OPERATOR'S MANUAL

Tunnel Boring Machine

Wheel Machines

360 - 420 - 48SC - 480 - 540 - 600 - 660 - 720 - 780

BH S/N: 25300 - 23700 - 19650 - 23800 - 18300 - 19325 - 4410 - 20800 - 25000

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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, pump unit/power pack operator's manual, and your gas detection system 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 Aftermarket Support Department, or downloaded from the Akkerman web site at www.akkerman.com.

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 Tunnel Boring 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 Tunnel Boring Machine With 5000 Pump Unit

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 or pump unit 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. Email your comments via the form on the Contact Us page of the Akkerman web site, or 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.

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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.

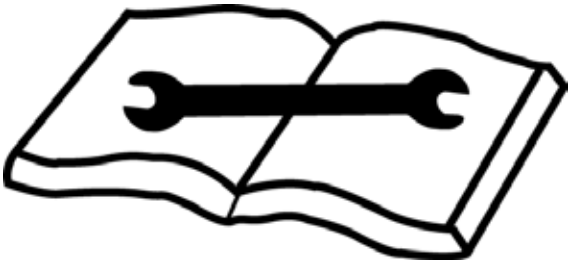
ATTENTION!
BECOME ALERT!
YOUR SAFETY IS INVOLVED!

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.

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.

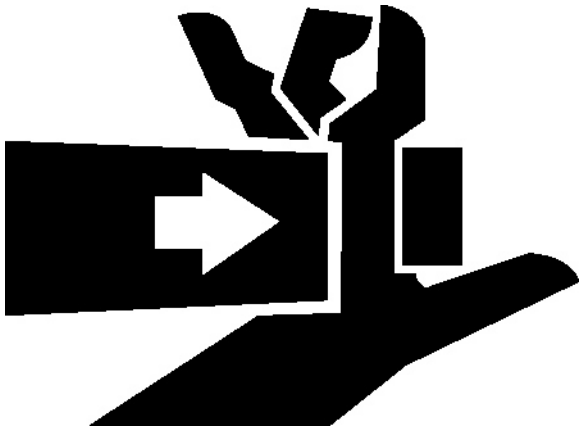
AVOID PINCH POINTS

⚠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.

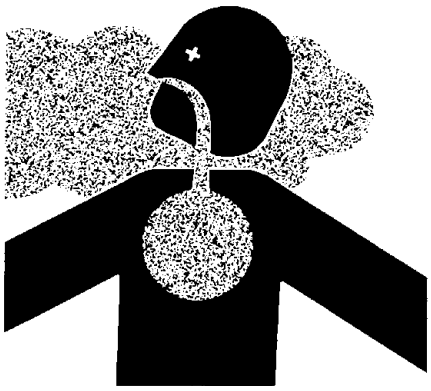
Handle parts carefully to avoid crushing and pinch point hazards.



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 TBM, tunnel and shafts 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.

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.

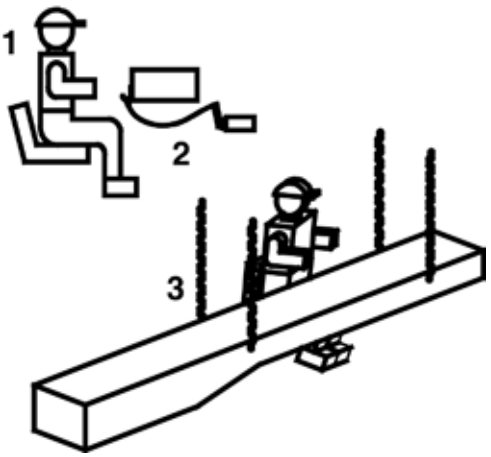
CONVEYOR OPERATION

⚠WARNING Conveyor can jam in rotating cutterhead causing conveyor to swing into operator, resulting in severe personal injury.

While cutterhead is rotating:
1. Operator MUST remain seated in normal operating position.

2. Cutterhead drive dump valve (conveyor safety valve) MUST be tethered to conveyor.

3. ALL FOUR safety chains MUST be secured to conveyor.



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.

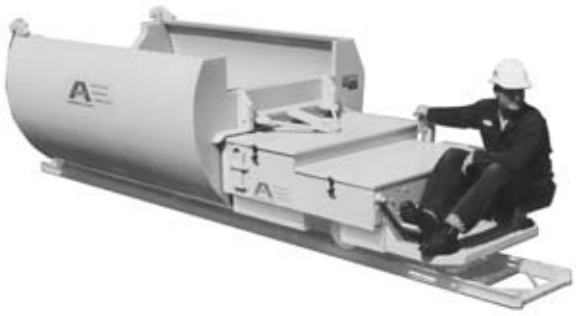
Lockout power before servicing.

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.

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.

