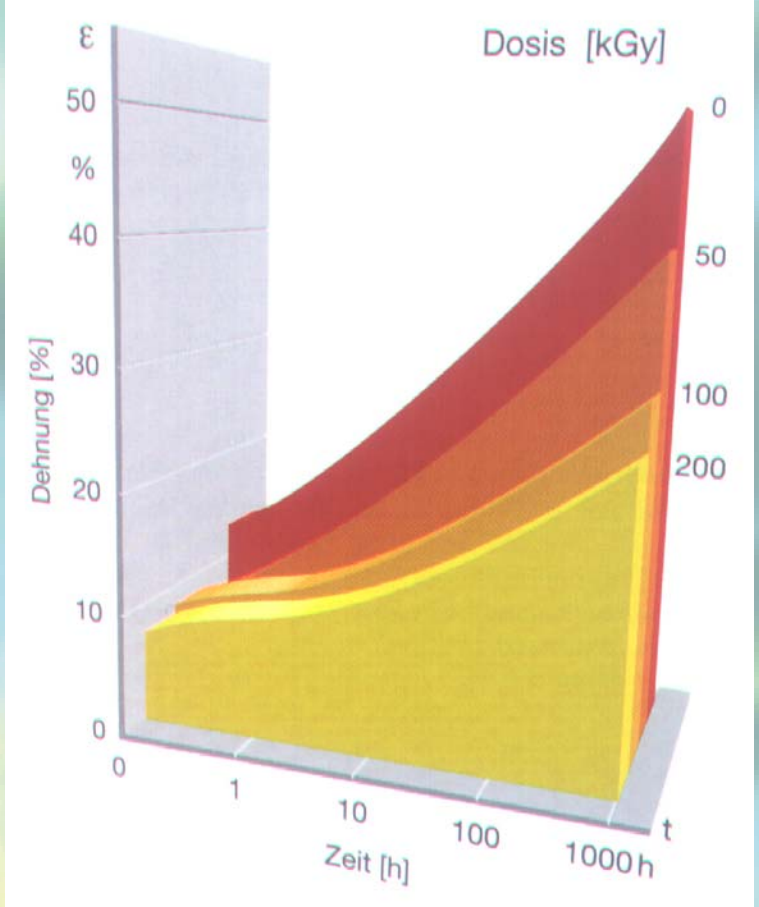
V-PTS-CREATEC-B3HG7ZB



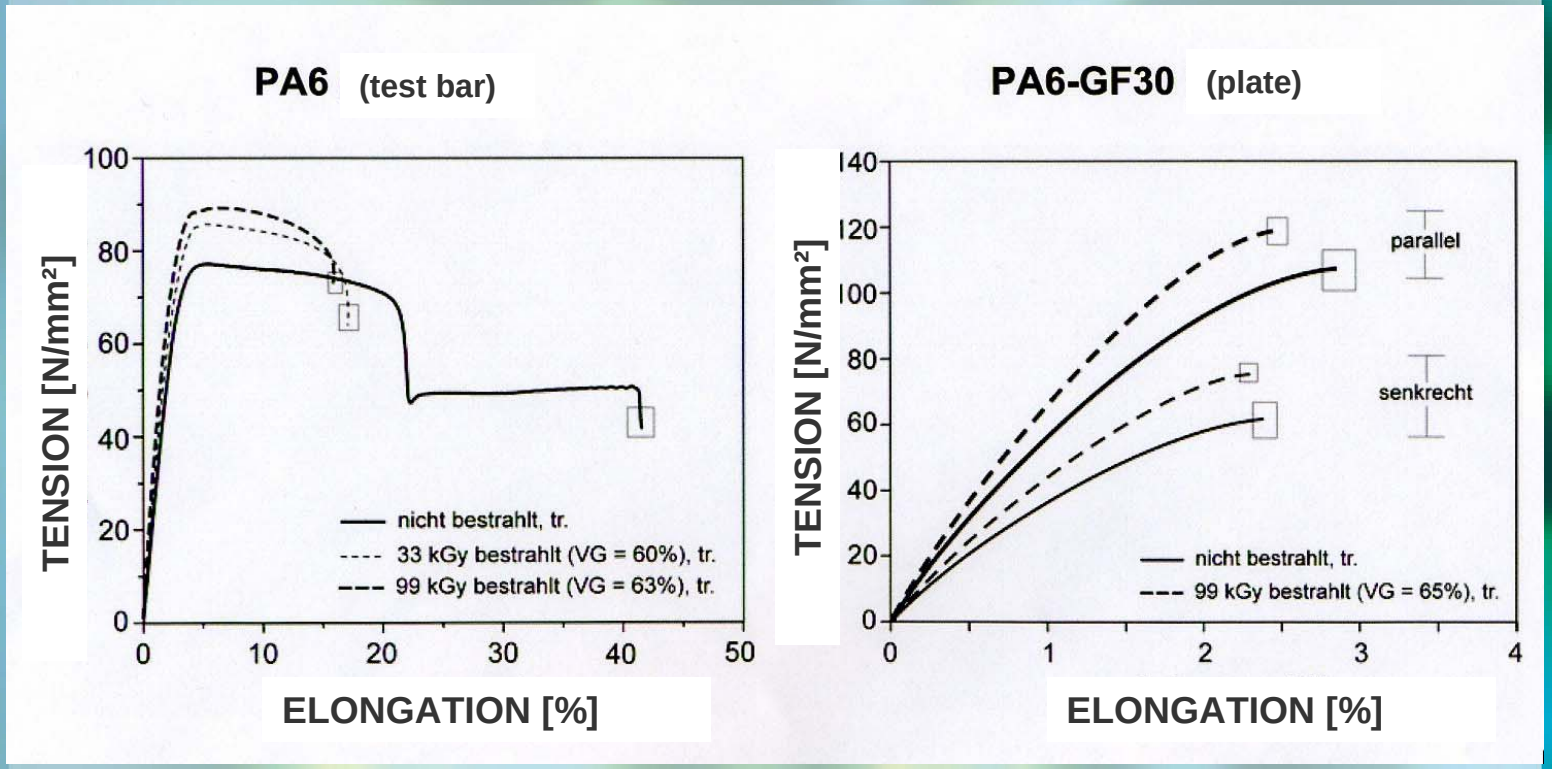
PBT-GF 35 impact modified

Crosslinked with 150 KGy

Creeping behaviour

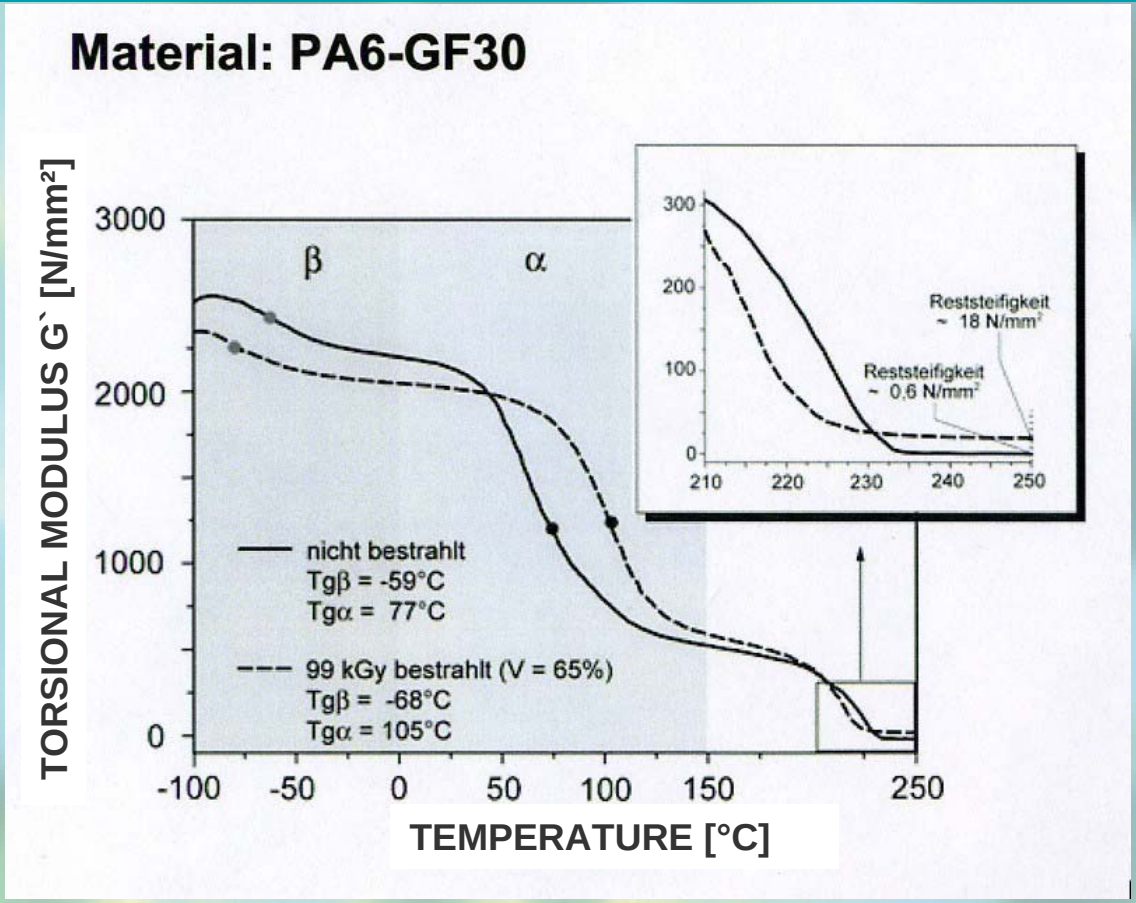


Mechanical Properties – Tensile Test in accordance to DIN ISO 527-1



Crosslinking leads to higher tensile strength and reduced elasticity.

