



GLASS FIBRE REINFORCED PIPELINES (GRP)

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GFK Unlimited,
TÜV SÜD, München 2018

Verifying the Impermeability of GRP
Regarding Hydrocarbons

VERIFYING THE IMPERMEABILITY OF GRP REGARDING HYDROCARBONS



GFK Unlimited

10. Internationale Tagung
München | 06. – 07.02.2018

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- Preface, motivation
- Analytical method
- Comparison to other plastics
- Direct proof of suitability for GRP pipes
- General proof of suitability for GRP pipes
- Future prospects

VERIFYING THE IMPERMEABILITY OF GRP REGARDING HYDROCARBONS

- Motivation (about 7 years ago)

Grundwasser von Söhligen vergiftet?



Das NDR-Wirtschaftsmagazin "Markt" deckte die Umweltverschmutzung durch den Exxon-Konzern auf. (Archivbild)

Bei der Erdgasförderung in Niedersachsen sind Substanzen ins Grundwasser gelangt. Das hat das NDR Wirtschaftsmagazin "Markt" aufgedeckt. In Söhligen im Landkreis Rotenburg hat es besonders gefährliche Stoffe in das Grundwasser und in die Bäche gesickert. Die Anwohner sind besorgt.



Hamburg (ots) - Der Wirtschaftsminister von Niedersachsen, Jörg Bode (FDP), äußert im ARD-Magazin "Panorama" deutliche Kritik am niedersächsischen Landesamt für Bergbau, Energie und Geologie (LBEG). Die dem Wirtschaftsministerium unterstehende Behörde hatte nach der Entdeckung eines Giftunfalls mehr als drei Jahre gebraucht, um mit der Untersuchung auch anderer Gasfelder auf vergleichbare Gefahren zu beginnen. Bei dem Unfall auf dem von ExxonMobil betriebenen Erdgasfeld Söhligen im Jahr 2007 war es zu

NIEDERSACHSEN

Giftige Stoffe gerieten bei Erdgasförderung in Söhligen ins Grundwasser

Woher stammt das Gift im Blut der Anwohner?

Ein Bericht des Wirtschaftsmagazins "Markt" war die Basis für die Untersuchungen. Die Behörden wollen nun die möglichen Ursachen für die erhöhten Giftkonzentrationen suchen, erklärte Klaus Söntgerath vom Landesbergamt.

