CIPP - Curing and quality assurance

A Really Brief History of CIPP

SBKS GmbH & Co. KG
Dr. J. Sebastian

SBKS GmbH & Co. KG

Managing director: Dr. rer. nat. J. Sebastian

By German government approved expert for CIPP

NACE Inspector

Head of inspection body of DIBt

Member of committee of experts of DIBt

Member of ISO

....

independent third party monitoring testing lab

ilac-MRA

DAkkS
Deutsche
Akkreditierungsstelle
D-PL-11303-01-00

A Really Brief History of CIPP

CIPP produced in the same way,

a magician pulls rabbits out of his hat.

CIPP

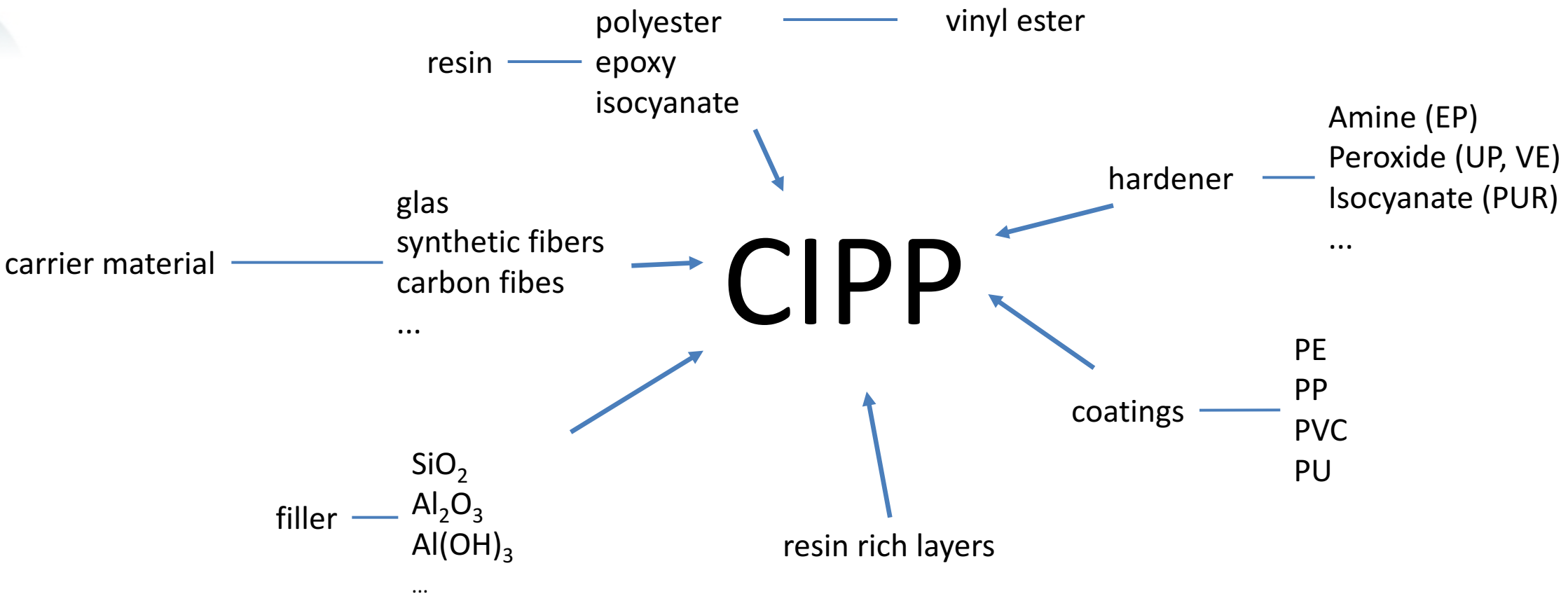
Cured **I**n **P**lace **P**ipe

DIFFICULT

or

Confide **I**n **P**olymer **P**roducts

CIPP - consistency

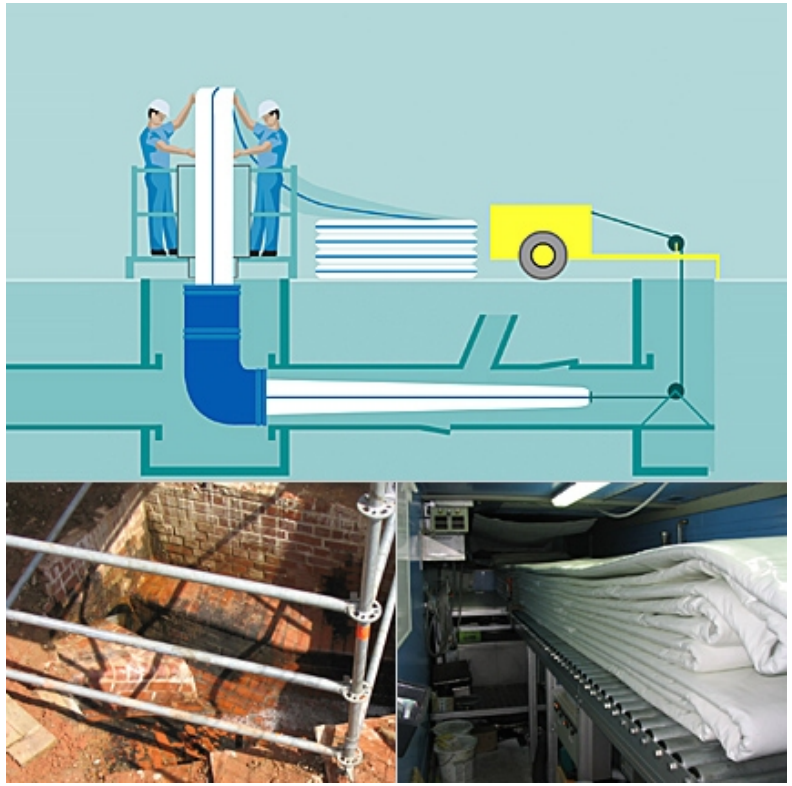


...and the winner is...

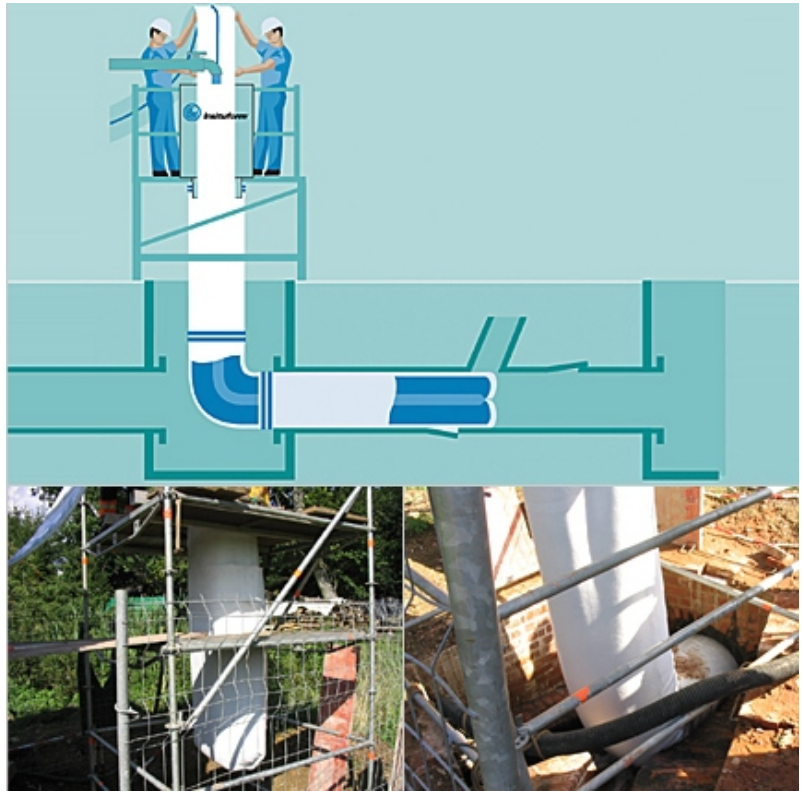
	PE	SF	GRP
E-Modulus /MPa	800	3000	20000
Wallthickness /mm	16	8	3

