



PIPE JACKING & TUNNELING

Method of Operation



AKKERMAN

METHOD OF OPERATION - PIPE JACKING & TUNNELING

PIPE JACKING AND TUNNELING SYSTEMS OVERVIEW

Pipe jacking and tunneling are trenchless technology methods where pipe is installed, or a tunnel lining is created using a Tunnel Boring Machine (TBM) or Excavator Boring Shield (EBS). The machines are advanced by hydraulic jacking cylinders to install the tunnel between two shafts. Avoiding surface disruption caused by open-trench pipe laying, circumventing existing utilities, and access to the front of the machine are key advantages of these methods.

Pipe jacking and tunneling applications are suitable in sand, medium to stiff clay and silt with strong cohesion values, dry or dewatered materials, weathered rock and non-pressurized groundwater soil conditions.

Common types of jacking pipe used in for direct jacking applications are steel casing, reinforced concrete, and centrifugally cast fiberglass reinforced polymer mortar varieties. TBMs and EBSs can also install liner plate and ring beam and lagging tunnels for temporary ground support for a carrier pipe if a liner can also is used.

Akkerman TBM systems are designed to install 48-96-in. tunnels and feature a rotating cutter head that excavates spoil. Akkerman EBS systems, for 96-168-in. tunnels feature an open face shield and a mechanical excavator removes the soil. An operator interiorly controls both systems.

The average pipe jacking and tunneling drive lengths are limited by jacking thrust potential, visibility of the pipe laser, spoil removal efficiency, production efficiency, and safe oxygen levels for personnel. Average pipe jacking lengths range from 500-1,000-ft. and even longer distances with tunneling since less jacking force is required to move the entire pipe string in this application.

Tunnel alignment is maintained by using a passive pipe

laser guidance system or a the AZ100 Total Guidance System for extended length and curved tunnels.

INSTALLING A TUNNEL WITH A TBM OR EBS

Pipe Jacked Alignments

When pipe jacking, the TBM is launched by the hydraulic cylinders of the Tunnel Boring System's pump unit or a jacking frame. After the TBM is launched and buried, the hydraulic cylinders are retracted, and sections of pipe are added behind the TBM. The pipe string is advanced by transferring force from the hydraulic jacking cylinders to a thrust ring to the pipe string to the TBM which excavates the ground in front of the cutter head (see Figure 1).

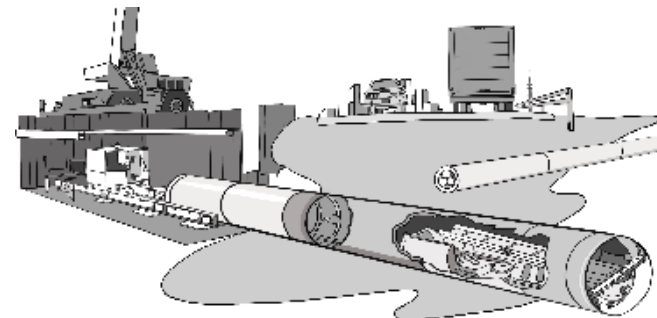


Figure 1. Diagram demonstrating the transfer of thrust from the jacking frame, to the pipe to the TBM for excavation.

The operator controls steering, maintains line and grade by periodically lowering the conveyor to check the laser point and monitors the spoil removal process from an internal control station (See Figure 2).

The pipeline is continuously moving until the full length, quantified by lengths of pipe, is added and the TBM or EBS is removed from the reception area.

Launch shaft design is critical to the success of the bore. The shaft must accommodate the TBM or EBS, jacking frame and thrust wall. The thrust block or reaction wall



Figure 2. The operator's control station is located inside the TBM alongside the spoil removal conveyor.

and shaft floor must be able to bear high jacking forces and weight of the equipment.

Ring Beam and Lagging and Liner Plate Alignments

When tunnel building, the TBM or EBS advances itself off a completed tunnel ring and is the only portion that is jacked forward rather than moving the entire pipe string. Since the required jacking force is much less, great tunnel lengths can be achieved. Steering corrections are easily made with this method, and curved tunnels are simple to install.