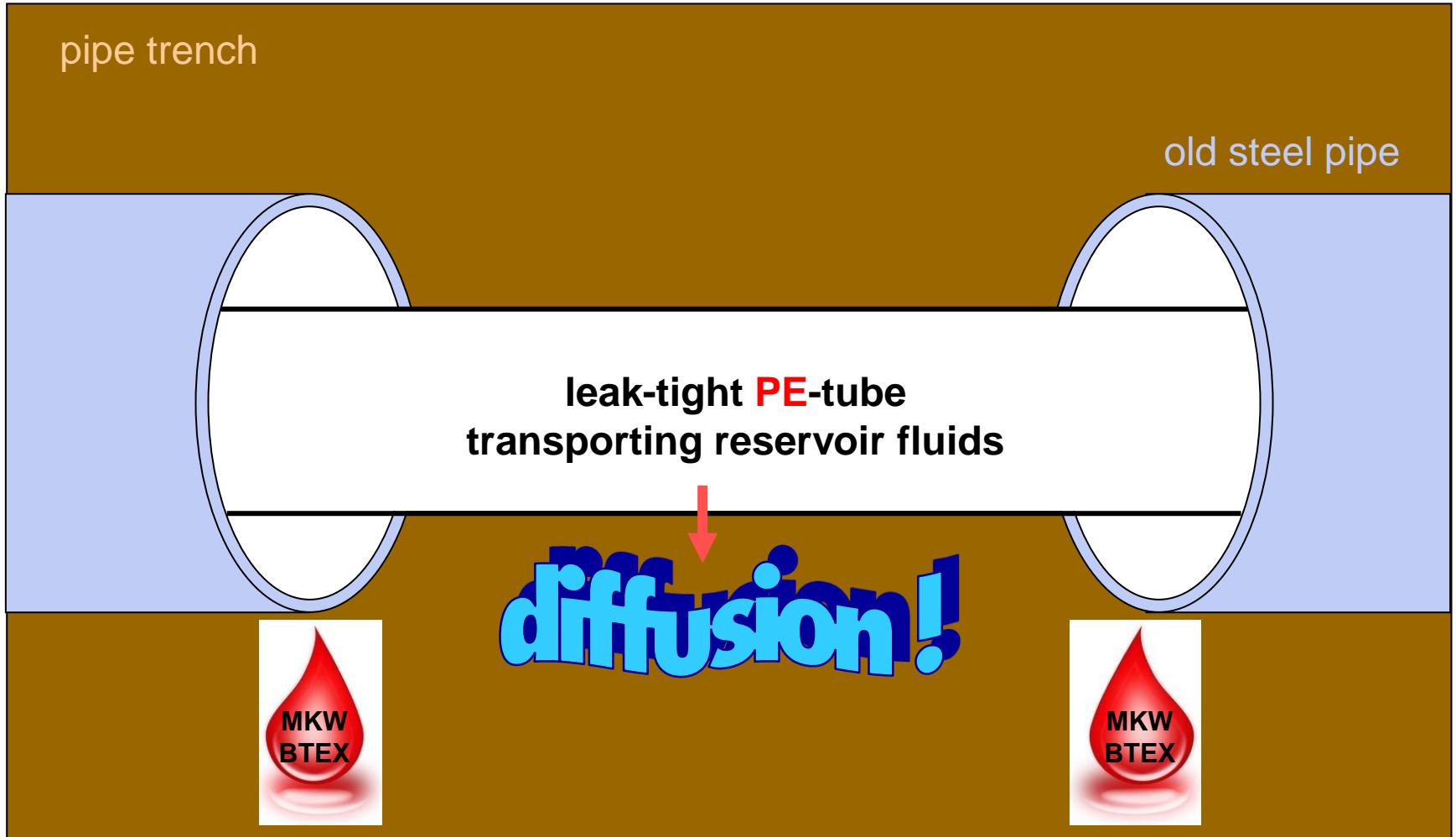
14.01.2011

Rundschau

Familie Schoon lebt mitten im Fördergebiet Söhligen

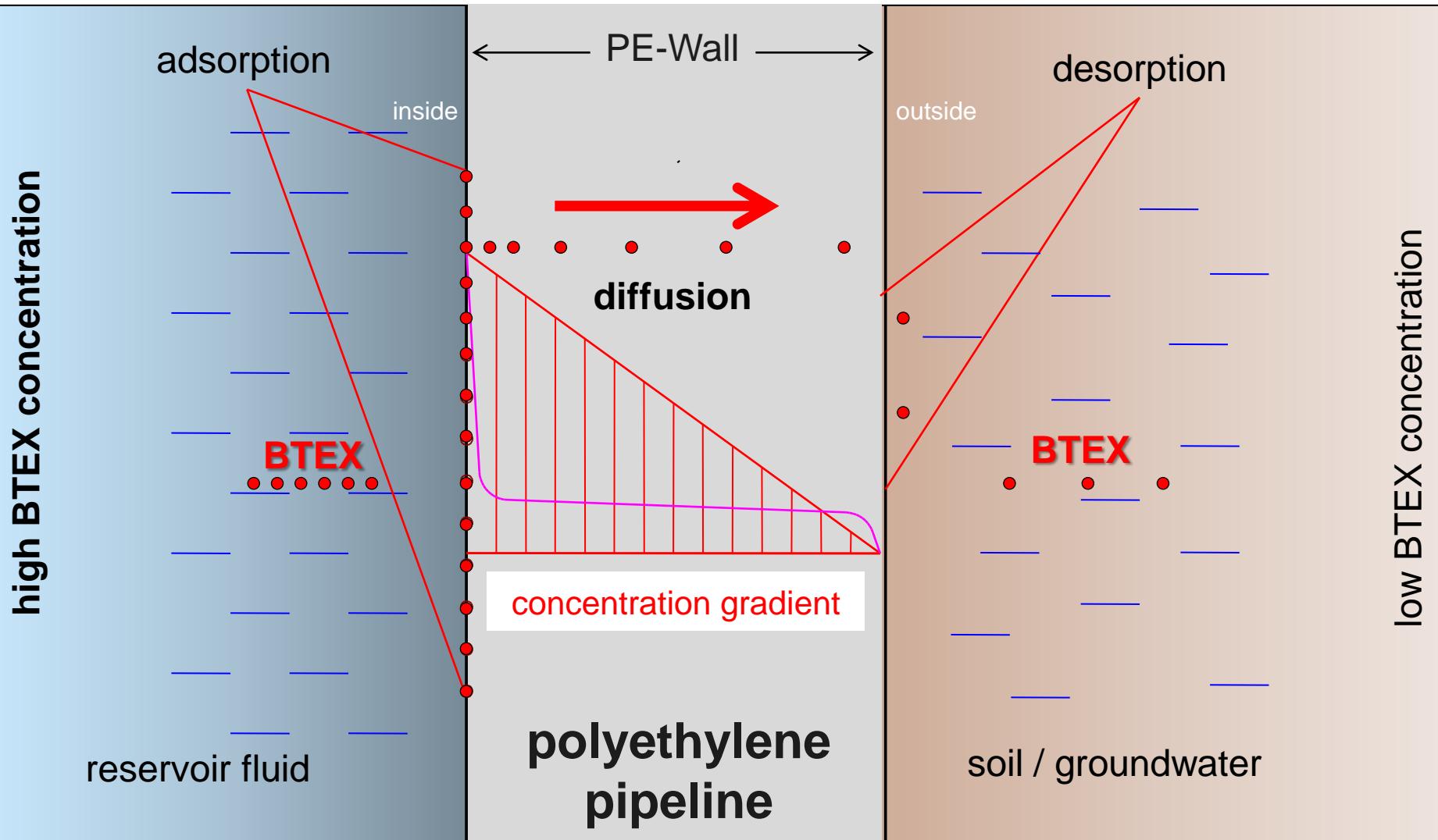
VERIFYING THE IMPERMEABILITY OF GRP REGARDING HYDROCARBONS

- Incident: oil field Söhlingen, 7 years ago



VERIFYING THE IMPERMEABILITY OF GRP REGARDING HYDROCARBONS

- Preface



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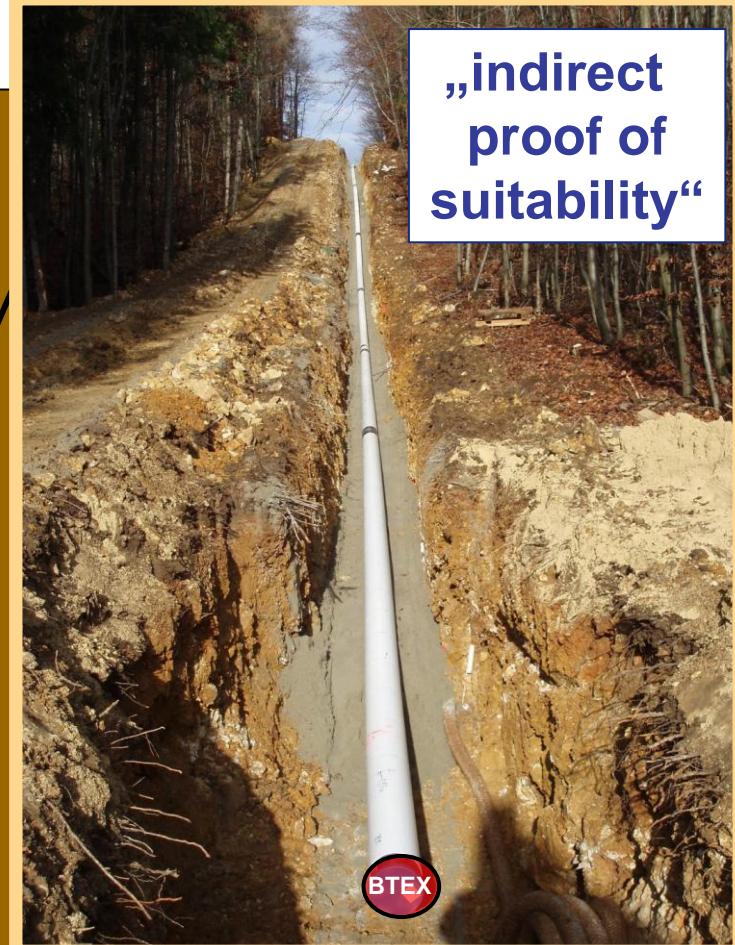
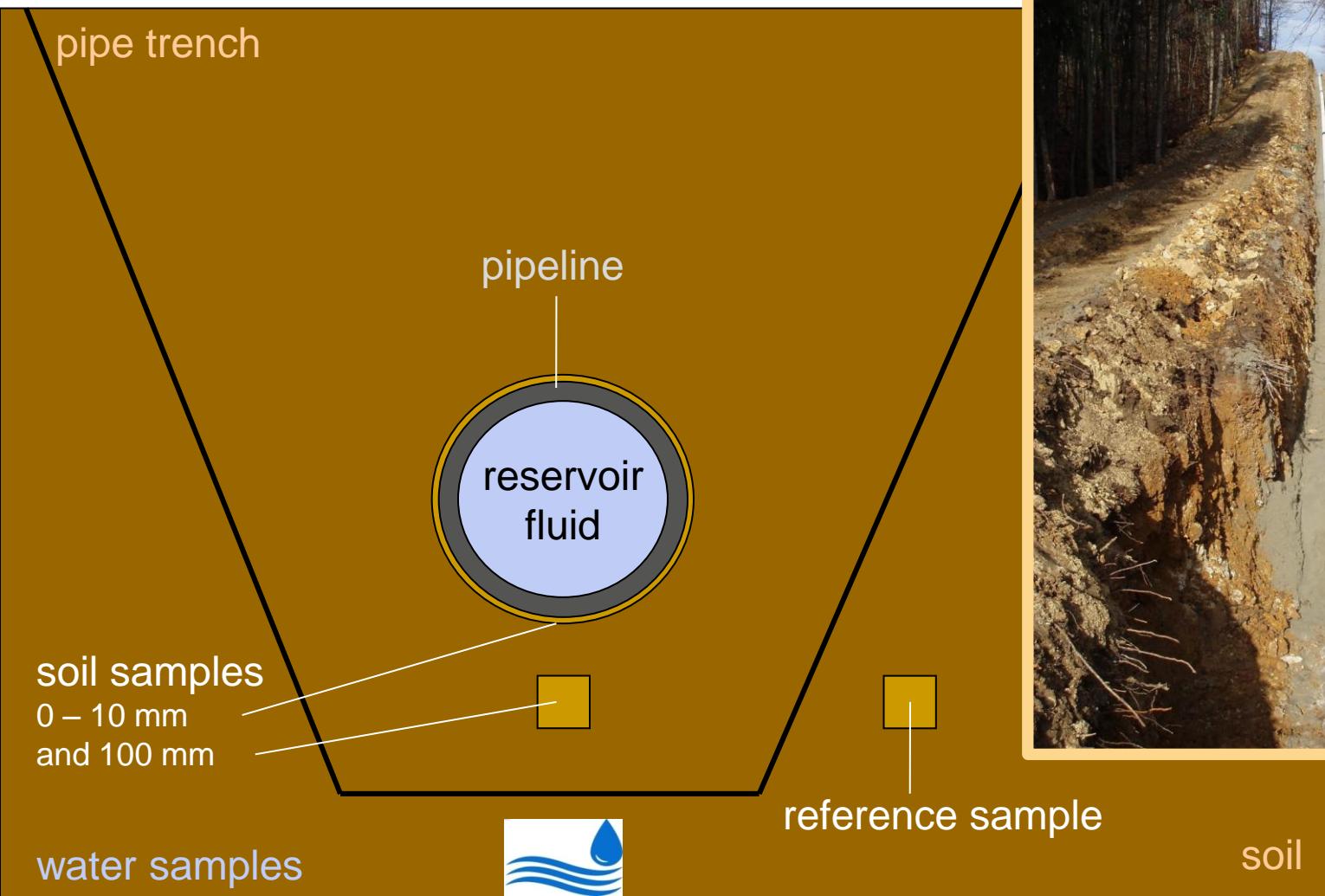
Official directives of the LBEG

- **3. Anordnung L2.1/L67911-06/2012-0003 vom 21.12.2012**
(Nachweis der Eignung von Kunststoffrohren bei Verwendung als Feldleitung in Erdöl- und Erdgasbetrieben bzgl. des sicheren Einschlusses des zu transportierenden Mediums (keine messbare Permeation) im Sinne des § 49, Abs. 1, BVOT mittels wiederkehrender Prüfungen durch Analysen von Boden- und Wasserproben, ggf. alternativer Verfahren im Einvernehmen)
- **Bescheid L1.5/L67911-06/2016-0002 vom 07.11.2016**
(Einvernehmen bzgl. Anwendung Genereller Eignungsnachweis für GFK)

LBEG: Landesamt für Bergbau, Energie und Geologie (*mining authority*) für die Länder Schleswig-Holstein, Hamburg, Bremen und Niedersachsen

VERIFYING THE IMPERMEABILITY OF GRP REGARDING HYDROCARBONS

- Preface



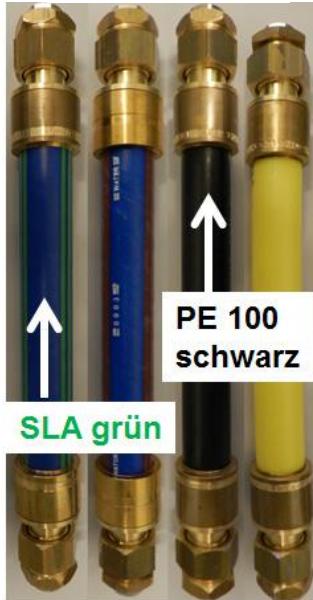
VERIFYING THE IMPERMEABILITY OF GRP REGARDING HYDROCARBONS

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VERIFYING THE IMPERMEABILITY OF GRP REGARDING HYDROCARBONS

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 **Fraunhofer**
WKI

emission measuring cell
→ evaluating the permeation rate
(difficulty: tight sealing)

VERIFYING THE IMPERMEABILITY OF GRP REGARDING HYDROCARBONS

- Preface

Used PE pipeline (transported reservoir fluid for over 1,5 years,

BTEX $\leq 3.000 \mu\text{g/l}$)



10 mg/m·d BTEX



PERMEATION !

permeation measuring cell

→ Permeation: 10 mg/m·d (4“, 10 mm PE wall)