Thermo mechanical Properties – DMA Torsion Test

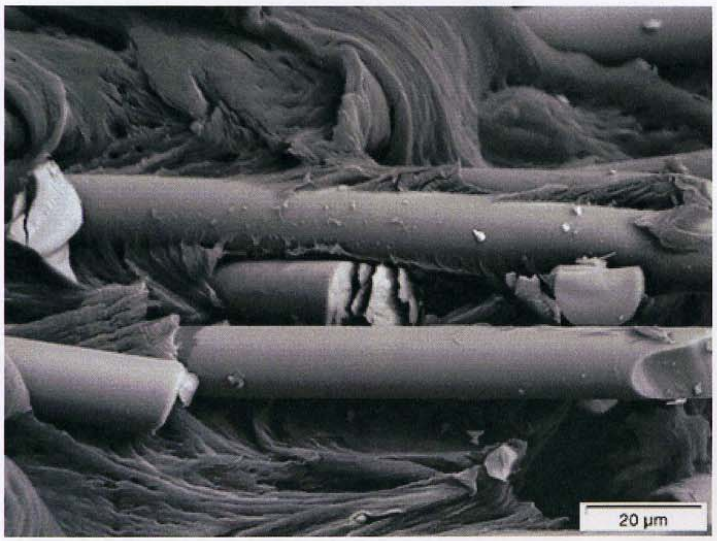


Increasing of glass transition temperature and remaining stiffness by means of crosslinking.

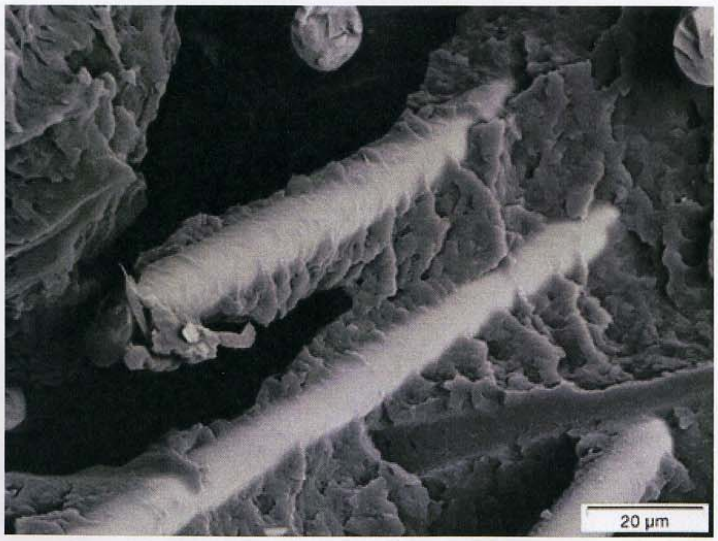
Fiber-Matrix bonding of PA6

Material: PA6-GF30

Not crosslinked



Crosslinked (99 KGy)

