New development of fibre-reinforced plastic piping for the chloralkali electrolysis

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ALPHAPLAST, S.L.U., Vilanant (ES)
ALPHA RESIST

NEW GENERATION plastic piping with fibre free CRB for the chloralkali electrolysis

Content:
- Motivation
- Idea
- System
- Lab-testing
- Field-testing
- Summary

ALPHA RESIST is made by ALPHAPLAST, S.L., a member of the STEULER group
Motivation | Chlor-alkali-electrolysis

The membrane cell process with high-maintenance piping

Anolyte piping (Depleted brine)

Catholyte piping (Hydrogen gas)
### Motivation | Anolyte piping

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium</td>
<td>≈ 17 % NaCl, ≤ 1 % Na₂SO₄, ≤ 1 % NaClO₃, Cl₂ saturated</td>
</tr>
<tr>
<td>Temperature</td>
<td>≈ 85 – 95 °C</td>
</tr>
<tr>
<td>Working pressure</td>
<td>PS ≈ 0.2 barg – 3 barg</td>
</tr>
<tr>
<td>pH-value</td>
<td>1.5 – 5 (max. 12)</td>
</tr>
</tbody>
</table>
Motivation | Anolyte piping

Material system **CPVC/FRP**
Chemical resistance extremely dependent on pH-value
(pH ≥ 3 \(\rightarrow\) HOCl \(\rightarrow\) fast destruction)

Material system **FRP with corrosion resistance barrier (CRB)**
(Glass content CRB \(\leq\) 30%) or FRP with overall low glass content

Chemical attack dependent on load and:
- Resin type (VIAPAL UP 797, DERAKANE MOMENTUM 470, DERAKANE 510 N etc.)
- curing agents
- glass content \(\rightarrow\) glass is not resistant

Quantity of attack \(\approx 0.3\) to 1 mm/a

Obstruction of the cell membrane and the piping with worn out glass fibres
Motivation | Anolyte piping

Examples of annually attack:
- Length of Pipe: 50 m
- Glass content of CRB: 30 %
- Annual chemical abrasion: 0.5 mm/a
- Density of CRB: 1.6 kg/dm³

<table>
<thead>
<tr>
<th>Nominal diameter</th>
<th>Surface</th>
<th>Removal volume</th>
<th>FRP</th>
<th>glass</th>
</tr>
</thead>
<tbody>
<tr>
<td>DN 50</td>
<td>7.85 m²</td>
<td>3.93 dm³</td>
<td>6283 g</td>
<td>1885 g</td>
</tr>
<tr>
<td>DN 80</td>
<td>12.57 m²</td>
<td>6.28 dm³</td>
<td>10053 g</td>
<td>3016 g</td>
</tr>
<tr>
<td>DN 100</td>
<td>15.71 m²</td>
<td>7.85 dm³</td>
<td>12566 g</td>
<td>3770 g</td>
</tr>
<tr>
<td>DN 150</td>
<td>23.56 m²</td>
<td>11.78 dm³</td>
<td>18850 g</td>
<td>5655 g</td>
</tr>
<tr>
<td>DN 200</td>
<td>31.42 m²</td>
<td>15.71 dm³</td>
<td>25133 g</td>
<td>7540 g</td>
</tr>
<tr>
<td>DN 400</td>
<td>62.83 m²</td>
<td>31.42 dm³</td>
<td>50265 g</td>
<td>15080 g</td>
</tr>
</tbody>
</table>
Motivation | Catholyte piping

Medium  
≈ 32 \% \text{NaOH} , \leq 20 \text{ ppm NaClO}_3

Temperature  
≈ 85 – 95 °C

Working pressure  
< 1.5 barg

Material systems:

PP-B (PPH 2222/36)/FRP
PP-R (RA130E-8427)/FRP
PVC (DEKADUR Plus)/FRP (only in exeptional cases)
Motivation | Catholyte piping

Hot caustic
Decomposition of PP-stabilisers

Result
• Stress cracking in welds
• Caustic glass corrosion!
Motivation | Catholyte piping

Different coefficients of thermal expansion

Increase of starts and shutdowns results in debonding of lining
Motivation | Catholyte piping

Temperature changes generate high shear stresses between FRP and lining

Debonding of PP-lining
Idea | System for Anolyte piping

Development of an adapted FRP system without glass fibres in the CRB and reduced attack to the piping

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<tr>
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<th>CRB</th>
<th>Structural laminate</th>
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</thead>
<tbody>
<tr>
<td>Resin</td>
<td>VE-NK- or UP-HET-type</td>
<td>VE-NK- or UP-HET-type</td>
</tr>
<tr>
<td>“Reinforcement”</td>
<td>Instead of glass fibres use of inert mineral powder</td>
<td>Glass fibre</td>
</tr>
<tr>
<td>Type name</td>
<td>ALPHARESIST-A</td>
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Idea | System for Catholyte piping

Development of an adapted FRP system without glass fibres in the CRB and reduced attack to the piping

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<tr>
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<td>Resin</td>
<td>Resin</td>
<td>ALPHARESIST-K</td>
</tr>
<tr>
<td></td>
<td>Epoxy-type</td>
<td>Epoxy-type</td>
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Lab-testing | at Alphaplast, Spain