VERIFYING THE IMPERMEABILITY OF GRP REGARDING HYDROCARBONS

- Analytical method

Material tests

- Used plastic tube + brand new tube (reference sample)
- Cut sample out of tube (sawing)
- Chip layers on a turning lathe ($\geq 0,1$ mm/layer)
- Extract lathe turnings with methanol
- Analyse extract using gas chromatography BTEX as main parameter for hydrocarbons
- Evaluate concentration profiles in tube wall matrix [$\mu\text{g}/\text{kg}$ BTEX]

„direct proof of suitability“

VERIFYING THE IMPERMEABILITY OF GRP REGARDING HYDROCARBONS

- Analytical method



„direct proof of suitability“

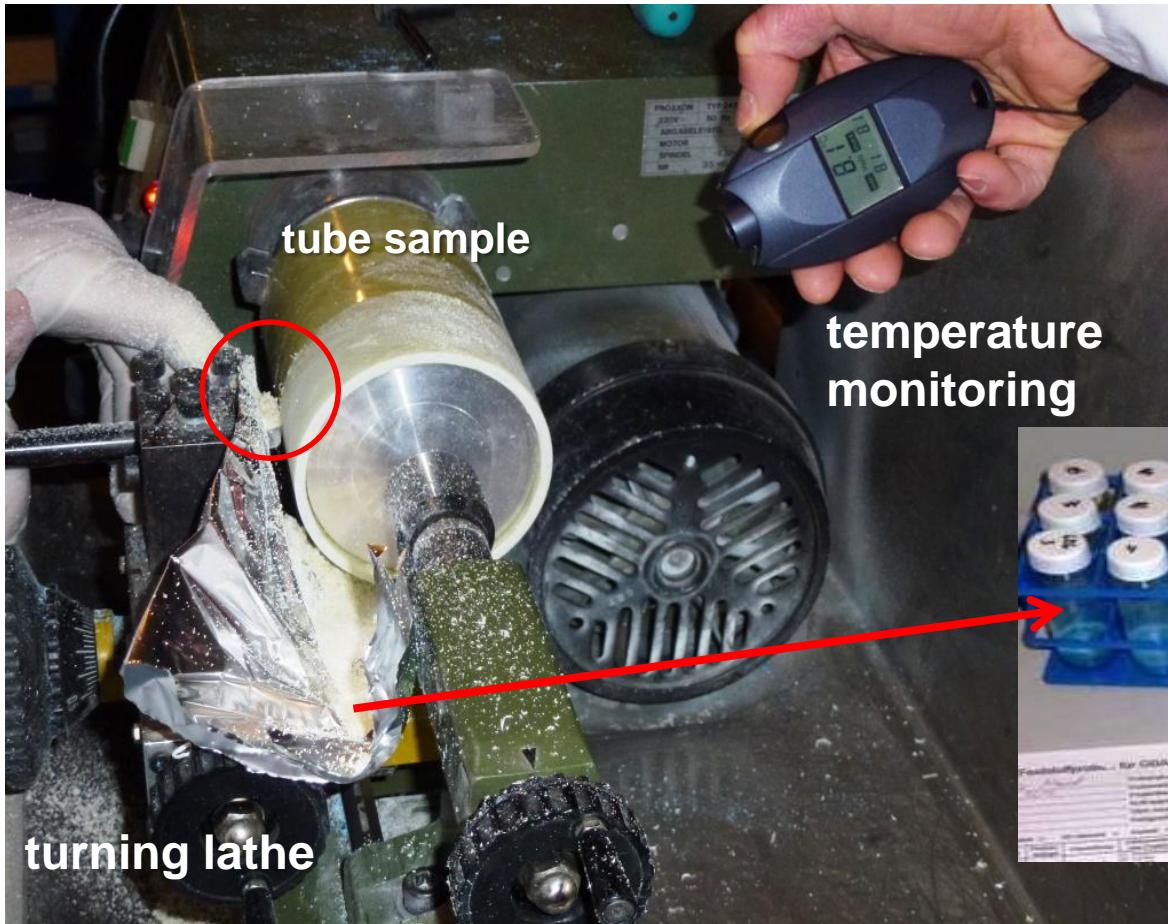
GFK material tests
with used
GFK pipelines ...
unfortunately a
destructive process

VERIFYING THE IMPERMEABILITY OF GRP REGARDING HYDROCARBONS

- Analytical method

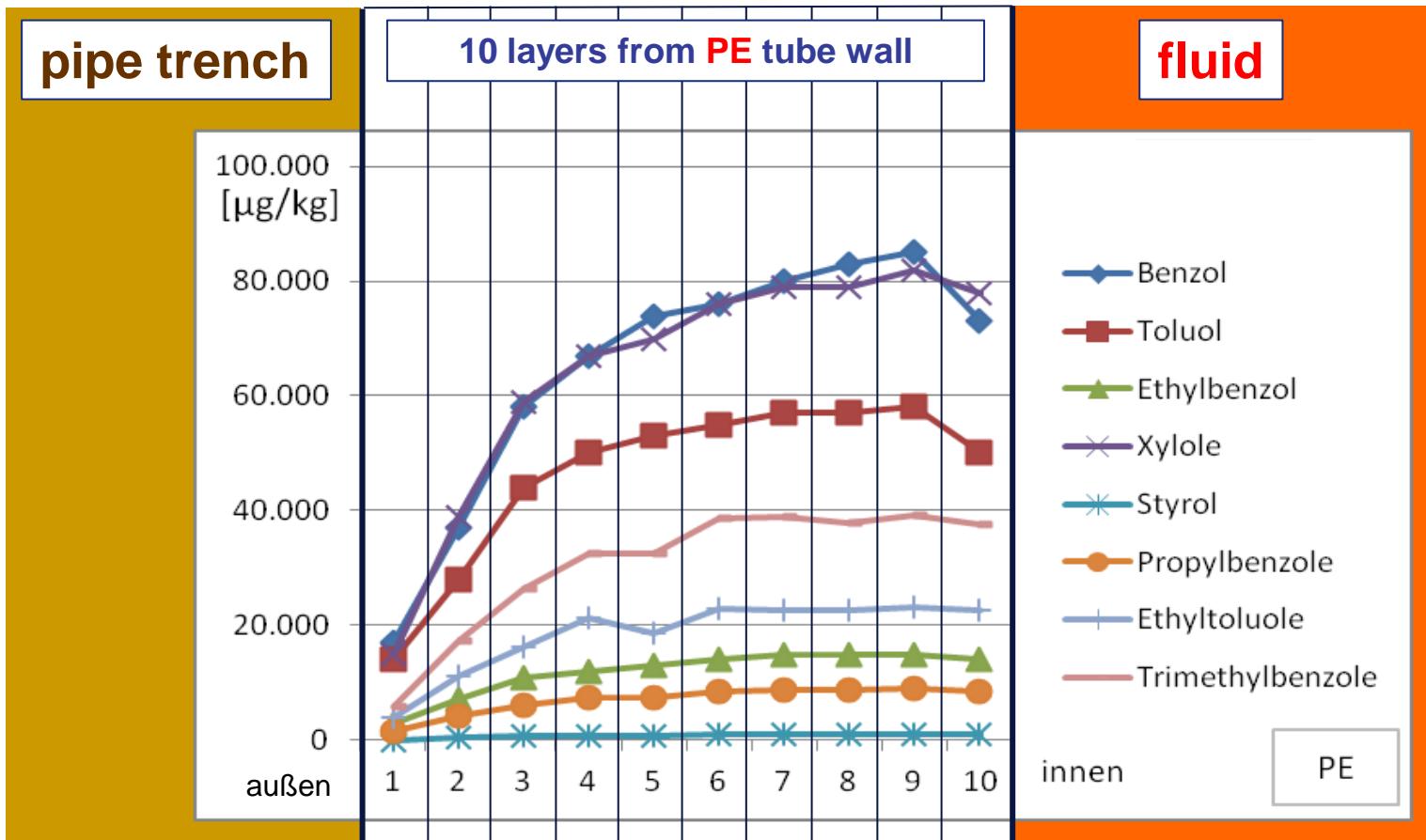
Chipping layers off of a tube wall on a turning lathe (lathe turnings in methanol)

