



TRENCHLESS EQUIPMENT SPECIALISTS

OPERATION MANUAL

**Tunnel Boring Machine
960B Wheel Machine**

BH S/N: 29800

Publication No. 050037A

Rev No. 061010

Akkerman Inc. 58256 266th Street Brownsdale, MN 55918
Phone: 507-567-2261 Fax: 507-567-2605 email: akk@akkerman.com

SERVICE • RELIABILITY • INNOVATION

Introduction

This operator's manual contains important safety, operation, and maintenance information for your Akkerman Tunnel Boring Machine (TBM). You must read and understand this manual, your haul unit operator's manual, gas detection system and jacking frame operation manual before you operate and maintain this equipment. Keep this manual with your TBM at all times. Additional copies of this manual may be purchased from the Akkerman Product Support Department.

The contractor is responsible for the overall safety program on the job site. Use this manual as a part of the safety program.

The use of second rate parts could affect the efficient performance of the Earth Pressure Balance Machine. ALWAYS use genuine Akkerman parts.

Understand safety signal words, DANGER, WARNING, CAUTION, SAFETY INSTRUCTIONS, and NOTICE. When you see these words in this manual or on safety decals mounted on your equipment, follow the safety message to avoid personal injury and/or property damage.

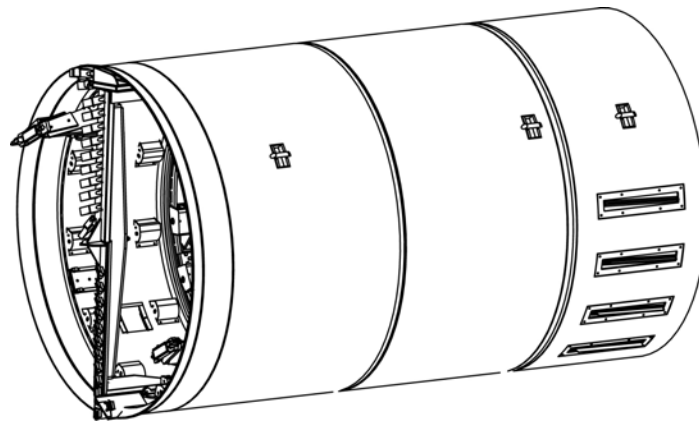
▲ DANGER Indicates an extremely hazardous situation which, if not avoided, WILL result in death or serious injury.

▲ WARNING Indicates a potentially hazardous situation which, if not avoided, COULD result in death or serious injury.

▲ CAUTION Indicates a potentially hazardous situation, which, if not avoided, MAY result in minor or moderate injury. It may also be used to alert against unsafe practices.

SAFETY INSTRUCTIONS Usually consists of individual messages stating procedures or actions that must be followed for the safe operation of a product.

NOTICE Identifies potential property damage and important installation, operator, or maintenance information.



**Akkerman
960B Tunnel Boring Machine**

Pipejacking and tunneling is a type of "trenchless technology" that utilize a tunnel boring machine (TBM). The TBM is advanced through the ground by hydraulic jacking cylinders on a jacking frame from the launch shaft. As the TBM is advanced, powerful hydraulic motors rotate an inner drum. A cutter head or closed face attachment is connected to the drum. As it rotates, the attachment teeth excavate the face and the spoils fall into the drum. Scoops and paddles in the drum dump the spoils onto a conveyor which carries the material to the dirt bucket. Once the dirt bucket is full, the dirt bucket is removed from the pipeline via a haul unit to the unloading area in the launch shaft where the dirt bucket is hoisted out of the shaft and unloaded.

If you find any errors with this manual or know of ways to improve procedures, please let us know. Mail your suggestions to: Akkerman Inc., ATTN: Technical Publications, 58256 266th Street, Brownsdale, MN 55918.

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

NOTES

Contents

Safety	1	Operation	5
Be Alert For Safety Information	1-1	Operating Guidelines	5-1
Read Operator's Manual	1-1	Checkout Equipment Prior To Start-Up	5-2
Wear Protective Clothing	1-1	Using Emergency Stop	5-3
Lockout Power Before Servicing	1-2	Gas Detector	5-3
Hydraulic Oil/Fluids Under Pressure	1-2	System Set-Up	5-3
Beware of Suspended Loads	1-2	TBM Hydraulic Dual &	
Keep Personnel Away From Moving Parts	1-3	Triple Supply Feed Setup	5-5
Unauthorized Welding	1-3	Start-Up Procedure	5-6
Regularly Clean/Inspect Equipment	1-3	Steering Adjustments	5-7
Inspect Electrical Connections	1-3	Using Dirt Wings	5-8
Practice Safe Maintenance	1-4	Inner Drum Rotation Control Adjustment	5-8
Avoid Pinch Points	1-4	Accessing Front of Machine	5-8
Stay Away From Crane	1-4	Daily Shut Down	5-8
Test Tunnel Ventilation	1-5		
Slippery When Wet	1-5	Transporting	6
Fire Prevention	1-5	Transporting Guidelines	6-1
No Smoking In Shaft Or Tunnel	1-6	Lifting Instructions	6-2
Keep Job Site Clean & Organized	1-6		
Keep Away From Belt Conveyor	1-6	Lubricants	7
Keep Away From Auger	1-6	Hydraulic Reservoir Lubricant	7-1
Keep Riders Off Haul Unit	1-7	Grease	7-1
Avoid Tunnel Wall Contact	1-7	Storing Lubricants	7-1
Watch For Conveyor	1-7		
Lockout Power Before Servicing Haul Unit	1-8	Periodic Maintenance	8
Avoid Laser Light Exposure	1-8	Lubrication and Maintenance Intervals	8-1
Recycle Waste	1-8	Before Performing Maintenance	8-1
		Lockout Power Before Servicing	8-1
		Hydraulic Oil/Fluids Under Pressure	8-2
		Avoid Pinch Points	8-2
		Unauthorized Welding	8-2
		Maintenance Chart	8-3
Safety Decals	2		
Tunnel Boring Machine - Left Side	2-1	Storage	9
Tunnel Boring Machine - Right Side	2-2	Preparing For Storage	9-1
Belt Conveyor	2-3	Removing From Storage	9-1
Laser Light Stand	2-4		
Terminology	3	Specifications	10
Tunnel Boring Machine	3-1	Identification Numbers	11
TBM Control Valve	3-3	Material Safety Data Sheets	12
Gauge Console	3-3	Warranty	13
Cutter Head Attachments	3-4		
Conveyor - Belt	3-5		
Laser Light Stand	3-6		
Pre-Start Inspection	4		

NOTES

Safety

BE ALERT FOR SAFETY INFORMATION

When you see this safety alert symbol on your equipment or in this manual, be alert to the possibility of personal injury or property damage.

Read all safety information.

Keep safety decals clean and in good condition.
Replace missing or damaged safety decals.



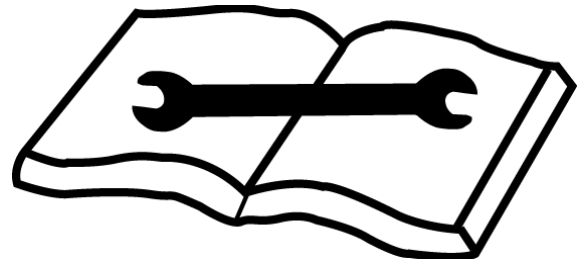
**ATTENTION!
BECOME ALERT!
YOUR SAFETY IS INVOLVED!**

READ OPERATOR'S MANUAL

⚠ WARNING Unsafe operation or maintenance can cause severe injury or death.

Read and understand the Operator's Manual before operating or servicing this equipment.

Any unauthorized modifications will void the warranty.



WEAR PROTECTIVE CLOTHING

Wear OSHA approved protective clothing, such as hard hat, gloves, safety goggles, earmuffs or ear plugs, face shield, and steel-toed boots, when operating and servicing this equipment.

Wear reasonably close fitting clothing and remove jewelry before working on or near this equipment. This will help prevent the danger of catching them in moving parts or controls.



LOCKOUT POWER BEFORE SERVICING

⚠ WARNING Failure to lockout power before servicing can cause severe personal injury or death.

This TBM contains high voltage electricity.

LOCKOUT main power supply before servicing. Electrical repairs must be performed only by a certified electrician.



HYDRAULIC OIL/FLUIDS UNDER PRESSURE

⚠ WARNING Escaping oil or other fluids under pressure can penetrate your skin causing serious injury or death.

Release all pressure before performing maintenance or repairs. Never weld near pressurized fluid lines.

DO NOT use your hands to check for leaks. When searching for leaks, use a piece of wood or cardboard.

Contact medical help immediately if any oil or fluid is injected into your skin. A serious infection or reaction can emerge without proper medical treatment.



BEWARE OF SUSPENDED LOADS

⚠ WARNING Suspended loads may fall and cause severe personal injury or death.

If a hydraulic hose from the boom of a crane or excavator breaks, the boom can fall instantly.

Do not enter area under or around a load.



KEEP PERSONNEL AWAY FROM MOVING PARTS

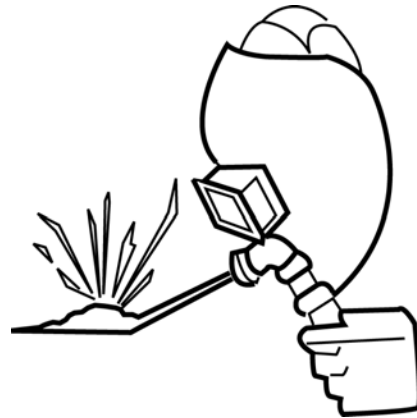
⚠ WARNING Crushing hazard.
Keep personnel away from inside of jacking frame.
Failure to do so could result in serious personal injury or death.



UNAUTHORIZED WELDING

⚠ WARNING Unauthorized welding can cause structural failure resulting in possible injury or death.

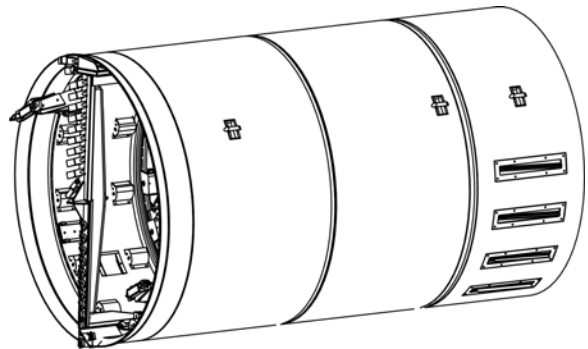
Do not weld on any structural member. Unauthorized welding or repair will void the warranty.



REGULARLY CLEAN AND INSPECT EQUIPMENT

Remove any grease, oil, or debris buildup to avoid potential injury or equipment damage.

Inspect equipment for damage. If damaged, repair or replace immediately.



INSPECT ELECTRICAL CONNECTIONS

⚠ WARNING Regularly inspect electrical connections to be sure they are secure. Failure to do so could cause an explosion if moisture enters an unsecured electrical connection.



PRACTICE SAFE MAINTENANCE

⚠ WARNING Unexpected equipment movement may cause serious personal injury.

LOCKOUT power before performing any maintenance.

Shut down equipment before making repairs, adjustments, or removing obstructions.

Only trained and qualified personnel should perform any maintenance or repairs.

Keep the area around the equipment clean and dry when performing maintenance.

Do not service the machine while it is in motion.

Replace worn or damaged parts. Remove grease, oil, or debris buildup.