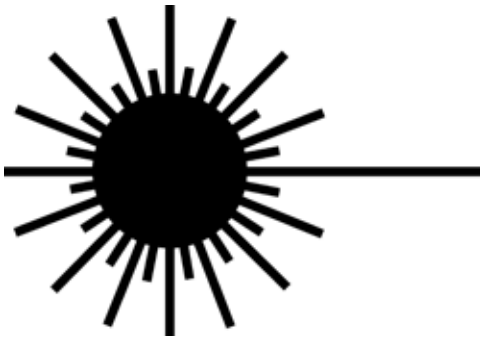
Be sure to keep job site clean and organized.

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

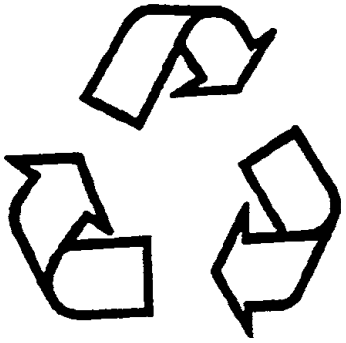


⚠DANGER Staring into laser light will cause severe injury.

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.

NOTES

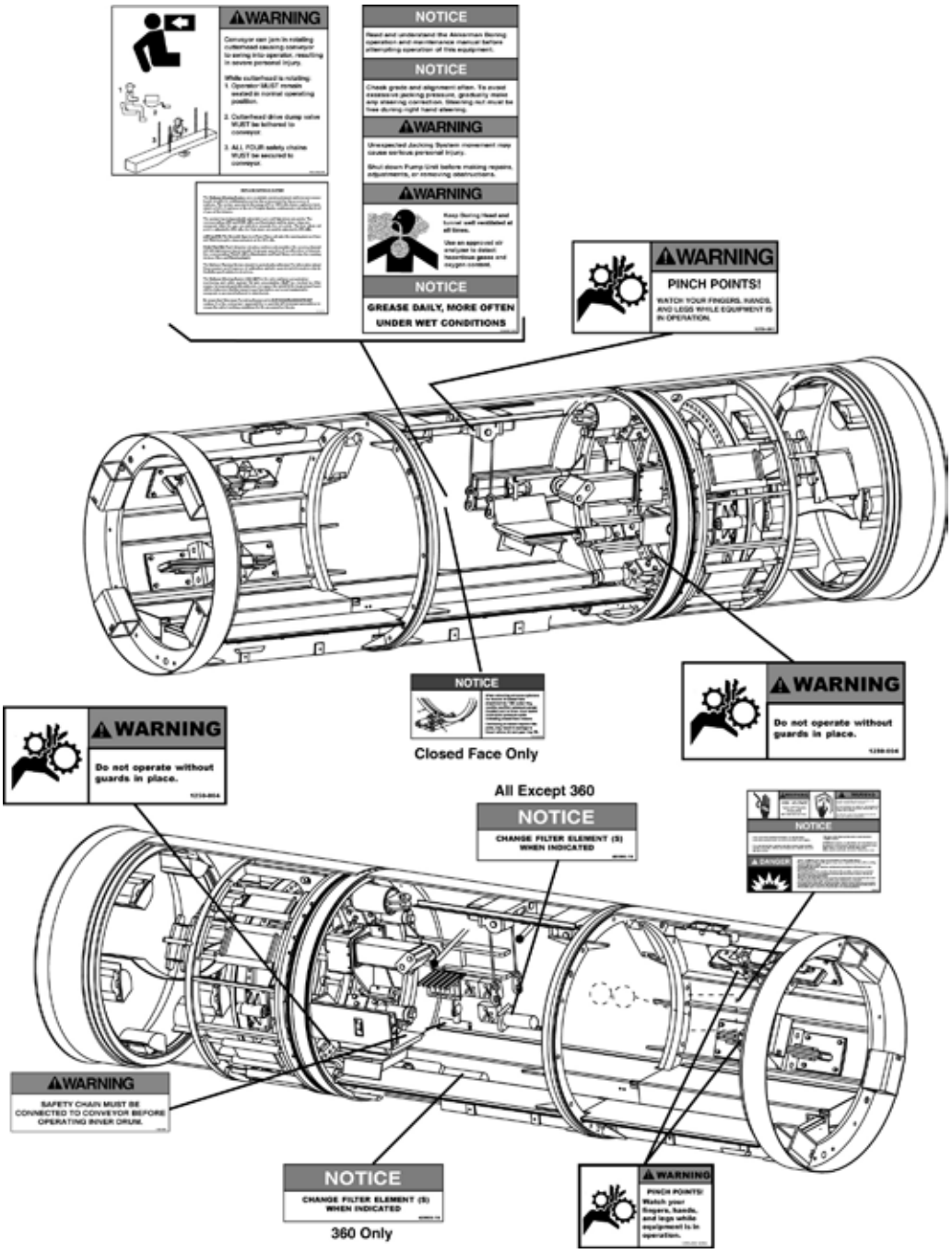
Safety Decals

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 will damage the surface of the decal. Replace safety decals immediately if they are damaged, missing, or hard to read.

