JoinTec:

Innovative and competitive new joining technology for steel pipes using adhesive bonding

University of Paderborn, Germany
Laboratory for Materials and Joining Technology (LWF)
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Agenda

TOP 1: Welcome and acceptance of the minutes of the last meeting (10:00)

TOP 2: Research results of project partners (10:10)

TOP 3: Lunch break (12:30)

TOP 3: Tour of Salzgitter Mannesmann Line Pipe (13:00)

TOP 4: Next steps (14:30)

TOP 5: Coordination (15:15)

TOP 6: Miscellaneous & end of the meeting (16:00)

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Welcome and Introduction

JoinTec

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Innovative and competitive new joining technology for steel pipes using adhesive bonding

Main objectives/ tasks:

- Elaborating an efficient, integrated and easy-to-use joining technique for adhesive bonding of steel pipes.
- Development of guidelines, design calculation methods and non-destructive testing methods including a repair concept for adhesively bonded steel pipes.

Welcome and Introduction

Programme bar chart (tasks, deliverables, milestones)

Work packages	Work packages' title	Deliverables	1st year	2nd year	3rd year
WP 1	**Joining Fundamentals**				
Task 1.1	Survey of requirements	Working points			
Task 1.2	Optimisation joint design	Joint geometry			
Task 1.3	Adhesive Development	Adequate adhesive			
Task 1.4	Selection of surface treatment	Surface treatment			
Task 1.5	Development of application method	Application method			
WP 2	**Process Quality Control**				
Task 2.1	Quality control system	Control system			
Task 2.2	Repair procedure	Repair procedure			
Task 2.3	Transfer to field conditions	Suitability			
WP 3	**Full scale testing**				
Task 3.1	Full scale tests	Stress strain curves			
Task 3.2	Defect tolerance criteria	Tolerance criteria			
Task 3.3	FEM-model	Calc. model			
WP 4	**Adhesive bonding concept**				
Task 4.1	Pipe laying test at site	Verification			
Task 4.2	Comparison with welding	Cost calculation			
Task 4.3	Guidelines, design criteria	Design criteria			
WP 5	**Co-ordination**				
Task 5.1	Co-ordination	Teamwork			
Task 5.2	Reports	Reports			

project start

25.06.2008

24.01.2008

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WP1: Differential Scanning Calorimetry (DSC)

→ **Determination of the time and temperature depending chemical und physical effects of the adhesive's curing reaction**

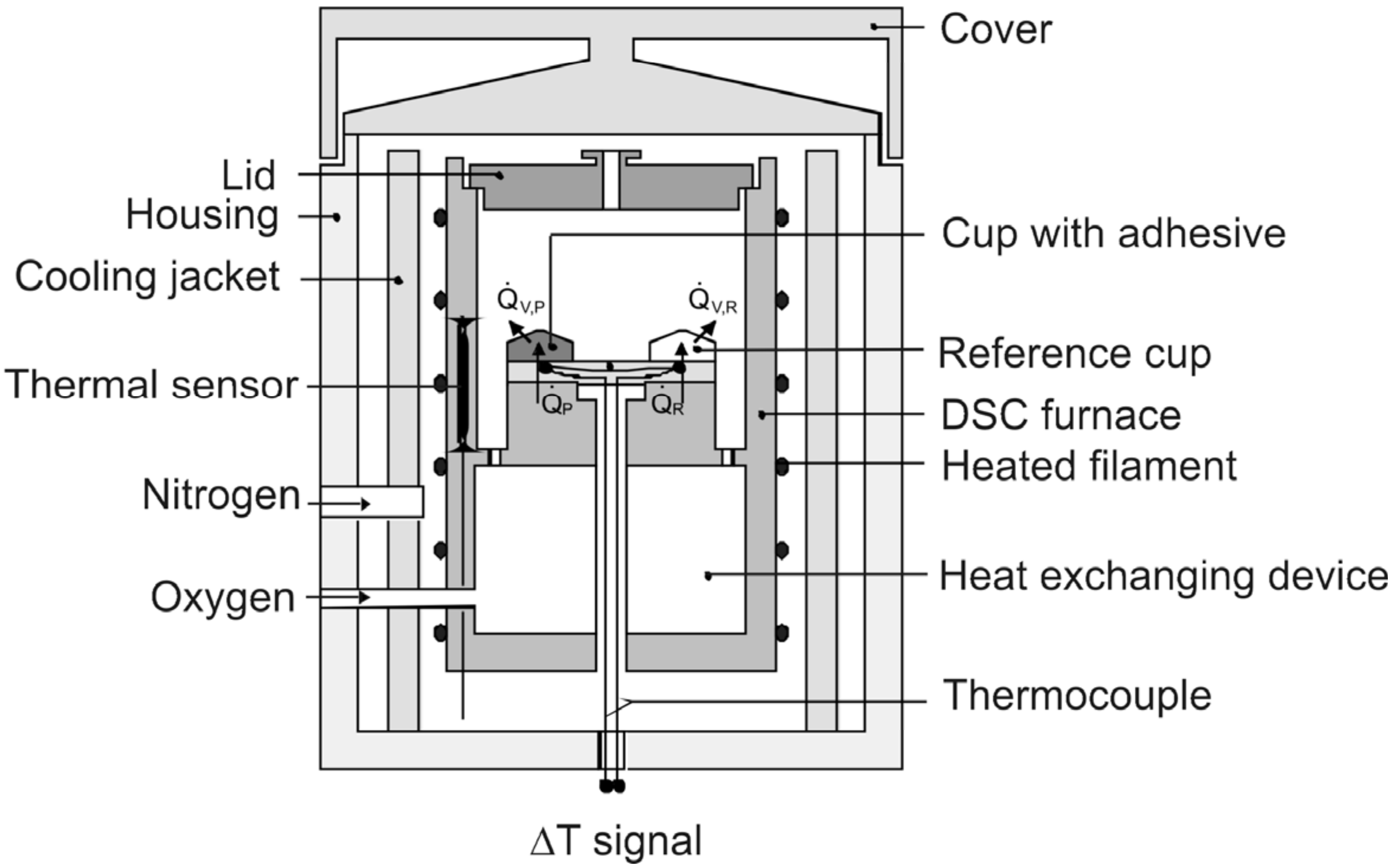
- **Testing device:** Mettler DSC30

- **Testing method:** measurement of the temperature differences of an adhesive filled cup and an empty cup that are exposed to the same temperature profile and determination of the standardised heat flux

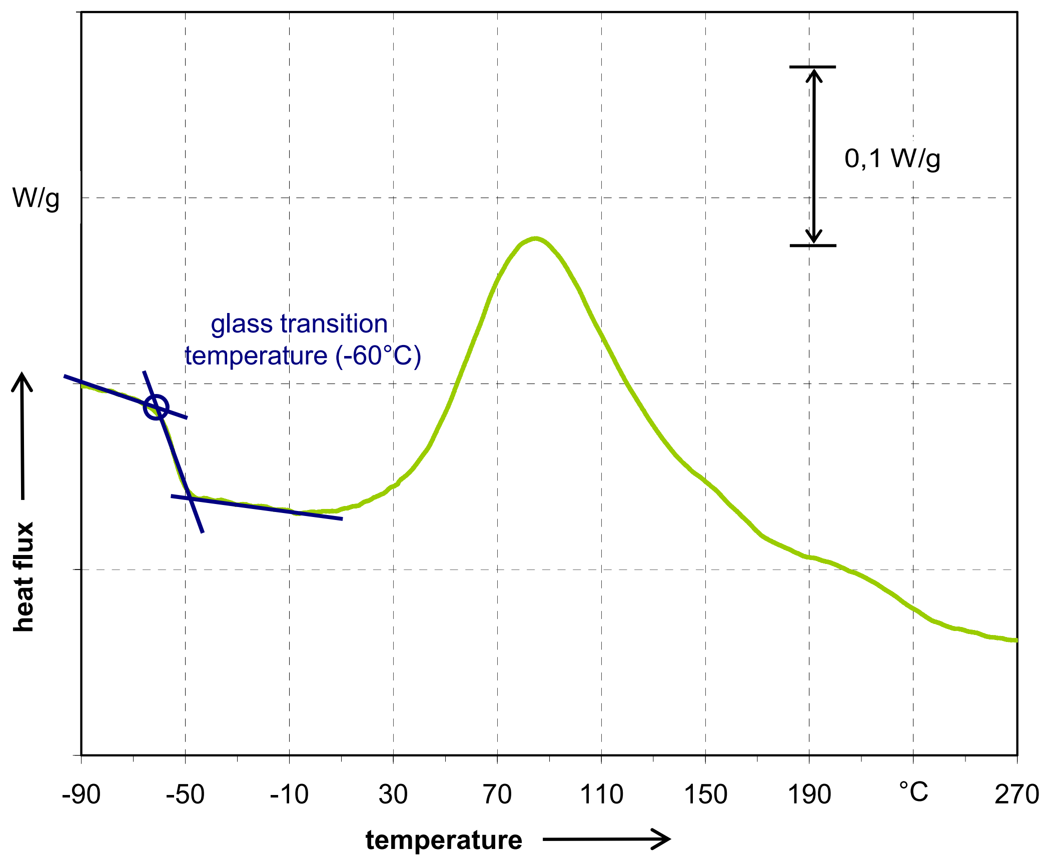
- **Results:**
  - reaction kinetics of the curing reaction (temperature- and time-relating)
  - specific enthalpy of the reaction
  - glass transition temperature

WP1: Differential Scanning Calorimetry (DSC)

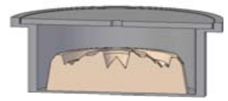
→ **schematic test setup of DSC testing device**



WP1: DSC analysis on PU156



Adhesive PU156
Testing device Mettler DSC30 S
Test method DSC analysis (DIN 53765)
Heating rate 8K/min
Displayed standardised heat flux
Mass of adhesive sample 19.95 mg
Specimen Al-cup (20µl) sample of adhesive



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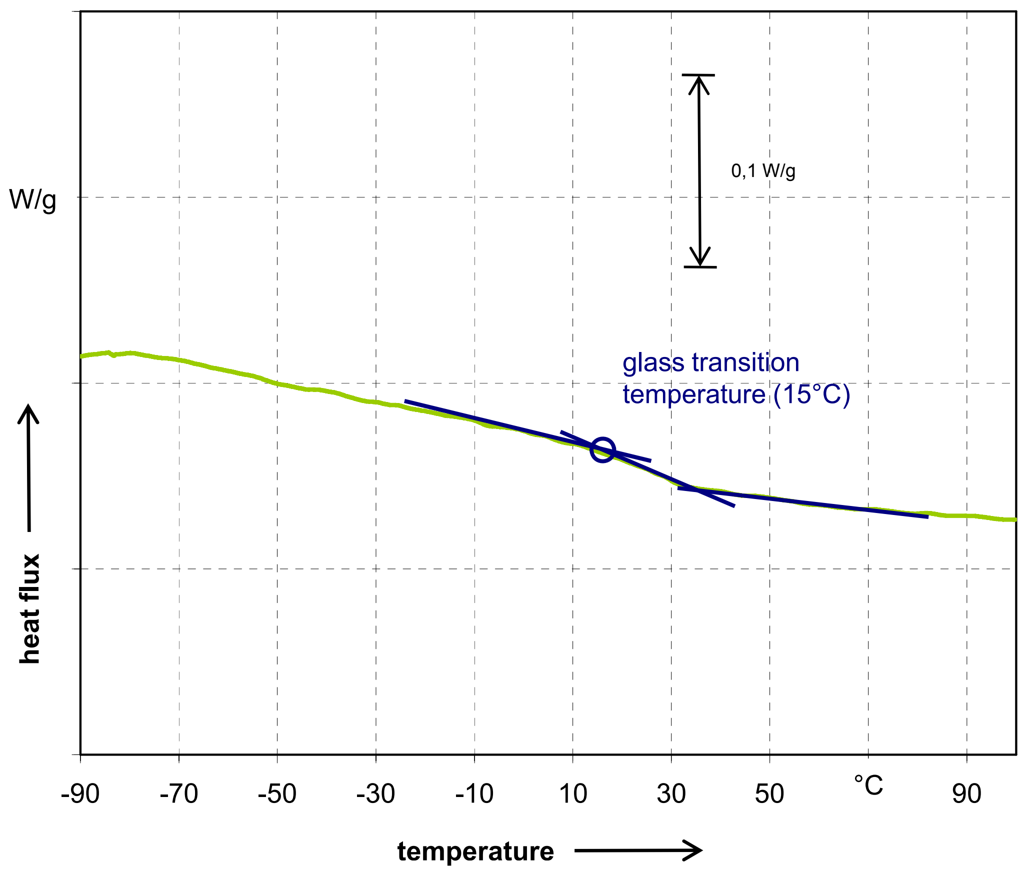
WP1: DSC analysis on cured PU156



Adhesive
PU156

Testing device
Mettler DSC30 S

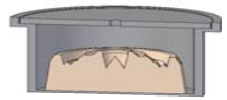
Test method
DSC analyses (DIN 53765)

Heating rate
8K/min

Displayed
standardised heat flux

Mass of adhesive sample
19.96 mg

Specimen
Al-cup (20µl)
sample of cured adhesive



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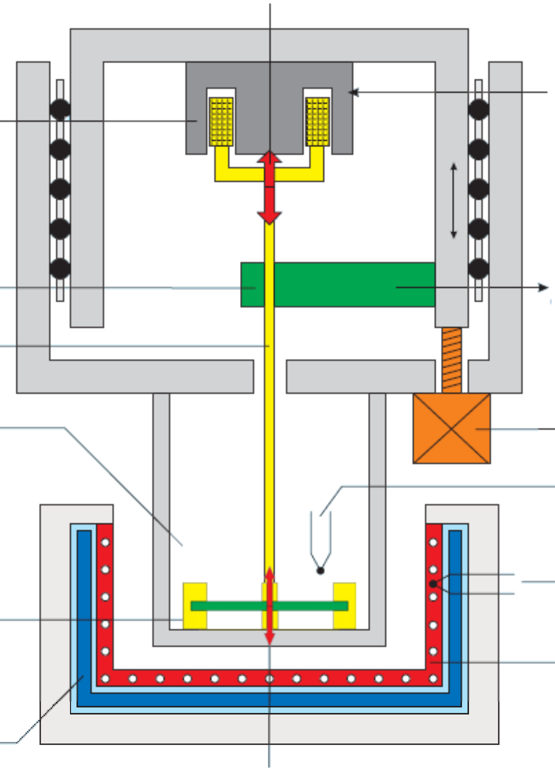
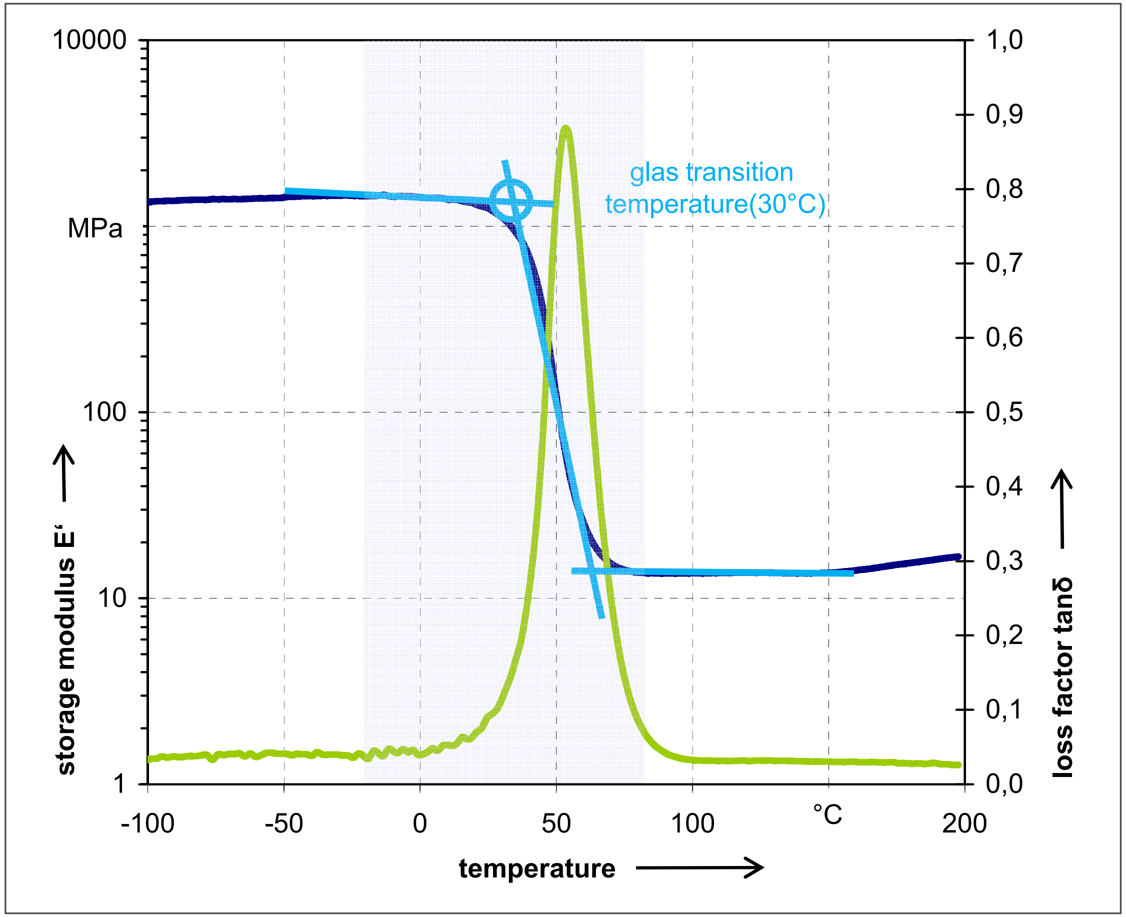
WP1: Dynamic Mechanical Analysis (DMA)



- Applying an oscillating force to a sample and measurement of the material's reaction to that force
- Measurands: dynamic storage modulus E', dynamic loss modulus E" and loss factor tan δ

WP1: DMA: PU156



Adhesive
PU156

Curing
10 d at room temperature

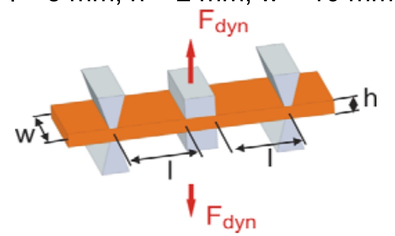
Testing device
Netzsch DMA 242

Testing frequency
1 Hz (shown)

Temperature sequence
-100°C - +200°C

Heating rate
3 K/min

Specimen
dual cantilever bending
l = 5 mm; h = 2 mm; w = 10 mm



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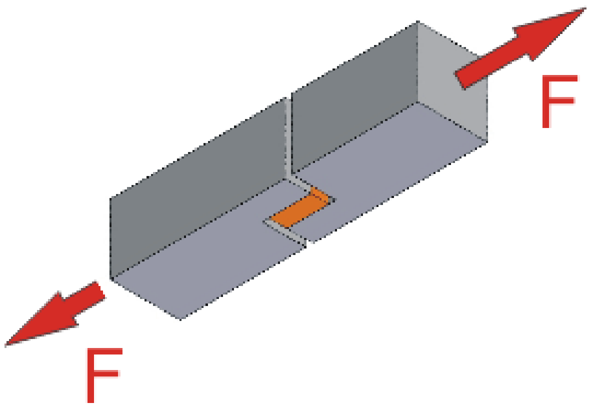
The stiffness of the adhesive PU156 decreases in a relavant temperature interval from 1470 MPa to 13,6 MPa.

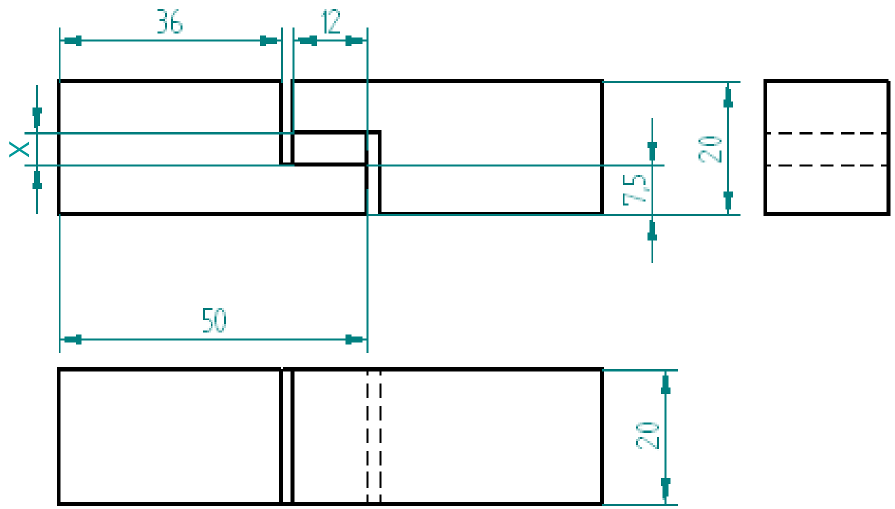
WP1: τ - γ tests on thick tensile specimens

τ - γ tests: Tests performed in dependence on DIN ISO 11003-2

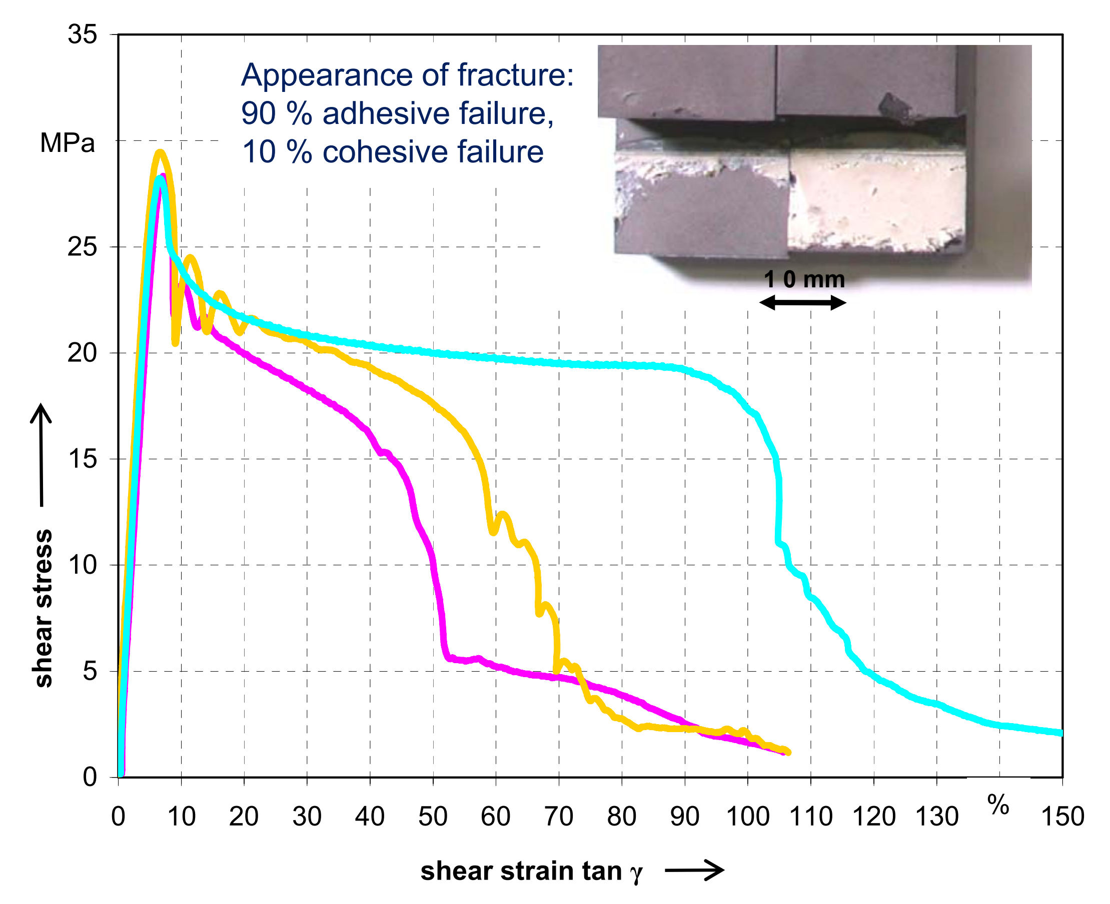
→ Determination of shear stress and shear strain behaviour of the adhesives