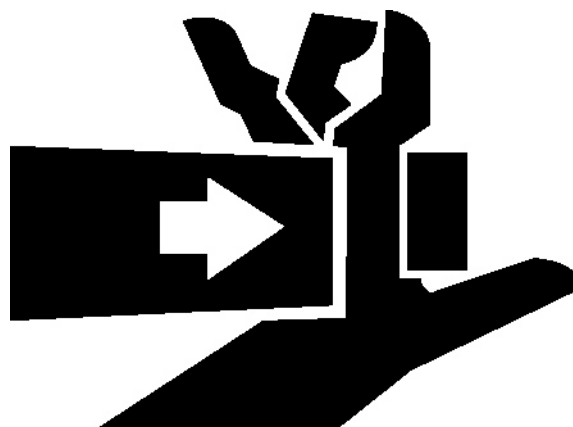
AVOID PINCH POINTS

⚠ WARNING Moving parts or the mishandling of parts can cause severe personal injury.

Keep hands away from moving parts.

Watch your fingers, hands, and legs while equipment is in operation.

Handle parts carefully to avoid crushing and pinch point hazards.



STAY AWAY FROM CRANE

⚠ DANGER Stay away from operating crane. If close to power lines, the crane, load, and ground may become electrified resulting in serious injury or death.



TEST TUNNEL VENTILATION

⚠ WARNING Keep boring head and tunnel well ventilated at all times.

Use an approved air analyzer to detect hazardous gases and oxygen content.

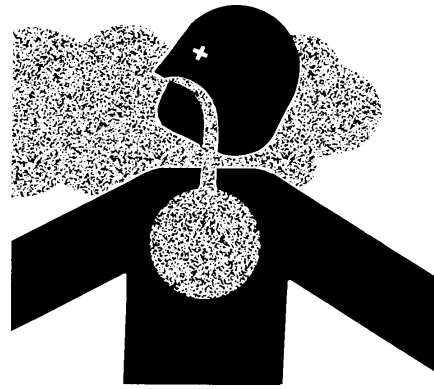
Before and during the shaft operation, test for combustible and toxic gases and oxygen deficiency.

If the levels exceed OSHA prescribed levels, leave tunnel and shaft immediately! Do not activate or deactivate any electrical or hydraulic devices, since any sparks could cause an explosion.

Once ALL personnel are out of tunnel/shaft, cut power from power source.

Gases must be removed before reentering tunnel/shaft.

Do not use haul unit to evacuate the tunnel. The electrical contacts with the unit can cause an explosion.



SLIPPERY WHEN WET

⚠ WARNING Slips and falls can cause serious personal injury.

Ensure firm footing in wet or slippery conditions.

Replace skid-resistant material if it is damaged or missing to prevent slips and falls.

Remove any buildup of grease, oil, or debris.



FIRE PREVENTION

⚠ CAUTION Fires can cause injury or property damage.

Keep equipment clean. Remove all debris from equipment.

Have a fire extinguisher available at all times. Keep the fire extinguisher fully charged.



NO SMOKING IN SHAFT OR TUNNEL

⚠ WARNING Smoking in shaft or tunnel could cause an explosion if combustible gases are present.

Do not smoke in shaft or tunnel.



KEEP JOB SITE CLEAN AND ORGANIZED

⚠ WARNING Tripping can cause serious personal injury.

Be sure to keep job site clean and organized.



KEEP AWAY FROM BELT CONVEYOR (IF EQUIPPED)

⚠ DANGER Contact with rotating conveyor belt or idler rollers will cause severe injury or death.

Keep hands, body, and objects clear of rotating conveyor.

Do not operate without covers and guards in place.

Lockout power before servicing belt conveyor.



KEEP AWAY FROM AUGER (IF EQUIPPED)

⚠ DANGER Contact with rotating auger will cause severe injury or death.

Keep hands, body, and objects clear of operating auger.

Do not operate without covers and guards in place.

Lockout power before servicing.

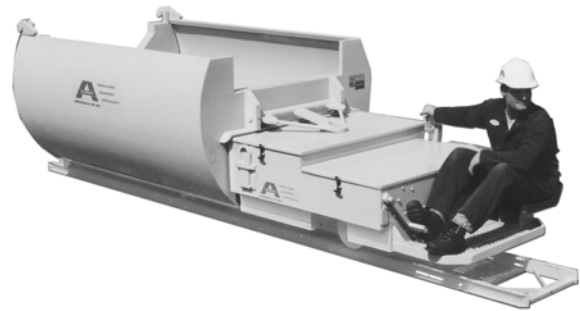


KEEP RIDERS OFF HAUL UNIT

Allow only operator on operating seat when moving haul unit. Keep riders off.

Riders on haul unit can be easily injured by being struck by objects or being thrown off of the equipment. Riders can also obstruct the operator's view resulting in the equipment being operated in an unsafe manner.

A rider may be allowed in an empty dirt bucket (with contractor approval only), to transport personnel from the tunnel opening to the boring head. If allowed, the rider **MUST** be fully inside dirt bucket, including head and all other body parts, to avoid contact with obstructions. Also, rider cannot obstruct the operator's view.



AVOID TUNNEL WALL CONTACT

⚠ WARNING Contacting tunnel wall and other pipeline obstructions can cause severe personal injury or death.

Keep all body parts on haul unit while unit is moving.



WATCH FOR CONVEYOR

⚠ WARNING Avoid contact with conveyor. Failure to do so could cause severe injury or death.

While moving haul unit into tunnel, avoid hitting the conveyor.



LOCKOUT POWER BEFORE SERVICING HAUL UNIT

⚠ WARNING Failure to lockout power before servicing can cause severe personal injury or death.

Disconnect battery harness from contactor harness and remove battery pack from haul unit to LOCKOUT power before performing any maintenance.

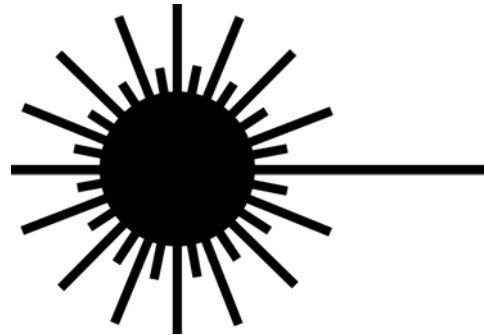


AVOID LASER LIGHT EXPOSURE

⚠ DANGER Staring into laser light will cause severe injury.

Do not stare into laser guidance system light beam. Avoid direct eye exposure.

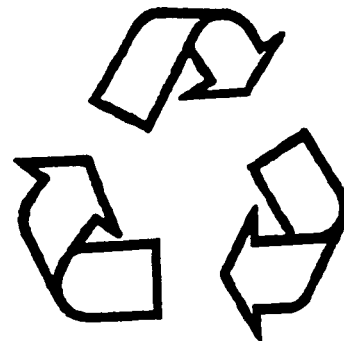
To avoid possible exposure to radiation in excess of acceptable emission limits, all repairs to laser must be performed by the original manufacturer or an authorized service technician.



RECYCLE WASTE

Follow local, state, federal, and international regulations when recycling or disposing of waste. Waste includes fluids/oil, fuel, filters, coolant, and batteries.

Use leakproof containers when draining fluids/oil. Do not pour waste on the ground, down a drain, or into any water source.



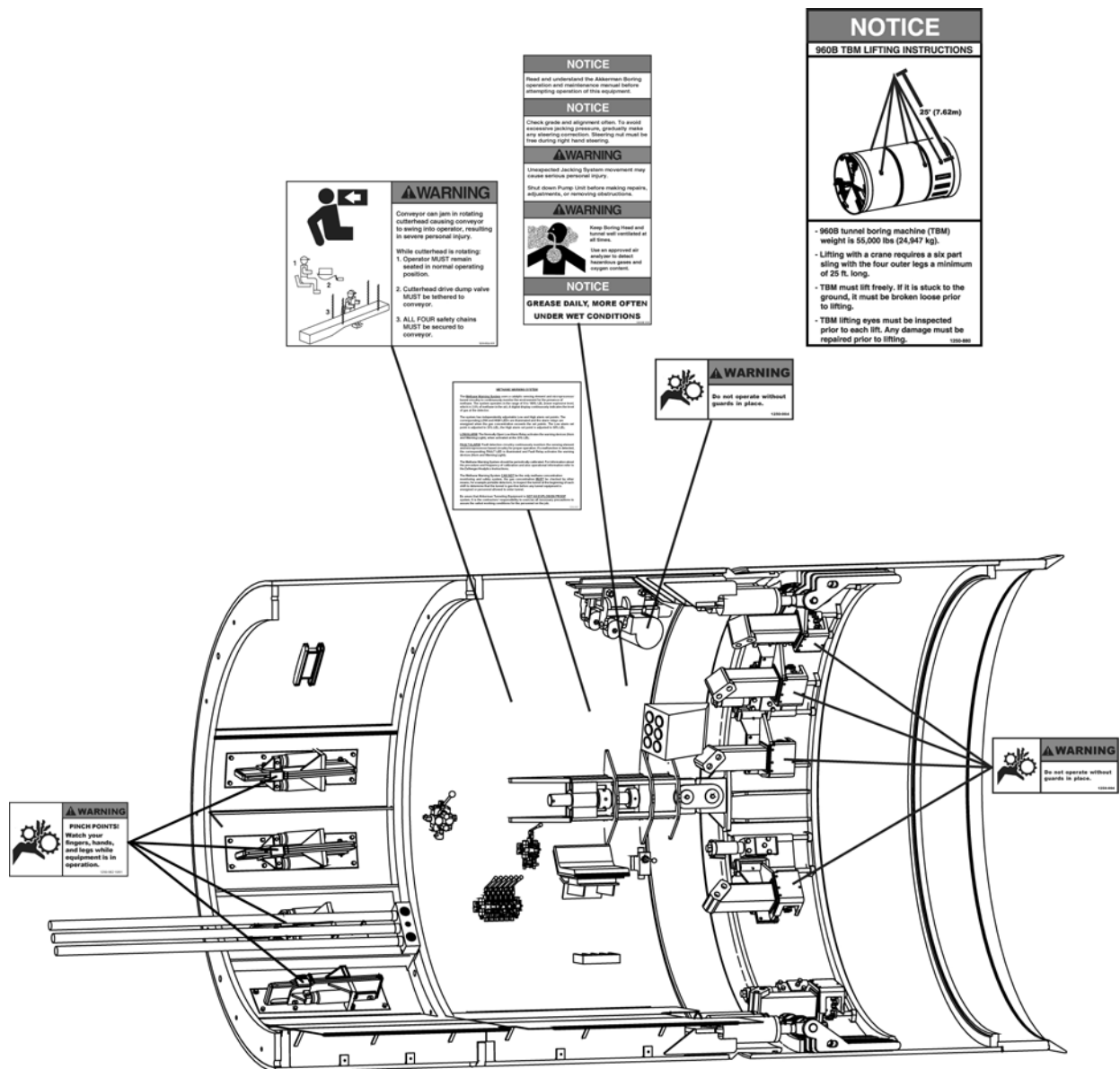
Safety Decals

Keep all safety decals clean and readable. Use soft cloth, water, and a mild soap to clean the decals if they are too dirty to read. DO NOT clean safety decals with solvent. Solvent can damage them. Replace safety decals immediately if they are damaged, missing, or hard to read.