Specimen preparation:
- Sheet
- Pipe

With different:
- Resins
- Curing systems / hardener
- Fillers (type, content)
Lab-testing | Impact properties

CHARPY impact strength according to DIN EN 179-1
Lab-testing | Impact properties

CHARPY impact strength according to DIN EN 179-1

Impact strength of ALPHARESIST CRB with a filler content of 30 % is slightly lower than that of PVC

Check of ultimate elongation
Lab-testing | Ultimate elongation

Design strain for ALPHARESIST anolyte piping determined with bending tests

Catholyte piping with epoxy resin shows higher ultimate strain

Requirement of design strain fulfilled by ALPHARESIST

ALPHARESIST anolyte piping CRB with 30 % mineral filler

Traditional CRB min. requirement according to DIN EN 13121-3

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Change of weight over time for different test specimen types and epoxy-hardener combinations.

**Test specimen type A**
- Before: [Image of test specimen]
- After 484 days: [Image of test specimen]

**Test specimen type 2**
- Before: [Image of test specimen]
- After 484 days: [Image of test specimen]

**Epoxy / hardener type A**
- 0% change at 0 days
- -1% change at 100 days
- -2% change at 200 days
- -3% change at 300 days
- -4% change at 400 days
- -5% change at 500 days

**Epoxy / hardener type 2**
- 0% change at 0 days
- -1% change at 100 days
- -2% change at 200 days
- -3% change at 300 days
- -4% change at 400 days
- -5% change at 500 days

**Immersion to 32% NaOH at 100 °C**

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Lab-testing | ALPHARESIST-K

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<table>
<thead>
<tr>
<th>Test piece</th>
<th>Load</th>
<th>Material</th>
<th>Resin</th>
<th>Filler</th>
<th>Location of electrolysis</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flanged pipe DN 100 x 600</td>
<td>Anolyte</td>
<td>Alpharesist-A</td>
<td>VE-NK, UP-HET</td>
<td>Two different types</td>
<td>Germany</td>
<td>Since April 2016</td>
</tr>
<tr>
<td>Flanged pipe DN 150 x 1000</td>
<td>Catholyte</td>
<td>Alpharesist-K</td>
<td>Epoxy</td>
<td>Ceramic</td>
<td>Middle East</td>
<td>Coming soon</td>
</tr>
<tr>
<td>Bypass piping DN 150 x 6000</td>
<td>Catholyte</td>
<td>Alpharesist-K</td>
<td>Epoxy</td>
<td>Ceramic</td>
<td>Germany</td>
<td>Since May 2017</td>
</tr>
<tr>
<td>Piping isometric DN 80</td>
<td>Anolyte</td>
<td>Alpharesist-A</td>
<td>VE-NK</td>
<td>Ceramic</td>
<td>Middle east</td>
<td>Upcoming</td>
</tr>
<tr>
<td>Piping isometric DN 100</td>
<td>Catholyte</td>
<td>Alpharesist-K</td>
<td>EP</td>
<td>Ceramic</td>
<td>Middle east</td>
<td>Upcoming</td>
</tr>
<tr>
<td>4 flanged pipes DN 100 x 600</td>
<td>Anolyte</td>
<td>Alpharesist-A</td>
<td>VE-NK UP-HET</td>
<td>Two types</td>
<td>Germany</td>
<td>Since May 2017</td>
</tr>
</tbody>
</table>
### Field test | **ALPHARESIST-A** in a anolyte piping

<table>
<thead>
<tr>
<th>Pipe</th>
<th>Load</th>
<th>Material</th>
<th>Resin</th>
<th>Filler</th>
<th>Location</th>
<th>Duration</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>DN 100 x 600</td>
<td>Anolyte</td>
<td>ALPHARESIST-A</td>
<td>VE-NK, UP-HET</td>
<td>Two different types</td>
<td>Germany</td>
<td>Since April 2016</td>
<td>No anomalies at inspection May 2017</td>
</tr>
</tbody>
</table>
### Field test | ALPHARESIST-K in a catholyte piping

<table>
<thead>
<tr>
<th>Pipe</th>
<th>Load</th>
<th>Material</th>
<th>Resin</th>
<th>Filler</th>
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<th>Duration</th>
<th>Remarks</th>
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<td>DN 150 x 6000</td>
<td>Catholyte</td>
<td>ALPHARESIST-K</td>
<td>Epoxy</td>
<td>Ceramic</td>
<td>Germany</td>
<td>Since May 2017</td>
<td>No anomalies</td>
</tr>
</tbody>
</table>
Summery | ALPHARESIST

Anolyte piping

• Glass-fibre free chemical protection layer based on special polyester or vinyl ester resin
• No contamination or blockage from removed glass fibres
• Optimized maintenance intervals

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Summery | ALPHARESIST

Catholyte piping

- Glass-fibre free chemical protection layer based on epoxy resin
- Full fibre-reinforced plastic piping without thermoplastic lining
- Homogenous material system
- Easy erection on-site without welding

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THANK YOU FOR
YOUR ATTENTION