CIPP liner tests
Standards
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1 General information

1.1 Application
The purpose of this ATCC is to eliminate the possibility for differing interpretations of the generally applicable standards for material inspection of on-site curing hose liners. For this purpose, the experimental design, the requirements for the sample specimen and the requirements for the experimental procedure for each material inspection for each testing laboratory are specified in a binding manner. In this way, the client and the company responsible for implementation are ensured that the comparability of the results of the material inspections are within the remaining experimental tolerance.

1.2 Definitions
Client
The client of the construction site is at the same time the client of the testing laboratory.

Company responsible for implementation
The company contracted to perform the installation of the hose liner.

1.3 Contractual basis
A material sample of the installed hose liner is sent to the testing laboratory by the client. This material sample is accompanied by a contract letter and the completed sample data sheet (see point 2 and Appendix 1). The criteria specified in this ATCC apply for the laboratory test on this material and as a supplement to the contract.

If prior notice of more than 5 working days is given, the 3-point deflection test and leak test are to be performed within 2 working days and the results are to be provided to the client. The creep tendency is to be determined 4 weeks after curing of the hose liner. All other tests are to be realized within 10 working days.

The results are: (to be filled out by the client)

☐ To be provided to the company responsible for implementation and client simultaneously.

☐ Only to be provided to the client.

The results of the material test are the property of the client. Any use of the results requires the consent of the client.

1.4 Expertise of the laboratory

1.5.1 Accreditation
The contracted testing laboratory has been accredited by the Deutscher Akkreditierungsрат (German Accreditation Council). The minimum requirement is accreditation according to DIN EN ISO/IEC 17025 for all contracted material tests, and thus all related national and international standards.

1.5.2 Recognized construction monitoring body
The contracted testing institute is recognized by the Deutsches Institute für Bautechnik (DIBt, German Institute for Construction Technology) as a monitoring body for monitoring according to § 17 Paragraph 6 of the Musterbauordnung (MBO, Master Building Code).
1.5.3 Supplement to the approvals from 1.5.1 and 1.5.2

Recognition as a monitoring body by the DIBt is required 1 year after the ATCC come into effect.

The client and the company responsible for implementation, via the client, have the right to inspect the certifications and accreditation certificates specified in 1.5 at any time. If this is not agreed to, the order can be revoked from the testing laboratory or the laboratory can be excluded from future consideration.

The aforementioned qualifications have been examined before commissioning by the client. If one of these requirements is rejected during the existing contractual relationship, the client must be informed immediately.

1.5 Commissioning of third parties

If a third party is commissioned to perform individual material tests, the client must be informed before the third party is commissioned. A third party may only be commissioned with the express consent of the client.

Third parties must be accredited for testing procedures according to DIN EN ISO/IEC 17025. Upon request, this will be demonstrated to the client of the material test.

1.6 Location of the samples, request for return

The client has the right to recover the analyzed samples. The company responsible for implementation can request, via the client, samples that have not fulfilled the values specified in the contract between client and implementing company. It is not permissible to return samples directly to the company responsible for implementation.

Handing samples over to third parties may only be performed with the express consent of the client.

The test specimens are stored by the test laboratory for 6 months and are then disposed of properly.

1.7 Handover and representation of the test results

The test results are summarized by the client in a test report, which contains the requirements specified in point 4 of this work. In this way, a clear, complete and comprehensible representation of the test results is created.

If there are individual deviations from the testing regulations specified under point 3, this must be explicitly noted and justified in the test report according to point 4.

If, when received by the test laboratory, the shape or geometry of the sample deviates from the specifications in point 3, the client is to be informed and it should be clarified whether or not the tests should be performed. Otherwise, no payment will be made.
2. Sample data sheet
The sample data sheet ensures that all necessary material and site data are recorded. The authorized signatory representative of the company responsible for implementation is required to examine the records regarding sample identification for completeness and accuracy and to confirm with a signature.

The sample data sheet is completed on site by the client and company responsible for implementation after the sample is taken. The correctness of the data is confirmed by both contract parties with signatures. Independent thereof, it is the responsibility of the client to commission any additional tests.