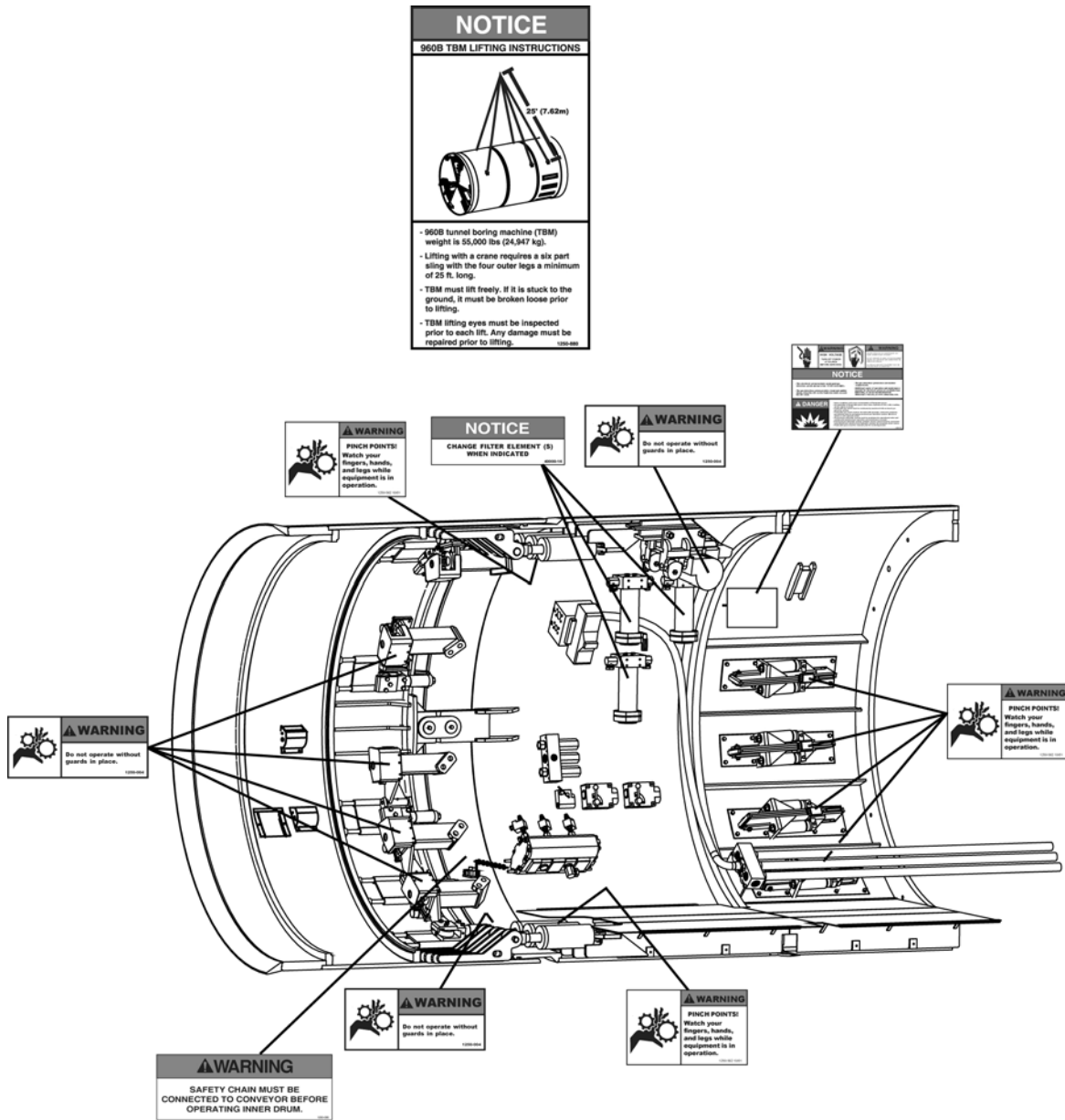
Serious injury or property damage can occur if safety instructions are not followed. Contact your Akkerman Product Support representative for free replacement safety decals.

If a part is replaced that has a safety decal on it, apply a new safety decal to the replacement part. Before applying a new decal, be sure the surface is clean and dry.