- used specimen: thick tensile specimen in dependence on DIN ISO 11003-2 (adhesive thickness x = 0.5 mm, 3 mm & 5 mm)
- testing velocity depending on the thickness of the adhesive layer: $\dot{\gamma} = 0.001\ s^{-1};\ 0.006\ s^{-1};\ 0.01\ s^{-1}$
- dimensions of the used thick tensile specimen:





WP1: τ - γ tests on thick tensile specimens: PU154



Adhesive
PU154

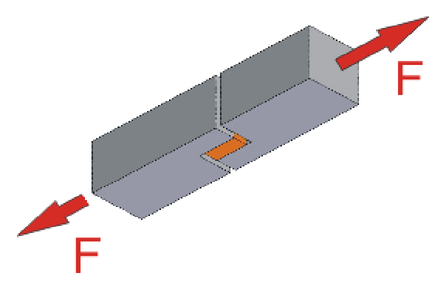
Curing
10 d at room temperature

Testing device
Zwick Z100

Testing velocity
depending on thickness of adhesive layer, $\dot{\gamma} \approx 0.01$ 1/s

Specimen
thick tensile specimen

Thickness of adhesive layer
0.5 mm



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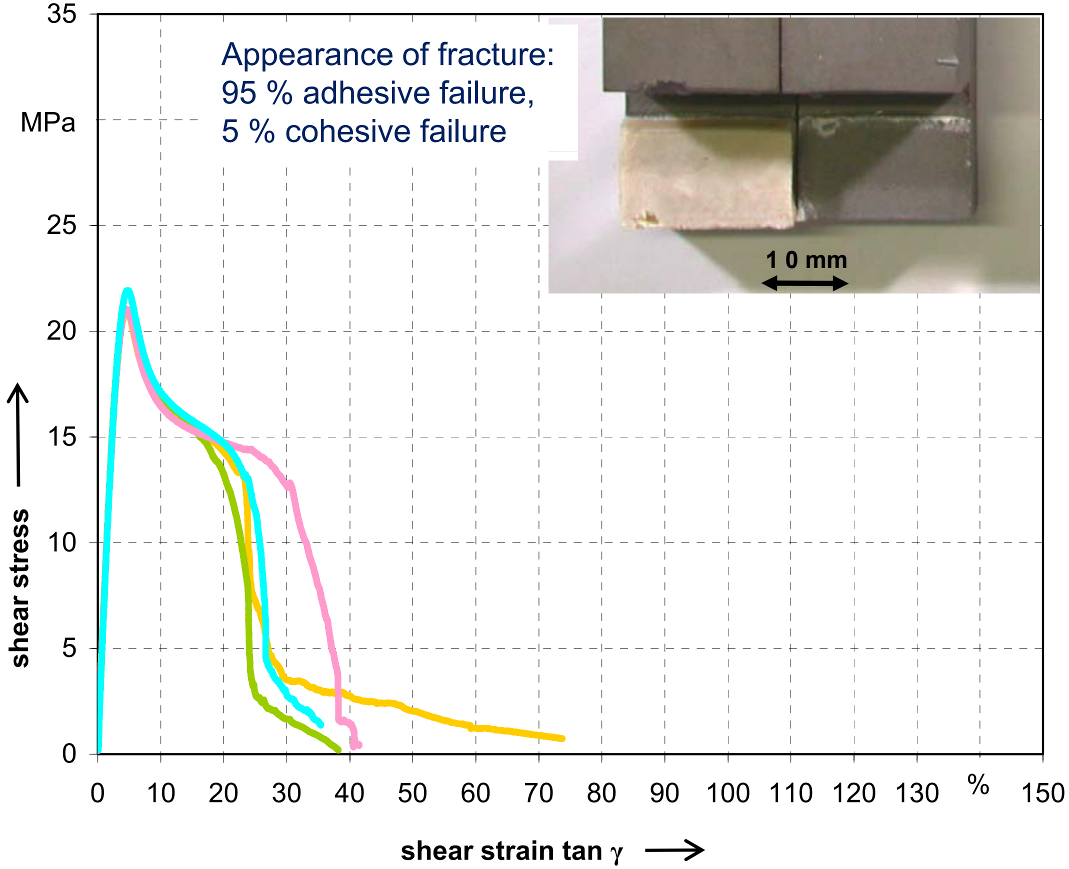
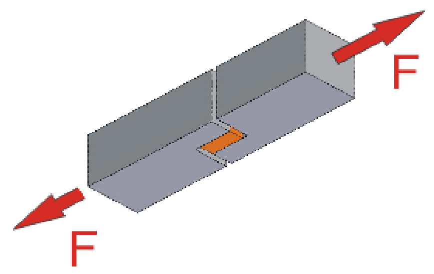
WP1: τ - γ tests on thick tensile specimens: PU154



Adhesive	PU154
Curing	10 d at room temperature
Testing device	Zwick Z100
Testing velocity	depending on thickness of adhesive layer, $\dot{\gamma} \approx 0.006$ 1/s
Specimen	thick tensile specimen
Thickness of adhesive layer	3 mm



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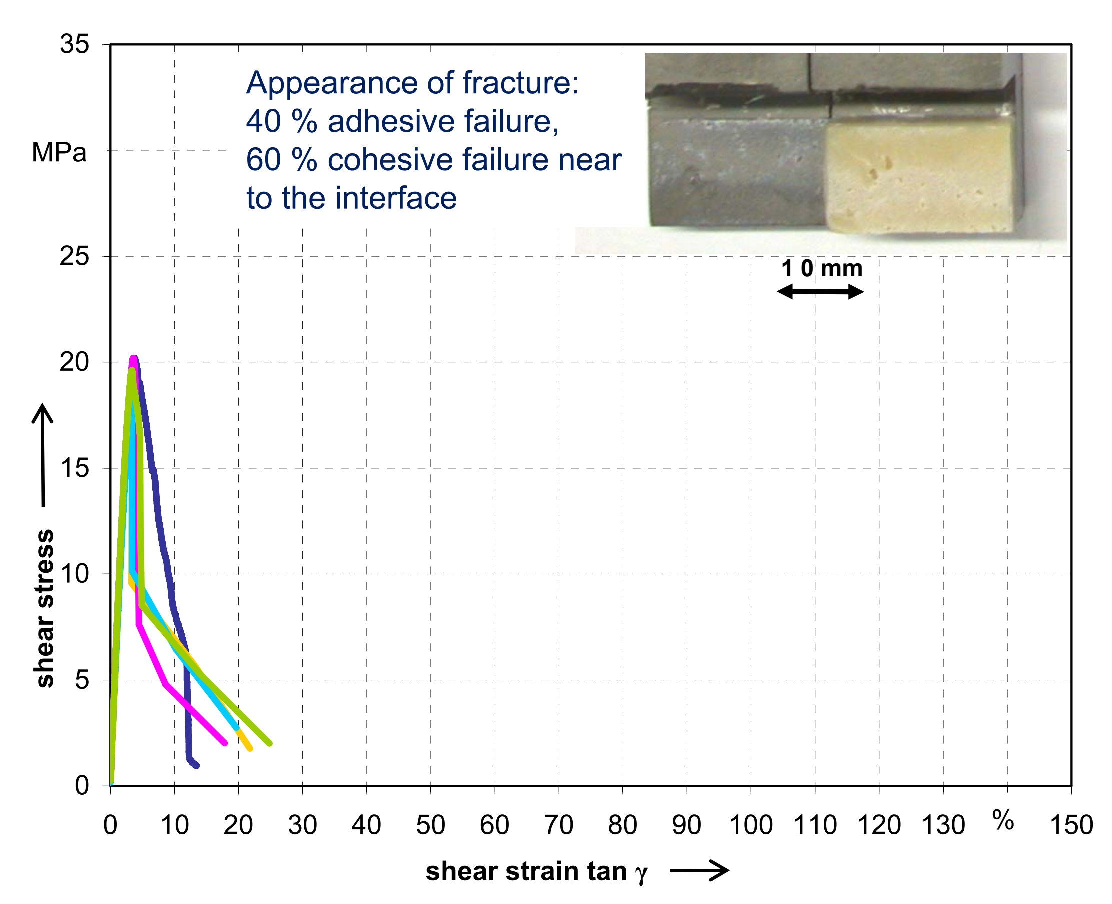
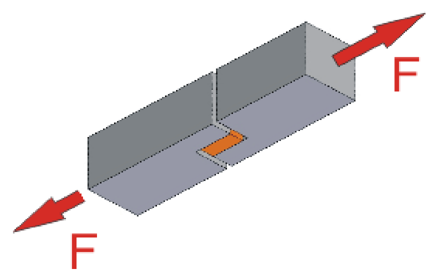
WP1: τ - γ tests on thick tensile specimens: PU154



Adhesive
PU154
Curing
10 d at room temperature
Testing device
Zwick Z100
Testing velocity
depending on thickness of adhesive layer, $\dot{\gamma} \approx 0.001$ 1/s
Specimen
thick tensile specimen
Thickness of adhesive layer
5 mm



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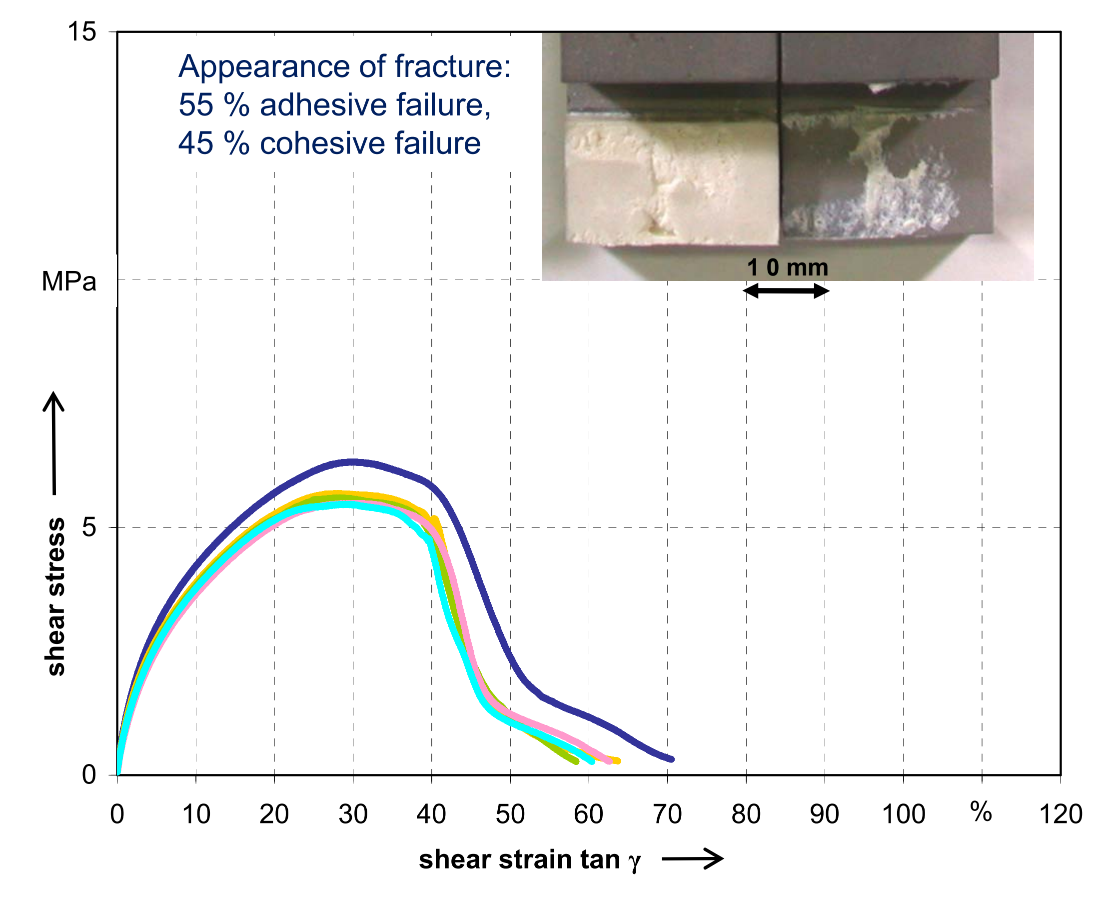
WP1: τ - γ tests on thick tensile specimens: PU155



Adhesive
PU155

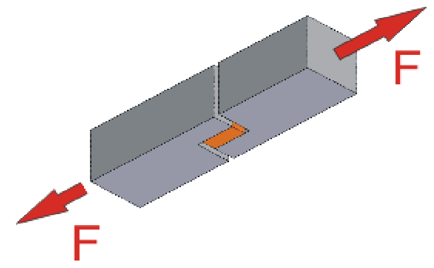
Curing
10 d at room temperature

Testing device
Zwick Z100

Testing velocity
depending on thickness of adhesive layer; $\dot{\gamma} \approx 0.006$ 1/s

Specimen
thick tensile specimen

Thickness of adhesive layer
3 mm



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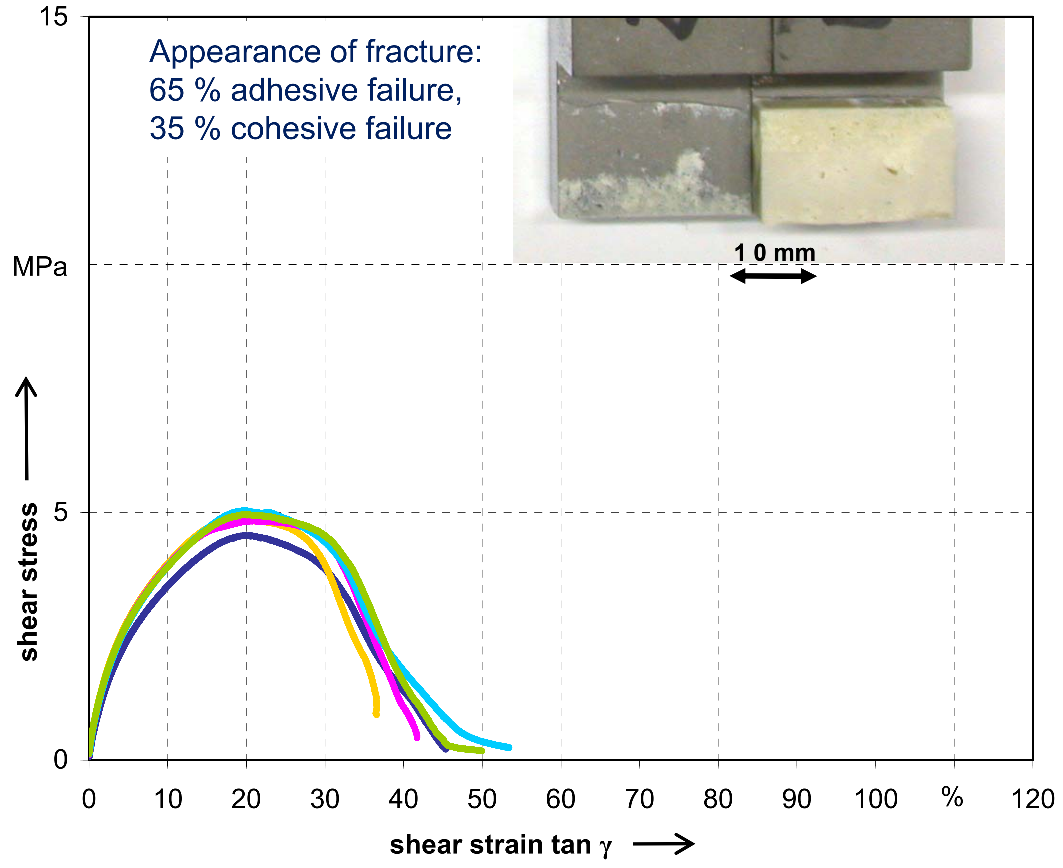
WP1: τ - γ tests on thick tensile specimens: PU155



Adhesive
PU155

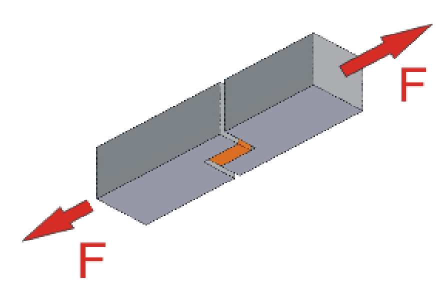
Curing
10 d at room temperature

Testing device
Zwick Z100

Testing velocity
depending on thickness of adhesive layer; $\dot{\gamma} \approx 0.01$ 1/s

Specimen
thick tensile specimen

Thickness of adhesive layer
5 mm



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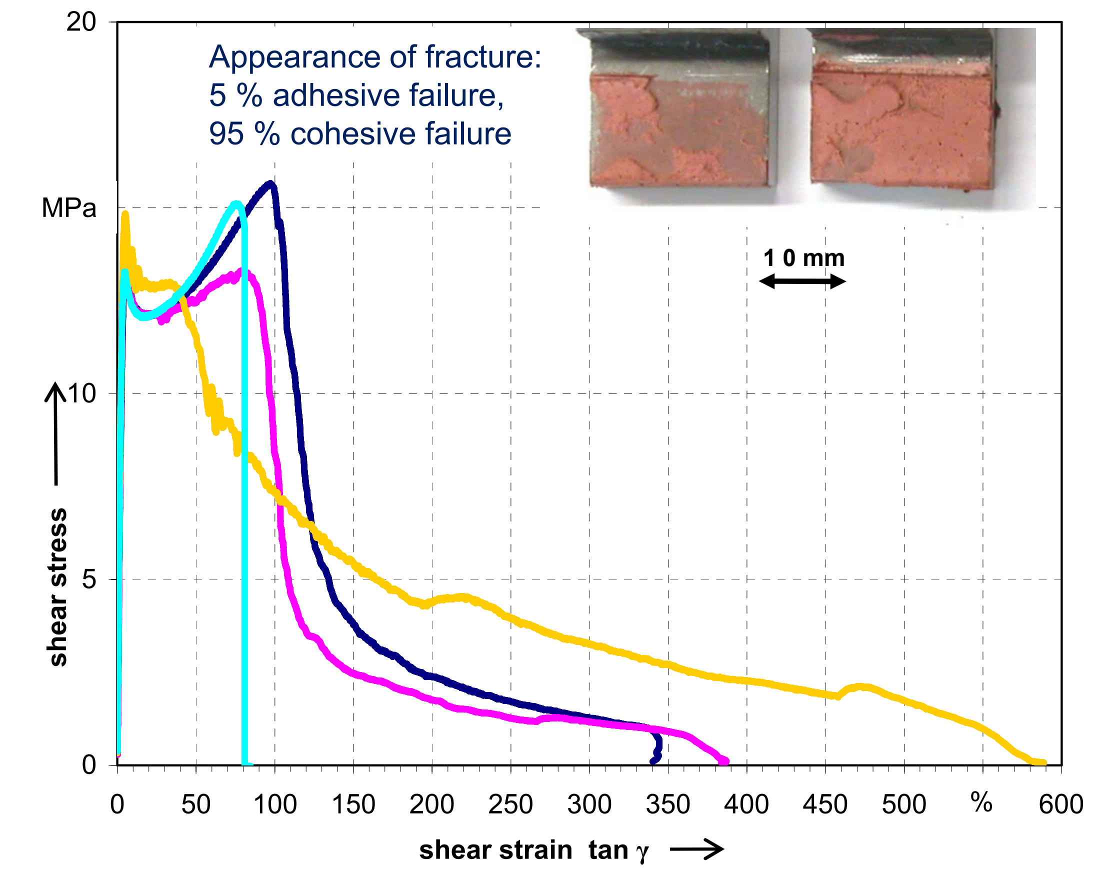
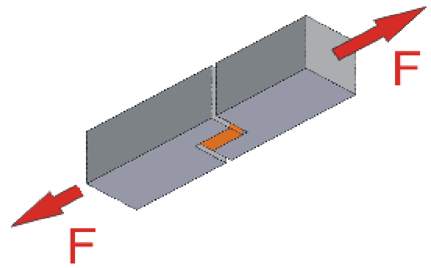
WP1: τ - γ tests on thick tensile specimens: PU156



Adhesive	PU156
Curing	10 d at room temperature
Testing device	Zwick Z100
Testing velocity	depending on thickness of adhesive layer, $\dot{\gamma} \approx 0.001$ 1/s
Specimen	thick tensile specimen
Thickness of adhesive layer	0.5 mm



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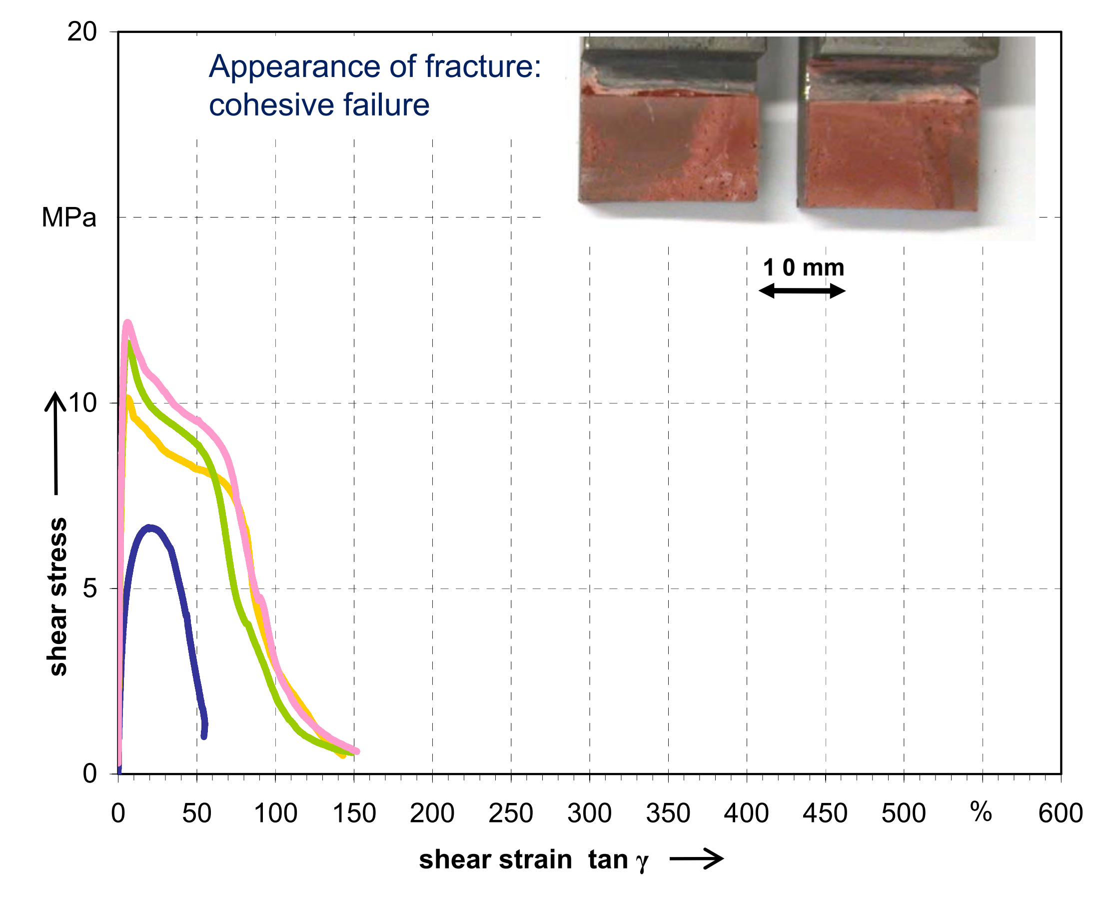
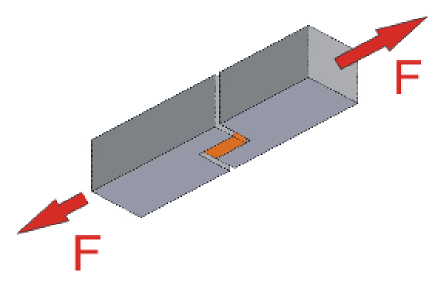
WP1: τ - γ tests on thick tensile specimens: PU156