The original sample data sheet remains with the client. The company responsible for implementation receives a copy. An additional copy of the original is sent with the sample to the testing institute.

3. Material tests
Material testing must be performed according to the following criteria. If there is a deviation from these specifications, this must be recorded in the test report. Point 1.8 is to be noted.

All material tests to be performed should ensure that the delivered quality complies with the ordered quality.

3.1 Three-point deflection test

Valid and applicable standards

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIN EN ISO 178</td>
<td>Plastics determination of flexural properties</td>
</tr>
<tr>
<td>DIN EN 13566-4</td>
<td>Plastics piping systems for renovation of underground non-pressure drainage and sewerage networks</td>
</tr>
<tr>
<td>Section 4 – On-site curing hose lining</td>
<td></td>
</tr>
<tr>
<td>Appendix C (normative) – modifications to DIN EN ISO 178 on deflection tests.</td>
<td></td>
</tr>
</tbody>
</table>

Test equipment
Test equipment is only permitted that fulfills the requirement of DIN EN ISO 178 with supplements from DIN EN 13566-4 Appendix C and those that comply with these ATCC.

Basic properties
Definition according to DIN EN ISO 178

Support
According to DIN EN 13566/4.
In addition to the standard: A support that can tilt perpendicular to the sample axis.

Pressure fin
Defined fin spacing according to DIN EN 13566-4: perpendicular tilt with respect to the sample axis (for radial test, in the longitudinal axis of the sample).

Display of force and deflection
According to DIN EN ISO 178, point 5.4

Sample specimen form and dimensions
Test in direction of circumference according to DIN EN 13566-4.

If the rise of the center of the sample specimen exceeds the level of the support “0.07 x support” (support center spacing), (see picture C.1 DIN EN 13566-4), the three-point deflection in the radial direction no longer complies with the standard. Here the apex pressure test according to EN 1228 or a three-point deflection test in axial direction is to be performed with the sample geometry according to Table C1 DIN EN 13566-4. In such a case the procedure must be clarified with the client. It is important that the results are comparable with the results of the same tests (axial, radial, apex pressure).
Sample width/length

According to DIN EN 13566/4
- The sample width must be 50 +/- 1 mm when it is taken.
- If the sample is taken axially, the sample width must be used according to DIN EN 13566-4, Table C1
- Performance of the apex pressure test according to point 3.2 of these ATCC

Average composite thickness $e_m$

The composite thickness is determined by subtracting the thicknesses of the inner and outer foil and the pure resin layers from the total thickness. The outer pure resin layer may not exceed 20% of the composite thickness. In case of thicker outer pure resin layers, the sample has to be discarded. Evaluation and sample scrap (10% deviation) according to DIN EN 13566-4, C4.1. The specification of the average composite thickness $e_m$ is performed in mm with one decimal place. The points at which the composite thickness is measured are marked with a color so that they can be found again at a later time.

Length of the sample specimen $L$

$L \geq L + 4 \times e_m$

Performance of material test

Span $L$

According to DIN EN 13566-4, point C4.2 and C4.3

$(10 \pm 1) \times e_m < L < (16 \pm 1) \times e_m$

The span distance of each test is to be measured with a measurement accuracy of ±1 mm (calipers) and photographic documentation is to be included in the test report.

Arrangement of the sample

According to DIN EN 13566-4, C4.4 and picture C.1.

Load speed

According to DIN EN ISO 178, point 8.5

10 mm/min

Pre-force

5N

Miscellaneous

All geometric data of the sample specimens and the actual span width $L$ as well as the test speed are to be documented in the test report. In addition, the span width is to be documented with pictures. Permissible tolerance ± 1 mm.

Determination of $\sigma_b$:

Measurement recording: 0.02 s, 1 µm

Break recognition:

Sensitivity: Strain 0.05 mm

Drop off: 0.05% $F_{max}$

For sample specimens that do not indicate fracture according to these criteria, the bending stress $\sigma_{bc}$ is determined using the conventional deflection $s_C$. (DIN EN ISO 178, 3.5)
If the $\sigma/\epsilon$ line continues to run parallel to the Hooke's line after a brief drop in the elastic range, then this brief drop is considered as insignificant.

