Centro Sviluppo Materiali S.p.A.

RFCS “JOINTEC” RESEARCH PROGRAM

FULL-SCALE TEST PROGRAM

PROPOSAL FOR TESTING PROCEDURE

Rome, 2-3 December 2008

JOINT GEOMETRY

The joint geometry identified involves the use of a sleeve to be used as protection for the adhesive and as the mean for load transfer

Small scale tests have been performed at LWF on this concept

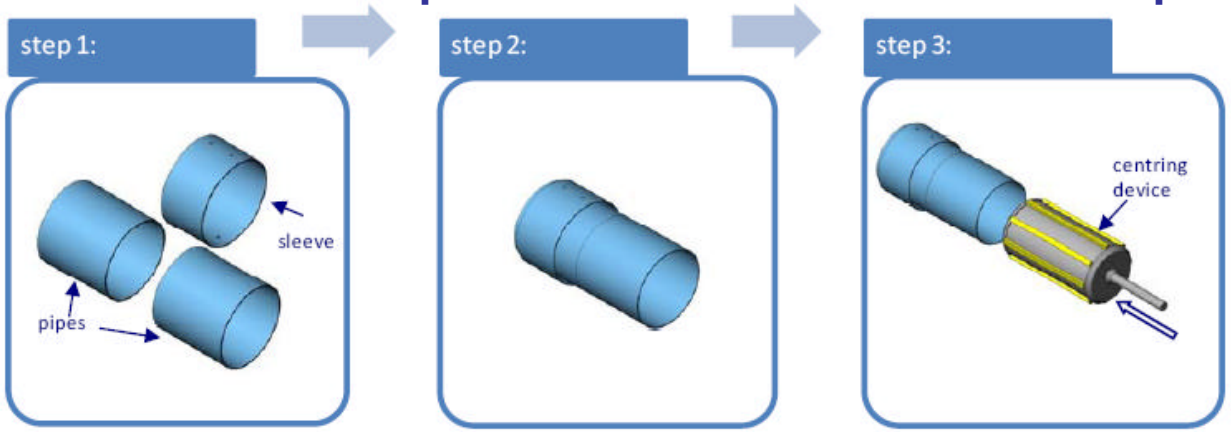


Figure 2: Concept for pipe joining using adhesive bonding (step 1 - 3)

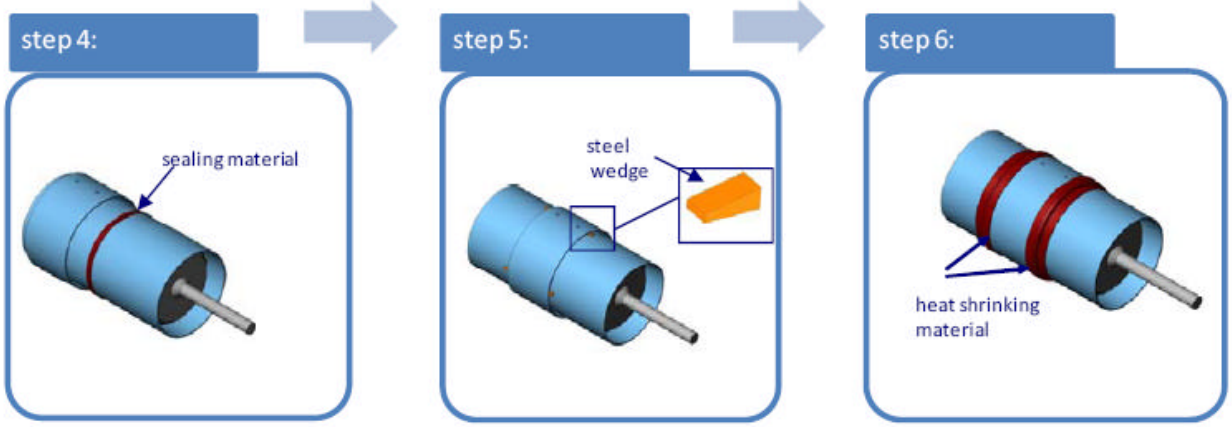


Figure 3: Concept for pipe joining using adhesive bonding (step 4 - 6)

