Pipe Jacking

An introduction to pipe jacking prepared by the
Pipe Jacking Association
Pipe Jacking – General Arrangement

Pipe Jacking is an integrated system linking:

- soils
- jacking shafts
- pipes
- shields
- jacking loads
- engineering
Major Applications

- New sewerage and drainage construction
- Sewer replacement and lining
- Gas and water mains
- Oil pipelines
- Electricity and telecoms cable ducts
- Subways
Pipe Jacking
Pipe Jacking
Microtunnelling
Technical Benefits

- Inherent strength
- Smooth internal finish
- No secondary lining
- Fewer joints
- Watertight
- Inverts for combined systems
- Less settlement
- Minimal surface impact
- Fewer utility diversions
Safety Benefits

- Inherently safer method
- Quicker installation
- Reduced labour input
- Utility strikes minimised
- Public interface reduced
- Reduced confined space man hours
Sustainability: Environmental and socio-economic benefits

- Reduces disruption
- Reduces damage to services
- Maintains highway integrity
- 90% fewer vehicle movements
- Less spoil
- Less quarried material
- Reduced CO₂ emissions
- No secondary lining
- Economic alternative to deep open cut
- Socially acceptable
Open trench vs Pipejacking

Carriageway

Undisturbed soil

Imported backfill

Undisturbed soil

PIPE

Surround bedding
## Open trench vs Pipejacking

### Lorry Movements

<table>
<thead>
<tr>
<th></th>
<th>600mm ID pipeline 4m deep, 100m length</th>
<th></th>
<th>1200mm ID pipeline 4m deep, 100m length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aspect</td>
<td>Open trench</td>
<td>Trenchless</td>
<td>Open trench</td>
</tr>
<tr>
<td>Excavated width</td>
<td>1400mm (trench width)</td>
<td>760mm (OD of jacking pipe)</td>
<td>2350mm (trench width)</td>
</tr>
<tr>
<td>Reinstatement width</td>
<td>1700mm</td>
<td>None</td>
<td>2650mm</td>
</tr>
<tr>
<td>Excavated volume per metre of pipeline</td>
<td>6.1m³</td>
<td>0.5m³</td>
<td>10.28m³</td>
</tr>
<tr>
<td>Imported stone fill and coated stone per metre of pipeline</td>
<td>11.9 tonnes</td>
<td>None</td>
<td>18.27 tonnes</td>
</tr>
<tr>
<td>Number of 20 tonne lorry loads per 100m pipeline (muck away and imported stone)</td>
<td>136</td>
<td>8</td>
<td>220</td>
</tr>
</tbody>
</table>
Carbon Calculator

- Easy to use
- Options:
  - Feasibility
  - As designed
  - As built
## Open trench vs Pipejacking

### CO₂ Savings – 100 metres

<table>
<thead>
<tr>
<th>Project Data</th>
<th>600mm diameter pipeline</th>
<th>1200mm diameter pipeline</th>
</tr>
</thead>
<tbody>
<tr>
<td>4m depth to invert</td>
<td>100m length x 4m deep</td>
<td>100m length x 4m deep</td>
</tr>
<tr>
<td><strong>Method</strong></td>
<td><strong>Open cut</strong></td>
<td><strong>Pipejacking</strong></td>
</tr>
<tr>
<td>Tonnes CO₂</td>
<td>66.7</td>
<td>27.1</td>
</tr>
<tr>
<td>CO₂ saving</td>
<td>39.6 tonnes = <strong>59% saving</strong></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Project Data</th>
<th>600mm diameter pipeline</th>
<th>1200mm diameter pipeline</th>
</tr>
</thead>
<tbody>
<tr>
<td>6m depth to invert</td>
<td>100m length x 6m deep</td>
<td>100m length x 6m deep</td>
</tr>
<tr>
<td><strong>Method</strong></td>
<td><strong>Open cut</strong></td>
<td><strong>Pipejacking</strong></td>
</tr>
<tr>
<td>Tonnes CO₂</td>
<td>92.7</td>
<td>30.4</td>
</tr>
<tr>
<td>CO₂ saving</td>
<td>62.3 tonnes = <strong>67% saving</strong></td>
<td></td>
</tr>
</tbody>
</table>
# Open trench vs Pipejacking

## CO₂ Savings – 500 metres

<table>
<thead>
<tr>
<th>Project Data</th>
<th>600mm diameter pipeline 500m length x 4m deep</th>
<th>1200mm diameter pipeline 500m length x 4m deep</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method</td>
<td>Open cut</td>
<td>Pipejacking</td>
</tr>
<tr>
<td>Tonnes CO₂</td>
<td>351.4</td>
<td>113.3</td>
</tr>
<tr>
<td>CO₂ saving</td>
<td>238.1 tonnes = <strong>68% saving</strong></td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Project Data</th>
<th>600mm diameter pipeline 500m length x 6m deep</th>
<th>1200mm diameter pipeline 500m length x 6m deep</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method</td>
<td>Open cut</td>
<td>Pipejacking</td>
</tr>
<tr>
<td>Tonnes CO₂</td>
<td>492.4</td>
<td>124.6</td>
</tr>
<tr>
<td>CO₂ saving</td>
<td>367.8 tonnes = <strong>75% saving</strong></td>
<td></td>
</tr>
</tbody>
</table>
Machine Technology