installation

pull in



inversion



curing

„energy!“

curing

hot water

UV

steam

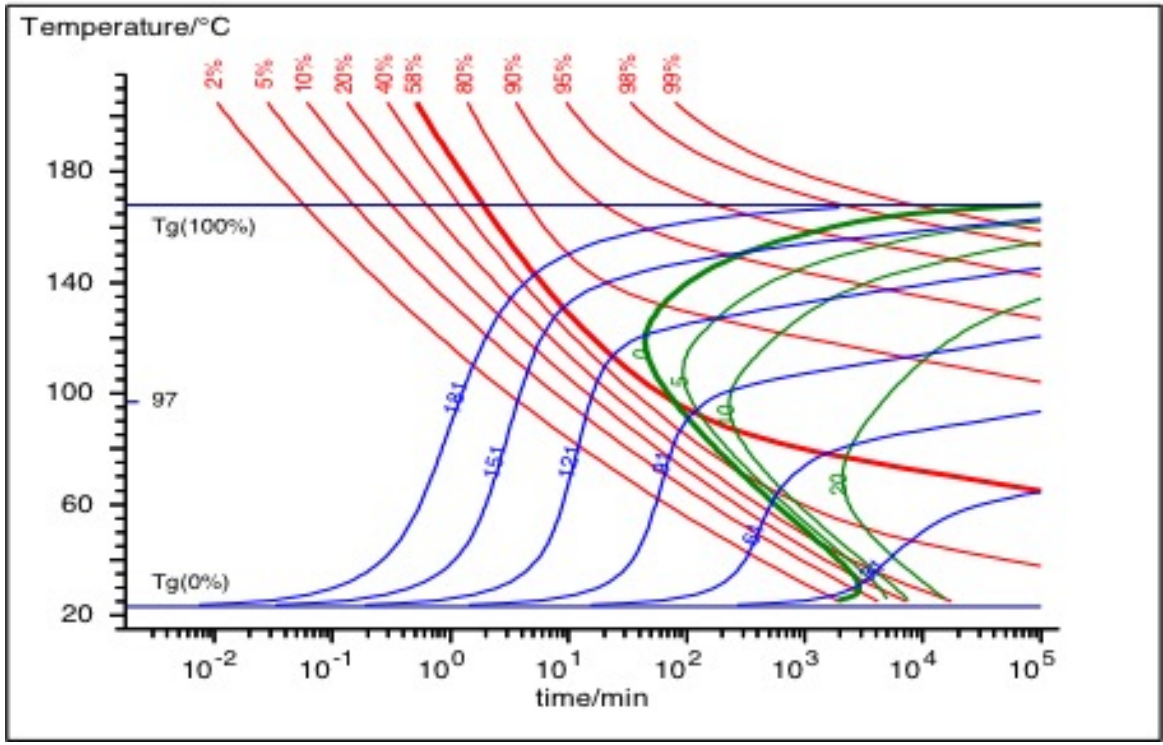
most common resin systems

characteristic	EP-system	UP-system
chemical resistance	better against alcalic solutions	Standard systems, without modification, better against organic acids
mixture	Fixed mixing ratio, resin – hardener – ratio is fixed!!!, mix carefully!	Hardener is initiator, ammount is variable in a certain range
shrinking	less shrink (approx. 3-5%)	approx. 8-12 %
storage	Polyaddition, starts after mixing	Polymerisation, starts after initiating (e.g. UV light, heat ...)
adhesion	Very good adhesive strength	Less adhesive strength because of shrinkage
mechanical property	Higher mechanical values (e-modulus, bending stiffness)	fillers (SiO_2, $Al(OH)_3$) can be used

curing

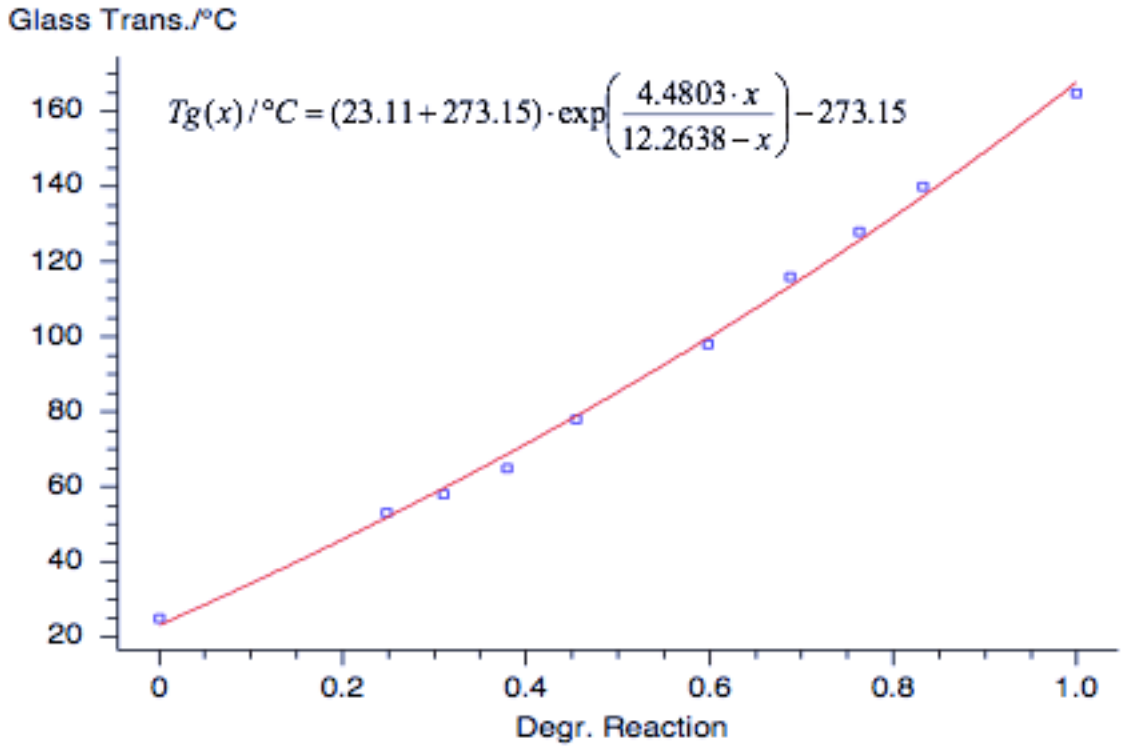
characteristic	EP-system	UP-system
Curing system	Ambient temperature curing	Energy initiated curing
Curing time after start	slower, stars after mixing	fast, after start of reaktion,
stop condition	./.	Energy level drops below certain level

