LONG TERM PERFORMANCE OF PVC PRESSURE PIPES

- M. Stahmer, Vinidex Pty. Ltd.
SUMMARY

• EXHUMATION OF PVC PIPES FROM RURAL WATER SCHEME CONSTRUCTED IN EARLY 1970’S

• THREE PIPE MANUFACTURERS

• SOLVENT CEMENT JOINTS & RUBBER RING JOINTS

• MATERIAL PROPERTIES EVALUATED
WHY EXHUME THESE PIPES?

- 30 YEARS SUCCESSFUL OPERATION
- KNOWN INSTALLATION AND OPERATIONAL CONDITIONS
- PIPES MADE FROM AUSTRALIAN AND JAPANESE RESINS
WHY EXHUME THESE PIPES?

• ONGOING INTEREST OF AUSTRALIAN WATER UTILITIES IN RESIDUAL LIFE OF PVC PRESSURE PIPES

• CONTINUED MISUNDERSTANDING OF REGRESSION CURVES
THE PROJECT

• RURAL CHANNEL REPLACEMENT TO REDUCE MASSIVE WATER LOSSES
  – 644 km OF SUPPLY PIPES
  – 500 km OF ON-FARM PIPES
  – ALL PVC EXCEPT FOR SOME 8” & 12” A.C.
PVC SPECIFICATION & MANUFACTURE

  - FLATTENING
  - IMPACT - 0°C, 20°C
  - ACETONE IMMERSION
  - SULPHURIC ACID IMMERSION
  - SOFTENING POINT
  - INTERNAL PRESSURE
MANUFACTURERS

• VINIDEX TUBEMAKERS - ICI (AUST) RESIN
• HARDIE EXTRUSIONS - BFG (AUST) RESIN
• HUME-S-LON - SEKISUI (JAPAN) COMPOUND
INSTALLATION

- SR&WSC SPECIFICATION
- SOLVENT WELD AND RUBBER RING JOINTS
- 750mm COVER, 900mm AT ROAD AND RAIL CROSSINGS
INSTALLATION

- GRANULAR PIPE SURROUND, INCLUDING 75mm BENEATH PIPE

- PRESSURE TESTING TO 1.3 TIMES RATED WORKING PRESSURE
PERFORMANCE

- AC LEAKING JOINTS, ROOT INTRUSION, PIPE BREAKAGES
- NO PVC FAILURES, APART FROM ONE JOINT.
- SPUR 3/1 IS EXCEPTION - 1230m OF 4” PB (DN 100, PN6) TESTED TO 80m HEAD
WATER QUALITY

• LEAD EXTRACTION FROM PIPES - EVALUATED IN 1971 AND FOUND TO BE ACCEPTABLE

• GREY SLUDGE IN THE PIPE ASSOCIATED WITH WATER QUALITY, NOT THE PIPES
EXHUMATION & TESTING

• RANGE OF PIPES WAS SELECTED FROM PLANS TO COVER THE RANGE OF TESTS AND TO MAKE PRODUCT COMPARISONS
  – ALL EXHUMED PIPES WERE IN GOOD CONDITION
  – ALL EXHUMED PIPES HAD RUBBER RING JOINTS
C-ring Fracture Toughness

- Humes 8" PB: $4.806 - 0.491 \log x$
- Hardietube 6" PC: $4.551 - 0.516 \log x$
- Humes 4" PD: $3.954 - 0.4532 \log x$
- Vinidex 2" PD: $4.668 - 0.7495 \log x$
Fracture Toughness Specifications

Fracture Toughness

4" PD
6" PC
8" PB
2" PD
# Gelation

<table>
<thead>
<tr>
<th>Pipe Identification</th>
<th>Percent Gelation</th>
<th>Heat of Fusion J/g</th>
<th>Melt Temp. °C</th>
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</thead>
<tbody>
<tr>
<td>Humes Plastics 6&quot; PD</td>
<td>44</td>
<td>1.9</td>
<td>185</td>
</tr>
<tr>
<td>Humes Plastics 8&quot; PB</td>
<td>48</td>
<td>1.9</td>
<td>183</td>
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<tr>
<td>Hardie Extrusions 4&quot; PD</td>
<td>44</td>
<td>2.3</td>
<td>175</td>
</tr>
<tr>
<td>Humes Plastics 4&quot; PD</td>
<td>54</td>
<td>2.2</td>
<td>183</td>
</tr>
<tr>
<td>Hardie Extrusions 6&quot; PC</td>
<td>64</td>
<td>2.7</td>
<td>183</td>
</tr>
<tr>
<td>Vinidex Tubemakers 4&quot; PC</td>
<td>60</td>
<td>3.5</td>
<td>181</td>
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</tbody>
</table>
Dispersion x60

Contemporary PVC Pressure Pipe

Hardies 4” PD

Humes 8’ PB

1980s Sewer

Vinidex 4” PD
## Flattening

<table>
<thead>
<tr>
<th>Pipe Identification</th>
<th>Passes (repeats)</th>
<th>Failures (repeats)</th>
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</thead>
<tbody>
<tr>
<td>Vinidex Tubemakers 4&quot; PC</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>Hardie Extrusions 4&quot; PD</td>
<td>2 (3)</td>
<td>1 (0)</td>
</tr>
<tr>
<td>Humes Plastics 4&quot; PD</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Hardie Extrusions 6&quot; PC</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Humes Plastics 6&quot; PD</td>
<td>2 (3)</td>
<td>1 (0)</td>
</tr>
<tr>
<td>Humes Plastics 8&quot; PB</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>
# Falling Mass Impact Resistance at 20°C

<table>
<thead>
<tr>
<th>Pipe Identification</th>
<th>Total Number of Strikes</th>
<th>Number of Failures</th>
</tr>
</thead>
</table>
| Vinidex Tubemakers 4" PC | 17  
2  
3          | 6  
2  
2          |
| Hardie Extrusions 4" PD | 24  | 0 |
| Humes Plastics 4" PD | 6  | 0 |
| Hardie Extrusions 6" PC | 24  | 7 |
| Humes Plastics 6" PD | 26  
3          | 4  
1          |
| Humes Plastics 8" PB | 34  | 1 |
| Vinidex 2” PD | 2  | 2 |
## Uniaxial Tensile Properties

<table>
<thead>
<tr>
<th>Pipe Identification</th>
<th>Tensile Strength at Yield (MPa)</th>
<th>Tensile Strength at Break (MPa)</th>
<th>Elongation at Break (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Humes Plastics 4&quot; PD</td>
<td>51.4</td>
<td>35.1</td>
<td>31.4</td>
</tr>
<tr>
<td>Vinidex 2&quot; PD</td>
<td>49.7</td>
<td>36.4</td>
<td>30.8</td>
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<tr>
<td>Hardie Extrusions 6&quot; PC</td>
<td>50.0</td>
<td>31.4</td>
<td>36.8</td>
</tr>
<tr>
<td>Humes Plastics 8&quot; PB</td>
<td>50.8</td>
<td>31.5</td>
<td>34.7</td>
</tr>
</tbody>
</table>
Conclusions

- No deterioration in the strength characteristics of the material during service
- Mixed performance on flattening and impact tests could be due to installation or exhumation damage
- Fracture toughness of the pipes is high and in all but one case exceed current requirements
Conclusions

- PVC pipes have satisfied the expectations of the operator of the system and should continue to provide satisfactory service for many years.