SUB WORKGROUP MEETING

A meeting was held end of October in Paderborn to examine the problems related to full scale tests

Some aspects need to be discussed and agreed in order to complete the joint design and proceed with the full scale tests

A proposal was outlined and will be presented

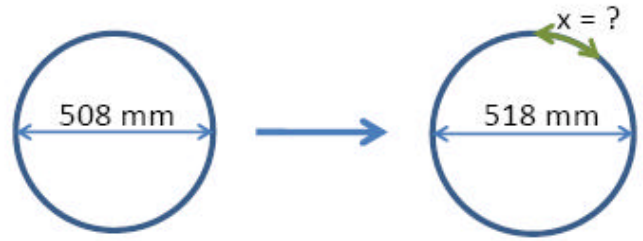
JOINT DESIGN REFINEMENT – SLEEVE PREPARATION

As no suitable pipes are available, at least for 20”, sleeve preparation should be as follows:

- cutting a pipe sample longitudinally
- widening the pipe
- welding a piece of steel into the gap

It shall be discussed:

- **sleeve geometry (length, amount of space for adhesive application and effect of ovality/eccentricity)**
- **effect on mechanical performance of plastic deformation caused by opening (likely negligible)**
- **effect of welded extension on the adhesive application (probably small if smoothed)**



$U_1 = 1595{,}93$ mm

$U_2 = 1627{,}34$ mm

$x = U_2 - U_1$

$x = 31{,}41$ mm

$x \approx 32$ mm

PROJECT PROPOSAL – INITIAL REQUIREMENTS

The test program will be subdivided in two phases: laboratory tests on small parts of pipe joints and full-scale tests performed on a limited numbers of selected joints. The tests performed on small-scale pipe joints will be executed by SZMF. In parallel, a dedicated full-scale test program will be performed, first, in order to verify the findings made on small-scale specimens and, second, to finally validate the new joint design concept under realistic service conditions. In detail, the full-scale test program will comprise the items listed below:

- Static tensile tests (positive axial force) …(SZMF)
- Static bending tests …(CSM)
- Static torsion tests …(SZMF)
- Static pressure containment tests …(SZMF)
- Alternating tensile/compression tests (positive/negative axial force) …(SZMF)
- Cyclic pressure containment tests …(SZMF)
- Multi-axial testing 1: pressure containment + positive/negative axial force (static and cyclic) …(SZMF)
- Multi-axial testing 2: pressure containment + bending moment …(CSM)
- Multi-axial testing 3: pressure containment + torsion …(SZMF)
- Evaluation of resistance against denting and puncture simulating dynamic external threats such as impact due to mechanical equipment like excavators …(CSM)

In the above tests, loads and displacements shall be recorded continuously during testing, notably in axial direction directly at the interface between joint and out-bounding pipe. Prototype testing shall neither lead to any form of burst failure nor de-bonding nor leakage.

The above indicated full scale test program will not only be performed on selected kinds of received joints, moreover it is planned to also perform these tests on joints with "defect" and joints damaged by environment and cyclic loads. About this last, a realistic load/environments laboratory cyclic to reproduce the potential in service damage will be fixed under consultancy of pipe laying industry (B&D) and end users (Gaz de France). The experimental tests will be done by CSM. UPB will work out the defect tolerance criteria based on the experimental test data (CSM).
MFR (Mannesmann Fuchs Rohr) is in charge for the supply of the pipes. All joints will be made and inspected by SZMF using the methods developed already in the previous work package WP2.

PIPE GEOMETRY, ESTIMATED LOAD SCHEDULE

The two pipe geometry selected for the Jointec Project are:

- **168.3mm OD, 7.0mm wt, grade X60 *(new geometry)***
- **508.0mm OD, 8.8mm wt, grade X60**

Nominal uniaxial limit (yielding) loads:

- **p_Y = 342 bar, T_Y = 1466 kN**
- **p_Y = 143 bar, T_Y = 5714 kN**

The working loads estimates are indicated in the tables (*to be updated with new geometry*)

