# Minutes of the fifth project team meeting:

## Participants:

**AGFW e.V.**

Besier, Rolf

**Centro Sviluppo Materiali S.p.A.:**

Bufalini, Andrea

**Gaz de France Suez**

Benamar, Aicha

**Salzgitter Mannesmann Forschung GmbH:**

Fluegge, Dr. Wilko; Hilgert, Dr. Oliver; Orth, Dr. Thomas, Zimmermann, Dr. Steffen, Kaack, Dr. Michael

**Salzgitter Mannesmann Line Pipe GmbH:**

Brauer, Dr. Holger

**Sika Danmark A/S:**

Andersen, Kenneth; Rasmussen, Lou V.

**Stepanski Engineering** (on behalf of University of Paderborn)**:**

Stepanski, Dr. Horst

**LWF - University of Paderborn, coordinator:**

Boeddeker, Tobias; Girolstein, Christian

## Agenda:

**TOP 1:** Welcome and acceptance of the minutes of the last meeting

**TOP 2:** Research results of project partners

**TOP 3:** Tour of Sika

**TOP 4:** Next steps

**TOP 5:** Coordination

**TOP 6:** Miscellaneous & end of the meeting

## TOP 1: Welcome and acceptance of the minutes of the last meeting

Mr. Boeddeker welcomes the participants and introduces the agenda. The minutes of the meeting held on 2nd and 3rd December 2008 in Rome were accepted by all partners without reservations.

Mr. Boeddeker reports from the TGS8 meeting that took place on 27th of May 2009 in Esch sur Alzette, Luxembourg. The aim of the meeting was to review the work done in the first half of the project and to compare the progress of work with the schedule of the project by experts of the European Commission. It was stated that due to the complexity of the project the delays in working on the working points are acceptable. It was stated, too, that at the end of the project, a proposal has to be made where the new developed joining technology can be applied, if the target of the project, to distribute gas and hot water, will be missed. It was pointed out, too, that a new adhesive has to be presented at the end of the project instead of using a commercially available product. It was also intended to show results not as force-displacement-diagrams but as stress-strain-curves including the specified yield strength of the pipes.

It was decided to request an elongation of the JoinTec project due to the insolvency of Bohlen & Doyen Polska, to be able to finish the work proposed concerning pipe laying at construction sites.

## TOP 2: Research results of the project partners

Mr. Boeddeker presents the research results of UPB. Tests were performed using small scale pipe specimens.

Tests were performed to qualify a procedure for accelerated curing of the adhesive. First, the curing speed of room temperature cured PU156 was determined. For this purpose, tensile tests were carried out after 12 h, 24 h, 48 h, 72 h, 96 h and 120 h of curing. Directly after these tests, DSC analyses were performed to get an indication of the residual reactivity of the adhesive after each curing period. Results show an increasing stiffness and strength of the adhesive after each elongation of curing period. After 72 h of curing, the strength of the adhesive reaches its maximum. After that, the strength of the adhesive stays on the same level despite elongation of the curing process. To obviate influences of the strain of the testing machine, measurement of the elongation of the specimens was done by using a contact free optical measurement system from company GOM called Aramis. The analysis of the results of the DSC measurement shows that after 72 h of curing only a small residual reactivity is in the adhesive (about 0.04 %). The adhesive can be assumed as fully cured between 72 h and 96 h.

Accelerated curing shall be performed by using an electrical heating sleeve, which will be pulled over the specimen. Curing temperatures of 60°C were used. First tests show that curing of the PU156 can be speeded up and that stiffness seems to increase due to the accelerated curing process. The tests concerning the accelerated curing are still running.

In the following, Mr. Boeddeker shows results in choosing a surface treatment for steel pipes with regards for using them under field conditions. Four coatings were used for the tests: two powder coatings, one catophoretic painting and one 2C-primer, all based on epoxy. Using drop shape analyses and calculated wetting envelopes it can be stated that the adhesive is able to wet all proposed coatings. As the 2C-epoxy primer is intended to be used for the full scale tests because by using it, a coating in the field can be realised, the thick tensile specimens was used to determine what influences on the mechanical properties of the adhesive have to be expected in using the primer. It can be shown that shearing strain of the primered specimens reach only small values in comparison to the unprimered specimens. The shear stresses decreased rapidly, too. This behaviour is related to the less cohesive strength of the primer. Tests performed using the small scale pipe specimen show that using powder coatings and electrophoretic painting has positive influences on the strength of the bonded pipes. First damage of the adhesive can be shifted from 35 kN to 45 kN. The maximum bond strength was shifted from 42 kN up to 60 kN. Results achieved using the thick tensile specimen concerning the 2C-epoxy primer could be affirmed. The force displacement curves show a brittle failure at about 25 kN. This is also related to the weak cohesion of the primer as the appearance of fracture shows. Due to these results, the project team decided not to use the 2C-epoxy primer for the full scale tests but to use sandblasted steel surfaces as this leads to better results, as tests showed.

Results were shown form Mr. Boeddeker concerning the optimisation of the joint geometry. Using the FE-method, the distribution of stresses in the standard pipe geometry was calculated. By the means of the results achieved, three different geometries were developed. Analysing simulations done with the FE-method under the use of the developed geometries shows that maximum stresses could be reduced. To show if this stress reduction has positive influences on the bond strength, tests using the small scale pipe specimens were performed. Results show positive influences on the bond strength by using all geometry modifications. Best results could be achieved using geometry modification B, which has a sealing at the butting edges of the pipes, preventing appearance of stress peaks resulting from direct stresses in this area.

To complete tests using different sleeve materials, Mr. Boeddeker presents results using GFRP-sleeves. Results show a cohesive appearance of fracture, but also a brittle behaviour of the joint at forces up to 42 kN. Due to the brittle behaviour, it was decided to use steel sleeves furthermore because of the higher deformability.

