AKKERMAN

SLURRY MICROTUNNELING HANDBOOK

AKKERMAN SL74P MTBM SYSTEM

JANUARY 2023

IDEAL FOR :

Pipe Jacking Installations

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Akkerman Inc.

EXECUTIVE SUMMARY

WHO WE ARE

Incorporated in 1973, Akkerman will be celebrating our 50th year as one of North America's leading and most-trusted manufacturers of online and grade trenchless equipment.

Founded in 1963 by D.H. Akkerman to support his own contracting efforts, Maynard Akkerman continued to drive corporate growth and innovation. Today, Akkerman is a third generation company that produces multiple products lines to support the trenchless industry.

Akkerman offers small town values coupled with a global perspective. Our business operates with the highest level of integrity and all Akkerman employees have a personal investment in our customers' success.

MADE IN AMERICA

Akkerman takes pride on our ability to manufacture high-quality trenchless products using American made materials with dedicated employees. For the past 50-years, Akkerman continues to support American jobs that ensure safety, quality, and reliability. We design, manufacture, and assemble all of our equipment in Brownsdale, Minnesota, USA.

Since nearly 98% of trenchless projects are funded through tax payer dollars, supporting American companies and their workers will stimulate additional infrastructure funding through tax revenue. This investment will strengthen the U.S. economy and further support future infrastructure projects. Akkerman will continue to support American trades by sourcing the highest quality raw materials, components, and supplies. Thank you for considering Akkerman as your trusted supplier.

CORE VALUES

- Teamwork
- Integrity
- Quality
- Innovation
- Safety

Certified System™
SAI GLOBAL
ISO 9001
Quality

MINNESOTA
MADE IN USA

Management Team

JUSTIN AKKERMAN, P.E.

President

Justin earned a bachelor's degree in civil engineering from the University of Minnesota and later obtained his Professional Engineer licensure in the State of Minnesota. As a third generation Akkerman, he has been immersed in the family business all of his life.

(507) 539-0028 (direct)

jakkerman@akkerman.com

JASON HOLDEN

V.P. - Chief Revenue Officer

Jason started his career with Akkerman in 2004 and previously served as the Director of Sales and as a Project Engineer. He holds a technical degree in mobile hydraulics as well as a bachelor's degree in mechanical engineering from Minnesota State University-Mankato.

(507) 539-0022 (direct)

jholden@akkerman.com

JAY ZIMMERMAN

V.P. - Chief Financial Officer

Jay plays an integral role in the company's stability with his financial strategy, planning, and related analysis. He joined Akkerman in 1998 after serving 11-years with a Fortune 500 company. Jay is a graduate of University of Wisconsin - Green Bay and holds CMA & CPA certificates. He is proud to be one of only a small number of Green Bay Packer fans working within the ranks of Akkerman.

(507) 539-0024 (direct)

jzimmerman@akkerman.com

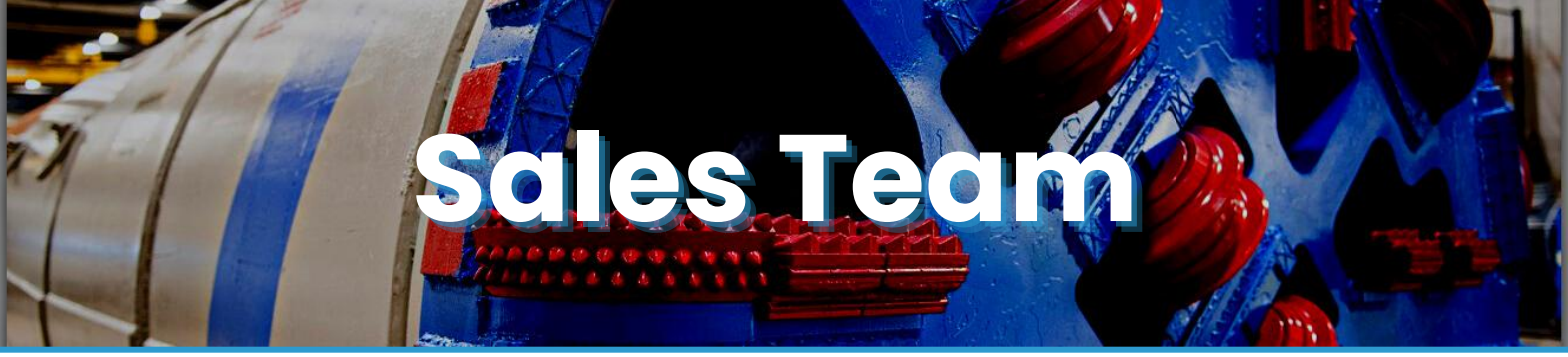
BRAD WHEELER, P.E.

Director of Engineering

Brad earned a bachelor's degree in mechanical engineering from North Dakota State University, a master's degree in business, and later obtained his Professional Engineer licensure in the State of Minnesota. His engineering design and business acumen has been proven throughout Akkerman product lines.

(507) 539-0012 (direct)

bwheeler@akkerman.com



Sales Team

TROY STOKES

Sales Manager - Florida

Troy's experience in the underground industry has spanned nearly four-decades and involved all trenchless technologies. He is a contributing author for several trenchless resource publications including the ASCE 36-15: Standard Design and Construction Guidelines for Microtunneling.
Territories: Southern & Southeastern US, Mexico, South America, Australia, New Yealand.

(507) 539-0055 (direct)

tstokes@akkerman.com

ROBIN LORENZEN

Sales Manager - Minnesota

Robin's decades of trenchless experience makes him an integral resource in the conceptualization and design of many Akkerman products. Since 1989, he has been helping contractors install thousands of feet of pipeline all over North America and Europe.
Territories: Midwestern US & Central Canada

(507) 539-0046 (direct)

rlorenzen@akkerman.com

CHRIS SIVESIND

Sales Manager - Washington State

Chris began his career at a young age while working at his father's pipejacking and auger boring business. After receiving a bachelor's degree in Business Administration from Washington State University, he continued in the trenchless industry as a specialty shoring installation consultant, and in sales for another trenchless manufacturer. Sivesind is an active participant in many industry associations and is a current NASTT board member.
Territories: West Coast, Canada, Europe, & Asia Pacific

(507) 539-0016 (direct)

csivesind@akkerman.com

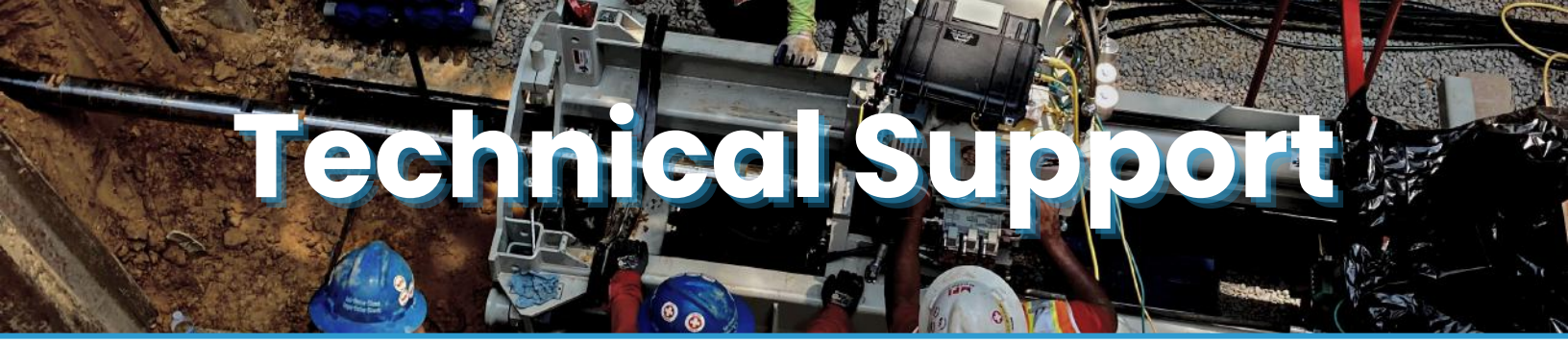
JON VALIN

Sales Manager - Wisconsin

Jon has served the heavy civil, construction, and repair industry for over 20-years and has developed the attention to detail required in the trenchless industry. His knowledge and expertise allow him to understand the challenges of contractors, while his position at Akkerman allows him to provide solutions they require.
Territories: Great Lakes Region, East & Northeastern US, Middle East, and India

(507) 539-0047 (direct)

jvalin@akkerman.com



Technical Support

DARYL ANDERSON
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Tech. Support & Service Manager

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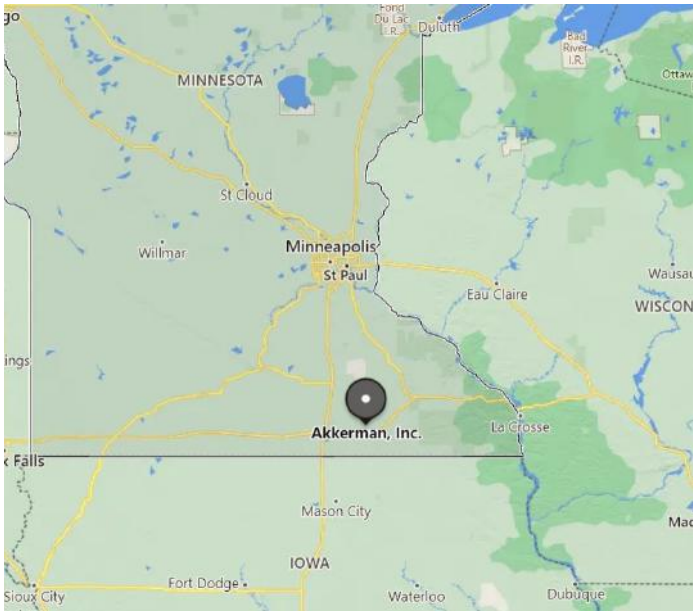
CORPORATE HEADQUARTERS



LOCATION

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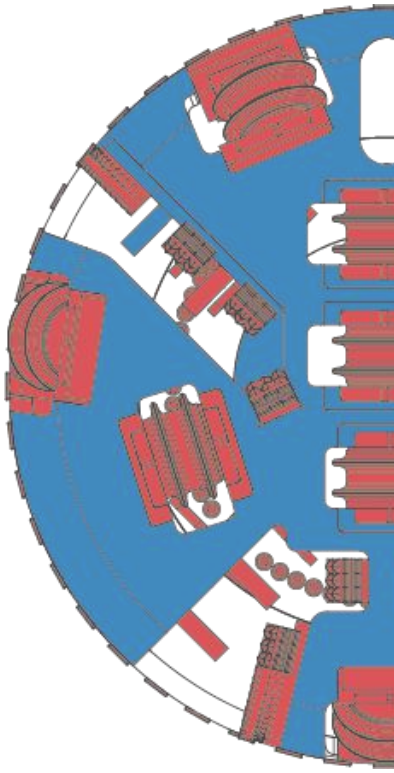
Akkerman Inc.

EXPERIENCE

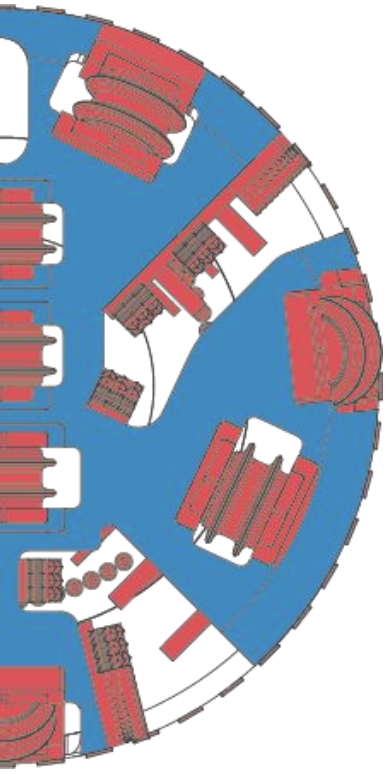


Statement of Experience

Akkerman takes pride on our ability to manufacture high-quality slurry microtunneling systems using American made materials with dedicated employees. For the past 50-years, Akkerman continues to support American jobs that ensure safety, quality, and reliability. We design, manufacture, and assemble all of our trenchless equipment in Brownsdale, Minnesota, USA.

We proudly designed, manufactured, sold, and provided technical support for the following MTBM(s).

MTBM TYPE	DATE	TRENCHLESS CONTRACTOR	PROJECT
Akkerman SL82P Microtunneling System	2022	Melcar Underground	RB Sims Bayou - Houston, TX
Akkerman SL74P Microtunneling System	2021	Huxted Trenchless	RB Sims Water Treatment Plant Intake - Chesnee, SC
Akkerman SL60P Microtunneling System	2020	Engineering Construction Inc. (ECI)	10th Ave Water Main River Crossing - Minneapolis, MN
Akkerman SL82P Microtunneling System	2020	Frontier Kemper Constructors, Inc. (FKCI)	River Supply Conduit Upper Reach Unit 7 - Los Angeles, CA
Akkerman SL86P Microtunneling System	2019	J & J Boring, Inc.	Prairie Creek Sanitary Sewer - Cedar Rapids, IA
Akkerman SL82P Microtunneling System	2018	Michels Trenchless	Lockbourne Intermodel Trunk Sewer - Lockbourne, OH



Akkerman Inc.

CERTIFICATION

Project Resume - Complex Projects

Since nearly 98% of trenchless projects are funded through tax payer dollars, supporting American companies and their workers will stimulate additional infrastructure funding through tax revenue. This investment will strengthen the U.S. economy and further support future infrastructure projects. Akkerman will continue to support American trades by sourcing the highest quality raw materials, components, and supplies. Thank you for considering Akkerman as your trusted supplier.

MTBM TYPE	PROJECT	DATE	TRENCHLESS CONTRACTOR	DESCRIPTION
Akkerman SL82P Microtunneling System	City Trunk Sewer - Burbank, CA	2022	Frontier Kemper Constructors, Inc. (FKCI)	**Pipe: 82-in Steel Casing** **Total: 900-lf / Longest: 900-ft** Clays with cobbles and boulders.
Akkerman SL74C Microtunneling System	Edgewood Avenue Near Surface Collector	2022	Super Excavators, Inc.	**Pipe: 72-in RCP** **Total: 1.670-lf / Longest: 1,670-ft** Mixed face conditions. Clays, sands, and silts with cobbles and boulders. Design Curved.
Akkerman SL74P Microtunneling System	RB Sims Water Treatment Plant Intake - Chesnee, SC	2021	Huxted Trenchless	**Pipe: 74-in Steel Casing** **Total: 336-lf / Longest: 221-ft** Hard Rock Microtunneling. UCS > 20,000-psi
Akkerman SL60C Microtunneling System	Sarnia Sewer Upgrade Project Phase 3 Trunk Sewer - Sarnia, ON	2021	Super Excavators	**Pipe: 54-in (DN1350) RCP** **Total: 5,830-lf / Longest: 2,200-ft** Mixed face conditions. Clays, sands, and silts with cobbles and boulders. Curved Alignment.