Adhesive
PU156
Curing
10 d at room temperature
Testing device
Zwick Z100
Testing velocity
depending on thickness of adhesive layer; $\dot{\gamma} \approx 0.006$ 1/s
Specimen
thick tensile specimen
Thickness of adhesive layer
3 mm



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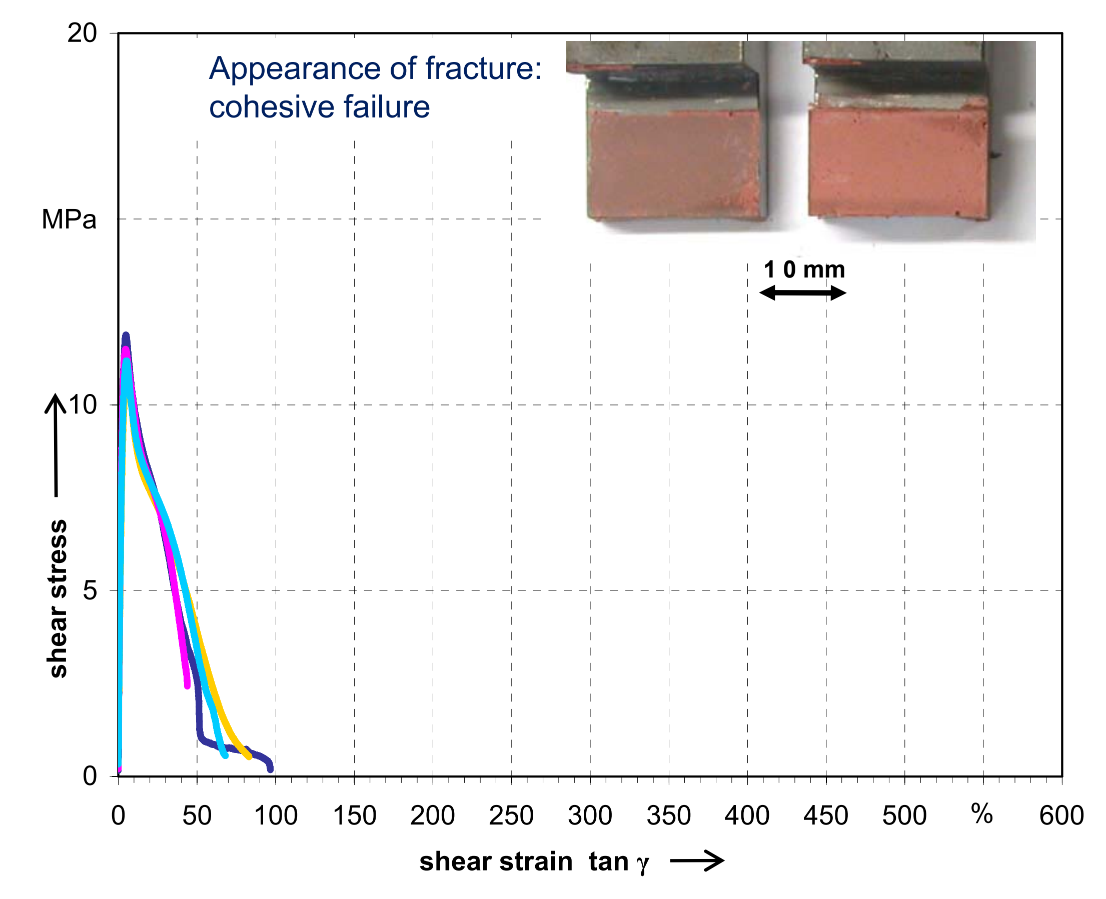
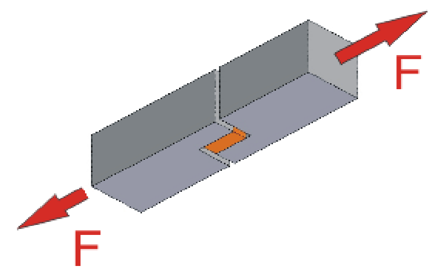
WP1: τ - γ tests on thick tensile specimens: PU156



Adhesive PU156
Curing 10 d at room temperature
Testing device Zwick Z100
Testing velocity depending on thickness of adhesive layer; $\dot{\gamma} \approx 0.01$ 1/s
Specimen thick tensile specimen
Thickness of adhesive layer 5 mm



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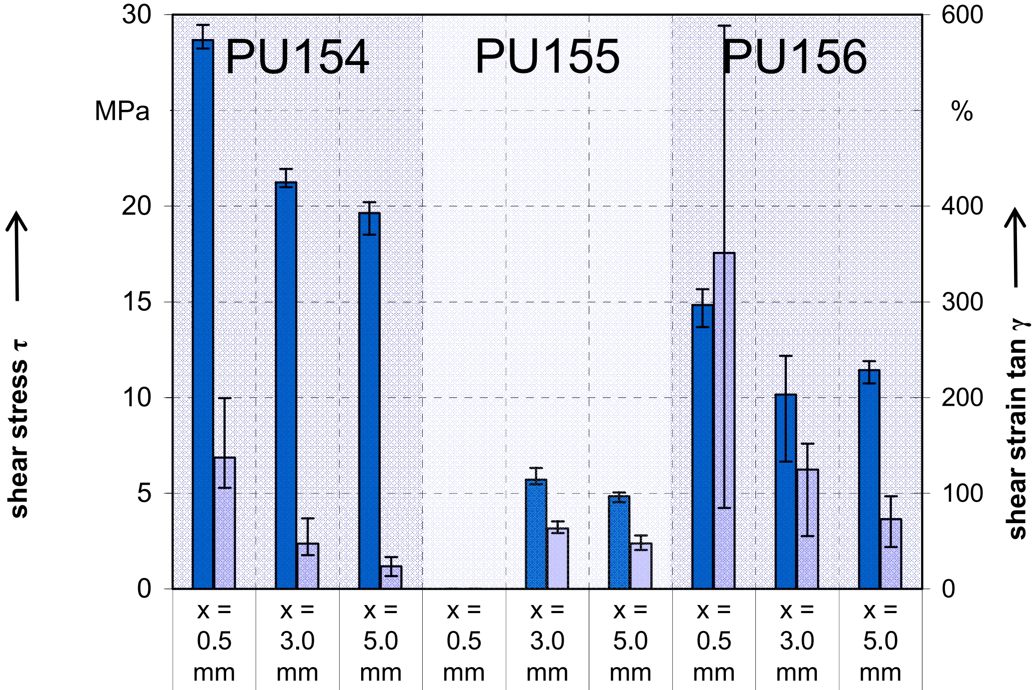
WP1: τ - γ tests on thick tensile specimens



	x = 0.5 mm	x = 3.0 mm	x = 5.0 mm	x = 0.5 mm	x = 3.0 mm	x = 5.0 mm	x = 0.5 mm	x = 3.0 mm	x = 5.0 mm
τ-max	28,67	21,25	19,64	0	5,712	4,839	14,83	10,15	11,43
+	0,792	0,686	0,561	0	0,61	0,195	0,836	2,027	0,478
-	0,446	0,258	1,133	0	0,244	0,307	1,147	3,5	0,693
tan γ-max	137,2	47,18	23,57	0	63,11	47,43	351,1	124,7	72,91

Adhesive
PU154, PU155; PU156

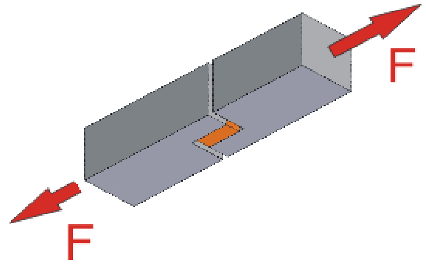
Curing
10 d at room temperature

Testing device
Zwick Z100

Testing velocity
depending on thickness of adhesive layer

Specimen
thick tensile specimen

Thickness of adhesive layer
x = see diagramm



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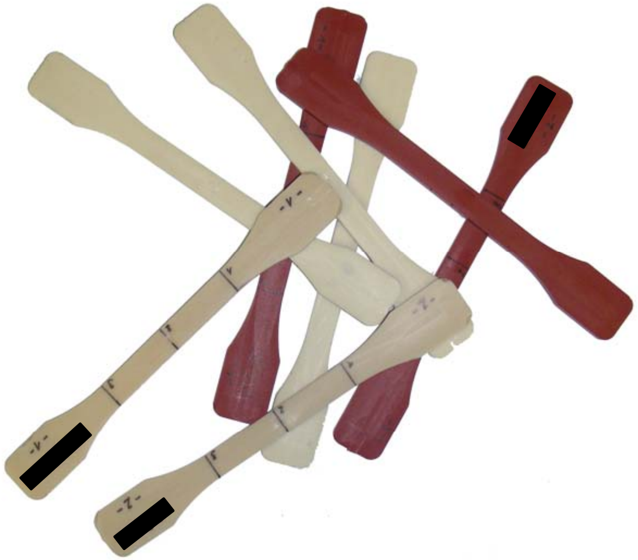
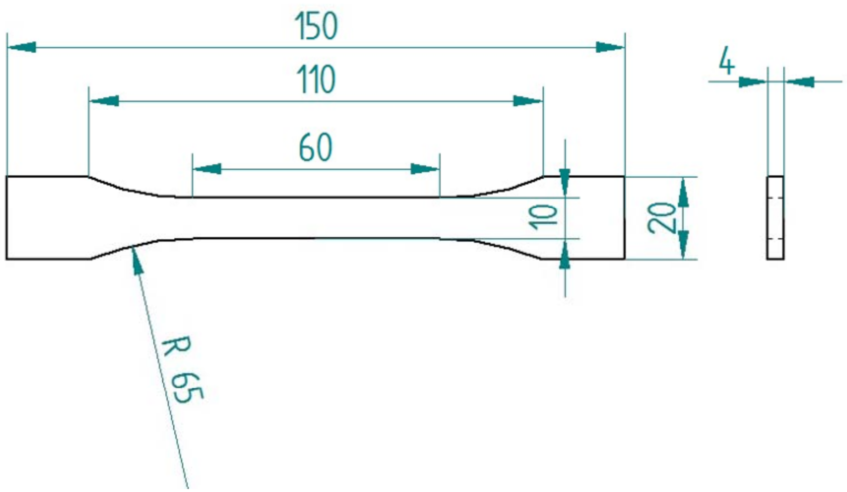
Increasing adhesive layer thicknesses are leading to decreasing shear stresses τ and decreasing shear strains tan γ.

WP1: σ - ε tests on tensile specimen (DIN ISO 527)

σ-ε tests: Tests performed according to DIN ISO 527 Plastics – Determination of tensile properties

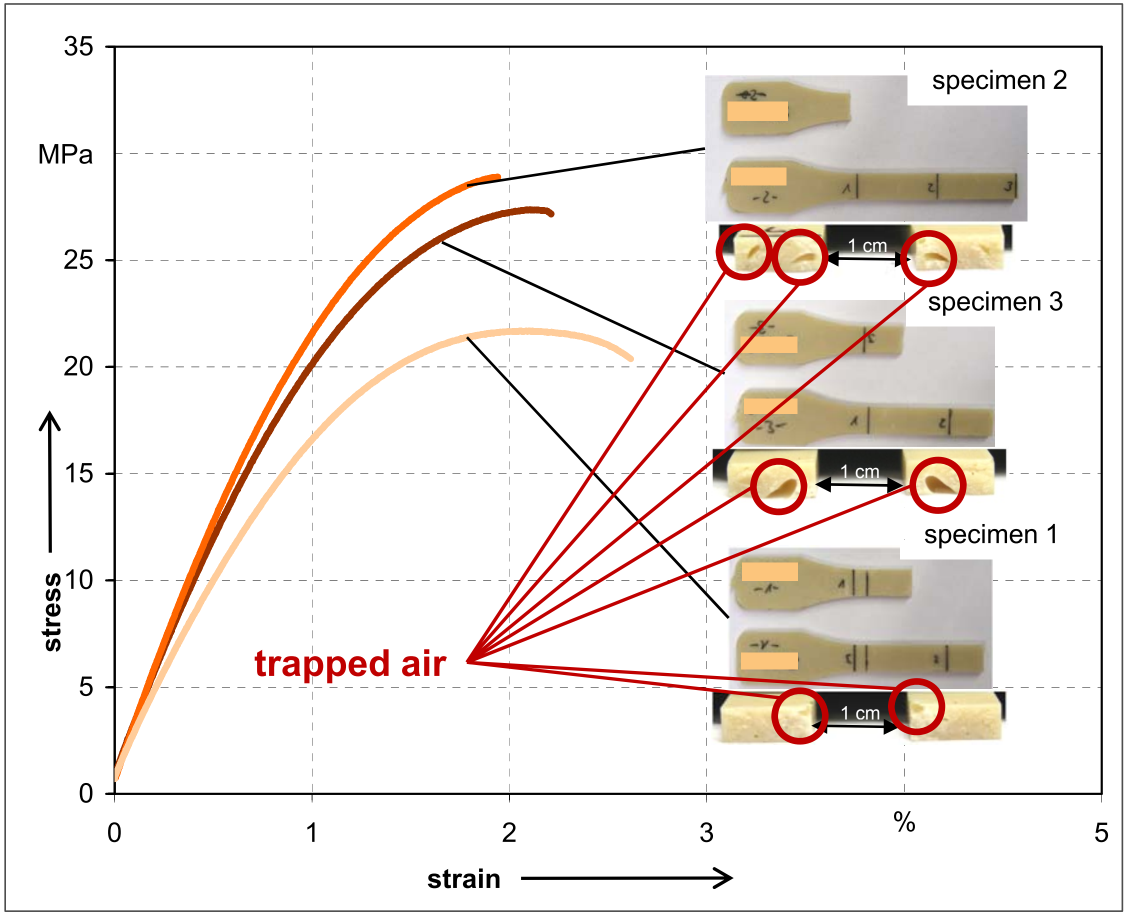
Specimen: tensile specimen made of proposed adhesives according to DIN ISO 527 type B



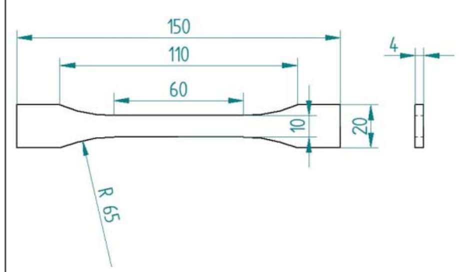


Testing device: Zwick Z100
Extensometer: Zwick digital macro extensometer
Testing velocity: 1 mm/min

WP1: σ - ε tests on tensile specimen: PU154



Adhesive
PU154
Curing
10 d at room temperature
Testing device
Zwick Z100
Testing Velocity
1 mm/min
Temperature
RT
Specimen
tensile specimen (DIN ISO 527)



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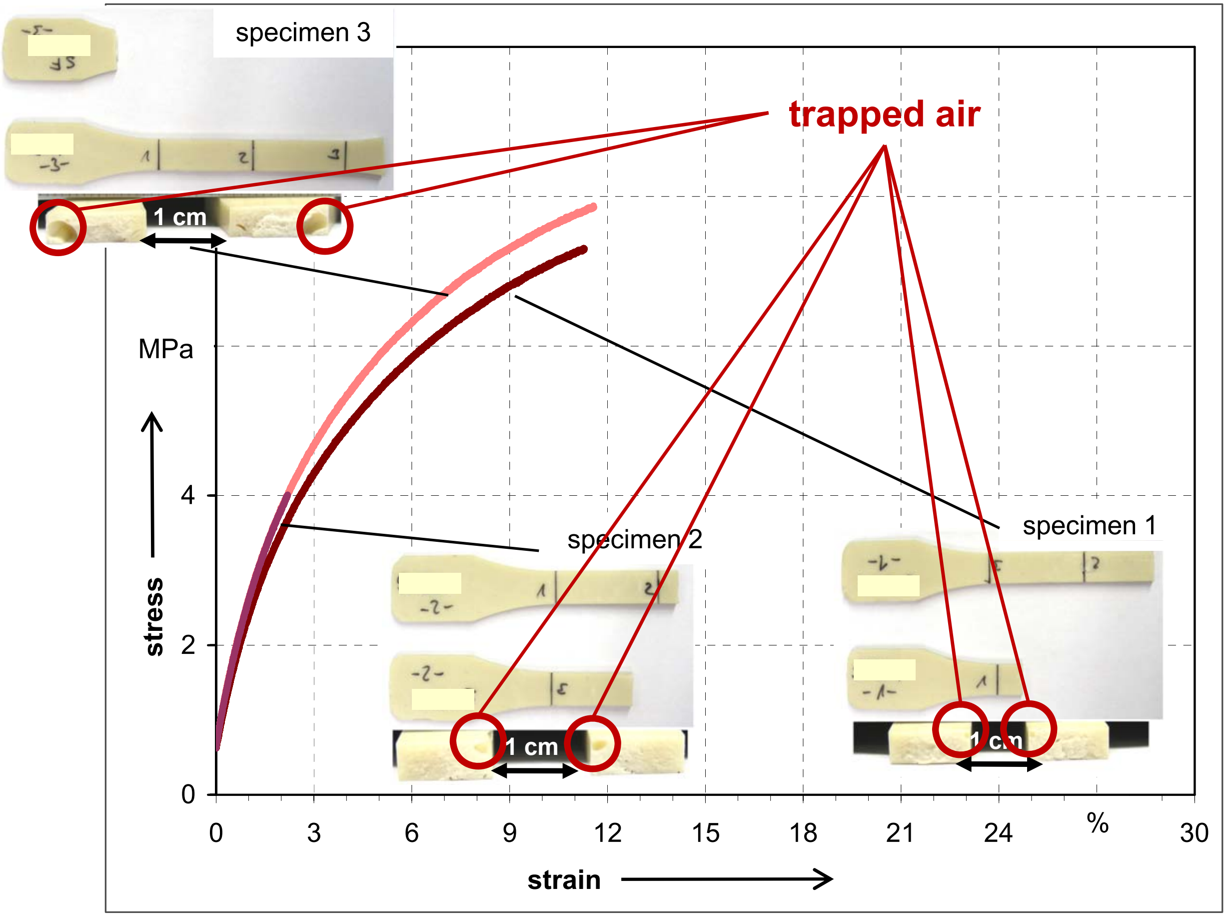
Problem: trapped air and shrink holes affecting the results

WP1: σ - ε tests on tensile specimen: PU155



Adhesive
PU155

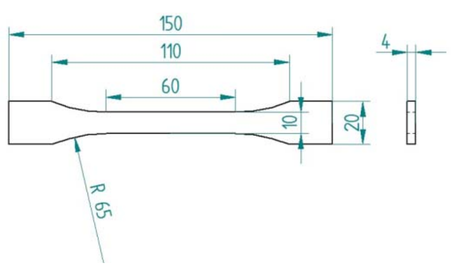
Curing
10 d at room temperature

Testing device
Zwick Z100

Testing Velocity
1 mm/min

Temperature
RT

Specimen
tensile specimen (DIN ISO 527)



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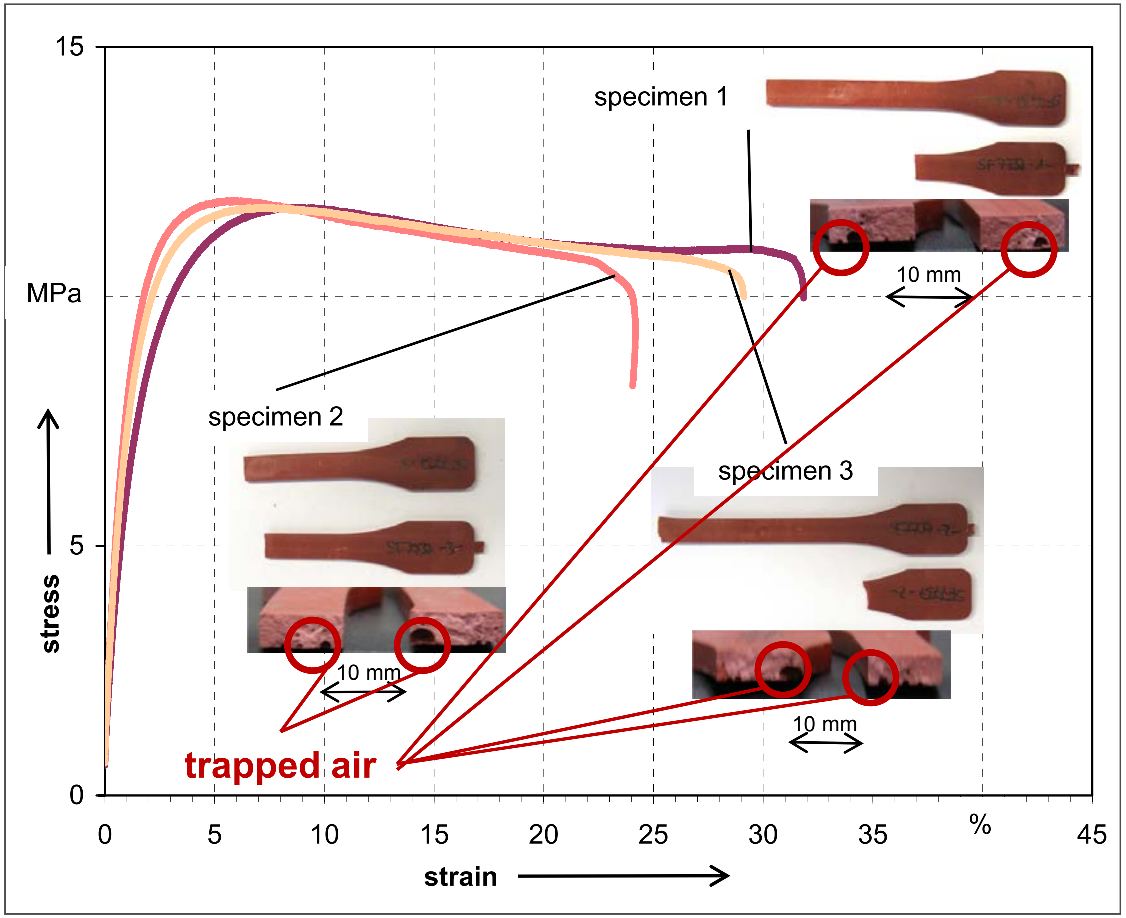
Problem: trapped air and shrink holes affecting the results

WP1: σ - ε tests on tensile specimen: PU156



Adhesive
PU156

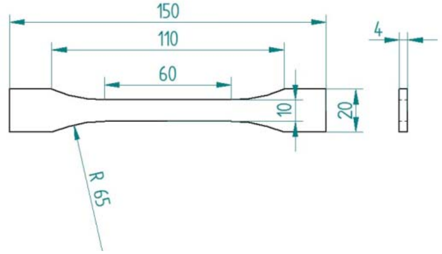
Curing
10 d at room temperature

Testing device
Zwick Z100

Testing Velocity
1 mm/min

Temperature
RT

Specimen
tensile specimen (DIN ISO 527)



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Problem: trapped air and shrink holes affecting the results

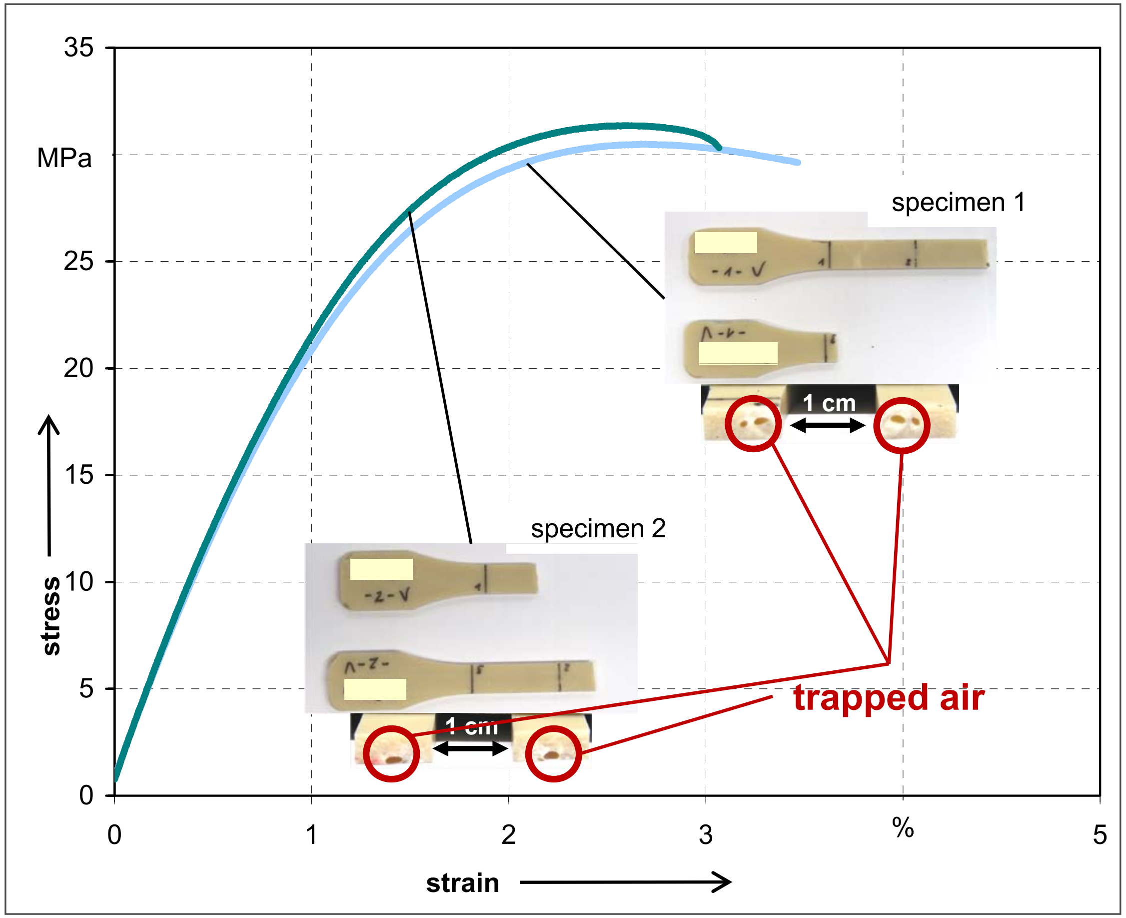
WP1: σ - ε tests on tensile specimen (DIN ISO 527)

Problem: trapped air / gas in the adhesive bulk

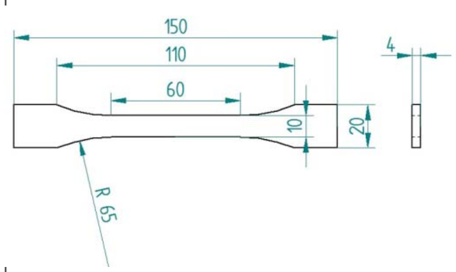
Approach:

- before mixing, resin and hardener are evacuated using a vacuum pump, to exhaust gases possibly dissolved in the adhesive's matrix
- the used moulds were filled using a pneumatically driven cartridge system. The use of this system should prevent airtrapping during the casting process as it can possibly occur while filling the moulds using a spatula
- for application only low air pressures were used; the applicated glue bead could fill up the complete mould at once

WP1: σ - ε tests on tensile specimen: PU154 vac.