Tabelle 1: Lasten infolge Innendruck — ***Service***

Rohrabmessung Da x t	Lastfall 1: Innendruck			
	Innendruck		Normalkraft aus Innendruck	
114.4 mm x 5.0 mm	$p_{Betrieb}$ [bar]	16	$N_{x,Betrieb}$ [kN]	15,7
	$p_{Erprobung}$ [bar]	24	$N_{x,Erprobung}$ [kN]	23,6
508.0 mm x 8.8 mm	$p_{Betrieb}$ [bar]	40	$N_{x,Betrieb}$ [kN]	797,0
	$p_{Erprobung}$ [bar]	60	$N_{x,Erprobung}$ [kN]	1195,0

Tabelle 2: Lasten infolge Verlegung — ***Installation***

Rohrabmessung Da x t	Lastfall 2: Verlegung der Rohrleitung			
	Biegemoment		Normalkraft	
114.4 mm x 5.0 mm	$M_{Verlegung}$ [kN m]	12,7	$N_{x,Verlegung}$ [kN]	416,0
	$M_{Erprobung}$ [kN m]	19,0	$N_{x,Erprobung}$ [kN]	624,0
508.0 mm x 8.8 mm	$M_{Verlegung}$ [kN m]	476,3	$N_{x,Verlegung}$ [kN]	3350,0
	$M_{Erprobung}$ [kN m]	714,5	$N_{x,Erprobung}$ [kN]	5025,0

For the full scale testing, there is the need to confirm / modify the load values and define the load sequence.
For test specimens preparation, there is the need to define and supply the sleeves, the adhesive and to prepare the detailed operating practice

DEFINITION OF TEST PROCEDURE

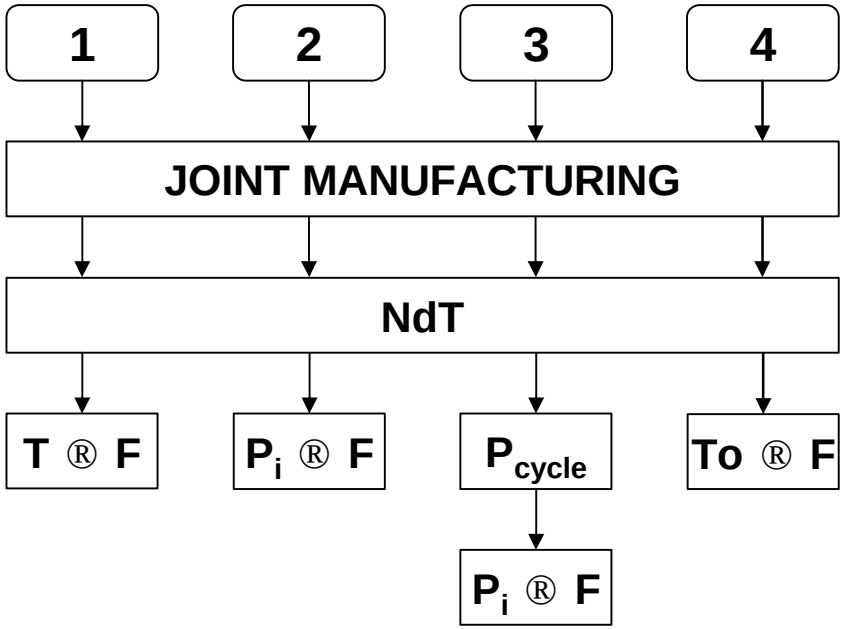
The definition of the test procedure has to consider several points:

- **Requirements from Technical Annex**
- **Real installation/service conditions**
- **Appropriate loading modes/levels**
- **Adequate number of specimens**
- **Availability of equipment at SZMF/CSM in view of the selected geometries**

In view of the above, a procedure involving the test of 8 specimens, to be divided between SZMF and CSM, has been outlined