curing



- red lines — temperature versus log(time) for given degree of reaction
  thick red line — temperature vs. log(time) at degree of conversion in gel point (α = 58 %)
- green lines — glass transition temperature Tg - temperature of curing
- **thick green line** — glass transition temperature Tg - temperature of curing = 0
- blue lines — glass transition temperature Tg vs. log(time)
  (curing temperature as parameter)

curing – Tg dependency



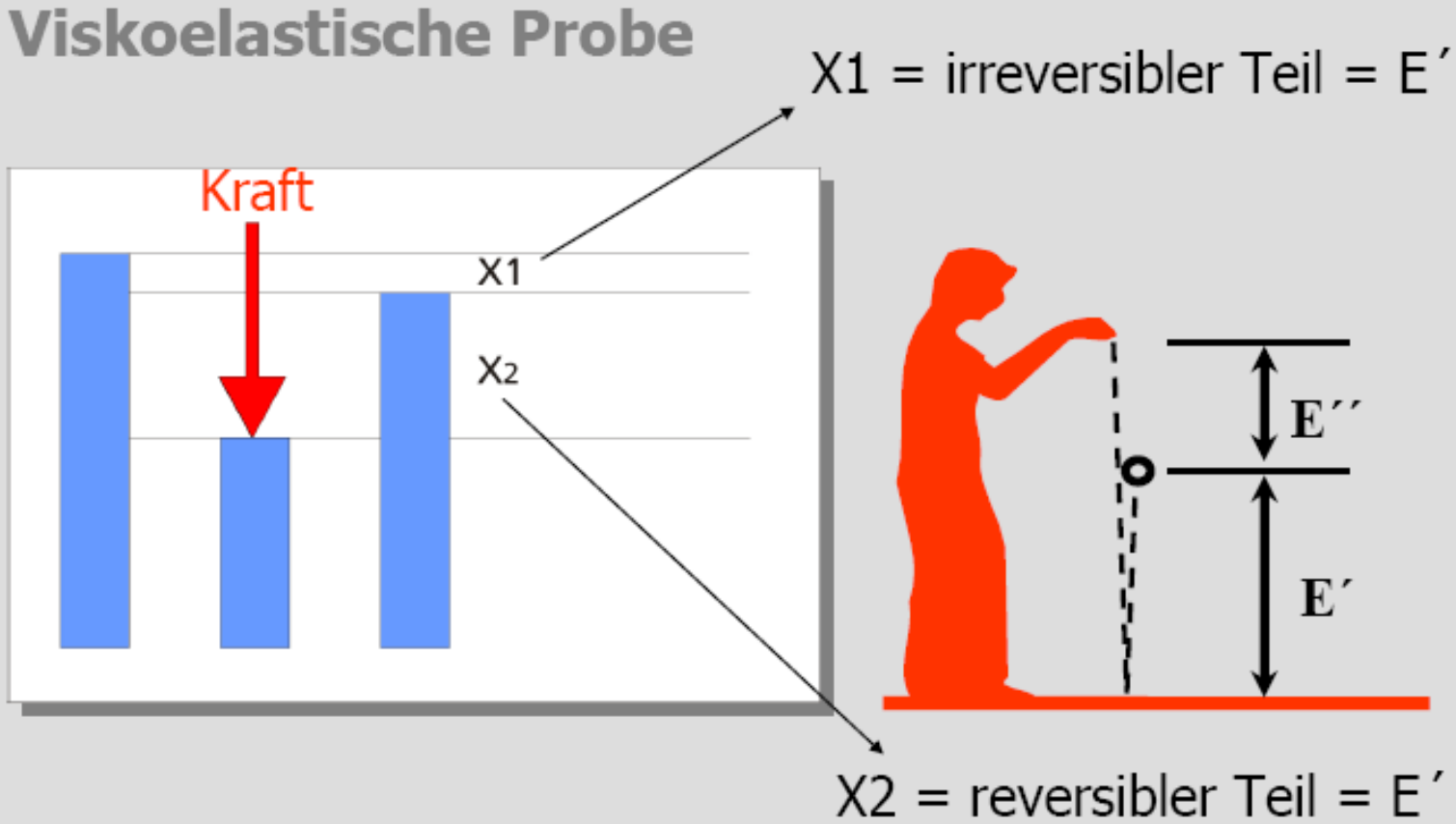
Dependence of glass transition temperature on degree of reaction for the system 2,2‘,6,6‘-tetrabrom-bisphenol-A-diglycidylether

What does curing mean???