Figure 1: (enlarged detail of the tension-strain curve) Break without subsequent change in the tension-strain behavior of the sample specimen. The break shown here indicates a failure of the pure resin layers without mechanical damage to the supporting laminate.

Determination of the E modulus: Regression in linear region of the curve, $\Delta \epsilon \geq 0.2\%$
### 3.2 Apex pressure test

**Valid and applicable standards**

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIN EN 1228</td>
<td>Determination of the specific initial annular rigidity</td>
</tr>
<tr>
<td>Average composite thickness $e_m$</td>
<td>Determination according to DIN EN 13566/4, C4.1. Number and distribution of measurement points according to EN 1228. It is not permissible to grind down the pure resin layers. The outer pure resin layer may not exceed 20% of the composite thickness. In case of thicker outer pure resin layers, the sample has to be discarded. The points at which the wall thickness is measured are marked with a color so that they can be found again at a later time. The specification of the average composite thickness $e_m$ is performed in mm with one decimal place.</td>
</tr>
</tbody>
</table>

**Length of the sample**

According to 13566 T4, point 7.5 Table 5

**Application of load**

EN 1228 point 7.3

Type of load: A

Procedure: B

**Load introduction**

Plate + flattened round bar, one of them can be tilted

**Pre-force**

5 N
3.3 24 h creep tendency

Valid and applicable standards

DIN EN ISO 899-2 Determination of creep behavior

Sample preparation, determination of the dimensions, test device analog to DIN EN ISO 178.

Formulas for calculation of the deflection stress and the E modulus analog to DIN EN ISO 178, where for the E modulus, not the slope of a straight line but rather the values of force/deflection are used after 1 hour or after 24 hours.

Pre-load 5 N

Determination of sample load

\[ s = 0.0206 \cdot \frac{L_v^2}{d_m} \]

\( L_v \) = Support spacing
\( d_m \) = average pipe diameter

Data recording after 1 hour and 24 hours

The 24-hour creep tendency is determined after 4 weeks of installing the liner.
3.4 Determination of the trace styrene content

The trace styrene content provides information on the curing of styrene-containing reacting resin materials.

Valid and applicable standards

DIN 53394 Part 2  Determination of monomer styrene in reacting resin molding materials on the basis of unsaturated polyester resins.

Test equipment and test methods

The test equipment used is described in detail in the listed standards.

Sample specimen

Taking the sample specimen  A diamond cutter is used to take the sample specimens; the blade is water cooled.

Sample specimen properties  The sample specimens are to be taken along the entire sample thickness of the liner sample; coatings are to be removed.

Sample specimen size  According to DIN 53394-2

Sample specimen preparation

For extraction procedures, sample specimen preparation is an important component of the analyses. The sample specimens required for extraction are to be removed from the part/material with little thermal stress (i.e. carefully avoiding local heating at the area of removal) so that the entire thickness of the product is recorded representatively.

Performance of the tests

Foils/coatings are to be removed directly before testing.

Number of samples according to DIN 53394-2.

Extraction tools

Dichloromethane according to DIN 53 394-2, other extraction methods are not to be used.

Results presentation

The result is specified according to DIN 53394-2 as a mass percentage \( \% \). The specified mass percentage is with respect to the entire amount weighed of liner material.
3.5 **Differential scanning calorimetry, DSC**

Using DSC testing methods, the curing of epoxy resin systems is determined and compared with a reference value.

**Valid and applicable standard**

DIN 53765 “Testing of plastics and elastomers; thermal analysis; DSC”

**Testing equipment and test methods, DIN 53765 - A - 20**

The test equipment used is described in detail in the listed standards. The maximum of the test temperature has to be 230 °C.

**Sample specimen form and mass**

Sample specimen form Flat with at least 4 mm² cross-sectional area

Mass to be weighed Table 2 DIN 53765

**Performance of the tests**

Foils/coatings are to be removed directly before testing.

The samples selected for the test must be taken from the outer area of the structural laminate. Outer pure resin collections must be excluded from testing.

**Results presentation**

The result is specified according to DIN 53765 with glass transition temperatures $T_{G1}$ and $T_{G2}$. 
3.6 Spectral analysis

Spectral analysis is used to examine whether the resin quality used corresponds to the offered resin quality. These methods do not determine the quantitative composition, but rather the qualitative composition.