When creating a ring-beam and lagging or liner plate tunnel, the TBM or EBS is launched with the hydraulic cylinders of a pump unit or jacking frame until the TBM or EBS is buried. Next, a liner can is launched behind it containing hydraulic cylinders around the interior mates to the back end of the TBM or EBS (see Figure 3). The first tunnel segment is incrementally constructed inside the back end of the liner can. The hydraulic cylinder's rod ends are connected to a thrust ring for evenly distributed thrust pressure. When the hydraulic cylinders are engaged, the liner can pushes against the completed tunnel section forcing the TBM or EBS forward, which creates space for assembly of the next tunnel section.

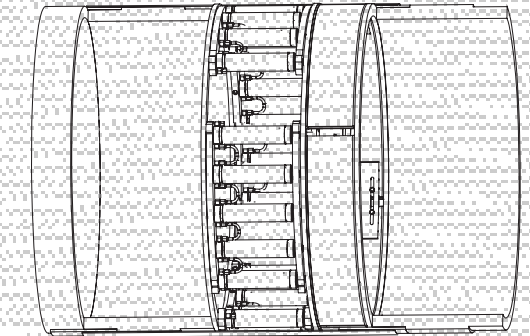


Figure 3. Cross view of liner can with hydraulic cylinders mates to the back of the TBM or EBS.

The tunnel is finished by adding spacers and the final carrier pipe to the interior of the tunnel and the annular space is grouted.

EQUIPMENT FOR PIPE JACKING AND TUNNELING

Tunnel Boring Machines

Akkerman TBMs range in size from 48-96-in. TBMs excavate soil at the face of the bore when hydraulic motors rotate the inner drum, the rotating cutter head excavates, and spoil is transported via conveyor and haul unit for disposal in the launch shaft.

The TBMs feature a sealed steering joint that allows for full articulation and a high capacity main bearing for hydraulic steering. Two-speed drive motors operate in either low-speed/high-torque or high-speed/low-torque modes to allow operators to precisely tailor cutting speeds and torque in varying geology for optimal productivity.

The TBM cutter head (see Figure 4, next page) is selected based on project ground conditions and is capable of bi- and unidirectional movement. Cutter face tooling comprises a combination of durable carbide gage cutter bits, clay spades, and disc cutters. Carbide single bar and

METHOD OF OPERATION - PIPE JACKING & TUNNELING

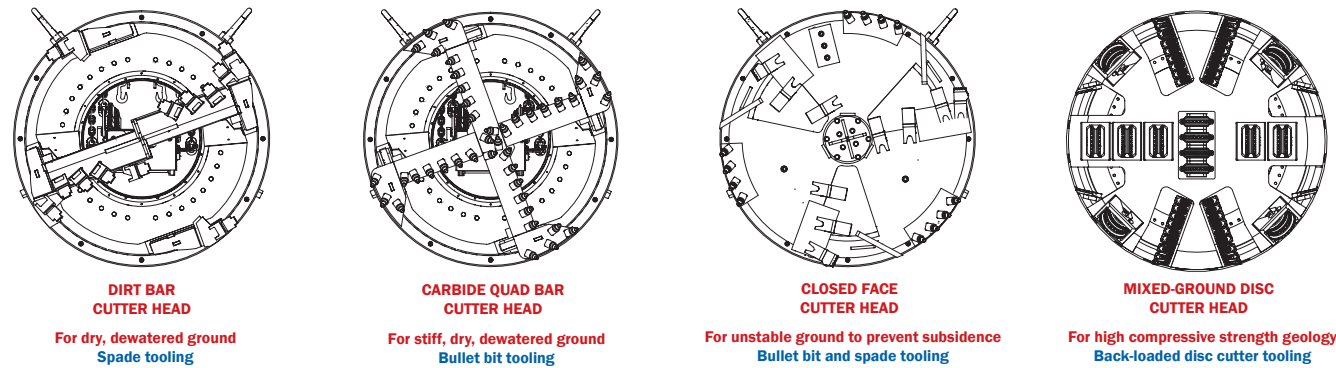


Figure 4: Standard Tunnel Boring Machine Cutter Heads.

quad bar cutter heads feature rotating cutter arms for use in dry, dewatered ground. Closed face cutter heads are used in unstable ground to prevent subsidence into the TBM interior. Soil is forced through openings on the cutter head during advancement while the remaining surface area provides face stability. Mixed ground disc cutter heads are used for high compressive strength geology and feature full-face support, and back-loaded tooling mounts for ease of replacement. Project-specific custom cutter heads are also available at request.