Adhesive
PU154
Curing
10 d at room temperature
Testing device
Zwick Z100
Testing Velocity
1 mm/min
Temperature
RT
Specimen
tensile specimen (DIN ISO 527)



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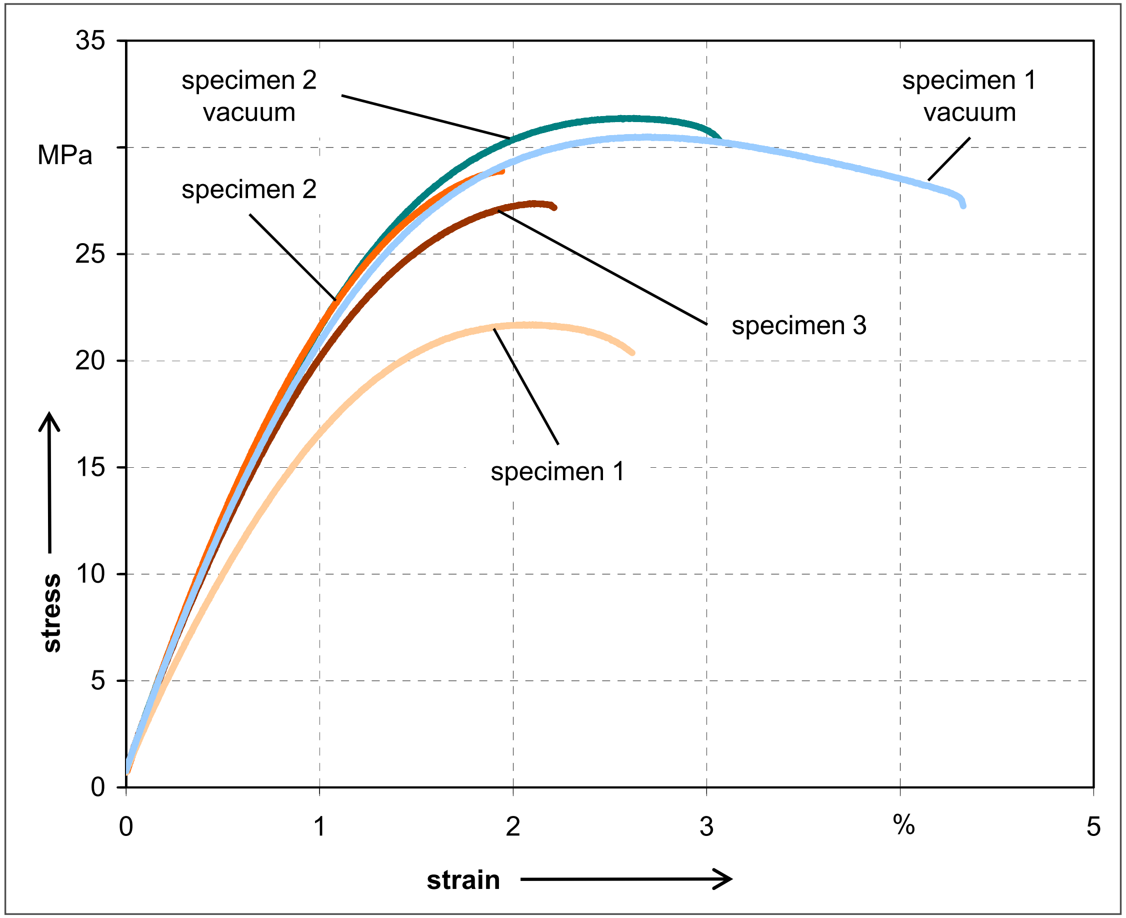
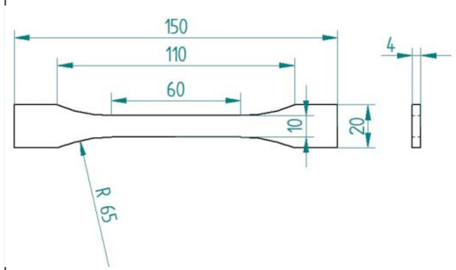
Problem: despite using vacuum, trapped air is still in the adhesive bulk

WP1: σ - ε tests on tensile specimen: PU154 & PU154 vac.

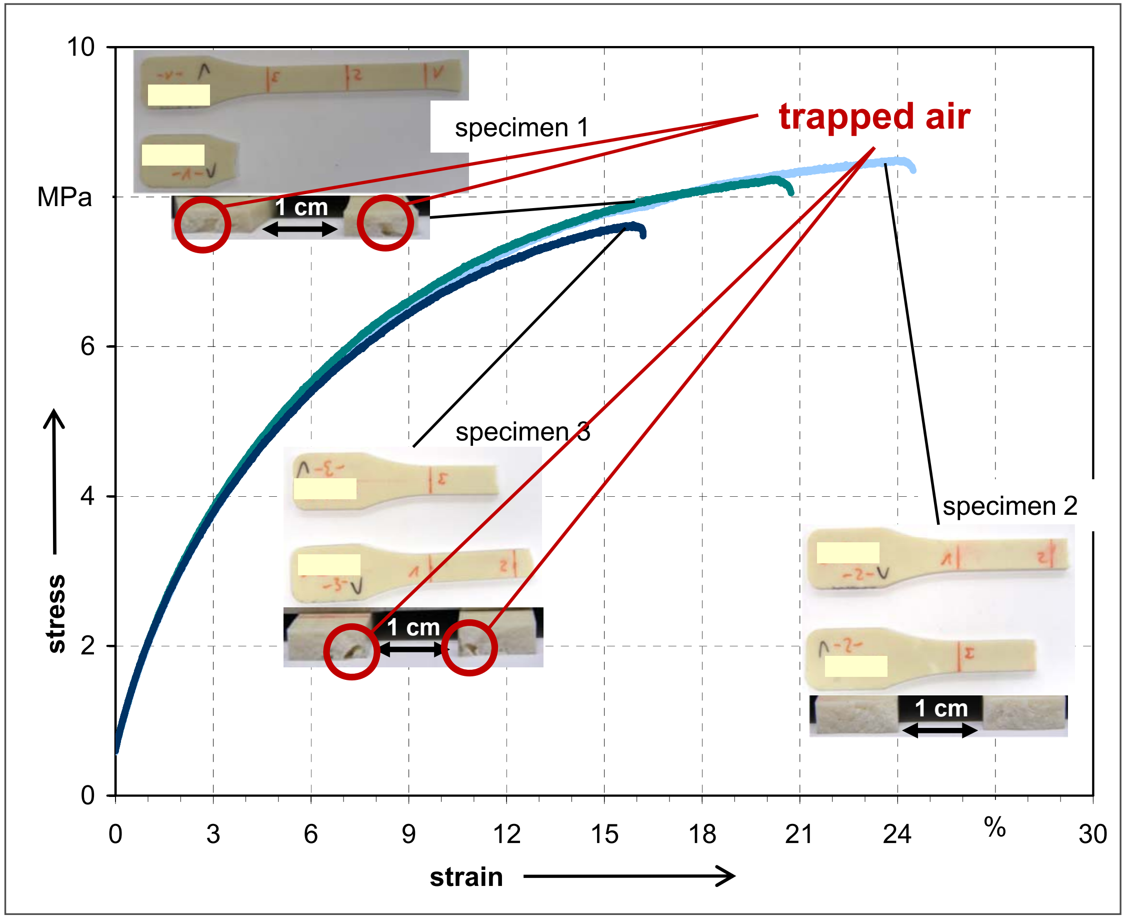


Adhesive	PU154
Curing	10 d at room temperature
Testing device	Zwick Z100
Testing Velocity	1 mm/min
Temperature	RT
Specimen	tensile specimen (DIN ISO 527)



Evacuating the adhesive components does not affect Young's modulus. Maximum stresses and elongation at break could be increased.

WP1: σ - ε tests on tensile specimen: PU155 vac.



Adhesive
PU155

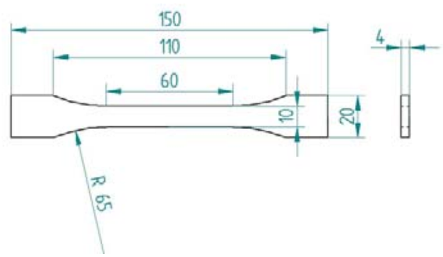
Curing
10 d at room temperature

Testing device
Zwick Z100

Testing Velocity
1 mm/min

Temperature
RT

Specimen
tensile specimen (DIN ISO 527)



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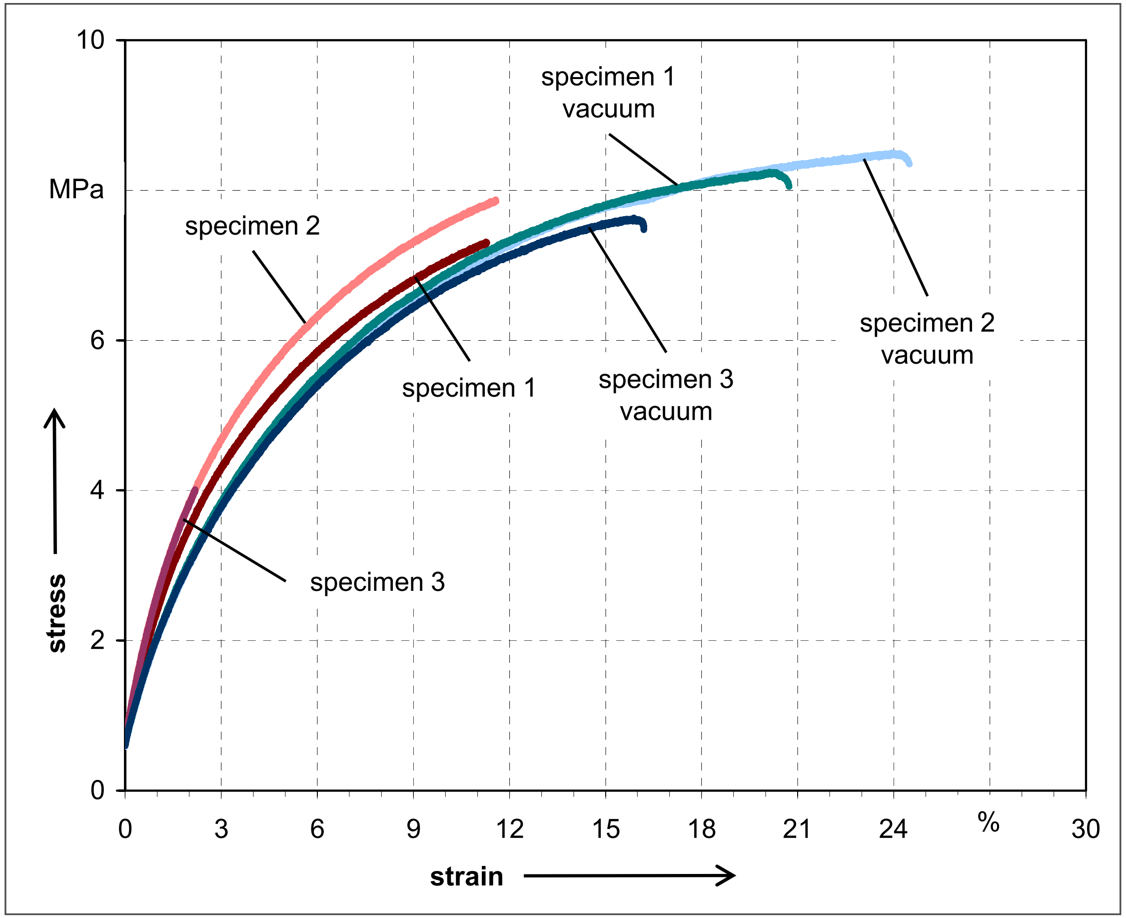
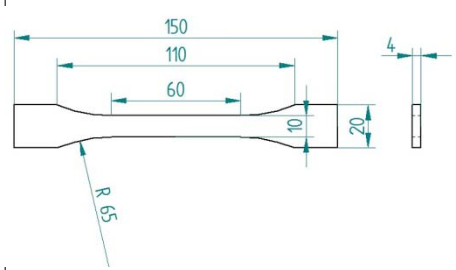
Problem: despite using vacuum, trapped air is still in the adhesive bulk

WP1: σ - ε tests on tensile specimen: PU155 & PU155 vac.

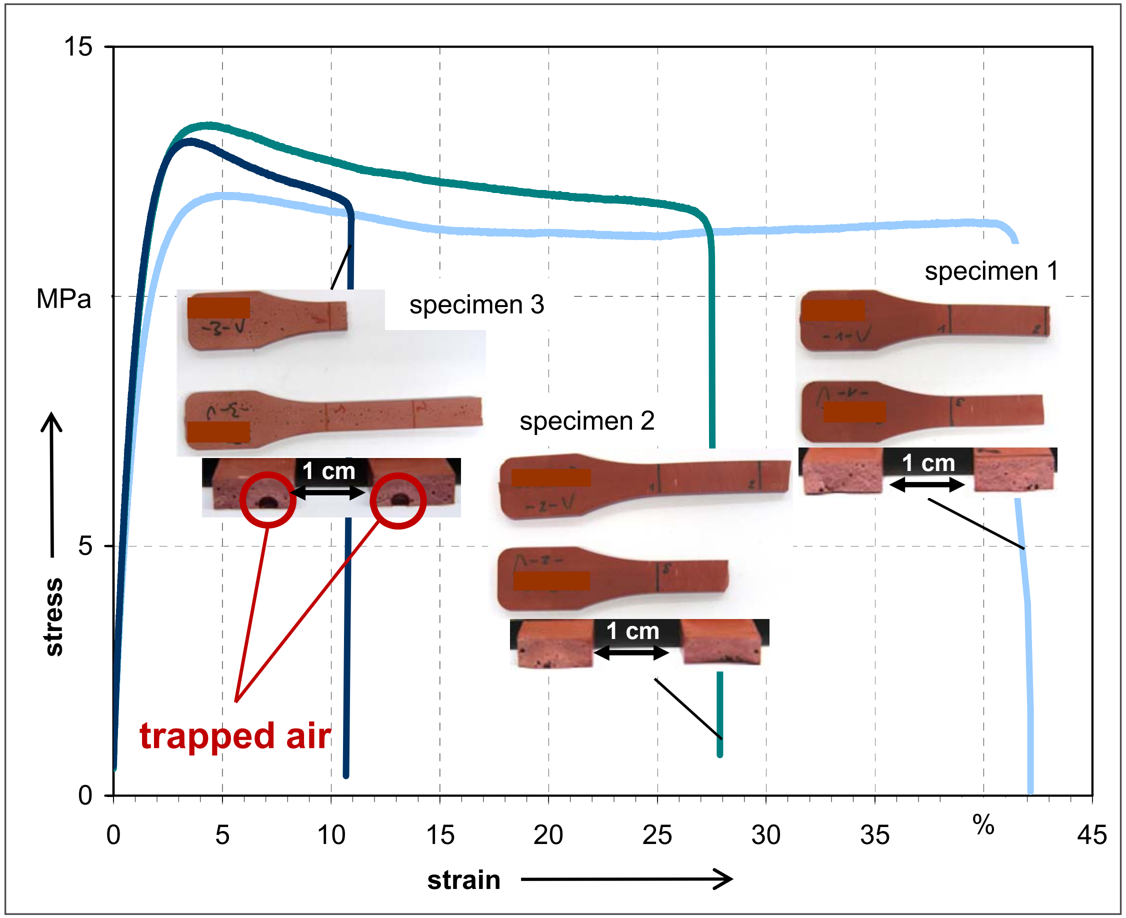


Adhesive PU155
Curing 10 d at room temperature
Testing device Zwick Z100
Testing Velocity 1 mm/min
Temperature RT
Specimen tensile specimen (DIN ISO 527)
Hahn / Boeddeker © LWF 2008



Using evacuated adhesive components decreased Young‘s modulus. Maximum stresses and elongation at break could be increased.

WP1: σ - ε tests on tensile specimen: PU156 vac.



Adhesive
PU156

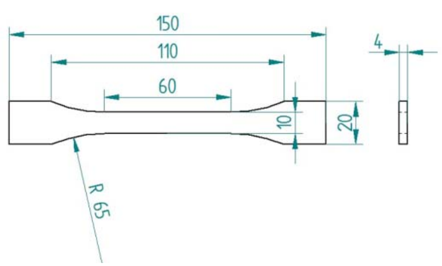
Curing
10 d at room temperature

Testing device
Zwick Z100

Testing Velocity
1 mm/min

Temperature
RT

Specimen
tensile specimen (DIN ISO 527)



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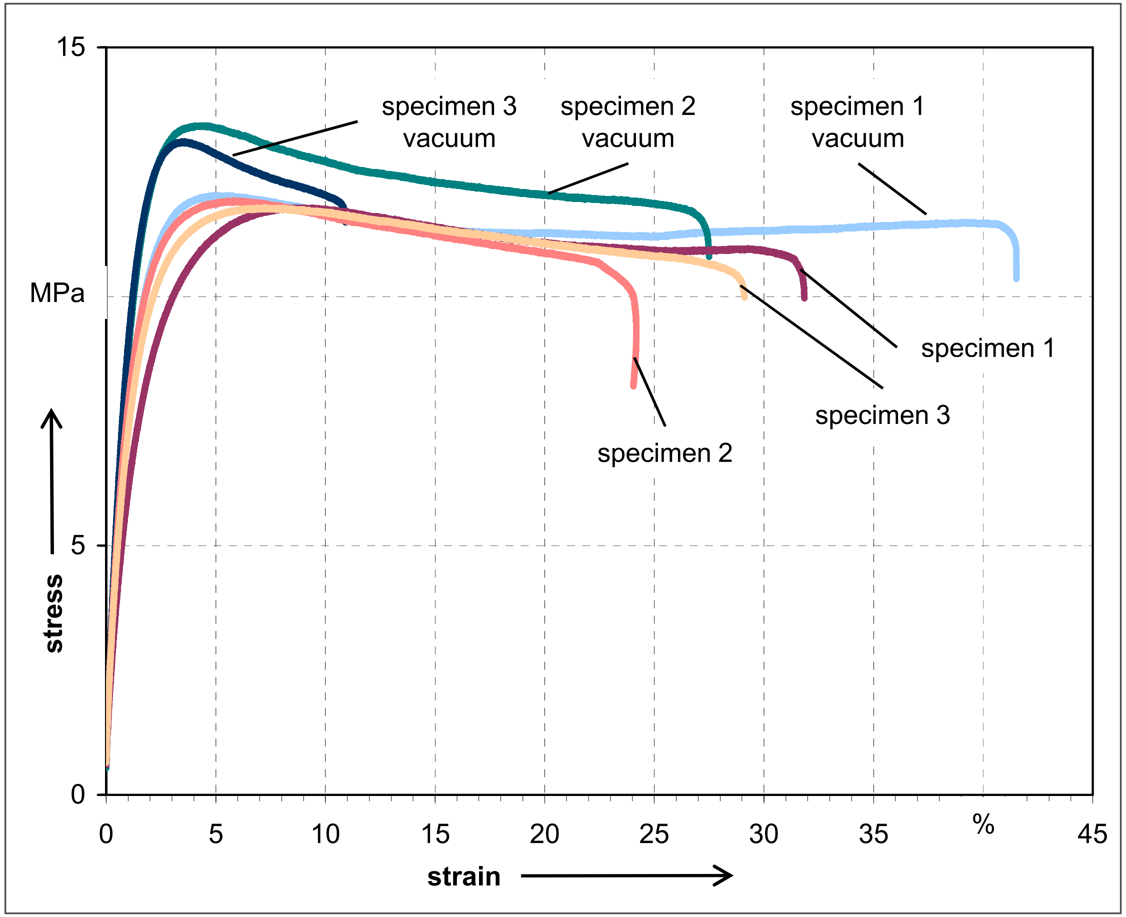
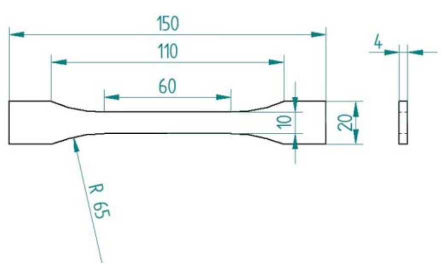
Trapped air has negative effects on elongation at break of the specimens. Young‘s modulus is not affected.

WP1: σ - ε tests on tensile specimen: PU156 & PU156 vac.