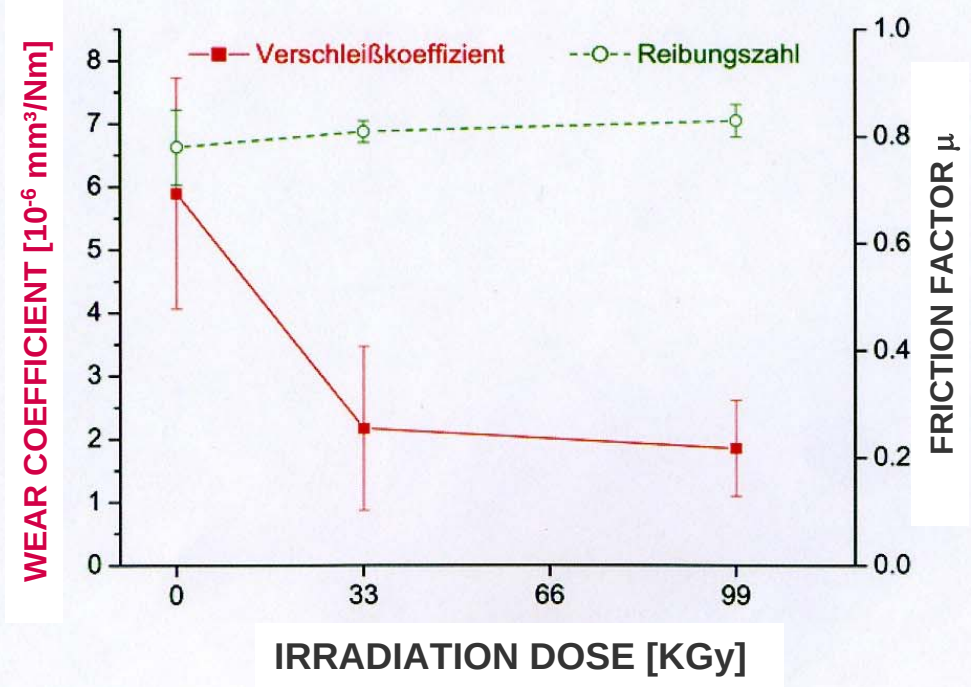


Fiber pull out force increased with crosslinked material

=> Improved strength behaviour

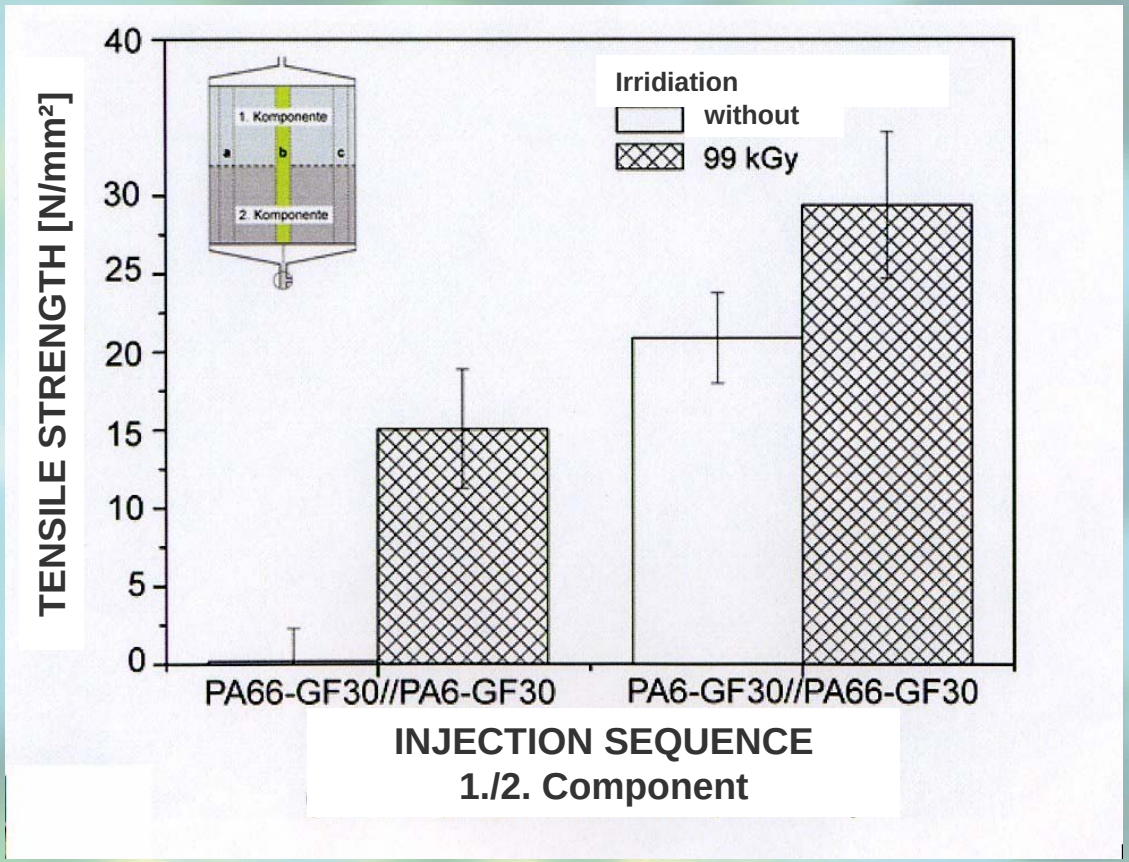
Tribological Properties

MATERIAL: PA66 (dry)