Continued on next page. Page 1 of 3

Akkerman Microtunneling Project Resume - Continued

MTBM TYPE	PROJECT	DATE	TRENCHLESS CONTRACTOR	DESCRIPTION
Akkerman SL60P Microtunneling System	10th Ave Water Main River Crossing - Minneapolis, MN	2020	Engineering Construction Inc. (ECI)	**Pipe: 60-in Steel Casing** **Total: 896-lf / Longest: 896-ft** Sands, silts, and sandstone with UCS up to 2800-psi. High probability of Alluvial along the alignment. Geotechnical Data Report No. 198371 (Black and Veatch)
Akkerman SL82P Microtunneling System	River Supply Conduit Upper Reach Unit 7 - Los Angeles, CA	2020	Frontier Kemper Constructors, Inc. (FKCI)	**Pipe: 104-in Steel Casing** **Total: 520-lf / Longest: 520-ft** Mixed face conditions. Clays with cobbles and boulders.
Akkerman SL82P Microtunneling System	City Trunk Line South Unit 3 - Las Angeles, CA	2020	WA Rasic Frontier Kemper Constructors, Inc. (FKCI)	**Pipe: 82-in Steel Casing** **Total: 4,186-lf / Longest: 1,100-ft** Firm cemented soils with rock. Alluvial.
Akkerman SL60C Microtunneling System	Bedford Replacement Pump Station and Sewer	2020	Super Excavators, Inc.	**Pipe: 48-in RCP** **Total: 5,872-lf / Longest: 2,215-ft** Mixed face conditions. Clays, sands, and silts with cobbles and boulders. Curved Alignment.
Akkerman SL86P Microtunneling System	Prairie Creek Sanitary Sewer - Cedar Rapids, IA	2019	J & J Boring, Inc.	**Pipe: 87.5-in Steel Casing** **Total: 313-lf / Longest: 313-ft** Mixed face conditions. Clays with cobbles and boulders. Glacial Till & Alluvial Deposits.
Akkerman SL60C Microtunneling System	SR37 Offsite Drainage Outfall Storm Sewer	2019	Super Excavators, Inc.	**Pipe: 72-in RCP** **Total: 6,000-lf / Longest: 1,130-ft** Mixed face & Glacial Till. Sands, silts, gravels, cobble, boulders, and rock.
Akkerman SL82P Microtunneling System	Lockbourne Intermodel Trunk Sewer - Lockbourne, OH	2018	Michels Trenchless	**Pipe: 78-in Hobas FRP** **Total: 10,210-lf / Longest: 1890-ft** Cohesive Alluvial (Type A), Sand (Type B), Silty Sand and Gravel (Type D), and Cohesive Till (Type E). Conditions included cobble and boulders while under 35-ft waterhead.
Akkerman SL86P Microtunneling System	South Interceptor Force Main (SIFM) - Omaha, NE	2017	Super Excavators, Inc.	**Pipe: 87.5-in Steel Casing** **Total: 803-lf / Longest: 803-ft** Mixed face conditions. Alignment ranged from UCS - 9,000-psi to sand, silt, alluvial with cobble and boulder.

Continued on next page. Page 2 of 3

Akkerman Microtunneling Project Resume - Continued

MTBM TYPE	PROJECT	DATE	TRENCHLESS CONTRACTOR	DESCRIPTION
Akkerman SL60C Microtunneling System	SR37 Offsite Drainage Outfall Storm Sewer	2019	Super Excavators, Inc.	**Pipe: 72-in RCP** **Total: 6,000-lf / Longest: 1,130-ft** Mixed face & Glacial Till. Sands, silts, gravels, cobble, boulders, and rock.
Akkerman SL74C Microtunneling System	Doan Valley Storage Tunnel Project - Cleveland, OH	2018	Super Excavators, Inc.	**Pipe: 72-in RCP** **Total: 1,130-lf / Longest: 1,130-ft** Mixed face & Glacial Till. Double Curve alignment.
Akkerman SL86P Microtunneling System	South Interceptor Force Main (SIFM) - Omaha, NE	2017	Super Excavators, Inc.	**Pipe: 87.5-in Steel Casing** **Total: 803-lf / Longest: 803-ft** Mixed face conditions. Alignment ranged from UCS - 9,000-psi to sand, silt, alluvial with cobble and boulder.
Akkerman SL86P Microtunneling System	Twinning of Etobicoke Creek Sewer - Toronto, ON	2016	CRS Tunnelling Inc. Super Excavators Inc.	**Pipe: 72-in RCP** **Total: 1890-lf / Longest: 1890-ft** Halton Till. Silt, sand, and clay. Cobbles and boulders consisting of shale, siltstone, limestone, and granatic rock. Geotechnical Baseline Report No. 11-2210 (Region of Peel)
Akkerman SL74C Microtunneling System	Villiage of Oak Lawn Watermain - Oak Lawn, IL	2020	Super Excavators, Inc.	**Pipe: 72-in RCP** **Total: 414-lf / Longest: 414-ft** Hard Rock Microtunneling. Dolomite up to UCS 20,000-psi.
Akkerman SL86P Microtunneling System	DC02 & DC03 Sewer Replacement. Phase III & IV. - Ladue, MO	2021	J & J Boring Inc.	**Pipe: 87.5-in Steel Casing** **Total: 705-lf / Longest: 322-ft** Split-face conditions. Clay & hard rock conditions.
Akkerman SL82P Microtunneling System	Simms Bayou Project - Houston, TX Current Project	2022	Melcar Underground	**Pipe: 80-in Steel Casing** **Total: 524-lf / Longest: 524-ft** Cohesive Alluvial (Type A), Sand (Type B), Silty Sand and Gravel (Type D), and Cohesive Till (Type E). Abrasive. Clays with boulders.
Akkerman SL60C Microtunneling System	North Brighton Outfall - Fort Lupton, CO	2021	BTrenchless, Inc.	**Pipe: 66-in Hobas** **Total: 820-lf / Longest: 820-ft** Silty Sand and Gravel (Type D)

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MICROTUNNEL SYSTEMS

General Microtunneling System Information

Section 3.0: Microtunneling - General Information

Akkerman slurry microtunneling systems are often selected due to the capacity to meet the performance requirements specified in contract documents. Below are the general minimum requirements for microtunneling projects:

- MTBMs are capable of provide both positive mechanical and hydrostatic earth pressure.
- MTBMs are fully guided, articulated, and includes a sealed steering joint to enable both vertical and horizontal directional control to a tolerance of +/- 3% of the MTBM diameter on grade or 1-in (25mm), whichever is greater, or +/- 6% of the MTBM diameter on line or 2-in (50mm), whichever is greater from the design line and grade.
- The MTBM functions, including the bi-directional cutterhead is remote-controlled from the control container. Cutterhead torque is equally powerful in each rotational direction for proper operation and roll correction.
- The microtunneling process allows the possibility to inject lubricant around the exterior of the jacked pipe at the back of the MTBM.
- With proper operation of the microtunneling system by the contractor, it is possible to control heave and settlement to acceptable tolerances, as generally indicated in the contract documents.

Sufficient detail and technical descriptions shall be provided to demonstrate additional performance capabilities of Akkerman slurry microtunneling systems.

Section 3.1: Definition of Microtunneling

Microtunneling (MT) is a specialized form of trenchless construction with capabilities that offer owners, engineers, and contractors many benefits. For a trenchless method to be considered microtunneling, the installation process must adhere to the following four rules (ASCE 36-15: Standard Design and Construction Guidelines for Microtunneling):

- **Remote-Controlled** - Personnel entry is not required in the tunnel for routine operation.
- **Guided** - Product pipe accuracy tolerances are required to be within the line and grade demands of the gravity flow sewer industry.
- **Pipe Jacking** - Product pipe is advanced by a pipe jacking sequence from the main launch pit.
- **Face Support** - The system must be capable of providing continuous face support at the point of excavation, shaft portals, and along the pipe string.

The trenchless industry has adopted two types of microtunneling; slurry and auger type microtunneling. The primary differentiation between the method of positive face support and how excavated material is conveyed from the MTBM. (ASCE 36-15: Standard Design and Construction Guidelines for Microtunneling)

Slurry Microtunneling - Slurry microtunneling is an accurate trenchless pipe jacking method that provides continuous face support, transports material via a closed-loop slurry circuit, and is remotely operated from the surface. Operators monitor mechanical face pressure to counterbalance earth and hydrostatic loads through slurry pressures in the **microtunnel boring machines (MTBM)** crushing and plenum chambers.

Auger Microtunneling - Often referred to as **Pilot Tube Microtunneling (PTMT)** on engineering specification documents, conveys spoils by a continuous-flight auger while face support through a mechanical earth plug created by controlling the advance rate, auger rotation speed, and soil conditioning.

Trenchless Method	Diameter Range, OD	Guidance System & Drive Length	Ground Conditions
Auger Microtunneling	8 - 48 in. (300 - 1200 mm)	**theodolite/target** 400-ft, straight	Ground conditions range from soft grounds to highly weathered shale & rock. Not suitable for gravels/cobble exceeding 6in (150mm) or alignments over 10ft of water table in permeable ground.
Slurry Microtunneling	30 - 120 in. (760 - 3000 mm)	**laser/target guidance** 1000-ft, straight **enhanced guidance** 2500-ft+, straight or curved alignments	Most suited for pressurized ground conditions. Suitable for wide range of ground conditions with experienced contractor using appropriately fitted equipment. Extreme caution should be practiced in unconsolidated ground with boulders in excess of 6in, and mixed-face conditions as alignment control issues may exist due to variable geology.

****Special Note**** - Nominal drive lengths decrease as pipe diameter decrease.

Table 3.1: Considerations between auger and slurry microtunneling.

Section 3.2: Microtunnel Shaft Construction

Slurry microtunneling projects require engineered construction shafts for safe and efficient operation. In some cases, the cost of the design and construction of proper launch shafts can surpass the cost of tunneling. Launch shafts, commonly referred to as jacking shafts, are in constant use during the construction phase and must be of sufficient size and depth to accomodate both the MTBM and jacking pipe installation.

The contractor is responsible for the design and construction of the trenchless shafts in accordance with Federal OSHA Code, Construction Standards for Excavations, 29 CFR, Part 1926, Subpart P.

MTBM Shaft	Considerations
Overall Size	Sufficient size to accommodate the earth support system, jacking frame, thrust reaction block, slurry system bypass assembly, launch seal & pipe brake, slurry pumps, guidance system, shaft access equipment for personnel, safety equipment, personnel workspace with safe harbor
Location	Consider practical drive lengths. Maximum drive lengths should be within 10% of industry accepted practical drive lengths for diameter of tunnel to be installed. Avoid existing overhead and subsurface utilities whenever possible. Minimize social distrubances such as traffic, commerce, and emergency services. Locate jacking and receiving shafts at manhole locations, changes in alignment (horizontal or vertical), changes in pipe diameter, changes in geotechnical conditions, or changes in methodology.
Seals	Entry and exit shaft design should be based off geotechnical information and included in shaft design. Groundwater and flowing ground may require enhanced high pressure shaft seals with pipe brakes.
Dewatering & Safety	Install pit sump pump(s). Position pump in corner location(s) that allow grade to induce flow towards sump pump location. Capacity of pumps should accomodate any seepage of groundwater or construction fluids that enter the shaft at anytime. Have contigency plan for emergency backup pumps during downtime periods.
Depth	Avoid launching an MTBM for a jacking shaft into a split face geology whenever possible. A homogeneous matrix is best suited for alignment control. Starting a drive in harder ground and transitioning to softer ground is a more controlled transition for all tunneling methods.

Table 3.2.1: Slurry microtunneling shaft considerations.

Section 3.3: Microtunnel Jobsite Consideration

Sufficient work space should be planned during the design phase of a microtunneling project to accomodate support equipment required during construction. A staging area is required immediately around the jacking shaft for the control container, hydraulic power pack, slurry pumps, separation plant, bentonite system, main generator, ventilation system, cranes, loaders, tunnel lines & cables, jacking pipe, and consumables required during operation such as bentonite, grease, and other common items.

Historically, minimum staging areas are 7,000 sq. ft. (256 sq. m.) for jacking shafts and 4,000 sq. ft. (146 sq. m) for reception shafts. (ASCE 36:15) Larger or smaller sites may be required based on specific requirements. The size and layout of the jobsite should be designed and pre-planned according to project conditions and consider traffic work zones and public safety.

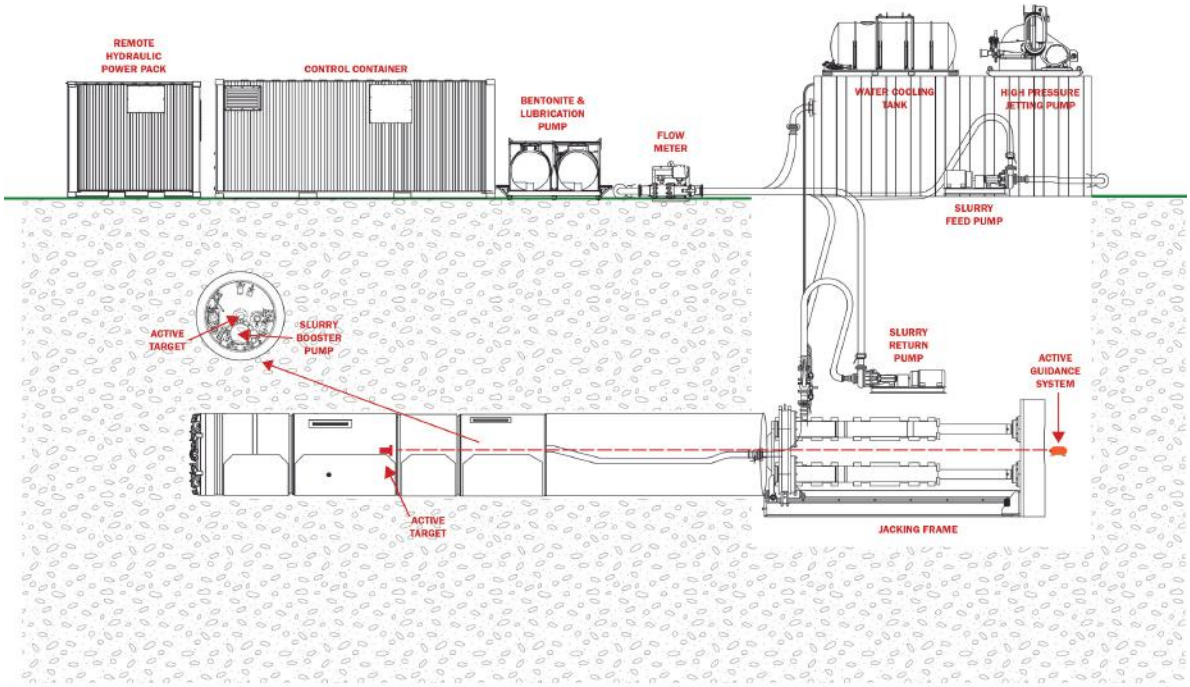

Figure 3.3.1: General arrangement of microtunneling jacking shaft setup

Shaft Construction Methods

- Segmental lining
- Sheet piling
- Secant piling
- Pre-cast segments
- Cast insitu caissons
- Trench box & speed slide rails
- Slurry walls
- Excavation with rock dowels & shotcrete
- Ground freezing

Shaft design must always be designed under direct supervision of a registered professional engineer licensed in the state where project is located.

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TECHNICAL DETAIL

Akkerman SL74P MTBM System

Section 4.0: Technical Presentation

The purpose of this technical presentation is to provide certification that Akkerman is the MTBM manufacturer. Sufficient detail and technical descriptions shall be provided to demonstrate that the specification requirements have been met in accordance to the Contract Documents.

Section 4.1: Akkerman Model SL74P MTBM

The Akkerman SL74P MTBM is a periphery drive slurry microtunneling machine designed to deliver powerful performance for extended distances and curved alignments. These units include an on-board power pack with remotely selectable torque ranges to conquer changing ground conditions. Like all Akkerman microtunneling systems, the SLP series is fully remote-controlled from the surface and offers face access for cutterhead inspection, tool replacement, or obstruction removal.