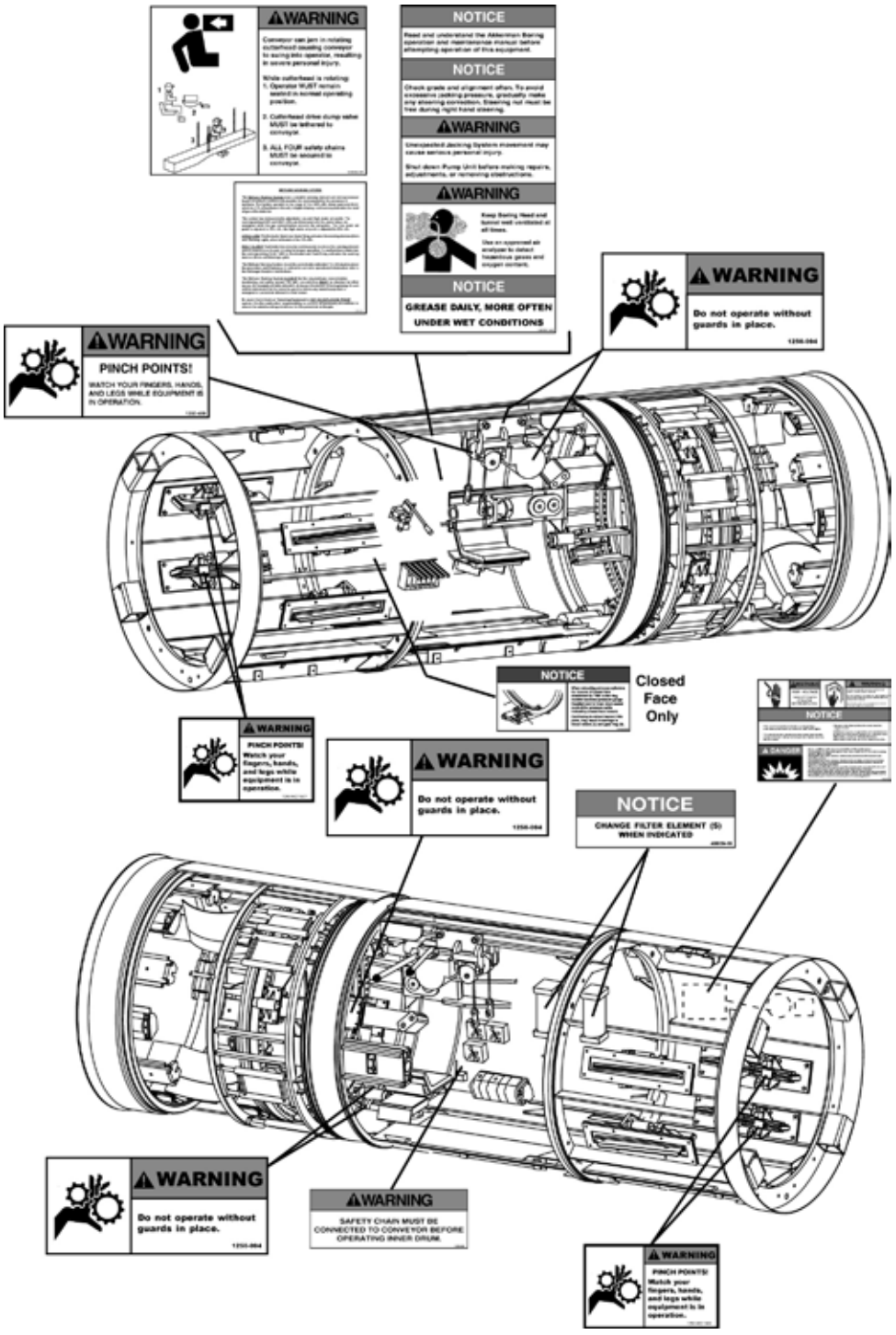
Serious injury or property damage can occur if safety instructions are not followed. Contact your Akkerman Aftermarket Support representative for free replacement safety decals.

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.

