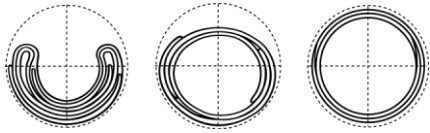




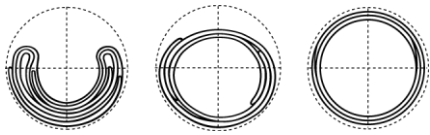
**BKP**  
**B E R O L I N A**



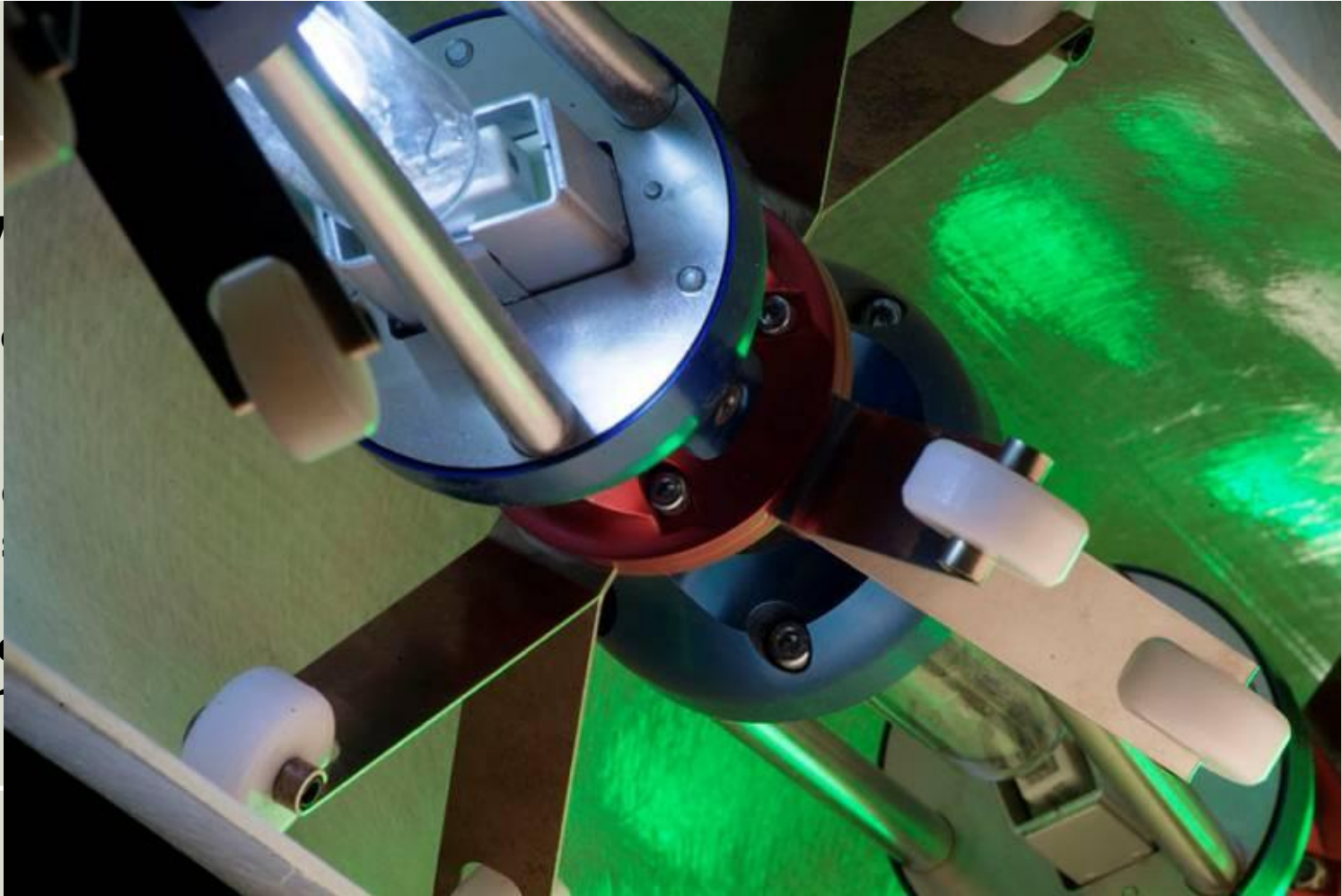
## **Paper 3-B-01 / Cured in Place Pipeliners**

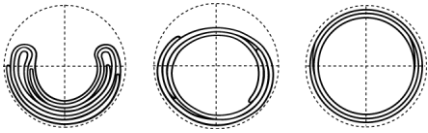
# **A New UV Sensor Method for Sewer Renovation**

Michael Roeling, Export Manager  
BKP Berolina Polyester GmbH & Co. KG, Velten, Germany



- UV
- be  
po
- go  
po
- sp  
nm





# Quality Managements steps at the installation site

## Data recording with PC



**Actual Values**

Date/Time: 20.08.2001 15:54:07 Distance = 0

Temp. Air [°C]: 25.5 Distance [m]: 123.45

Temp. Pyrometer 1 [°C]: 33.3 Speed [cm/min]: 123.4

Temp. Pyrometer 2 [°C]: 111.1 Pressure [bar]: 1.234

**Set Points**

Apply

Distance: 200.00 m

Speed: 35 cm/min

Measure Interval: 3 sec

**Lamp Status:**

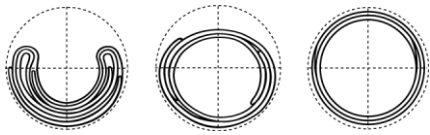
All Lamps ON	Lamp 1 (Aus)	Lamp 2 (Ein)	Lamp 3 (Ein)	Lamp 4 (Ein)	Lamp 5 (Aus)	Lamp 6 (Aus)	Curing (Aus)	SYSTEM STATE (OK)
All Lamps OFF	Lamp 7 (Aus)	Lamp 8 (Aus)	Lamp 9 (Aus)	Lamp 10 (Aus)	Lamp 11 (Aus)	Lamp 12 (Aus)	Drum (Aus)	AUTOMATIC MODE (OK)

**Log Table:**

Time	No	Error
20.08.2001 15:53	50	Warning reserved
20.08.2001 15:53	37	Temperature T3 is below warning limit
20.08.2001 15:53	34	Temperature T1 exceeds warning limit
20.08.2001 15:53	18	Lamp 08 has troubles
20.08.2001 15:53	2	Safely door not OK