Main Drive Type: ..... Electric / Hydraulic
Main Drive Power: ..... 400hp (298 kW)
No. of Hyd. Motors: ..... (4), 2-speed hyd. motors
Cutterhead Torque (max): .. 325,000 ft-lbs (LSHT)
Cutterhead Speed (max): ..... 0-10.5 rpm

Shield OD: 74-in
Longest Section: 11.5-ft
Weight (No Head): .... 48,000-lbs.
Articulation: ..... 3 degrees
Seal Capacity ..... 3 Bar

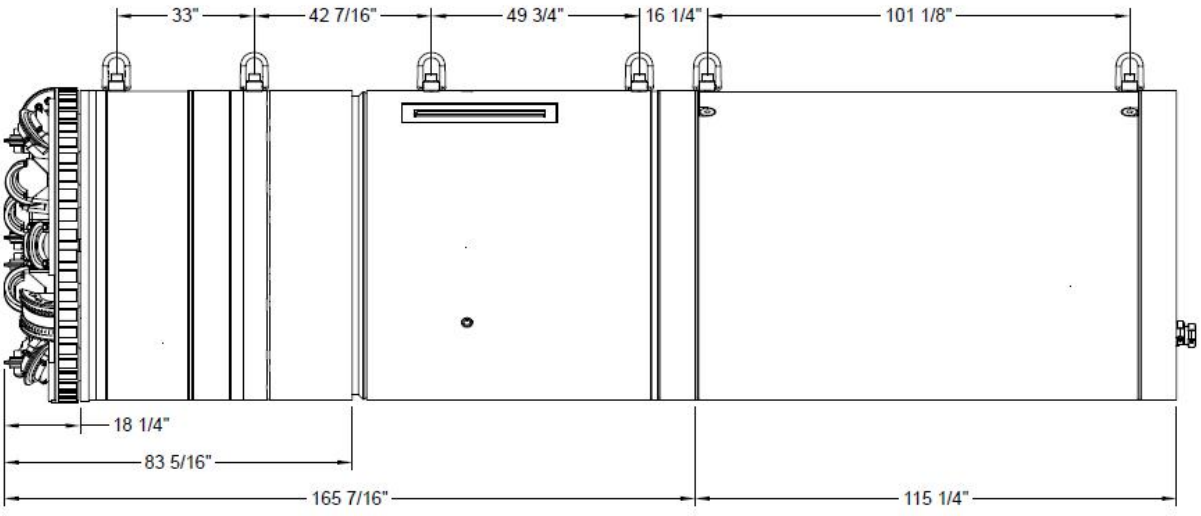


Figure 4.1: General Layout Dwg. of Akkerman SL74P MTBM

Section 4.1.1: MTBM Main Drive - Model SL74P

The Akkerman SL74P main cutterhead drive is a periphery-type, electric over hydraulic system with gear staged gear reduction that allows for face access. The MTBM has full bi-directional control of the cutterhead rotational speed and direction from the MCC control console. The bi-directional rotation is non-biased, meaning it has equal technical specifications in both clockwise and counterclockwise rotation. The main drive electric motor is positioned inside of the trailing section of the MTBM to maximize power and efficiency of the drive's capacity for long and difficult alignments.

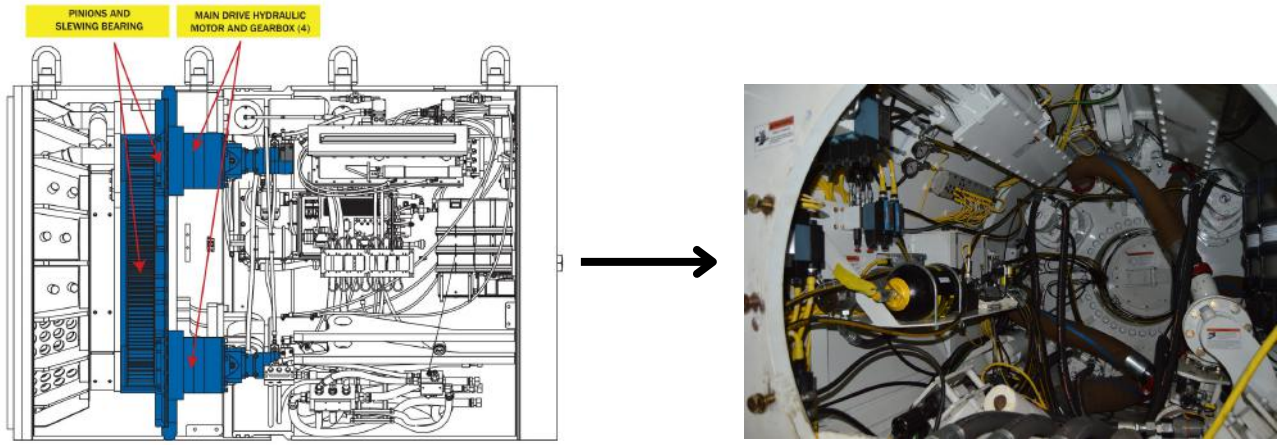


Figure 4.2: General arrangement and view of periphery drive MTBM.

MTBM Main Drive Bearing & Seals

The Akkerman SL74P MTBM cutterhead main bearing is a high-capacity Tri-Roller TBM type bearing with and integrated OD gear ring. The bearing assembly is designed with a filtered oil circulation system that allows the contractor to sample the condition of the lubricant for analysis. The lip seal design is rated to a capacity of 3.0 bar and includes a grease purging system to flush contaminants and lubricate the sealing surfaces between the inner and outer seals.

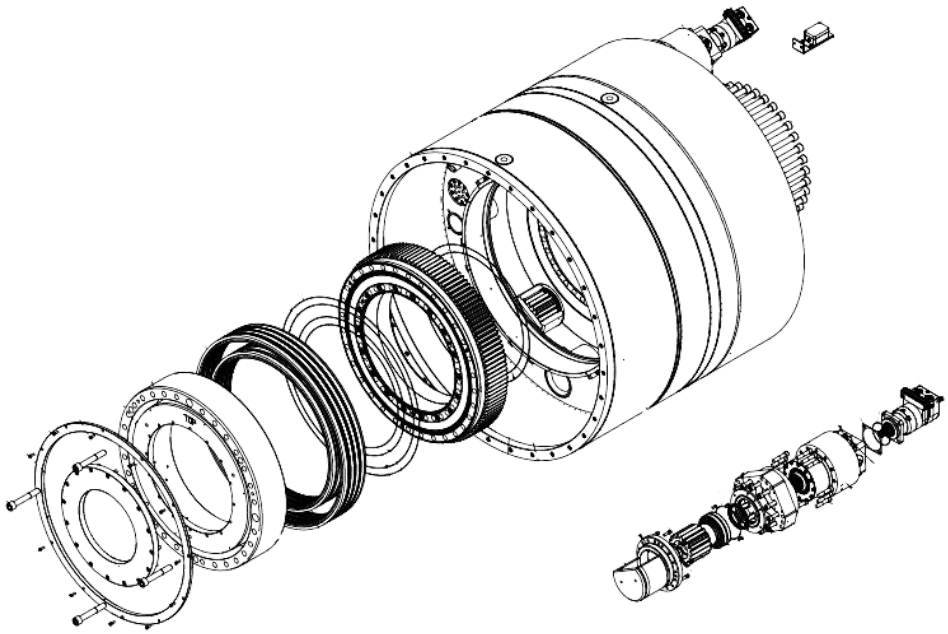


Figure 4.2: General arrangement of MTBM bearings and seals.

Section 4.2: Akkerman MTBM Cutterhead

Cutterheads are designed to excavate through the anticipated ground conditions as documented in a Geotechnical Baseline Report (GBR) with proper operation of the system. The final selection and approval of the cutterhead suitable for the anticipated ground conditions is the responsibility of the contractor. While cutterhead designs are generally customized for a specific project, the three main types of cutterhead types are as follows:

Figure 4.3: General microtunnel cutterhead options.

Soft Ground Cutterheads - Soft ground heads are not intended for soils with boulders, however are designed to ingest occassional rock & cobble up to 25 to 30 percent of the MTBM diameter. The processing and crushing of any rock must take place in the crushing chamber as the cutter face does not include disc cutters suitable for rock.

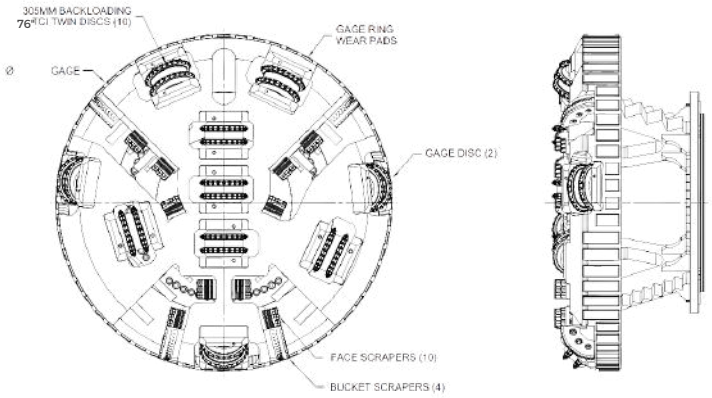
Mixed Ground Cutterhead - Mixed gound cutterheads are outfitted with a combination of disc cutters and a combination of soft ground tooling including carbide drag and/or conical bullet teeth. The opening ratio is reduced compared to soft ground cutterheads to allow rock and cobble to be processed by the disc cutters before entering the crushing chamber for final processing. Disc cutters are designed to engage the ground before the soft ground tooling on mixed ground cutterheads.

Rock Cutterhead - Rock cutterheads include high-capacity disc cutters and scoops positioned to clear excavated material from the face of the MTBM. The opening ration is greatly reduced in order to maximize the size and number and disc cutters mounted on the face of the MTBM. Back-loaded disc cutters can be interchangeable on MTBM diameters with face-access on diameters above 60-in OD, however compressed air intervention may be required. Back-loaded disc cutters require more mounting area and will negate design effeciency on smaller diameters.

Examples of cutterhead types: (Left to Right) Soft ground, Mixed Ground, Rock

All Akkerman MTBM systems are outfitted with pressure transducers that actively monitor the mechanical face pressure exerted onto the cutterhead. Maximum face pressure applied to the disc cutters are monitored by the operator and be adjusted according to the design specifications of the disc cutters. When mining in mixed face conditions, the position of varying strata in the geology may also be evident within the differential pressures.

Akkerman SL74P MTBM Cutterhead General Layouts



SL74P Mixed Face DCH

- Back-loaded twin disc cutters.
- COR - 18% approx.
- Thrust: 198-ton full / 145-ton conditional
- Optional carbide insert, carbide button, or harden steel disc cutters.
- HD bolt-on soft ground tooling.
- HD bolt-on periphery scraper tools.

Figure 4.4: General arrangement Dwg. of SL74P Mixed Face DCH.

SL74P Hard Rock DCH

- Front-loaded single disc cutters
- COR - 9% approx.
- Thrust: 225-ton full / 175-ton conditional
- Optional TCI or Hardened Steel discs
- 5 1/4" maximum particle size.
- HD bolt-on periphery scraper tools.

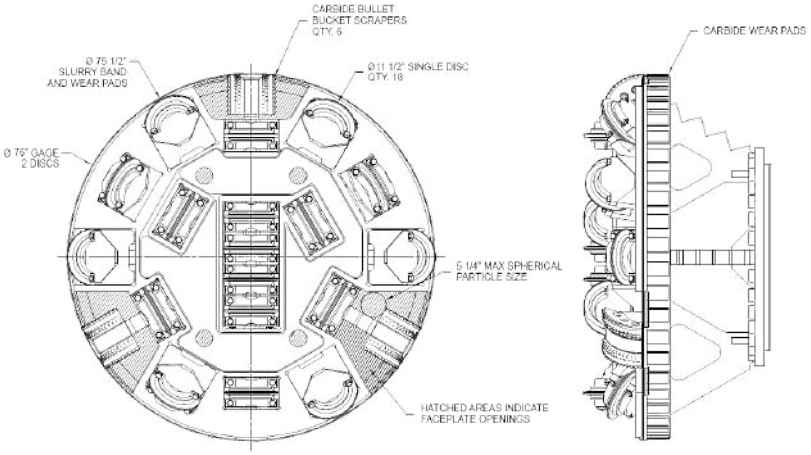


Figure 4.5: General arrangement Dwg. of SL74P Rock DCH.

Section 4.3: Crushing and Plenum Chamber

The Akkerman SL74P MTBM contains a high-strength rotating and stationary crushing cone assembly. Both the rotating and stationary crushing cones are manufactured from high strength steel and contain tight cross-welded hard facing throughout.

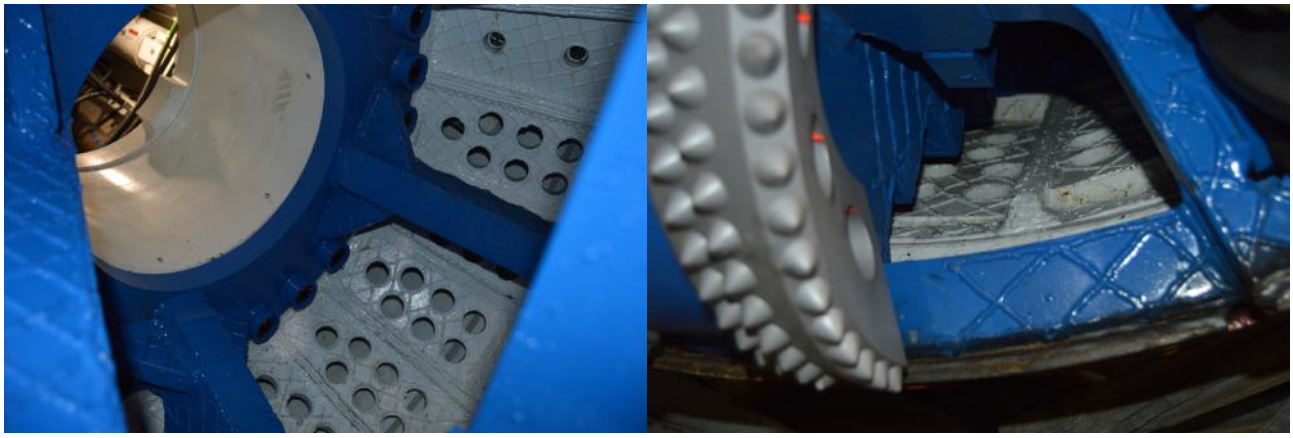


Figure 4.6: View of Stationary Crusher Cone (SCC) & Crushing Arms.

The rotating crusher cone contains crushing arms with varying degrees of offset to optimize crushing efficiency. This design allows for multi-step reduction of cobbles and boulder processing inside the crushing chamber.

The stationary crusher cone (SCC) contains various offset plates with porting. The top section of the SCC includes (5) high-volume slurry cutting nozzles that delivery drilling fluid directly to the back of the cutterhead. There are also slurry chamber nozzles that allow slurry flow to be directed behind the SCC to help form a slurry bubble when in non-consolodated materials. The MTBM operator can proportionally select the amount of flow directed to each of these nozzle systems.

Figure 4.7: MTBM w/ H.P.J.

The SCC also includes high-pressure jetting nozzles that allow extreme pressure to the cutterhead to assist cohesive ground conditions such as clays. The operator can control when this system is operational and the number of jets can be manually adjusted from inside the MTBM.

The slurry intake ports on the SCC are sized and specifically designed for the slurry piping system intended to be used on the project. A 5-in nominal slurry system is recommended for a SL74P MTBM system, however modifications can be adapted for 4-in to 6-in systems. The SL74P will allow for a partical size of approximately 1.8-in.

The trenchless contractor is responsible for the design of the drilling slurry mixture for anticipated ground conditions based on the geotechnical reports. The Akkerman SL74P MTBM crushing chamber can process cobble up to 30,000psi, however build-up of multiple cobble and boulders will cause wear which will reduce this capacity over time. If high volumes of cobble and boulder enters the crushing chamber prior to effectively crushing, the MTBM drive system may become worn or damaged.The crushing chamber components should be carefully inspected, rebuilt, and/or replaced if damaged prior to launching each drive. The replacement of the crushing chamber is only possible above ground. The MTBM operator should always monitor cutterhead torque, cutterhead speed, cutterhead rotation to ensure smooth transitions between mixed face ground conditions.

Section 4.4: MTBM Steering System

The Akkerman SL74P MTBM utilizes a three-point steering system. Three independent hydraulic cylinders are connected between the forward “Drive Section” and the rear “Trailing Section” via a sealed steering joint. Each steering cylinder can be independently controlled by the MTBM operator.

Each steering cylinder includes a pressure transducer on the bore (extend), rod (retract) and a linear position transducer to monitor face pressure and steering position. The max available thrust from each steering cylinder is 86-ton approx. Total allowable axial thrust force is 258-ton approx. The maximum anticipated load for the SL74P steering cylinders is 150-ton.

