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Jacking pipes

Humes leads the industry and develops world class jacking pipes ideally suited for use with modern, closed faced microtunnelling systems.

We provide a comprehensive range of both steel reinforced concrete and vitrified clay jacking pipes. They are available in a variety of sizes, classes and joint types to suit various applications and installation methods.

Our jacking pipes are available in the following ranges; Steel reinforced concrete pipe from DN300 to DN3600 and vitrified clay pipe from DN150 to DN1200.

Reinforced concrete pressure pipes are designed for the combined effects of the external load and internal (in service) pressure. Australian/New Zealand Standard AS/NZS 4058:2007 Precast Concrete Pipes (Pressures and Non-Pressure) gives a minimum requirement for factory test pressure of 120% of working pressure in the pipeline. STEINZEUG KERAMO vitrified clay jacking pipes are manufactured and inspected in accordance with European Standard EN 295.

The jacking technique (microtunnelling)

Pipe jacking is a method of tunnel construction where hydraulic jacks are used to thrust specially made pipes through the ground behind a shield machine, from launch shaft to receival shaft.

The term microtunnelling is also often used to describe this method of pipe installation.

Pipe jacking is used to install conduits below ground for a variety of applications including:

- sewerage pipelines
- stormwater pipelines
- road and rail culverts
- pressure pipelines
- as a sleeve pipe for other utility pipelines (water, sewage, and electricity and communication cables)
- pipe replacement and relining.
Benefits of pipe jacking

Technical
- Inherent strength of lining.
- Smooth internal finish giving good flow characteristics.
- No requirement for secondary lining.
- Considerably less joints than a segmental tunnel.
- Prevention of ground water ingress by use of pipes with sealed flexible joints.
- Provision of invert channels in larger pipes to contain the dry weather flow of a sewer in a combined system.

Safety
Pipe jacking is an inherently safer method than open trench construction or when considering the risks associated with deep, large section, open excavations:
- Major reduction in man-hours, opportunities for accidents to occur are less with pipe jacking.
- In busy urban centres, trenchless operation will not interfere with pedestrian and motor traffic movements.
- There is significant reduction in the risk of injury as a result of utility strikes and interface with the public.
- Less risk of settlement.

Economic
- Less affected by weather condition
- Less risk of settlement
- Minimal surface disruption
- Minimal reinstatement
- Reduced requirement for utilities diversions in urban areas

Environmental
There are substantial environmental benefits to be gained by the use of pipe jacking techniques when compared with the traditional open trench approach:
- Typically the trenchless method will reduce the quantities of incoming and outgoing materials, with a consequent reduction in tipping of spoil and quarrying of imported stone fill. This in turn leads to reduced vehicle movements and subsequently less associated disruption.
- Minimal surface disruption and reinstatement.
- Trenchless will not harm existing vegetation.
- Noise, dirt and smell are minimised.

Source: An introduction to pipe jacking and microtunnelling design – Pipe Jacking Association UK

Figure 1 – Typical pipe jacking set up
Steel reinforced concrete pipes (SRCP)

Humes is Australia’s leading manufacturer of SRCP. We have a wide range of diameters, lengths and strengths available. Our SRCP has a proven track record and can be custom designed for applications such as drainage, sewage, water supply and irrigation.

A milestone was achieved when Humes’ DN2100, fixed steel collar pipes were jacked 1,030 m without any intermediate shafts on the Northern Pipeline Interconnector – Stage 2, SEQ (refer to our case study on this project for further details).

Benefits of reinforced concrete jacking pipes

Optimal strength

Humes SRCP are manufactured and factory tested for quality to AS/NZS 4058:2007 “Precast concrete pipes (Pressure and Non-pressure)”: 

- A concrete pipe is a rigid pipe system that relies mostly on the strength of the pipe and is only slightly dependent on the strength derived from the soil envelope. The inherent strength of concrete pipe can compensate for site problems not designed for, such as construction shortcomings and higher fill heights and trench depths.
- Concrete pipes are less susceptible to damage during construction, and maintain their shape by not deflecting.
- All concrete pipe strengths are standardised by AS/NZS 4058 “Precast Concrete Pipes”. Concrete pipes are strength-tested by the manufacturer to proof loads, or test loads, as nominated by the standard for particular diameter and class.
- Steel reinforcement in concrete pipes adds significantly to their inherent strength. The steel reinforcement is shaped into cages by automatic cage welding machines. The machines ensure that the reinforcement cages are dimensionally correct and have tight engineered tolerances.