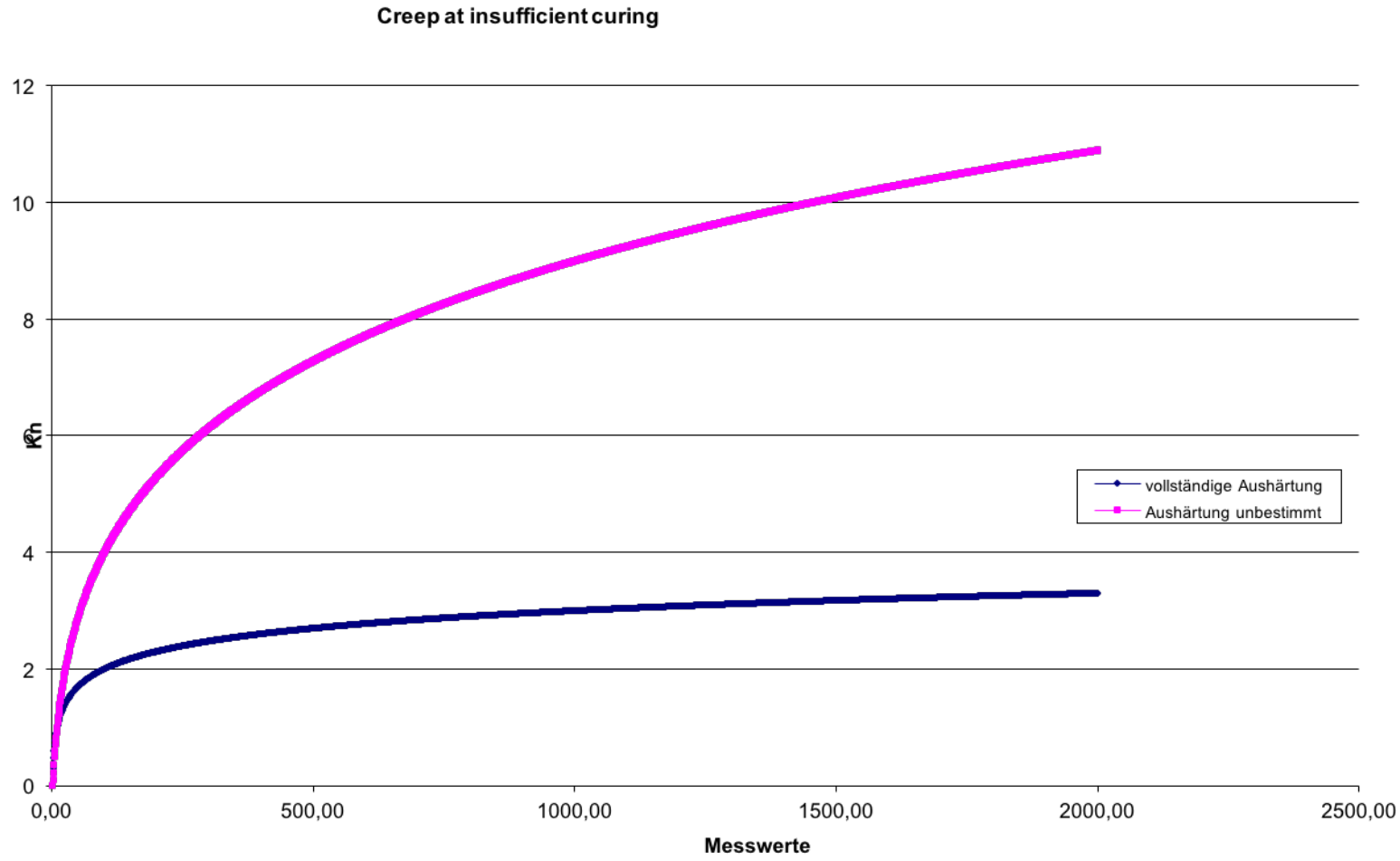
Changing from liquid to „solid“

E-Modulus

Elastic part



creep


Creep at insufficient curing
12
10
8
6
4
2
0
0,00
500,00
1000,00
1500,00
2000,00
2500,00
Messwerte
vollständige Aushärtung
Aushärtung unbestimmt

Quality Assurance

Quality
(qualitas = feature, characterisitic)

Assurance
(= maintenance)

☞ Achieve the highest possible standards and consistent

Quality Assurance

- QA to verify/certify the product to the requirments

- QA either **self** monitoring or **external** monitoring

Quality Assurance

- QA specialties for CIPP
  - Product formation just at jobsite
  - Only QA for single components in advance
  - QA just possible at final stage
  - Random inspection not possible

CIPP testing

Type test

In-situ test

specification

approval

Jobsite samples

comparison

Mechanical tests

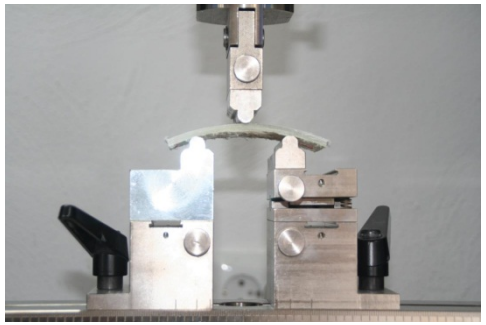
Mechanical tests

- Three-point-bending test
- Ringstiffness test
- Tensile test
- Longterm test
  - Creep test
  - Tensile test
  - Bending test
- Abrasion test
- Microscopy
- Watertightness test

Bild Quelle: Zwick/Roell GmbH

Mechanical tests

Bending test (ISO 178)
- Bending E-modulus
- Flexural strength
- Flexural strain
- Wallthickness



Ringstiffness test (EN 1228)
- E-modulus
- Ringstiffness
- Wallthickness

Tensile test (ISO 527)
- E-modulus
- Tensile strength
- Tensile strain

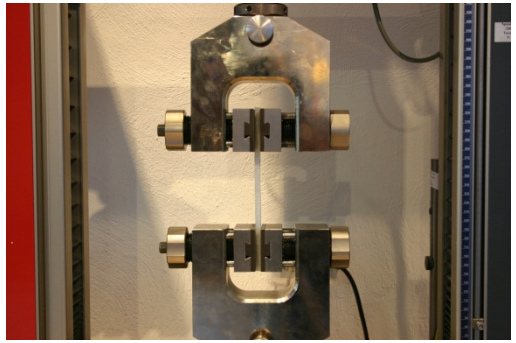
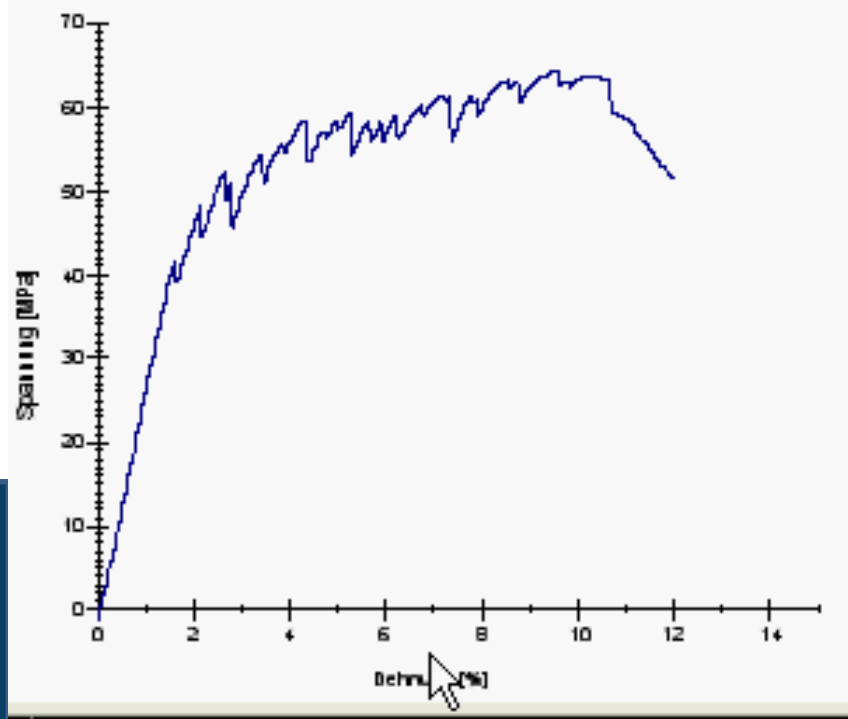
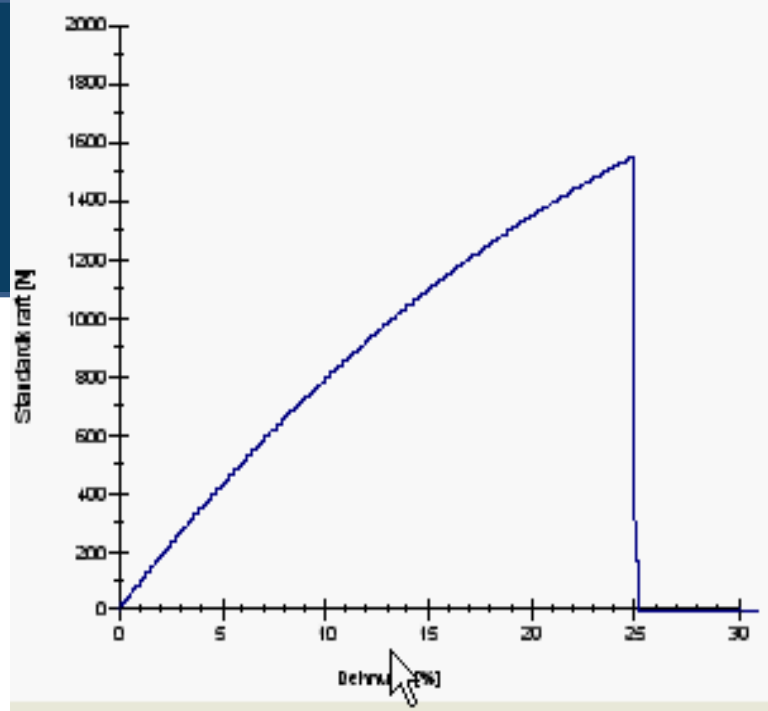