PROPOSED TEST PROCEDURE - SUMMARISED PROCEDURE

SZMF



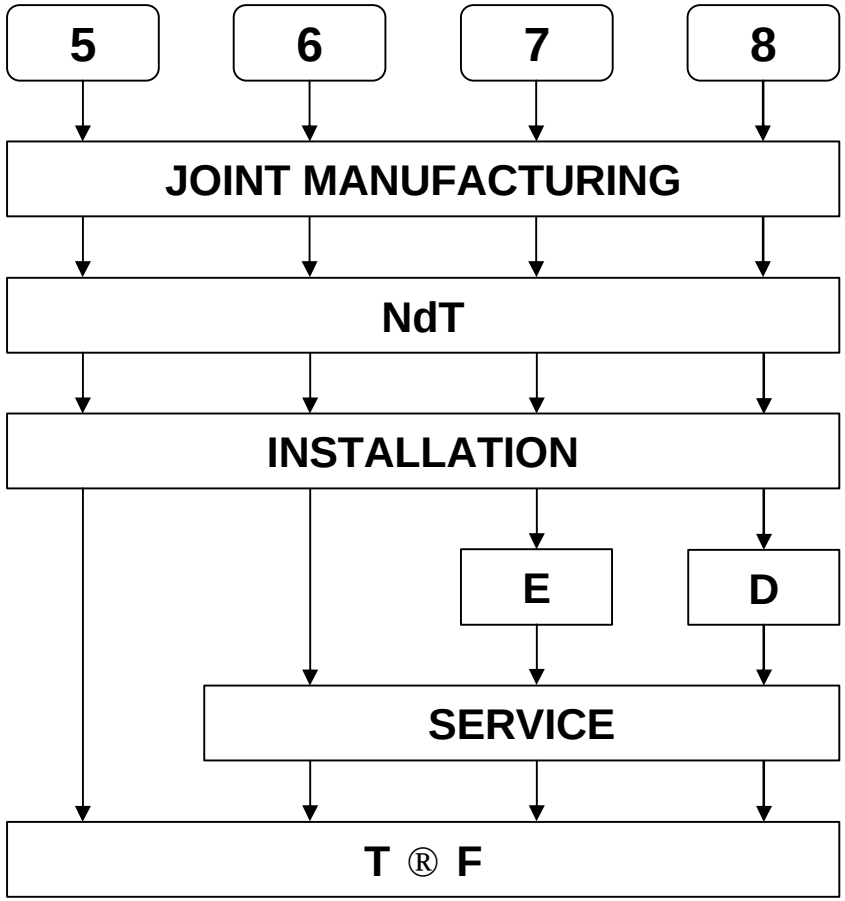
T ® F: Tension to Failure

P_i ® F: Internal Pressure to Failure

To ® F: Torsion to Failure

P_{cycle}: n cycles 0-P_i

CSM



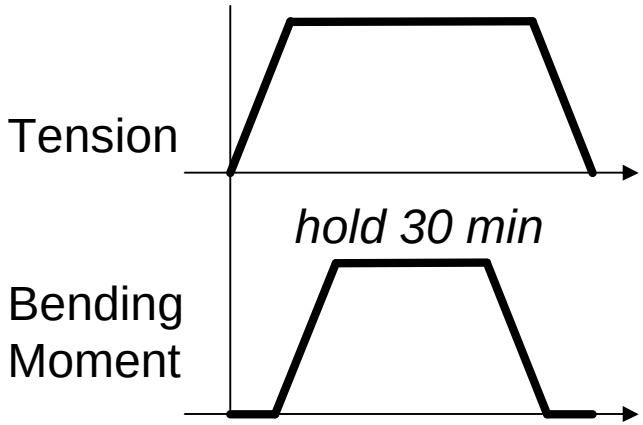
E: Environment

D: Damage

PROPOSED TEST PROCEDURE – SCHEMATIC LOADING MODES

INSTALLATION

Tension and Bending Moment to maximum values typical of installation



ENVIRONMENT

24h @ 80 °C *(moisture not a problem due to insulation)*

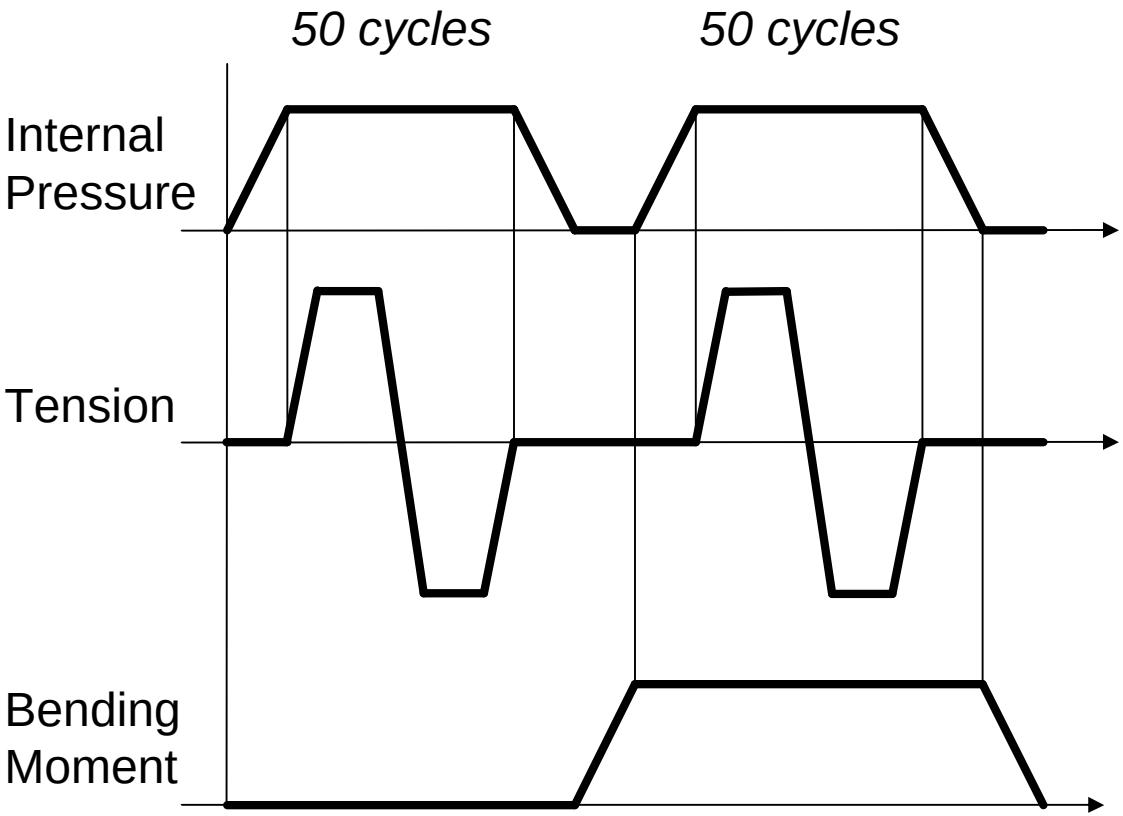
DAMAGE

Dent and gouge from typical excavator on the connection *(to be verified for 6 5/8")*

PROPOSED TEST PROCEDURE – SCHEMATIC LOADING MODES

SERVICE

Tension, Internal Pressure and Bending Moment to values typical of service life for a characteristic (and reasonable) number of cycles



Hold 5 min @ ET and P_i without and with bending

Verifying sealing integrity during holding periods (20" with water and 6 5/8" with gas)

LVDT on joint sides, to monitor debonding

COMMENTS

- Joint design and geometry, also relating to sealing mechanism, to be subject to final verification (discussion) and agreed
- Need of verification (consolidation) of installation and service loads
- Test procedure needs to be discussed and finalized soon, preferably at this meeting
- Delivery schedule for the sleeves to be decided
- NdT location to be discussed, to optimise time and costs (moving specimens or equipment?)
- It has been agreed to perform a trial test at SZMF on smaller pipe size. as final verification of adhesive, assembling process, NdT procedure
- Testing schedule to be finalized, depending on resolution of pending points (including adhesive selection and supply), aiming to conclude the tests within Summer 2009 as per Project plan