Adhesive PU156
Curing 10 d at room temperature
Testing device Zwick Z100
Testing Velocity 1 mm/min
Temperature RT
Specimen tensile specimen (DIN ISO 527)



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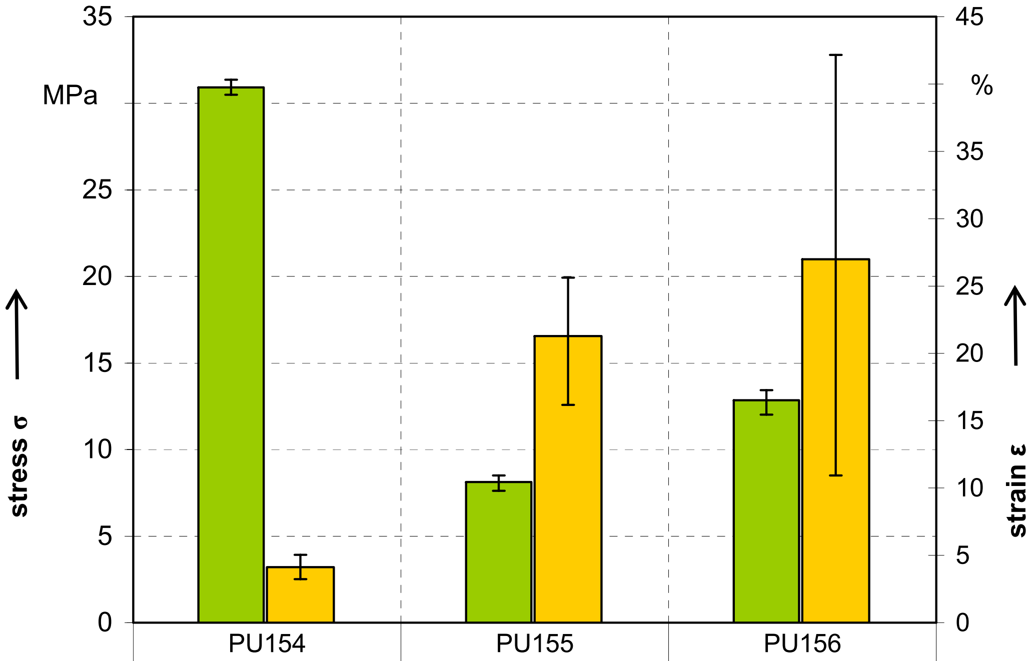
Using evacuated adhesive components increases maximum stresses and elongation at break.

WP1: σ - ε tests on tensile specimen



	PU154	PU155	PU156
σ-max	30,93	8,12	12,86
+	0,44	0,37	0,57
-	0,43	0,49	0,83
ε-max	4,14	21,28	26,99

Adhesive
PU154, PU155, PU156

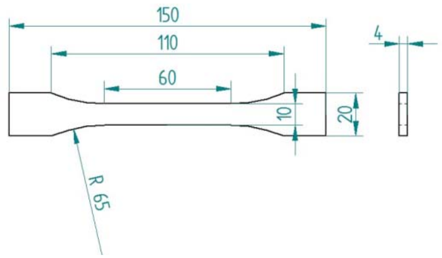
Curing
10 d at room temperature

Testing device
Zwick Z100

Testing Velocity
1 mm/min

Temperature
RT

Specimen
tensile specimen (DIN ISO 527)



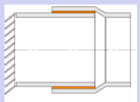
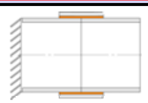
Hahn / Boeddeker

WP1: Choice of joint design
- benchmarking

For choosing a joint design, a benchmark was performed using the following criteria:

- Production: every step necessary to create the specific pipe geometry for pipe bonding
- Flow obstruction/Piggability: cranks obstructing flow of conducted medium and usage of pigs
- Resources: needed material and adhesives to bond pipes adhesively
- Strength: progress of stress in the bondline of adhesively bonded pipes
- Assembly: all work necessary to bond pipes adhesively under field conditions

WP1: Choice of joint design
- benchmarking

			Production	Flow/ Piggability	Resources	Strength	Assembly	
		weighting coefficient	0,1	0,3	0,3	0,1	0,2	Σ = 1
option 1		benchmarking	5	8	7	7	7	
		weighting	0,5	2,4	2,1	0,7	1,4	7,1
option 2		benchmarking	10	4	3	9	7	
		weighting	1	1,2	0,9	0,9	1,4	5,4
option 3		benchmarking	4	5	4	3	6	
		weighting	0,4	1,5	1,2	0,3	1,2	4,6
option 4		benchmarking	2	10	7	3	6	
		weighting	0,2	3	2,1	0,3	1,2	6,8
option 5		benchmarking	2	10	7	7	7	
		weighting	0,2	3	2,1	0,7	1,4	7,4
option 6		benchmarking	8	3	6	9	6	
		weighting	0,8	0,9	1,8	0,9	1,2	5,6
option 7		benchmarking	9	3	7	5	7	
		weighting	0,9	0,9	2,1	0,5	1,4	5,8
option 8		benchmarking	9	10	7	5	9	
		weighting	0,9	3	2,1	0,5	1,8	8,1

WP1: Concept for pipe joining

Basing on the chosen joint design, a concept for pipe joining was developed:

step 1:

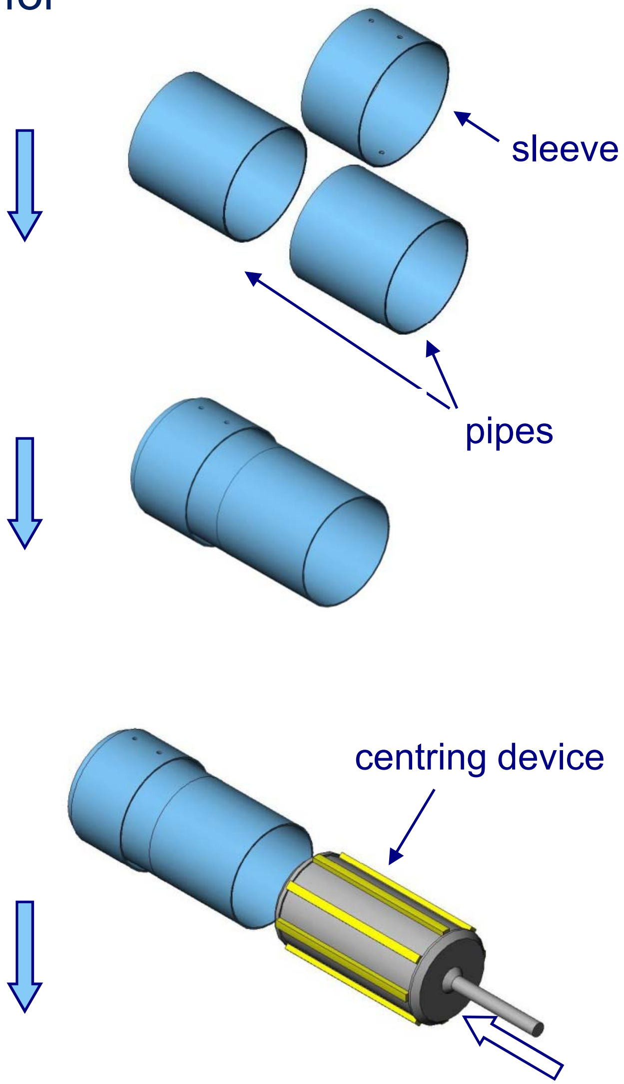
For joining, pipes and a sleeve are needed

step 2:

After sliding the sleeve over the pipe already laid, the ends of the pipes to be joined are positioned to each other.

step 3:

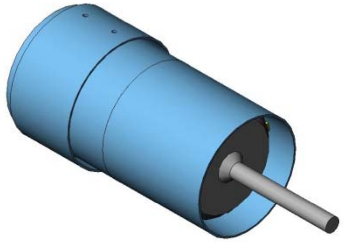
To align the pipes, a centring device is inserted into the pipes.



WP1: Concept for pipe joining

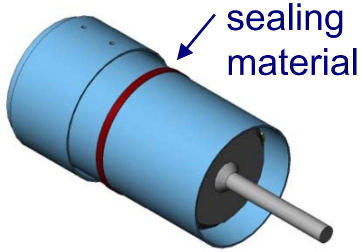
step 4:

Hydraulic clamps lock the aligned pipes into position.



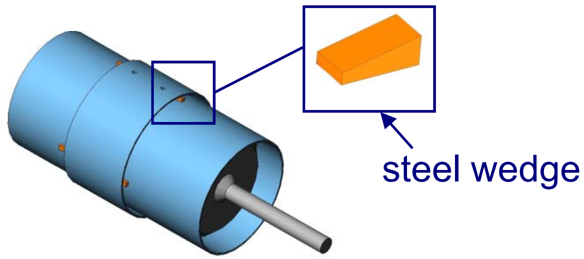
step 5:

To avoid contact between the adhesive and the transported medium, a sealing material is applied to the gap between the pipes.



step 6:

Adjusting a defined glue line between the bonding components will be realised by using small steel wedges which will be driven into the gap.



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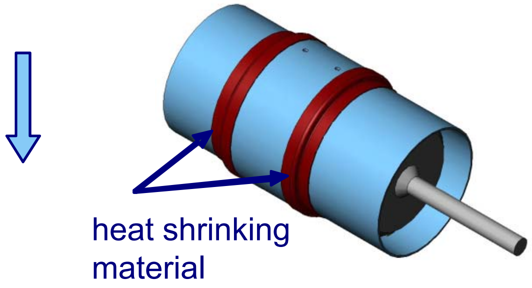
Dipl.-Ing. T. Boeddeker

WP1: Concept for pipe joining

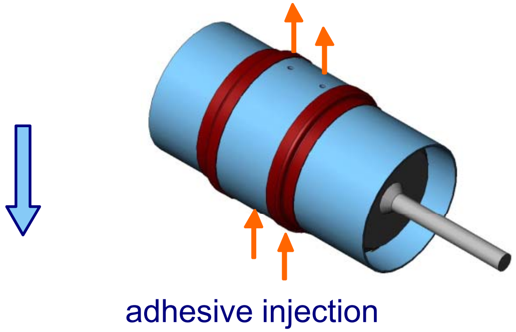
step 7:

To prevent an adhesive leakage off the glue line, the gap between sleeve and pipes is sealed with heat shrinking materials.



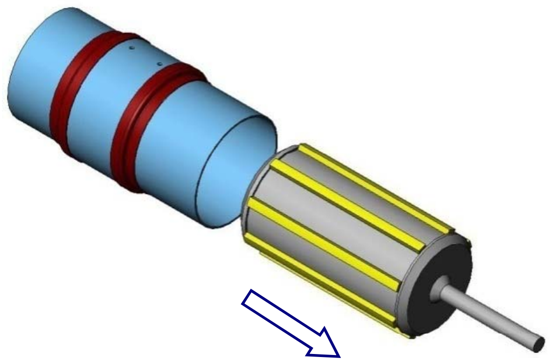
step 8:

The adhesive will be injected through holes into the gap, until it leakes out of the upper boreholes. That guarantees a complete gap-filling.



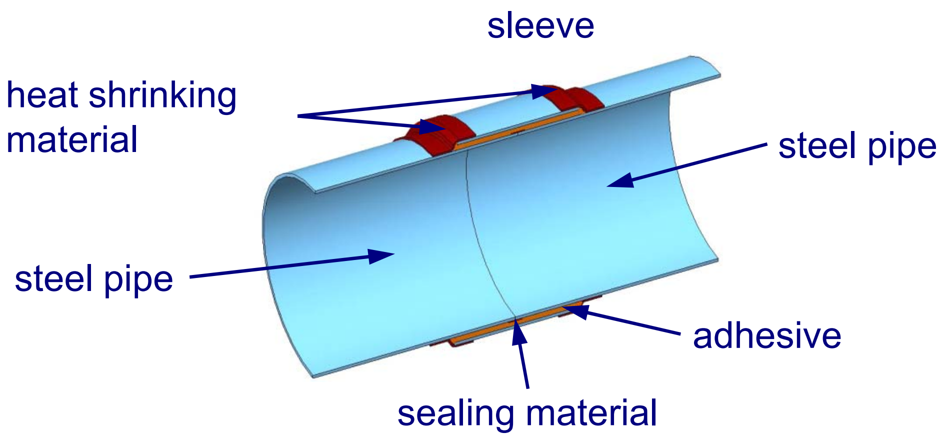
step 9:

After curing, the centering device can be removed.



Pipes bonded adhesively!

WP1: Concept for pipe joining



cut-away view of adhesively bonded pipes

Features:

- application of materials and methods already in use on pipeline construction sites
- easy to define and reliable glue line
- filling of the gap can be easily checked
- separation of adhesive and conducted medium
- easy adhesive application
- corrosion protection of blank sleeve‘s edges
- cathodic corrosion protection possible

WP1: Transfer of the pipe joining concept into reality
- Joint geometry and application method

To proof the feasibility of the presented pipe joining concept, tests with small pipes were and will be performed.

Material & geometrical properties of used pipes:

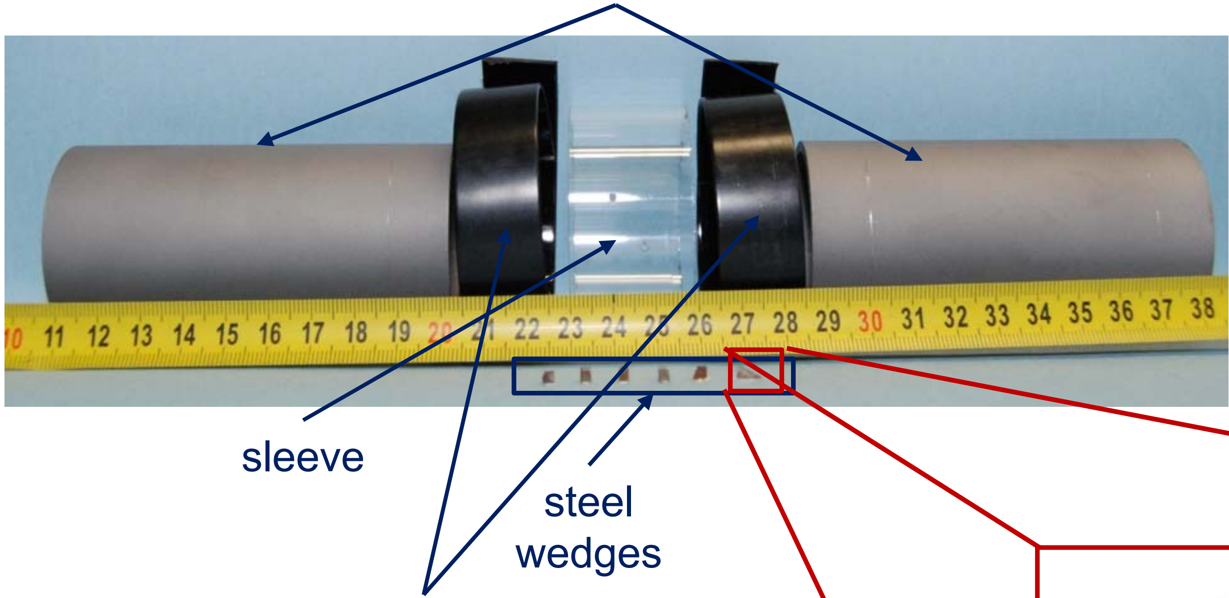
	geometry	material
Pipe	50 x 3 mm	S235-JR
Sleeve	60 x 3 mm	S355J2G3

Material & geometrical properties of fixing materials:

	geometry	material
Steel wedges	5 x 2,5 mm	S235-JR
Shrinking material	Ø d = 77 mm to Ø d = 22 mm	modified polyolefins

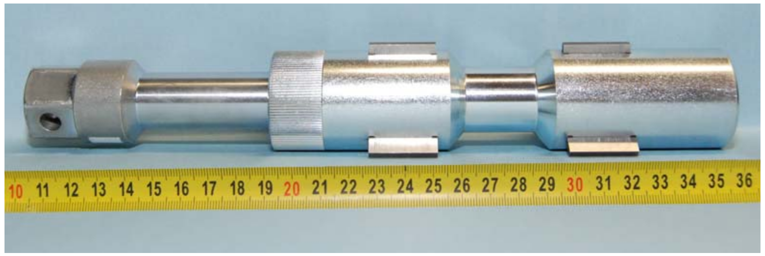
WP1: Transfer of the pipe joining concept into reality

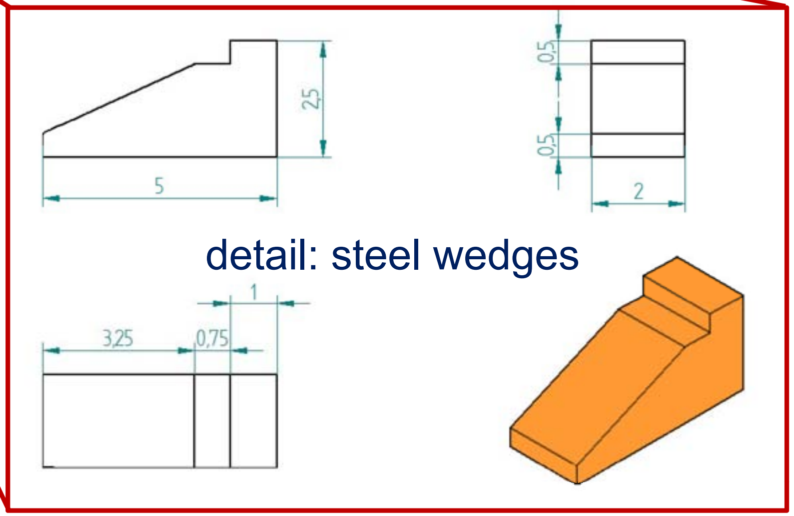
- Joint geometry and application method



Needed material:
- steel pipes
- sleeve (acrylic glass/steel)
- steel wedges
- heat shrinking material

centring device



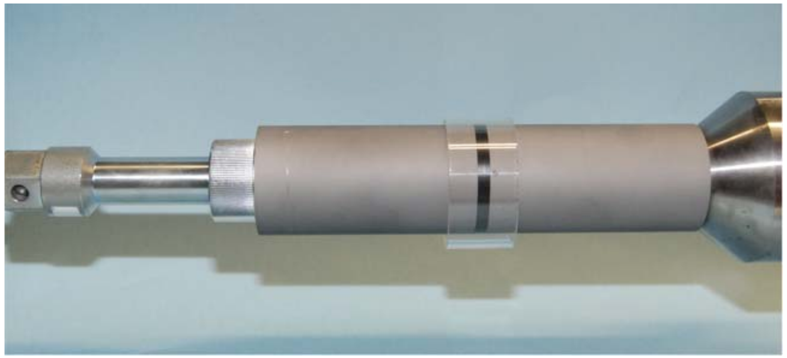


WP1: Transfer of the pipe joining concept into reality

- Joint geometry and application method

step 1: centring of pipes

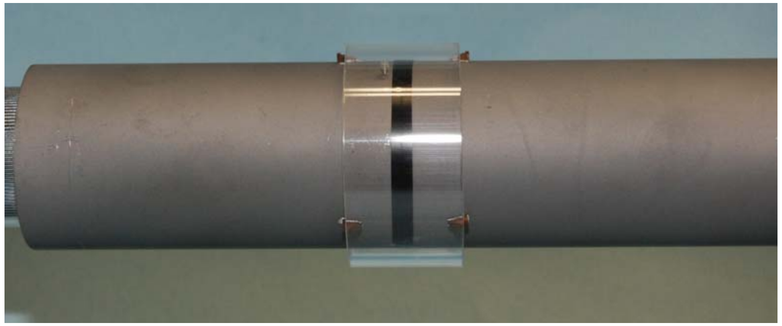
step 2: sealing of abutting edges



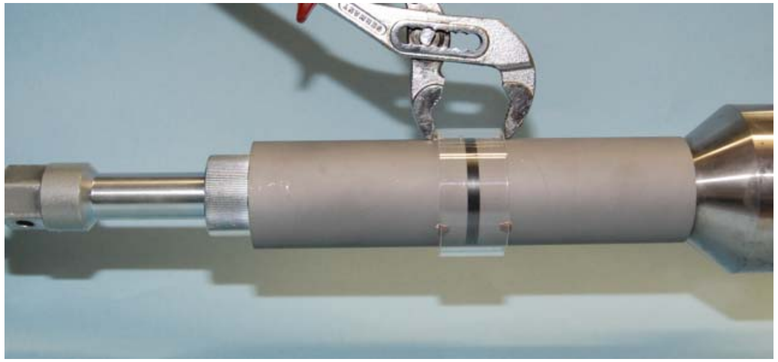
step 3: positioning of the sleeve

step 4a: defining the glue line using steel wedges

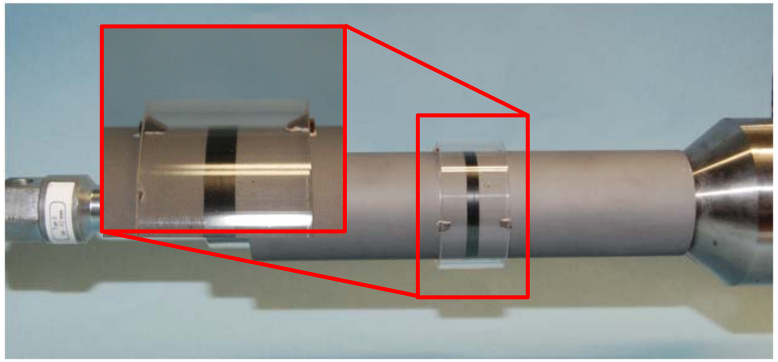
WP1: Transfer of the pipe joining concept into reality
- Joint geometry and application method