Machines are available for pipe jacking in most ground conditions
Machines are available for pipe jacking in most ground conditions

- Backacters
Machines are available for pipe jacking in most ground conditions

- Backacters
- Open face cutter booms
Machine Technology

Machines are available for pipe jacking in most ground conditions

- Backacters
- Open face cutter booms
- Tunnel boring machine
Machine Technology

Machines are available for pipe jacking in most ground conditions

- Backacters
- Open face cutter booms
- Tunnel boring machine
- Earth pressure balance
Machines are available for pipe jacking in most ground conditions

- Backacters
- Open face cutter booms
- Tunnel boring machine
- Earth pressure balance
- Pressurised slurry
Microtunnelling

- Fully guided machines
- Controlled from surface
- 1000mm id and below
- Non man entry
- Two options:
  - Pressurised slurry
  - Screw auger
Advantages of Mechanisation

- Significantly safer working
- Efficient
- Hand arm vibration eliminated
- Quicker installation
- Ground support
- Remote control
- Risks mitigated
# Drive Lengths and Diameters - HSE Recommendations

<table>
<thead>
<tr>
<th>EXCAVATION TECHNIQUE</th>
<th>&lt;0.9M</th>
<th>0.9M</th>
<th>1.0M</th>
<th>1.2M</th>
<th>1.35M</th>
<th>1.5M</th>
<th>1.8M</th>
<th>&gt;1.8M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipe jack – machine; remote operation from surface</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drive length limited only by capacity of jacking system</td>
<td>250m</td>
<td>400m</td>
<td>&gt;500m</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Man entry not acceptable</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avoid man entry</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pipe jack – machine; operator controlled below ground</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not Acceptable</td>
<td>125m</td>
<td>200m</td>
<td>300m</td>
<td>500m</td>
<td>&gt;500m</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pipe jack – hand dig</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not Acceptable</td>
<td>25m</td>
<td>50m</td>
<td>75m</td>
<td>100m</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>2 drive lengths</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use minidigger if &gt; 2.1m</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>1 drive length</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Laser Guidance

- Real-time line and level checks
- Maintains accuracy in difficult ground
- Allows remote operations
Pipe Jacking Pipes

- Concrete jacking pipes: BS EN 1916
- Clay pipes: BS EN 296-7 and BS EN 12899: 2000
- Installation forces are key
- Follow manufacturers recommendations
- Steel pipes: sleeves for pressure mains
Site Investigation
# Soil Conditions

<table>
<thead>
<tr>
<th>Test</th>
<th>Non-Cohesive Soils</th>
<th>Cohesive Soils</th>
<th>Mixed Soils</th>
<th>Fill Material</th>
<th>Rock</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit weight and moisture content</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Angle of friction</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Particle size distribution</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
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<tr>
<td>Abrasivity</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Cohesion</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Types and proportions of minerals</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
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<tr>
<td>Standard penetration tests</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Permeability and nature of ground water flows (seasonal/tidal changes)</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td></td>
<td>✓</td>
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<tr>
<td>Toxic/hazardous constituents in the ground/groundwater</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td></td>
<td>✓</td>
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<tr>
<td>Frequency and physical properties of boulders, cobbles or flints</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
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<tr>
<td>Pump down tests</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Presence of gases</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Compressive strength</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rock quality designation (RQD)</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Core logging (TCR, SCR, FI)</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tensile strength</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
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<tr>
<td>Specific energy (excavatability)</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slake durability</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
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<tr>
<td>Geological description</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plasticity indices (SL, PL, PI)</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
University research programme initiated in 1986 – projects include:

- Laboratory testing of model jacked pipes
- Field testing of performance of pipes
- Finite element analysis of concrete jacking pipes
- Full scale testing of concrete pipes
- Soil conditioning and lubrication materials
- Field testing of soil conditioning and lubrication methods
- Slurry management
Guide to Best Practice

- Soils investigation
- Excavation systems
- Temporary and permanent works
- Jacking lengths and friction forces
- Best installation practice
- Worked examples and checklists
Additional Applications

Box Sections
- Subways
- Roadways

Other uses
- Jacked arches
- Bridge slide foundations
Summary

- Engineering integrity
- Low capital costs
- Low maintenance
- Cost-effective
- Safe installation
- Environmental benefits
- Reduced CO₂ emissions
- Extensively used
- 150mm to 3m diameters
- Long drive lengths
- Engineering performance