Acknowledge

Copyright: BKP



# Quality Managements steps at the installation site

## Data recording with PC – control mode

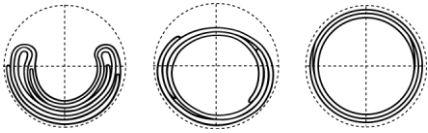
The screenshot shows the 'ORI UVA - Control' software interface. It includes a menu bar (File, View, Help), a toolbar on the left, and several data fields for 'Actual Values' and 'Set Points'. The 'Actual Values' section displays Date/Time (20.08.2001 15:54:07), Distance (0), Temp. Air (25.5 °C), Distance (123.45 m), Temp. Pyrometer 1 (33.3 °C), Speed (123.4 cm/min), Temp. Pyrometer 2 (111.1 °C), and Pressure (1.234 bar). The 'Set Points' section includes Distance (200.00 m), Speed (35 cm/min), and Measure Interval (3 sec). Below these are controls for 'All Lamps ON', 'All Lamps OFF', and 'Apply'. The main control area features 12 lamp indicators (Lamp 1 to Lamp 12) and buttons for 'Curing' and 'Drum'. The 'SYSTEM STATE' and 'AUTOMATIC MODE' are also visible. A table at the bottom shows a log of events.

Annotations with arrows point to specific elements:

- lamp started**: Points to the 'All Lamps ON' button.
- lamp switched on**: Points to Lamp 1 (yellow circle with a black 'X').
- lamp defect**: Points to Lamp 7 (red circle with 'Aus').
- lamp switched off**: Points to Lamp 8 (red circle with 'Aus').
- on/off of winch**: Points to the 'Curing' button (red circle with 'Aus').
- lamp not activated**: Points to Lamp 12 (grey circle).

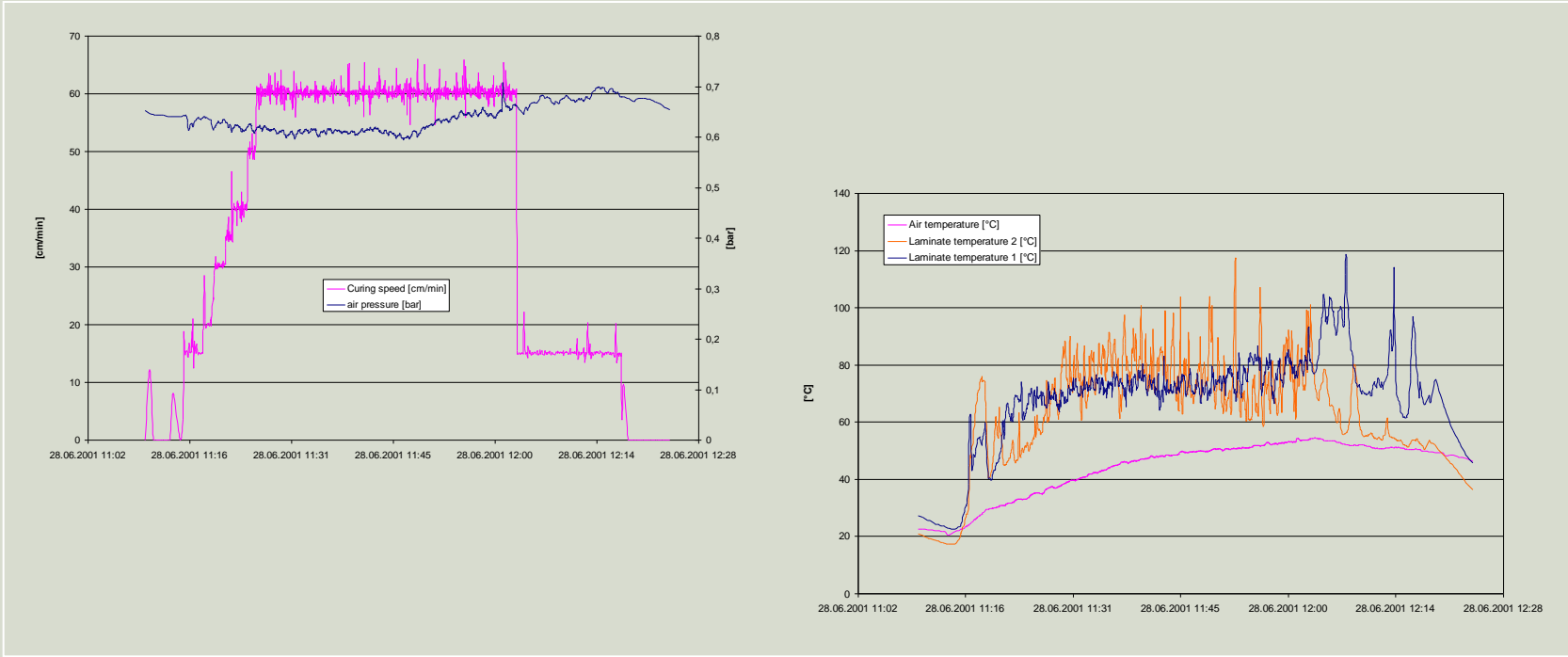
Time	No	Error
20.08.2001 15:53	50	Warning reserved
20.08.2001 15:53	37	Temperature T3 is below warning limit
20.08.2001 15:53	34	Temperature T1 exceeds warning limit
20.08.2001 15:53	18	Lamp 08 has troubles
20.08.2001 15:53	2	Safety door not OK