Durable

Humes SRCP has a number of concrete properties that influence long service life. These properties are:

- Ultimate compressive strength: Humes SRCP compressive strength is usually in the range of up to 60 MPa and above. The strength of the pipe is a result of the materials used in the concrete mix, the mix design, manufacturing techniques and the curing process.
- Low water absorption, below 4%, due to the density and impermeability of the concrete used and manufacturing process. AS/NZS 4058-2007 specifies a maximum allowable absorption of 6% for all concrete pipes.
- A low water/cement (W/C) ratio of below 0.35. The W/C ratio is considered a trademark for durable concrete pipe, particularly as high compressive strength is related to this criterion.
- High alkalinity is controlled by cementitious content maintained by a proper mix design, material properties as well as the manufacturing and curing process.
- Concrete pipe aggregates, both coarse and fine, meet the requirements of AS 2758. Aggregates are a key element in producing quality concrete and in turn, quality pipe.

**Fixed steel collar pipes**

A wide robust range is available from DN300 to DN3000 inclusive. They are a custom designed reinforced concrete jacking pipe incorporating a single wide jacking face including timber packers, a secure steel collar cast onto the pipe and a flexible watertight joint. All these being essential for longer pipe jacks and unstable ground conditions.

**Applications**

The fixed steel collar jacking pipes provides high axial load transfer capacity and a flexible watertight joint. This is the ideal jacking pipe for all stormwater, sewerage, sleeve pipe and jacked low pressure pipeline applications.

**Steel collar types**

Humes offer two different types of fixed steel collars: the S type which is fitted into pipes up to DN700 and the J type fitted into remaining sizes (mainly from DN800 to DN3000). The steel collar bands are fabricated to high tolerances to ensure optimum joint performance.

Both steel collars include a water stop hydro-seal to prevent ingress of water between the band and the concrete pipe wall.

**Elastomeric seal**

The elastomeric seal is located with the corrugated steel collar in the S type collar band, factory secured internally to the steel socket band with adhesive. While, in the J type the seal is retained within the accurately formed recess on the pipe spigot.

Both unique designs will ensure that the elastomeric seal remains in place in compression even if joint deflection occurs. The joint integrity remains intact when subjected to either internal or external hydraulic pressure.

A muck ring is fitted within the J type joint; limiting the ingress of soil into the joint during jacking. The muck ring will be compressed by the end of the steel collar.

**Watertight joint – (External pressure testing)**

Humes have undertaken external pressure testing of deflected joints with external hydrostatic pressures up to 400 kPa without visible leaks. On this basis, fixed steel collar jacking pipes are rated for 250 kPa external pressure for the joint deflections shown in Figures 4 and 5 on page 7. Humes can design pipes for higher external pressure ratings if required.

**Bentonite or grout injection fittings**

Pipes can be supplied with or without threaded sockets and plugs, which are cast into the pipe wall in locations to meet the project specific requirements for grout and/or lubrication injection.
### Inert thermoplastic linings

Humes are able to supply the J type steel collar jacking pipes complete with corrosion protection linings (either High Density Polyethylene (HDPE) or Plastiline®- Polyvinyl Chloride (PVC)) in accordance with Water Services Association of Australia (WSAA) standard specification WSA113. These linings are a proven method of concrete protection against H₂S attack in trunk sewers.

### Secondary sealing recess

All J type steel collar jacking pipes are supplied with a recess on the internal pipe ends which allows for locating a flexible sealant, applied internally after installation, if required by the project designer for isolation of the joint from the pipeline environment (see Figure 21 on page 26). The combination of mild steel collars with internal joint gap sealant can provide a cost effective solution in certain ground conditions.

### Intermediate jacking stations

Humes have standard designs for intermediate jacking stations and these include trail and lead pipes for all diameters DN1000 to DN2000. The arrangement of these pipes at the intermediate jacking station is shown in Figure 1 on page 24.

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**Table 1 – Features and benefits**

<table>
<thead>
<tr>
<th>Features</th>
<th>Benefit to asset owner</th>
<th>Benefit to contractor</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Elastomeric seal</strong></td>
<td>Watertight joint Prevents ingress or egress of water and soil surrounding the pipes and allows pressure grouting of the excavated annulus at the completion of jacking (if required).</td>
<td>Flexibility Allows joint rotation without damage to the pipe joint.</td>
</tr>
<tr>
<td><strong>Steel collar fixed to pipe with in-built water stop</strong></td>
<td>Collar material The designer has many options for the grade of steel to suit the intended design life in the installed environment of the pipe. Generally, mild steel is considered suitable for in-ground conditions and a non-aggressive environment.</td>
<td>Secure system Steel collar will remain watertight and secured in place during jacking, even in variable ground conditions. Efficient jointing Rapid pipe jointing ensures operational efficiency in the jacking pit.</td>
</tr>
<tr>
<td><strong>Corrugated collar recess (S type) Deep spigot groove (J type)</strong></td>
<td>Permanent seal location The seal remains in place throughout the design life of the pipeline providing a long-term watertight structure under external groundwater pressures or ground movement.</td>
<td>restrained seal Ensures that the seal remains in place during jointing and jacking with external pressure from groundwater or lubrication injection.</td>
</tr>
<tr>
<td><strong>Single wide jacking face</strong></td>
<td>Efficient construction Long drives, lower construction costs and less disturbance to above-ground activities.</td>
<td>Long drives The wide face on the pipe end enables transfer of high jacking forces through the centerline of the pipe wall enabling accurate steering and long drives.</td>
</tr>
<tr>
<td><strong>Muck ring (J type)</strong></td>
<td>Maintain watertight joint After installation the muck ring protects the rubber ring and the steel collar to maintain watertightness.</td>
<td>Maintain watertight joint Prevents ingress of soil into joint during jacking.</td>
</tr>
<tr>
<td><strong>Internal joint recess</strong></td>
<td>Additional sealing options The recess is shaped to allow retention of a flexible sealant if secondary joint sealing is required.</td>
<td>No spalling Prevents spalling of inside concrete face if the packer is displaced during jacking.</td>
</tr>
</tbody>
</table>
Optimal strength