„direct proof of suitability“



VERIFYING THE IMPERMEABILITY OF GRP REGARDING HYDROCARBONS

- Analytical method
Evaluation of gas chromatogram from 10 tube wall layers

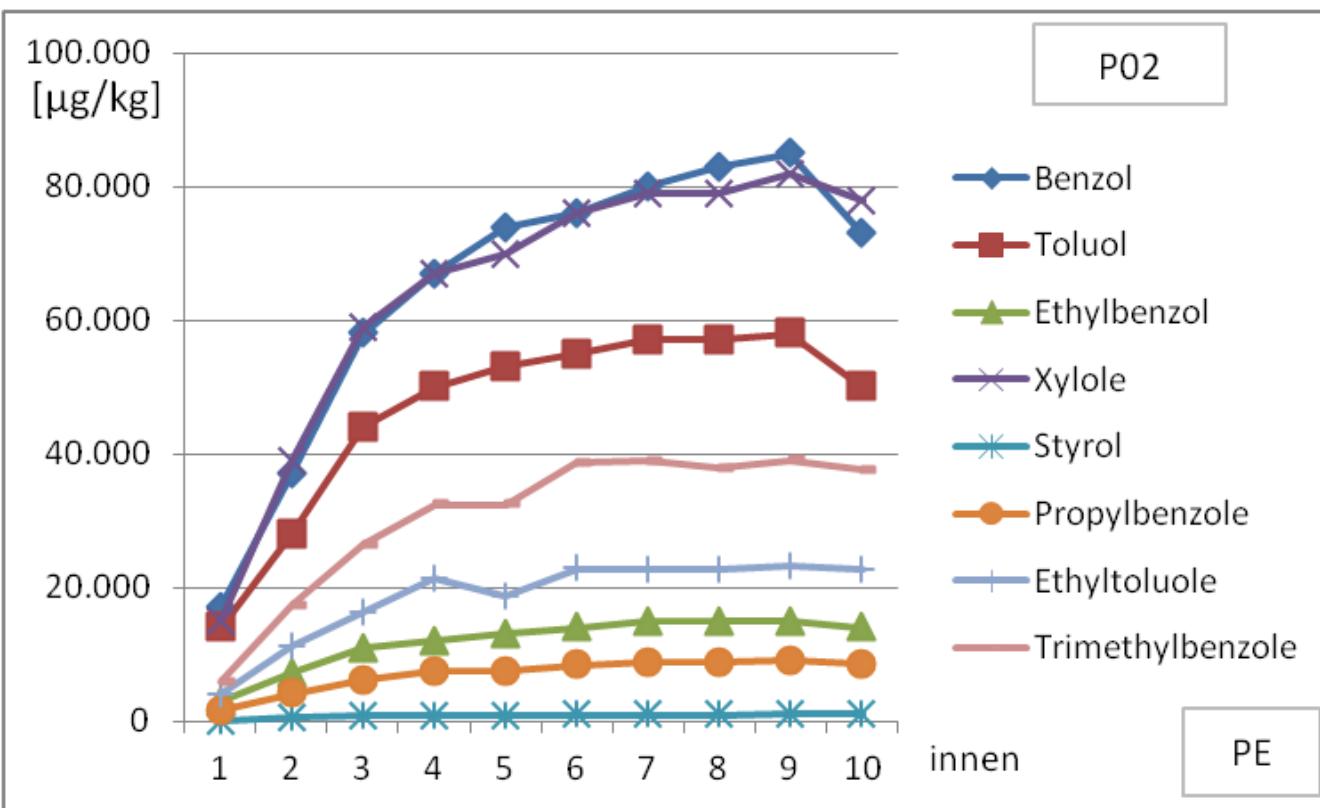


VERIFYING THE IMPERMEABILITY OF GRP REGARDING HYDROCARBONS

- Comparison to other plastics

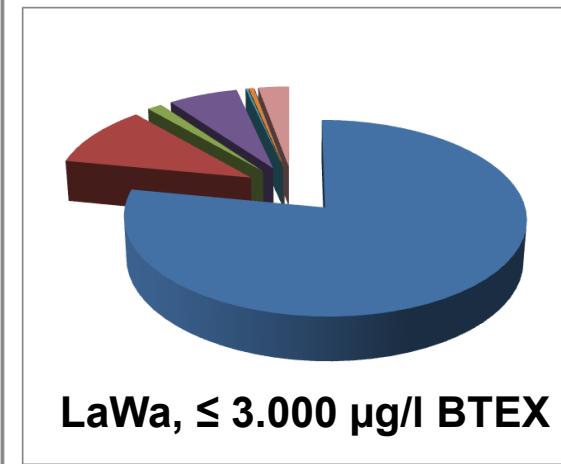
used **PE** pipeline

(transported reservoir fluids for over 1,5 years , BTEX \leq 3.000 $\mu\text{g/l}$)



„direct proof of suitability“

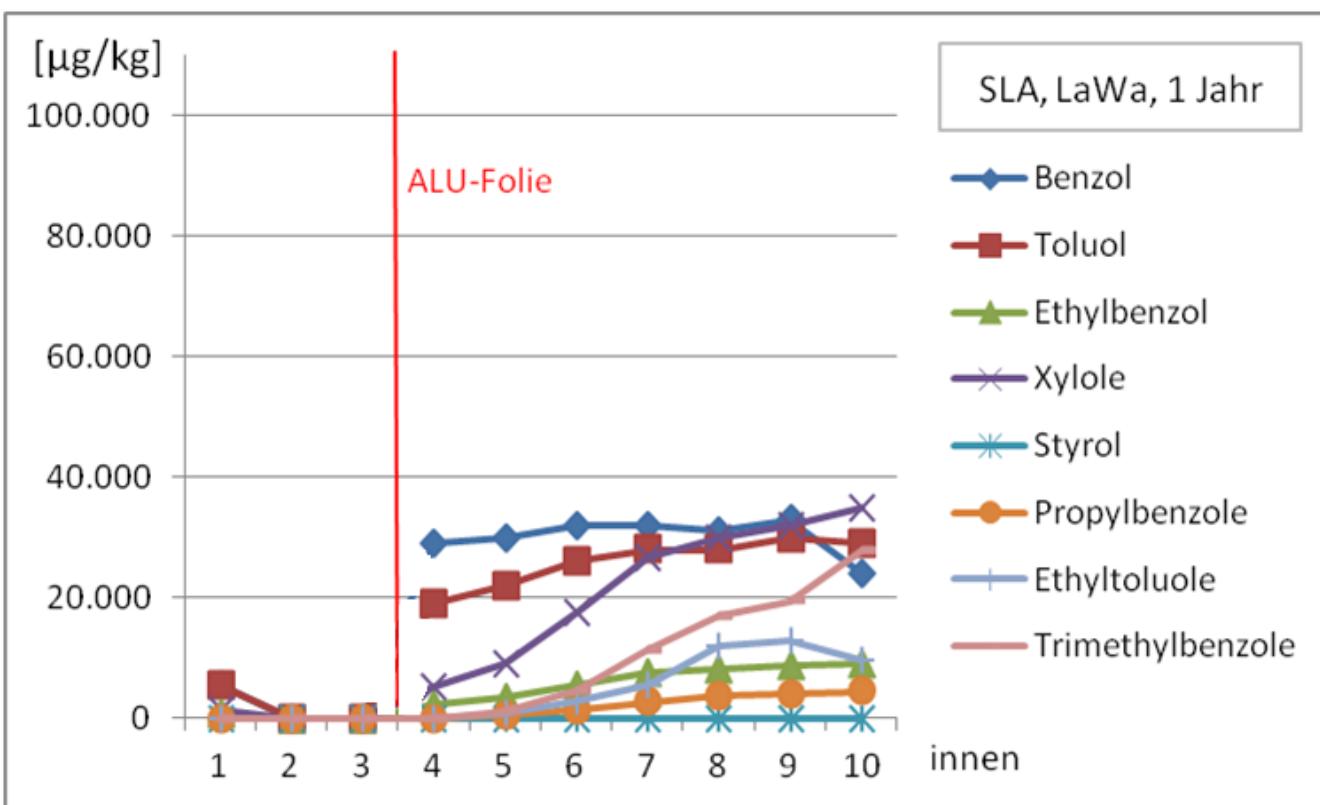
LaWa: reservoir fluid



PERMEATION !

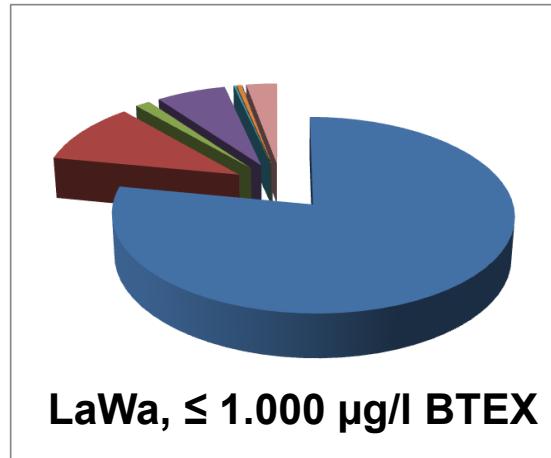
VERIFYING THE IMPERMEABILITY OF GRP REGARDING HYDROCARBONS

- Comparison to other plastics used **PE-ALU** composite pipeline
(transported reservoir fluids for over 1 year, BTEX $\leq 1.000 \mu\text{g/l}$)