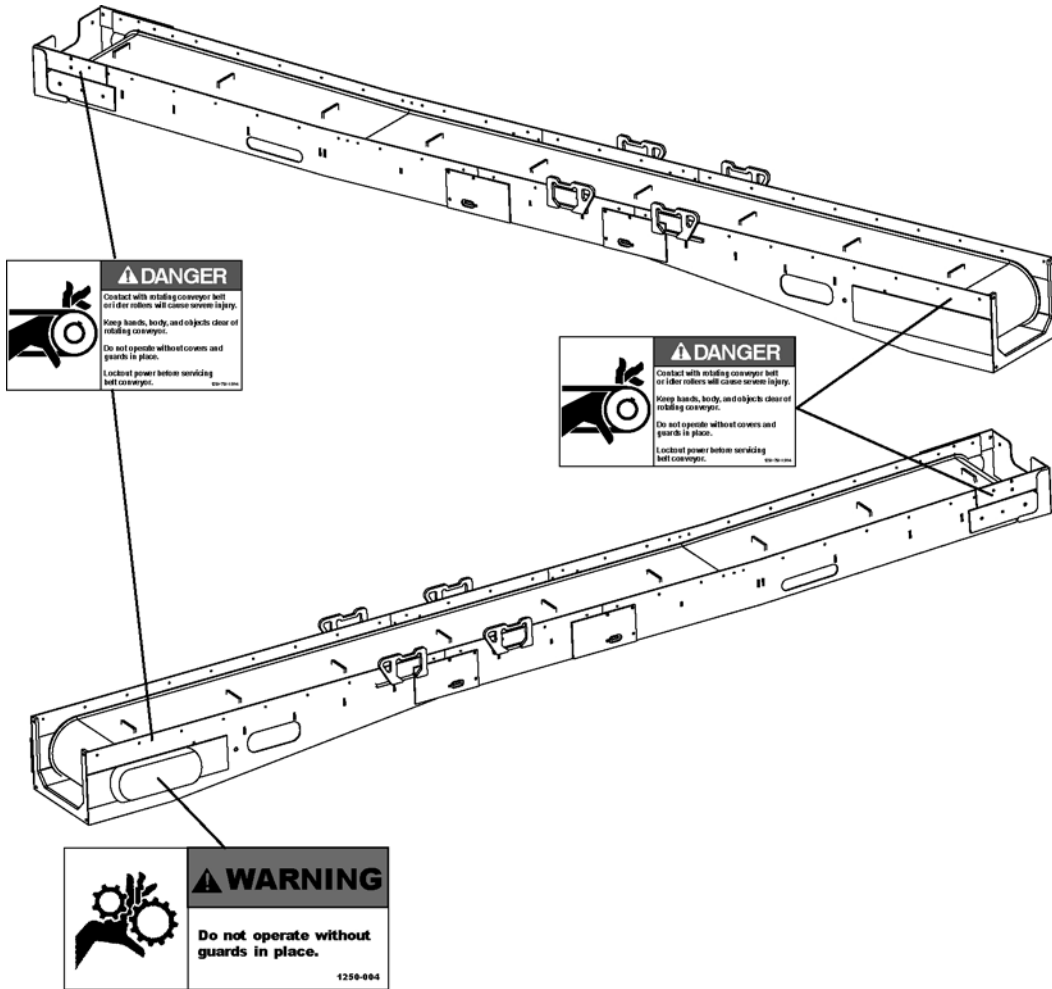
TUNNEL BORING MACHINE - LEFT SIDE



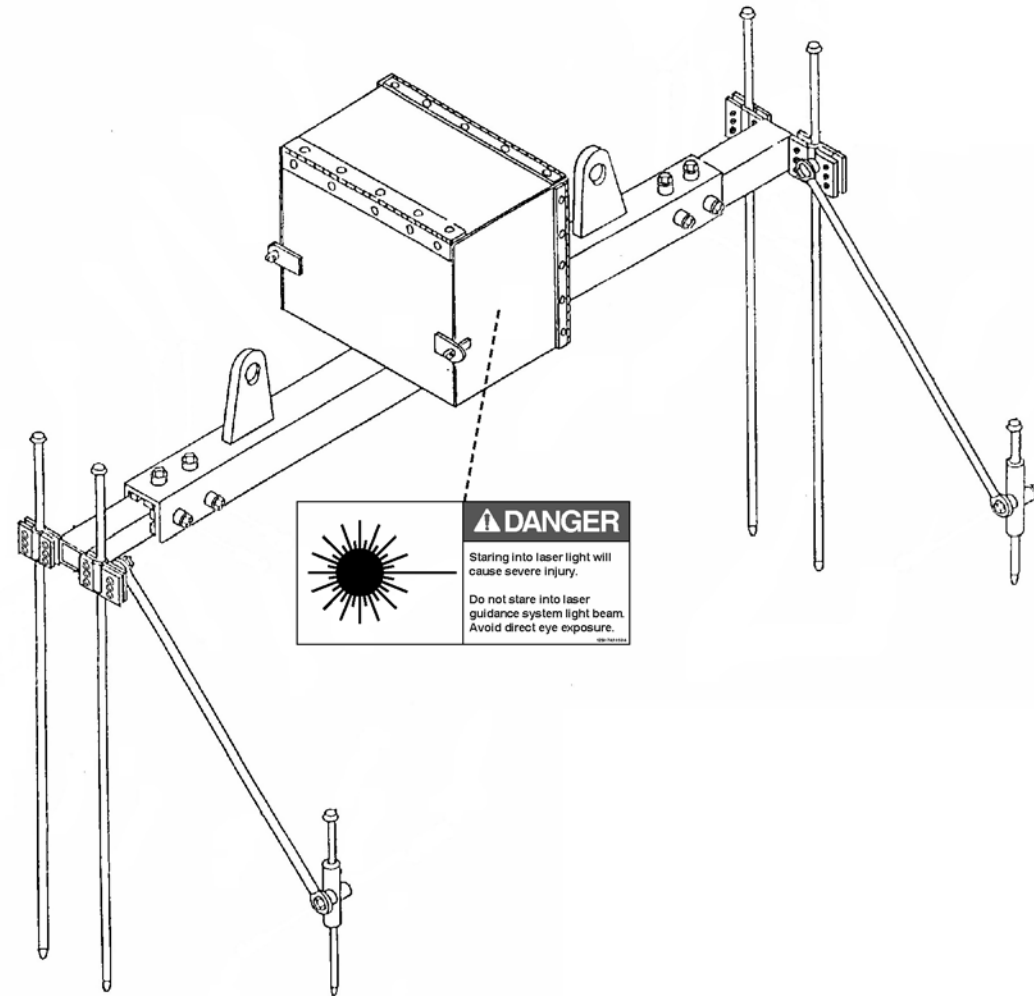
TUNNEL BORING MACHINE - RIGHT SIDE



BELT CONVEYOR



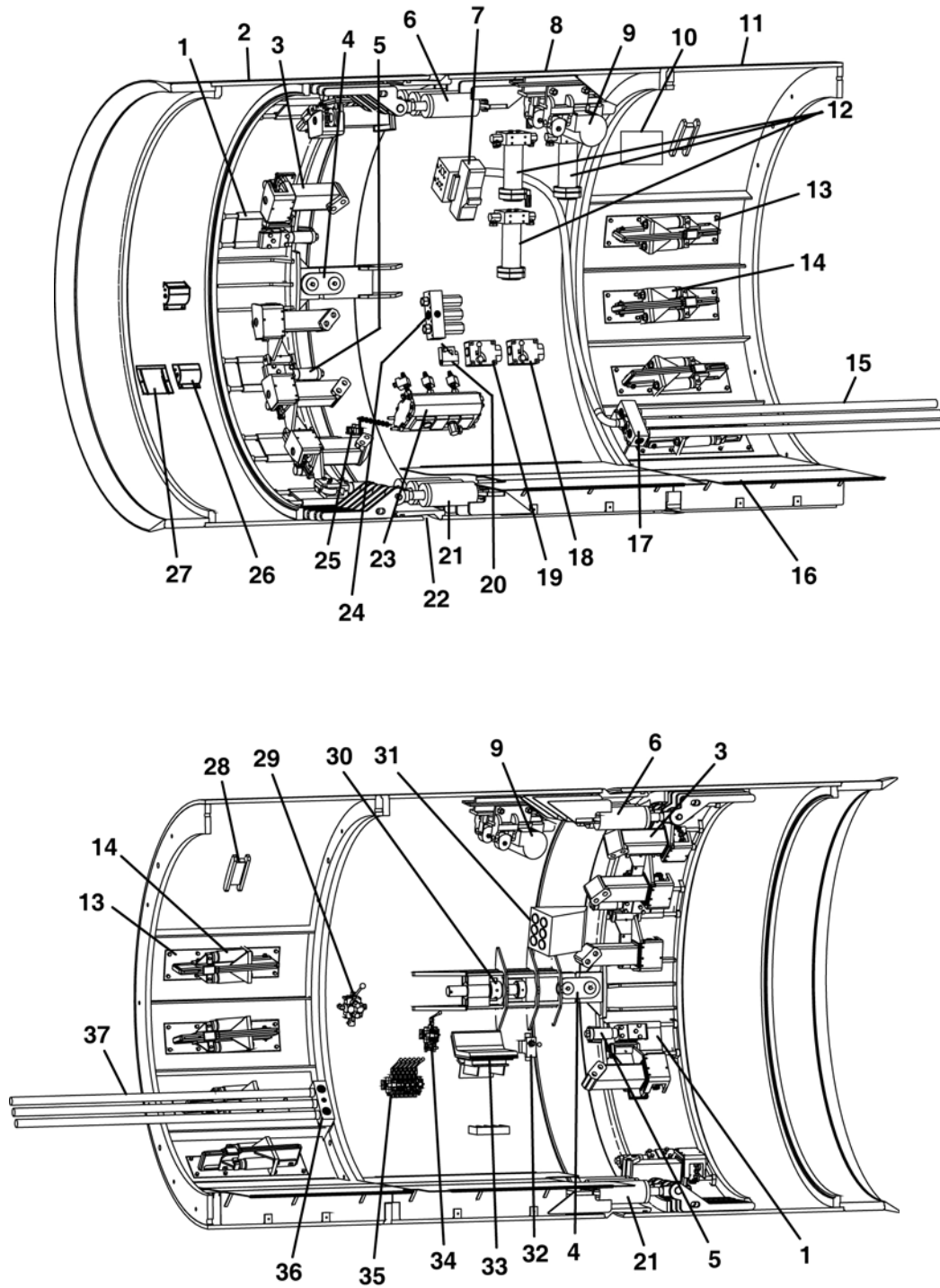
LASER LIGHT STAND



NOTES

Terminology

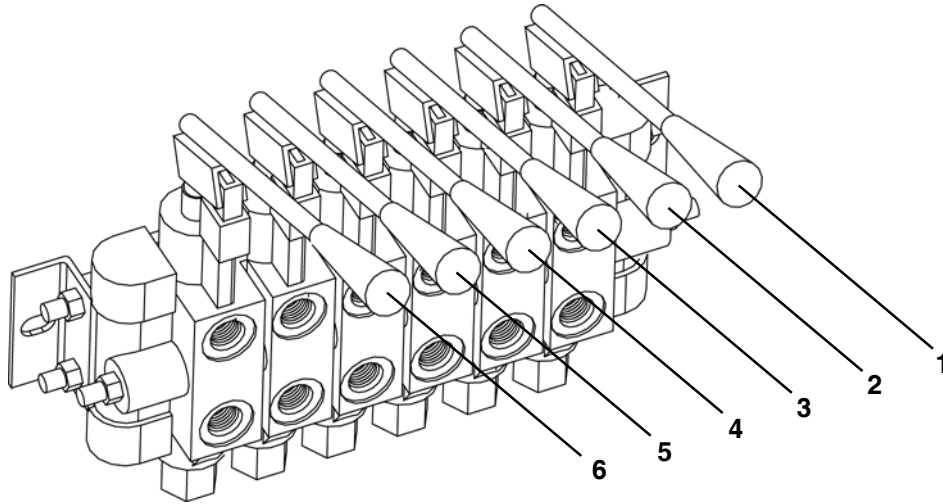
TUNNEL BORING MACHINE



Tunnel Boring Machine Terminology (continued)

1. Advance Assembly
2. Front Drum & Drive Assembly
3. Drive Motor
4. Steering Link
5. Advance Cylinder
6. Steering Cylinder (Top)
7. Motor Valve
8. Mid Drum Assembly
9. Conveyor Lift
10. Gas Detection System
11. Dirt Wing Drum Assembly
12. Pressure Filters
13. Dirt Wing Assembly
14. Dirt Wing Cylinder
15. Return Hoses
16. Floor Assembly
17. Return Manifold
18. Conveyor Speed Control
19. Inner Drum Speed Control
20. Selector Speed Control
21. Steering Cylinder (Bottom)
22. Steering Joint
23. Flow Divider
24. Supply Manifold
25. Conveyor Safety Valve
26. Drum Roller
27. Dirt Scoop
28. Lift Pocket
29. Conveyor Drive Control
30. Steering Adjustment (Side to Side)
31. Gauge Console
32. Inner Drum Rotation Control
33. Operator Seat
34. Grade/Alignment Control
35. TBM Control Valve
36. Supply Manifold
37. Supply Hoses

TBM CONTROL VALVE

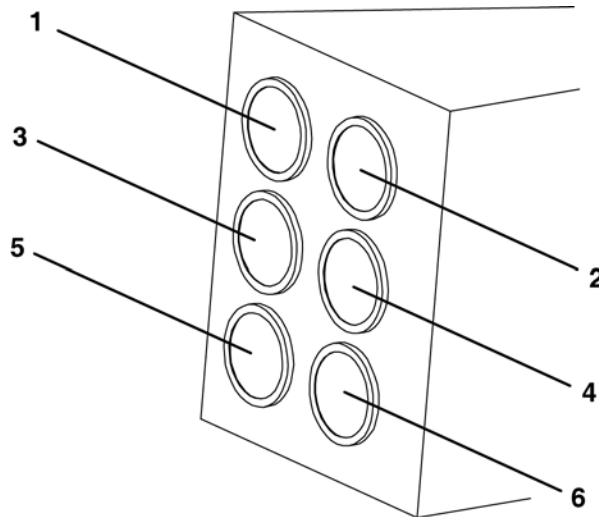


1. Inner Drum Advance
2. Conveyor Lift

3. Steering Cylinders
4. Auxiliary

5. Dirt Wing Cylinders
6. Dirt Wing Cylinders

GAUGE CONSOLE



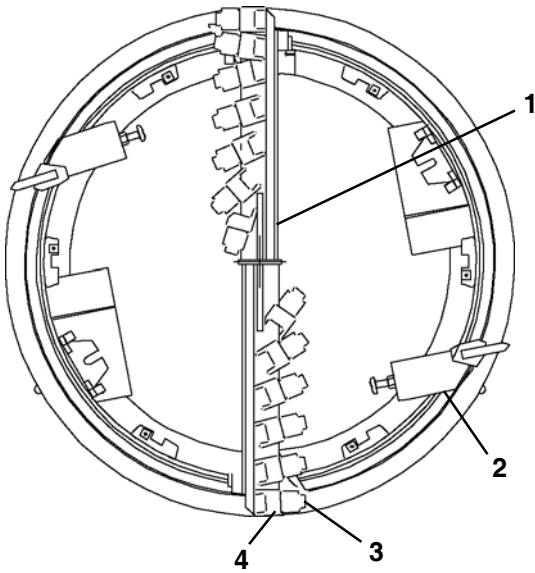
1. Top Steer PSI
2. Bottom Steer PSI

3. Pilot PSI
4. Drum Rotation PSI

5. Auxiliary PSI
6. Conveyor PSI

CUTTER HEAD ATTACHMENTS

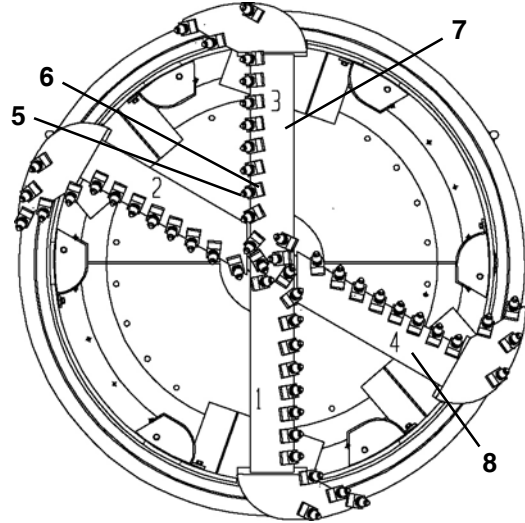
Dirt Cutter Head



Dirt Cutter Head

- 1. Cutter Bar
- 2. Adjustable Cutter
- 3. Tooth Cutter
- 4. Tooth Pocket

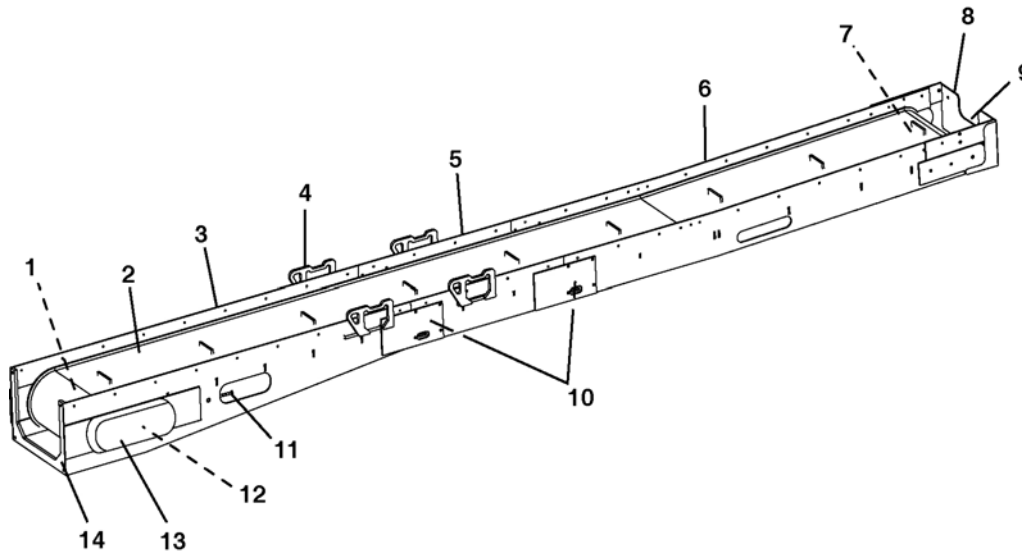
Quad Carbide Bar Head



Quad Carbide Bar Head

- 5. Carbide Tooth
- 6. Tooth Holder
- 7. Cutter Bar Weldment
- 8. Quad Bar Weldment