Humes fixed collar jacking pipes, both with S and J type collar, are designed with steel reinforcement placed for optimal strength, which combined with the strength and durability of Humes concrete pipes, provides an excellent jacking pipe. Steel reinforced concrete jacking pipes are capable of withstanding higher jacking loads.

The jacking load capacity of standard pipes for a range of joint deflections is illustrated in Figures 4 and 5 on the following page. Pipes with higher jacking loads and/or joint deflections can be designed for specific projects.

Jacking design and forces

The Concrete Pipe Association of Australasia (CPAA) publication, Jacking Design Guidelines is a recommended guide to calculate and define jacking forces. The guide can be downloaded by visiting: www.cpaa.asn.au/CPAA-Online-Shop.html

Jacking forces and lateral displacement off line and level have to be recorded at regular intervals of jacking distance (not exceeding 200 mm or every 90 seconds).

Ensure that jacking forces are maintained within the limits specified in Figures 4 and 5 on the following page. If circumstances cause a jacking force/deflection combination outside of these limits, hold the jacking operation and contact Humes for assistance.
Figure 4 – S type jacking pipes deflection curves

Figure 5 – J type jacking pipes deflection curves
### Table 2 – Fixed steel collar pipes dimensions, mass, jacking loads and deflections

<table>
<thead>
<tr>
<th>Nominal diameter</th>
<th>Internal diameter 'A' (mm)</th>
<th>External diameter 'B' (mm)</th>
<th>Wall thickness 'T' (mm)</th>
<th>Effective length 'L' (mm)</th>
<th>Min. joint packer 'Pt/Pw' (mm)</th>
<th>Length 'C' (mm)</th>
<th>ID 'D' (mm)</th>
<th>Thickness 't' (mm)</th>
<th>Pipe mass (kg)</th>
<th>Max. jacking load (tonnes)</th>
<th>Collar type</th>
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<tr>
<td>300</td>
<td>300</td>
<td>430</td>
<td>65</td>
<td>2,400</td>
<td>3/40</td>
<td>50</td>
<td>412</td>
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<td>500</td>
<td>100</td>
<td>S</td>
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<td>480</td>
<td>65</td>
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<td>3/40</td>
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<td>462</td>
<td>1.5</td>
<td>660</td>
<td>135</td>
<td>S</td>
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<td>725</td>
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<td>989</td>
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<td>125</td>
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<td>1,785</td>
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<td>4,800</td>
<td>840</td>
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<td>1,800</td>
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<td>175</td>
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<td>16/125</td>
<td>160</td>
<td>2,135</td>
<td>6</td>
<td>6,700</td>
<td>1,050</td>
<td>J</td>
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<td>2,100</td>
<td>2,100</td>
<td>2,500</td>
<td>200</td>
<td>2,985</td>
<td>16/160</td>
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<td>2,481</td>
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<td>12,050</td>
<td>1,440</td>
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<td>16/175</td>
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<td>2,759</td>
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<td>12,950</td>
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<td>175</td>
<td>2,977</td>
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<td>10</td>
<td>19,700</td>
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</table>
Loose steel collar pipes

Humes offer two types of loose steel collar SRCP jacking pipes, butt joint and in-wall joint. They are available from DN300 to DN3000 (standard range DN300 to DN2100).

The steel collar is not attached to the pipe (cast with) but rather is fitted onto the pipe before installation. The collars can be supplied by either Humes or the contractor.

Butt joint pipes

Butt joint jacking pipes incorporate a single wide jacking face. External recesses at each end of the pipe allow for a rolled steel collar to be located between adjacent pipes, providing the necessary shear connection (see Figure 6).

• Applications
  Butt joint jacking pipes can provide a cost effective solution for typically short length applications where only limited flexibility is required and a soil or watertight joint is not required. This pipe is also suited to sleeve pipe applications for road and rail crossings where the annulus between the utility pipeline and conduit is to be filled with grout after installation.