„direct proof of suitability“

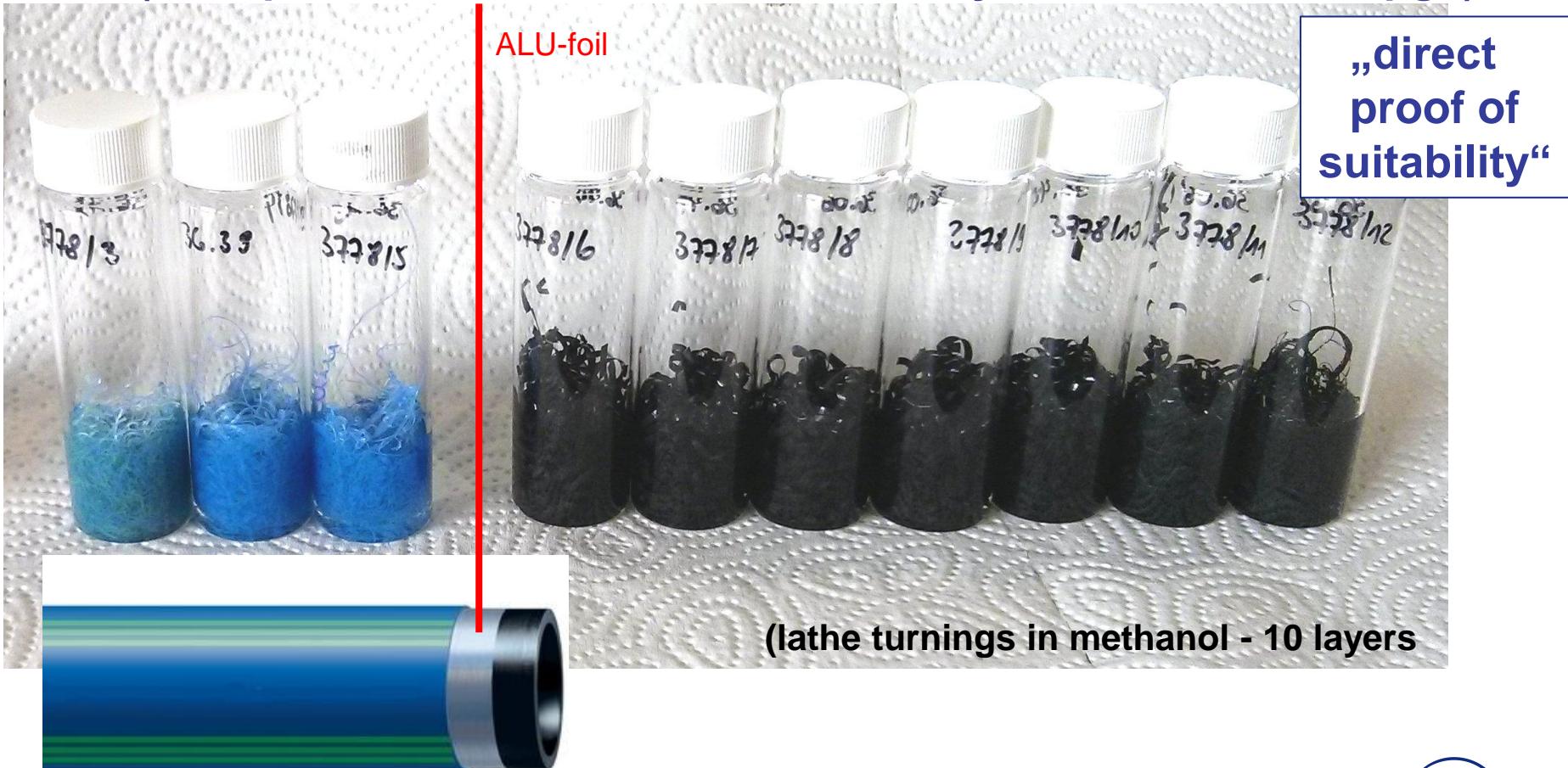
LaWa: reservoir fluid



NO PERMEATION !

VERIFYING THE IMPERMEABILITY OF GRP REGARDING HYDROCARBONS

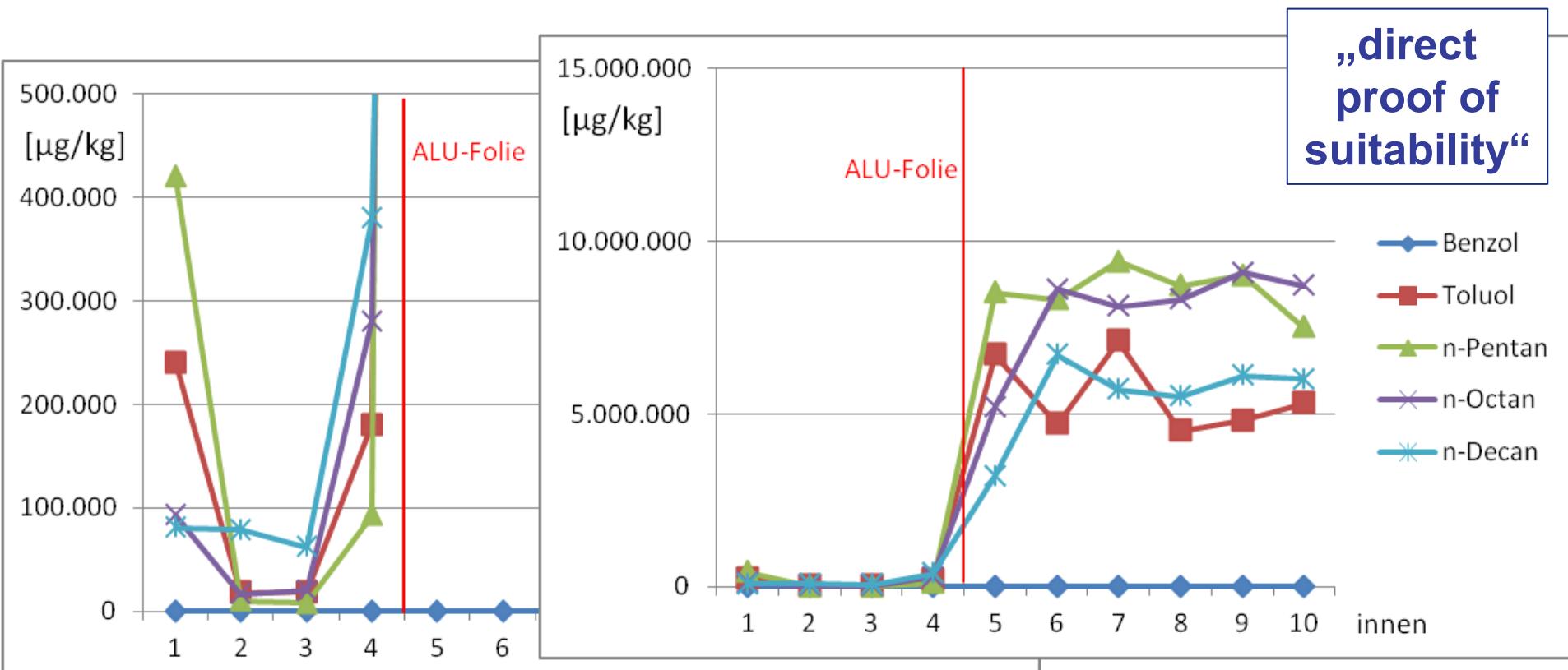
- Comparison to other plastics used **PE-ALU** composite pipeline (transported reservoir fluids for over 1 year, BTEX $\leq 1.000 \mu\text{g/l}$)



VERIFYING THE IMPERMEABILITY OF GRP REGARDING HYDROCARBONS

- Comparison to other plastics

**PE-ALU composite pipeline in a laboratory test at DBI-GUT
(18 month, 10% Toluol, 90% n-alkenes at 30°C, 8 bar)**



BEGINNING OF PERMEATION !

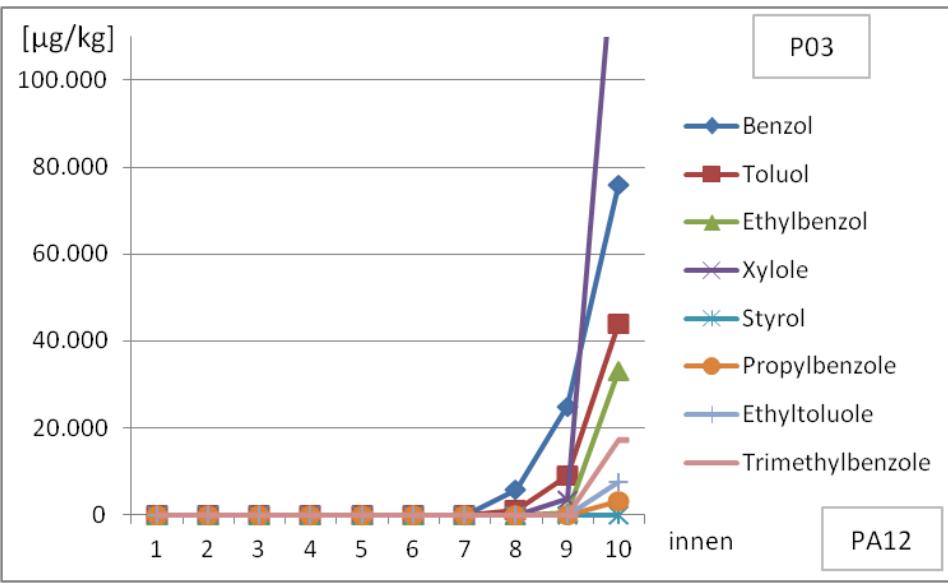
VERIFYING THE IMPERMEABILITY OF GRP REGARDING HYDROCARBONS

- Comparison to other plastics

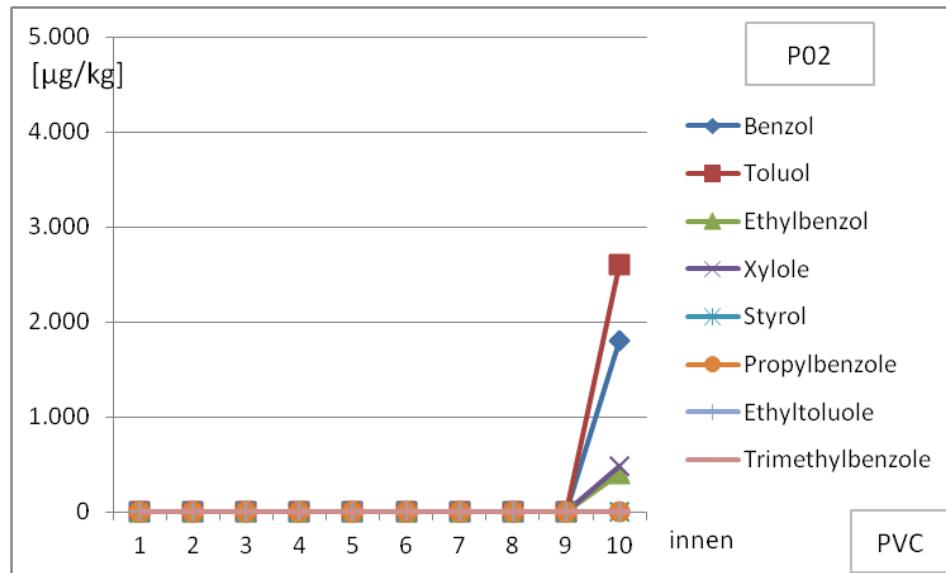
PA12 pipeline in a field test (2,5 years)