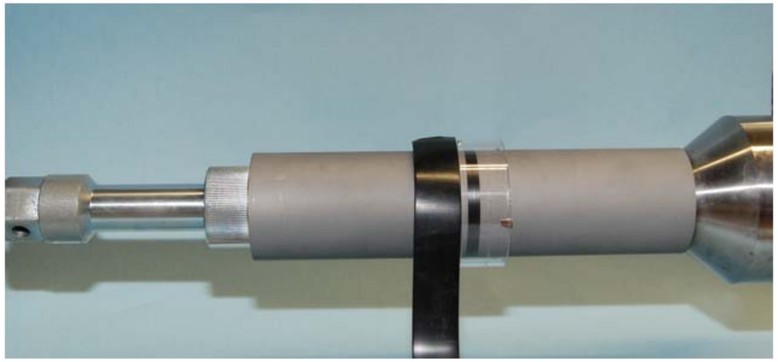
step 4b: steel wedges put on the other side of the sleeve



step 4c: last pair of steel wedges is driven into the glue line

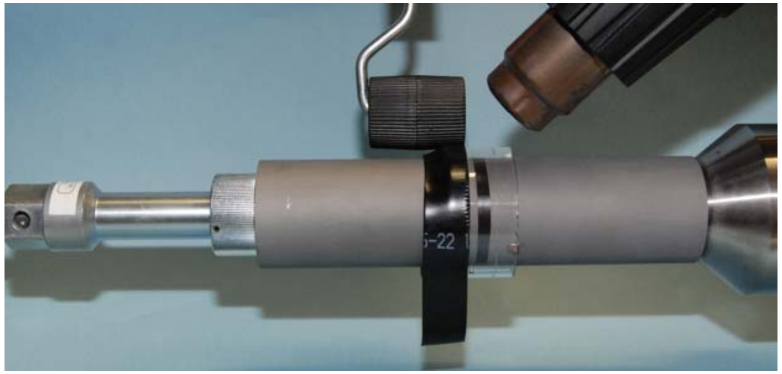


step 4d: detail of adjusted sleeve

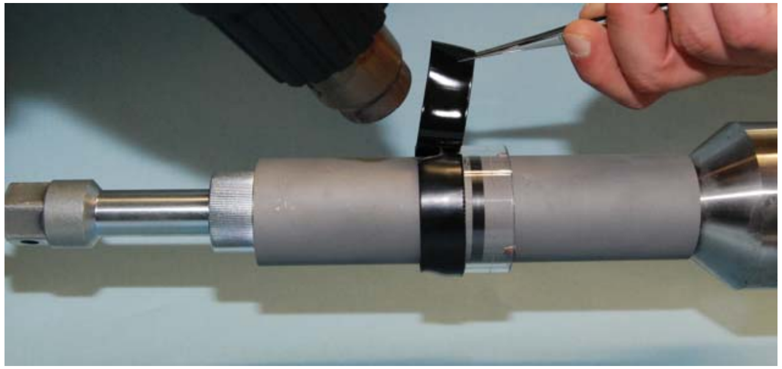


step 5a: application of shrinking material; tacking of the shrinking tube

WP1: Transfer of the pipe joining concept into reality
- Joint geometry and application method



step 5b: shrink-fit on the whole circumference



step 5c: sealing the overlap of the shrinking material

step 5d: sealing the overlap of the shrinking material

step 6: specimen prepared for adhesive injection

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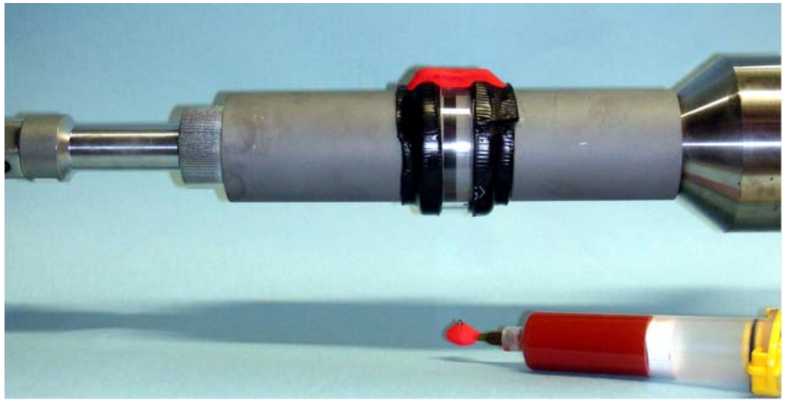
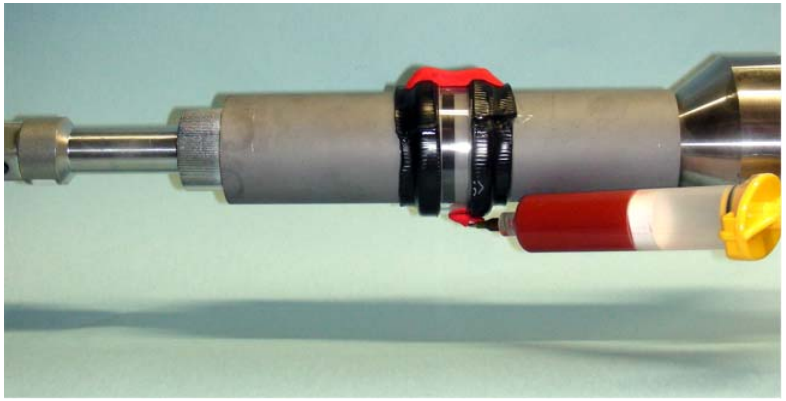
WP1: Transfer of the pipe joining concept into reality
- Joint geometry and application method



step 6a: sealing of the upper hole

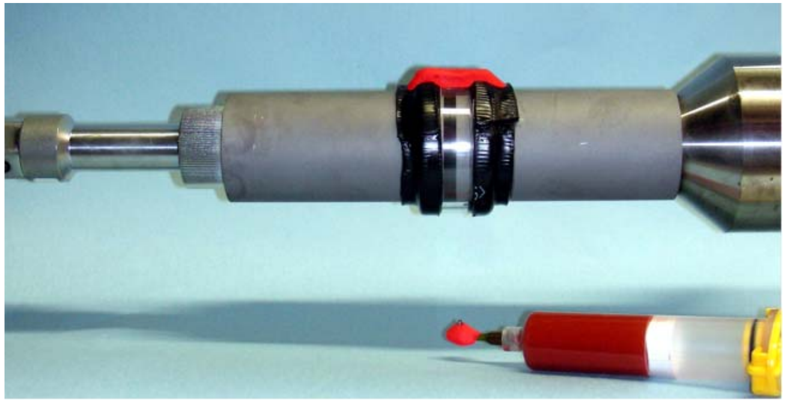


step 6b: injection starts using a pressure air cartridge

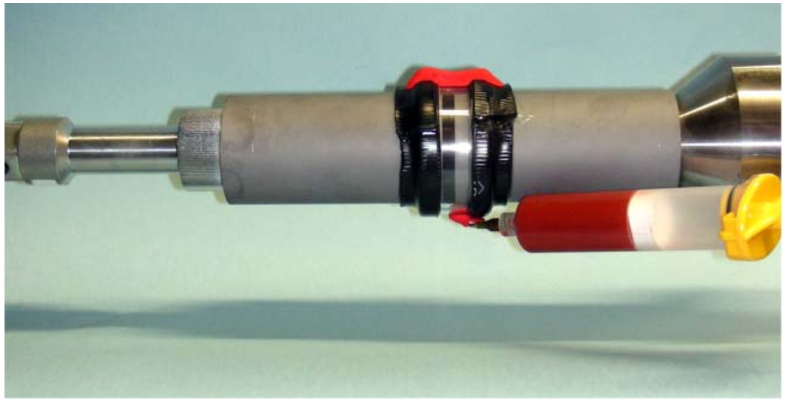
step 6b: filling of the gap

step 6c: injection complete, pipe joined

WP1: Transfer of the pipe joining concept into reality
- Joint geometry and application method



step 6a: sealing of the upper hole



step 6b: injection starts using a pressure air cartridge

step 6b: filling of the gap

step 6c: injection complete, pipe joined

WP1: Transfer of the pipe joining concept into reality
- Filling of the gap

Filling of the gap depends on following parameters:

- position of the injection holes
- pressure of adhesive injection
- viscosity of the adhesive
- geometry of the joint

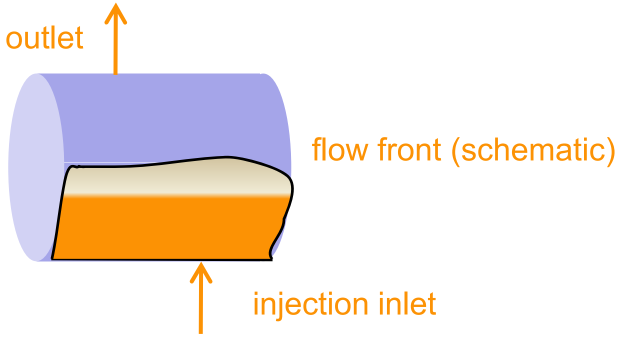
⇒ Tests were and will be performed to determine the influences of this parameters on the filling of the gap.

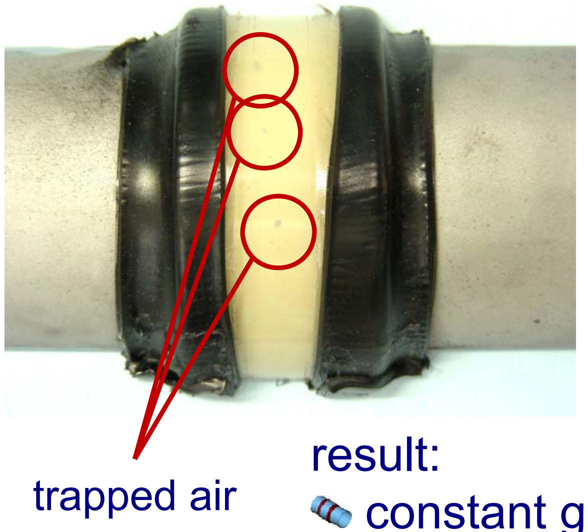
First tests were performed using the adhesives PU154 and PU156s.

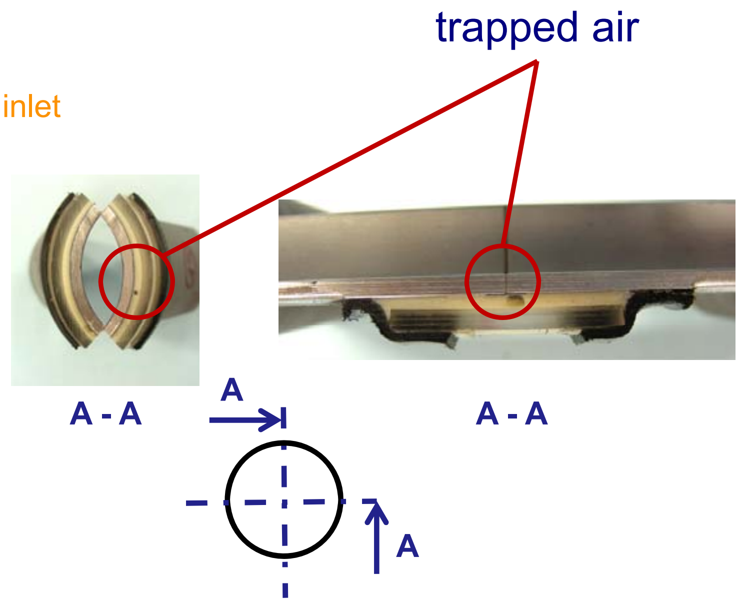
WP1: Transfer of the pipe joining concept into reality
- Filling of the gap: PU154

Parameters:

Adhesive	PU 154
Viscosity	pasty
Overlapping	30 mm
air pressure	1 bar







result:

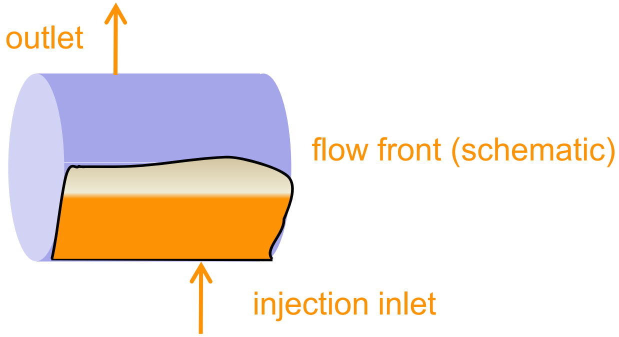
- constant glue line
- trapped air over the whole circumference, maybe caused by bubbles in the cartridge for adhesive application

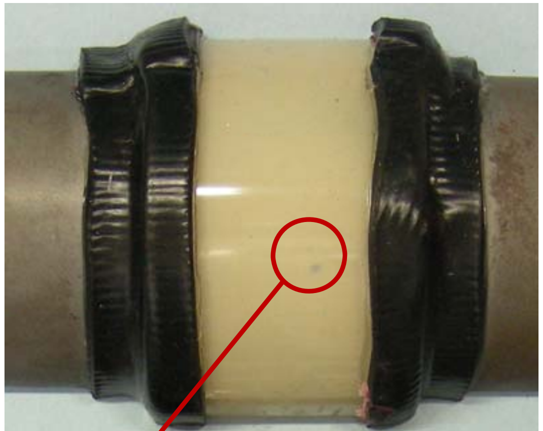
⇒ not optimal

WP1: Transfer of the pipe joining concept into reality
- Filling of the gap: PU154

Parameters:

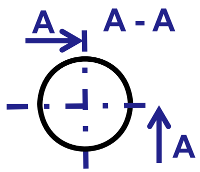
Adhesive	PU 154
Viscosity	pasty
Overlapping	40 mm
air pressure	5 bar





trapped air

A - A



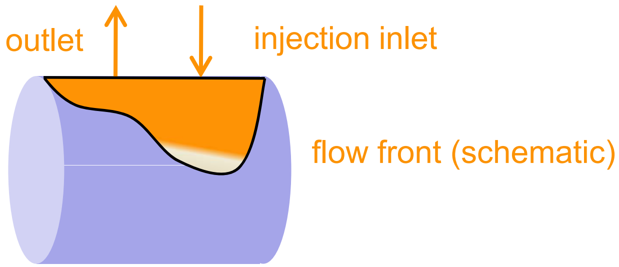
result:
- constant glue line
- trapped air
- air pressure 5 bar to fill the gap with adhesive

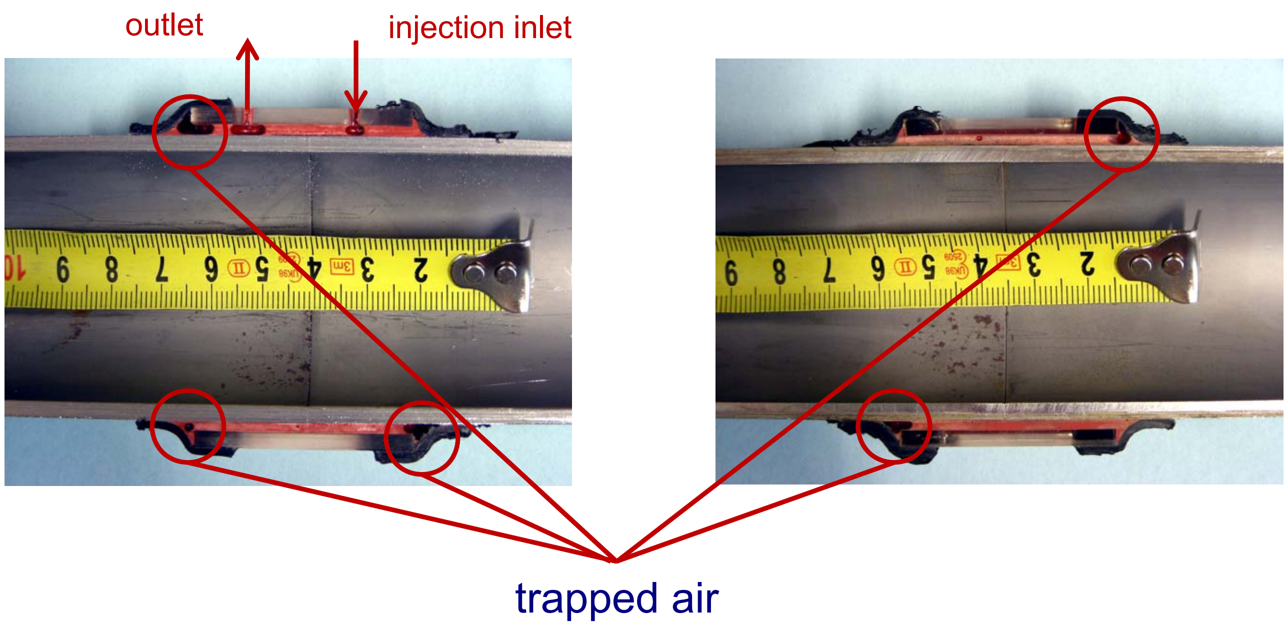
→ not optimal

WP1: Transfer of the pipe joining concept into reality
- Filling of the gap: PU156

Parameters:

Adhesive	PU 156
Viscosity	3200 mPa*s
Overlapping	40 mm
air pressure	1 bar





result:
- constant glue line
- trapped air at the overlapping's ends
- imperfections at injection inlet and outlet

⇨ not optimal

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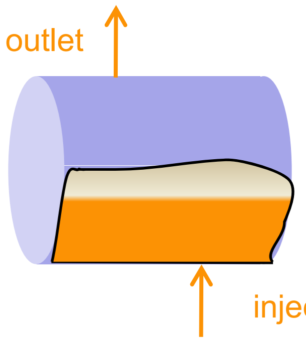
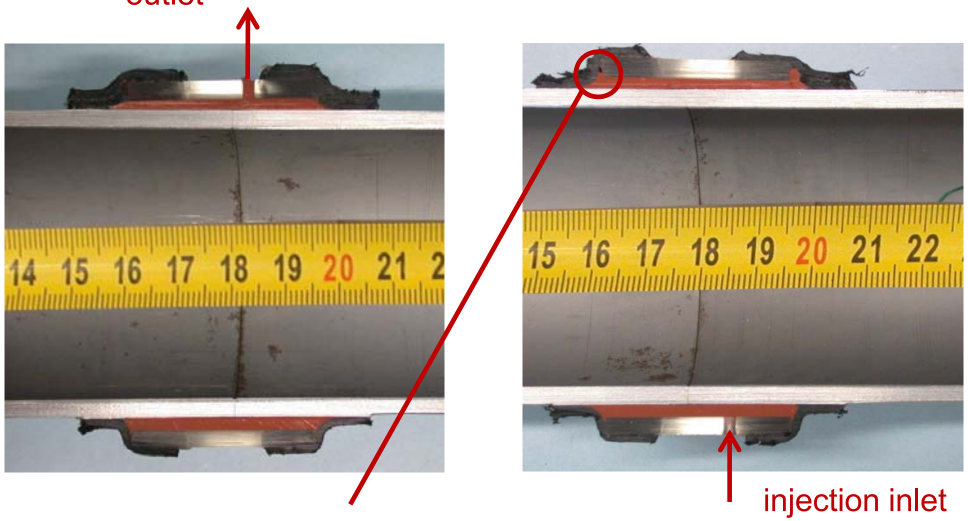
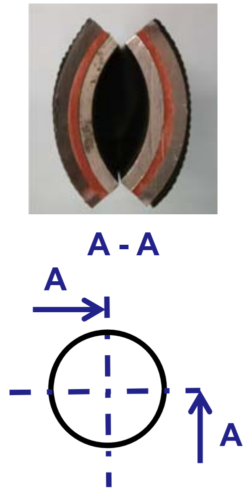
WP1: Transfer of the pipe joining concept into reality
- Filling of the gap: PU156

Parameters:

Adhesive	PU 156
Viscosity	3200 mPa*s
Overlapping	30 mm
air pressure	1 bar







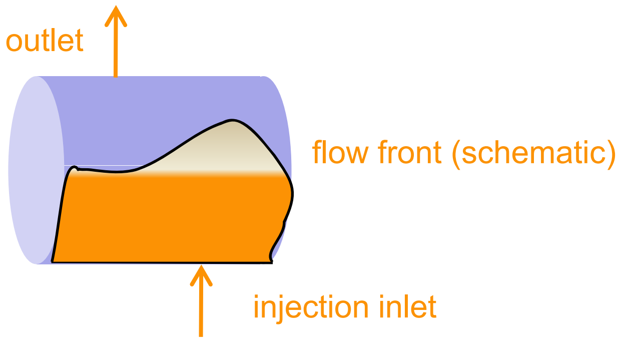
result:
- constant glue line
- small area with trapped air at the overlapping's ends

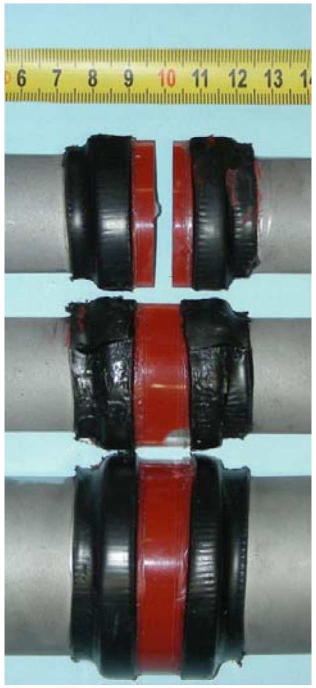
⇒ very good gap filling

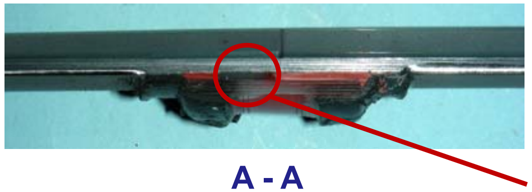
WP1: Transfer of the pipe joining concept into reality
- Filling of the gap: PU156

Parameters:

Adhesive	PU 156
Viscosity	3200 mPa*s
Overlapping	30 mm
air pressure	4 bar



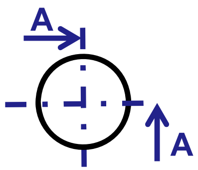




A - A

air pocket

A - A



result:
- constant glue line
- huge air pocket

→ not optimal

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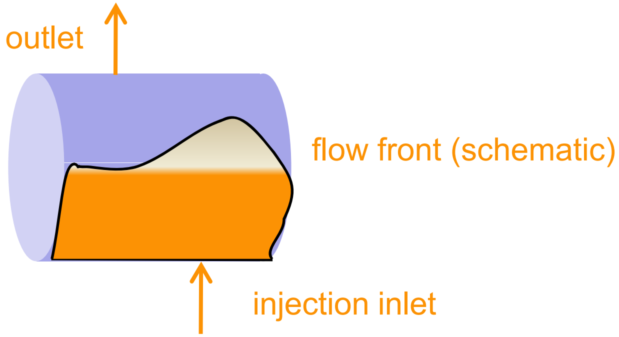
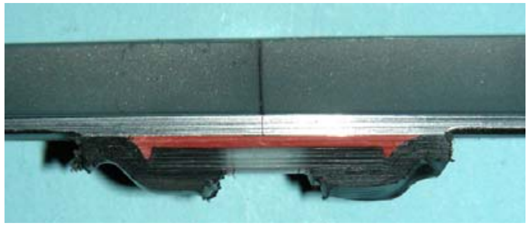
WP1: Transfer of the pipe joining concept into reality
- Filling of the gap: PU156

Parameters:

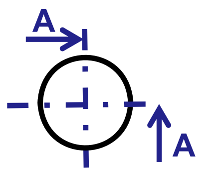
Adhesive	PU 156
Viscosity	3200 mPa*s
Overlapping	30 mm
air pressure	7 bar





A - A

A - A



result:

- constant glue line
- no visible failures

→ very good gap filling

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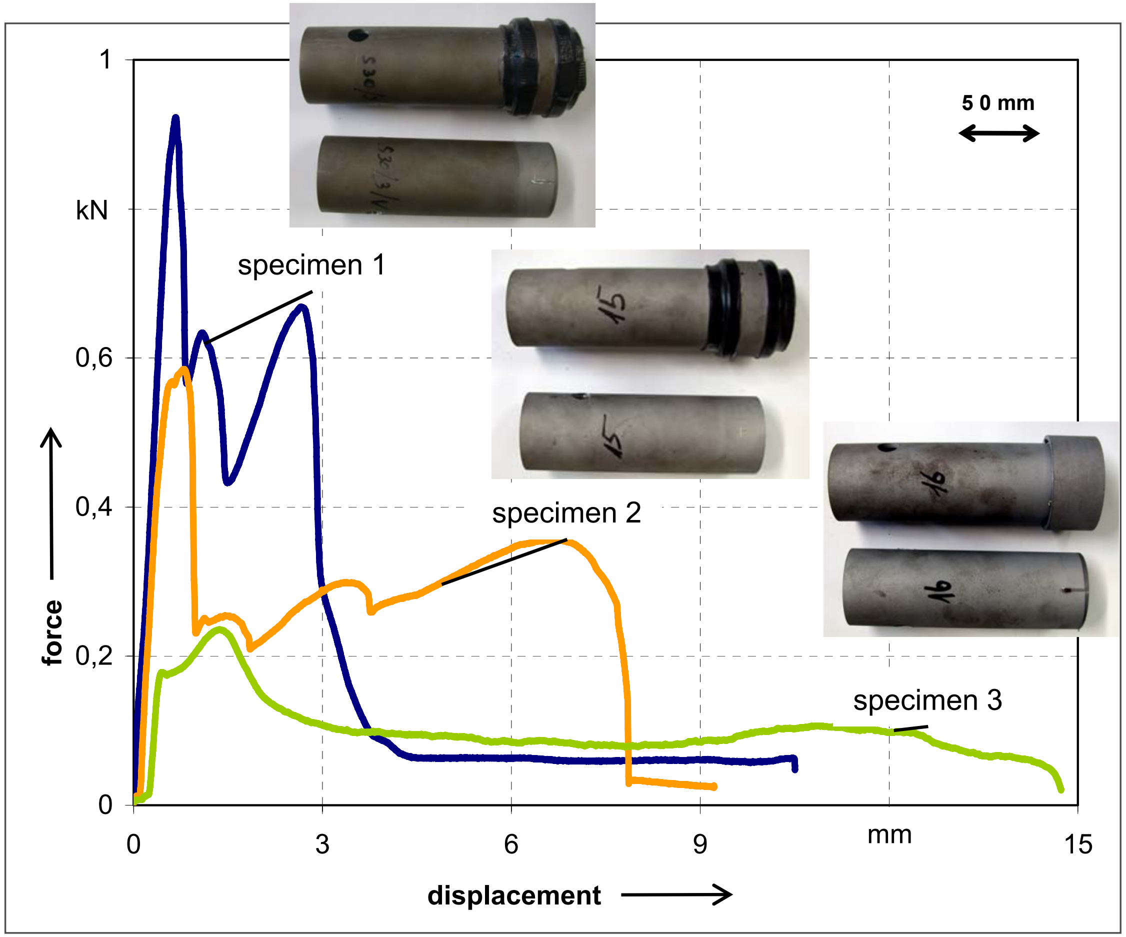
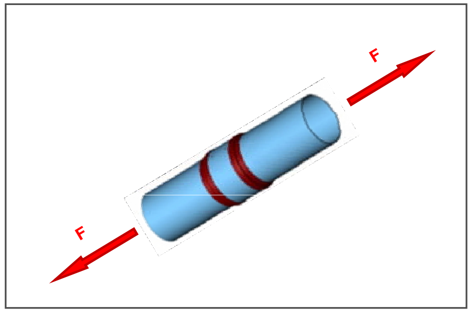
WP1: Transfer of the pipe joining concept into reality
- Mechanical handling of non-bonded pipes; preliminary tests