CONVEYOR - BELT

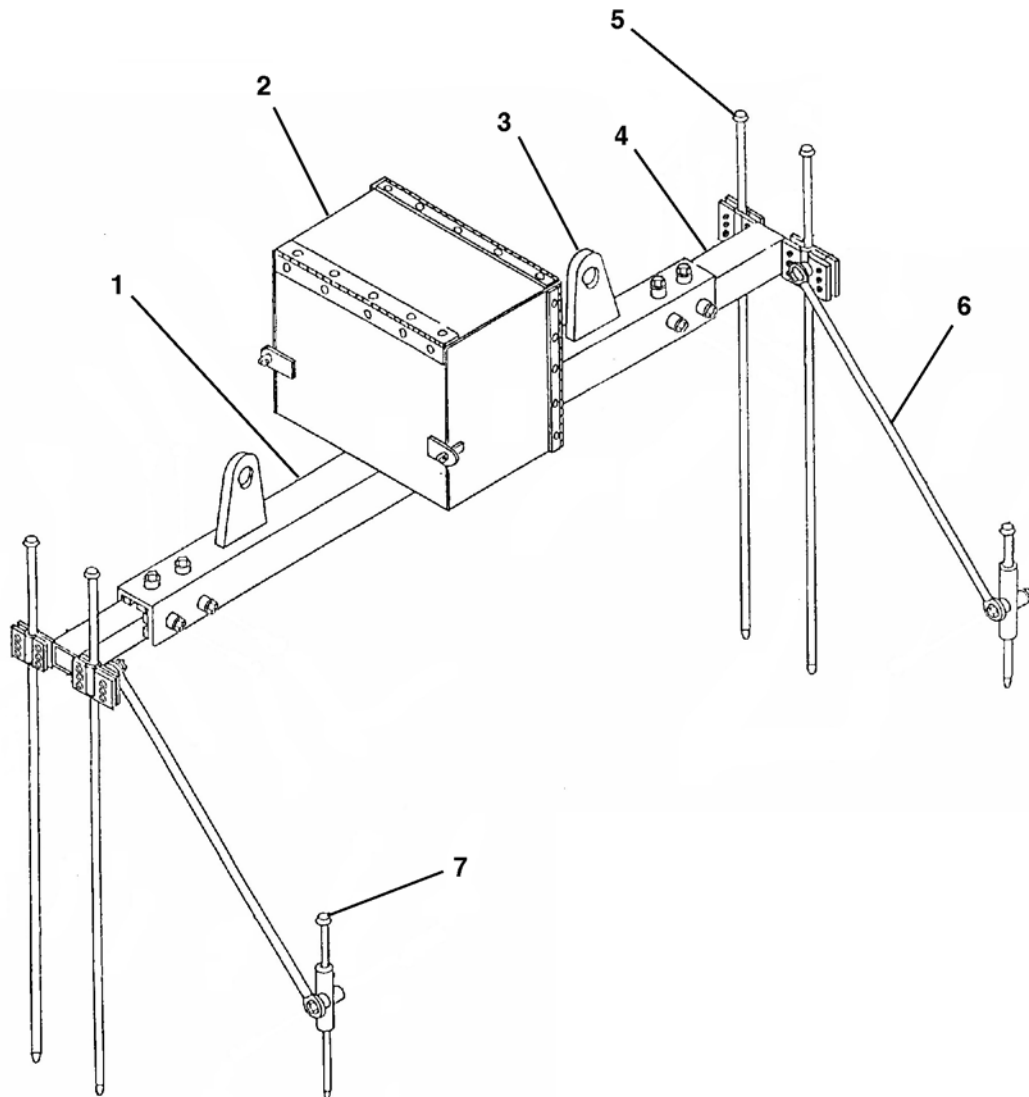


- 1. Drive Motor Frame Assembly
- 2. Belting
- 3. Drive Frame Assembly
- 4. Lift Bracket
- 5. Extension Frame Assembly

- 6. Feed Frame Assembly
- 7. Front Roller Assembly
- 8. Dirt Guard
- 9. Carrier Bearing
- 10. Idler Roller

- 11. Belt Tensioning Screw
- 12. Drive Motor & Roller Assembly
- 13. Conveyor Chain Cover
- 14. Drive Frame Free End Support
- 15. Safety Chain (not shown)

LASER LIGHT STAND



- 1. Adjustable Frame
- 2. Laser Box Assembly
- 3. Lift Bracket
- 4. Sliding Tube

- 5. Long Stake
- 6. Support Tube
- 7. Short Stake

Pre-Start Inspection

⚠ WARNING

Do not operate this equipment until you read, study, and understand this manual and your power pack, haul unit, gas detection system, and jacking frame operation manuals. A daily inspection of the equipment must be performed to prevent severe personal injury or death and equipment damage.

The contractor is fully responsible for the safety of all personnel on the job site. Check with the contractor that all site preparation requirements are in place. Be sure to comply with all OSHA regulations, such as: an active safety program is in practice, a confined space permit (if needed) is issued, personal protective equipment is being worn; flammable, combustible, and hazardous materials are properly stored; and a lockout/tag out procedure is in place.

Use the following checklist ✓ as a guide for your daily pre-start inspection.

	1. Use "ONE-CALL" notification to check for buried utility lines prior to tunneling.
	2. Check the excavated launch and reception shafts for proper shoring or bracing to prevent slides or cave-ins.
	3. Thoroughly clean equipment of mud and dirt. Keep job site clean and organized.
	4. Check condition of personal protective equipment. Replace equipment if defective.
	5. Contractor is responsible for all personnel to wear proper protective equipment on the job site.
	6. Remove combustible or flammable materials from equipment. Store materials properly.
	7. Test Emergency Stop button on power pack (and any remote E-Stops) for proper operation at the start of each shift.
	8. Test air monitoring and ventilation detectors for proper operation.
	9. The gas detector sensor must be installed with the sensor facing down to ensure proper operation and to prevent the buildup of moisture or contaminants, such as oil and dirt.
	10. Thoroughly inspect all equipment for damage, including loose or missing hardware. Repair or replace before operating.
	11. Be sure all covers and guards are in place before operation.
	12. Check electrical lines for frayed, damaged, or worn insulation or wires. Replace damaged or worn electrical lines/connections.
	13. Check for fluid leaks. Repair leak or replace components.
	14. Keep job site clean and organized.
	15. Perform all lubrication and maintenance procedures. Refer to Section 9, Periodic Maintenance.
	16. Test each function and control to ensure correct operation.
	17. Check hydraulic hoses and lines for leaks, wear and/or damage. Replace any defective hoses and/or lines.
	18. Check oil level in hydraulic oil reservoirs. Add as needed.
	19. Perform pre-start inspection on your equipment. Refer to your equipment's operator's manual.
	20. Conveyor MUST be secured with four safety chains to conveyor bracket in TBM, and cutterhead drive valve chain must be tethered to conveyor.
	21. Test the electrical motors for proper rotation prior to operating boring machine.

Operation

OPERATING GUIDELINES

⚠WARNING Do not operate this equipment until you read, study, and understand this manual and your haul unit, gas detection system, and jacking frame operation manuals. Failure to do so, could result in severe personal injury or death.

1. Before operating, read and understand the Safety, Pre-Start Inspection, Operation and Maintenance sections.
2. Do not operate this equipment while under the influence of alcohol, drugs, or medication.
3. Follow all Federal, State, and Local safety regulations and procedures.
4. Be sure OSHA prescribed safety protective equipment is being worn by all personnel.
5. Be sure the area is safe for operation. Keep work site clean and orderly.
6. NEVER operate equipment if it has been engulfed with water. Contact your Akkerman Product Support representative for proper procedures on how to restore equipment for operation.
7. Have a fully charged fire extinguisher on the job site at all times.
8. Before operating, thoroughly inspect all equipment and repair equipment problems. Check hoses for cuts or bulges. Replace worn or damaged hoses.
9. Be sure the excavated launch and reception shafts are properly shored or braced to prevent slides or cave-ins.
10. Test air monitoring and ventilation detectors for proper operation. Never enter a tunnel without combustible gas detectors and oxygen deficient detectors.
11. Fresh air must be supplied to all underground work areas in sufficient amounts to prevent any dangerous or harmful accumulation of dusts, fumes, mists, vapor, or gases.
12. A fully trained and qualified signal person must direct the excavator or crane operator when lifting and lowering equipment into the launch or reception shafts.
13. Never walk or work under any part of the excavator or crane and suspended loads.
14. Test each function and control to make sure they work properly.
15. Lock out electrical power at the source (generator) before servicing electrical components.
16. Do not make any modifications to any Akkerman products. Doing so could cause structural failure and will void the warranty.
17. Check shields and guards. All must be in place and undamaged.
18. Before starting equipment, thoroughly inspect all equipment. Let all job site personnel know that you are starting up the equipment. Do not start until all unauthorized personnel are clear of the equipment.
19. Before leaving the operator's seat, release hydraulic pressure, perform daily system shutdown, and disconnect the main power supply.

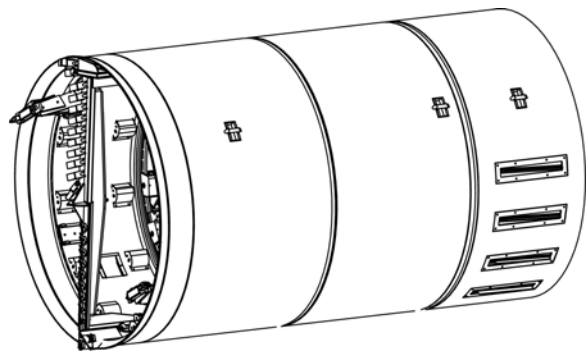
(continued on next page)

Operating Guidelines (continued)

20. Lock out the main disconnect, shut off generator or other external power source, and attach a DO NOT OPERATE tag or similar warning tag to the main power disconnect before performing maintenance.
21. Check line and grade alignment often.
22. Conveyor MUST be secured with four safety chains to conveyor bracket in TBM, and cutter head drive valve chain must be tethered to conveyor.
23. If this manual becomes lost, contact your Akkerman Product Support representative for a new manual.
24. The operator must note and report any slow down of machine operating time that might be an early warning of future problems.
25. Do not make adjustments or repairs to any of the system components while in operation or until all pressure is released and electrical power is locked out, tagged out.
26. High pressure hydraulics are used in this tunnel boring machine. Be sure all covers and guards are in place before operating.
27. Check laser beam often to avoid mis-alignment. Keep boring head well ventilated to achieve a consistent temperature throughout the pipeline since changes in temperature inside the pipe can cause laser beam to stray off target.

CHECKOUT EQUIPMENT PRIOR TO START-UP

1. Grease components as shown in Periodic Maintenance section.
2. Check the oil level in power pack hydraulic reservoir. Add oil if necessary.
3. Inspect conveyor lift cables daily and replace immediately at the first sign of wear.
4. Inspect all hoses and electrical lines for proper installation or damage. If damaged, replace with new before operating.
5. Refer to your power pack, haul unit, gas detection system, and jacking frame operation manuals for pre-start checks.



USING EMERGENCY STOP

An E-Stop (Emergency Stop) button is equipped on the P600 Power Pack control panel, and pendants.

Push IN E-Stop (Emergency Stop) button to stop electrical and hydraulic power, though the operation lights will remain ON.

The E-Stop button must be pulled out to restart operation.

GAS DETECTOR

⚠ DANGER Be aware that the harmful effects of entering an oxygen-deficient atmosphere can be so immediate that it is impossible to retreat to safety.

The gas detection system installed in the TBM system, monitors only combustible gas levels. Monitoring of gas levels is the responsibility of the contractor. This includes the accumulation of combustible and toxic gases, and depletion of oxygen. The contractor must keep the tunnel ventilated with fresh air.

The gas detection system installed in the TBM CANNOT be the only methane or other combustible monitoring system. The gas concentration must be checked by other portable detectors to inspect the tunnel at the beginning of each shift to determine that the tunnel is gas free before any tunnel equipment is energized or personnel are allowed to enter the tunnel. The contractor is responsible for providing air analyzers to detect hazardous gases or oxygen deficiency on the job and in the tunnel at all times.

SYSTEM SET-UP

1. The contractor is fully responsible for the design and construction of the OSHA required launch and reception shafts. For setup and installation drawings specific to the project, pipe size and shoring type, contact the Akkerman Sales Department.

⚠ WARNING Gases may be present during excavation and could cause severe personal injury or death. Use an approved air analyzer to detect hazardous gases on the job site and in the tunnel at all times.

2. After the soil analysis, shaft layout design, and survey are complete, excavate the launch and reception shafts. Be sure the shafts will be well drained and use proper shoring or bracing in accordance with your local, state, and federal regulations.

3. Construct a shaft floor with a solid base suitable for the weight of the jacking system, TBM system and pipe. Consult your civil and structural engineers for your shaft floor requirements.

4. Place steel plates on the jacking shaft floor for supporting the base of the skid (rails), jacking frame, TBM, and pipe.