PVC pipeline in an oil field (36 years)

„direct proof of suitability“



Reservoir fluids with $\leq 3.000 \mu\text{g/l}$ BTEX both cases



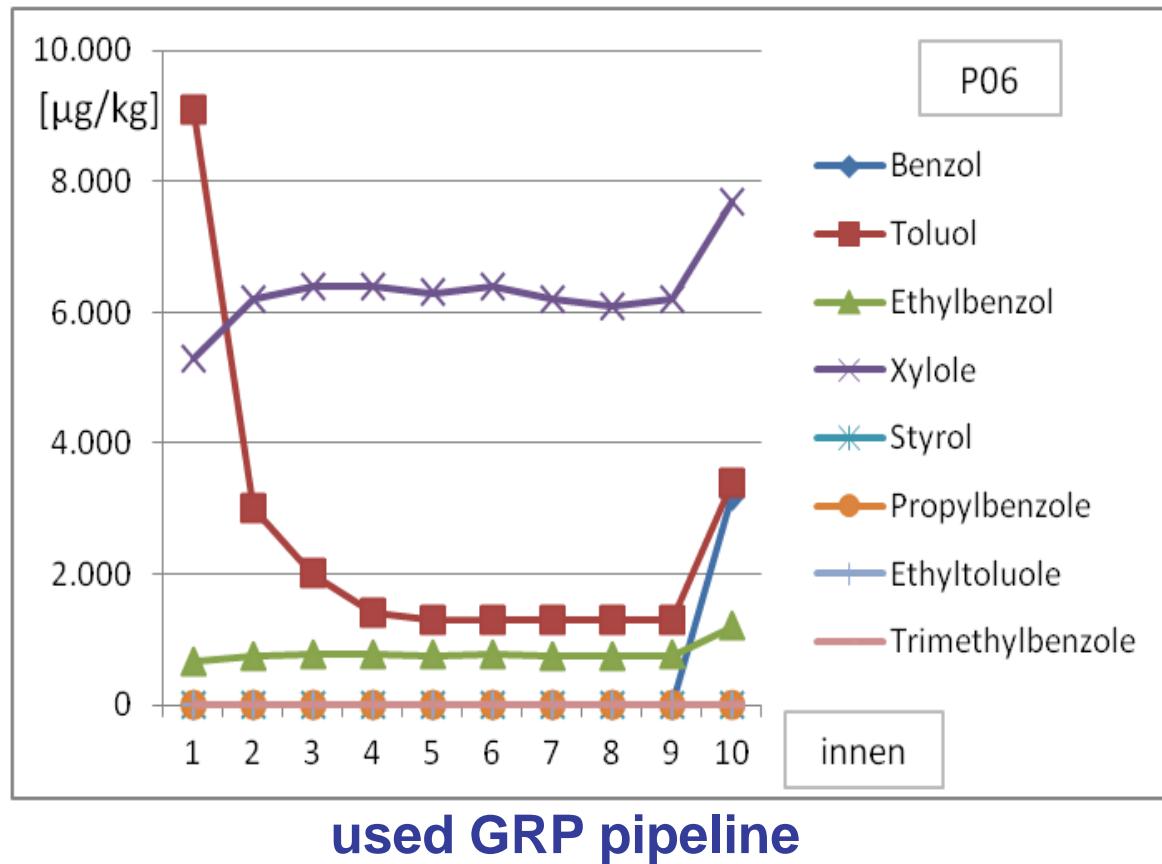
NO PERMEATION !

VERIFYING THE IMPERMEABILITY OF GRP REGARDING HYDROCARBONS

- Direct proof of suitability for GRP pipes

Evaluation of BTEX penetration in **GRP** matrix

BTEX concentration profiles within the **GRP** tube wall [$\mu\text{g}/\text{kg}$]
used GRP pipeline, transported cut oil for over 30 years



„direct
proof of
suitability“

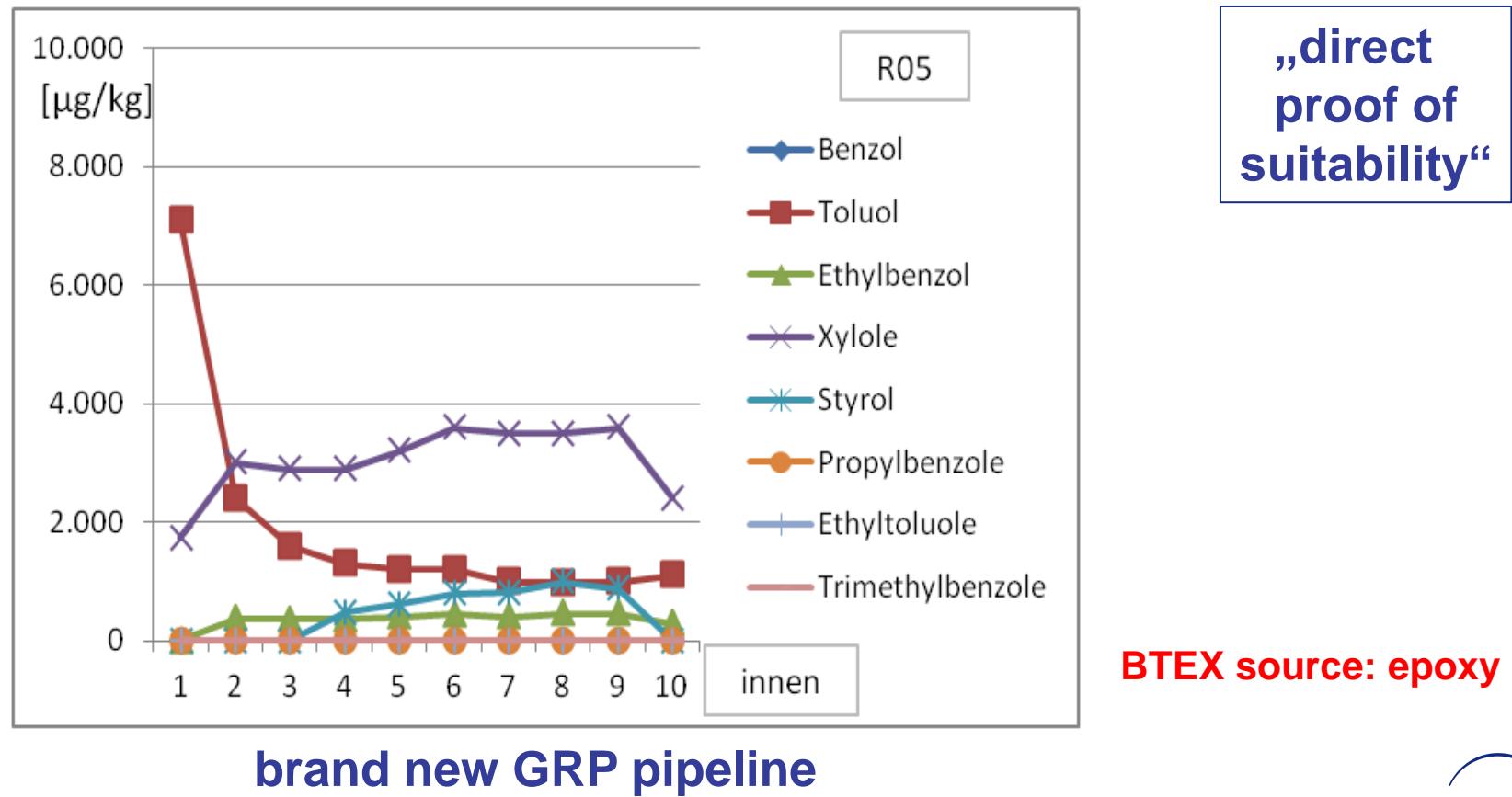
PERMEATION ?