Copyright: BKP

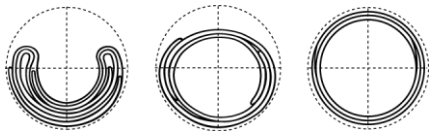


# Quality Managements steps at the installation site

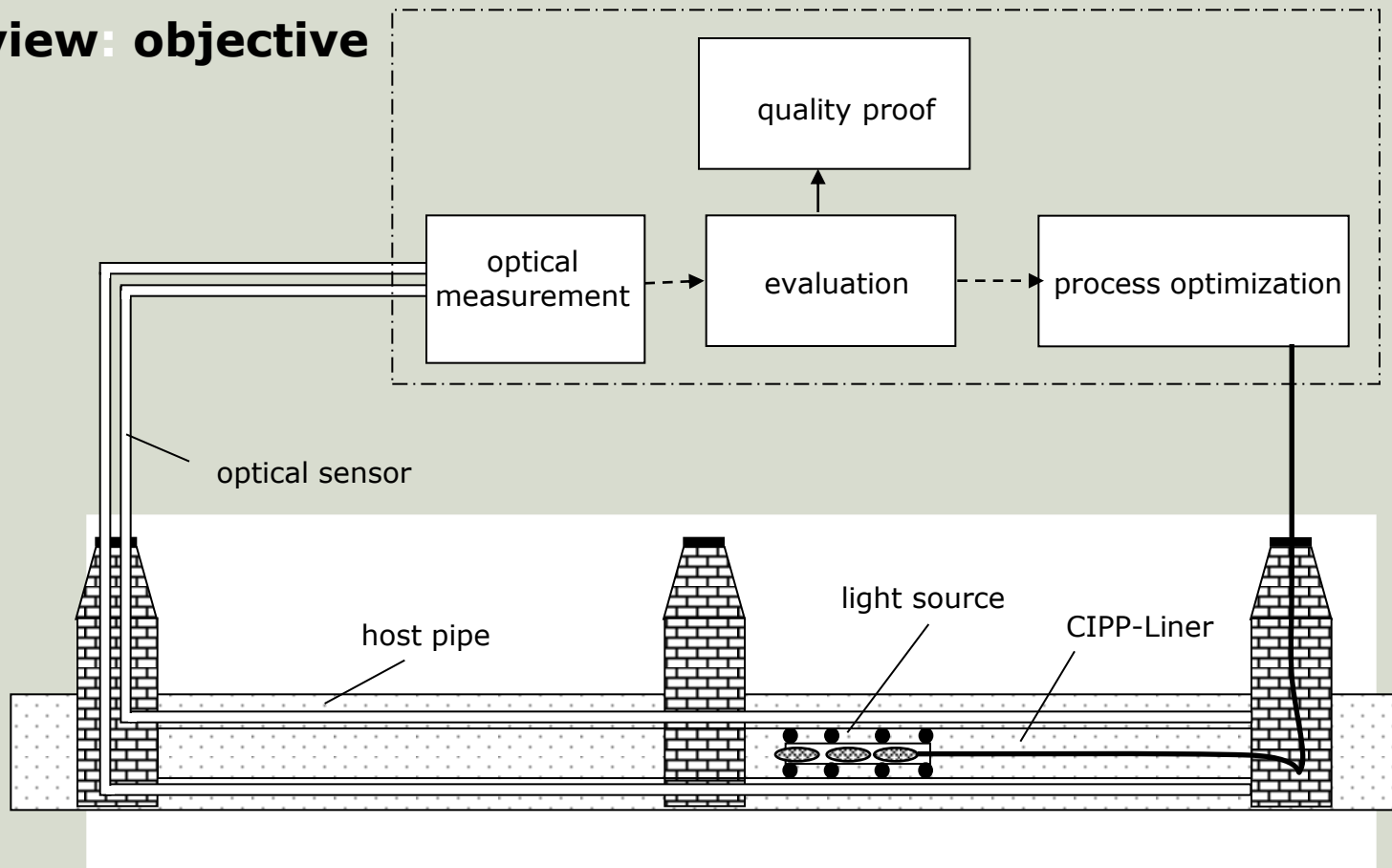
## Data recording with PC – evaluation



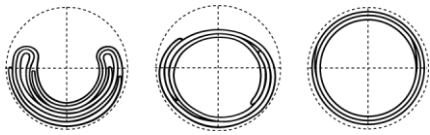
Copyright: BKP



## Overview: objective



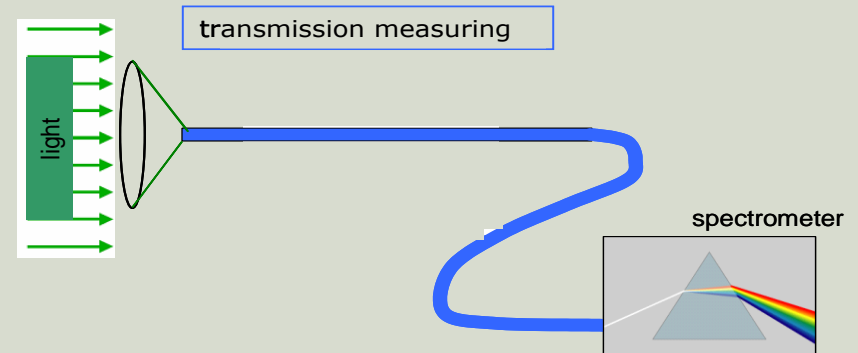
Source: OSSCAD



## Principal configuration of UV-light measuring

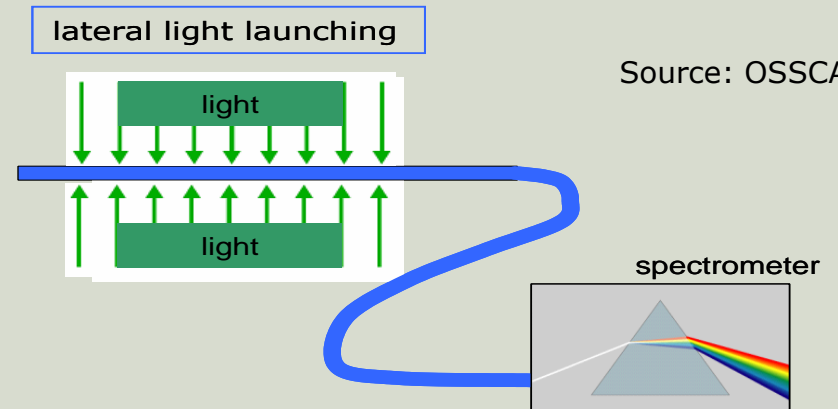
Transmission measuring:

- UV collimation device
- optical fiber
- wavelength selective receiver



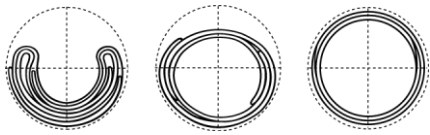
Lateral UV-light launching:

- no UV collimation device
- special optical fiber
- wavelength selective receiver