Excavator Boring Shields

An Akkerman EBS is a simple and economical choice for 96-168-in. OD mechanical excavation for pipe jacking, liner plate, ring-beam and lagging, and tunnel building applications (see Figure 5). An EBS excavates soil with a backhoe excavator at the face of the bore and spoil is removed in the same manner as with the TBMs.

An EBS system contains a boring shield with an excavator, jacking frame, thrust yoke, conveyor, haul unit, and power pack or pump unit. The EX-50 Excavator is positioned in a slide mount on the interior top of the EBS and is



Figure 5. The EBS matches the diameter of the pipe and an interior mounted backhoe excavator removes spoil which is transported from the conveyor to the haul unit system.

interchangeable between shield models. The excavator is controlled with a joystick and foot controls to remove spoil and obstacles between the shield's shelves and are guided onto the conveyor (see Figure 6). Spoil is transported by a belt conveyor to a large capacity haul unit for removal from the launch shaft. Boring Shields can be equipped with close-able, hydraulic doors to prevent subsidence from entering the EBS interior (see Figure 7).

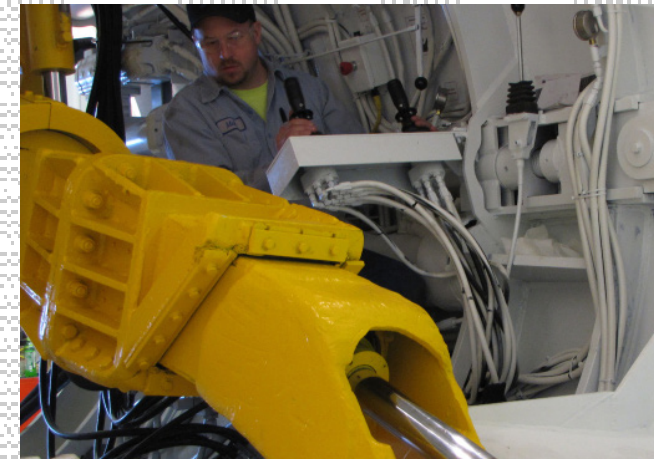


Figure 6. Operator controlling the excavation process.



Figure 8. The Tunnel Boring System is an all-in-one pipe jacking solution.



Figure 7. EBS equipped with hydraulic closeable doors to prevent subsidence.

Thrust yokes match the pipe diameter and provide a 360-degree surface to minimize point pressure on the pipe and transfer thrust from the pump unit to the pipe.

Skid bases accommodate various shaft configurations and are available in standard lengths of 2.5, 7, 15 and 22.5-ft. to accommodate various shaft sizes or pipe lengths.

Pipe jacking takes place when the operator on the pump unit's platform engages controls to extend jacking cylinders to advance the yoke and TBM and pipe along the skid base.

Tunnel Boring System

The Tunnel Boring System, exclusive to Akkerman, adapts to any jacking pipe with matching diameter TBM and thrust yoke, skid sections and pump unit with hydraulic jacking cylinders (See Figure 8). A complete Tunnel Boring System comprises a TBM, pump unit, yoke, skid, haul unit, conveyor, and often a bentonite pump or system.