VERIFYING THE IMPERMEABILITY OF GRP REGARDING HYDROCARBONS

- Direct proof of suitability for GRP pipes

Evaluation of BTEX penetration in **GRP** matrix

BTEX concentration profiles within the **GRP** tube wall [$\mu\text{g}/\text{kg}$]
brand new GRP pipeline from inventory stock (reference sample)

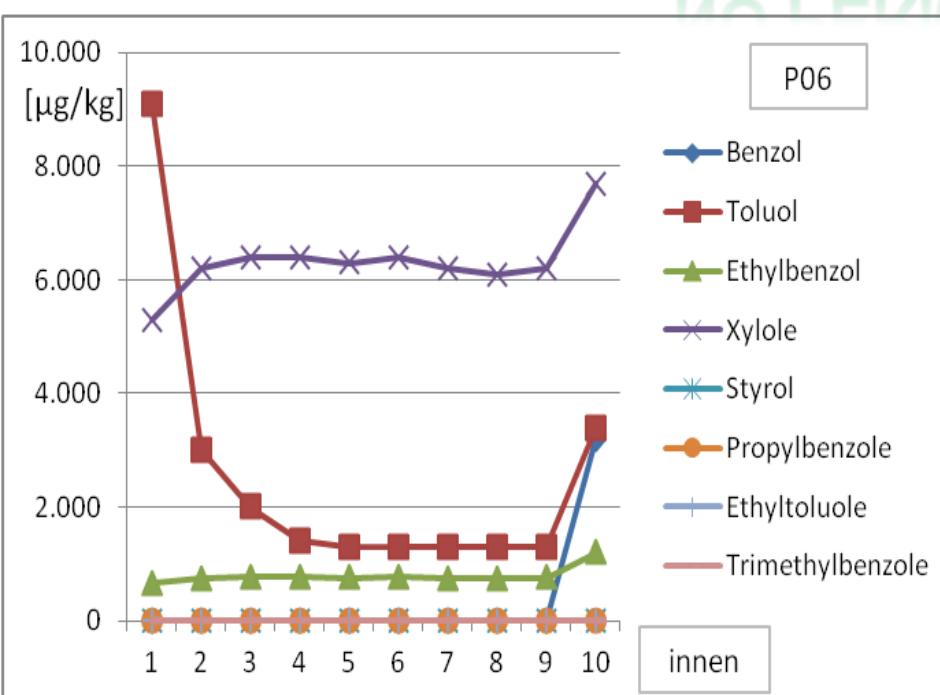


VERIFYING THE IMPERMEABILITY OF GRP REGARDING HYDROCARBONS

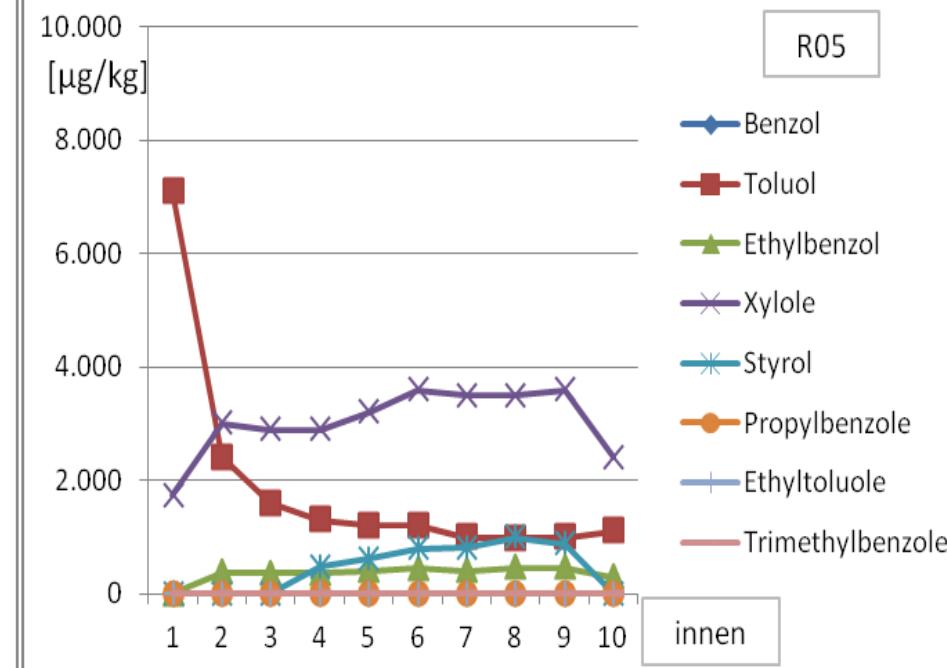
- Direct proof of suitability for GRP pipes
Evaluation of BTEX penetration in **GRP** matrix
BTEX concentration profiles within the **GRP tube wall [µg/kg]**

NO PERMEATION !

BTEX-source: epoxy resin



used GRP pipeline

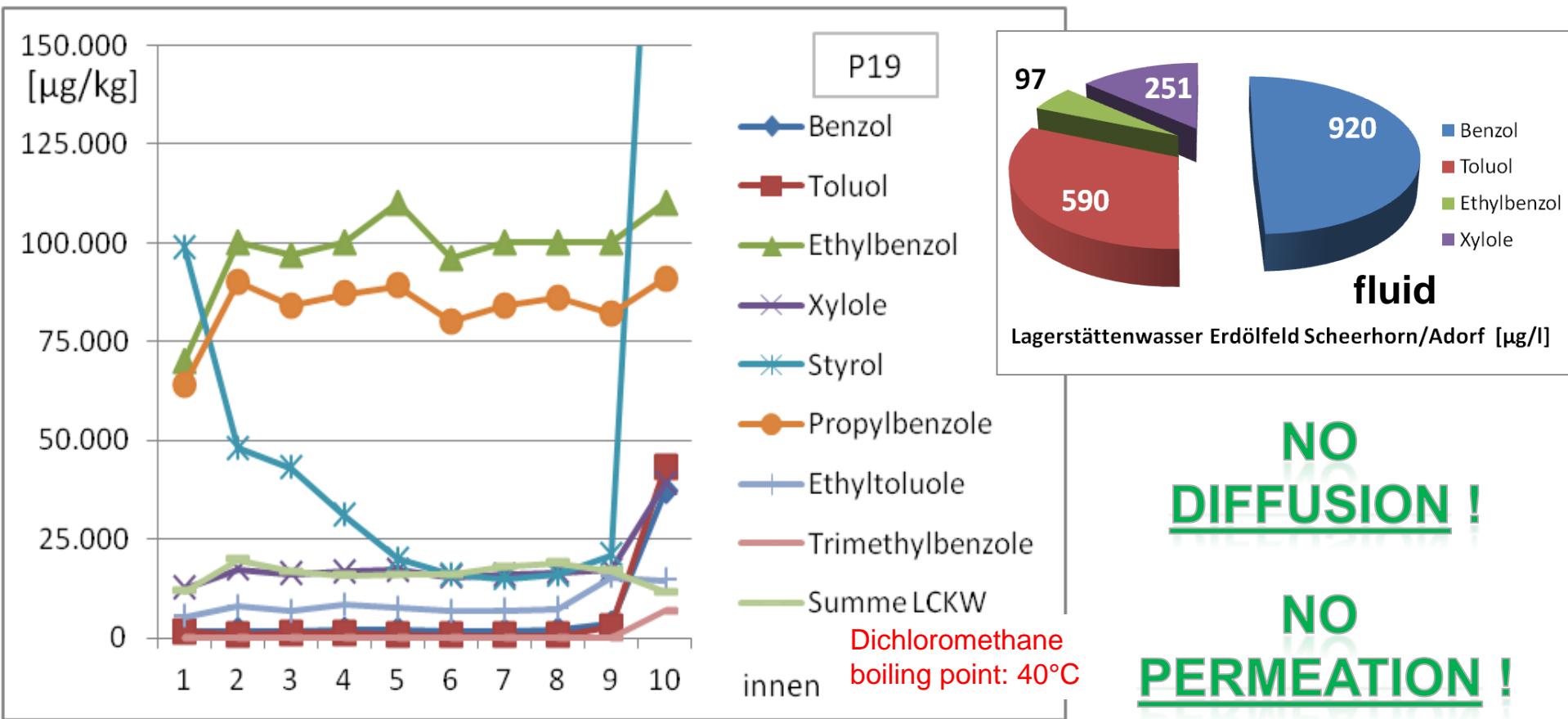


brand new GRP pipeline

VERIFYING THE IMPERMEABILITY OF GRP REGARDING HYDROCARBONS

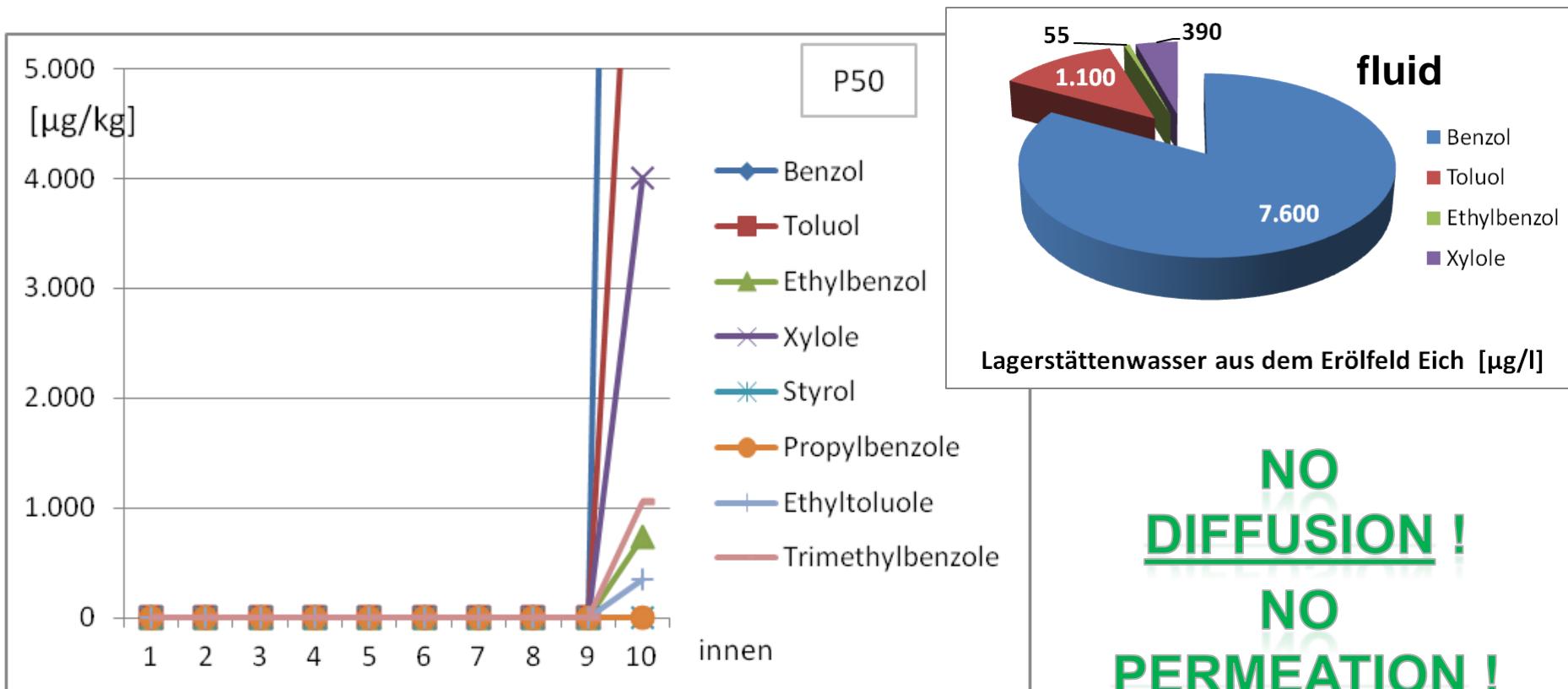
- Direct proof of suitability for GRP pipes