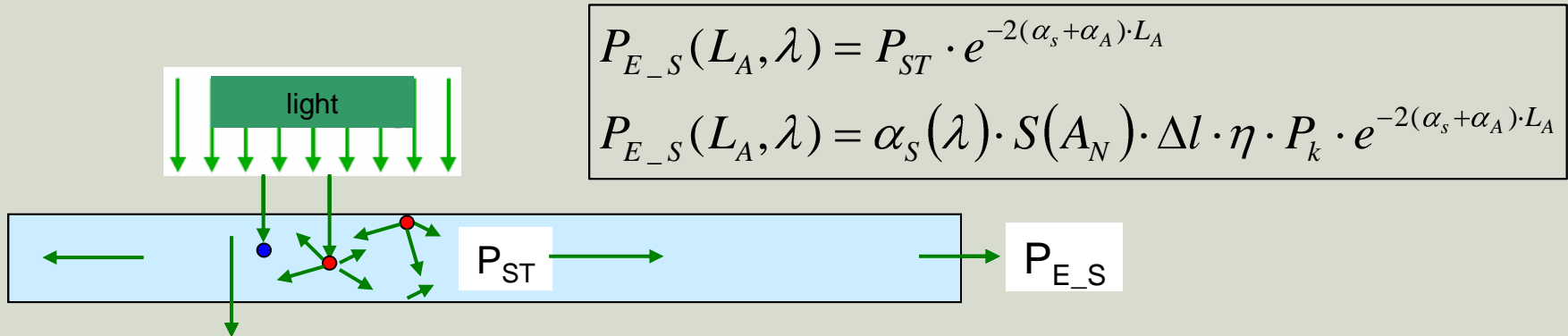


**New: measuring the UV light by lateral launching it into optical fibers!**



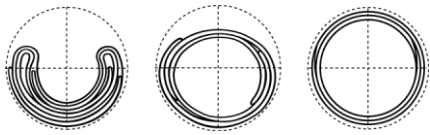


## Mathematical model of UV light measuring



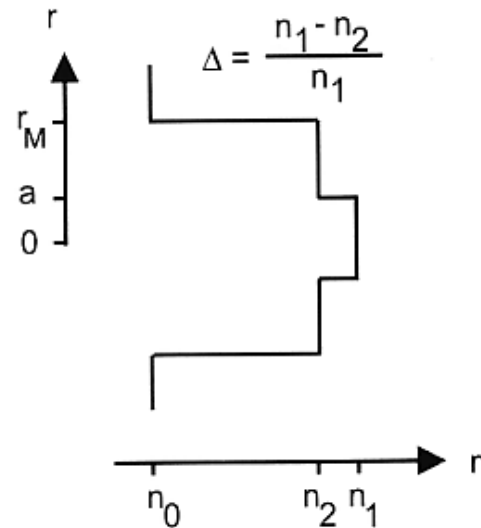
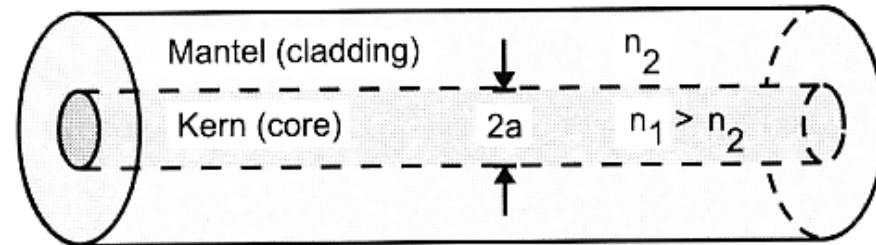
- $P_{E\_S}$ : received power with lateral launching
- $P_{ST}$ : stray power related to the interaction length
- $e$ : Euler's constant
- $\alpha_S$ : stray coefficient of sensor fiber
- $\alpha_A$ : absorption coefficient of sensor fiber
- $\lambda$ : central wave length of light
- $S$ : catch factor
- $A_N$ : numerical aperture
- $\Delta l$ : length of interaction
- $\eta$ : lateral launch efficiency
- $P_k$ : optical power (outer core area)
- $L_A$ : length of sensor fiber

Source: OSSCAD



# Spectral attenuation of optical fibers – standard fibers

Composition of a step index fiber



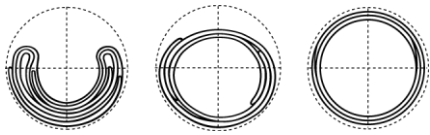
typical data of quartz fibers:

$$2 r_M = 125\mu\text{m}$$

$2a \cong 10\mu\text{m}$  ,  $\Delta \cong 0,3\%$   
for single mode fibers

$2a = 50\mu\text{m}$  ,  $\Delta \cong 1\%$   
for multi mode fibers

Source: [https://www.tu-harburg.de/et3/students/Skripte\\_ss10/V772.pdf](https://www.tu-harburg.de/et3/students/Skripte_ss10/V772.pdf)



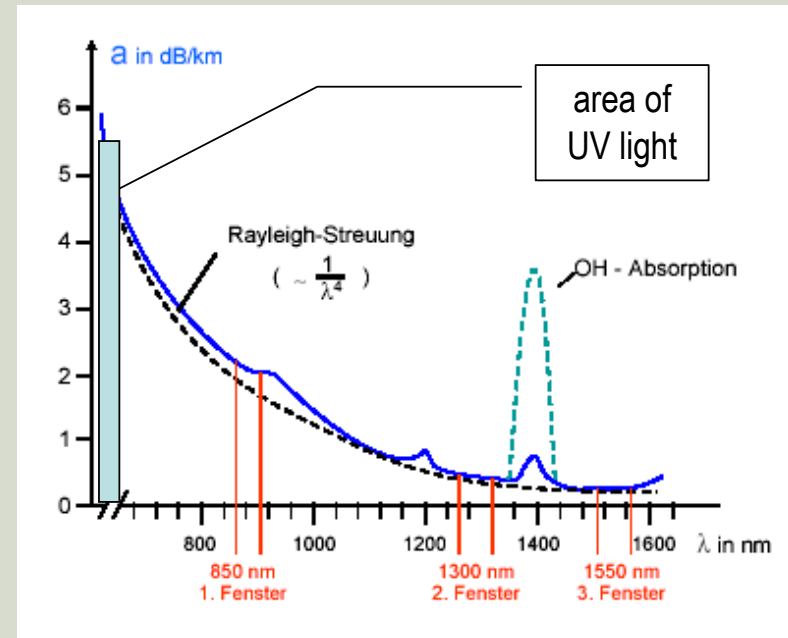
## Spectral attenuation of optical fibers – standard fibers

Spectral attenuation behavior of standard fibers

wavelength range: 800nm to 1600nm

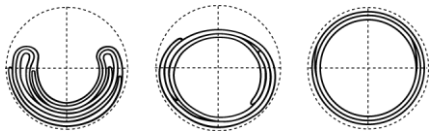
composition of fiber:

Cladding: 125 $\mu$ m, SiO<sub>2</sub> – quartz glass  
Core: 50 $\mu$ m, Ge-SiO<sub>2</sub> – Germanium doped quartz glass  
Coating: 250 $\mu$ m, UV resistant material