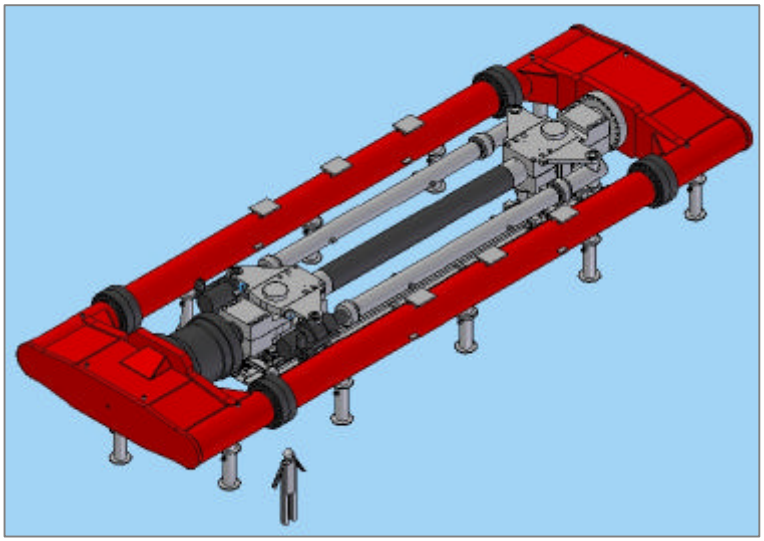
FULL SCALE TESTING AT CSM
PIPE SIZE 168.3 mm OD x 7 mm wt

For the smaller size, the full scale test frame dedicated to testing of connections for Oil&Gas wells may be used

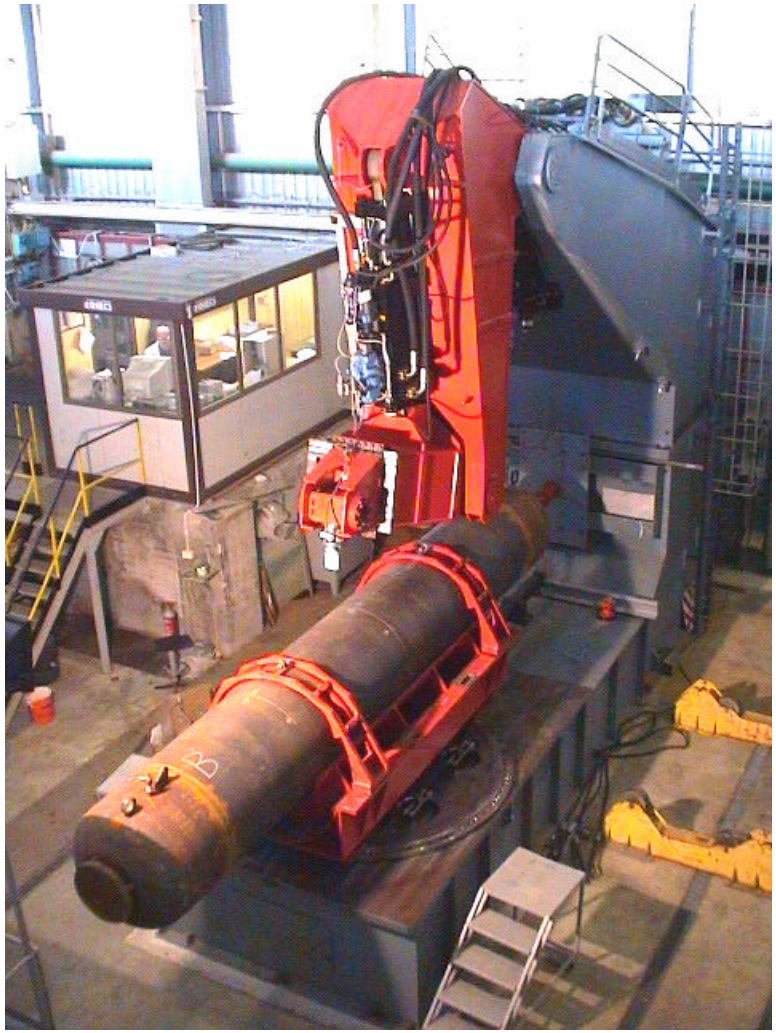
Max Tension 1300t
Max Compression 1000t
Max Bending 30 t·m
Max Int. Pressure (gas) 2000 bar

FULL SCALE TESTING AT CSM
PIPE SIZE 508 mm OD x 8.8 mm wt

MAX tension 2000t
MAX compression 2500t
MAX bending 300 t·m



FULL SCALE TESTING AT CSM
EXTERNAL DAMAGE SIMULATOR FOR PUNCTURING TEST



Nominal range 16” – 48”