Bild Quelle: DIN EN ISO 1120

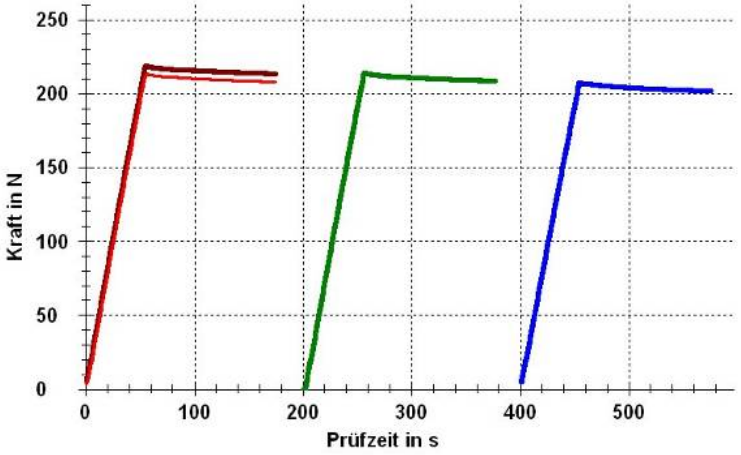
Three point bending

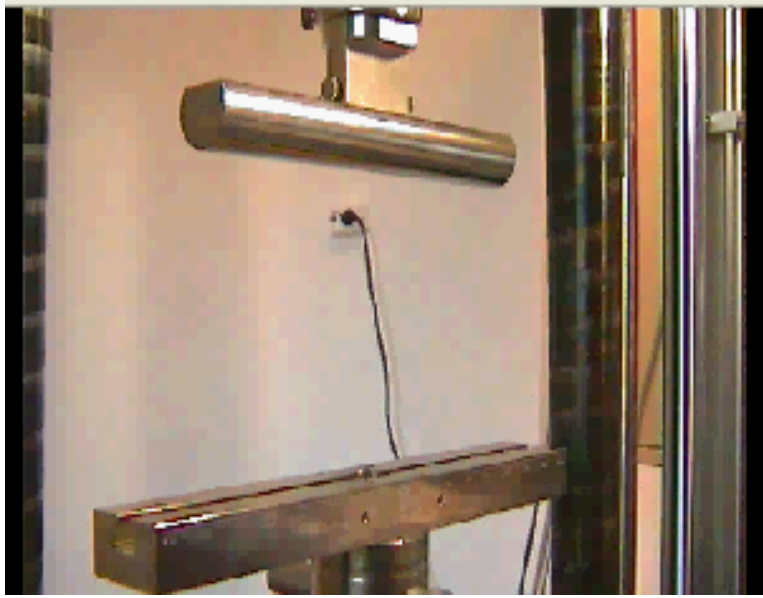


Initial ring stiffness



- DIN EN 1228 / DIN 53 769
  - defomation: 3%
  - Load period: 120s





Stability against chemicals

Stability against liquid chemicals
(ISO 175, ISO 1120)

- Stabilty (visual)
- Testing of the mechnical behaviour during / after the storage in chemicals

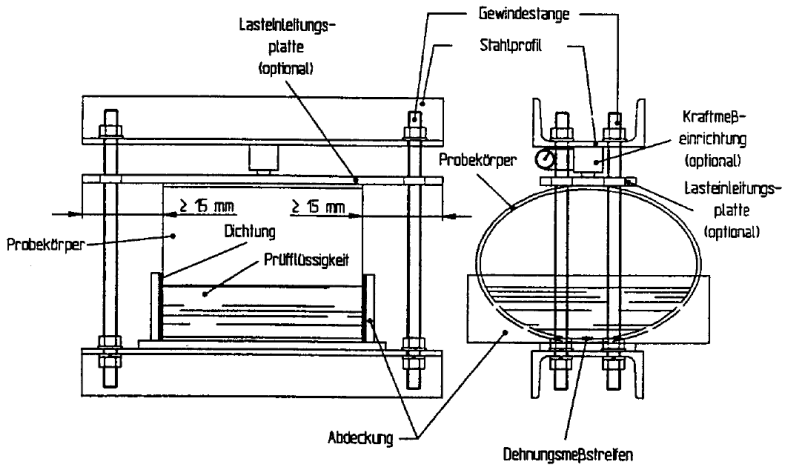


Bild Quelle: DIN EN ISO 1120

Mechanical tests

Longterm tests

- Ring creep test (EN 761)
- Tensile creep test (ISO 899-1)
- Bending creep test (ISO 899-2)

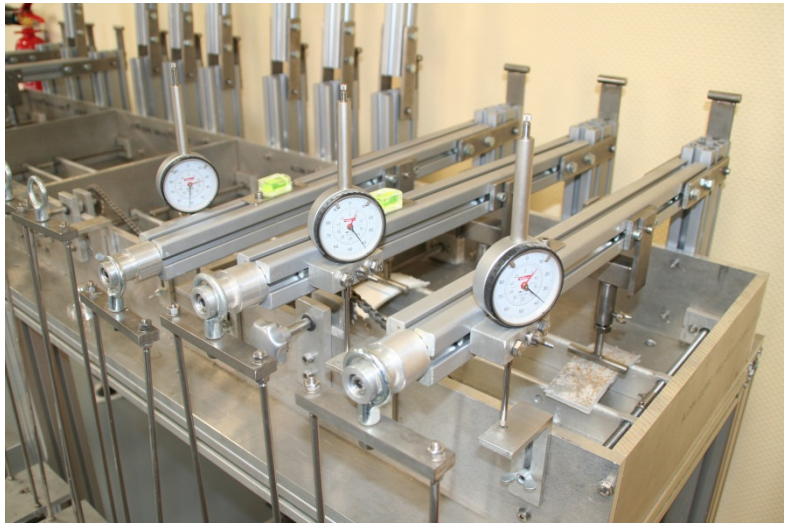
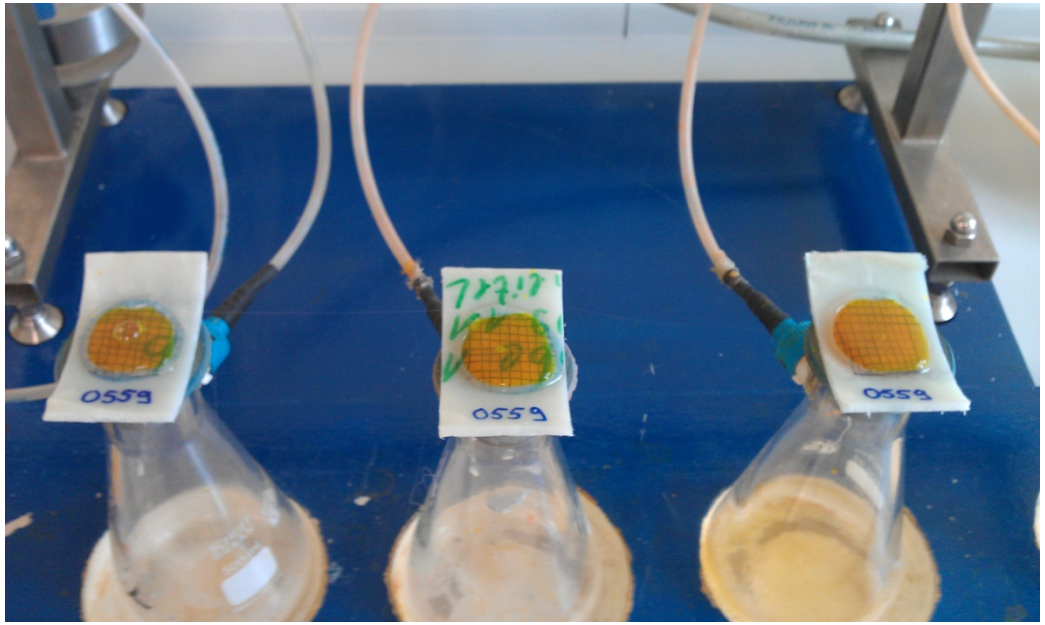