Refer to Table 4 – Selection of jacking pipes (page 11), which provides a summary of capabilities for each of the different types of jacking pipes for different requirements and applications.

In-wall joint pipes

In-wall joint jacking pipes are available from DN1200 to DN3600 (standard range DN1200 to DN2100). In-wall joint jacking pipes incorporate a concrete socket formed in the wall of the pipe, a rubber ring located on the pipe spigot and timber packers on one or both joint faces (see Figure 7).

• Applications
  In-wall joint jacking pipes are an economical viable alternative for typically short length applications where a flexible watertight joint is required, however, this type of joint can have limitations in jacking load transfer. A J type pipe should be specified in these situations.

Figure 6 – Butt joint profile

Figure 7 – In-wall joint profile
Selection of jacking pipes

The most basic requirements for all jacking pipes is that they must be capable of supporting the excavation (earth and traffic loads), transferring axial load, providing a shear connection between adjacent pipes and joint flexibility that allows for each pipe to follow the path excavated in front of the shield.

In addition, jacking pipes may need to prevent ingress of surrounding soil, groundwater, lubricants or grouts and provide a joint capable of withstanding internal pressure in sewerage or pressure pipeline applications.

Jacking pipes must meet both the needs of the contractor and asset owner who is usually represented by the pipeline designer. Table 4 opposite provides a summary of the capabilities of each of our types of jacking pipes for different requirements and applications.

### Table 3 – Loose steel collar pipe range

<table>
<thead>
<tr>
<th>Nominal diameter</th>
<th>In-wall joint</th>
<th>Butt joint</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Internal diameter</td>
<td>External diameter</td>
</tr>
<tr>
<td>DN300</td>
<td>280 mm</td>
<td>362 mm</td>
</tr>
<tr>
<td>DN375</td>
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<td>DN475</td>
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<td>534 mm</td>
</tr>
<tr>
<td>DN525</td>
<td>518 mm</td>
<td>616 mm</td>
</tr>
<tr>
<td>DN600</td>
<td>586 mm</td>
<td>698 mm</td>
</tr>
<tr>
<td>DN675</td>
<td>653 mm</td>
<td>781 mm</td>
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<tr>
<td>DN2100</td>
<td>2,088 mm</td>
<td>2,388 mm</td>
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</table>

Notes:
1. Alternative internal diameters (and external diameters) may be available to suit project specific requirements, contact Humes for assistance.
2. Standard range is equivalent to load class 4 pipes.
3. Contact Humes for in-wall joint pipes in this range.
### Table 4 – Selection of jacking pipes

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Jacking pipe requirements or application</th>
<th>Fixed steel collar</th>
<th>Loose steel collar</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>S type</td>
<td>J type</td>
</tr>
<tr>
<td>Asset owner</td>
<td>Standard size class DN300 – DN700</td>
<td>DN800 – DN3000</td>
<td>DN300 – DN2100</td>
</tr>
<tr>
<td></td>
<td>Extended diameter range*</td>
<td>Up to DN3600</td>
<td>DN2250 – DN3000</td>
</tr>
<tr>
<td></td>
<td>Incorporation of inert thermoplastic lining</td>
<td>N/A</td>
<td>Available</td>
</tr>
<tr>
<td></td>
<td>External grouting</td>
<td>Suitable for short lengths</td>
<td>Ideally suited</td>
</tr>
<tr>
<td></td>
<td>Internal pressure test capability (kPa)‡</td>
<td>90</td>
<td>150§</td>
</tr>
<tr>
<td></td>
<td>Application of internal secondary sealants</td>
<td>N/A</td>
<td>Suitable</td>
</tr>
<tr>
<td>Sewerage pipelines</td>
<td>Limited suitability†</td>
<td>Ideally suited</td>
<td>Not suitable</td>
</tr>
<tr>
<td>Stormwater pipelines</td>
<td>Ideally suited</td>
<td>Ideally suited</td>
<td>Limited suitability</td>
</tr>
<tr>
<td>Road and rail culverts</td>
<td>Ideally suited</td>
<td>Ideally suited</td>
<td>Limited suitability</td>
</tr>
<tr>
<td>Sleeve pipe applications</td>
<td>Ideally suited</td>
<td>Ideally suited</td>
<td>Limited suitability*</td>
</tr>
<tr>
<td>Asset owners and contractors</td>
<td>Length of jacked pipeline (m)</td>
<td>0 – 50††</td>
<td>&lt; DN1000: 0 – 150 DN1000 – DN3000: no limit‡‡</td>
</tr>
<tr>
<td></td>
<td>External pressure test capability§§</td>
<td>90</td>
<td>250</td>
</tr>
<tr>
<td></td>
<td>Jacking force transfer</td>
<td>Excellent</td>
<td>Excellent</td>
</tr>
<tr>
<td></td>
<td>Intermediate jacking stations pipes</td>
<td>N/A</td>
<td>Available DN900 – DN3000</td>
</tr>
<tr>
<td>Contractors</td>
<td>Open face shields</td>
<td>Suitable</td>
<td>Suitable</td>
</tr>
<tr>
<td></td>
<td>Closed face pressure shields</td>
<td>Ideally suited</td>
<td>Ideally suited</td>
</tr>
<tr>
<td></td>
<td>Lubrication along length of pipeline</td>
<td>N/A</td>
<td>Ideally suited</td>
</tr>
</tbody>
</table>