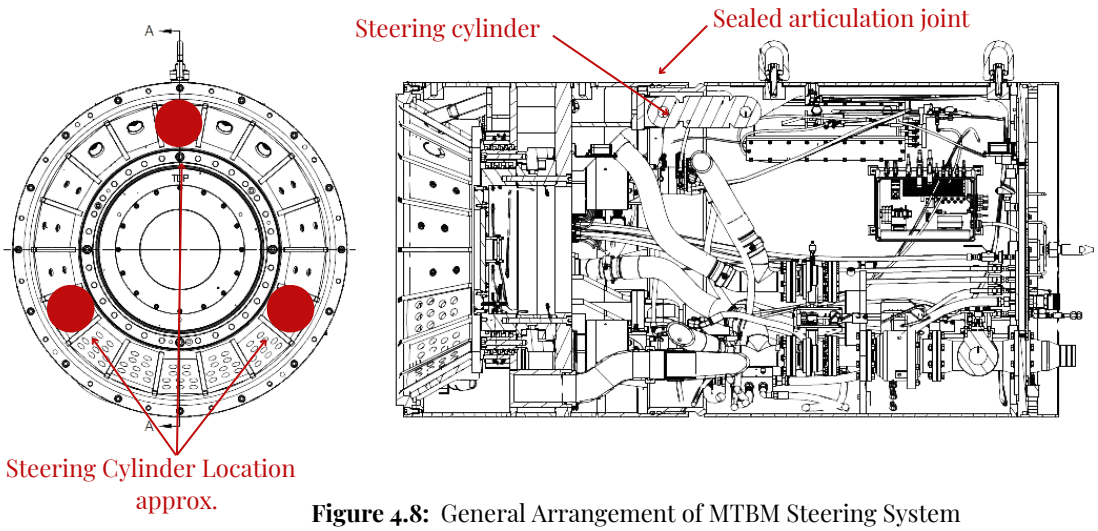
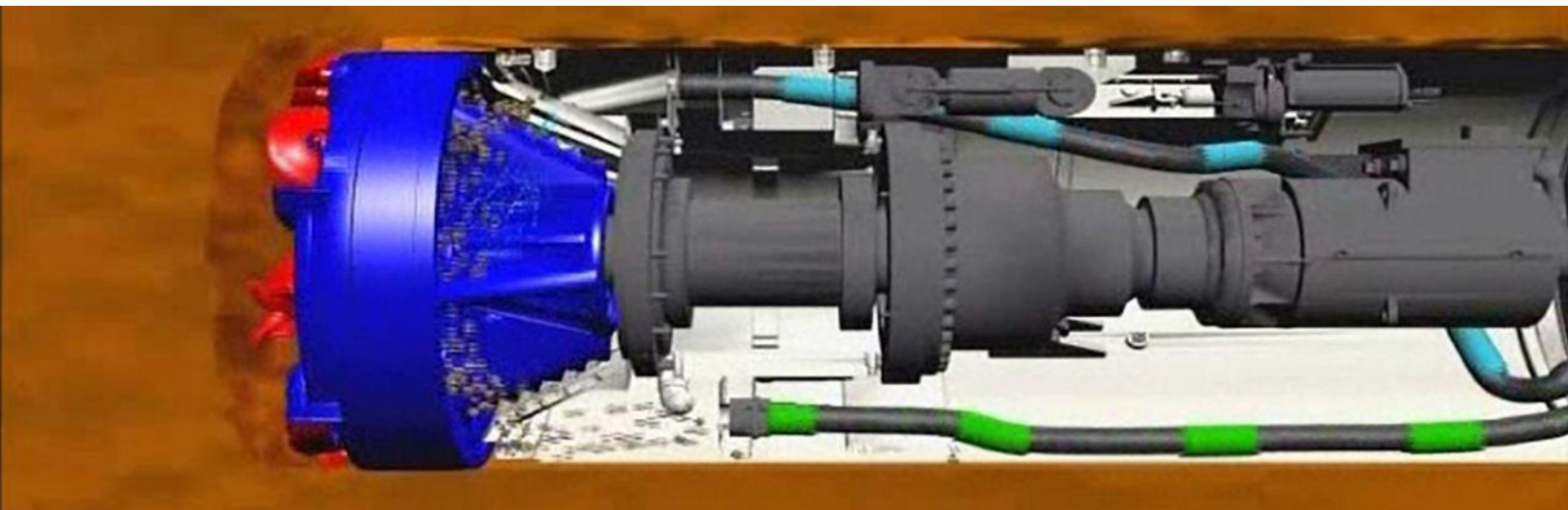


Figure 4.8: General Arrangement of MTBM Steering System

The MTBM articulation joint is sealed and has a capacity to 3.0 bar when the steering cylinders are in the fully retracted position. The SL74P MTBM articulation joint allows for approximately 3 degrees of steer in all quadrants based on the three-point design.

Section 4.5: MTBM Slurry System - Earth & Hydrostatic Balance

Akkerman MTBM's utilizes active slurry pressure transducers for both the inlet slurry as well as the slurry return chamber. Static groundwater pressure can be monitored with the pressure transducer located between the MTBM crushing chamber and the slurry stop valve. The measurement of slurry pressure at this position during shutdown mode allows direct measurement of the existing hydrostatic pressure inside the slurry chamber, thereby allowing for an operation that is balanced with slurry pressure.



MTBM Slurry System - continued

The MTBM will also monitor mechanical face pressure with active hydraulic pressure transducer sensing on both the bore and rod side of the steering cylinders. The three (3) articulation cylinders will provide the operator with real time feedback of the mechanical face pressure. The steering cylinder pressure(s) and the location of the face pressure helps in estimating the face pressure and the location of face pressure in mixed face ground conditions.

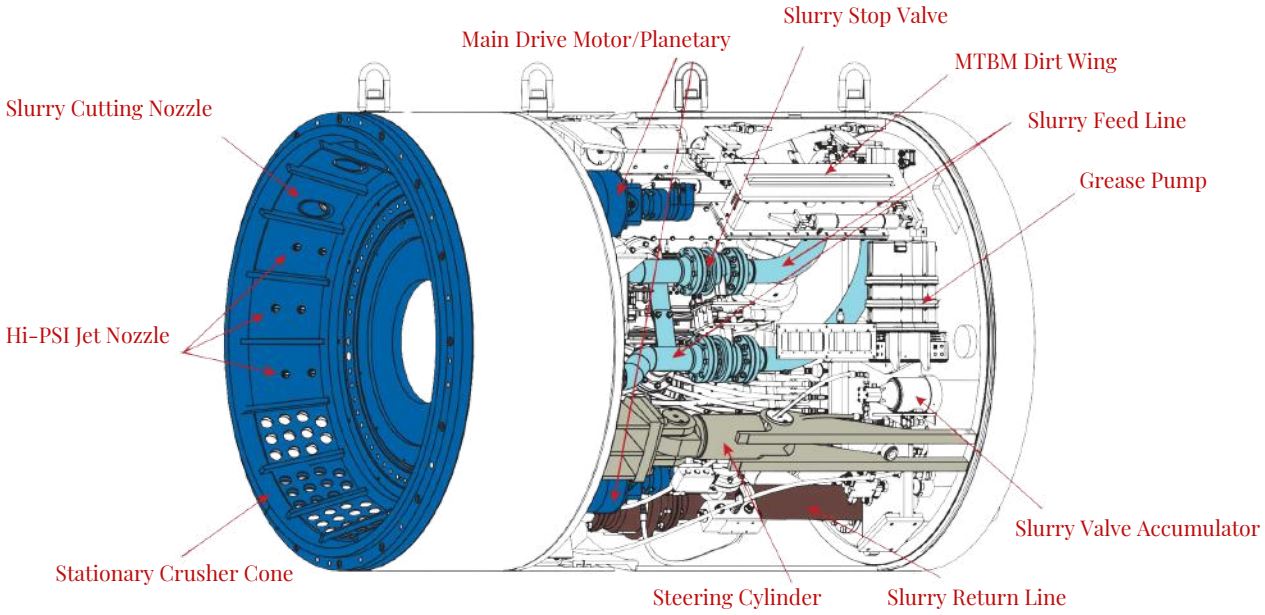


Figure 4.9: General Arrangement of Akkerman Periphery-Type MTBM

The Akkerman MTBM systems have the capability to utilize dual and variable flow modes to regulate the drilling slurry flow to the cutting and slurry chamber. This variability is used to control slurry pressures and flow interactions for cohesive and non-cohesive ground conditions.The MTBM operator can proportionally control the slurry volume percentage to each passaged based on the ground type that is being encountered.

Figure 4.10: Magnetic type slurry flow meters. Non-density type meters.

Drilling slurry flow is metered on both the inlet and the return side of the MTBM system. Magnetic type flowmeters monitor and provide the MTBM operator with real time data of the flow rates.
The composition of the slurry drilling fluid mix varies according to the ground conditions and will be the responsibility of the trenchless contractor. For non-cohesive soils that contain sands, gravels, cobbles and boulders, a drilling fluid may be recommended to effectively control the face during excavation. The density of the drilling fluid should be carefully monitored to not exceed 1.2 specific gravity approx. (10 lb/gal approx.) per ASTM D4380. High slurry densities will increase the pressure drop through the slurry distribution system and could lead to internal damage or high slurry pressures.

Section 4.6: MTBM Guidance System

Akkerman microtunneling systems can operate on both a standard laser-to-target guidance system or an enhanced AZ-100 Total Guidance System (TGS) for diameters larger than 60-in. The AZ100-TGS guidance system is an azimuth based total station guidance system designed for extended and/or complex pipe jacking tunnel alignments. The system consists of a "Shaft Station", which is a total station that includes a self-leveling Tribach and reference prisms. The reference prisms are permanently attached to the launch shaft wall and provide the shaft station an exact surveyed reference location (azimuth). During the launching sequence of the MTBM, the shaft station acts much like a traditional pipe laser to the Akkerman TGS target located directly inside the Akkerman MTBM shield. Direct communications to the MTBM operator through the MCC control console is continuous and measures the distance, Target Horizontal, Target Vertical, Real Time Cutterhead Location, vertical deviation, and horizontal deviation through Akkerman's proprietary software.

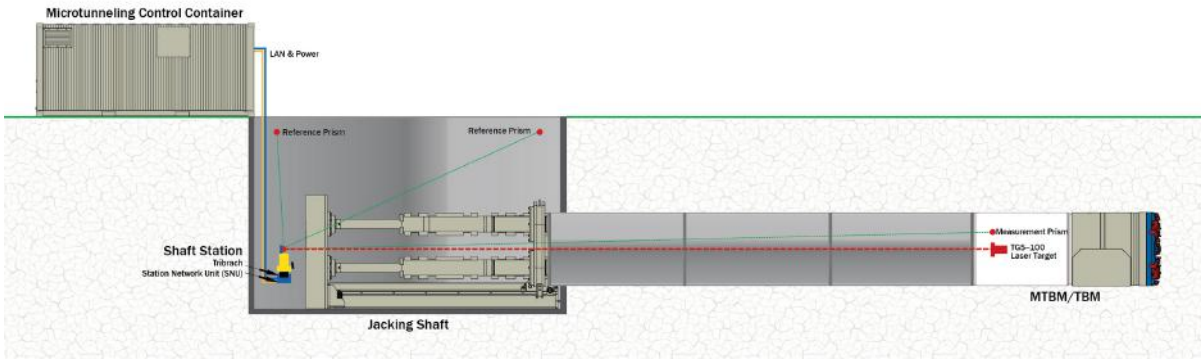


Figure 4.11: Akkerman AZ-100 Total Guidance System at launch.

Once the Akkerman MTBM is launched, a "tunnel station" can be mounted inside the tunnel with a mount specifically made to the jacking pipe. The initial tunnel station is installed at approximately 300ft (100m) behind the MTBM head. This distance will then remain constant for the remainder of the pipe jacking process and is designed to remain consistent to negate laser deviation that have traditionally faulted pipe laser to target systems due to temperature and air quality deviations. Additional pipe stations can be added as required along the alignment to maintain a line of site between all pipe stations and the shaft station. A detail of a pipe station added to the system is shown below:

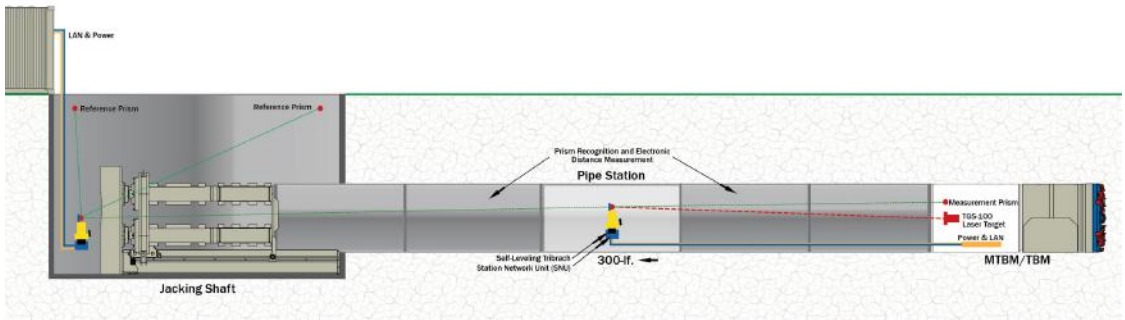


Figure 4.11: Installing first intermediate pipe station. Akkerman AZ-100 TGS

MTBM Guidance System - continued

To increase the system accuracy and maximize productivity on the project, the AZ100TGS will "survey itself" 3-4 times every ten (10) lineal feet of pipe during mining by looking back and reverse checking the position of each pipe station and shaft station in respect to the reference prisms (azimuth points) in the launch shaft. The process of "self-surveying" takes less than one minute to accomplish. The MTBM operator can also perform a manual "self-survey" at any point by activating the recalibrate function on the guidance system control screen.