5. Construct a concrete thrust block to withstand the applied load. A structural engineer must be consulted on the design of this block. This block must be square with the line of the tunnel axis and skid assembly.

NOTICE If using a jacking frame, space must be provided for the mounting of the laser behind the jacking frame.

(continued on next page)

System Set-Up (continued)

▲ WARNING Suspended loads may fall and cause severe injury or death. Do not allow anyone to enter area under or around a suspended load.

NOTICE Be sure the crane or excavator and all lifting equipment is rated to lift load. Remember, you may be able to lift the load in close at ground level, but as the load radius and elevation change, the lifting capacity of the crane or excavator or other lifting equipment decreases.

6. Lower skid assembly into launch shaft using lift eye assemblies and place against the thrust block. Correct the skid assembly line and grade with leveling screws. Be sure there is at least 6 inches between the front of the jacking rails and where the launch seal will be located. Lower other skid assembly(s) into launch shaft as needed. Align skid sections and mount together with 2 in. bolts and nuts.
7. Install skid split bars into side skid base assembly making sure the holes of the bar line up with the holes in the skid assembly. Insert skid split pins with slot of pin at the 12 o'clock position for set screw. Secure skid split pin with set screws.

8. Check to be sure that the skid assembly is making full contact against thrust block.

NOTICE Both the left and right ends of the skid frame **MUST** be against thrust block, otherwise damage will occur to the skid frame during jacking operation.

9. Once skid assemblies are properly joined, correct the skid assembly line and grade with leveling screws.
10. Lower jacking system onto skid assembly rails and make sure the frame is properly centered on the rails.
11. Lower P600 power pack on a level, solid foundation an appropriate distance from the edge of the shaft to prevent shaft cave-in.
12. Lower tunnel boring machine (TBM) onto the front of the skid assembly, making sure the cutter teeth on the TBM will not strike the side assembly when the cutterhead is rotated.
13. Place the generator or main power source as far away from the launch shaft as possible. This will reduce the noise to the operator and make it easier to communicate with the launch and reception shaft personnel.
14. Lower the stand for the laser guidance system as close to the rear of the jacking shaft as possible without contacting skid assembly, jacking system, or thrust block. Be sure the guidance system will not be affected by thrust applied to jacking system.

NOTICE For proper guidance system installation, refer to your laser manufacturer's installation requirements. Be sure laser beam has a clear path to target.

15. Install the launch shaft seal and casing in the front of the launch shaft, if required.
16. Recheck the jacking system base frame and alignment. Check machine elevation and make final pipe line calculations allowing for the cutter bit "over cut".
17. Set up the power pack, hydraulic setup (see TBM Hydraulic Dual & Triple Feed Supply Setup in this section), and jacking frame hydraulics and electrical connections. Check electric motor for proper rotation.
18. Ensure the TBM alignment and grade are steered parallel to the jacking system base.
19. Install conveyor into the TBM and connect the lifting cables to the front lifting position on the conveyor lifting eyes. Lift the conveyor with the conveyor lift and slip bearing at the front of the conveyor onto the pin at the center of the cutter bar. Connect the safety chains to the conveyor and lower the conveyor lift just enough to provide adequate slack in the lift cables to move the lifting hooks to the rear (operating) position on the conveyor lifting eye. Raise the conveyor to the operating position.

TBM HYDRAULIC DUAL & TRIPLE SUPPLY FEED SETUP

There are two hydraulic supply/return options available to setting up the P600 Power Pack with the 960B Tunnel Boring Machine; dual feed supply and triple feed supply.

The dual feed option supplies 120 gpm of low pressure (3,000 psi) oil to the boring head, steering, and conveyor. Specifically, 60 gpm @ 3,000 psi feeds the the conveyor circuit, auxiliary circuit (steering, dirt wing cylinder, inner drum advance, etc.) and head drive, and an additional 60 gpm @ 3,000 psi is dedicated to the cutting head drive motors.

The triple feed option supplies an additional 60 gpm of low pressure (3,000 psi) oil for the cutting head drive motors, becoming a total of 120 gpm @ 3,000 psi dedicated to the cutting head drive motors.

At maximum flow, the double feed supply with 8 head drive motors produce approximately 3 rpm. The triple feed supply with 8 head drive motors produce approximately 5 rpm at maximum flow.

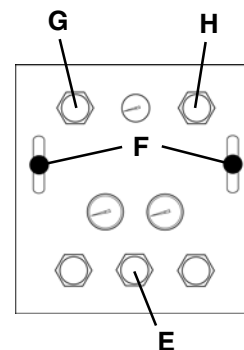
TBM Hydraulic Connections:

• Dual Feed (120 gpm of low pressure oil)

1. Connect two supply hoses from P600 to the top two port hoses (A) in supply manifold.
2. Connect two return hoses from P600 to the top two ports hoses (B) in return manifold.

• Triple Feed (180 gpm of low pressure oil)

1. Connect three supply hoses from P600 to the three port hoses (A, C) in supply manifold.
2. Connect three return hoses from P600 to the three port hoses (B, D) in return manifold.



P600 Low Pressure Module

Power Pack Connections:

• Dual Feed

1. Connect the two TBM supply hoses to port (E) on two low pressure modules.
2. On each module, move BOTH control levers (F) down for 60 gpm for each module.

NOTICE

Both pump controls on each module must be activated to combine the flow to 60 gpm for each module; or a 120 gpm combined flow from both low pressure modules. Activating one pump control will produce only 30 gpm of oil from each low pressure module, or a combined flow of 60 gpm from both modules.

3. Connect the TBM return hoses to the return ports (G or H) on the Power Pack modules.

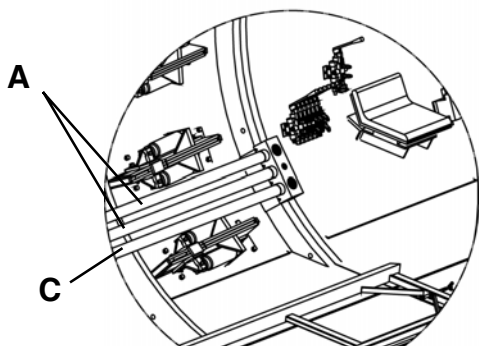
• Triple Feed

1. Connect the three TBM supply hoses to port (E) on three low pressure modules.
2. On each module, move BOTH control levers (F) down for 60 gpm for each module.

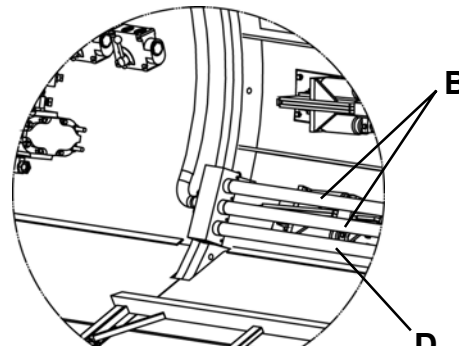
NOTICE

Both pump controls on each module must be activated to combine the flow to 60 gpm for each module; or a 180 gpm combined flow from three low pressure modules. Activating one pump control will produce only 30 gpm of oil from each low pressure module, or a combined flow of 90 gpm from three low pressure modules.

3. Connect the TBM return hoses to the return ports (G or H) on the Power Pack modules.



Supply Manifold



Return Manifold

START-UP PROCEDURE

NOTICE The system set-up and hydraulic dual or triple feed supply procedures (refer to previous pages) must be completed prior to performing the start-up procedure.

1. With Emergency Stop button pushed IN to stop position and all other controls turned to OFF position, hook up generator or other external power source (480V, 450 AMP minimum [recommended not to go below 500 am]) to pump unit/power pack.
2. Move all TBM controls to the OFF position.
3. Turn on cooling water supply to pump unit/power pack heat exchanger.
4. Pull out E-Stop button to start power.
5. Turn on power pack power to run the main drive, auxiliary, cooling and conveyor functions. Refer to your P600 Power Pack operation manual for details.
6. Operate the Inner Drum Advance control valve to the full advanced position.

NOTICE Be sure that a forward pull exists on the conveyor lifting cables and safety chains throughout the full advance travel.

7. Lower conveyor and then retract the Inner Drum Advance 1/4 of the cylinder stroke. If an obstruction is encountered or cutter teeth need to be replaced, the advance cylinders can be retracted to allow room to remove the obstruction or replace teeth.

NOTICE Before retracting inner drum, be sure to lower conveyor. Failure to do so will cause damage to conveyor.

⚠ DANGER Staring into laser light will cause severe injury. Do not stare into laser guidance system light beam. Avoid direct eye exposure.

8. Set laser guidance system to grade and alignment. Be sure the laser beam can be easily seen on the cutter bar target bolt from the operator seat when the cutter bar is plumb. Raise the conveyor into the operating position.

⚠ WARNING Suspended loads may fall and cause severe injury or death. Do not allow anyone to enter area under or around a suspended load.

9. Lower the dirt bucket into position behind the conveyor; do not install the haul unit at this time.
10. Operate the Conveyor Control and the Inner Drum Control valves and apply forward thrust to the TBM.
11. Check if the TBM over cut is sufficient to allow steering corrections, but does not exceed job specifications. Readjust over cut and check tooth wear daily, and more often in severe conditions.
12. Check and adjust grade and alignment often, after each dirt bucket removal, to avoid excessive jacking pressure.
13. Continue operation until TBM has been advanced forward enough to lower the first pipe into place.
14. Remove dirt bucket.
15. On power pack, press E-Stop button IN to shut down TBM power and shut off all jacking system power.
16. Perform lock out, tag out procedure on generator or other power source, and power pack.

(continued on next page)

Start-Up (continued)

17. Lower pipe onto the jacking system base.
18. Perform system start up procedure.
19. Set the first pipe by slowly mating the jacking frame with the pipe and TBM.
20. When the first pipe has been set, install the first track section and secure to TBM. Refer to your Haul Unit Operator's Manual for track installation. Sections of track will need to be added as new pipe is lowered. Also, be sure there is always track connecting the pipeline and the jacking frame, for the haul unit and the loading and unloading of the dirt bucket.
21. Lower haul unit onto track. Refer to your Haul Unit Operator's Manual for haul unit installation.
22. Lower dirt bucket into place on haul unit. Move the haul unit into the pipeline until the dirt bucket is underneath the conveyor.
23. Recheck laser guidance system accuracy often, with and without forward thrust applied, to avoid making improper steering corrections. In most cases, the conveyor must be raised to check line and grade target.
24. Continue to install additional pipe. If there is a possibility that the maximum jacking capability will exceed the maximum jacking force of your jacking system, intermediate jacking stations should be installed.

STEERING ADJUSTMENTS

When steering corrections are necessary (laser is not illuminating on target bolt) , be sure to make **ONLY** minor adjustments. Making more extreme steering adjustments will increase the jacking forces due to the front and trailing sections are not in parallel.

Use the steering selector to select the grade or alignment adjustment.

GRADE (up/down):

Move steering selector UP to select Grade, then operate the steering valve on the TBM control valve up or down to adjust the steering cylinders accordingly. This will move the front drum up or down. **DO NOT** use steering nut for grade adjustment.

ALIGNMENT (left/right): Move steering selector DOWN to select Alignment.

Left Turn: operate the steering cylinder valve on the TBM control valve up while turning steering nut forward.

Right Turn: operate the steering cylinder valve on the TBM control valve down while turning steering nut back.

NOTICE If TBM rolls 1/4" to 1/2" (6.35 to 12.7 mm) from level, dirt wings adjustments will be required. Refer to Using Dirt Wings in this section.

USING DIRT WINGS

When the TBM rolls 1/4" to 1/2" (6.35 to 12.7 mm) from level, dirt wings need to be extended. When extending dirt wings for TBMs with four, six, or eight dirt wings (half clockwise/half counterclockwise), the selected dirt wings cylinders are fully extended once the pressure on the control valve gauge reads 2,800 - 3,000 psi.