Every provider must hand over a cured reference sample to the corresponding test laboratory for its approved liner system-resin system. The test laboratory commissioned by the client prepares a reference spectrum for the provided sample.

Valid and applicable standard

No valid standard; ASTM 5576, DIN 55673 (basis)

Test equipment and test methods

FT-IR (with ATR) based on DIN EN 1767

Performance of the tests

Light penetration: Resolution 2% transmission
At least 8 scans are required.
Comparison with reference spectra

Results presentation

Presentations are to be prepared in at least the following wave number areas: 600–2000 cm\(^{-1}\).

The degree of agreement of the two spectra (reference spectrum and spectrum of the material at hand) is to be determined with respect to the band position. The test spectra are to be included on the report of the results.
3.7 Determination of the filler material and glass content

Valid and applicable standard

DIN EN ISO 1172 Determination of textile glass and mineral filler material content, calcination processes (ISO 1172: 1996)

This standard specifies two calcination processes for determination of textile glass and mineral filler material content of glass-fiber reinforced plastics.

Procedure A: For determination of textile glass content if there is no mineral filler material.

Procedure B: For determination of textile glass and mineral filler material content when both components are present. Deviating from the norm, the separation of the residue is done by hand.

Test equipment and test methods

The test equipment and test methods used are described in detail in the standard.

Sample preparation

The preparation of the sample is described in point 6 of DIN EN ISO 1172 “Preparation of sample specimens”.

Results presentation

For the presentation of the results, the result of the end sample material and the initial sample material as a mass percentage, with respect to the total sample mass, is specified. The specification of the filler material used is performed in the sample data sheet.

1. Example: Synthetic fiber felt with aluminum hydroxide filler. The measurement is the weight of aluminum oxide of the sample. From this value, the aluminum hydroxide content is determined using the molar ratio of the initial material (aluminum hydroxide) and end material (aluminum oxide) using calcination.

2. Example: The GFRP base material without filler is the measurement of the glass weight of the sample.

Nominal value (initial material mass content of the composite material, indicated in the sample data sheet) and actual value (mass content of the initial material) of the total sample are to be compared in the presentation of the results.
3.8 Leak test of the material sample of the liner

Valid and applicable standard
The leak test described in DIN EN 1610 is leak test performed on a conduit basis. This can not be transferred to laboratory test with very small test surfaces. For this reason, the following leak test is to be performed on the material sample specimens of the liner.

Test equipment and test methods
The test is performed at three locations on the sample specimen.
The test is to be performed at room temperature (23 ± 5 °C).

Sample preparation
Coatings that are an integral component of the liner according to DIBt certification are not destroyed.
For coatings that are not an integral part of the liner according to DIBt certification, the following procedure is used:
- The foil thickness or coating thickness is measured with precise digital calipers.
- The depth of the cut is to be limited so that the installation aids such as outer and inner foil are cut and significant damage to the laminate is prevented.
- A grid of cuts of 10 perpendicular cuts is made. The spacing between the cuts is 4 mm.

The samples are to be stored at least 4 hours before testing at the specified test climate conditions.

Performance of material test
Low-pressure test: negative pressure is applied to the sample from the outside.
The probe surface has a diameter of 45 mm ±5 mm.
The testing medium is attached to the inside of the sample.
Testing pressure -0.5 bar ±25 mbar
Test duration: 30 minutes
Test medium: drinking water (colored) without wetting agent
Selection of three individual tests per sample

Test result
There may not be water penetration at any of the three test locations. Water penetration is considered to have occurred if paper laid on the sample becomes colored by the moisture. Coloring in the laminate is permissible.
4. Test results
The results of the material test are to be entered in Appendix 2 of this ATCC and to be reported to the client in this form. Evaluation of the results by the test institute is only to be performed where it is explicitly requested. Only a record of the actual state is required.