Bild Quelle: DIN EN ISO 1120

Mechanical tests

Watertightness test



Chemical analysis

- Chemical resitance test acc.to ISO 175
- Gaschromatography
- HPLC
- FT-IR analysis

Chemical analysis

Residual monomers by means of Gaschromatography (DIN 53394-2)

•Determination e.g. styrene
>> conclusion about polymerisation

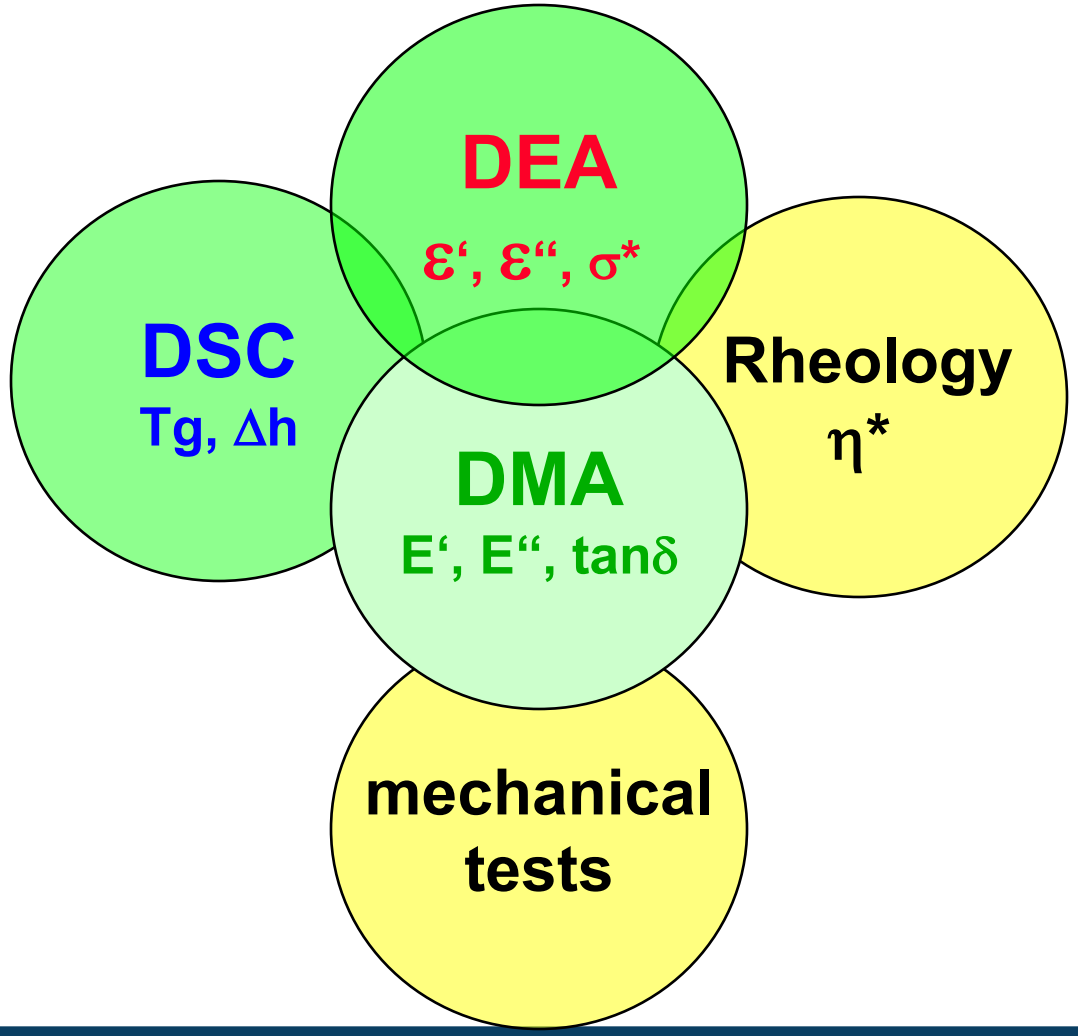
Alternatively: residual monomers by means of HPLC

Chemical analysis

FT-IR Anlysis
(Fourier-Transform-Infrarotspektroskopie)

Assignment of resintype - fingerprint

Thermal Analysis in polymer testing



Thermal analysis

DSC (ISO 11357-1)

- Determination polymerisation
- Determination enthalpy

- Determination of melting points (thermo plastic)

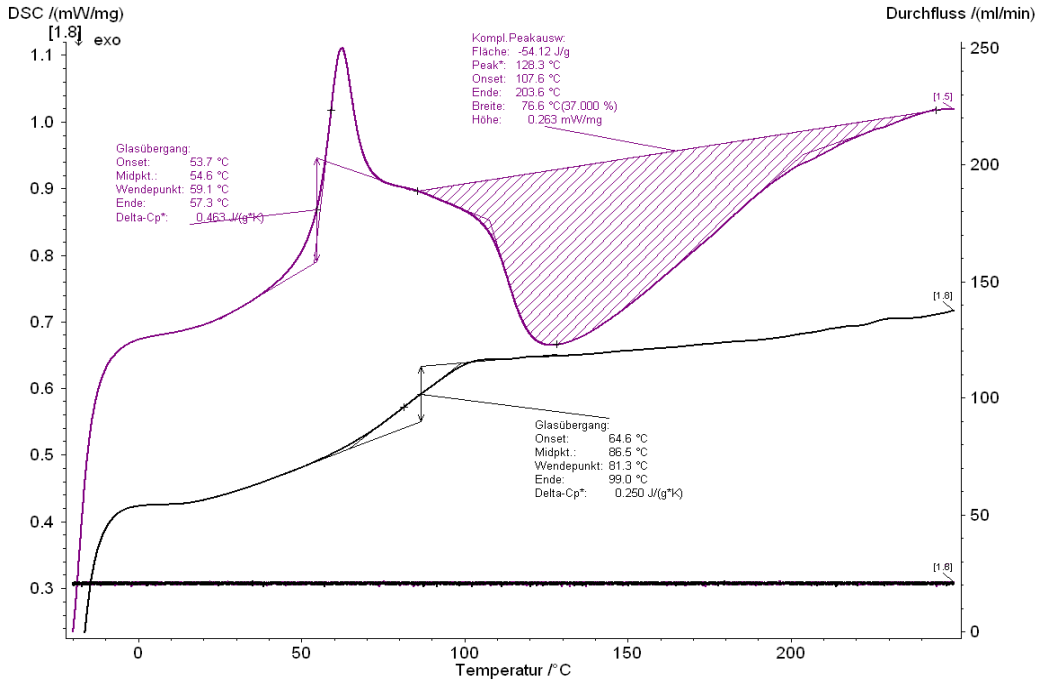
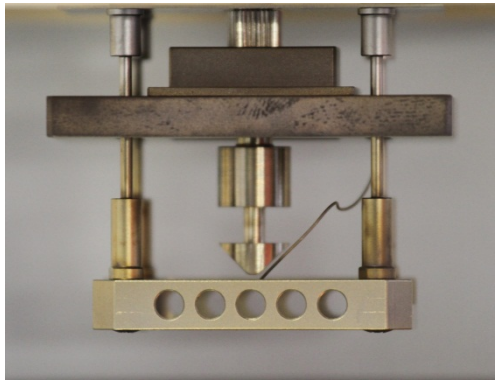