Hydraulic Jacking Frames

A TBM or EBS can also be launched with an 800-1,200 ton thrust capacity jacking frame powered by a power pack. Akkerman high capacity keyhole jacking frames fit in a 28-32-ft. shaft and are configured with a dirt bucket bay for pipe jacking spoil removal (see Figure 9, next page). The jacking frame's hydraulic cylinders extend to

METHOD OF OPERATION - PIPE JACKING & TUNNELING

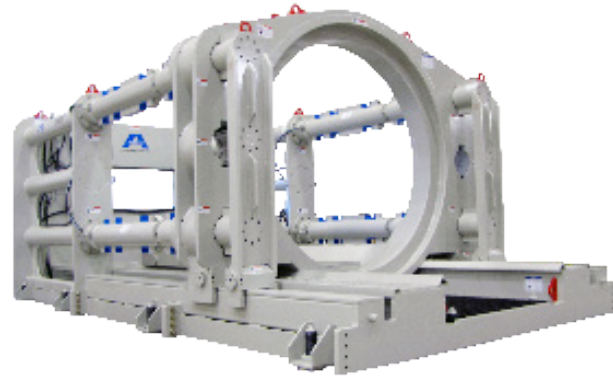


Figure 9. The keyhole jacking features up to 1,2000 tons of thrust capacity for pipe jacking operations.

advance the TBM and pipeline. As the cylinders extend, notches on the cylinders lock into place to ensure smooth continuous advancement. A hydraulic winch at the base of the reaction wall is used to retract the jacking frame thrust block.

Power Packs

Akkerman's electric P600 Power Pack powers the keyhole jacking frame and is operated with an in-shaft pendant. The P600 features a 600-gallon hydraulic reservoir with three interchangeable low and high pressure pump and motor modules.

SPOIL TRANSPORTATION

Excavated spoil from the TBM face enters the holes on the rotating cutter head, are forced onto dirt paddles behind the cutter head, and get deposited onto a belt or screw conveyor (see Figure 10). With an EBS, the operator

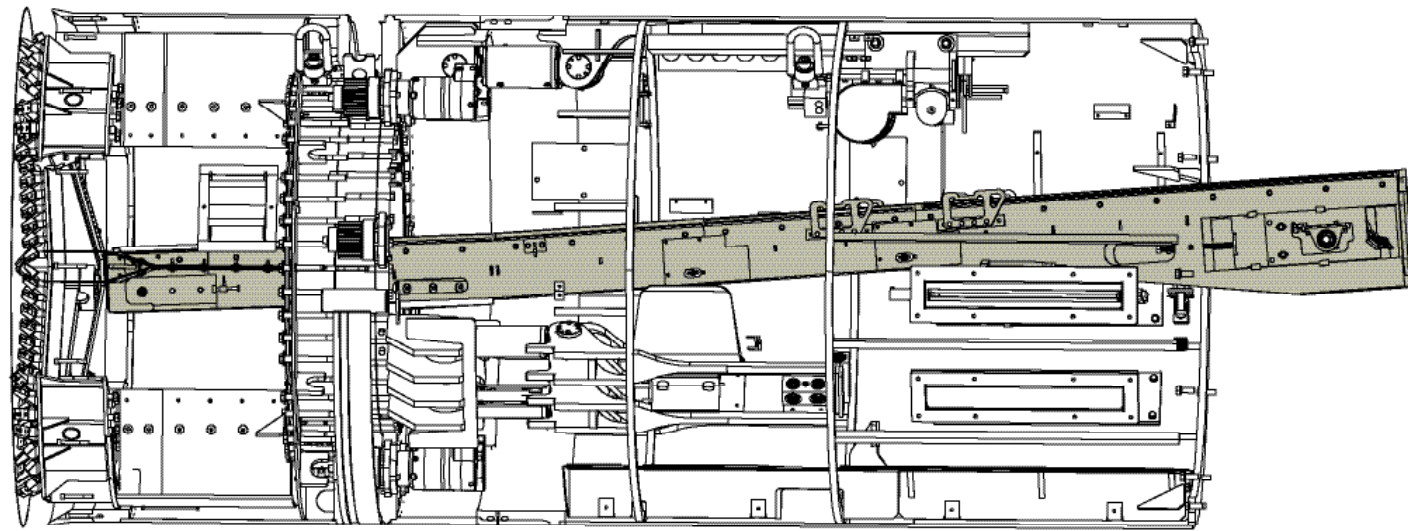


Figure 10: Side view of the TBM with conveyor for spoil transportation from the cutter head to the haul unit dirt bucket.

manually excavates and guides the spoil between the sand shelves to fall onto the conveyor.