BTEX concentration profiles within the **GRP** tube wall [$\mu\text{g}/\text{kg}$]
used 12"GRP pipeline, transported reservoir fluids for over 50 years



VERIFYING THE IMPERMEABILITY OF GRP REGARDING HYDROCARBONS

- Direct proof of suitability for GRP pipes
BTEX concentration profiles within the **GRP** tube wall [$\mu\text{g}/\text{kg}$] used GRP pipeline, transported reservoir fluids for over 17 years



no BTEX detectable in epoxy resin matrix (< 300 $\mu\text{g}/\text{kg}$)

NO
DIFFUSION !
NO
PERMEATION !

VERIFYING THE IMPERMEABILITY OF GRP REGARDING HYDROCARBONS

- Direct proof of suitability for GRP pipes

Statistical data

- **GRP pipelines - direct proof of suitability (61 samples) none with any indication for diffusion or permeation**

GRP pipelines in oil / gas fields Germany			
GRP type	total	direct proof of suitability	
GRP-EP (epoxy resin)	423	42	9,9%
GRP-VE (vinylester resin)	34	18	52,9%
GRP-PE (polyester resin)	1	1	
GRP overall	458	61	13,3%

- **GRP pipelines - indirect proof of suitability (91 samples)
additional 91 from 458 = 19,9 % (only „negative“ findings)**

VERIFYING THE IMPERMEABILITY OF GRP REGARDING HYDROCARBONS

- Direct proof of suitability for GRP pipes

Variable

➤ Producer		
➤ Resin / curing agent		
➤ Wall thickness	2 mm	(min.)
➤ Inner diameter	300 mm	(max.)
➤ Temperature	60 °C	(max.)
➤ Pressure	60 bar	(max.)
➤ Transfer rate	2.000 m ³ /h	(max.)
➤ Operating time	50 years	(max.)
➤ Oil / gas field		
➤ Fluid type (reservoir fluid, cut oil, oil, gas condensate)		
➤ BTEX concentration in fluid	(1.000 up to 75.000.000 µg/l)	

No measurable influence on permeation observed

VERIFYING THE IMPERMEABILITY OF GRP REGARDING HYDROCARBONS

- Direct proof of suitability for GRP pipes (61 pipe samples)

variable	variance				
producer	Future Pipe In.	NOV-FGS	Smith	Koch	Fibercast u.a.
quantity	16	4	17	8	16
curing agent	arom. Amines	aliph. Amines	anhydrides	peroxides	
quantity	19	4	19	19	
wall thickness	up to 2,5 mm	up to 3,5 mm	up to 4,5 mm	up to 5,5 mm	> 5,5 mm
quantity	7	17	22	8	7
inside diameter	DN 50	DN 80	DN 100	DN 150	DN 250
quantity	15	28	13	2	3
fluid temperature	up to 20 °C	up to 30 °C	up to 40 °C	up to 50 °C	up to 60 °C
quantity	18	20	20	2	1
operating pressure	up to 5 bar	up to 10 bar	up to 20 bar	up to 50 bar	> 50 bar
quantity	10	25	20	5	1
transfer rate	up to 50 m³/d	up to 100 m³/d	up to 500 m³/d	up to 1000 m³/d	> 1000 m³/d
quantity	31	8	14	3	5
operating time	up to 10 years	up to 20 years	up to 30 years	up to 40 years	up to 50 years
quantity	16	12	24	8	1
oil / gas field	oil field	gas field			
quantity	45	16			
fluid type	cut oil	reservoir fluid	gas condensate	oil	
quantity	26	33	1	1	
BTEX concentration in fl	up to 5 mg/l	up to 10 mg/l	up to 50 mg/l	up to 500 mg/l	> 500 mg/l
quantity	21	11	16	3	10

VERIFYING THE IMPERMEABILITY OF GRP REGARDING HYDROCARBONS

• General proof of suitability for GRP pipes



- ✓ Old facilities
 - ❖ 50 years overall running time
- ✓ New construction of GRP pipes:
 - ❖ ≤ 65 °C fluid temperature
 - ❖ Operating pressure → BVEG-manual
 - ❖ Epoxy resin or vinyl ester resin
 - ❖ ≥ 65 mass-% glass fibre content
 - ❖ ≥ 105 °C glass transition temperature
 - ❖ $\geq 4,0$ mm wall thickness
 - ❖ Permeation tight for 50 years (general proof, no periodic inspections regarding permeation)

VERIFYING THE IMPERMEABILITY OF GRP REGARDING HYDROCARBONS

- Future prospects

**General proof of impermeability
of GRP Pipes
regarding hydrocarbons**

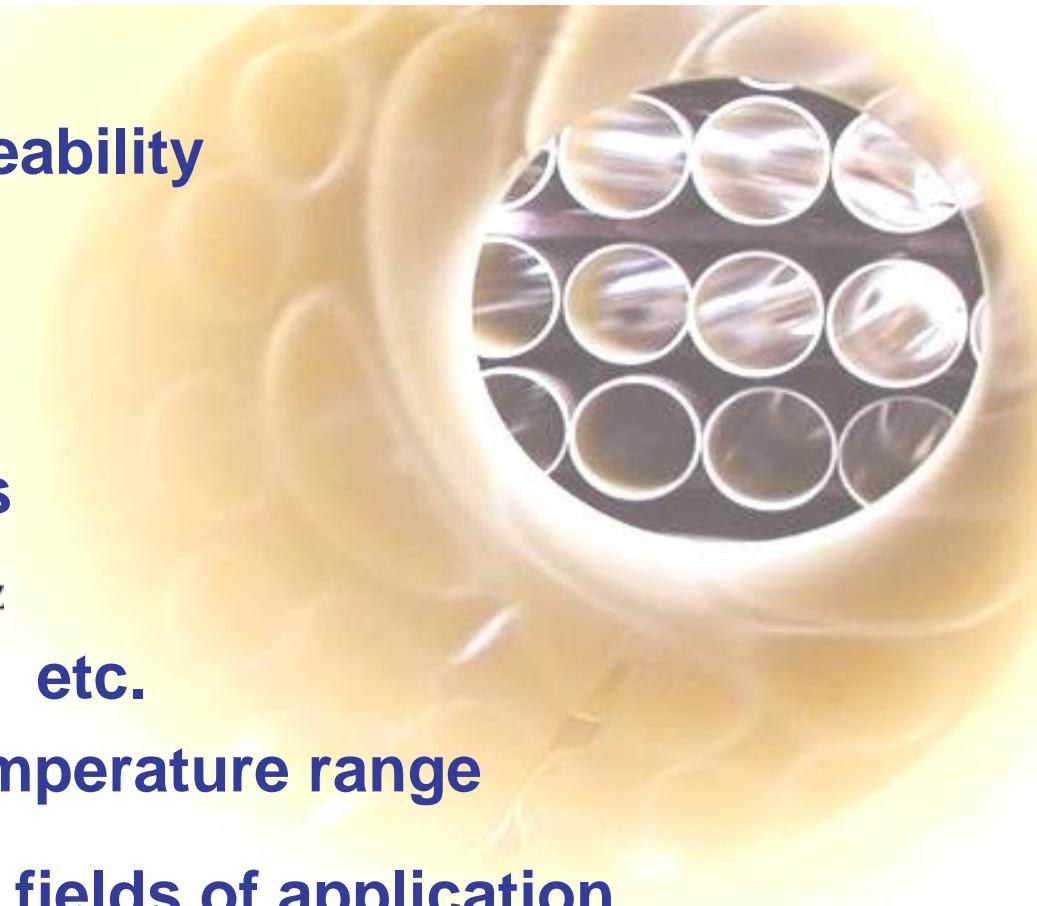
- Approval by authorities



RheinlandPfalz
LANDESAMT FÜR GEOLOGIE
UND BERGBAU

etc.

- Expand permissible temperature range
- Apply findings to other fields of application





GLASS FIBRE REINFORCED
PIPELINES (GRP) ...

... are impermeable
to hydrocarbons