Petroleum and natural gas industries—
Ceramic lined tubing

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Outline

1、Background

2、Ceramic lined tubing

3、Application

4、Standardization
Background

Failures of steel tubing

- Corrosion
- Abrasion
- Scale and wax

Amounts of waste tubing every year

Diagram of oil well
Solutions

- Corrosion resistance alloy pipe: too expensive
- Coated pipes: easy to fall off
- Inhibitors: complicated procedure
- ?
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A composite pipe comprised of a ceramic layer formed by self-propagating high-temperature synthesis (SHS) on the inner wall of the tubing.

- No dissolution in acid, base and water
- Excellent anti-corrosion performance
- Better anti-scaling effect

**SHS reaction**: \( 2\text{Al} + \text{Fe}_2\text{O}_3 = \text{Al}_2\text{O}_3 + 2\text{Fe} + 836\text{kJ/mol} \)
History of Development

- **1967**: SHS was invented
- **1980**: Study SHS in Japan
- **1985**: Study SHS in the US
- **1989**: Study SHS in China
- **1995**: Prof. Osamu Odawara in Japan
  - OD: 300mm
  - L: 5m
- **2000**: China published YB/T 176
  - OD: 63~630mm
  - L: 3m
- **2007**: Company in China
  - OD: 114mm
  - L: 12m
- **2016**: China published SY/T 6662.8
  - OD: 42~323mm
  - L: 13.72m
- **2016**: Study SHS in Korea
Manufacturing Process

- Unload coupling
- Magnetic flux leakage test and wall thickness selection
- Remove the oil
- Pre-alignment
- Lined ceramic
- Length separation
- Sand blast
- Cropping
- Inspection
- Honing
- Drifting
- Threading
- Storage
- Packaging
- Length, weight, marking and painting
- Hydrostatic test
# Manufacturing Process

<table>
<thead>
<tr>
<th>Product</th>
<th>Outside diameter (mm)</th>
<th>Wall thickness (mm)</th>
<th>Thickness of composite layer (mm)</th>
<th>Pipe length (m)</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceramic-lined tubing</td>
<td>42-114</td>
<td>3-16</td>
<td>2-4</td>
<td>6.1-7.32</td>
<td>H, J, N</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8.53-9.75</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>11.58-12.80</td>
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</table>

![Manufacturing Process](image-url)
Pipe-to-pipe joint

- Inlay seal ring
- Turn up protection ring
Key Properties of Ceramic Lined Tubing

- Corrosion test
- Wear resistance test
- Flattening test
- Bonding strength test
- Tensile to failure test
- Impact test
- Bend test
- Full scale bend test
**Key Properties of Ceramic Lined Tubing**

<table>
<thead>
<tr>
<th>Performance</th>
<th>Assessment method</th>
<th>Assessment effect</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Thermal shock resistance</strong></td>
<td>Liquid nitrogen and heating furnace -50°C to 400°C for three times</td>
<td>No cracks and obvious change No reduce in mechanical performance</td>
</tr>
<tr>
<td><strong>Tensile strength</strong></td>
<td>Take 3 average values /</td>
<td>J55: 680MPa N80: 716MPa</td>
</tr>
<tr>
<td><strong>Bond strength</strong></td>
<td>Take 3 average values Separate the ceramic from the pipe body by using an indenter</td>
<td>J55: 36.68MPa N80: 47.61MPa</td>
</tr>
<tr>
<td><strong>Crushing strength</strong></td>
<td>Take 3 average values Crush from outside to inside in the radial direction</td>
<td>J55: 624.6MPa N80: 771.5MPa</td>
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<tr>
<td><strong>Fatigue test</strong></td>
<td>/ Circulate for 73124 times under the pressure of 5kN</td>
<td>No damage</td>
</tr>
<tr>
<td><strong>Bend property</strong></td>
<td>/ Bend by 0.87m with 8.8m of support distance</td>
<td>No damage</td>
</tr>
<tr>
<td><strong>Impact resistance</strong></td>
<td>/ Impact the 73mm tubing by using 10kg of heavy hammer with 750mm of height</td>
<td>73.5J</td>
</tr>
</tbody>
</table>
## Key Properties of Ceramic Lined Tubing

<table>
<thead>
<tr>
<th>Grade</th>
<th>Sample No.</th>
<th>Burst pressure (MPa)</th>
<th>Grade</th>
<th>Sample No.</th>
<th>Tensile strength (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>J55</td>
<td>1Z</td>
<td>106.2</td>
<td>J55</td>
<td>1Y</td>
<td>617.91</td>
</tr>
<tr>
<td></td>
<td>2Z</td>
<td>108.7</td>
<td></td>
<td>2Y</td>
<td>720.52</td>
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<tr>
<td></td>
<td>3Z</td>
<td>105.9</td>
<td></td>
<td>3Y</td>
<td>705.35</td>
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<tr>
<td>API TR 5C3-2008</td>
<td></td>
<td>≥50.0</td>
<td>API TR 5C3-2008</td>
<td></td>
<td>≥443.5</td>
</tr>
</tbody>
</table>
Outline

1. Background
2. Ceramic lined tubing
3. Application
4. Standardization
Application

Application fields

- Depth < 3500m
- Mainly in water injection, oil recovery
- Highest operating temperature 300°C
- Repair the waste pipes

More than 3 million meters of ceramic lined tubing have been used in more than 20 oilfields in China
Application

Before:

◆ Jilin Oilfield
◆ API tubing, 1 Year

(CO$_2$:22.4%, Depth:1800m, Temp: 80°C)
◆ Serious corrosive perforation

After:

◆ Jilin Oilfield
◆ Ceramic lined tubing, 3 Years

(CO$_2$:24.5%, Depth:1850m, Temp: 80°C)
◆ No corrosion
Some reports of users
Outline

1. Background
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SY/T 6662.8-2016 Non-metallic composite pipes for petroleum and natural gas industries – Part 8: Ceramic-lined pipe and fittings
ISO/TC 67/SC 5 plenary meeting
2019-05-28
Presented the NWIP

NWIP has been officially submitted to ISO/TC 67/SC 5
<table>
<thead>
<tr>
<th>No.</th>
<th>Name</th>
<th>Country</th>
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</tbody>
</table>
This standard will be for manufacture, type and structure, technical requirements, inspection and testing, marking, packing and transportation of ceramic lined tubing for wells. Ceramic lined tubing in this standard are applicable to oil fields with corrosion, abrasion, and high temperature in oil, gas and water system.

- Scope
- Normative references
- Terms, definitions, symbols and abbreviated terms
- Information to be supplied by the purchaser
- Process of manufacture
- Structure
- Technical requirements
- Testing
- Inspection
- Marking, Packing and Transportation
- Annex
What We Need to do Next

- Ballotage of the NWIP in ISO/TC 67/SC 5
- Need more experts like Osamu Odawara to join the work group

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Thanks a lot!

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