Specimen small scale pipe specimen
Testing device Zwick Z100
Testing velocity 10 mm/min
Fixing Specimen 1: steel wedges + shrinking material Specimen 2: shrinking material Specimen 3: steel wedges

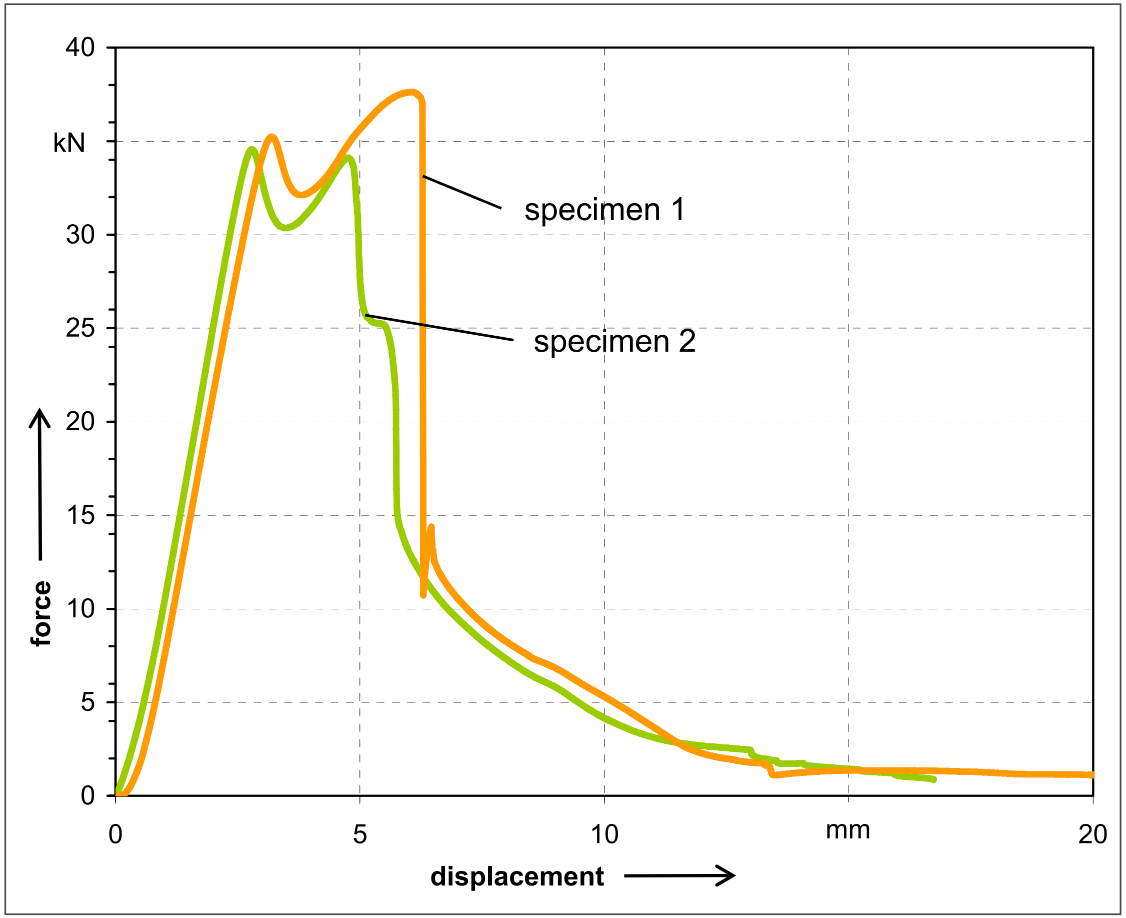


Hahn / Boeddeker

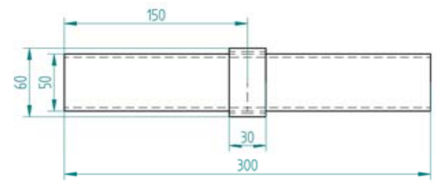
Usage of wedges, shrinking material and both, shrinking material and steel wedges allows mechanical handling of not already adhesively bonded pipes:
⇒ potential to renounce special fixing during the curing process!

WP1: Transfer of the pipe joining concept into reality

- strength of adhesively bonded pipes; preliminary tests



Specimen
small scale pipe specimen
Testing device
Zwick Z100
Testing velocity
10 mm/min
Adhesive
PU156
Curing
RT, 10 d
Overlapping
30 mm



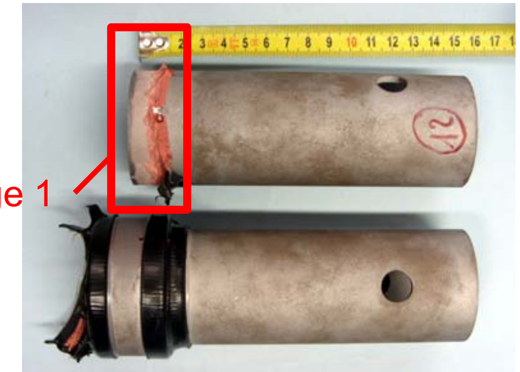
Hahn / Boeddeker

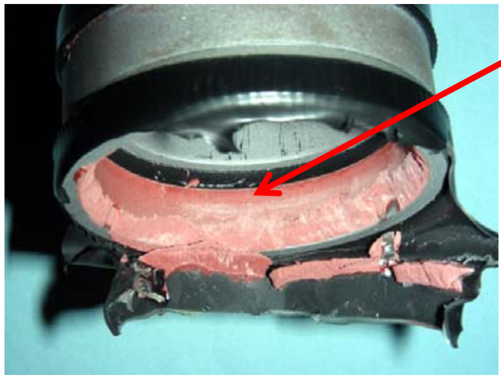
Comparable failure and forces at failure. Failure of the bonded pipe proceeds in two stages. This specific behaviour can be explained using the appearance of fracture and the qualitative stress progress simulation.

WP1: Transfer of the pipe joining concept into reality -

strength of adhesively bonded pipes; preliminary tests - appearance of fracture

stage 1

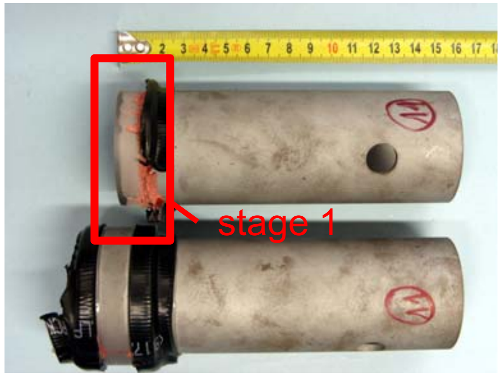




stage 2

result:

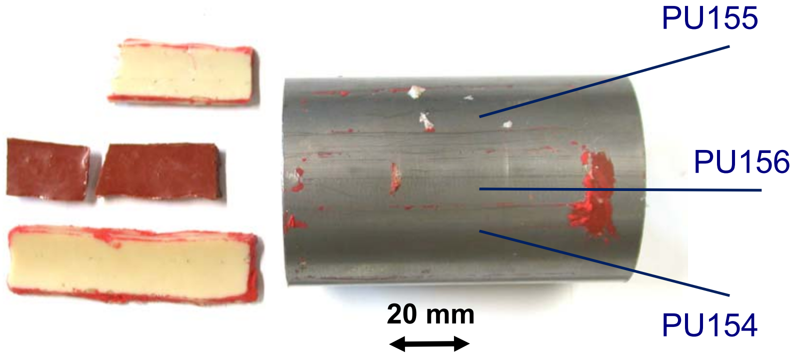
- comparable appearance of fracture
- cohesive failure near to the interface
- failure in two stages in the adhesive
- sleeve seems not to affect the results of the test



Tests using sleeves made from HDPE to be performed

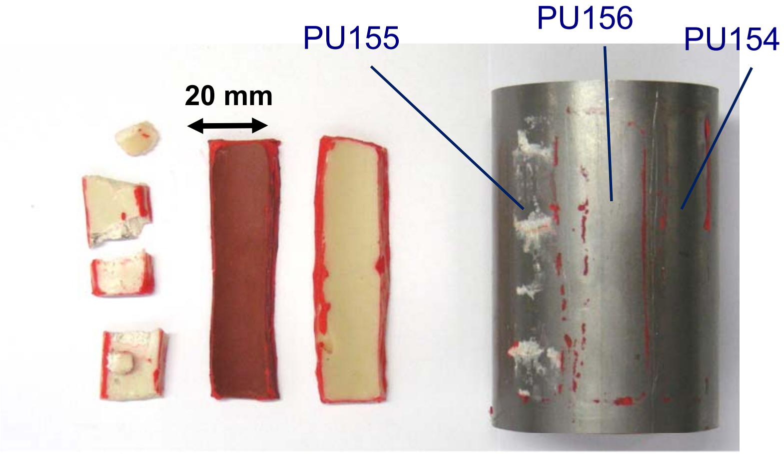
WP1: Surface treatment

To determine the adhesive behaviour of the adhesives, peel tests were performed using different surface treatments



- surface treatment: none
- appearance of fracture: adhesive failure of all adhesives

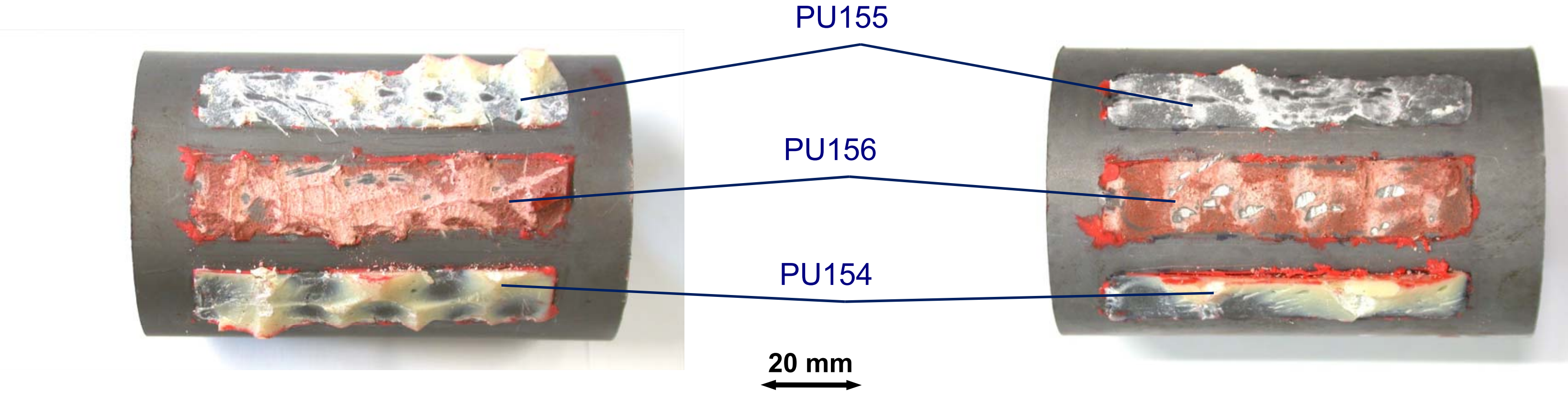
→ not recommended



- surface treatment: cleaning with acetone in an ultrasonic bath
- appearance of fracture: adhesive failure of PU154 and PU156; PU155 shows partial cohesive failures

→ not recommended

WP1: Surface treatment



- surface treatment: sandblasting and cleaning with acetone in an ultrasonic bath
- appearance of fracture: cohesive failure of all adhesives

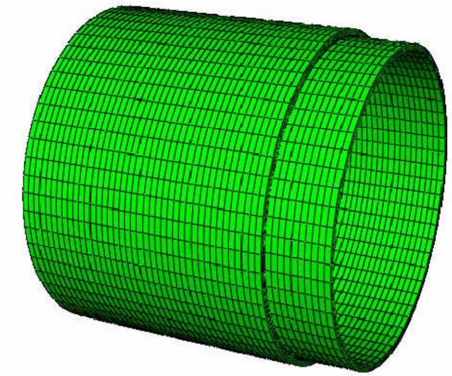
➡ appropriate for surface treatment

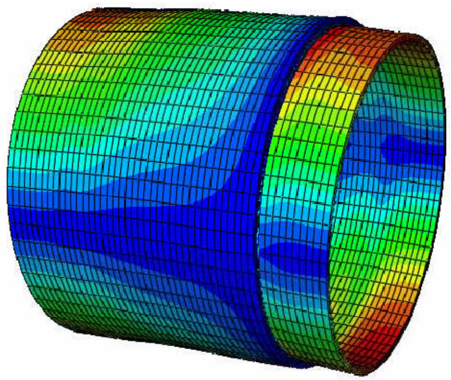
- surface treatment: blasting with SACO Pre and SACO Plus ⇨ application of a siliceous surface coating
- appearance of fracture: cohesive failure of all adhesives

➡ appropriate for surface treatment

WP3: FEM-Calculation model

Setup of FEM-models to calculate the progress of stress in the adhesive bondline





- Pipes and adhesive layer are connected using tied contact
- Applied forces have the value "1"

⇨ Qualitative progress of the stresses in the adhesive bondline

Properties of FEM model:

Pipes

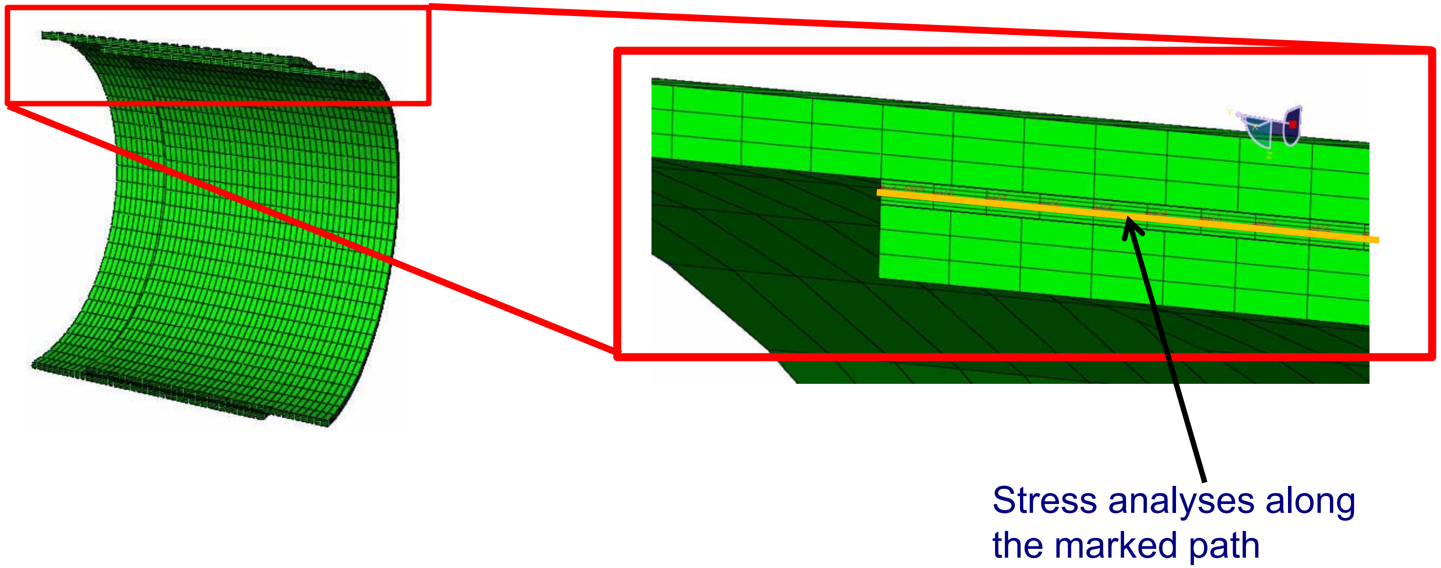
Length of pipes	400 mm
Overlapping	300 mm
Elements	6500

Adhesive bondline

Length of adhesive layer	300 mm
Thickness of adhesive layer	3 mm
Elements	14400

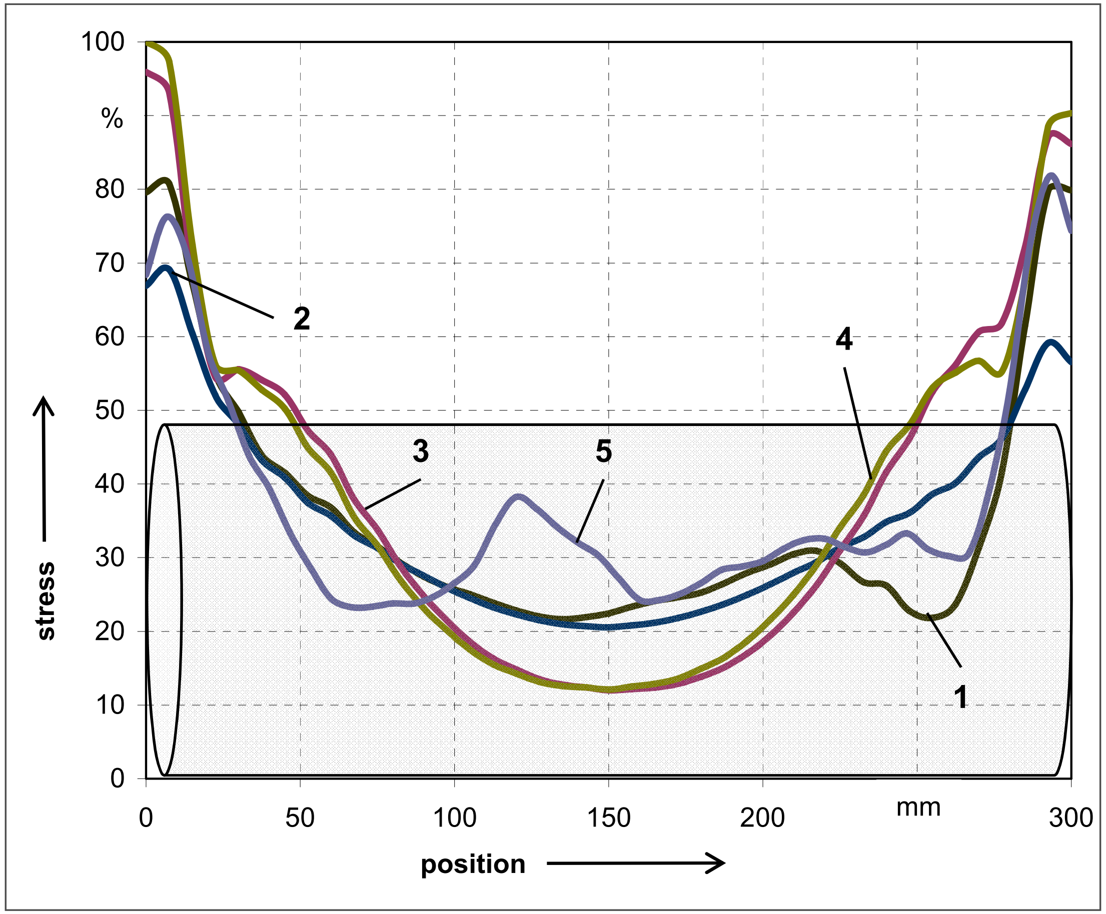
WP3: FEM-Calculation model

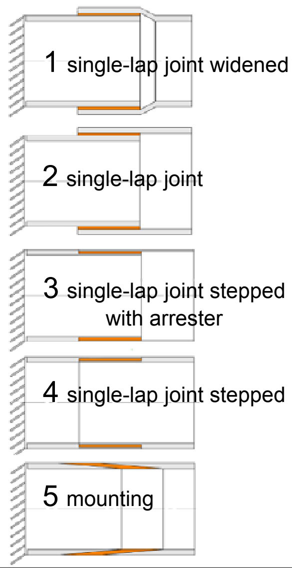
Analyses of stress progress along the adhesive bondline under tensile, bending, torsion, und pressure loads



WP3: FEM-Calculation model

- Pipe geometries under tension loads I.



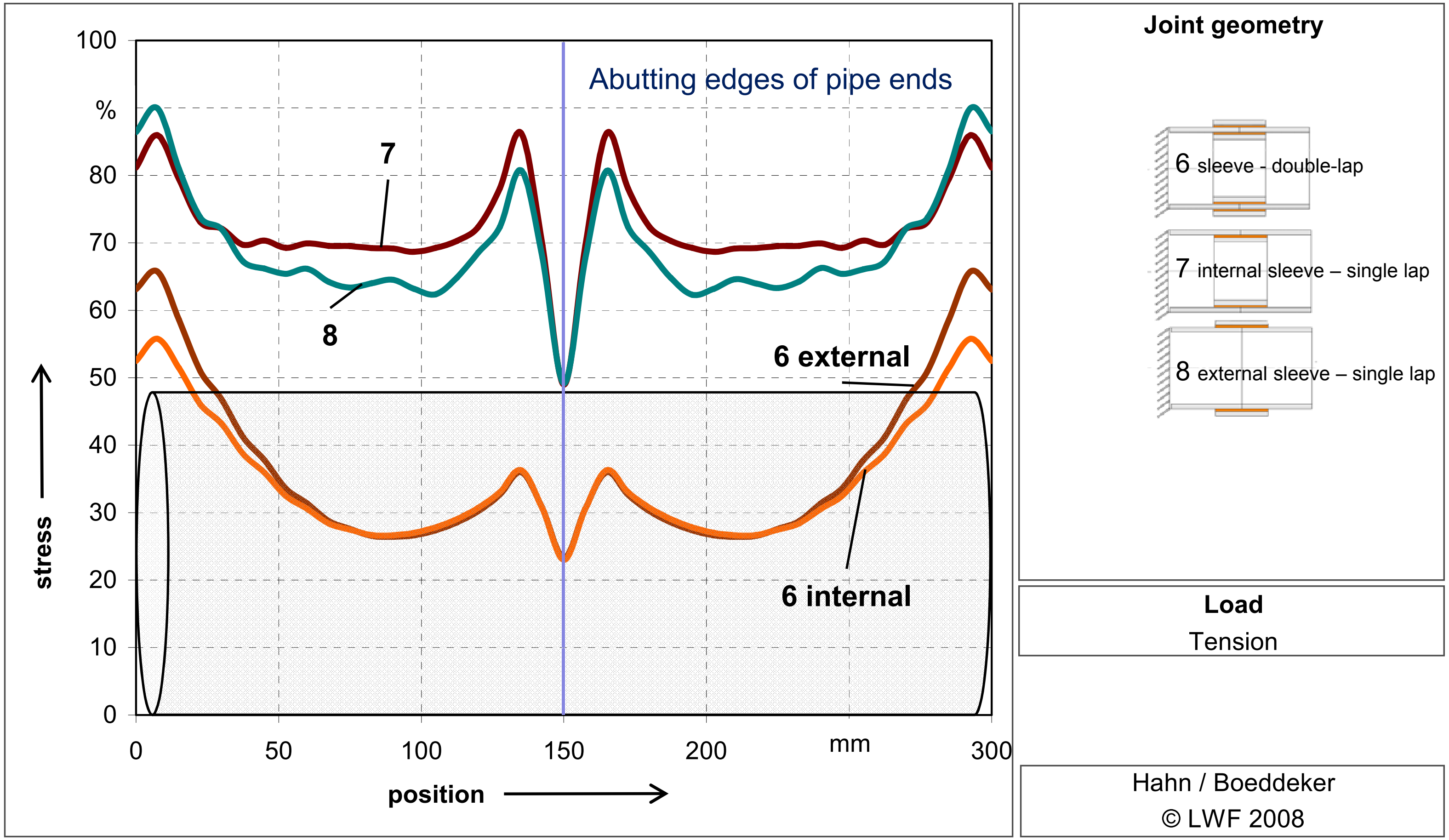


Load

Tension

Hahn / Boeddeker

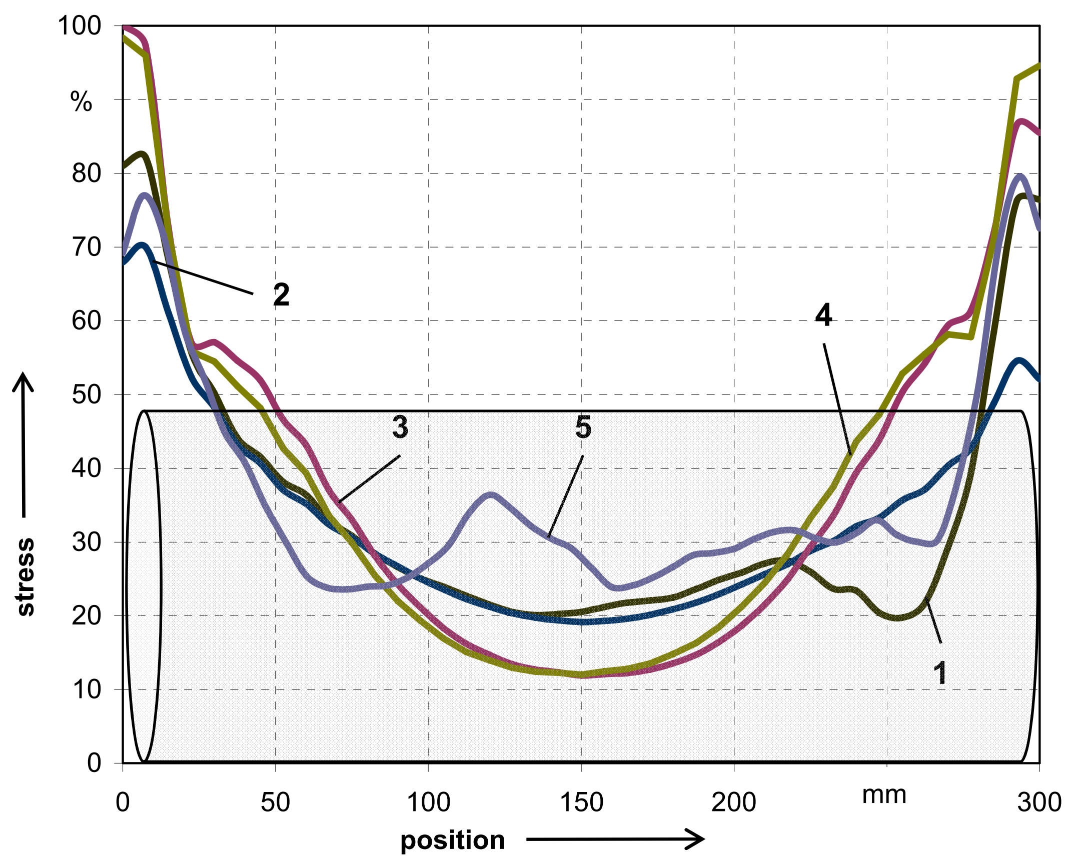
WP3: FEM-Calculation model
- Pipe geometries under tension loads II.