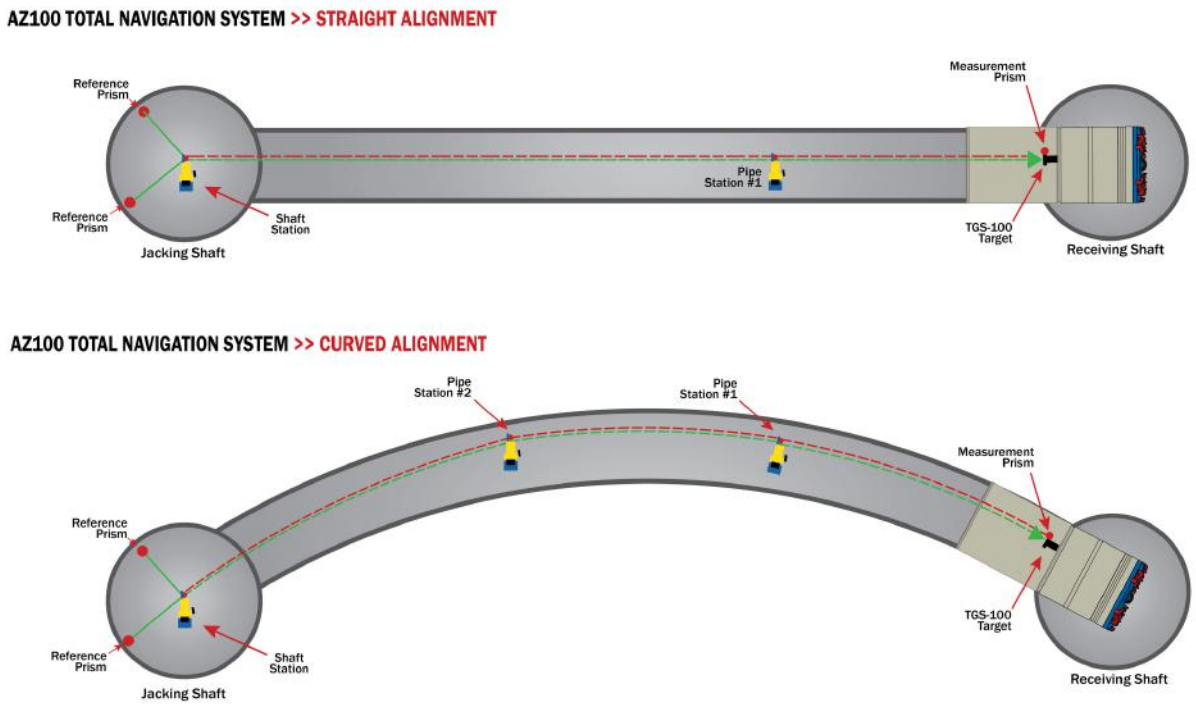
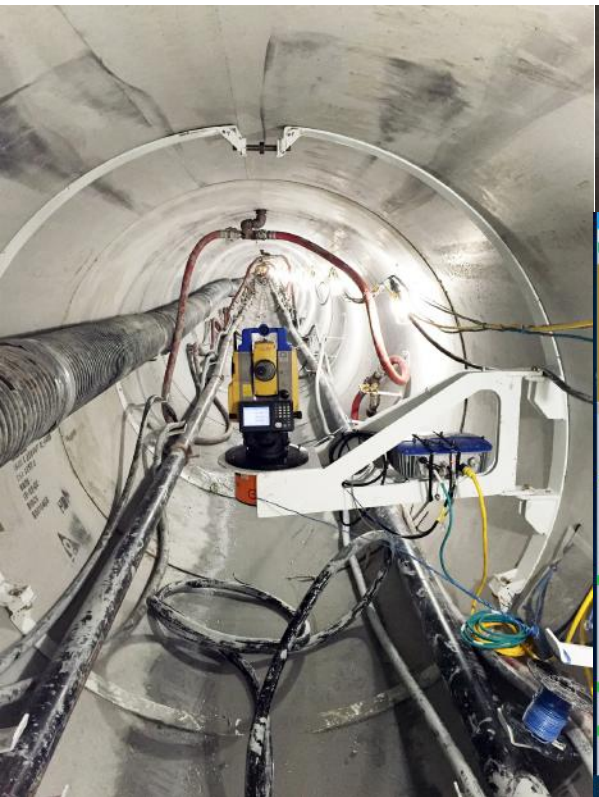
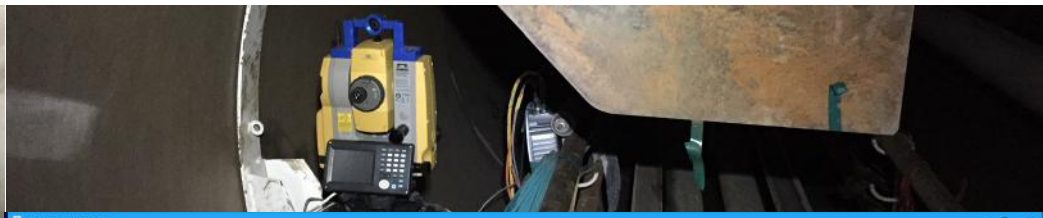


Figure 4.12: General Arrangement of Akkerman AZ-100 Total Guidance System Set-up.





Section 4.7: Akkerman Automatic Lube and Jacking Can

The Akkerman SL74P MTBM is available with an integrated propulsion & primary lubrication system located directly behind the MTBM shield. Jacking cans provides up to 510-ton approx. of thrust with the use of six (6) hydraulic cylinders.

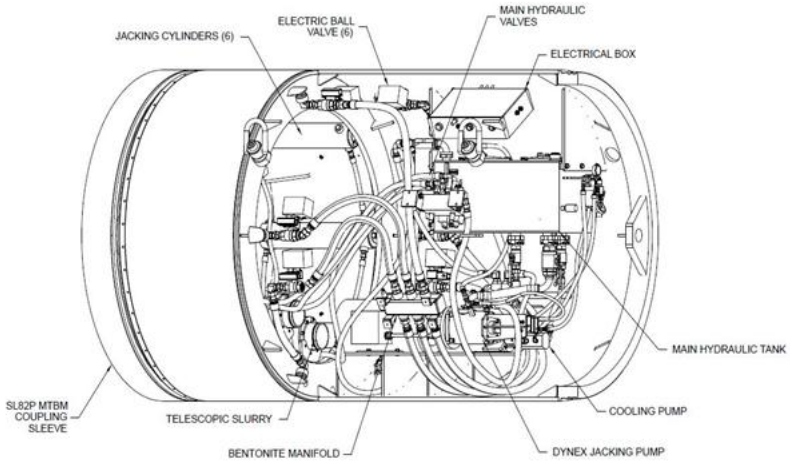


Figure 4.13: General Arrangement of Akkerman Lube and Jacking Can.

Launched directly behind the MTBM during the launch sequence, the lube and jacking can allows the operator to have full control all thrust forces being applied directly at the face of the MTBM. The on-board powerpack allows multiple remote intermediate jacking stations to be remotely controlled from inside the tunnel versus running multiple high-pressure hydraulic service lines from the launch portal.
Benefits:

- On-board hydraulic powerpack with remote control.
- Ability to operate additional IJS stations from powerpack.
- Monitor actual thrust pressure applied to the MTBM face.

Integrated with the jacking can and launched directly behind the MTBM, this additional lubrication system acts as the primary Automatic Bentonite Injection System (ABIS) for the installation. The injection ports are all controlled by electric ball valves which can be operated manualled through the MCC or sequenced automatically by adjusting volume and pressure. This lube system ensures that proper lubrication is being applied to all points around the diameter when it is required.
Benefits:

- Metered and controlled lubrication flow. (pressure/volume)
- Greatly reduces jacking forces required on a project.
- Automatic programming with data logging.

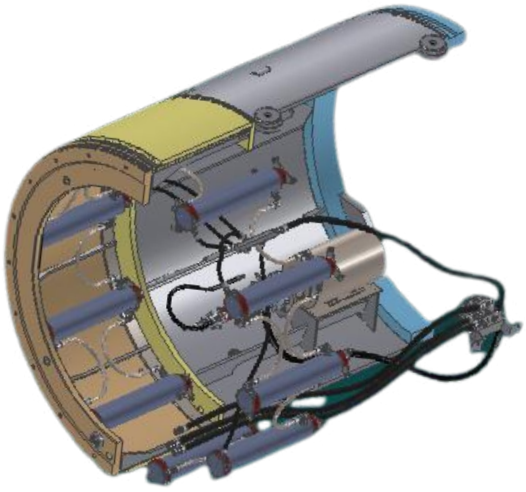


Figure 4.14: General CAD view of Akkerman Lube and Jacking Can.

Section 4.8: Akkerman Automatic Bentonite Injection System

The Akkerman Bentonite Injection System (ABIS) is designed to maintain bentonite suspension between the overcut and the outside diameter of the pipe. In conjunction with a lube and jacking can, the ABIS system will simply replenish lubrication that has been washed-out or absorbed. While this ABIS system can act alone as it's an independent unit, the combination of the lube & jacking can with the ABIS system allows the contractor to monitor injection at the MTBM, while independently monitor supplemental lubrition throughout the tunnel string as necessary.

The Akkerman ABIS system includes a series of master tunnel control stations. Each master tunnel control station contains a tunnel light and can operate three (3) tunnel bentonite injection control valves as well as an IJS station. Each tunnel bentonite injection control valve will then feed bentonite into a series of injection ports that are precast or drilled into the jacking pipe.

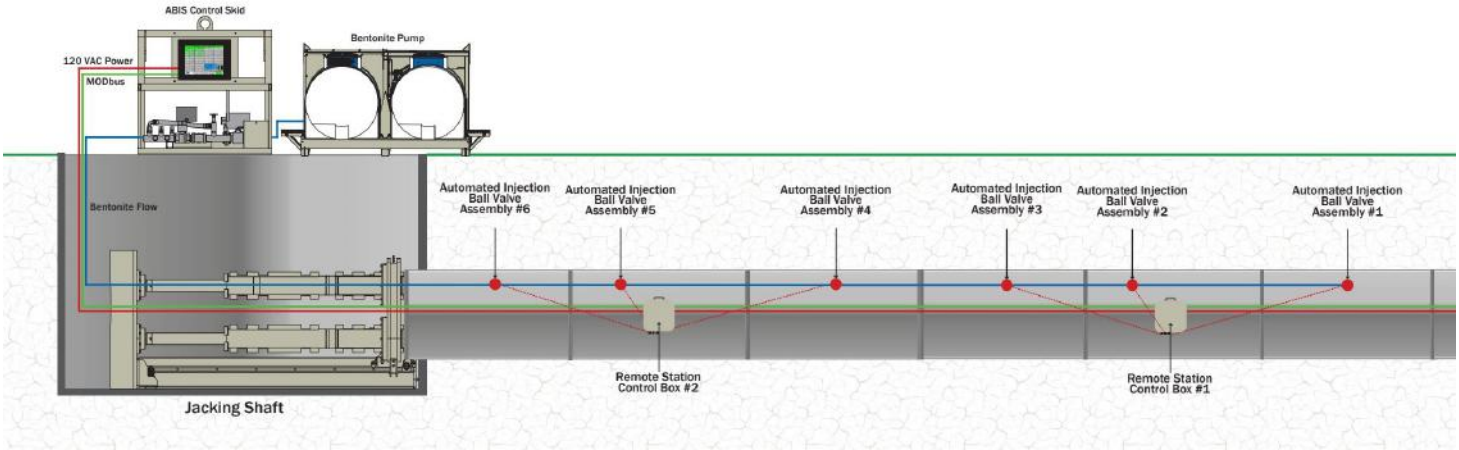
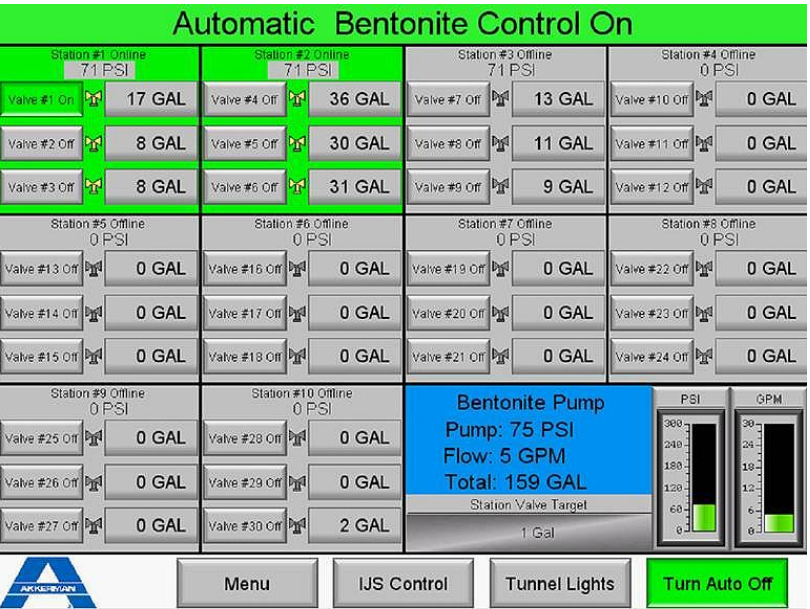
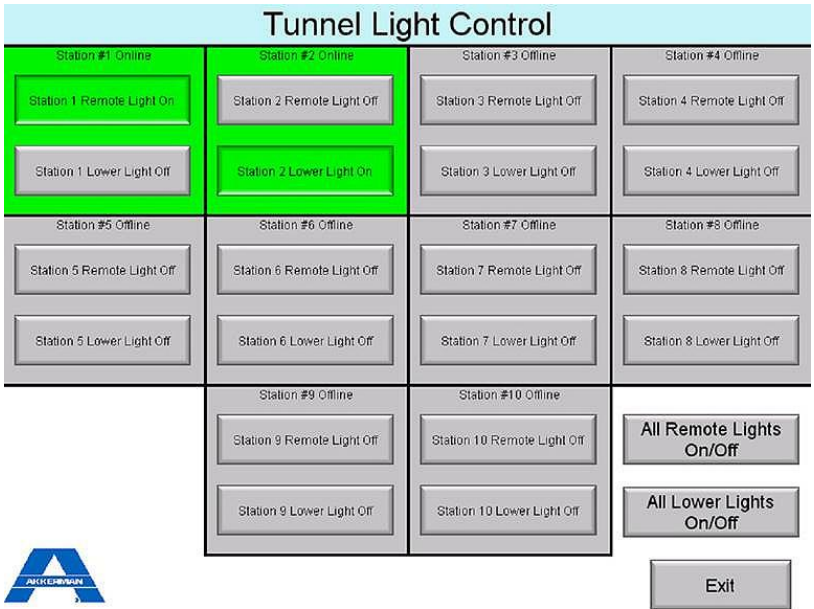


Figure 4.15: General Arrangement of Automatic Bentonite System

The Akkerman ABIS is considered as a "stand-alone" system that will be installed into the control room of the MCC container and controlled by the MTBM operator. The system will have feedback monitoring and display via a 10.4in touch screen monitor for bentonite flow and pressure.

The Akkerman ABIS systems come standard in 1000-ft & 2000-ft packages. Custom and extended distances can be designed based on a project requirement. Each system integrates directly into Akkerman microtunneling systems and will be fully data-logged. Remote-use is also available for alternative brands.





Section 4.9: Sealed Intermediate Jacking Station

Intermediate Jacking Stations (IJS) require sealed joints for microtunneling applications. The pipe manufacturer will be required to manufacturer a special lead and lag pipe specifically with dynamic seal rings specifically for this applications. Akkerman will work provide technical information to ensure fitment with outside housings per our recommendations. See below for a general arrangment drawing of a sealed IJS for microtunneling.

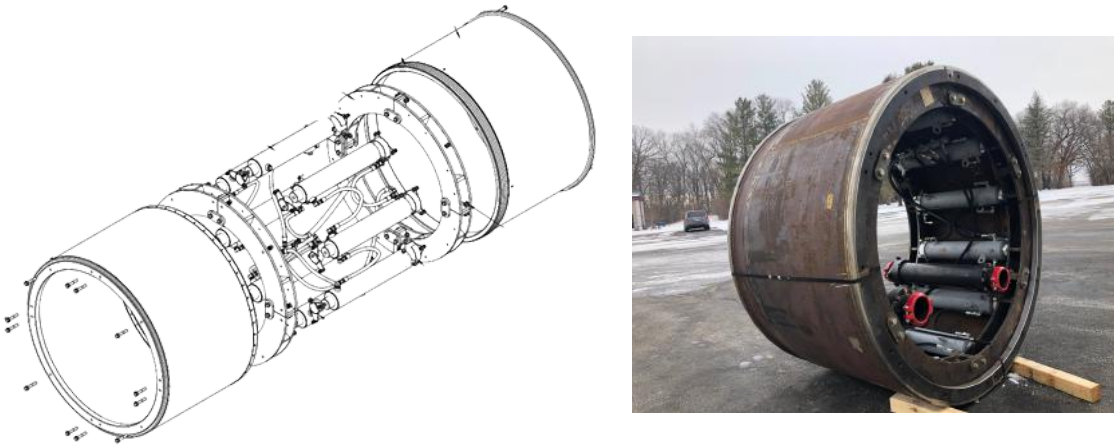


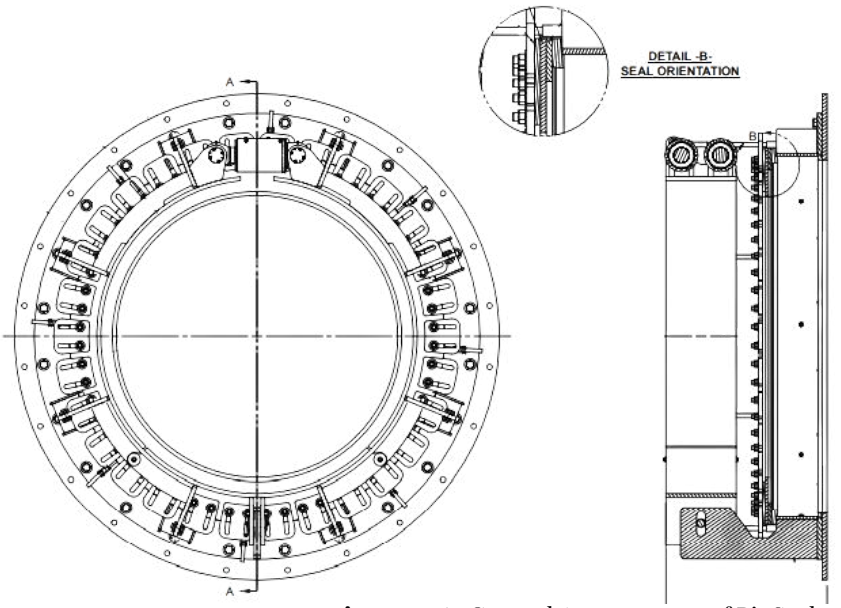
Figure 4.15: General Arrangement of Sealed IJS Station for Microtunneling

Section 4.10: Shaft Seals & Pipe Clamps

Akkerman manufactures project-specific shaft seals and pipe clamps to complement our MTBM system on projects presenting high-water head.