Conveyors transport the spoil from behind the cutter head to the back of the TBM or EBS where it falls into the haul unit dirt bucket. Once the dirt bucket is full, the haul unit operator drives the haul unit and spoil filled dirt bucket along the track to the launch shaft (see Figure 11). The dirt bucket is hoisted out of the shaft, the spoil is dumped, and the bucket is returned to the haul unit which travels back to the back of the TBM or EBS for refilling.

The haul unit system contains the haul unit, dirt bucket and track. Multiple dirt bucket systems are sometimes used for increased productivity and efficiency on larger diameter and extended length projects. Haul units are electrically driven by an operator, powered by a battery pack and equipped with disc brakes.

ADDING THRUST TO THE ALIGNMENT

Intermediate Jacking Stations (IJSs) distribute thrust loads to facilitate longer drives. An IJS's steel housing cylinder

matches the outside diameter of the pipe and interior ram segments exert additional thrust tonnage to aid in pipeline movement. As jacking pressures increase due to long drives and difficult ground conditions, an IJS can be added to the pipe string at a sequence (see Figure 12) to best alleviate pressures on the main hydraulic jacking cylinders, overall ground resistance and friction loads. Multiples of five ram segments, each with a seven-inch stroke that exert 60-tons of thrust to the pipeline. More than one IJSs can be used in one pipeline as needed. The IJS steel housing is non-recoverable.

LUBRICATION

The introduction of bentonite and polymers into the annulus between the pipe and ground reduces friction and decreases jacking thrusts. Contractors should consult with a mud supplier for a ground appropriate solution before pipe jacking begins.

If it's suspected that lubrication will be necessary on a project, it should be used from the get-go, throughout the full length of the bore, and not just as an emergency



Figure 11. Dirt bucket and haul unit on a track.



Figure 12. An IJS is used to reduce thrust on longer drives.

METHOD OF OPERATION - PIPE JACKING & TUNNELING

procedure. The use of lubrication should only take place during pipe advancement otherwise the drilling fluid could flow into the launch shaft or plug the cutter face.

The following is a general rule of thumb on the function of drilling fluids for generalized spoil types:

In unstable sands and gravels, a bentonite mix will provide fluid pressure to support the ground outside the tunnel. It should act as an impermeable layer and often bentonite slurries with polymer additives work well.

If the ground is stable and dry, a slight overcut will minimize friction between the pipe and ground. In this instance, an added lubricant will become buoyant and reduce contact forces.

In stiff, plastic-like clays, sometimes called squeezing clay, a lubricant with water inhibiting agents works best. When the water-based lubricants are mixed with clays of this nature, clay will absorb the water, swell, and close in on the pipe. Clay inhibitors keep the clay from hydrating upon contact with water, which in-turn, keeps jacking forces down.

Akkerman diesel and electric bentonite and lubrication pumps feature independent flow control of pumping applications of water and water with polymer with high psi pressure from dual-325-gallon tanks for mixing and pumping or pump supply from both tanks (see Figure 13).

For extended length pipe jacking projects, the Akkerman Bentonite Injection System (ABIS) delivers automated bentonite injection at specific intervals and is controlled touch screen monitor. Remote station control boxes link three automated injection ball valve assemblies to inject bentonite along the tunnel (See Figure 14, next page). The ABIS is also capable of controlling IJS functions.



Figure 13. Bentonite and lubrication pumps for independent control of pumping applications and high psi pressure.

TUNNEL NAVIGATION

With many tunnel installation methods, standard navigation is controlled with a traditional passive pipe laser that projects a laser point on the cutter face for the operator to monitor and make steering corrections as necessary to keep the laser on target. On extended length and curved drives, the AZ100 Total Guidance System (TGS) maintains a surveyed connection throughout the alignment.