Presentation of the test results

<table>
<thead>
<tr>
<th>Test</th>
<th>Standard</th>
<th>Value</th>
<th>Unit</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Three-point deflection</td>
<td>DIN EN ISO 178, DIN EN 13566-4</td>
<td>Composite thickness $e_m$</td>
<td>mm</td>
<td>1 decimal place</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bending modulus of elasticity</td>
<td>N/mm²</td>
<td>3 significant numerals ¹)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bending failure stress $\sigma_B$</td>
<td>N/mm²</td>
<td>3 significant numerals ¹)</td>
</tr>
<tr>
<td>Apex pressure trial</td>
<td>DIN EN 1228</td>
<td>Composite thickness $e_m$</td>
<td>mm</td>
<td>1 decimal place</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Annular rigidity $S_0$</td>
<td>N/m²</td>
<td>Integer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Circumference modulus of elasticity $E$</td>
<td>N/mm²</td>
<td>3 significant numerals</td>
</tr>
<tr>
<td>Creep tendency</td>
<td>DIN EN ISO 899-2</td>
<td>Composite thickness $e_m$</td>
<td>mm</td>
<td>1 decimal place</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Modulus of elasticity $E_{1\text{h}}$</td>
<td>N/mm²</td>
<td>3 significant numerals</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Modulus of elasticity $E_{24\text{h}}$</td>
<td>N/mm²</td>
<td>3 significant numerals</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Creep tendency $K_{N24\text{h}}$</td>
<td>%</td>
<td>1 decimal place</td>
</tr>
<tr>
<td>Creep tendency</td>
<td>DIN EN761</td>
<td>Composite thickness $e_m$</td>
<td>mm</td>
<td>1 decimal place</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Circumference modulus of elasticity $E_{1\text{h}}$</td>
<td>N/mm²</td>
<td>3 significant numerals</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Circumference modulus of elasticity $E_{24\text{h}}$</td>
<td>N/mm²</td>
<td>3 significant numerals</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Creep tendency $K_{N24\text{h}}$</td>
<td>%</td>
<td>1 decimal place</td>
</tr>
<tr>
<td>Trace styrene content</td>
<td>DIN 53394, Part 2</td>
<td>Weighted sample</td>
<td>g</td>
<td>3 decimal places ¹)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Trace styrene content</td>
<td>%</td>
<td>1 decimal place ¹)</td>
</tr>
<tr>
<td>DSC analysis</td>
<td>DIN 53765</td>
<td>Glass transition temperature $(T_{G1}, T_{G2})$</td>
<td>°C</td>
<td>Integer ¹)</td>
</tr>
<tr>
<td>Determination of the filler material and glass content</td>
<td>DIN EN ISO 1172</td>
<td>Resin content</td>
<td>%</td>
<td>1 decimal place</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Filler material content</td>
<td>%</td>
<td>1 decimal place</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Glass content</td>
<td>%</td>
<td>1 decimal place</td>
</tr>
</tbody>
</table>

¹) According to the applicable standard
## ADDITIONAL TECHNICAL CONTRACT CONDITIONS (ATCC)
For CIPP liner testing

### Appendix 1: Sample data sheet

<table>
<thead>
<tr>
<th>Initial test</th>
<th>Repeat test</th>
<th>For testreport no.:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample-taking</td>
<td>Confirmation that the sample has been taken (company responsible for implementation/ construction management)</td>
<td>Confirmation that the sample has been taken (client/construction management)</td>
</tr>
<tr>
<td>Date</td>
<td>Block letters</td>
<td>Signature</td>
</tr>
</tbody>
</table>

### Sample identification

<table>
<thead>
<tr>
<th>Client, material testing</th>
<th>Liner material ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Client</td>
<td>Length of the liner</td>
</tr>
<tr>
<td>Building project</td>
<td>Conduit identification</td>
</tr>
<tr>
<td>Company responsible for implementation</td>
<td>Sample identification</td>
</tr>
<tr>
<td>Liner manufacturer</td>
<td>Date of installation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Resin type</th>
<th>UP</th>
<th>VE</th>
<th>EP</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base material</td>
<td>Synthetic f.</td>
<td>GFRP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pipe geometry</td>
<td>Circle DN</td>
<td>Extraction location</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oval</td>
<td>Conduit</td>
<td>End shaft</td>
<td>Inter. Shaft</td>
<td></td>
</tr>
<tr>
<td>Extraction position</td>
<td>Apex</td>
<td>Springer</td>
<td>Base</td>
<td></td>
</tr>
<tr>
<td>Coating is an integral component of the liner</td>
<td>Yes</td>
<td>Outside</td>
<td>No</td>
<td>inside</td>
</tr>
</tbody>
</table>