**Notes:**

* Refer to Humes for availability.
† Grit pressures need to be carefully monitored.
‡ Test to AS/NZS 4058: 2007.
§ Higher pressures are possible with certain diameters – refer to Humes for advice if higher pressures are required.
¶ If corrosive sewage gases are expected consider using vitrified clay jacking pipes distributed by Humes.
|| If corrosive sewage gases are expected consider using vitrified clay jacking pipes distributed by Humes.
†† Intermediate jacking stations are not available and length is mainly limited by installation equipment. Some pipe jacking contractors may be able to achieve longer lengths of individual drives in certain soil conditions. Refer to jacking pipe contractor for advice for longer drives.
‡‡ The maximum length will be controlled by installation equipment rather than pipe capability.
** Lack of joint flexibility largely controls maximum length. This could be extended in certain soil conditions.
§§ There is no published test method for external joint testing of reinforced concrete pipes. External pressures due to lubrication or grouting can be well in excess of ground water pressures.
|| For lubrication to be effective, the annulus between the external diameter of the pipe and the excavated soil needs to be filled. The butt joint pipe may not provide an effective sealed joint.
Load class

Jacking pipes, as opposed to pipes laid in open excavations, are subjected to both jacking forces, external earth loads and life loads (permanent loads) and all of these have to be considered when specifying the pipes.

The effect of the jacking force on the pipe barrel is small on account of the high compressive strength of the concrete. The joint, however, must be considered because the joint cross-section is smaller, as a rule, than that of the barrel and the jacking force is transferred eccentrically across the joint.

The external earth load on the barrel is equal to or smaller than the trench load on a pipe bedded in a trench of same width as the excavation (i.e. the outside diameter of the pipe plus a margin for over-excavation). The jacking method of installation, therefore, is very efficient from an external load point of view since the external earth load is smaller than both trench and embankment load on pipes of the same diameter under the same height of fill.

As such a minimum Class 4 pipe is usually recommended although in some short length drives a Class 3 may be suitable. The Class 4 pipe to Australian Standard AS/NZS 4058: 2007 has very similar strength requirements to load classes specified for jacking pipes in European and Japanese Standards.

AS/NZS 4058: 2007 outlines the technique for determining the permanent vertical loads acting on pipes installed using pipe jacking. The jacking pipe is installed underground into undisturbed natural ground where the soil’s natural cohesion contributes to arching over the pipe. Where the calculation includes the effects of arching due to soil cohesion extensive soil investigations should be carried out to determine the appropriate design soil properties.

The jacking installation results in a recommended bedding factor between two and three that is used to determine the minimum suitable pipe class required due to permanent loads.

The higher value is recommended when the annulus between the pipe and ground is grouted. Grouting of this annulus with a suitable cementitious grout is recommended in most installations as any voids could create a drainage path external to the pipeline which in turn could lead to soil erosion, lowering of ground water tables and, in aggressive soil conditions, an increased risk of corrosion of pipe materials.

The axial loading from the pipe jacking is not directly included in the selection of the pipe load class. Timber packers are placed between the jacking faces of the concrete pipes to avoid high stresses that could result from direct concrete to concrete contact. The axial load capacity of the concrete pipe is determined based on the minimum pipe wall thickness, concrete strength, properties of the timber packers and the deflections that can be expected at pipe joints during installation.

The allowable jacking forces and associated maximum joint deflections are calculated in accordance with the Concrete Pipe Association of Australasia (CPAA) publication, *Jacking Design Guidelines*.

Source: Jacking Design Guidelines, Concrete Pipe Association of Australasia.

Jacking design and forces

The CPAA publication, *Jacking Design Guidelines*, is a recommended guide to calculate and define jacking forces. The guide can be downloaded by visiting: [www.cpaa.asn.au/CPAA-Online-Shop.html](http://www.cpaa.asn.au/CPAA-Online-Shop.html)

Jacking force and lateral displacement off line and level have to be recorded at regular intervals of jacking distance (not exceeding 200 mm or every 90 seconds).