Shaft Seals contain a hydraulically adjustable pipe brake to control the pushback movement of the pipe string. Redundant rubber seals are efficiently spaced around the shaft seal to deter inflow into the shaft. Shaft seals are positioned on the entrance and exit shaft walls at project line and grade.

A Pipe Clamp, sometimes called a pipe brake, is used to contend with buoyant forces when installing an MTBM within a water body or on any projects with high water pressures. The pipe clamp's adjustable chocker plates ensure that the Shaft Seal rubber does not invert with a high axial holding capacity.



Nominal Rating

- Seal rated for 15-psi hydrostatic psi.
- Two primary rubber seals w/ backup
- Pipe Clamp Holding Force: 150-ton
- Tension Cable Rating: 235-ton
- Anticipated pushback: (80in) 35-ton

Figure 4.16: General Arrangement of Pit Seal with Pipe Clamp.

Section 4.10: MTBM Jacking Frame

The Akkerman Model MT875K will be utilized for this project. The MT875K will produce up to 800ton @ 8500psi for pipe diameters up to 75in OD (1900mm). The MTBM operator controls the jacking frame movement through the MCC control console.In-shaft personnel are required to latch the thrust block into position along the cylinder barrels. An in-shaft hydraulic winch will be supplied along with a High Flow Return Valve to expedite the retraction of the jacking frame and minimize pipe intervals.

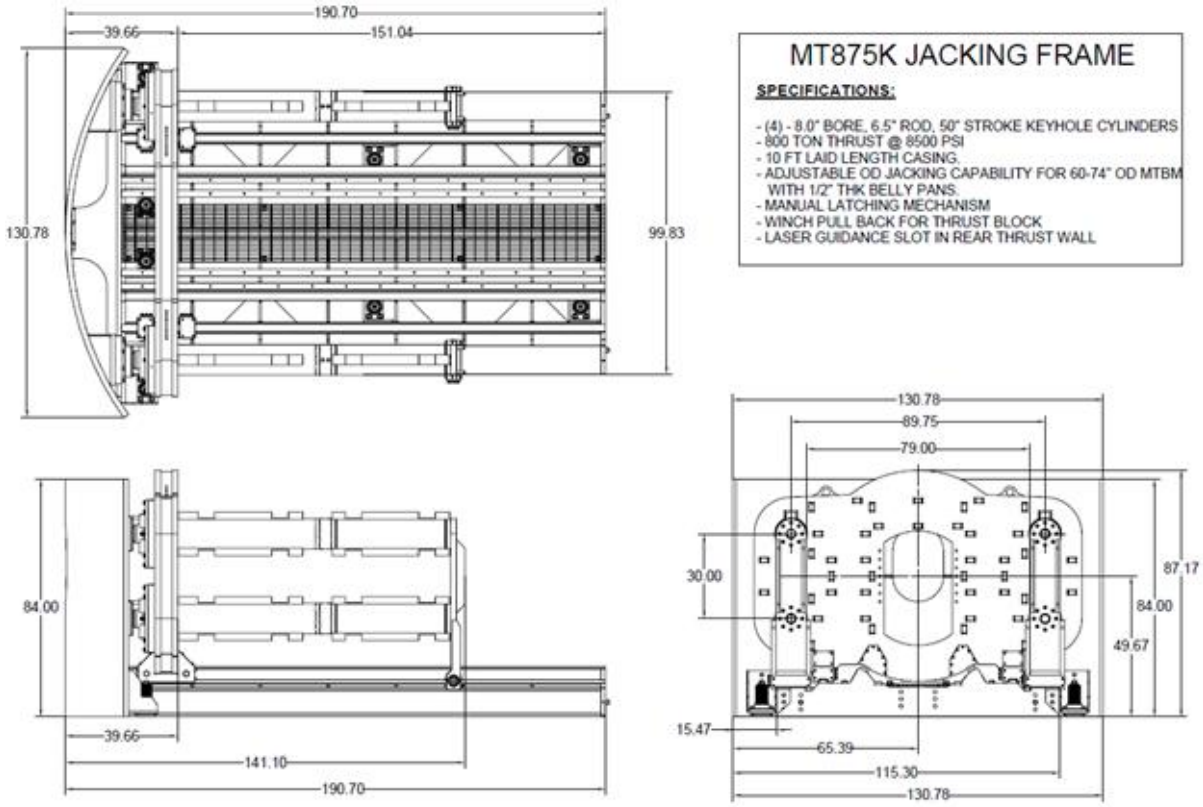
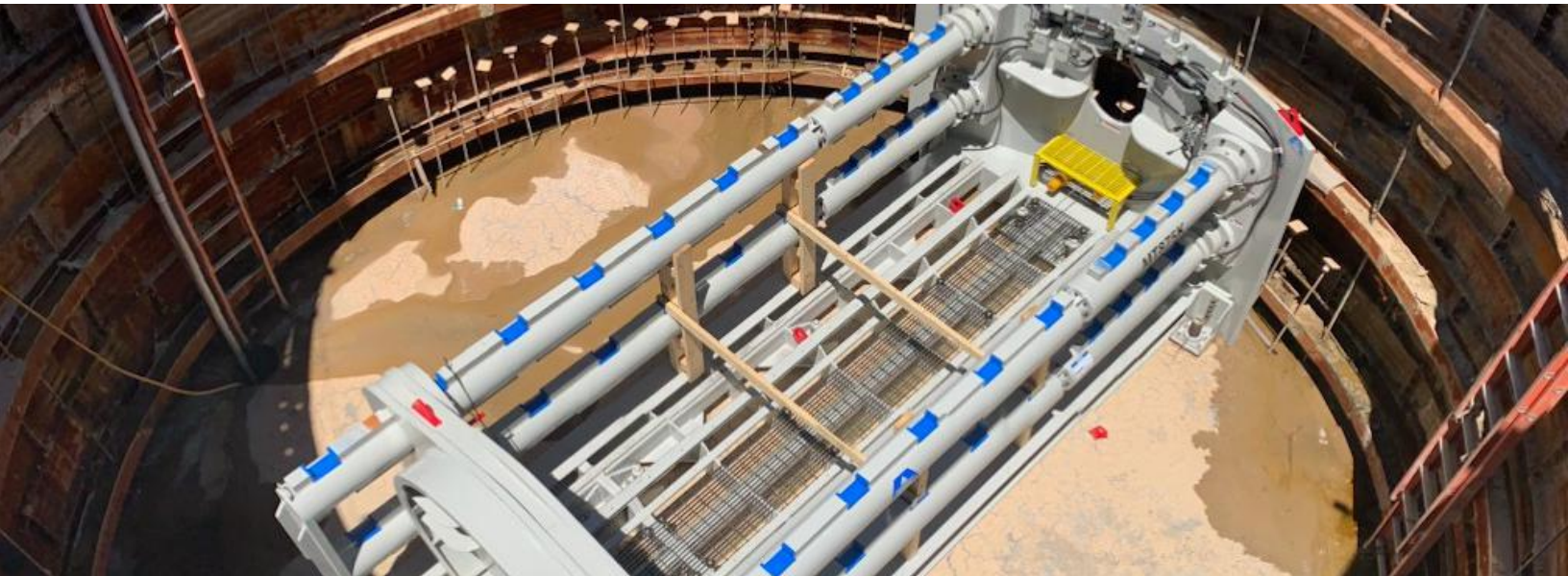
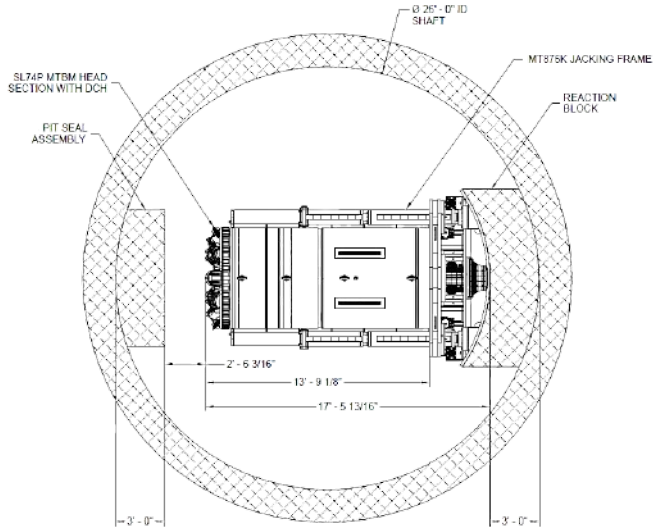


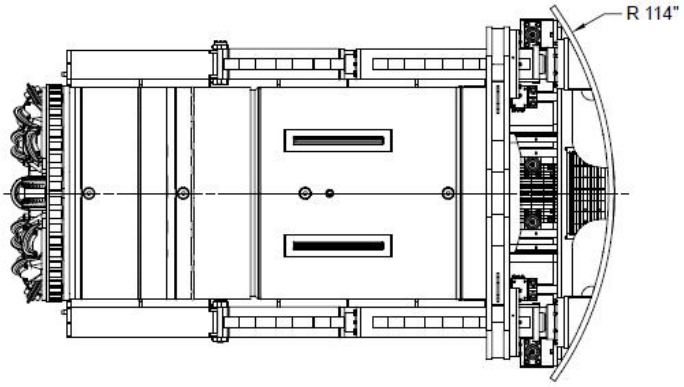
Figure 4.17: General Arrangement of Akkerman Model MT875K Jacking Frame.

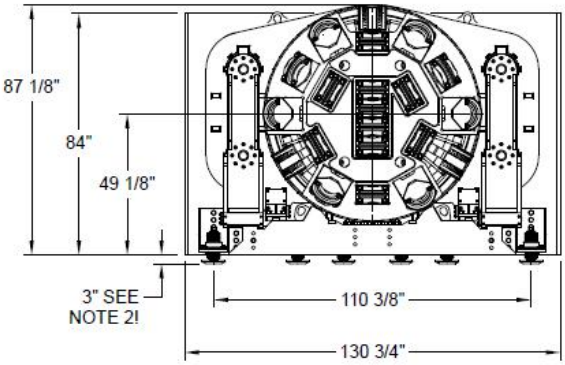
The MT875K jacking frame is designed to accommodate 10ft long pipe in the standard configuration.Extension kits will be supplied to accommodate longer 20ft pipe joints. Final shaft size and configuration are to be determined by the trenchless contractor and are subject to many factors such as pipe length, pit construction, design, etc.

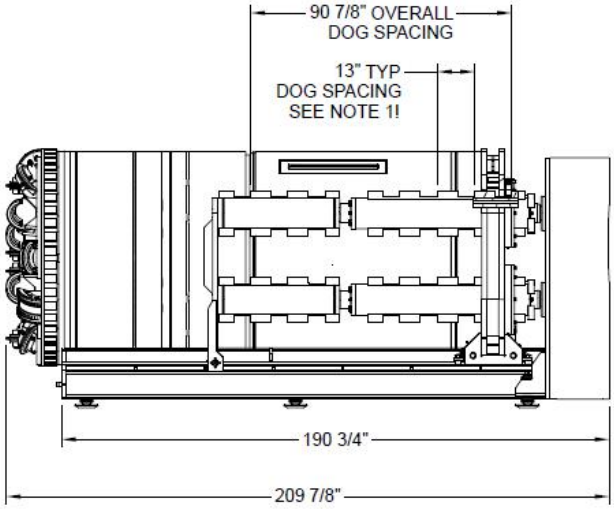


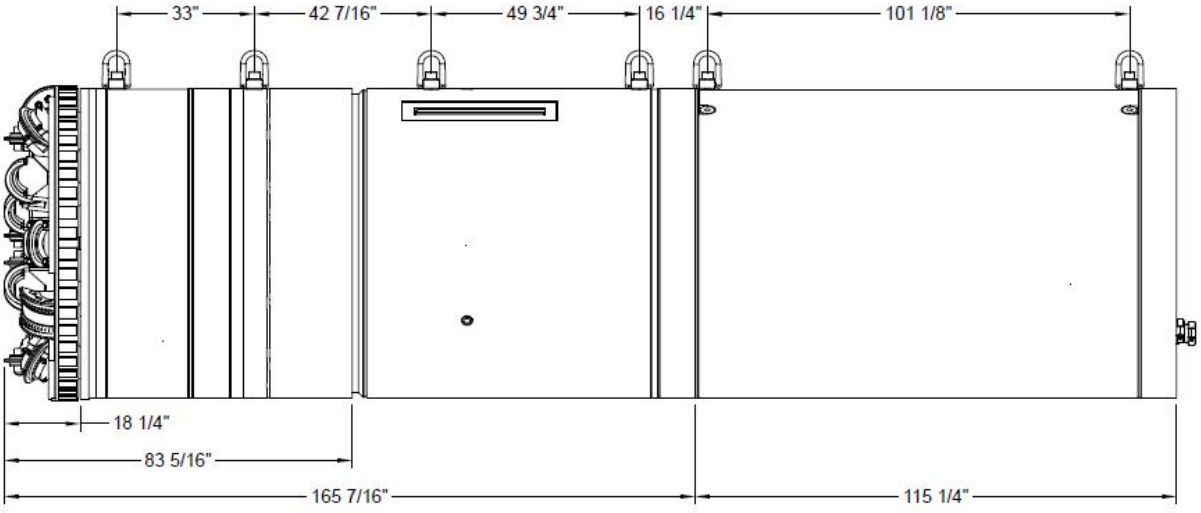
Akkerman MTBM System Layout - MT875K & SL74P









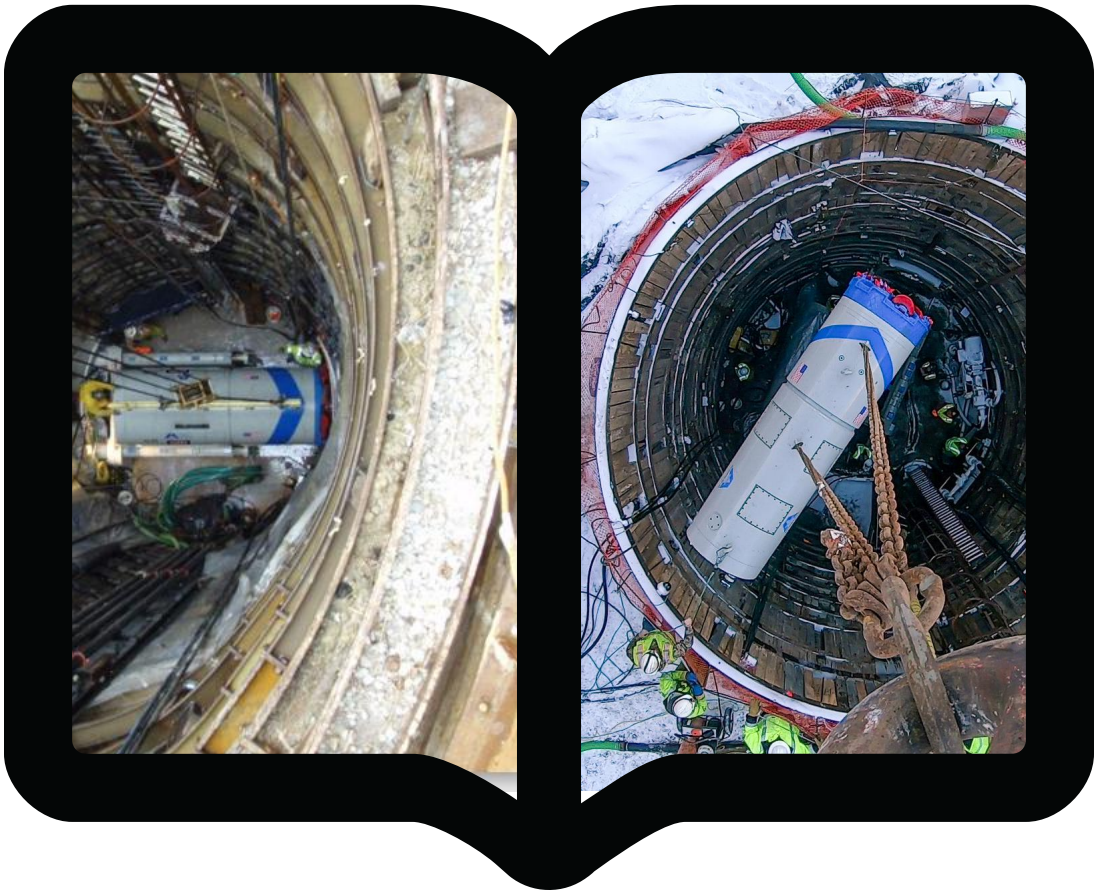


Section 4.11: Akkerman Microtunnel Control Container

The Akkerman MCC is the central nervous system of the microtunneling operation and the location of the primary electrical, communication, and operation for the jobsite. Akkerman MCC(s) have evolved to include remote monitoring, external displays, and several customer modifications.