Tests done with incompletely filled bond lines show that this processing defect is the most crucial defect that might appear in bonding pipes. This mistake can be easily avoided by observation if the adhesive leaks out the adhesive outlets during the adhesive application process.

Climate tests on uncoated pipes were done. Tests according to VDA 621-415, VW P1200 were performed as well as an outdoor weathering. Results show that all tests have major influences on the performance of the bond. As the pipes were uncoated, they were exposed to the climate without any protection what results in a major corrosion attack on the steel pipes accompanied with a creeping corrosion beneath the shrinking material which allows direct contact of humidity and adhesive. Appearances of fracture show that the interface between adhesive and steel surface gets affected by humidity, too. This leads to significant loss of bond strength to all specimens regardless which climate tests they were exposed to. Using the results of the climate tests, geometry modifications will be developed which will allow a better resistance against climate influences. The same climate tests were performed with tensile specimens made of PU156. It could be shown that climate tests have positive influence on the tensile strength of the specimens due to additional curing at test intervals at higher temperatures. Negative influences occurred concerning the strain of the bulk specimens. It decreased from an average value of 50 % to average strains of about 10 %.

Concluding, Mr. Boeddeker shows first results of fatigue tests on adhesively bonded steel pipes. Under swelling loads and maximum forces of 25 kN, specimens reached up to 34500 lifecycles (21000 in average).

In the following, Mr. Hilgert presents the results of the work done at SZMF. Burst tests have been performed on pipes with OD = 168.3 mm. The pipes were closed with endcaps and put into a burst pit for the tests. Pipes reached a pressure maximum of 87 bar what equates 1.23 MPa in shear stresses. As PU156 can resist shear stresses up to 15 MPa, the lower shear stresses may be related to a pressure induced peeling of the adhesive. Therefore, Mr. Hilgert proposes a modification of the joint-geometry to change the load case on the adhesive. After that, Mr. Hilgert shows the schedule concerning the full scale tests for future tests to be performed at SZMF.

Mr. Fluegge presents the results in adopting the joining process for linepipes with OD = 168.3 mm. For aligning the pipes a device based on an I-beam was build up for centring the pipes. Sleeves were manufactured to act as auxiliary joining parts. Pipes were grinded and cleaned with acetone and afterwards painted with a 2C-primer. After that the sleeve was positioned over the abutting edges. The adhesive was injected through two injection holes at the bottom side of the sleeve using a manually driven cartridge. Based on this specimen a second specimen was build up with incorporated failures for testing the non destructive testing equipment.

Mr. Kaack explains the research work done in the field of non destructive testing. Air voids and PTFE-plates can be detected using ultrasound techniques. The signals resulting from these reference defects are comparable. As moisture gets in contact with polyurethane, a chemical reaction starts generating foam, which has no significant strength. This foam can be detected as a mistake as well. Wall thickness differences do not affect the detection of defects. Frequencies and wavelength of the ultrasound affects the attenuation of the ultrasound waves in the adhesive and with it the detection of defects. Tests to show the usability of electromagnetic-acoustic transducers (EMAT) were performed. Advantages for the use in the field arise as a coupling media like water is not needed. In testing full scale tubes problems emerged because of changing transducer head surface distance. This changes the angle of incidence in using piezo-transducers respectively the magnetic forces and the eddy-currents in using EMAT-transducers. If the ovality of the pipes/sleeves is kept low, defects can be detected, otherwise detection will not be possible. Areas of weld seems can not be inspected using EMAT. Mr. Kaack states that achieved results are promising but further research work has to be done. To get indications, were cracks appear first in adhesively bonded pipes, Mr. Boeddeker will analyse the crack growth in the adhesive during tensile testing.

Mr. Bufalini presents the work done at CSM the previous reporting period. A trial specimen for the full scale tests to be performed with the OD = 508 mm pipes was prepared. The corresponding test setup was arranged including the set up of strain gauges, displacement transducers and pressure transducers. Loads for testing the pipes are assumed to stress the pipe within the elastic limits.

## TOP 3: Next steps

Full scale tests:

For full scale tests, sleeves with an appropriate geometry have to be ordered for the small pipes and the big pipes. This task will be done by SZMF and CSM.

It was decided to bond the pipes for full scale testing in Germany to be able to perform non-destructive testing after performing the joining process. The pipes will be bonded by SZMF. For injecting the adhesive, an application device provided by Sika will be used. In addition an expert of Sika will train workers at SZMF in using the application device. For sealing the gap of the pipes to be bonded, a sealing material has to be chosen. This will be done by UPB and SZMF. Following schedule was agreed for pipe bonding, if all components necessary are available:

- Preparing trial pipe specimen (2 – 3 weeks)
- Non destructive testing of trial specimen after one week curing of adhesive (1 day)
- Preparing two big pipe specimens and two small pipe specimens (2 weeks)
- Shipping to CSM (1 week)

- Testing at CSM (2 weeks)

Publications:

Before publications of the research work performed in the JoinTec project will be prepared, a patent search shall be performed. All information needed for performing this patent search have to be provided to MLP by UPB.

## TOP 4: Co-ordination

The project team decides to change the co-ordinator of the JoinTec project from Mr. Hahn to Mr. Boeddeker as proposed by the European Commission.

The next project team meeting will take place at Duisburg at SZMF on the 2nd and 3rd of December 2009.

## TOP 5: Tour of Sika

During the tour of Sika, the project team got an impression of high volume adhesive production.

## TOP 6: Miscellaneous & end of the meeting

Mr. Boeddeker thanks all participants on the meeting for their constructive work and discussions.