Pin-Disc equipment
Disc: steal (Rz = 1,5 µm)
T=100°C; v=0,5 m/s; p=4 N/mm²

Influence on Weld line strength



Tensile Test in accordance to DIN 2156; 2mm/Min; σ_{max}

Influence of molding

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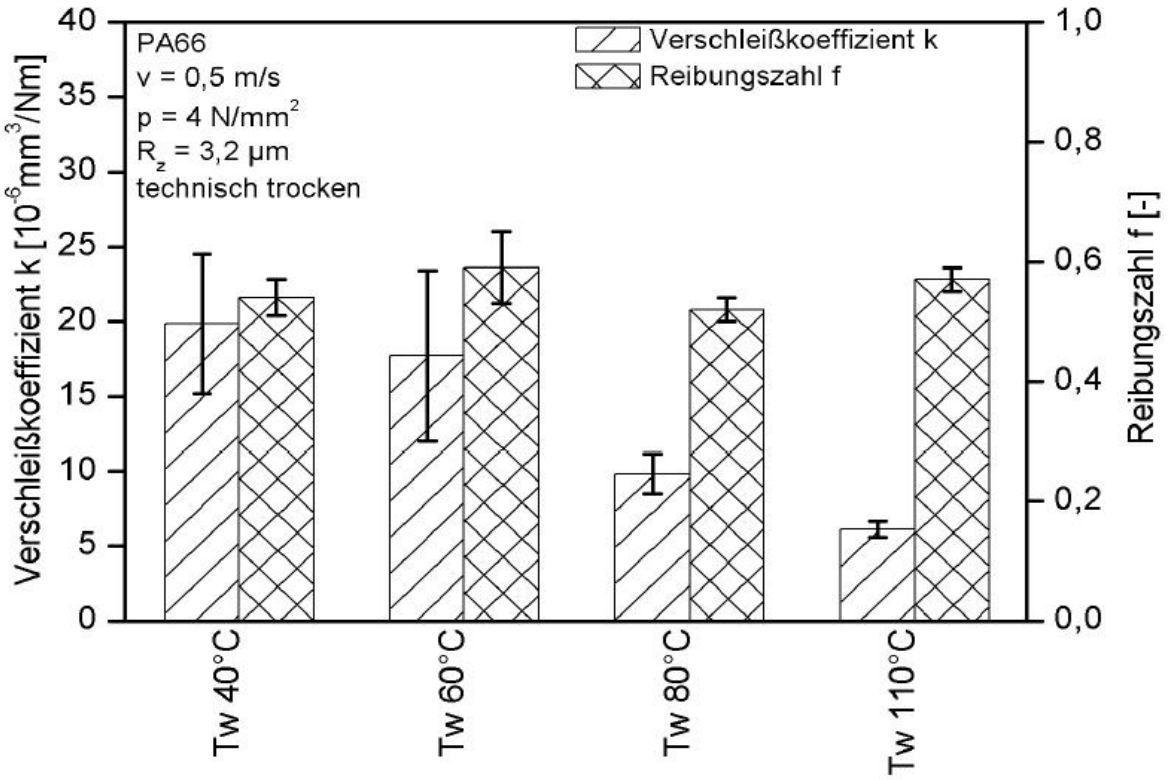


Material:

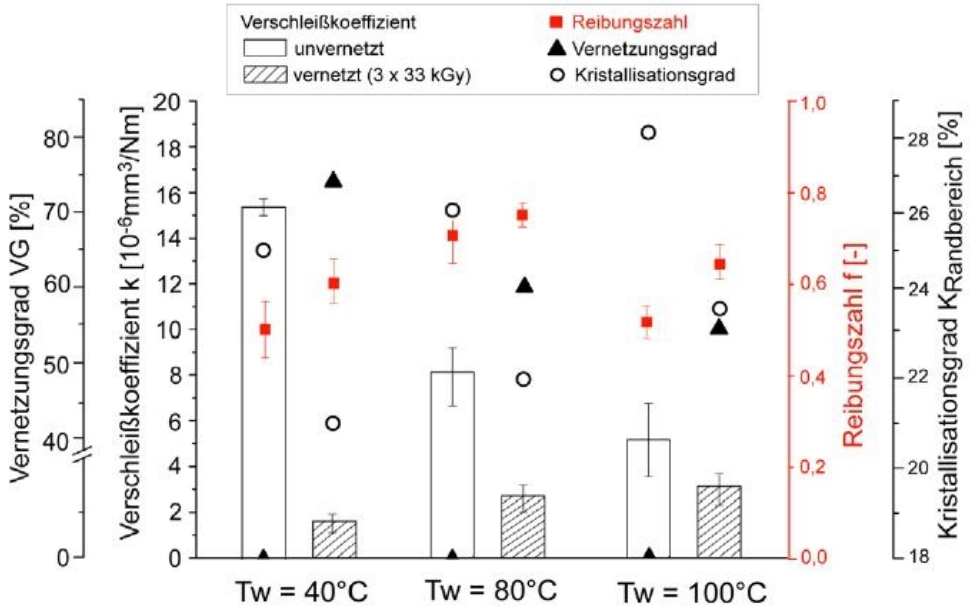
PA66

Abrasion behaviour

LKT - Universität Erlangen-Nürnberg

Material:

PA66
Vernetzungsmittel (Betalink IC/W65PA6*natur, Fa. PTS)



Stift-Scheibe-Untersuchung

Gleitpartner: Stahl (R_z = 1,5 µm)
T = 100°C; v = 0,5 m/s; p = 4 N/mm²

Surface pressure

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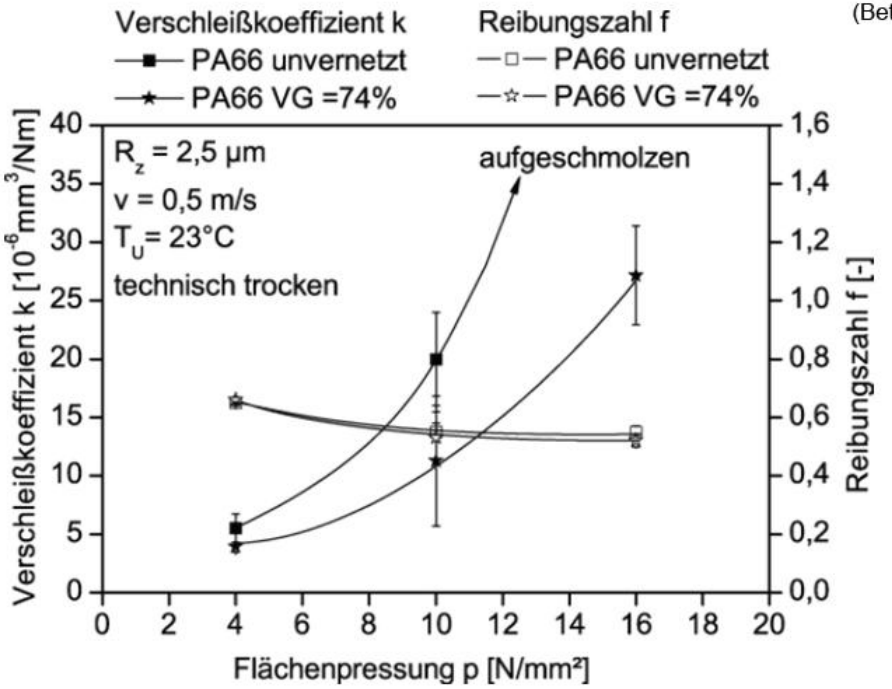
Material:

PA66

+ 4 Gew.-% VM Vernetzungsmittel
(Betalink IC/W65PA6*natur, Fa. PTS)