Ensure that jacking forces are maintained within the specified limits. If circumstances cause a jacking force/deflection combination outside of these limits, hold the jacking operation and contact Humes for assistance.
Vitrified clay pipes

Humes vitrified clay jacking pipes are manufactured by STEINZEUG-KERAMO (STEINZEUG Abwassersysteme GmbH) and inspected in accordance with the European standard for vitrified clay pipes, fittings and joints for drains and sewers - EN 295.

Features and benefits

Watertightness

The joints are tested in accordance with EN 295, which means that they are guaranteed to be watertight at 0.5 bar, including the angular deflections and radial loads specified in the standard. They are also tested in accordance with ZPWN 2951 and ATV A142, with guaranteed watertightness at 2.4 bar. Watertightness is also tested at an external pressure of 6 bar, which provides a high level of security against penetration of soil slurries and bentonite.

Corrosion resistance

Vitrified clay material is resistant to all types of chemicals over the entire wall thickness. The resistance of the vitrified clay material and seals is tested using chemicals, including sulphuric acid at pH 0 and NaOH at pH 14, in conformance with EN 295 and ZPWN 295.

High mechanical strength

Vitrified clay jacking pipes generally have greater wall thicknesses than corresponding standard vitrified clay sewer pipes, that results in high crown pressure ratings and high resistance to ground and traffic loads.

Strength in the length direction is the most important factor for jacking pipes, because they must withstand the high jacking forces necessary to overcome the resistance of the cutting face and the external pipe surface. According to the EN 295 standard, the longitudinal compressive strength of the surfaces that transfer the force between pipe sections must be at least 75 N/mm². STEINZEUG-KERAMO guarantees a value of at least 100 N/mm². That is higher than the values stated for other types of current jacking material. It allows very high jacking forces to be used, although this capability is only partially utilised in practice. The glazed outer surface of the pipe strongly reduces friction between the pipe and the surrounding soil.

High abrasion resistance

Vitrified clay has high abrasion resistance, which is equally true for the glaze and the rest of the wall. Abrasion values encountered in the tests are approximately 0.08 mm, which is much lower than the typical abrasion values of 0.2 mm to 0.5 mm after 100,000 load cycles measured using the Darmstadt test as specified in the EN 295 standard or the maximum value of 0.25 mm in the ZPWN 295 standard. Abrasion does not accelerate even with extended load cycles, such as up to 400,000, in contrast to what is often suggested in data sheets for competitive materials. The depth of abrasion remains limited to 0.3 - 0.8 mm after 400,000 cycles. Compared with the large wall thicknesses of vitrified clay jacking pipes, that represents a negligible loss of wall thickness.

1. ZPWN 295 is an internal manufacturer standard of STEINZEUG-KERAMO.
Resistance to high-pressure cleaning

The requirement included in the ZPWN 295 standard is met (resistance with regard to a standardised maintenance cleaning test at 120 bar and a deblocking test at 340 bar). Here again, vitrified clay scores considerably better than many other types of material.

Temperature resistance

Pipes and seals are tested at up to 70 °C. Vitrified clay pipes can tolerate even higher temperatures.

Long service life

After being properly installed, vitrified clay pipe requires very little maintenance. As vitrified clay scores very high with respect to all the requirements that must be imposed on sewer pipes, vitrified clay pipes have very long service lives. The important properties mentioned above do not degrade over time. This is especially true for jacking pipes, because they are structurally over dimensioned for their subsequent use and optimally bedded in the ground.
Product range

The entire range of vitrified clay jacking pipes DN200 to DN1200 are fitted with a stainless steel coupling which has a high chrome and nickel content and a relatively significant molybdenum content. This coupling is highly resistant to corrosion in aggressive soils (acids, chlorides and halogens).

Two different types of stainless steel couplings are used, Type 1 and Type 2.

DN200 to DN300 with Type 1 stainless steel coupling

- The moulded elastomer seal is integrated into the ring.
- The packing ring, which transmits the jacking force is made from elastomer for diameters up to DN300 and forms a unit with the moulded sealing ring.
- Pipes are sawn at both ends to yield parallel end faces.
- The spigot ends are milled. The precision ground spigots as for larger dimension jacking pipes permit a safe internal working pressure of 2.4 bar.
- The sealing capabilities of the coupler due to its special design not only guarantees joint integrity, but ensures full protection from the ingress of matter during the jacking process.

DN400 to DN1200 with Type 2 stainless steel coupling

- The moulded rubber seal is integrated in a milled groove.
- The packing ring, which transmits the jacking force, is made from particle board and is prefitted to the coupling.
- Pipes are sawn and milled at both ends to yield parallel end faces.
- For diameters DN600 and above a clamping (prestressing) ring is fitted at each spigot end. This ring increases the permissible jacking force and provides additional protection in case of poorly controlled steering motions during jacking or when angular deflections occur due to variations in soil conditions.
- Intermediate re-usable jacking stations can be used with diameters of DN600 and above. This is advisable for long jacking distances and when jacking forces exceeding the specified limits are anticipated. The intermediate jacking stations are coupled to the spigot ends of the pipes and recovered in the receival pit or an intermediate shaft.