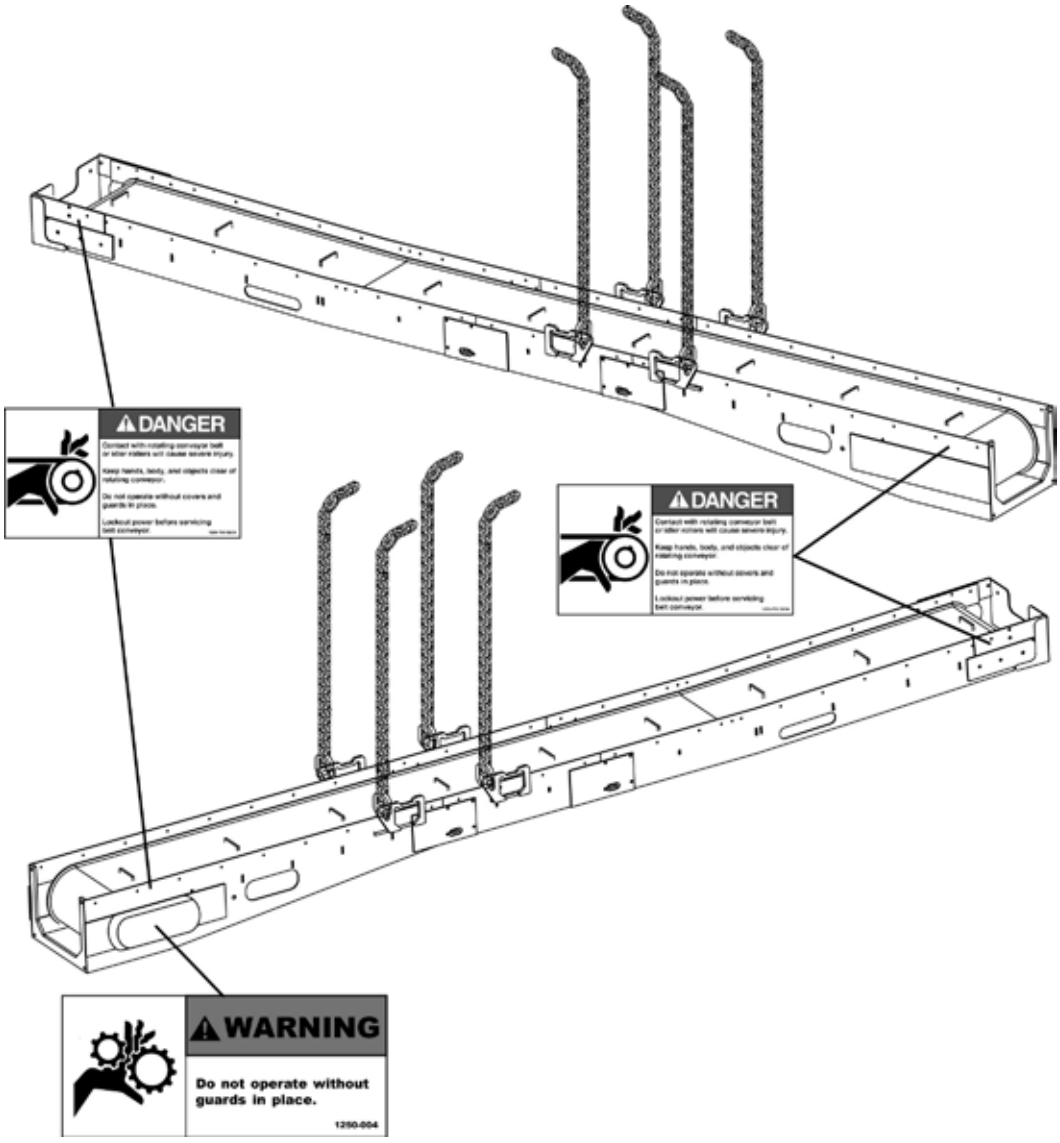
TUNNEL BORING MACHINE - 360 - 48SC - 420 - 480 - 540 (SN1-3)



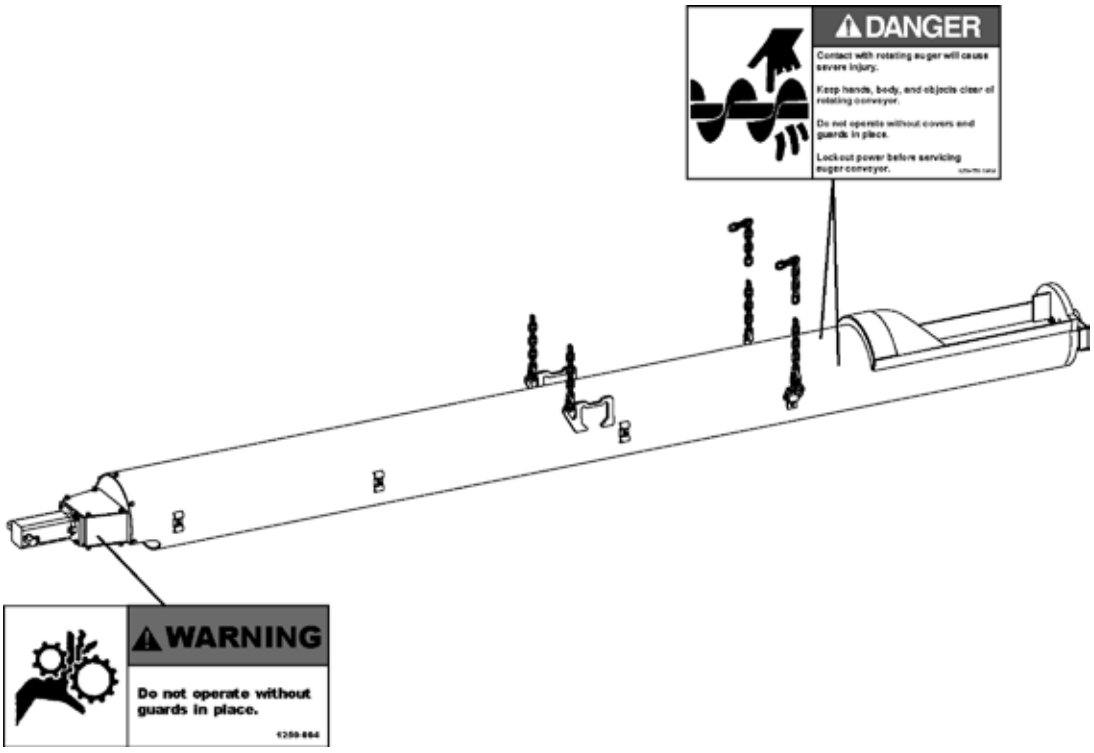
TUNNEL BORING MACHINE - 540 (SN4 & AFTER), 600 - 660 - 720 - 780