Surface roughness

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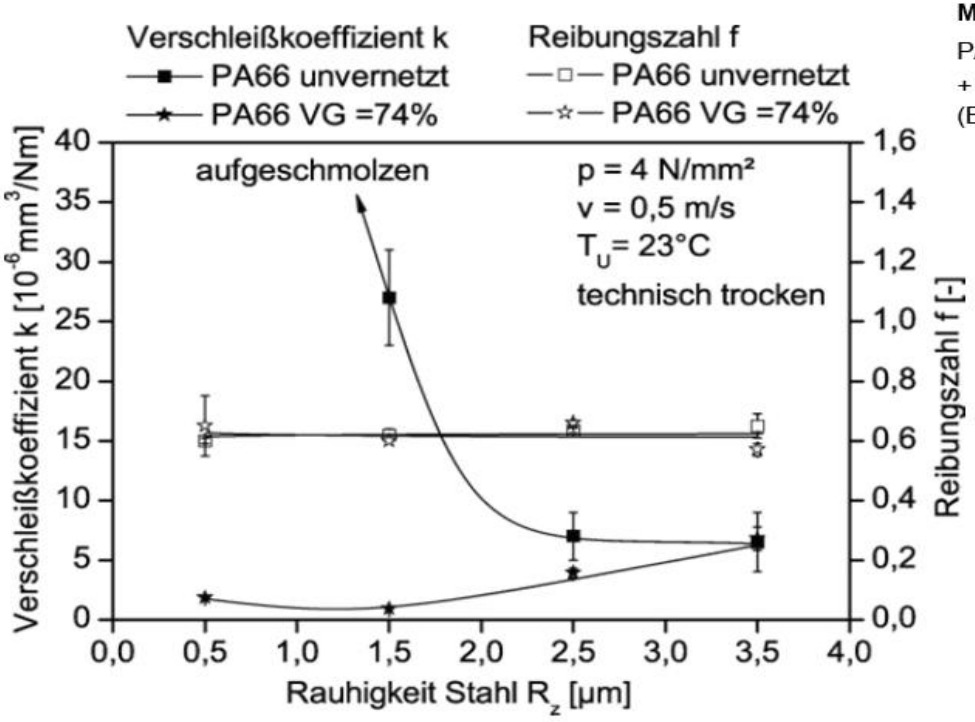

Material:

PA66

+ 4 Gew.-% VM Vernetzungsmittel
(Betalink IC/W65PA6*natur, Fa. PTS)

Ergebnis:

- kein Aufschmelzen bei geringen Rauhigkeiten

Influence of Temperature

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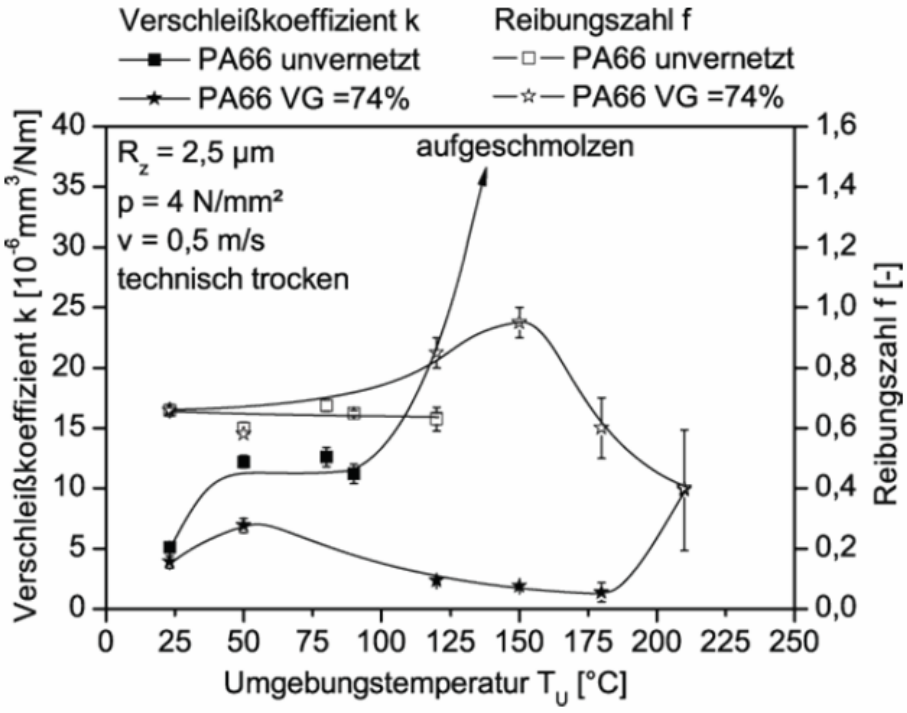

Material:

PA66

+ 4 Gew.-% VM Vernetzungsmittel
(Betalink IC/W65PA6*natur, Fa. PTS)

Ergebnis:

erhöhte Temperaturbeständigkeit

erhöhte Verschleißfestigkeit

Sliding speed

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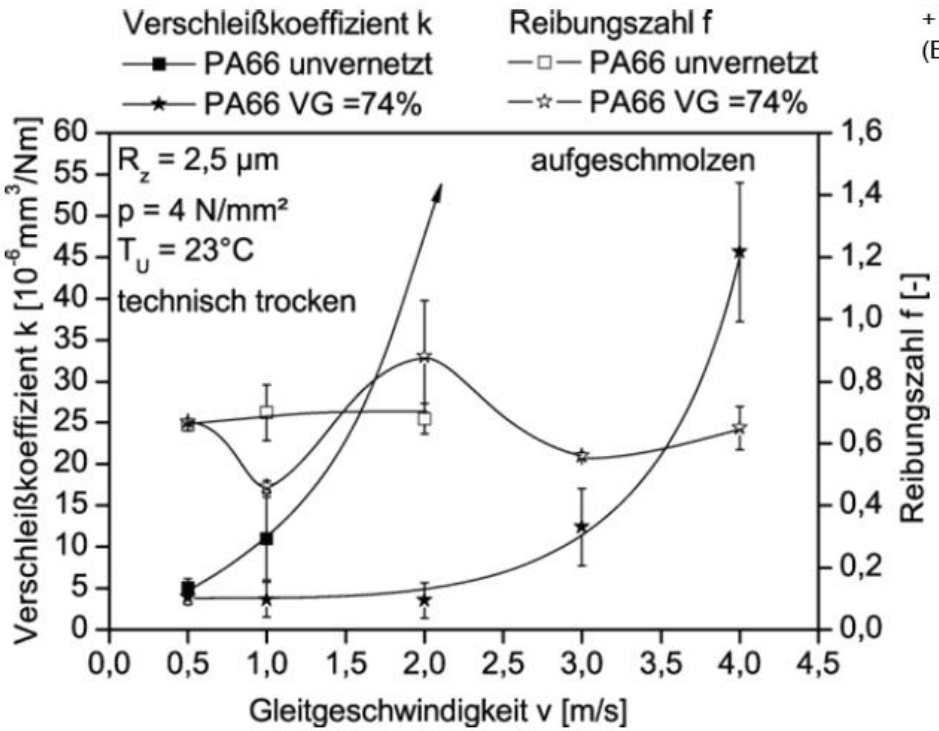
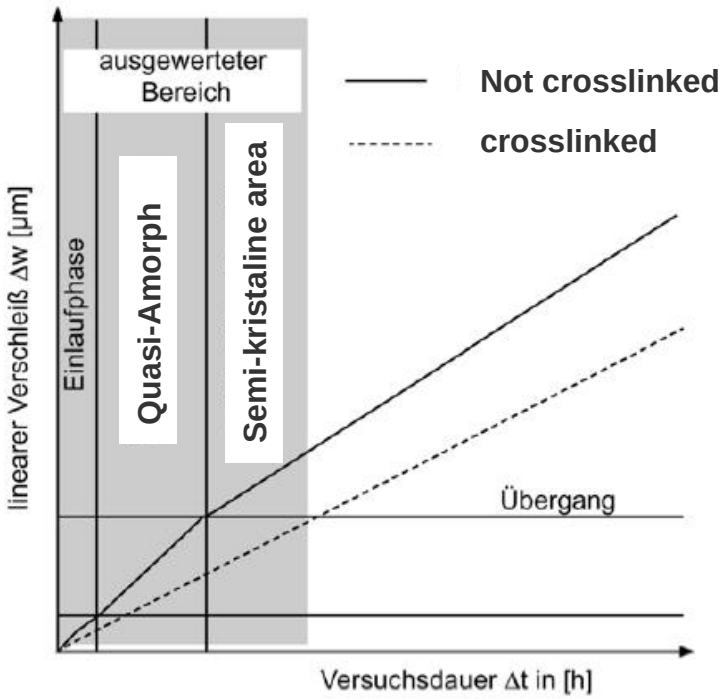