If the TBM rolls in a clockwise direction, the counterclockwise dirt wings must be extended.
If the TBM rolls in a counterclockwise direction, the clockwise dirt wings must be extended.

Keep the dirt wings extended until the TBM roll is back to level position. Typically in hard or tight ground, the dirt wings will cut into the ground and quickly move the TBM back to the level position. Whereas in soft or loose ground, it may take quite a distance to move the TBM back to the level position.

NOTICE Depending upon ground conditions and/or overcut, you may need to add extensions to the standard dirt wings to stabilize the roll.

INNER DRUM ROTATION CONTROL ADJUSTMENT

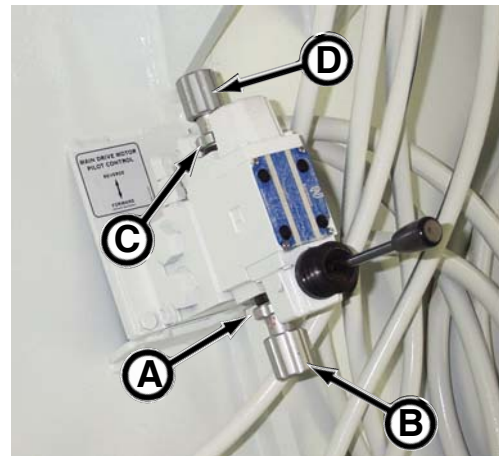
If the inner drum motor engagement is too abrupt or jerky, or too slow, adjust the motor engagement with the flow controls on the inner drum rotation control (Main Drive Motor Pilot Control).

Forward Motor Engagement Adjustment

Loosen nut (A) and turn flow control (B) clockwise to decrease inner drum motor engagement speed or counterclockwise to increase motor engagement speed. Retighten nut (A).

Reverse Motor Engagement Adjustment

Loosen nut (C) and turn flow control (D) clockwise to decrease inner drum motor engagement speed or counterclockwise to increase motor engagement speed. Retighten nut (C).



ACCESSING FRONT OF MACHINE

To access the front of the machine and the face of the bore, retract the inner drum advance cylinders and perform lock out, tag out procedure. This allows for the removal of large obstructions, whether planned or unexpected and makes it easy to perform routine maintenance and repairs.

DAILY SHUT DOWN

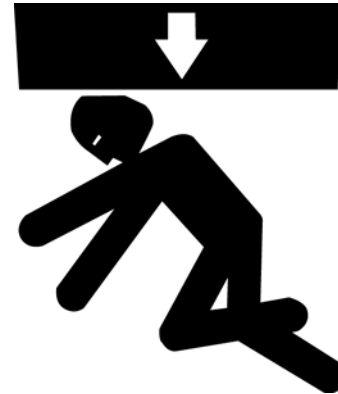
1. Stop jacking frame hydraulics.
2. Turn all levers and/or switches to OFF position.
3. Push E-Stop in to shut down power pack power.
4. Shut off water supply to power pack heat exchanger.
5. Shut off main power source and perform lock out, tag out procedure.
6. Perform a visual machine inspection by checking the following items: all fluid levels, and machine damage. Make repairs before operating. Also check to be sure all hydraulic and electrical connections are properly connected and secured.

Transporting

TRANSPORTING GUIDELINES

⚠ WARNING Suspended load may fall and cause severe personal injury or death.

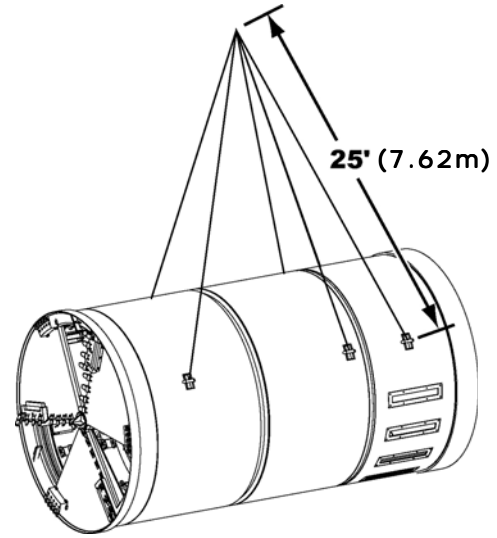
Do not enter area under or around a load.



1. Know the local, state, and federal transportation regulations.
2. Obtain required permits for transporting.
3. Remove any obstacles from the trailer floor.
4. Clean debris from equipment.
5. Load and unload on level ground.
6. If lifting equipment with a hoist or other lifting device, the equipment lifting eyes and sling must be inspected for damage before lifting. If damaged, replace.
7. Securely fasten equipment to trailer floor.
8. Observe and follow the lifting instructions on the following page.

LIFTING INSTRUCTIONS

- 960B tunnel boring machine weight is 55,000 lbs. (24,947 kg).
- Lifting with a crane requires a six part sling with the four outer legs a minimum of 25 ft. (7.62 m) long.
- TBM must lift freely. If it is stuck to the ground, it must be broken loose prior to lifting.
- TBM lifting eyes must be inspected prior to each lift. Any damage must be repaired prior to lifting.



Lubricants

NOTICE

Use of inferior lubricants can affect the efficient performance of your Tunnel Boring Machine. Always use high quality lubricants as specified in this section. Refer to the Periodic Maintenance section for proper lubrication quantity, maintenance intervals, and procedures.

HYDRAULIC RESERVOIR LUBRICANT

The 5000 Pump Unit and P400/P600 Power Pack hydraulic reservoirs are filled with ISO-VG-46 20W Premium Hydraulic/Turbine Oil.

Use an API GL-1/GL-2 or equivalent when adding or changing lubricant.

NOTICE

If you change to a different oil, use a reputable oil supplier to meet or exceed the ISO-VG-46 20W or API GL-1/GL-2 oil specification. Do not mix oil manufacturers or grades.

The hydraulic reservoir capacity is approximately:

P600 Power Pack - 600 gal. (2,271 L)

GREASE

The lubrication fittings are greased with Mobilgrease® XHP222 Premium Lubricating Grease.

The XHP222 grease is a multi-purpose, high performance, high temperature, lithium grease.

Use Mobilgrease® XHP222 Premium Lubricating Grease or equivalent when lubricating the lubrication points.

STORING LUBRICANTS

Your equipment can operate at maximum performance only if clean lubricants are used. Use clean containers to handle all lubricants.

Lubricants should be stored in an area protected from dust, moisture, and other contaminants.

Periodic Maintenance

⚠ WARNING Review the Safety section in this manual before performing maintenance. Failure to do so, could cause severe injury or death.

Maintenance and repairs must only be performed by a qualified service technician.

LUBRICATION & MAINTENANCE INTERVALS

The requirements for lubrication and maintenance are shown on the maintenance charts in this section.

Intervals of maintenance are based on normal operating conditions. If operating under more difficult conditions, use a shorter time interval between maintenance.

BEFORE PERFORMING MAINTENANCE

1. Push in E-Stop button(s).
2. Relieve hydraulic pressure.
3. Do not work on hydraulic system if oil temperature exceeds 125° F (51° C).
4. **Lockout all power. Perform lock out/tag out procedure.**

LOCKOUT POWER BEFORE SERVICING

⚠ WARNING Severe personal injury or death can result from unexpected pump unit start-up or machine movement.

LOCKOUT power before attempting to make repairs or adjustments to this equipment, unless otherwise indicated. Proper lockout will prevent accidents and save lives. Performing the lockout will also prevent the equipment from moving or operating unexpectedly.



HYDRAULIC OIL/FLUIDS UNDER PRESSURE

⚠ WARNING Escaping oil or other fluids under pressure can penetrate your skin causing serious injury or death.

Release all pressure before performing maintenance or repairs. Never weld near pressurized fluid lines.

DO NOT use your hands to check for leaks. When searching for leaks, use a piece of wood or cardboard.

Contact medical help immediately if any oil or fluid is injected into your skin. A serious infection or reaction can emerge without proper medical treatment.



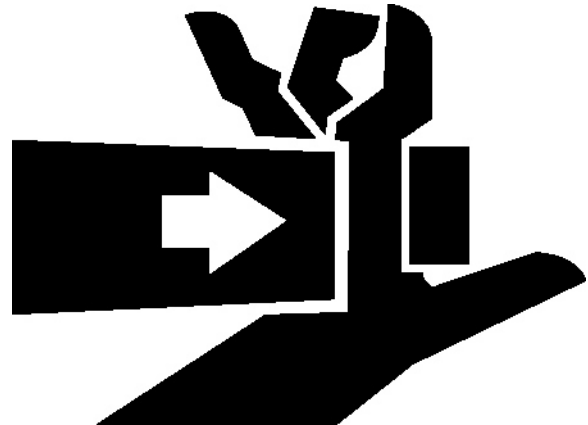
AVOID PINCH POINTS

⚠ WARNING Moving parts or the mishandling of parts can cause severe personal injury.

Keep hands away from moving parts.

Watch your fingers, hands, and legs while equipment is in operation.

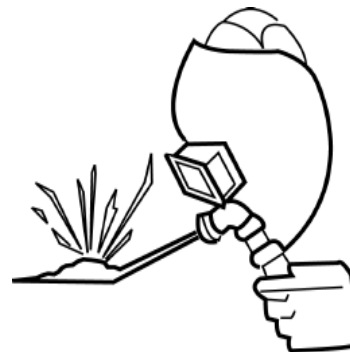
Handle parts carefully to avoid crushing and pinch point hazards.



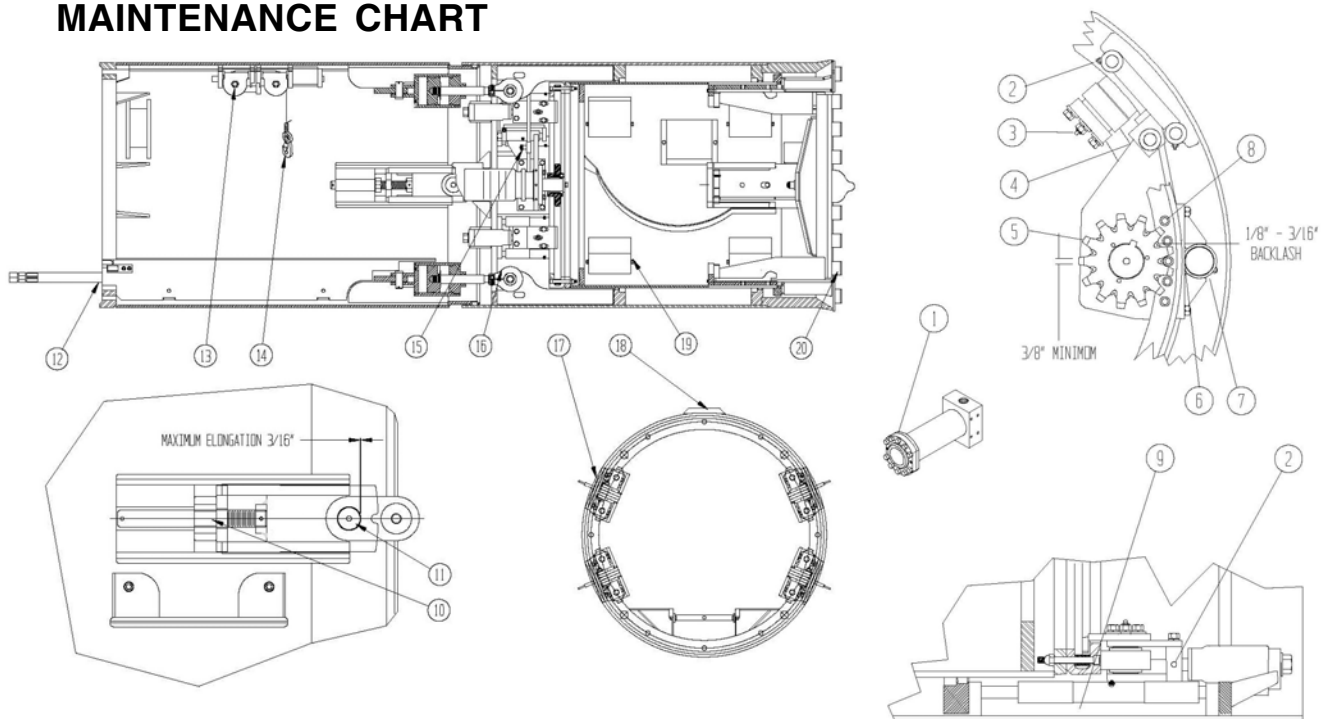
UNAUTHORIZED WELDING

⚠ WARNING Unauthorized welding can cause structural failure resulting in possible injury or death.