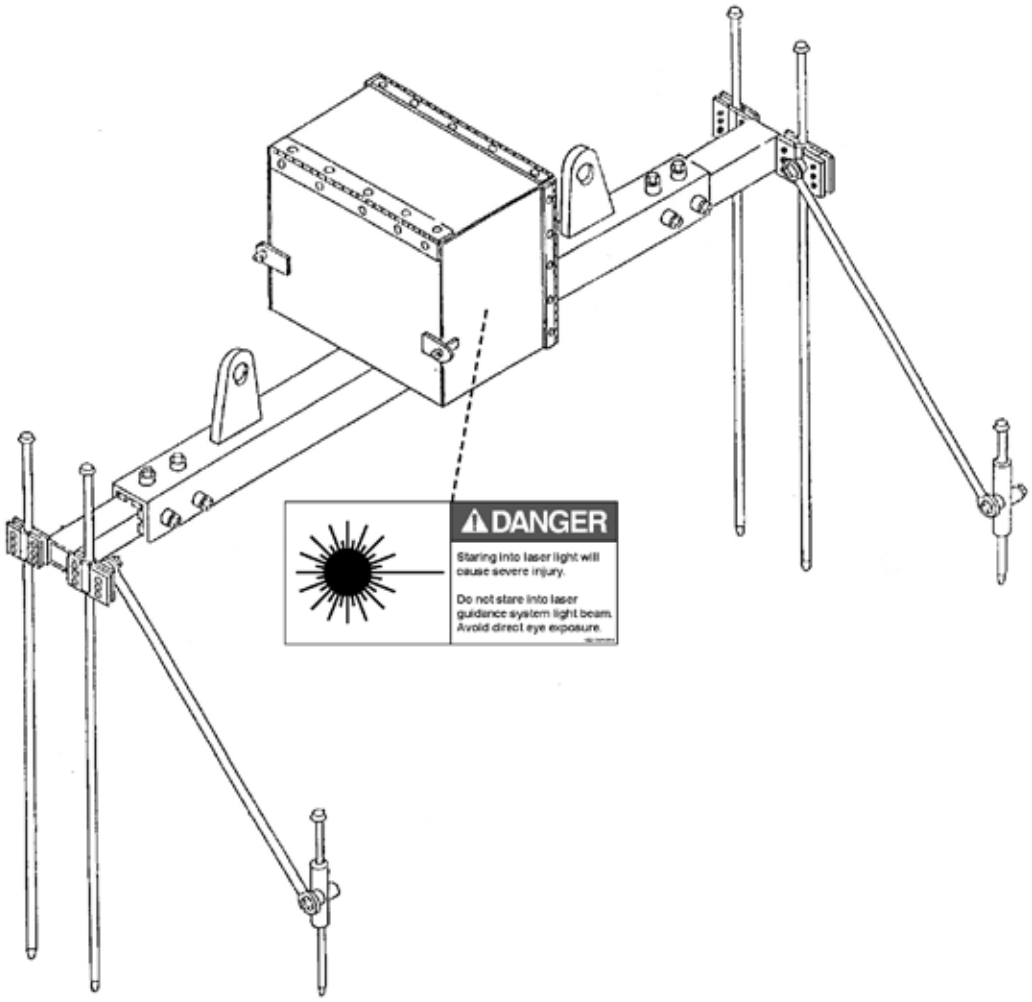
BELT CONVEYOR



SCREW CONVEYOR



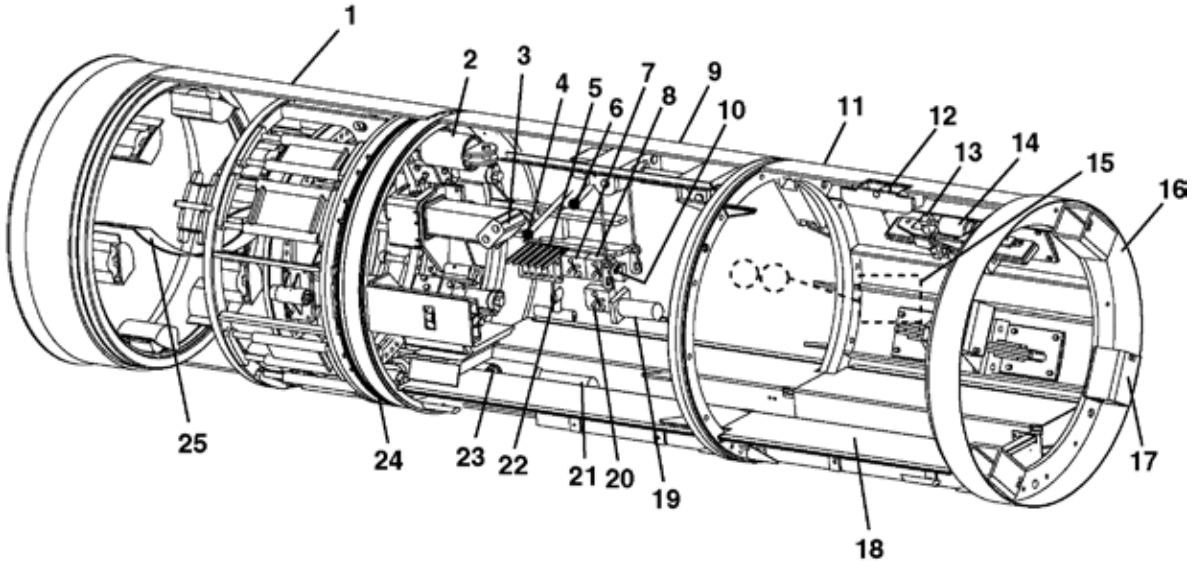
LASER SIGHT

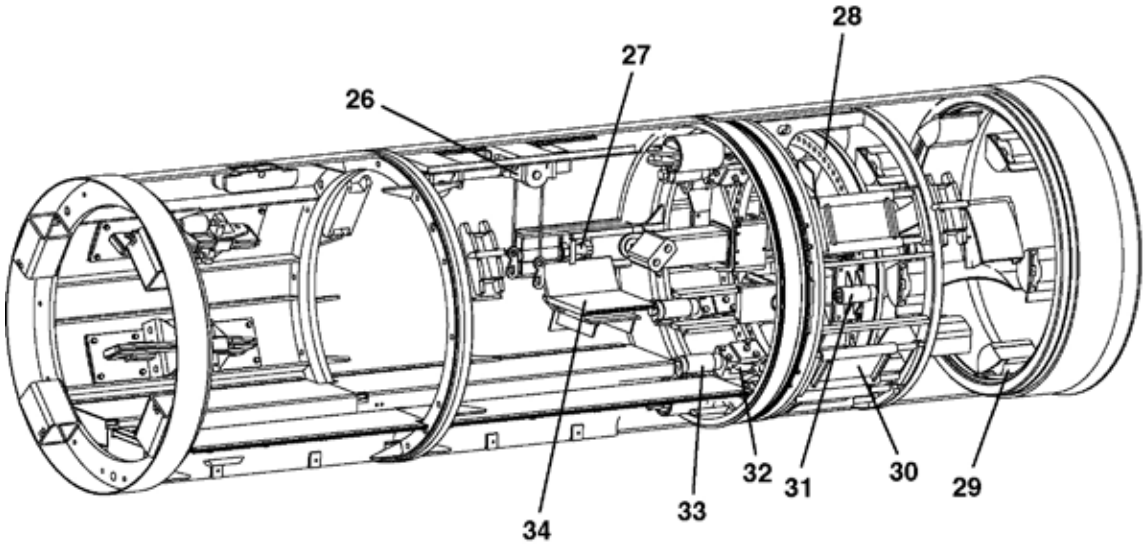

DANGER
Staring into laser light will cause severe injury.
Do not stare into laser guidance system light beam. Avoid direct eye exposure.