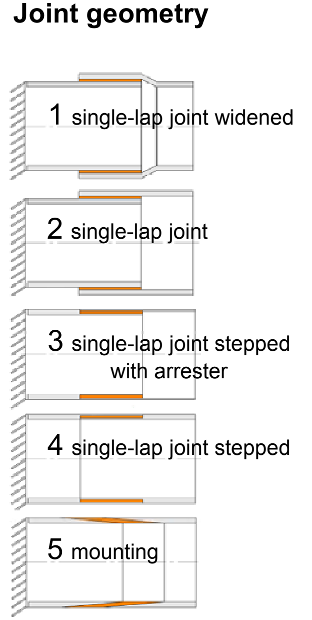


Highest potential stresses under tension loads using geometry 4, lowest stresses using geometry 6.

WP3: FEM-Calculation model

- Pipe geometries under bending loads I.





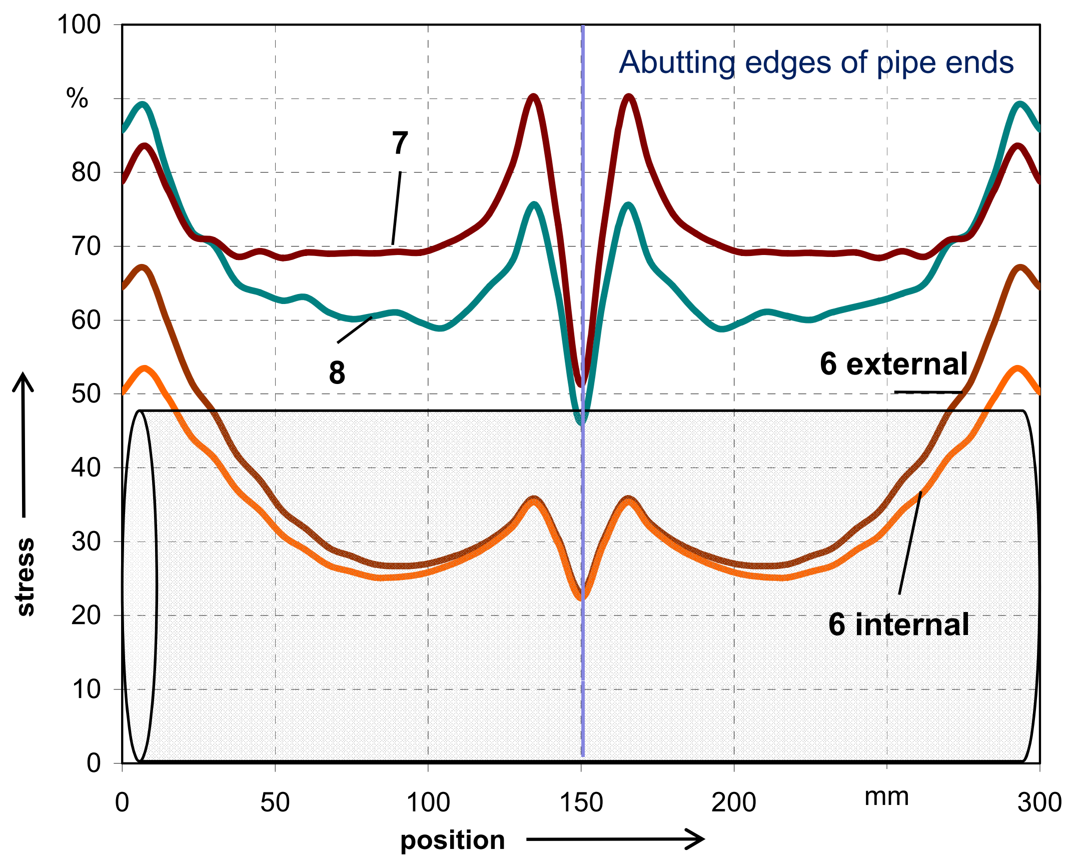
Load

Bending

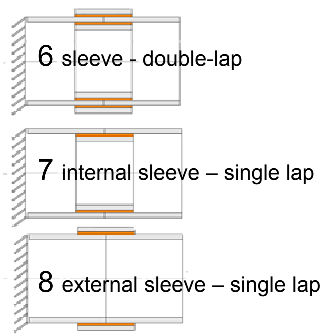
Hahn / Boeddeker

WP3: FEM-Calculation model

- Pipe geometries under bending loads II.



Joint Geometry



Load

Bending

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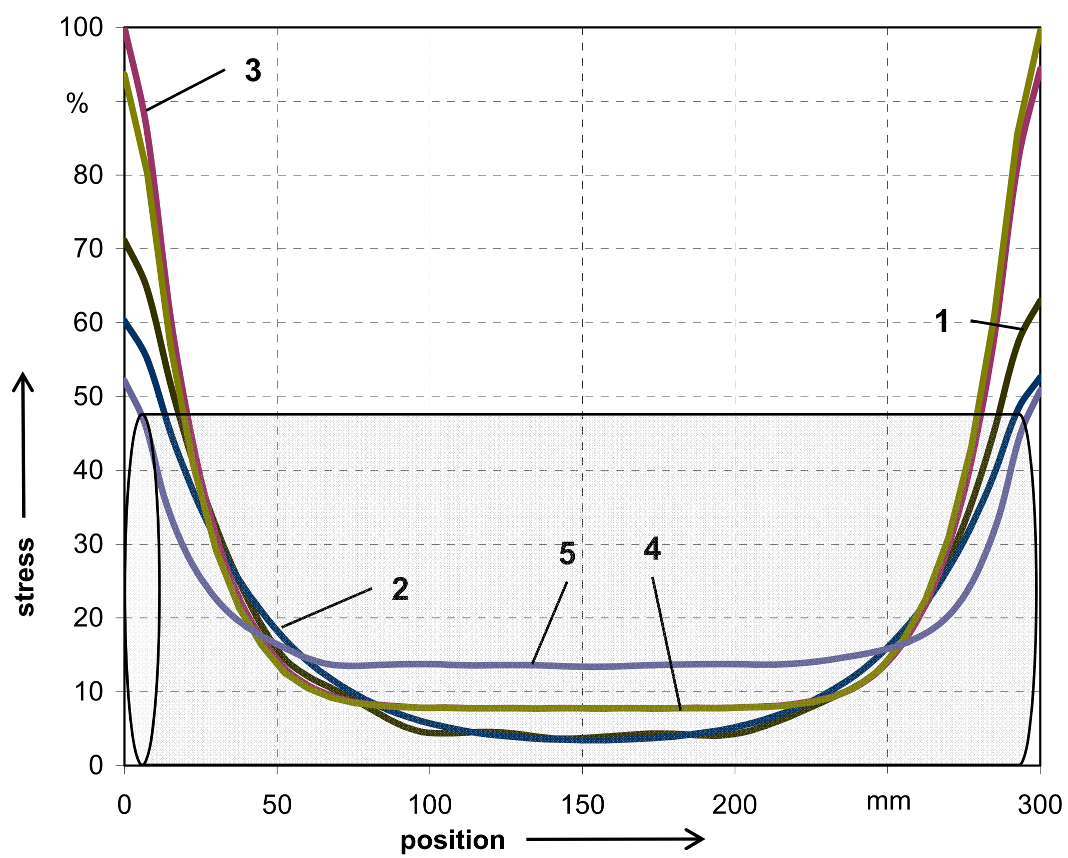
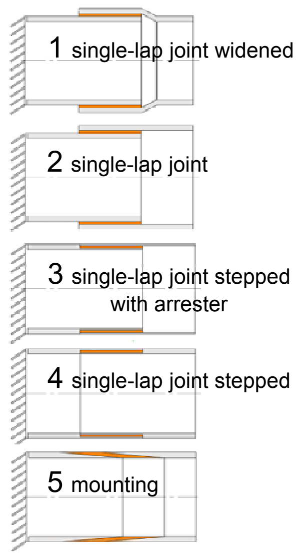
Highest potential stresses under bending loads using geometry 3, lowest stresses using geometry 6.

WP3: FEM-Calculation model

- Pipe geometries under torsion loads I.



Joint geometry



Load

Torsion

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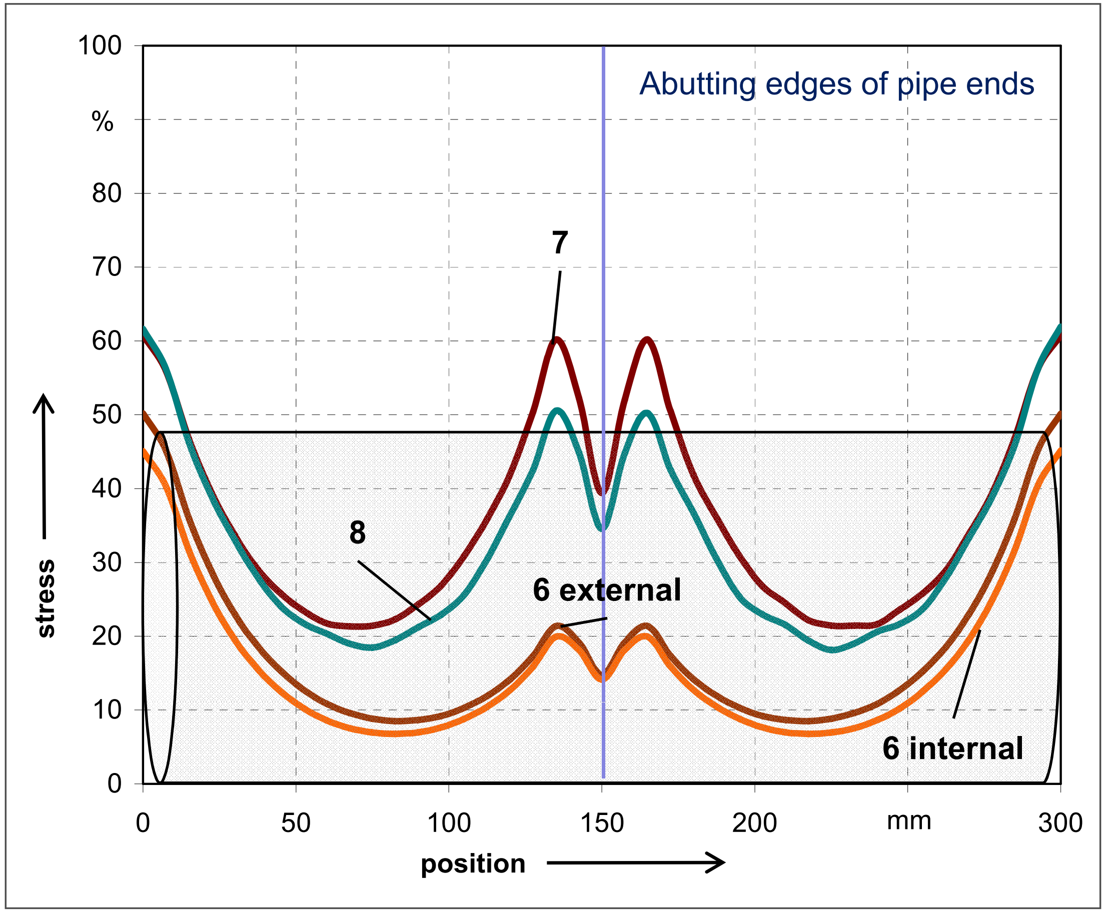
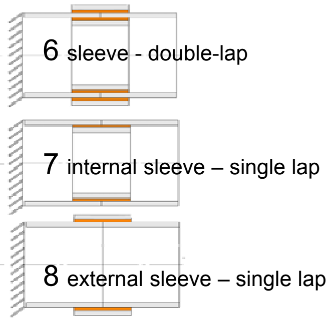
WP3: FEM-Calculation model
- Pipe geometries under torsion loads II.



Joint geometry



Load

Torsion

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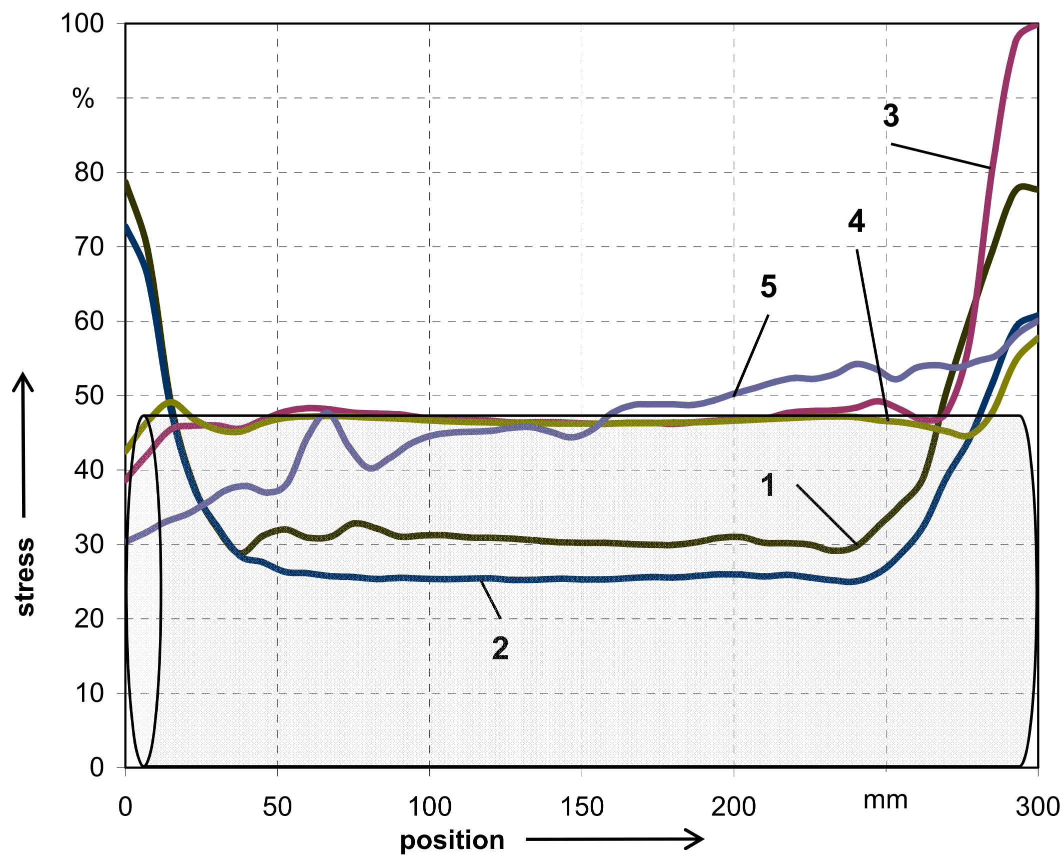
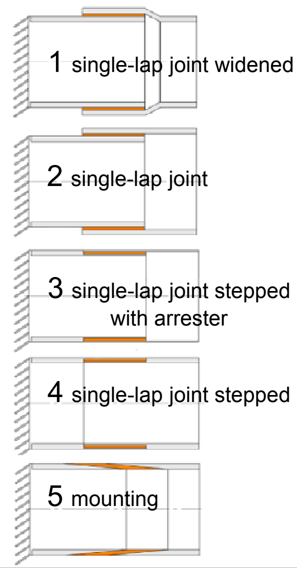
Highest potential stresses under torsion loads using geometry 3, lowest stresses using geometry 6.

WP3: FEM-Calculation model

- Pipe geometries with internal pressure I.





Load

Internal Pressure

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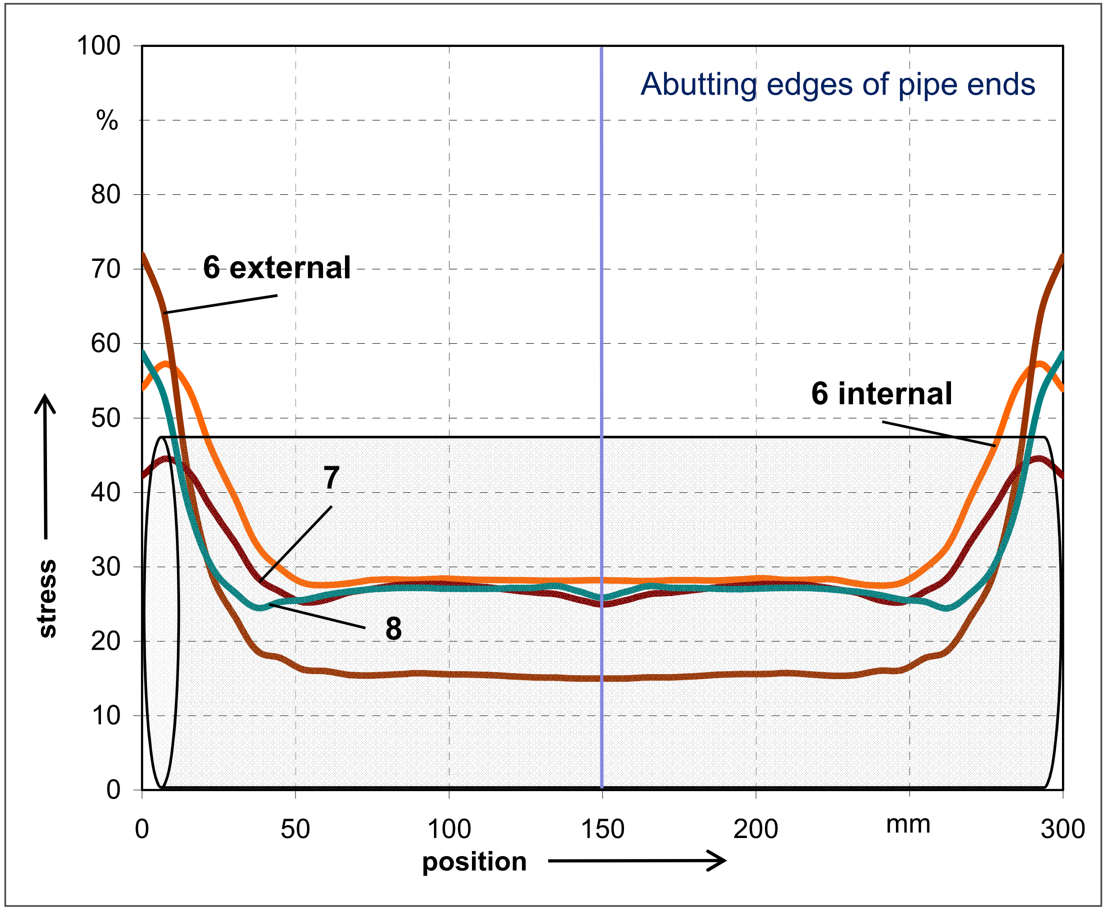
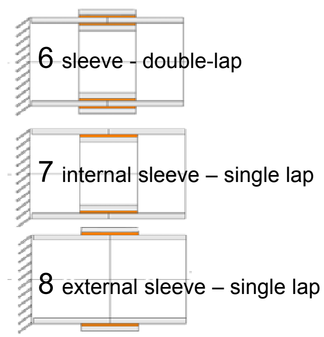
WP3: FEM-Calculation model

- Pipe geometries with internal pressure II.





Load
Internal Pressure

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Highest potential stresses under internal pressure using geometry 3, lowest stresses using geometry 7.

Agenda

TOP 1: Welcome and acceptance of the minutes of the last meeting (10:00)

TOP 2: Research results of project partners (10:10)

TOP 3: Lunch break (12:30)

TOP 3: Tour of Salzgitter Mannesmann Line Pipe (13:00)

TOP 4: Next steps (14:30)

TOP 5: Coordination (15:15)

TOP 6: Miscellaneous & end of the meeting (16:00)

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Tour of Salzgitter Mannesmann Line Pipe

Source: Mannesmann Fuchs Rohr Magazin 2/2007

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Next steps

- Further tests to determine optimal parameters for gap filling in dependence of viscosity, injection inlet positions, and filling pressure
- Tests with further joint geometries
- Optimisation of application method; vacuum to support adhesive injection
- Choice of surface treatment
- Strength tests with adhesively bonded pipes under bending, torsion, tensile and pressure loads using the proposed adhesives. Determination of needed properties of an adhesive specially developed for pipe joining
- Determination of influences on the strength of adhesively bonded pipes appearing by irregularities while assembling the pipes.
- Aging of adhesively bonded steel pipes
- Strength tests on full scale pipes

Agenda

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Coordination

- Amendment N° 1 to the project contract:

The amendment was launched due to changes of bank details of Salzgitter Mannesmann Forschung. Because of different changes emerged during the circulation of signature, the amendment was drawn back by the European Commission.
A new amendment will be set up by the European Commission including following changes:

- changed banking details of SZMF
- changed name of Mannesmann Fuchs Rohr GmbH in Salzgitter Mannesmann Line Pipe
- changed CEO of Sika Danmark A/S
- change of partner from Bohlen & Doyen Polska spol. to Bohlen & Doyen Bauunternehmung

Coordination

- Bayer MaterialScience AG is interested to participate in the project.

  What benefit would a participation of Bayer MaterialScience AG have for the project?

  How should a participation of Bayer MaterialScience AG be arranged?

- The next six-monthly report has to be delivered to the European Commission until the end of **September 2008**.

  - Task for the coordinator: preparing the report
  - Task for the project partners: deliver all relevant data for the next six-monthly report to the coordinator until **31st July 2008.**

- Next project team meeting:

  Proposal: **Wednesday, 3rd December 2008**

Agenda

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