⇒ **Standard fibers are not usable for measuring UV light!**

Source: OSSCAD

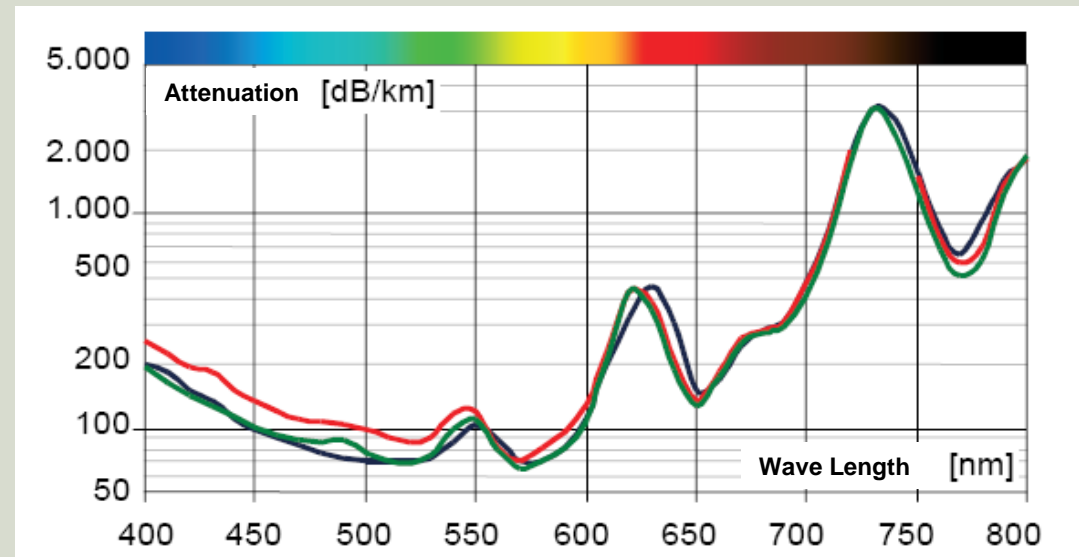


## Optical characteristics of special fibers – plastic optical fiber (POF)

Spectral attenuation behavior of POF

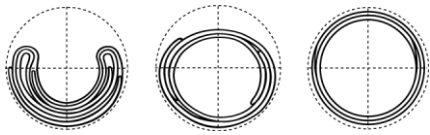
In comparison with quartz fibers POF have:

- ⇒ higher path attenuation (absorption)
- ⇒ less temperature resistance



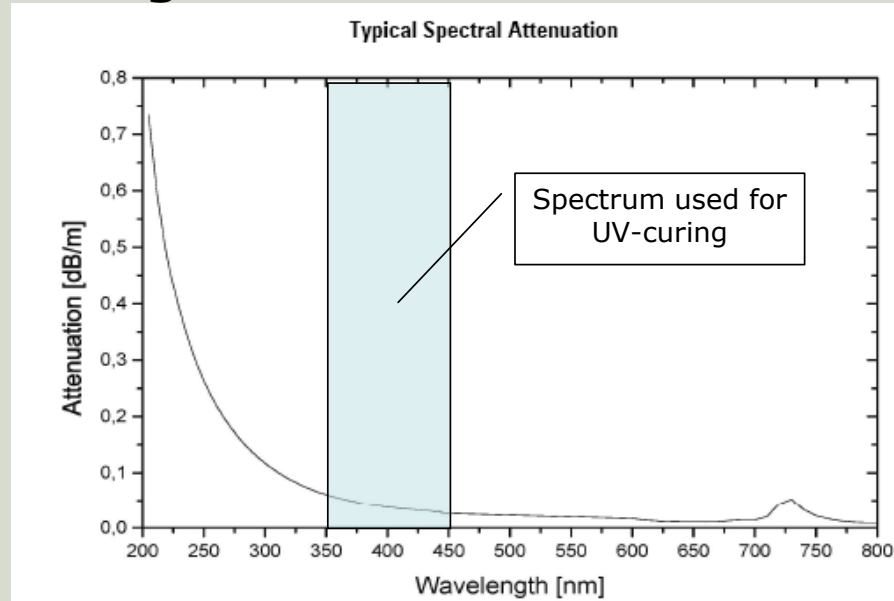
⇒ **POF are not usable for measuring UV light!**

Source: OSSCAD



## Use of a UV transparent coating

Development of a UV resistant fiber with UV transparent coating.



Wavelength range: 200nm to 800nm

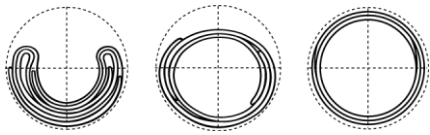
Composition of glass fiber:

Cladding: 220 $\mu$ m, F-SiO<sub>2</sub> – Fluorine-doped quartz glass

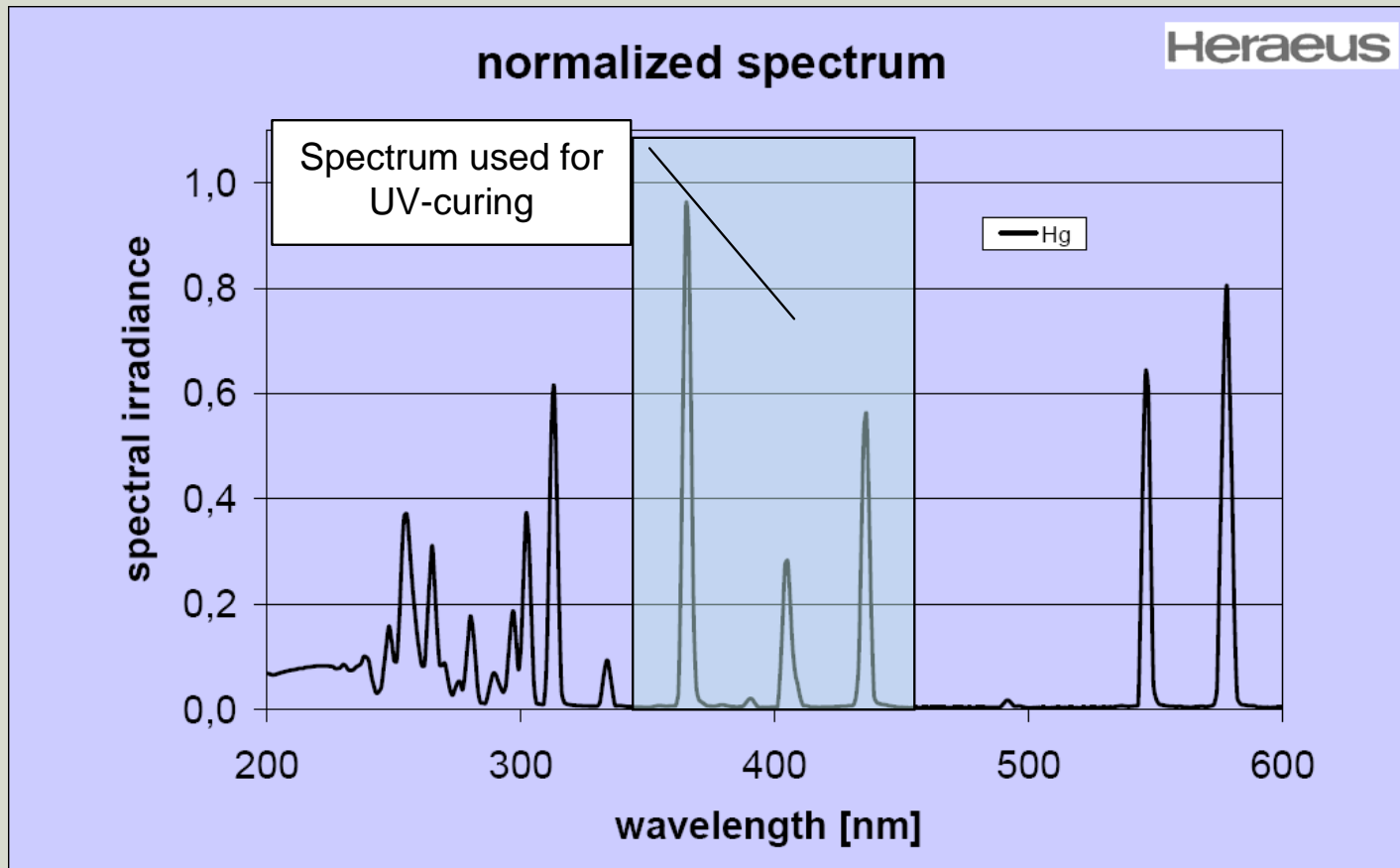
Core: 200 $\mu$ m, SiO<sub>2</sub> – quartz glass