NOTES

Terminology

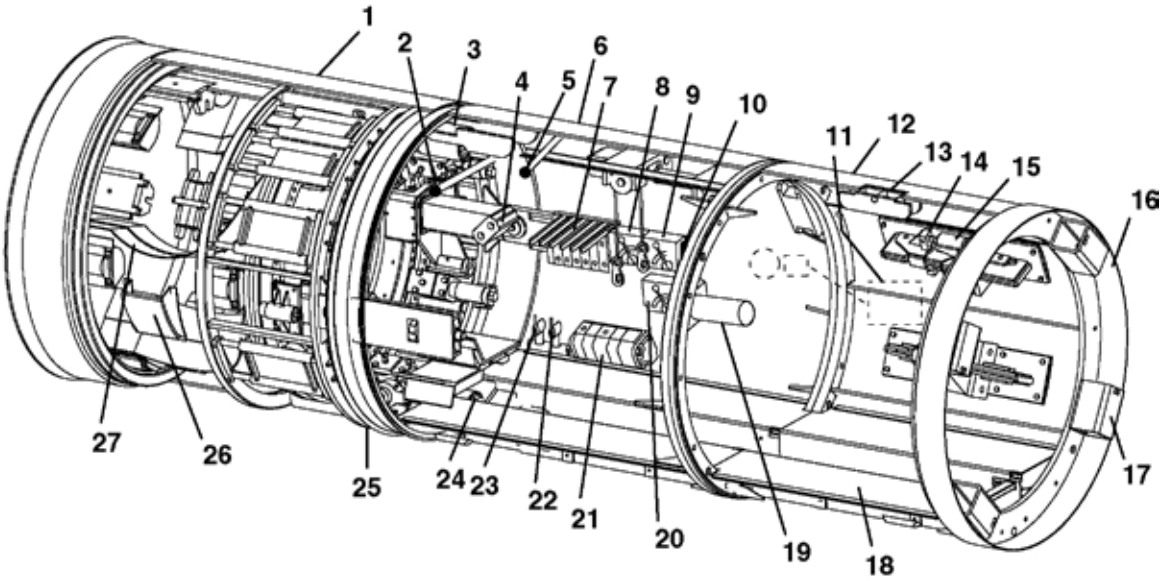
TUNNEL BORING MACHINE (360 - 48SC - 420)

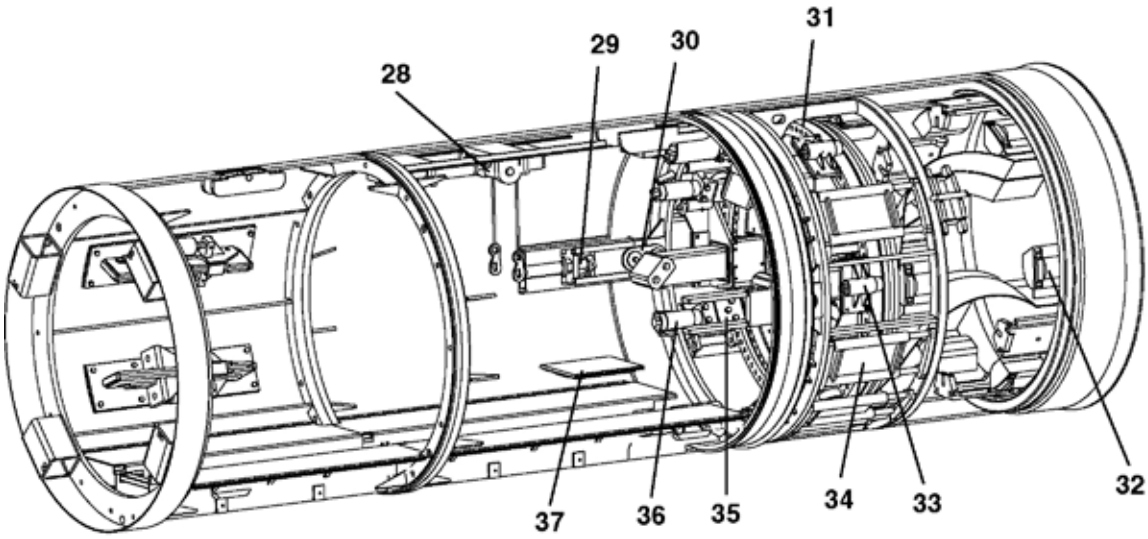




1. Front Drum & Drive Assembly
2. Steering Cylinder (Top)
3. Drive Motor
4. Inner Drum Control
5. TBM Control Valve
6. Conveyor Drive Control
7. Conveyor Speed Control
8. Inner Drum Speed Control
9. Mid Drum Assembly
10. Grade/Alignment Control
11. Dirt Wing Drum Assembly
12. Lift Pocket
13. Dirt Wing Assembly
14. Dirt Wing Cylinder
15. Gas Detection System
16. Bell End Ring
17. Push Block
18. Floor Assembly
19. Pressure Filter (420, 48SC)
20. Steering Speed Selector
21. Pressure Filter (360)
22. Conveyor Safety Valve
23. Steering Cylinder (Bottom)
24. Steering Joint
25. Dirt Paddle
26. Conveyor Lift
27. Steering Adjustment (Side to Side)
28. Gear Ring
29. Drum Roller
30. Advance Slide Bracket
31. Idler Roller
32. Advance Assembly
33. Advance Cylinder
34. Operator Seat