Figure 8 – Typical vitrified clay pipe jacking set up
Table 5 – Dimensions for DN200 to DN300 pipe with Type 1 coupling (refer Figure 9 above)

<table>
<thead>
<tr>
<th>DN</th>
<th>Internal dimensions</th>
<th>Pipe body</th>
<th>Length</th>
<th>e</th>
<th>Pressure transfer ring</th>
<th>Max. jacking force*</th>
<th>Min. crushing load</th>
<th>Average weight</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>d₁ / d₂</td>
<td>d₃</td>
<td>d₄</td>
<td>l₁</td>
<td>d₅ / s₁</td>
<td>s₂ / s₃</td>
<td>b₄ / s₅</td>
<td>d₆ / s₆ / s₇</td>
</tr>
<tr>
<td></td>
<td>mm</td>
<td>mm</td>
<td>mm</td>
<td>mm</td>
<td>mm</td>
<td>mm</td>
<td>mm</td>
<td>mm</td>
</tr>
<tr>
<td>200</td>
<td>199</td>
<td>244</td>
<td>276</td>
<td>990</td>
<td>49 / 4</td>
<td>267.8</td>
<td>1.5 / 103</td>
<td>10 / 241 / 205</td>
</tr>
<tr>
<td></td>
<td>± 0.2</td>
<td>± 0.6</td>
<td>± 1.5</td>
<td>± 1</td>
<td>± 0.5</td>
<td>± 0.5</td>
<td>± 0.5</td>
<td>± 0.5</td>
</tr>
<tr>
<td>250</td>
<td>250</td>
<td>322</td>
<td>360</td>
<td>990</td>
<td>48 / 4</td>
<td>342.8</td>
<td>1.5 / 106</td>
<td>10 / 320 / 257</td>
</tr>
<tr>
<td></td>
<td>± 0</td>
<td>± 0.6</td>
<td>± 1.5</td>
<td>± 1</td>
<td>± 0.5</td>
<td>± 0.5</td>
<td>± 0.5</td>
<td>± 0.5</td>
</tr>
<tr>
<td>300</td>
<td>300</td>
<td>374</td>
<td>406</td>
<td>990</td>
<td>48 / 4</td>
<td>395.8</td>
<td>2.0 / 106</td>
<td>10 / 372 / 309</td>
</tr>
<tr>
<td></td>
<td>± 0.2</td>
<td>± 0.6</td>
<td>± 1.5</td>
<td>± 1</td>
<td>± 0.5</td>
<td>± 0.5</td>
<td>± 0.5</td>
<td>± 0.5</td>
</tr>
</tbody>
</table>

Notes:
2. Compressive strength = 100 N/mm².
3. Bending tensile strength = 14 N/mm².
4. Supplied with wooden pressure transfer ring according to EN 312 P5.
5. The ground spigot ends (d₃) are trimmed ca. 2 x 2 mm.
Figure 10 – Joint profiles for DN400 to DN1200 pipe with Type 2 coupling

Table 6 – Dimensions for DN400 to DN1200 pipe with Type 2 coupling (refer Figure 10 above)

<table>
<thead>
<tr>
<th>DN</th>
<th>Internal Pipe end</th>
<th>Pipe body</th>
<th>Length</th>
<th>e ±2</th>
<th>d₁ ±1</th>
<th>s₁ ±0.2</th>
<th>b₂ ±1</th>
<th>d₄ ±1</th>
<th>d₅ ±1</th>
<th>d₆ ±1</th>
<th>Max. jacking force</th>
<th>Min. crushing load</th>
<th>Average weight</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>d₂</td>
<td>d₃ ±0.2</td>
<td>d₄</td>
<td>l₁ ±1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>400</td>
<td>400 ±0.6</td>
<td>528</td>
<td>556 ±0.12</td>
<td>984</td>
<td>1,984</td>
<td>65</td>
<td>536</td>
<td>3</td>
<td>130</td>
<td>16</td>
<td>518</td>
<td>413</td>
<td>2,350</td>
</tr>
<tr>
<td>500</td>
<td>498 ±0.75</td>
<td>632</td>
<td>661 ±0.13</td>
<td>1,984</td>
<td>65</td>
<td>640</td>
<td>3</td>
<td>130</td>
<td>16</td>
<td>624</td>
<td>513</td>
<td>3,000</td>
<td>140</td>
</tr>
<tr>
<td>600</td>
<td>599 ±0.9</td>
<td>723</td>
<td>766 ±0.14</td>
<td>1,981</td>
<td>70</td>
<td>731</td>
<td>3</td>
<td>143</td>
<td>19</td>
<td>713</td>
<td>615</td>
<td>3,100</td>
<td>120</td>
</tr>
<tr>
<td>700</td>
<td>695 ±0.12</td>
<td>827</td>
<td>870 ±0.24</td>
<td>1,981</td>
<td>70</td>
<td>837</td>
<td>4</td>
<td>143</td>
<td>19</td>
<td>816</td>
<td>715</td>
<td>3,300</td>
<td>140</td>
</tr>
<tr>
<td>800</td>
<td>792 ±0.12</td>
<td>921</td>
<td>970 ±0.24</td>
<td>1,981</td>
<td>70</td>
<td>931</td>
<td>4</td>
<td>143</td>
<td>19</td>
<td>911</td>
<td>823</td>
<td>3,700</td>
<td>128</td>
</tr>
<tr>
<td>1000</td>
<td>1,056 ±0.15</td>
<td>1,218</td>
<td>1,275 ±0.26</td>
<td>1,981</td>
<td>70</td>
<td>1,230</td>
<td>5</td>
<td>143</td>
<td>19</td>
<td>1,208</td>
<td>1,077</td>
<td>5,700</td>
<td>120</td>
</tr>
<tr>
<td>1200</td>
<td>1,249 ±0.18</td>
<td>1,408</td>
<td>1,475 ±0.36</td>
<td>1,981</td>
<td>80</td>
<td>1,422</td>
<td>6</td>
<td>163</td>
<td>19</td>
<td>1,397</td>
<td>1,277</td>
<td>6,400</td>
<td>114</td>
</tr>
</tbody>
</table>