Do not weld on any structural member. Unauthorized welding or repair will void the warranty.



MAINTENANCE CHART



- 1 Replace filter elements when indicator located on filter remains red after oil is up to operating temperature.
- 2 Grease thrust bracket guides and check cylinder pin for damage weekly. More often in wet conditions.
- 3 Grease thrust roller daily, more often under high thrust or wet conditions (Caution: pump no more than two strokes of grease gun).
- 4 Grease motor bracket pivot pin weekly, more often in wet conditions.
- 5 Remove motor sprocket (drum advance) covers, and inspect sprockets for wear, replace when flat at outside of tooth is less than 3/8" (9.5mm).
- 6 Check drive motor to gear backlash, re-shim to obtain 3/16" (4.7mm) backlash. If proper backlash cannot be obtained, replace idler roller shaft.
- 7 Grease idler roller daily, more often in wet conditions. Inspect roller shaft and replace when worn more than 1/8" per side.
- 8 Inspect drive gear pins in gear ring daily. Roller spools must rotate freely. Replace pins and spools when worn more than 1/8" (3.2mm).
- 9 Do not allow spoil material to build up under the drive gear area.
- 10 Oil steering link nuts and threads regularly.
- 11 Remove bolt and washer from steering link and check for elongation, replace if more than 3/16" (4.7mm).
- 12 Visually inspect all hoses for damage and replace as necessary.
- 13 Grease conveyor lift pulley roller pins (4 places), slides, and pulley bracket pivots (4 places).
- 14 Inspect conveyor lift cables daily and replace immediately at the first sign of wear.
- 15 Operate oiler flow control valve as required to maintain proper lubrication to drive gear.
- 16 Grease steering clevis joints weekly, more often in wet conditions.
- 17 Grease dirt wing roller pins weekly, more often in wet conditions.
- 18 Inspect lifting eye areas for damage or wear before each lift.
- 19 Remove drum roller covers & grease drum rollers daily, more often under wet conditions. Remove shims under roller hold down bolts to compensate for roller wear.
- 20 Inspect cutter bar and adjust over cut daily. Promptly replace worn or damaged teeth.
- 21 Replace load sense filters after 10 hours of operation and then after each hydraulic reservoir oil change.
- 22 Perform oil analysis every 250 hours or operation. If analysis indicates, drain and replace oil.
- 23 Check hydraulic reservoir oil level. Drain and replace with fresh oil every 500 hours.
- 24 Grease motors annually.
- 25 At completion of each drive: Clean & empty conveyor; inspect cables for wear or damage - repair or replace; inspect cutters for wear or damage - repair or replace.
26. Refer to P400/P600 Power Pack, and haul unit operation manuals for maintenance.

Storage

PREPARING FOR STORAGE

NOTICE

Follow the lubrication and maintenance requirements in the Periodic Maintenance section.

1. Repair worn or damaged parts.
2. Wash all equipment thoroughly.
3. Lubricate all grease points. Grease threads on bolts used for adjustments.
4. Retract all hydraulic cylinders if possible. If not, coat exposed cylinder rods with a corrosion preventive.
5. Repaint equipment where necessary.
6. Drain hydraulic oil, flush oil reservoirs, change hydraulic filters, and refill hydraulic reservoirs. Check for leaks.
7. Wipe up lube spills. Dispose of rags and trash properly. Store oily rags and other flammable material in protective containers.
8. If possible, store equipment under cover and out of the weather in a ventilated area.
9. Remove guidance target and place it in the storage box.
10. Loosen conveyor belt to prevent stretching of belt.
11. Do not smoke in areas where flammable materials are stored.
12. Store fuels and lubricants in properly marked containers.

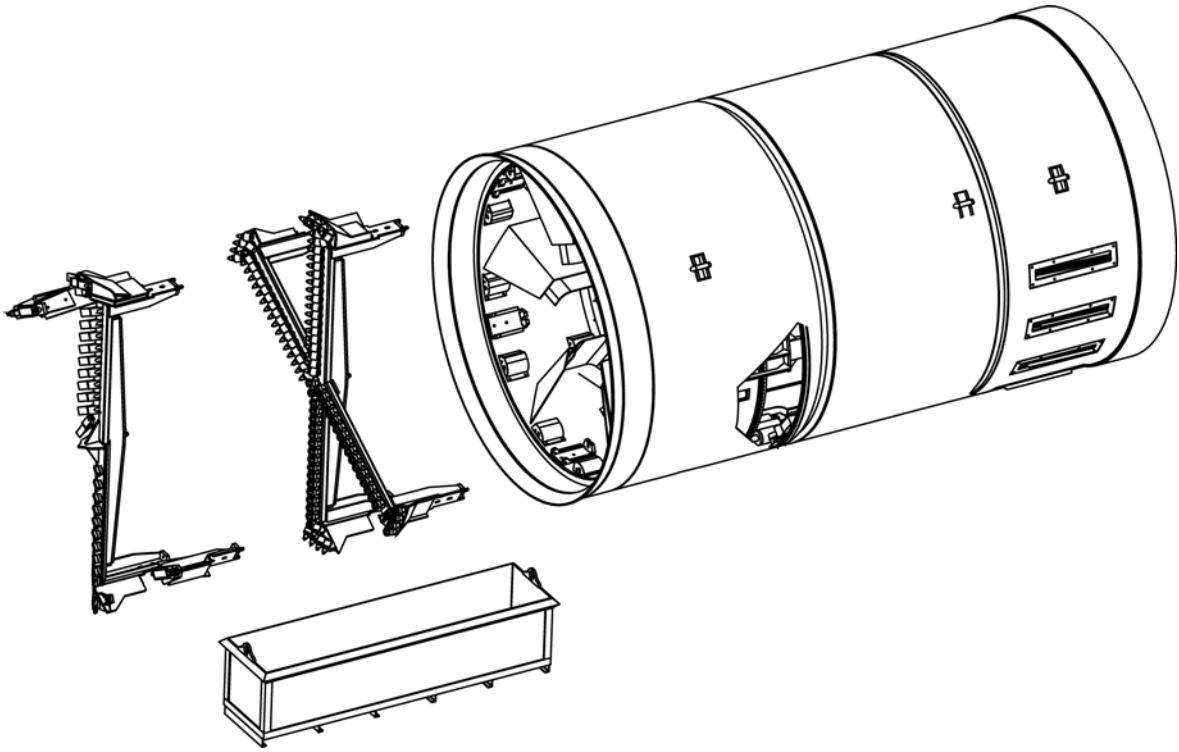
REMOVING FROM STORAGE

NOTICE

Follow the lubrication and maintenance requirements in the Periodic Maintenance section.

1. Clean equipment thoroughly.
2. Check to make sure all decals including safety decals are clean and readable.
3. Check condition of wires and cables. Repair or replace as necessary.
4. Remove the cylinder corrosion preventive from the cylinder rods if it is not compatible with hydraulic oil or seal materials.
5. Check for leaks. Repair or replace as necessary.
6. Check hydraulic oil level in reservoirs. If fluid is low, check for leaks and add oil as required. Refer to Lubricants section.
7. Check condition of all hoses and connections. Tighten, repair or replace with new as needed.
8. Before operating, cycle hydraulic functions several times to purge air from the hydraulic system.
9. On conveyor, readjust belt to proper tension.
10. Review this Operator's Manual.

Specifications



- Standard cutter heads: dirt cutter bar, and quad carbide cutter bar.

TBM

Outside Diameter	114"/116"	Cutter Head Flow	150 gpm
Cutting Diameter	115.5"/117.5"	Drive Motors	(8) 57 CID
Cutting Torque	200,000 ft-lbs.	Operating Voltage for TBM ..	120 VAC Single Phase
Cutting Speed	0 - 5 rpm	Operating Current for TBM	20 AMP
		Operating Pressure (Maximum)	2,800 psi

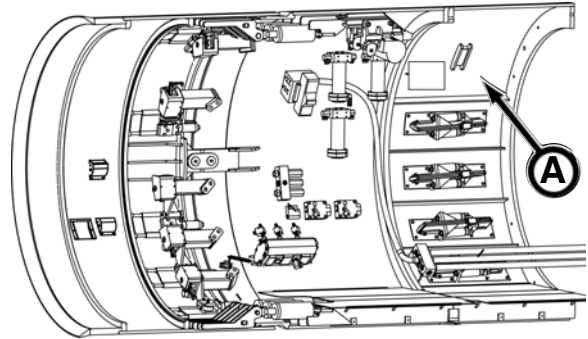
Identification Numbers

Model and serial numbers are required when ordering parts or requesting service information. Record your model and serial numbers below.

TUNNEL BORING MACHINE (A)

Model Number _____

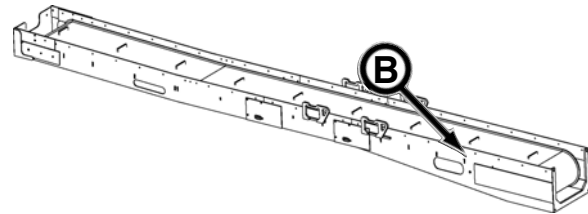
Serial Number _____



CONVEYOR (B)

Model Number _____

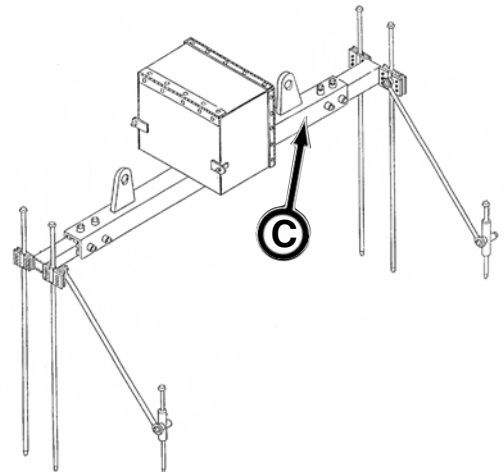
Serial Number _____



LASER LIGHT STAND (C)

Model Number _____

Serial Number _____



Material Safety Data Sheets

The Federal Occupational, Safety, and Health Administration (OSHA) Standard 29 CFR 1910.1200, require that specific material safety data sheets (MSDS) be available to employees before operating this equipment. This may include information on substances contained in this equipment such as hydraulic fluid and gear lubricant.

Akkerman Inc. will provide, at no cost, MSDS which apply to its product line. Simply contact your Akkerman Product Support representative for a copy.

To ensure a prompt response to your MSDS request, include your return address (including zip or postal code) and the equipment's model numbers and serial numbers with your request.

Warranty

Akkerman Inc. warrants that all equipment manufactured by it be free from defects due to workmanship or material under normal use and service for a period of 90 days. This warranty does not apply to normal wear items such as cutter teeth, filters, etc. Akkerman Inc. does not warrant the fitness of its equipment for a particular purpose or application.

NOTES