Minimum probe size: 20 x wall thickness in direction of circumference and 35 cm in longitudinal direction. If a creep tendency test is commissioned, the length must be at least 40 cm. It is possible to divide the sample. Minimum size of the individual segments: 50 mm width and 20 x wall thickness in the longitudinal direction. For apex pressure test, a ring section of least 40 cm in length must be extracted.

### Tests to be performed (to be marked by the client)

#### Mechanical properties (standard test)

- 3-point deflection test in radial direction (standard test) according to DIN EN ISO 178/DIN EN 13566-4 and Section 3.1 of the ATCC material test for determination of - E modulus - Bending stress
- 3-point deflection test in axial direction (necessity see 3.1 “Sample specimen form and dimensions”) according to DIN EN 1228 and Section 3.2 of the ATCC material test for determination of the E modulus

#### Waterproof test (standard test)

- Determination of the trace styrene content according to DIN 53394-2 and Section 3.4 of the ATCC (GC) (for UP resins)
- Thermal analysis (DSC measurement) according to DIN 53765 and Section 3.5 of the ATCC material test (for epoxy resins)

#### Inspection of the curing of the laminate if the E modulus or bending stress is too low

- 24-hour creep tendency 3-point based on DIN EN ISO 899-2 and Section 3.3 of the ATCC material test
- 24-hour creep tendency apex pressure according to DIN EN 761 (not addressed in the ATCC material inspection)

#### Material identification

- Spectral analysis based on DIN 55673, DIN EN 1767 and Section 3.6 of the ATCC material test
- Calcination method based on DIN EN ISO 1172 and Section 3.7 of the ATCC material test
- Density measurement based on DIN EN ISO 1183-1 (not addressed in the ATCC material test)

---

**Actual sample size**

<table>
<thead>
<tr>
<th>In direction of circumference cm</th>
<th>In longitudinal direction cm</th>
</tr>
</thead>
</table>

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## Appendix 2: Presentation of the results

**Initial test**

<table>
<thead>
<tr>
<th>Information on the taking of the sample</th>
<th>Sample-taking</th>
<th>Confirmation that the sample has been taken (company responsible for implementation/ construction management)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supervision by (name)</td>
<td>Sample-taking</td>
<td>Confirmation that the sample has been taken (company responsible for implementation/ construction management)</td>
</tr>
<tr>
<td>Date</td>
<td>Time</td>
<td>Block letters</td>
</tr>
</tbody>
</table>

### Sample identification

- Client, material testing
- Liner material ID
- Length of the liner
- Building project
- Conduit identification
- Sample identification
- Company responsible for implementation
- Liner manufacturer
- Date of installation
- Resin type
- Synthetic f.
- UP
- VE
- EP
- Other
- Base material
- Synthetic f.
- GFRP
- Pipe geometry
- Circle DN
- Extraction location
- Conduit
- End shaft
- Inter. Shaft
- Extraction position
- Apex
- Springer
- Base
- Coating is an integral component of the liner
- Yes
- No
- Outside
- Inside
- Circle DN
- Oval

According to ATCC material test and the supplements to the standards contained therein, the following test results have been achieved:

### Bending E modulus, bending stress

<table>
<thead>
<tr>
<th>Test date</th>
<th>$E_i$ [MPa]</th>
<th>$\sigma_{B_i}$ [MPa]</th>
<th>Test direction</th>
<th>$K_{24}$ [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>$\bigcirc$ axial</td>
<td>$\bigcirc$ radial</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total thickness $e$ [mm]</th>
<th>Composite thickness $e_m$ [mm]</th>
</tr>
</thead>
</table>