Bild Quelle: DIN EN ISO 1120

Thermal analysis

DMA (ISO 6721)

- Determination of mechanical properties under influence of temperature
- Determination of polymerisation



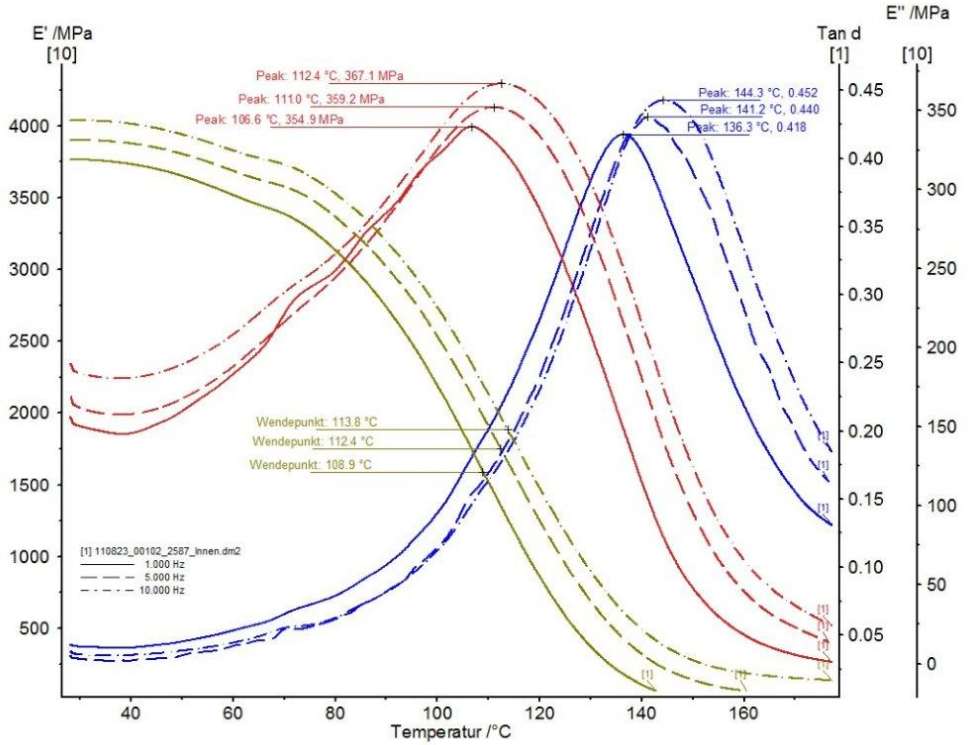
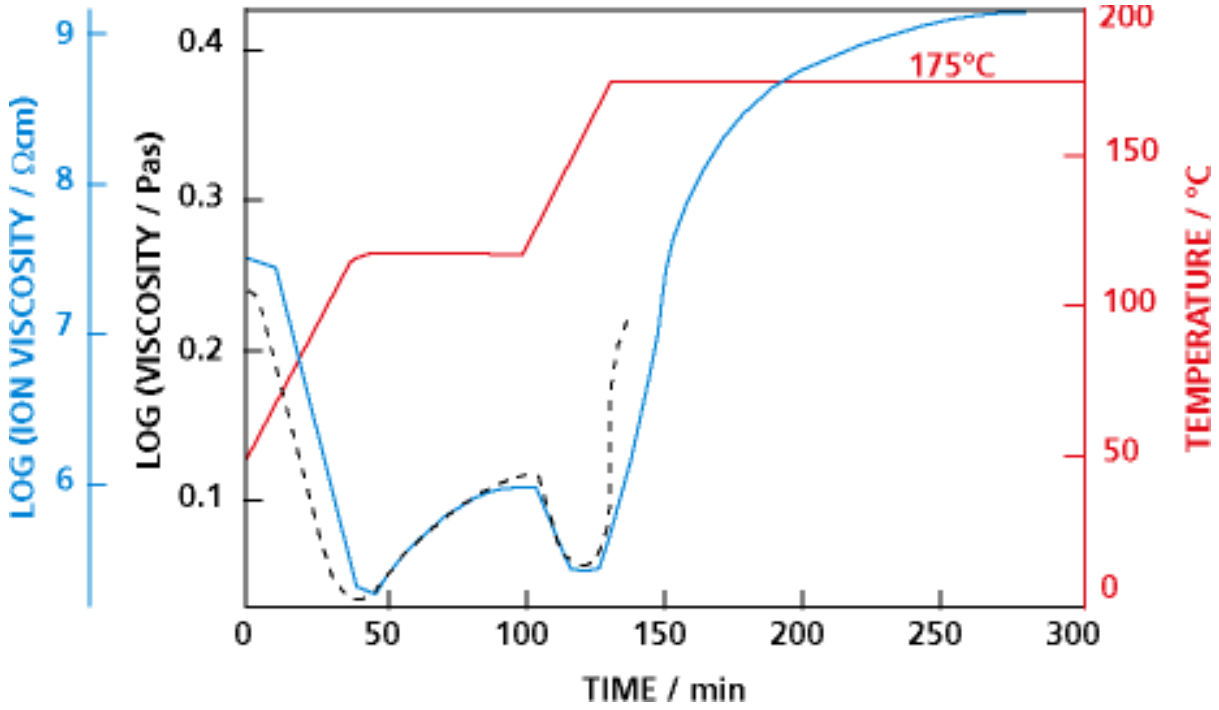