See **Appendix A** for minimum specifications.

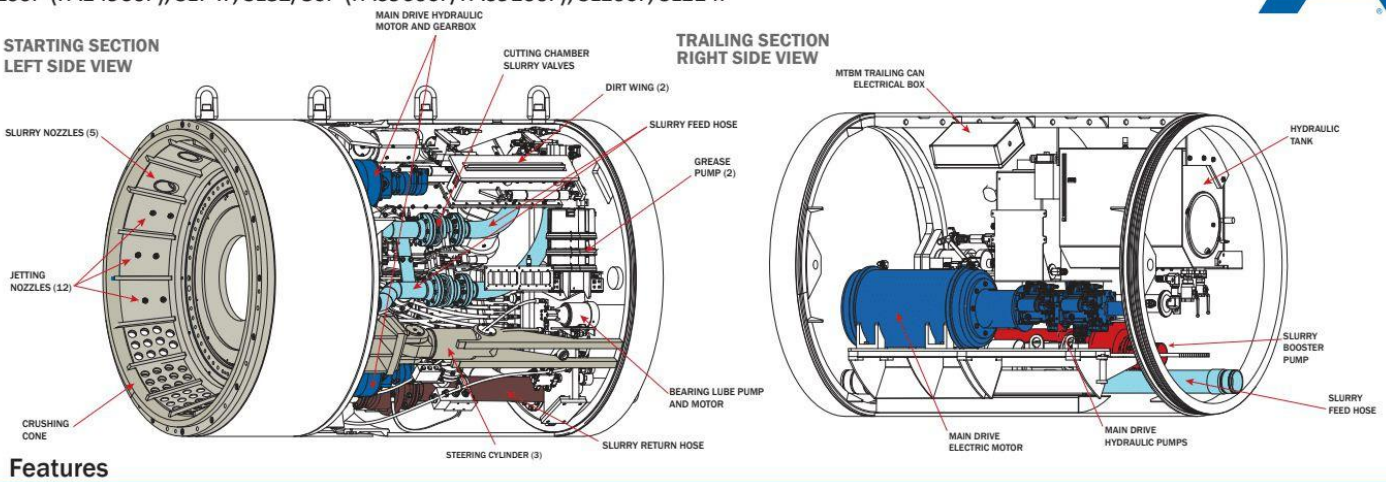
Appendix A: Manufacturer's Literature



- **Operator's Manual available online:** www.akkerman.com/literature-and-manuals/manuals-specs/
- **Create personalized online user account and password.**
- **Download appropriate Operator's Manual and Part's Manual.**

MICROTUNNEL BORING MACHINE - PERIPHERY DRIVE

SL60P (FA14960F), SL74P, SL82/86P (FA09600F/FA09100F), SL100P, SL114P



Features

Face Access, Periphery Drive MTBMs are used on extended length, and curved 60-114-inch OD slurry microtunneling, and perform in a wide range of soil from sand to rock in high a ground water table

Cutter heads feature back-loaded tooling mounts to replace cutter head tooling

On-board main drive electric motor over hydraulic pumps for cutter head drive with low, medium and high torque modes for accurate control

Slurry earth pressure balanced cutting chamber with slurry spoil removal

Slurry modulating valves regulate flow to slurry chamber or crushing chamber

High pressure jetting nozzles in the cutting chamber assist with soil conveyance and prevent clogging

Crushing cone chamber features carbide hard-facing for durability

Equipped with torque wing assembly to minimize potential MTBM roll

Three-point steering control system

Active target system relays MTBM (X) and (Y) coordinates, roll in degrees and anticipated position in 10-ft.

On-board hydraulic pump for steering, system flow, slurry adjustments and torque wing functions

Interior camera for viewing maintenance needs and guidance system's passive target

Audio system microphone for live, one-way audio monitoring by the operator

Gas detector system monitors combustible gas levels

Contains submersible pump with automated float switch to remove excess water

Increase kits are available to accommodate larger diameter pipe

Can be configured with mixed-ground, soft ground dual -gage, rock or project specific cutter head

SL82P, SL86P, SL100P and SL114P MTBMs can be configured for use with a compressed air lock package

Specifications

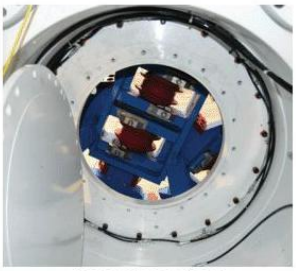
SPECIFICATIONS	SL60P	SL74P	SL82P/SL86P	SL100P	SL114P
Outside Diameter/ Max. Pipe OD	60-in (1,524 mm)	74-in (1,880 mm)	82-in (2,083 mm) 86-in (2,184 mm)	100-in (2,540 mm)	114-in (2,896 mm)
Starting Section Length/ Weight*	11.5-ft/44,000 lbs (3.5 m/19,958 kg)	11.5-ft/48,000 lbs (3.5 m/21,772 kg)	11.5-ft/50,000-52,000 lbs (3.5 m/22,680-23,587 kg)	11.5-ft/60,000 lbs (3.5 m/27,215 kg)	11.5-ft/69,000 lbs (3.5 m/31,298 kg)
Trailing Section Length/ Weight*	10-ft/20,000 lbs (3 m/9,071 kg)	10-ft/24,000 lbs (3 m/10,886 kg)	10-ft/24,000-25,000 lbs (3 m/10,866-11,340 kg)	10-ft/29,000 lbs (3 m/13,154 kg)	10-ft/33,200 lbs (3 m/15,059 kg)
Lubrication Jacking Section Length/Weight*	10-ft/15,200 lbs (3 m/6,894 kg)	10-ft/18,400 lbs (3 m/8,346 kg)	10-ft/23,000 lbs (3 m/10,433 kg)	10-ft/23,200 lbs (3 m/10,523 kg)	10-ft/26,600 lbs (3 m/12,066 kg)
Overcut			1.5-2 in (38-51 mm)		
Drive Type			Hydrostatic Drive Motor		
Drive Motor	250 HP (186 kW), Water-Cooled, Electric Motor	400 HP (298 kW), Water-Cooled, Electric Motor	400 HP (298 kW), Water-Cooled, Electric Motor	500 HP (373 kW), Water-Cooled, Electric Motor	500 HP (373 kW), Water-Cooled, Electric Motor
Cutter Head Drive Speed (in HSLT) Max. Max. Torque (in LSHT) Rotational Speed Drive Motors	0-11 rpm, 185,000 ft-lbs (250,827 Nm) Continuously variable CW/CCW 3, 2-Speed, 480cc, 29.3-in^3	0-9 rpm, 300,000 ft-lbs (406,746 Nm) Continuously variable CW/CCW 4, 2-Speed, 480cc, 29.3-in^3	0-9 rpm, 350,000-404,000 ft-lbs (474,537-547,751 Nm) Continuously variable CW/CCW 4, 2-Speed, 480cc, 29.3-in^3	0-8 rpm, 500,000 ft-lbs (677,910 Nm) Continuously variable CW/CCW 4, 2-Speed, 480cc, 29.3-in^3	0-7 rpm, 600,000 ft-lbs (813,492 Nm) Continuously variable CW/CCW 4, 2-Speed, 480cc, 29.3-in^3
Safety Circuit			E-Stop Button Control		
Steering System Articulation Steering Control System No. of cylinders Cylinder stroke Pressure Bore	 3 Degrees 3 Point 3 1.75-in (44 mm) 7,250 psi (50 mPa) 5.5-in (140 mm)	 3 Degrees 3 Point 3 1.75-in (44 mm) 7,250 psi (50 mPa) 5.5-in (140 mm)	 3 Degrees 3 Point 3 4-in (102 mm) 7,250 psi (50 mPa) 7-in (178 mm)	 3 Degrees 3 Point 3 4-in (102 mm) 7,250 psi (50 mPa) 7-in (178 mm)	 3 Degrees 3 Point 3 4-in (102 mm) 7,250 psi (50 mPa) 7-in (178 mm)

Specifications

SPECIFICATIONS	SL60P	SL74P	SL82P/SL86P	SL100P	SL114P
Gas Detector	Methane Gas	Methane Gas	Methane Gas	Methane Gas	Methane Gas
Camera	Passive target, MTBM maintenance	Passive target, MTBM maintenance	Passive target, MTBM maintenance	Passive target, MTBM maintenance	Passive target, MTBM maintenance
Control System	Akkerman Gen. 3 with Ethernet	Akkerman Gen. 3 with Ethernet	Akkerman Gen. 3 with Ethernet	Akkerman Gen. 3 with Ethernet	Akkerman Gen. 3 with Ethernet
Auxiliary Hydraulic Power Pack					
Motor	2 HP, 480V, 3-phase	2 HP, 480V, 3-phase	2 HP, 480V, 3-phase	2 HP, 480V, 3-phase	2 HP, 480V, 3-phase
System flow	0.5 gpm	0.5 gpm	0.5 gpm	0.5 gpm	0.5 gpm
Steering system pressure	7,200 psi (50 mPa) max.	7,200 psi (50 mPa) max.	7,250 psi (50 mPa) max.	7,200 psi (50 mPa) max.	7,200 psi (50 mPa) max.
Slurry valves & torque wing pressure	3,500 psi (24 mPa) max.	3,500 psi (24 mPa) max.	3,500 psi (24 mPa) max.	3,500 psi (24 mPa) max.	3,500 psi (24 mPa) max.
Filtration	10 micron	10 micron	10 micron	10 micron	10 micron
Main Drive Hydraulic System					
Motor	250 HP (186 kW),	400 HP (298 kW)	400 HP (298 kW)	500 HP (373 kW)	500 HP (373 kW)
System flow	0-150 gpm (0-568 L/min)	0-150 gpm (0-568 L/min)	0-150 gpm (0-568 L/min)	0-150 gpm (0-568 L/min)	0-150 gpm (0-568 L/min)
Hydrostatic pumps	1, 210cc, 12.8-in^3	2, 165cc, 10.1-in^3	2, 165cc, 10.1-in^3	2, 165cc, 10.1-in^3	2, 165cc, 10.1-in^3
Electrical					
Power supply to MTBM	4160V	4160V	4160V	4160V	4160V
Tunnel cable	6AWG/SHD-GC 5 kv	6AWG/SHD-GC 5 kv	6AWG/SHD-GC 5 kv	6AWG/SHD-GC 5 kv	6AWG/SHD-GC 5 kv
Submersible Pump					
Motor	2 HP, 480V, 3-phase	2 HP, 480V, 3-phase	2 HP, 480V, 3-phase	2 HP, 480V, 3-phase	2 HP, 480V, 3-phase
System Flow	20 gpm max. @ 200-ft head (87 psi)	20 gpm max. @ 200-ft head (87 psi)	20 gpm max. @ 200-ft head (87 psi)	20 gpm max. @ 200-ft head (87 psi)	20 gpm max. @ 200-ft head (87 psi)
Jetting Nozzles					
No. of nozzles	0-8	0-12	0-12	0-12	0-12
Recommended Pressure	2,300 psi (15.9 mPa)	2,300 psi (15.9 mPa)	2,300 psi (15.9 mPa)	2,300 psi (15.9 mPa)	2,300 psi (15.9 mPa)
Accumulator					
Hydraulic charge	3,500 psi (24 mPa)	3,500 psi (24 mPa)	3,500 psi (24 mPa)	3,500 psi (24 mPa)	3,500 psi (24 mPa)
Nitrogen charge	2,500 psi (17 mPa)	2,500 psi (17 mPa)	2,500 psi (17 mPa)	2,500 psi (17 mPa)	2,500 psi (17 mPa)
Slurry System					
Feed/Return	4-in (102 mm)	6-in (152 mm)	6-in (152 mm)	6-in (152 mm)	6-in (152 mm)
Cutting Chamber	3-in (76 mm)	4-in (102 mm)	4-in (102 mm)	4-in (102 mm)	4-in (102 mm)
Bypass	automatic activation on power loss	automatic activation on power loss	automatic activation on power loss	automatic activation on power loss	automatic activation on power loss

*Actual weights may vary based on specific configuration.

Akkerman reserves the right to improve its products without notice or obligation.