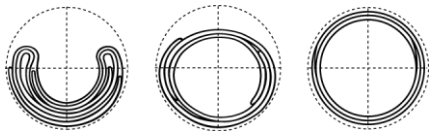
Coating: 260 $\mu$ m, UV transparent material

Source: OSSCAD



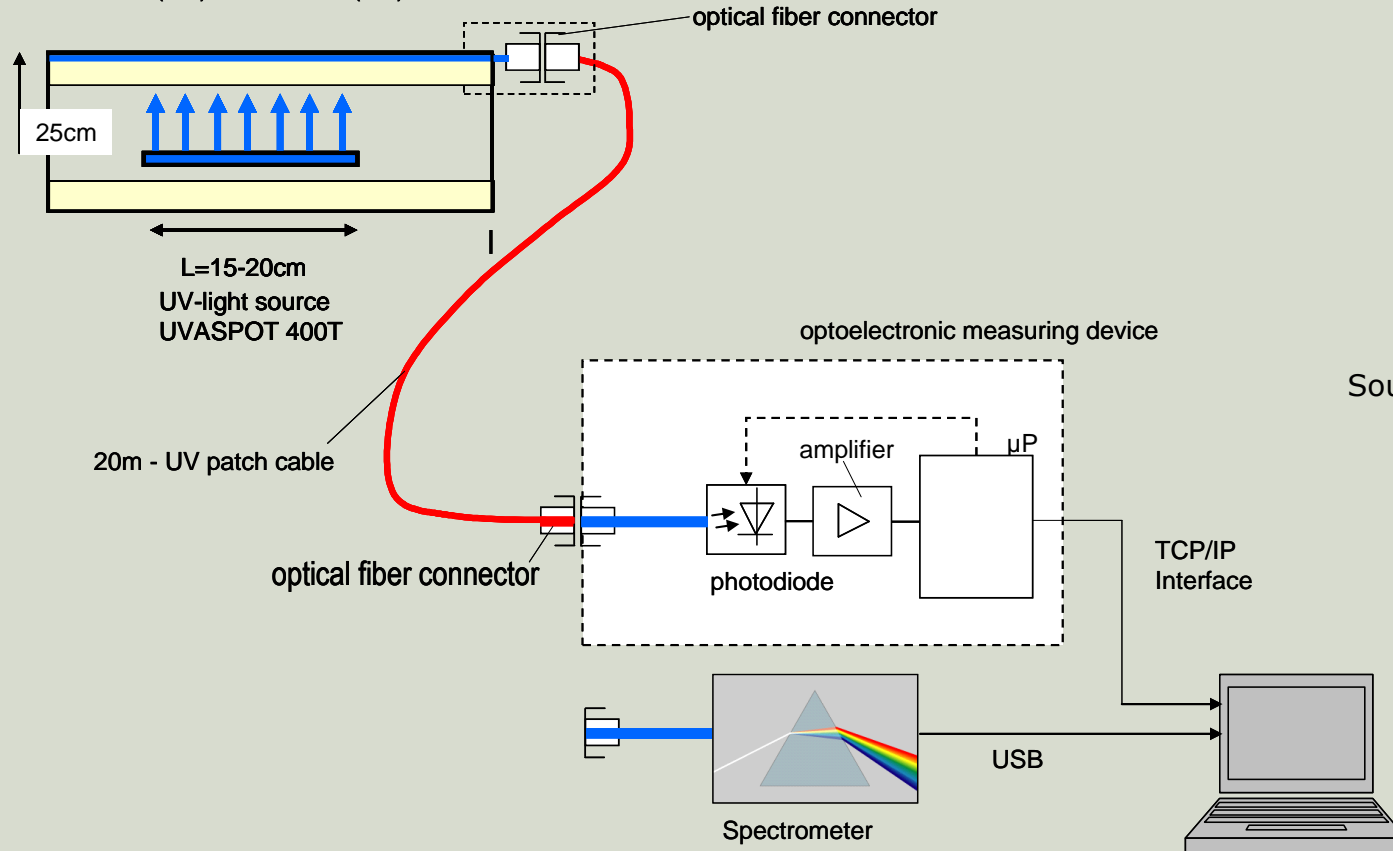
## Spectral distribution of UV- light source (mercury vapor lamp):