The pipe laser is placed inside a laser stand which is positioned behind the pump unit on the skid when using a tunnel boring machine system or behind the reaction wall of the jacking frame. The pipe laser sights down the tunnel to reflect a point on the cutter head. The operator navigates by making corrections to the TBM or EBS steering as necessary to keep the laser point at the correct position.

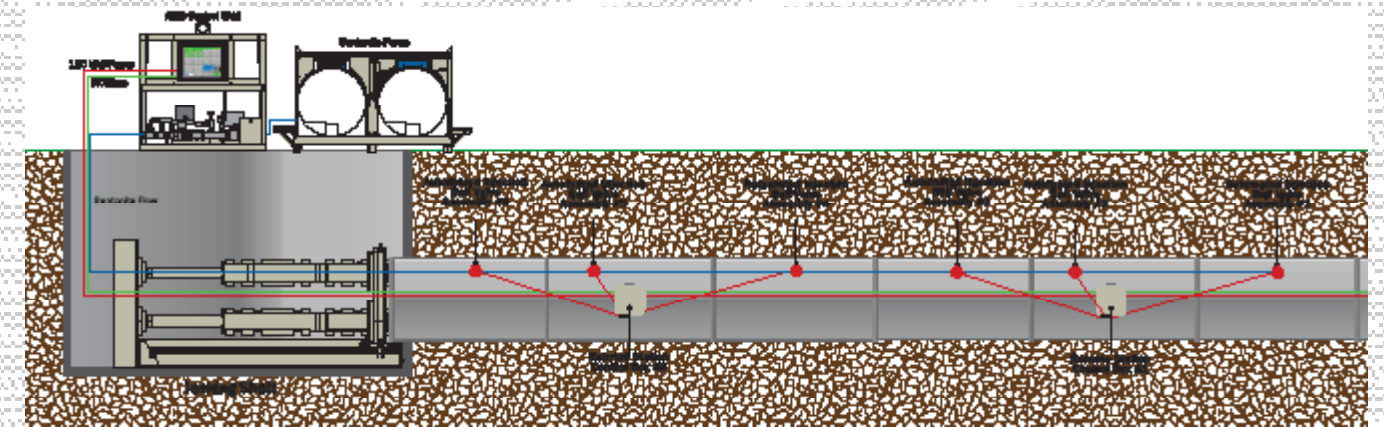


Figure 14: The ABIS system is used to automatically deliver bentonite at specific intervals from a touch screen monitor.

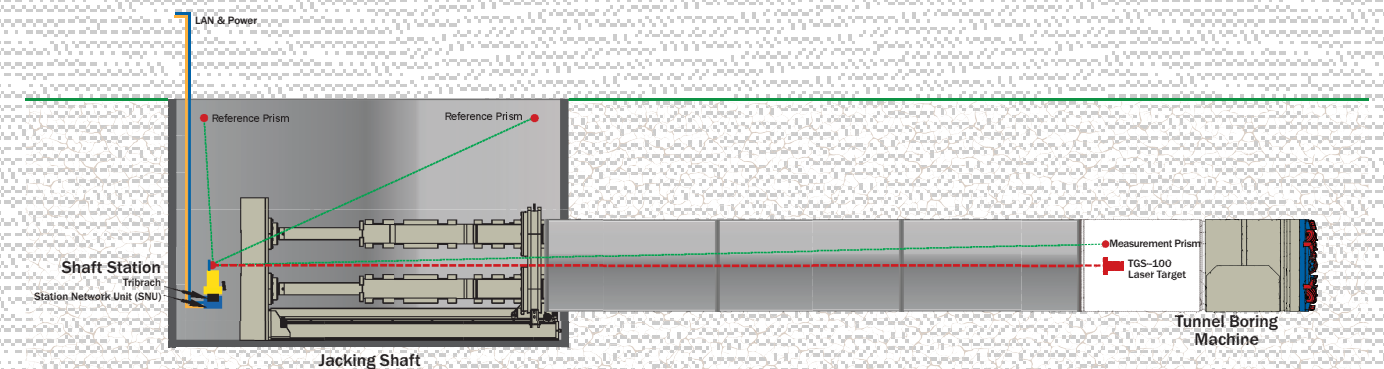


Figure 15: The AZ100 TGS shaft station is positioned behind the thrust block in a pipe jacking operation