Face access door

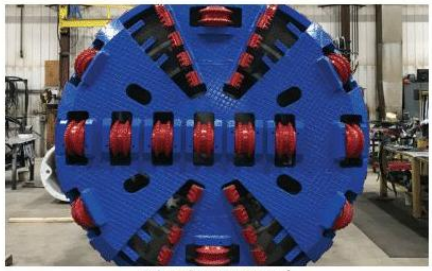

Trailing section back view


Main drive hydraulic motors and gear boxes (4)


Back view of Starting, Trailing and Jacking and Lubrication Can

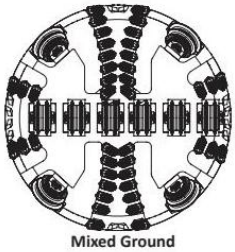

Main drive 250-500 HP electric motor and hydraulic pumps

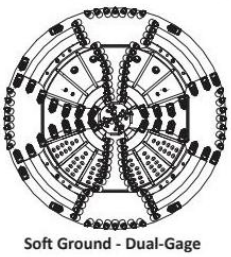

MTBM Operator at Control Console

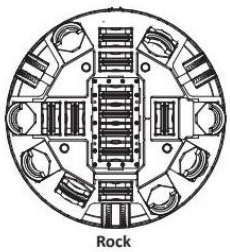

Disc Cutter Head


MTBM Crushing cone

Cutter Head Options - Configured to suit project demands


Mixed Ground


Soft Ground - Dual-Gage


Rock

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AZ100 TOTAL GUIDANCE SYSTEM

Part Nos. F0251-158 TGS 100 Target, FA09504F Shaft Station Assembly, FA09503F Pipe Station Assembly, F0251-707H License Key

Azimuth Tunneling Navigation System with Self-Leveling Station Units for Microtunneling, Pipe Jacking and Tunneling Operations

Maintains Location Measurement Connection Throughout the Alignment Without the Need for Continuous Manual Surveying

Pipe Station center mounted

Shaft Station positioned behind the jacking frame thrust block in the launch shaft

Combined station units communicate EDM to the operator

FEATURES

Assembly includes: TGS 100 Active Target, Shaft Station Assembly, Pipe Station Assembly, prism mount with adjustable pipe ring, storage container, and license key

For extended and curved tunneling, pipe jacking and microtunneling applications

Initial tunnel survey for tunnel and ends points is the only survey required

Comprised of individual station units with motorized/robotic theodolites on self-leveling tribrachs that maintain a location measurement connection throughout the alignment without the need for continuous manual surveying

TGS 100 Active Target is axially mounted behind the machine's articulation cylinders at line and grade, and registers the position and angles of incidence of the red laser emitted from the guidance system

Shaft Station in positioned in the launch shaft, acts much like a traditional pipe laser

The first Pipe Station is added at 300-ft., and additional pipe stations are added as required along the alignment to maintain a location measurement connection between all stations, pipe station with self-leveling tribrach is mounted to adjustable pipe ring with hinged blocker plate to prevent false readings

Stationary measurement prisms located around the jacking shaft provide known reference points for guidance system location and azimuth

1,000-3,500-ft. range of distance between stations can be achieved, dependent upon prism size, tunnel diameter and atmospherics

Combined stations communicate a continuous electronic distance measurement to monitor exact machine X, Y and Z positioning, and real-time cutter head location with the proprietary AZ100 software program on the operator's control console

Shaft station power is derived from the control container/center, pipe stations are powered by the MBTM/TBM

AZ100 TGS surveys itself 3-4 times per 10-ft. of pipe during mining operations; location measurement takes less than one minute, survey interval is programmable

Operators are able to manually activate a location measurement from the control container to calibrate during pipe changes

Can be utilized as a stand alone guidance system for any tunneling, pipe jacking or microtunneling application regardless of equipment manufacturer

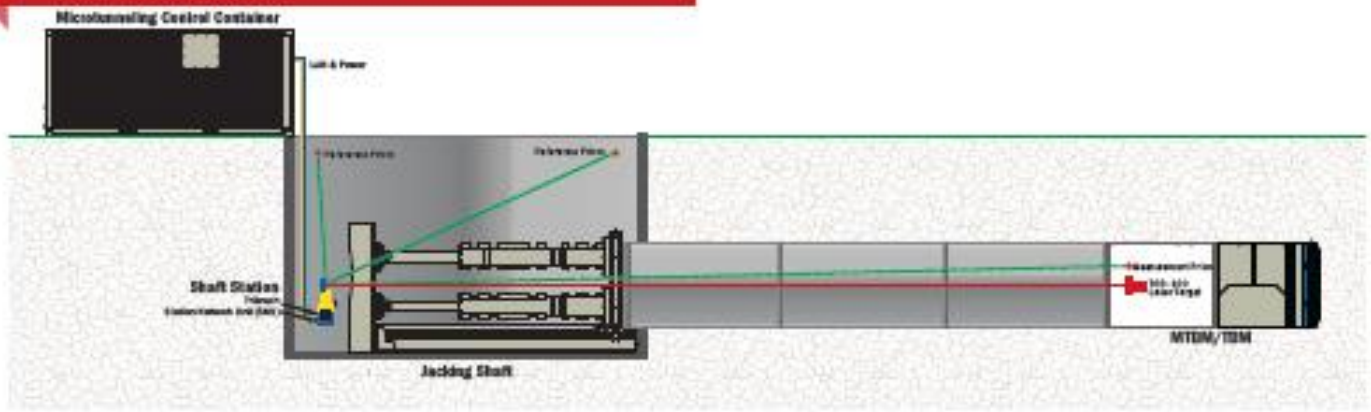
Data recording and reporting capabilities for customizable reporting at any mining interval

Control Container Screen with AZ100 TGS Control Module

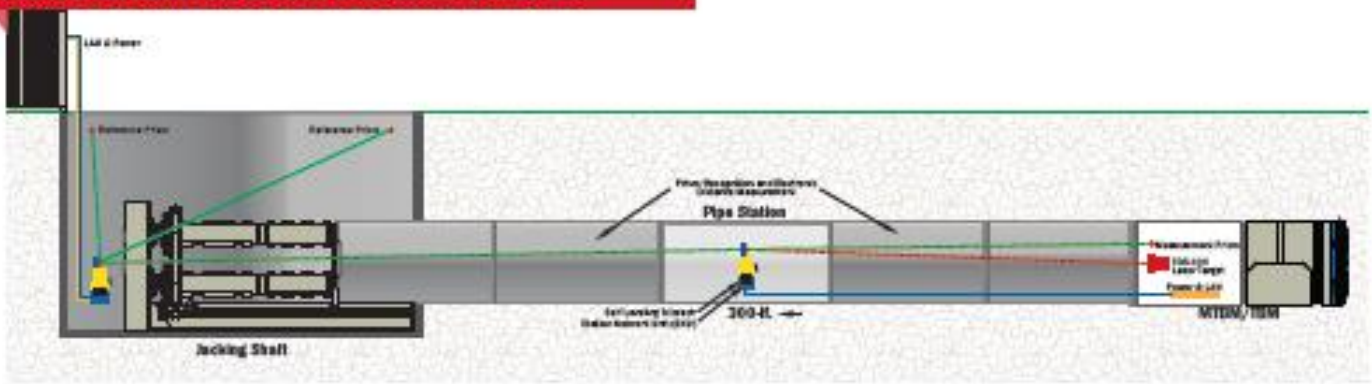
Pipe Station with adjustable pipe ring and hinged blocker plate to prevent false prism readings

TGS 100 target is axially mounted behind the MTBM's articulation cylinders at line and grade, registers the position and angles of incidence of the red laser

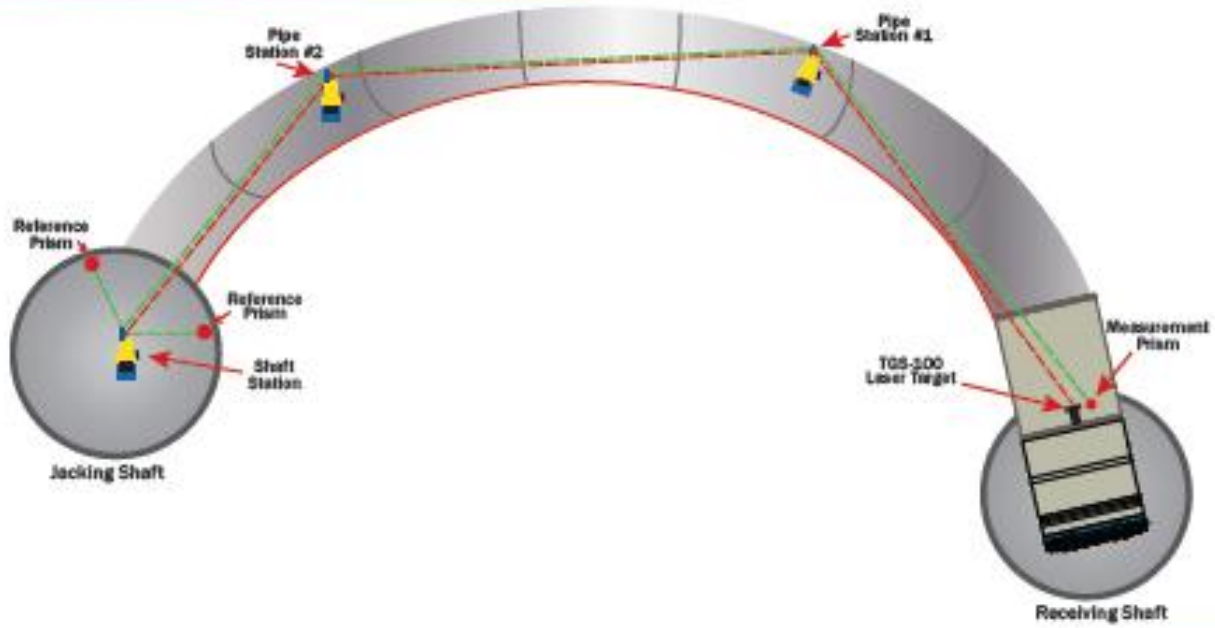
STAGE 1: LAUNCH MTBM/TBM WITH SHAFT STATION



STAGE 2: INSTALLATION OF THE PIPE STATION AT 300-LF.



INSTALLATION ON AN ALIGNMENT WITH A CURVE



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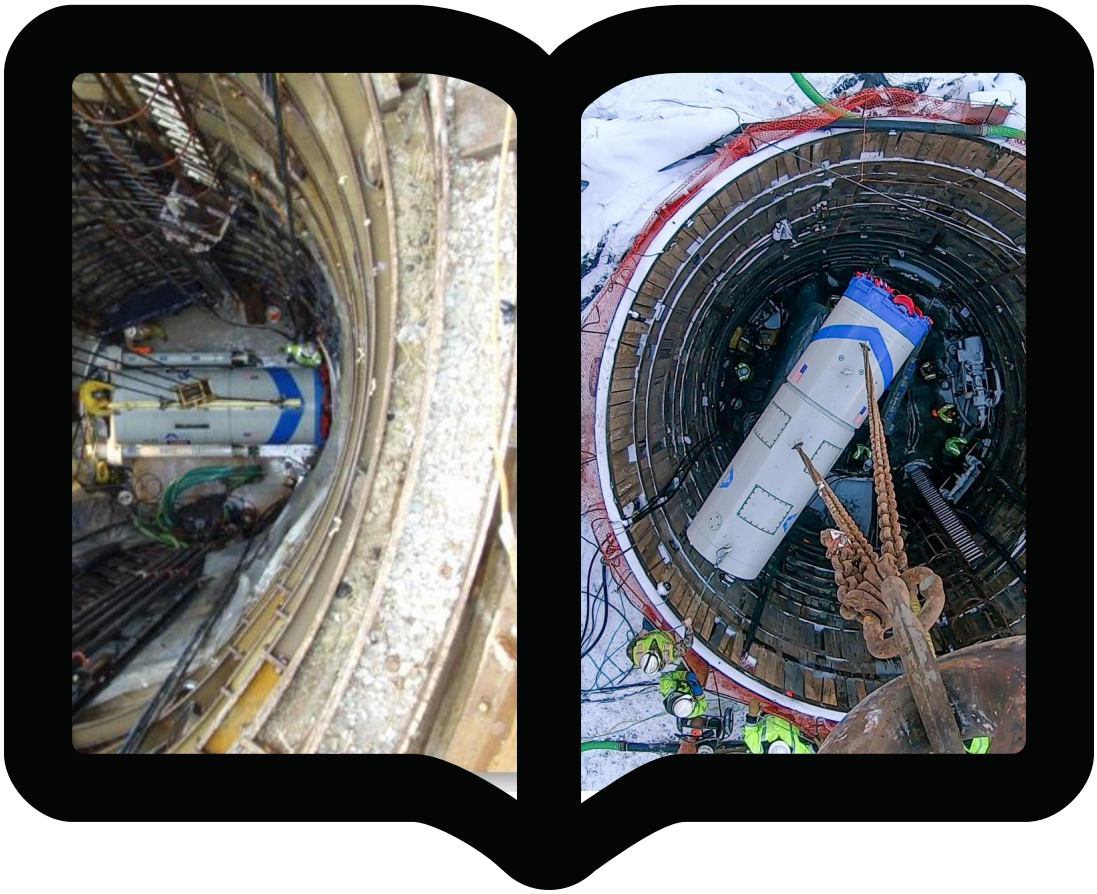
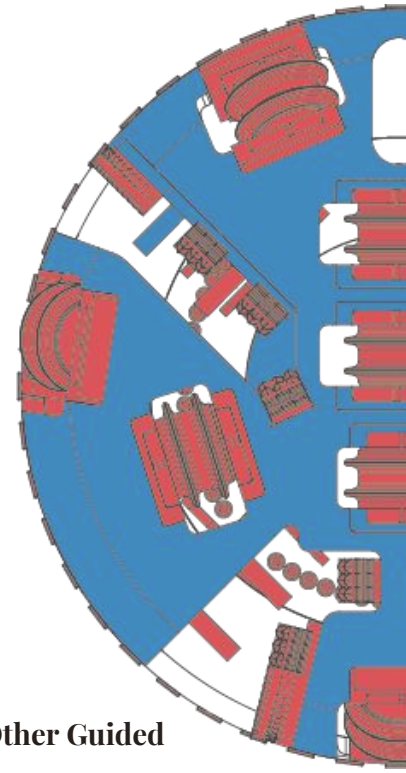
Appendix B: Trenchless Resources



Trenchless Industry

RESOURCES



Standards & Best Practices

Akkerman has been invested in advancement of the trenchless industry for over 50-years. We recommend the following resources that are available to further your trenchless knowledge and assets of the industry. These resources were referenced in the creation of this document.

ASCE Manual and Reports on Engineering Practice No. 133. Pilot Tube and Other Guided Boring Methods. 2017

- This abstract was prepared by a professional task commitee and covers the design and installation of utility pipelines of various types of pilot tube applications under roads, railroads, constructed and natural structures, and other surface obstacles.

The National Utility Contractor's Association. Trenchless Construction and New Installation Methods - 5th Edition. 2022

- This manual was prepared by a commitee of trenchless professionals selected from all aspects of the project phase including owners, engineers, contractors, manufacturers, attorneys, and more. This manual covers a wide variety of new construction trenchless installations.

American Society of Civil Engineers (ASCE/CI 36-15). Standard Design and Construction Guidelines for Microtunneling. 2015

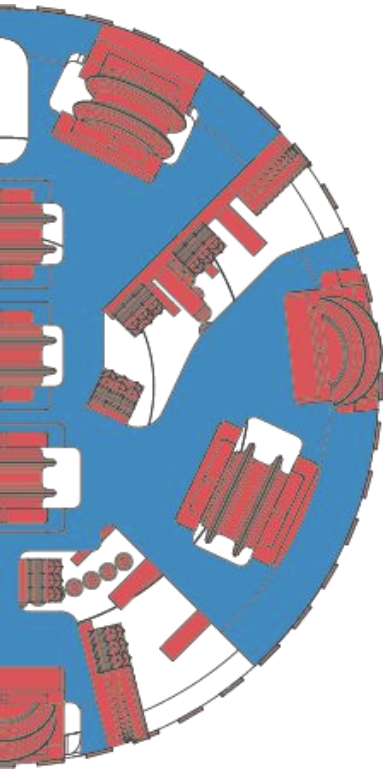
- This standard guideline covers planning, design, pipe materials, and construction of microtunneling.

Trenchless Australasia. A Comprehesive Guide to Microtunneling. 2015

- This document is a comprehensive review of both microtunneling and pipejacking.

Pipe Jacking Association. An Introduction to pipe jacking and microtunnelling. 2017

- This document is produced by the Pipe Jacking Association and provides valuable information regarding various pipe jacking techniques.



Trenchless Industry

ORGANIZATIONS

Dedicated to Trenchless Construction

Akkerman supports the advancement of the trenchless industry through education, membership, and advocacy to several industry organizations that are dedicated to furthering the growth of utility construction. These organizations can offer several benefits to owners, engineers, and contractors in the trenchless construction industry. Listed below are a few examples. Several opportunities exist on a local region or state level.

North American Society For Trenchless Technology - NASTT

- "NASTT is an engineering society of individuals, public organizations and private companies with strong beliefs in the practical, social and environmental benefits of trenchless technology."
- www.nastt.org

National Utility Contractors Association - NUCA

- "NUCA is the leading trade association working solely for the utility construction and excavation industry in the United States. NUCA's core purpose is to improve the operational proficiency and financial performance of its members."
- www.nuca.com

International Society of Trenchless Technology - ISTT

- "ISTT seeks to advance the science and practice of trenchless technology for the public benefit and to promote education, training, study and research in the said science and practice for the public benefit, and to publish the useful results of the same"
- www.istt.com

Underground Construction Association - UCA

- "UCA provides technical resources, professional development, and networking opportunities to engineers and related professionals in the tunneling and underground construction industries.
- www.smenet.org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