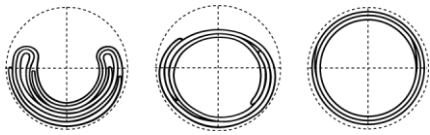


## Laboratory test – test set-up

Liner sample:  
L=50cm (20"), ID=300mm (12"), wall thickness=4.3mm



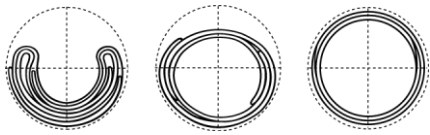
Source: OSSCAD



## Test with site simulation – test set-up



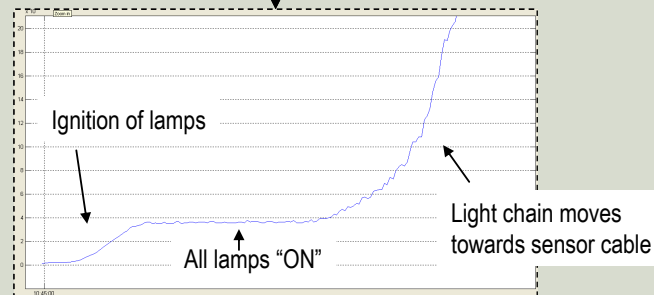
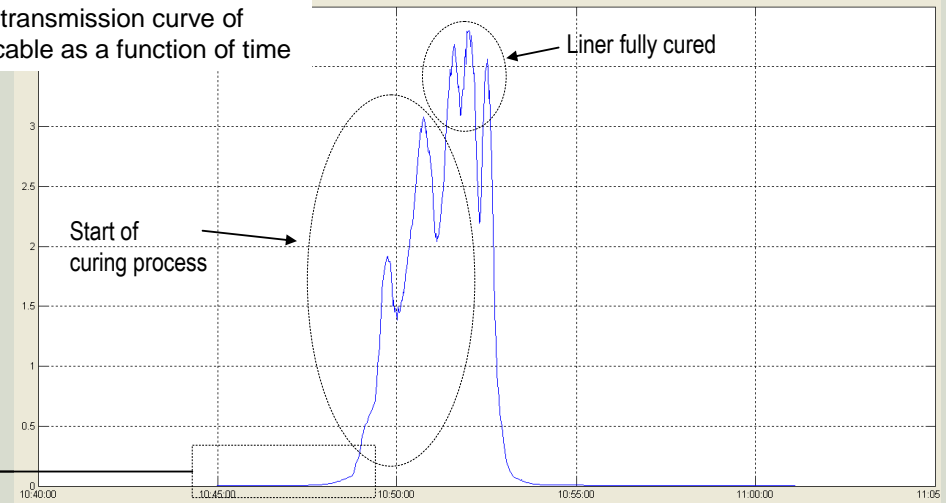




# UV-measuring with UV-filter and automatic amplification light chain 8 UV-lamps

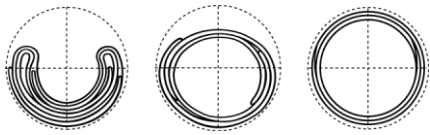
UV-measuring test:  
September 30th 2010  
length of sensor cable: 1m  
test 1

Integral transmission curve of sensor cable as a function of time



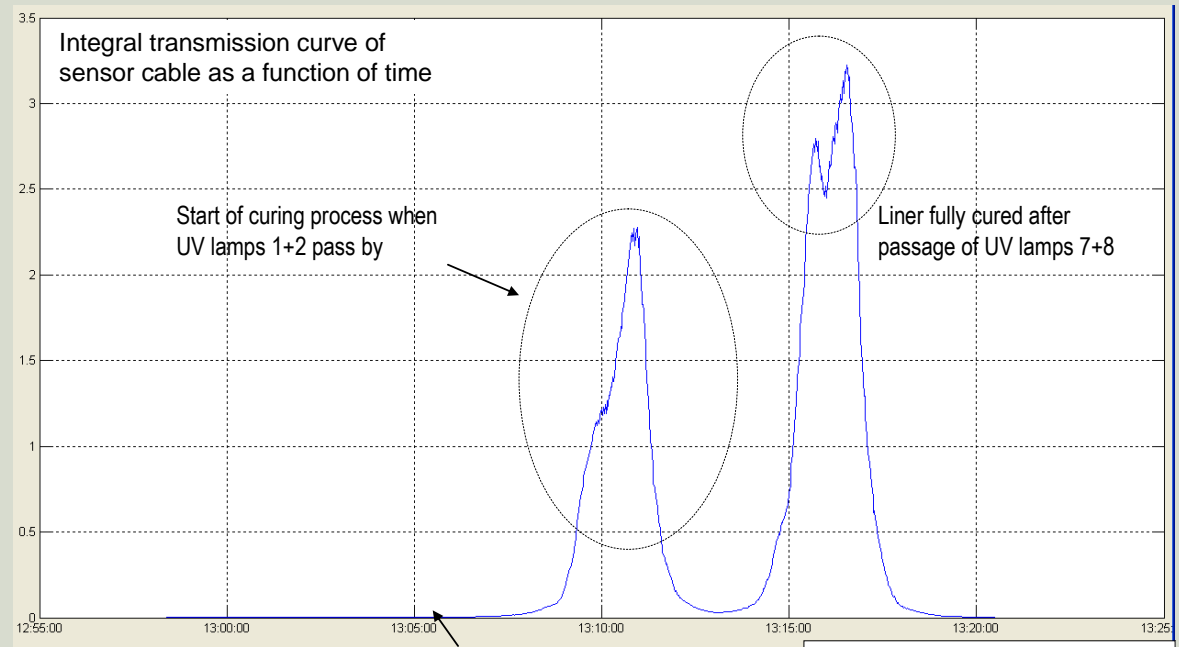
- Conditions:
- curing speed: 67cm/min
  - all 8 UV lamps „On“
  - UV lamp (bulb 17cm, center 10cm)
  - distance between lamps: 17cm
  - length of light chain: 2,48m

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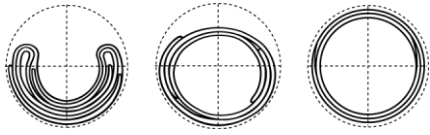
## UV-measuring with UV-filter and automatic amplification light chain with lamps 1+2 and 7+8 only