Bild Quelle: DIN EN ISO 1120

Thermal anaylysis

DEA



CIPP tests

Standard for CIPP

- Ringstiffness test / bending test
- Watertightness test

Advanced testing

- DSC / DMA
- Styrene test
- Calcination test
- Creep test
- …

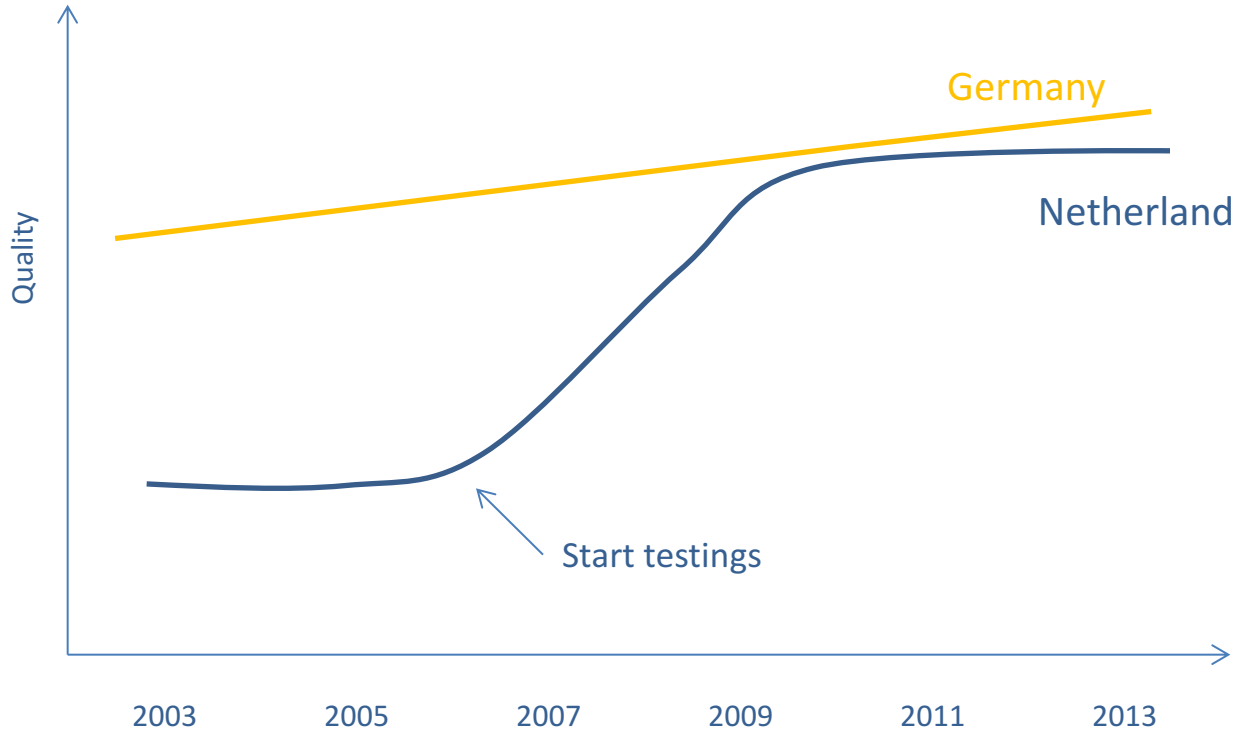
Type test

- Longterm tests
- Chemical resistance
- Highpressure jetting test
- Abrasion test
- In-Situ test
- Hygiene test
- …

Lifespan

- Calculated lifespan for 50 years (depreciation of values)
- Oldest CIPP sewer > 40 years (still working)
- Standars are designed for longterm tests
- Static (structural) calculations Acc. To DWA M 143-2

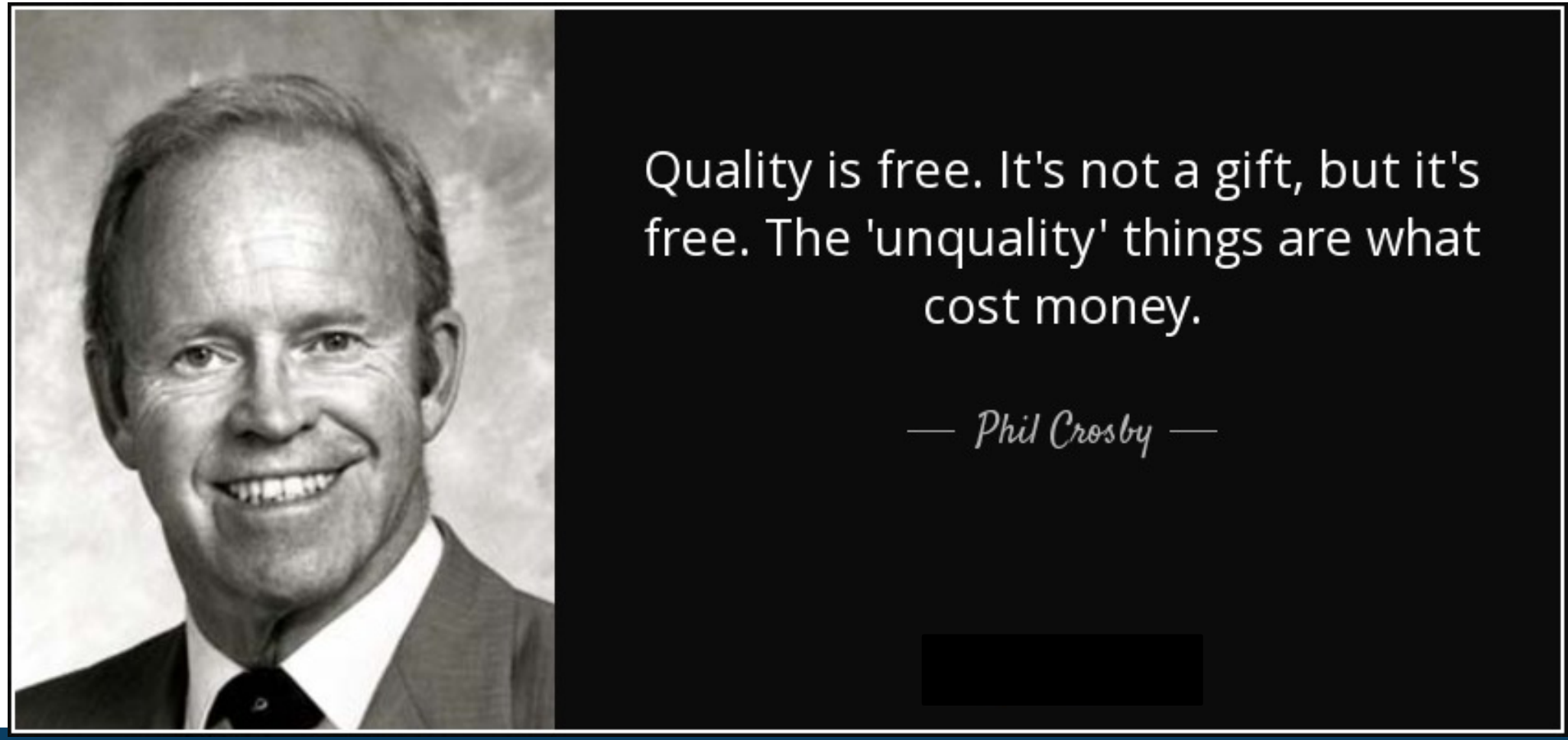
Experience


Germany
Netherland
Quality
Start testings
2003
2005
2007
2009
2011
2013

Quality assurance

Quality = if customer comes back, not the product!

Responsible for Quality – all employees


Quality is free. It's not a gift, but it's free. The 'unquality' things are what cost money.
— Phil Crosby —