Material:

PA66

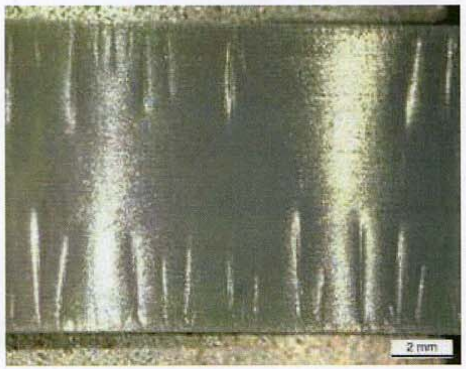
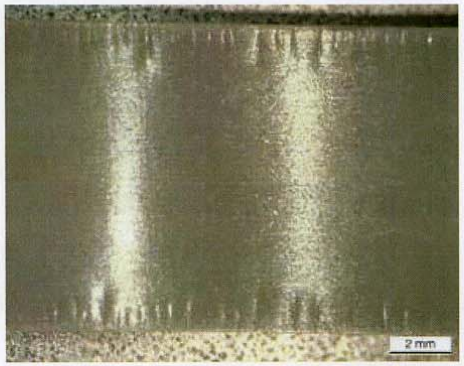
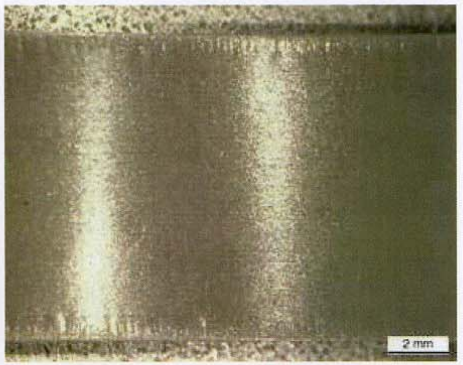
+ 4 Gew.-% VM Vernetzungsmittel
(Betalink IC/W65PA6*natur, Fa. PTS)

Abrasion behaviour in different layers



Stress crack resistance

Material: PA6

Not crosslinked	Crosslinked (33 KGy)	Crosslinked (99 KGy)
		
INDICATOR A2	**INDICATOR A1**	**INDICATOR A1**

Crosslinked areas prevent disentanglement of molecules => higher stress crack resistance

Bending test in accordance to DIN 4599
R = 50mm, ε = 3,8%
30% $ZnCl_2$
24h test

Long term behaviour

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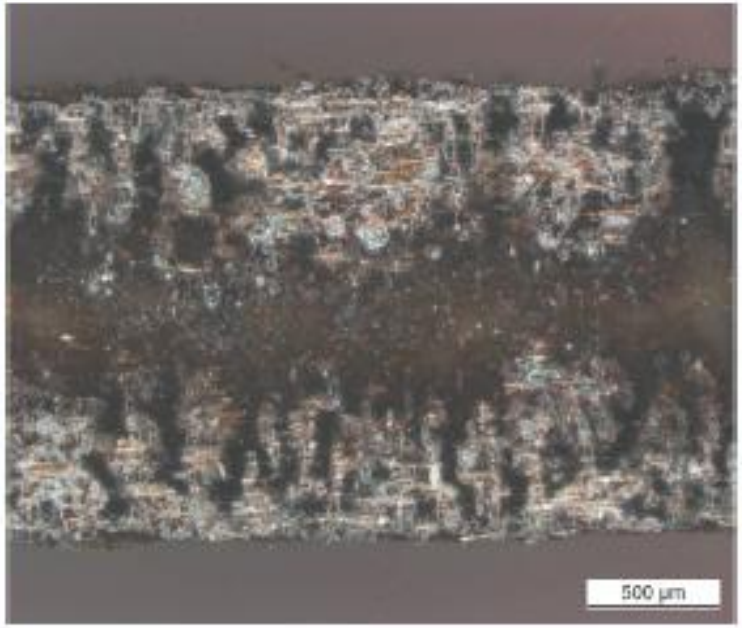
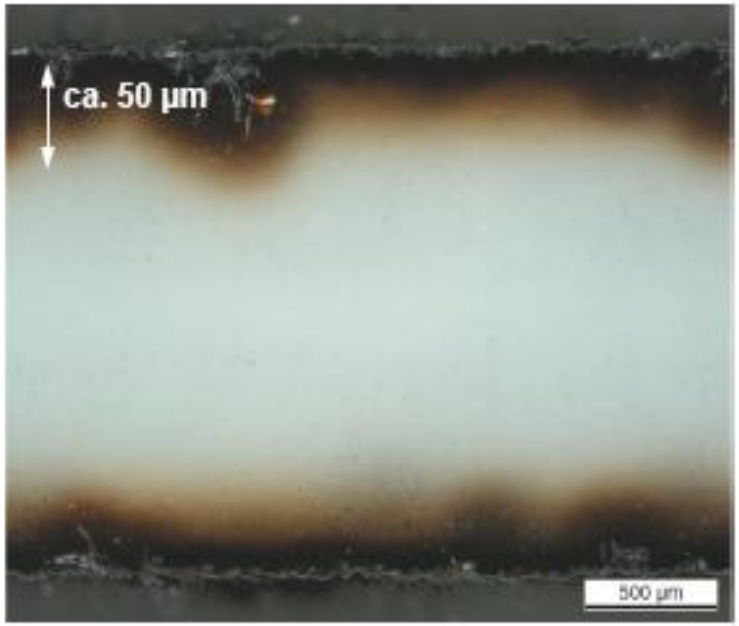
Material: PA66-GF30