UV-measuring test:  
September 30th 2010  
length of sensor cable: 1m  
test 2

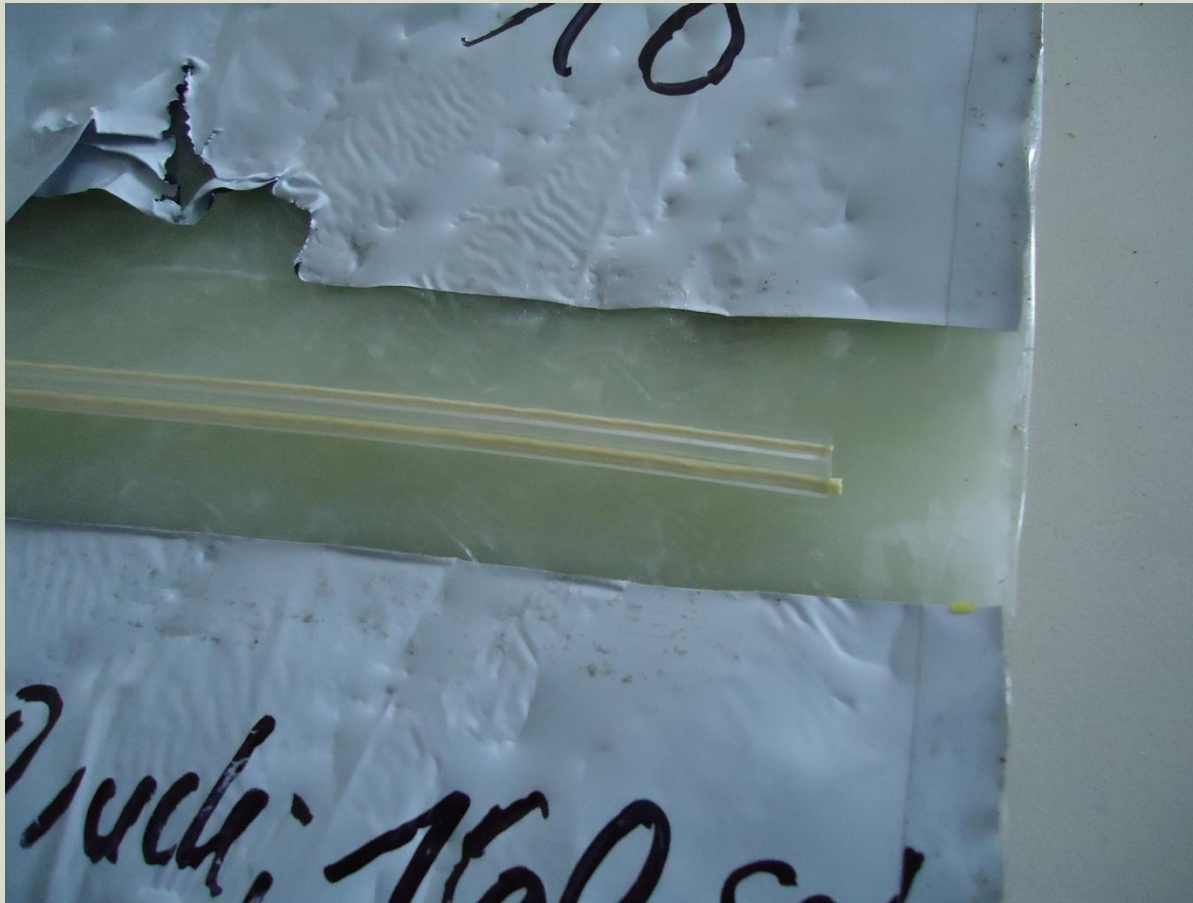


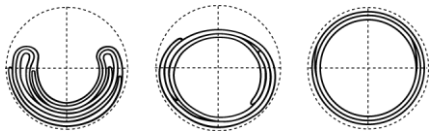
Conditions:

- curing speed: 33cm/min
- UV lamps 1+2+7+8 „On“
- UV lamp (bulb 17cm, center 10cm)
- distance between lamps: 17cm
- length of light chain: 2,48m

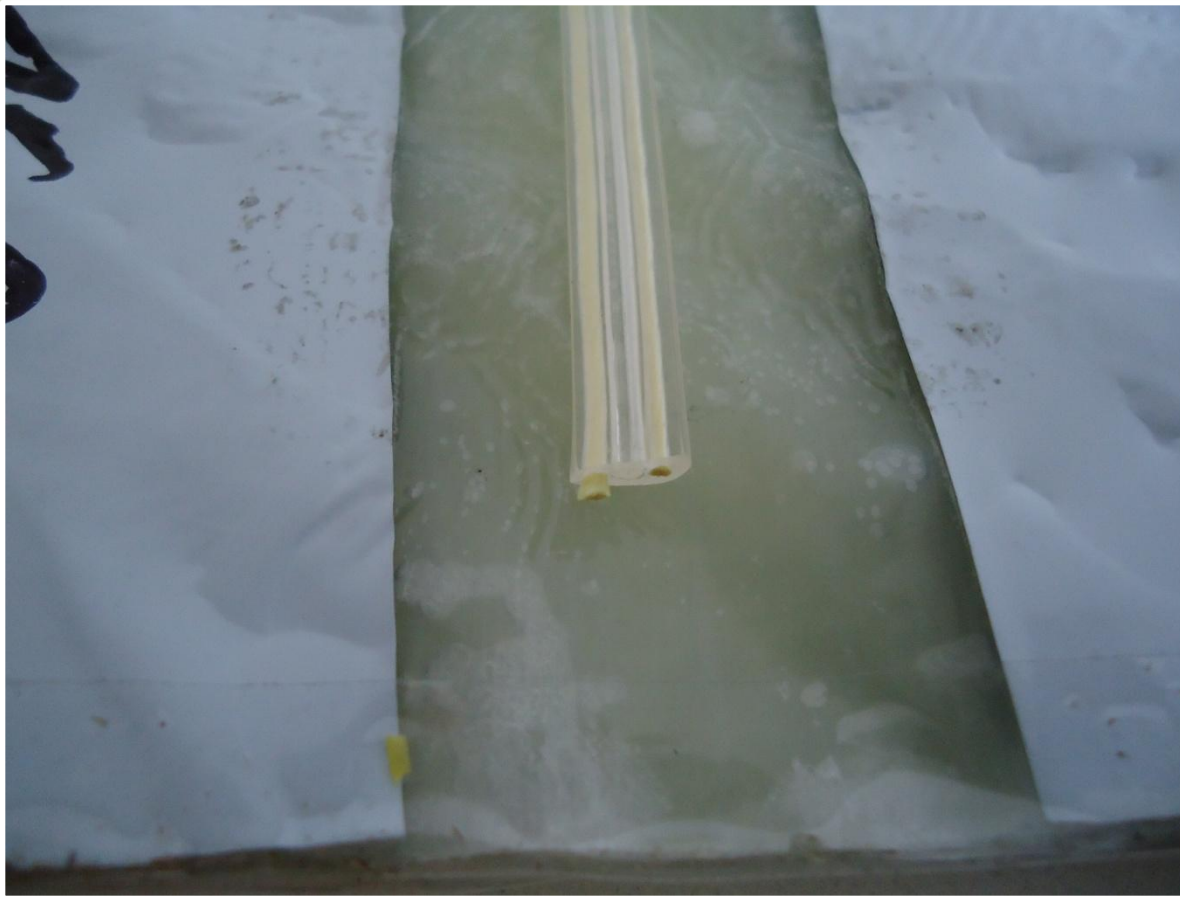


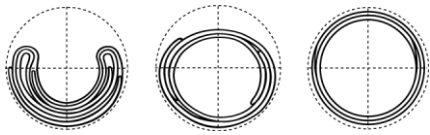
## Laboratory test – sample for calibration





## Laboratory test – sample for calibration





# Thank You For Your Attention!

## **BKP Berolina Polyester GmbH & Co. KG**

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