### Circumferential E modulus, start annular rigidity

<table>
<thead>
<tr>
<th>Test date</th>
<th>$E_0$ [MPa]</th>
<th>$S_0$ [N/m$^2$]</th>
<th>Total thickness $e$ [mm]</th>
<th>Composite thickness $e_m$ [mm]</th>
<th>$K_{24}$ [%]</th>
</tr>
</thead>
</table>

### Waterproof

<table>
<thead>
<tr>
<th>Test date</th>
<th>Testing time [min]</th>
<th>Testing pressure [bar]</th>
<th>Test result</th>
<th>$\bigcirc$ no leak</th>
<th>$\bigcirc$ leak</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30</td>
<td>0,5 ± 5%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Calcination procedure

<table>
<thead>
<tr>
<th>Test date</th>
<th>Resin content [%]</th>
<th>Total residue [%]</th>
<th>Glass content [%]</th>
<th>Aggregate [%]</th>
</tr>
</thead>
</table>

### Spectral analysis

<table>
<thead>
<tr>
<th>Test date</th>
<th>Resin</th>
<th>Density according to DIN EN ISO 1183-1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Test date</td>
</tr>
</tbody>
</table>

### Thermal analysis

<table>
<thead>
<tr>
<th>Test date</th>
<th>Glass transition temperature $T_g$ [°C]</th>
<th>Enthalpy [J/g]</th>
<th>$\bigcirc$ exothermic</th>
<th>$\bigcirc$ endothermic</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_{g1}$</td>
<td>$\Delta T_g$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$T_{g2}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Trace styrene content

<table>
<thead>
<tr>
<th>Test date</th>
<th>Weight of sample [mg]</th>
<th>Trace styrene content [mg/kg]</th>
<th>Trace styrene content [%]</th>
<th>Sample weight with respect to Total weight</th>
<th>Pure resin</th>
</tr>
</thead>
</table>

### Evaluation of the results

To be performed by the test institute: $\bigcirc$ yes $\bigcirc$ no

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Actual value</th>
<th>Nominal value</th>
<th>Requirement</th>
<th>Actual value</th>
<th>Nominal value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modulus of elasticity in bending</td>
<td>$E_i$ [MPa]</td>
<td>$E_m$ [MPa]</td>
<td>$\bigcirc$ Initial annular rigidity</td>
<td>$\bigcirc$ Base</td>
<td>$\bigcirc$ Outside</td>
</tr>
<tr>
<td>Bending stress</td>
<td>$\sigma_{B_i}$ [MPa]</td>
<td>$\sigma_{B_m}$ [MPa]</td>
<td>$\bigcirc$ 24h creep tendency</td>
<td>$\bigcirc$ Density</td>
<td>$\bigcirc$ Inside</td>
</tr>
<tr>
<td>Static rec. composite thickness</td>
<td>$e$ [mm]</td>
<td>$e_m$ [mm]</td>
<td>$\bigcirc$ 24h creep tendency</td>
<td>$\bigcirc$ Density</td>
<td>$\bigcirc$ Inside</td>
</tr>
<tr>
<td>Waterproof</td>
<td>$\bigcirc$ Yes</td>
<td>$\bigcirc$ No</td>
<td>$\bigcirc$ 24h creep tendency</td>
<td>$\bigcirc$ Density</td>
<td>$\bigcirc$ Inside</td>
</tr>
</tbody>
</table>
Appendix 3: Flow diagram

**Standard check three-point deflection test radial** (if depth gauge < 0.07 x support spacing)

- Measurement of the total and composite thicknesses
- 10% criterion according to point 3.1 fulfilled?
  - Yes: Modulus of elasticity (-10% perm.) bending stress (not with apex pressure test)
  - No: Do not continue test; inform customer

- Both nominal values reached?
  - Yes: Check curing, trace styrene content (UP resins) DSC (epoxy resins)
  - No: Check long-term behavior (determine creep tendency)

- Both nominal values reached?
  - Yes: Linguistic test passed; examination of stress analysis by customer and executing company
  - No: Possibility of a second test (as regulated contractually)

**Standard leak tightness test (porosity test) of the laminate**

- No sample leak?
  - Yes: Test passed
  - No: Possibility of a second test (as regulated contractually)

**Spectral analysis** (optional)

**Determination of filler material and glass content** (optional)
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