Not crosslinked



crosslinked 3 x 33 kGy (VG = 62 %)

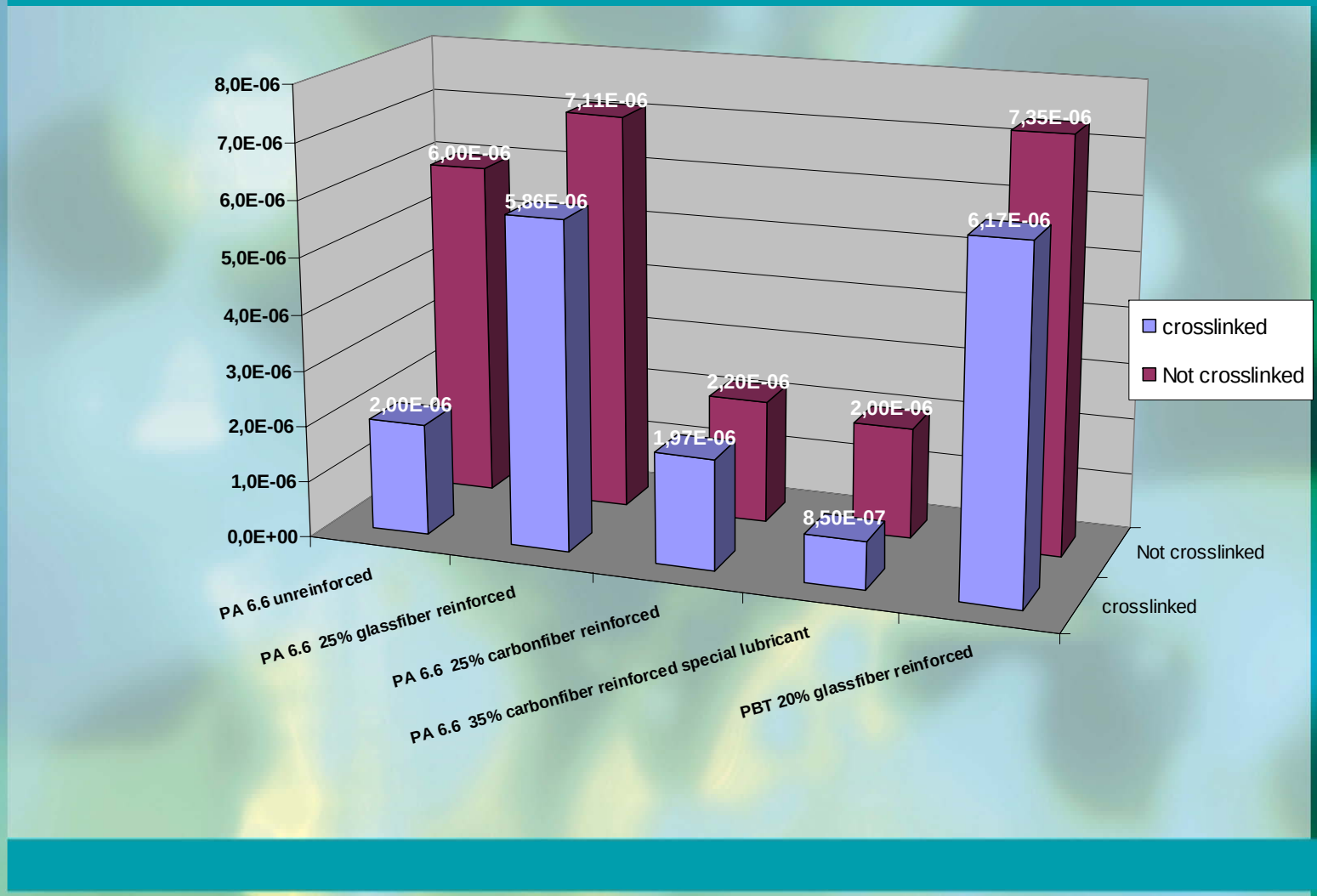


Auflichtmikroskopie DF

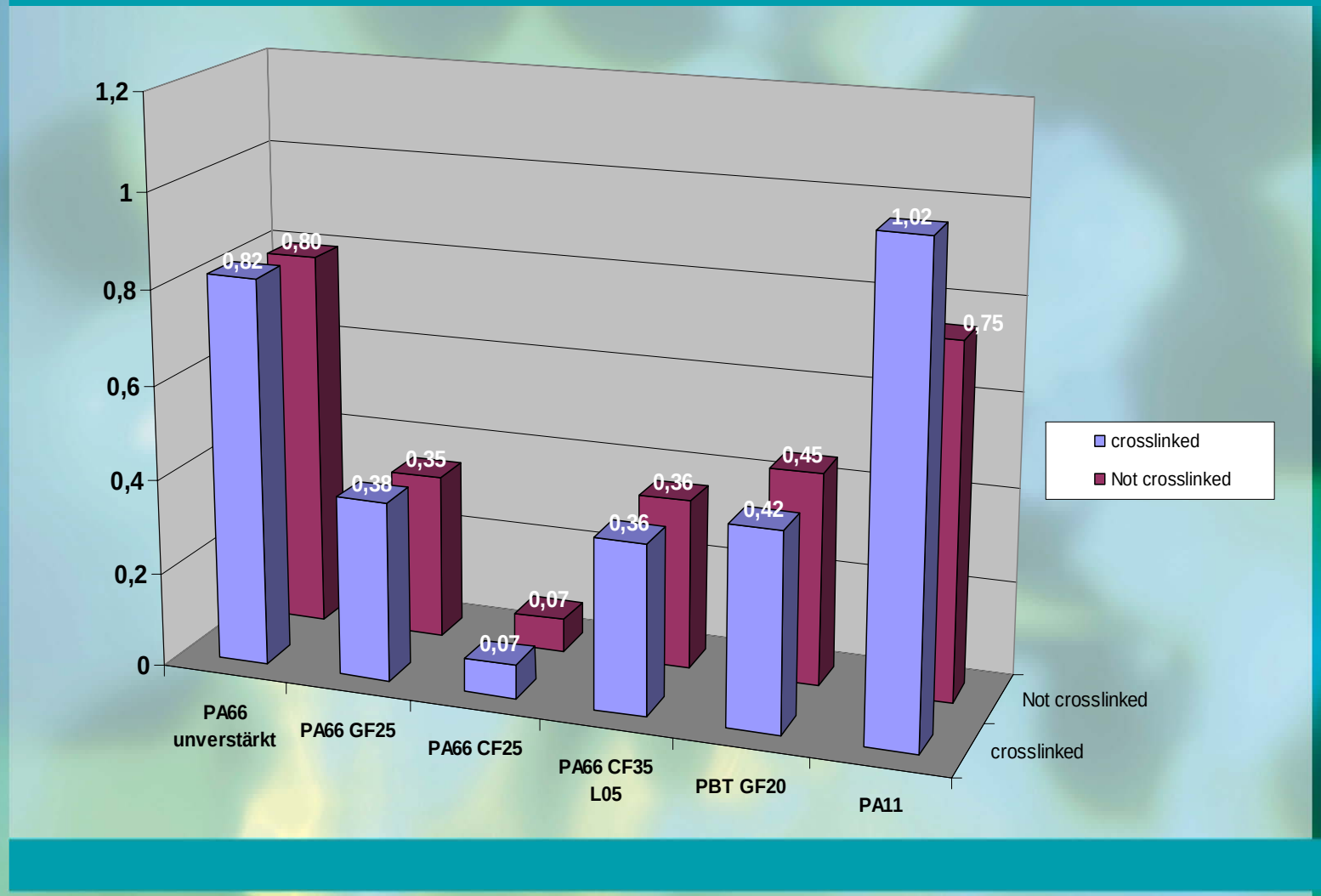
Ofenalterung nach DIN IEC 216:

Temperatur	180 °C
Time	16 Wochen

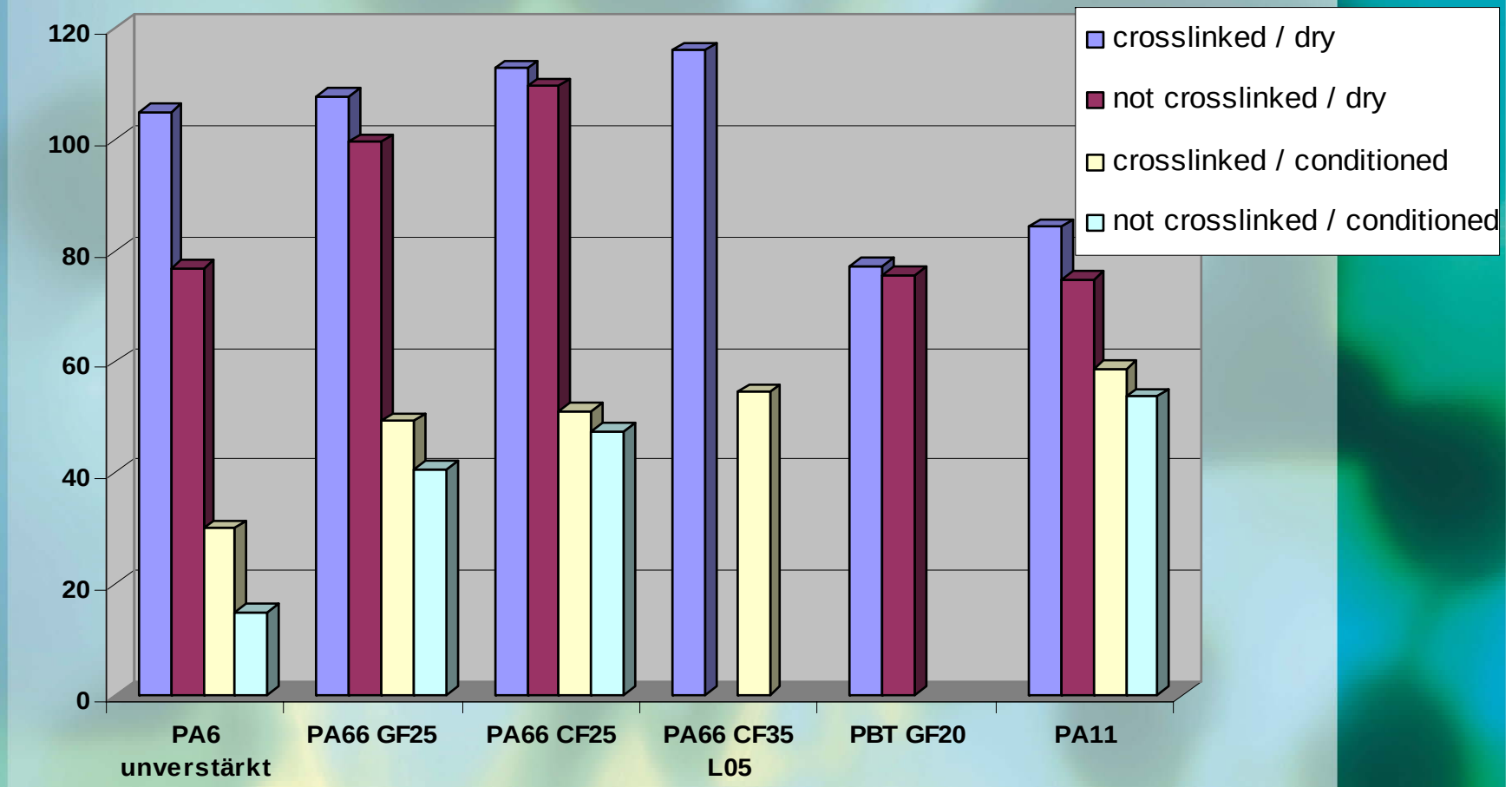
Tribological properties / abrasion coefficient



Tribological properties / frictional index



Effects of crosslinking on the glass transition



Crosslinkable Materials from PTS:

- PE, PP
- TPE-E, TPU
- PA11, PA12, PEBA
- PBT
- PA6, PA66
- PA9T

Increase of ....
(Thermoplastic Materials)

.... mechanical properties

- Increase of Module
- Increase of mech. Strength (esp. Long term)
- Reduction of Elongation at break
- Reduction of creep behaviour
- Increase of hardness
- Increase of wear resistance
- Increase of Tear strength
- Increase of welding line strength
- Increase of crack resistance
- Improvement of Memory Effect

.... thermal properties

- Increase of Heat deflection Temperature
- Increase of Flame retardant

.... chemical properties

- Gradual increase of resistance against chemicals
- Reduction of solubility
- Reduction of swelling behaviour

END