METHOD OF OPERATION - PIPE JACKING & TUNNELING

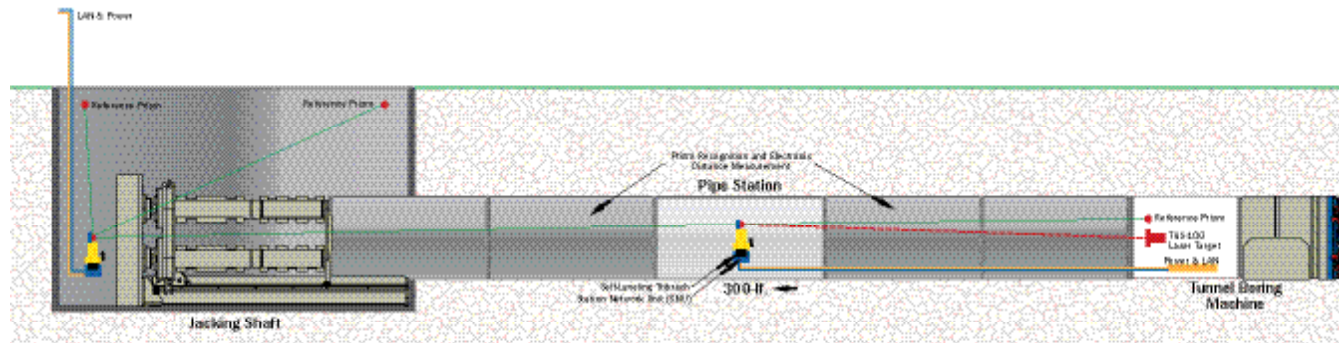


Figure 16: The AZ100TGS pipe stations are added throughout the tunnel to maintain a line of sight between all stations.

The AZ100 TGS is used for extended lengths and alignments with curves.

The AZ100 TGS is comprised of individual, self-leveling, station units that maintain a surveyed connection throughout the alignment without the need for continuous, manual surveying. The AZ100 TGS registers the position and angle of incidence of the red laser emitted from the guidance system.

The first pipe station is positioned at 300-lf. (see Figure 15, previous page) and additional pipe stations (see Figure 16) are added as required along the alignment to maintain a line of sight between all stations. An impressive range of distance between pipe stations can be achieved, on average 1,000-3,500-lf. dependent upon prism size, tunnel diameter, and atmospheric.

NOTES:

AKKERMAN



MADE IN THE
USA

DRIVEN FOR CUSTOMER SUCCESS

Since 1973, Akkerman has developed, manufactured and supported quality pipe jacking and tunneling solutions that accurately install a variety of underground infrastructure. We are proud to be the only North American manufacturer of our range of equipment and a global competitor.

Symmetry with contractors has been the backbone of our business and a point of distinction above our competition. Before Akkerman the equipment manufacturer there was D. H. Akkerman Construction Company. To satisfy their need to accurately install pipe under crossings, the manufacturing branch of Akkerman was founded forty five years ago.

Our business operates with the highest level of integrity and Akkerman employees have a personal investment in our customers' success. Our highly skilled sales team has a clear understanding of industry demands. Our in-house engineering department applies the most current standards and continually reviews, reassesses and enhances our equipment offerings.

We are committed to making every effort to position our equipment on your next project. As an added benefit, the purchase of a complete equipment system includes crew training and technical support. Akkerman systems are available for purchase, lease-to-purchase, or rent from our rental fleet. Select equipment will be considered for trade-in. Contact a sales engineer to pair the best option with your requirements.



58256 266th Street Brownsdale, MN 55918 | USA
Ph.: +1 (800) 533-0386 | akkerman.com



rev. 011119