Notes:
2. Compressive strength = 100 N/mm².
3. Bending tensile strength = 14 N/mm².
4. Supplied with wooden pressure transfer ring according to EN 312 P5.
5. The ground spigot ends (d₃) are trimmed ca. 2 x 2 mm.
6. For diameters DN600 and above a prestressing (clamping) ring is fitted at each spigot end.
Connection to standard pipes and access chambers

Three different components are used to connect vitrified clay jacking pipes to standard vitrified clay pipelines and access chambers.

1. Adaptor pipe for DN200 to DN600 pipes

The adaptor pipe is used for connection of vitrified clay jacking pipes to open trench vitrified clay pipes normal/high strength class or access chambers. They consist of 1.0 m long jacking pipes with a coupling on one end and the other end milled to the external diameter of the pipe to which the adaptor is to be connected.

Table 7 – Dimensions for adaptor pipe for DN200 to DN600 pipes (refer Figure 11 above)

<table>
<thead>
<tr>
<th>DN</th>
<th>d₁</th>
<th>d₃ ⁶⁺₀⁻₁</th>
<th>d₂ ⁶⁺₀⁻₁</th>
<th>d₄ ⁶⁺₀⁻₁</th>
<th>l₁ ⁶⁺₁⁻₁</th>
<th>Average weight (kg/piece)</th>
</tr>
</thead>
<tbody>
<tr>
<td>250</td>
<td>250⁺₃⁻₀</td>
<td>299</td>
<td>318</td>
<td>360⁺₀⁻₆</td>
<td>1,000</td>
<td>105</td>
</tr>
<tr>
<td>300</td>
<td>299⁺₅⁻₀</td>
<td>355</td>
<td>376</td>
<td>406⁺₀⁻₁₀</td>
<td>1,000</td>
<td>125</td>
</tr>
<tr>
<td>400</td>
<td>400⁺₆⁻₁</td>
<td>486</td>
<td>492</td>
<td>556⁺₀⁻₁₂</td>
<td>1,000</td>
<td>240</td>
</tr>
<tr>
<td>500</td>
<td>498⁺₇⁻₅</td>
<td>581</td>
<td>609</td>
<td>661⁺₀⁻₁₅</td>
<td>1,000</td>
<td>295</td>
</tr>
<tr>
<td>600</td>
<td>601⁺⁰⁻₉</td>
<td>687</td>
<td>721</td>
<td>766⁺₀⁻₁₈</td>
<td>1,000</td>
<td>305</td>
</tr>
</tbody>
</table>
2. M-seal and bush ring

Another way of achieving the transition from a vitrified clay jacking pipe to an open trench vitrified clay socketed pipe of different external diameter is by using an M-seal and bush ring.

The bush ring is used to equal out the outside diameters of the two pipes. The M-seal is a metal banded flexible coupling providing a watertight and reliable connection between the jacking and trench pipes.

3. Short length pipes

Connection of vitrified clay jacking pipes to access chambers can also be achieved using short length, 350 mm to 500 mm pipes. Three different types of short length pipes are available to suit various applications and installation methods.

**Type A** – One end sawn flat and the other with a steel coupling,

**Type B** – Both ends are sawn flat.

**Type C** – One end sawn flat and one spigot end.

An M-seal and bush ring is used to connect these three types together.
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Vitrified clay pipes – jacking

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