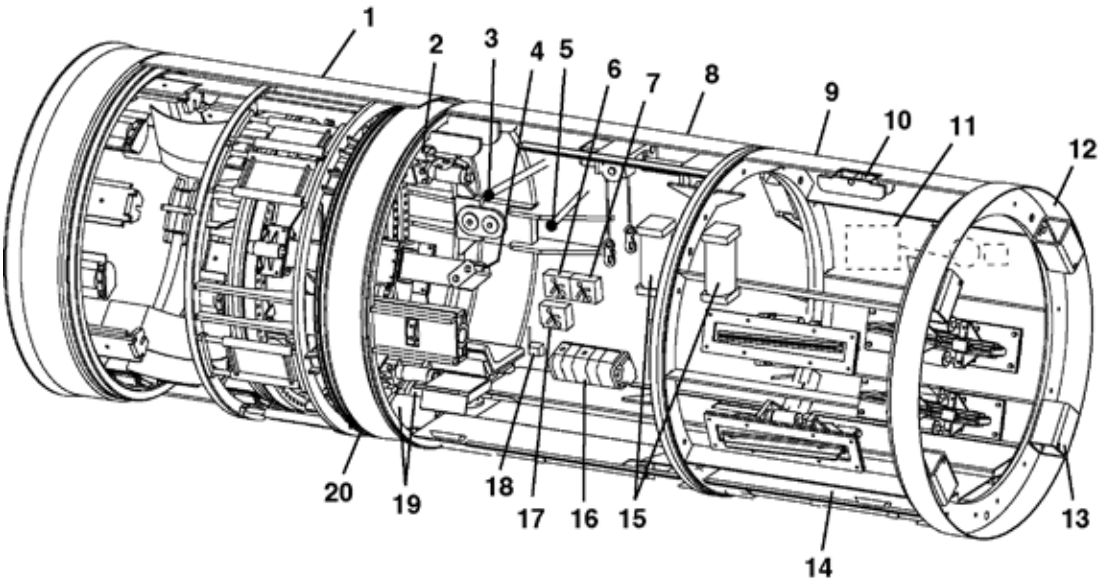
TUNNEL BORING MACHINE - 480, 540 (SN BH18300-01 THRU -03)

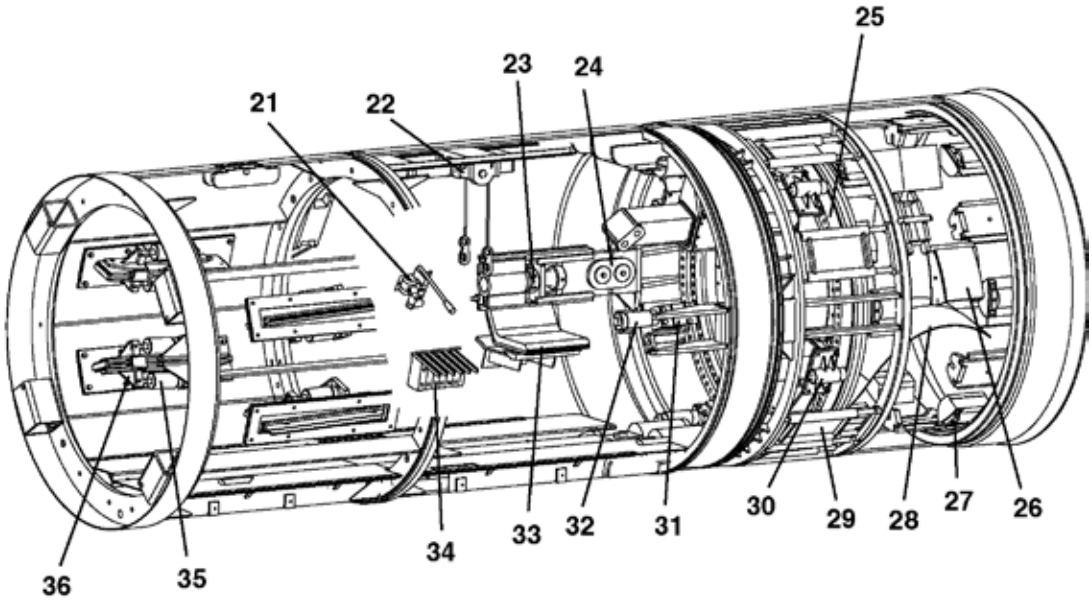




1. Front Drum & Drive Assembly
2. Inner Drum Control
3. Steering Cylinder (Top)
4. Drive Motor
5. Conveyor Drive Control
6. Mid Drum Assembly
7. TBM Control Valve
8. Conveyor Speed Control
9. Inner Drum Speed Control
10. Grade/Alignment Control
11. Gas Detection System
12. Dirt Wing Drum Assembly
13. Lift Pocket
14. Dirt Wing Assembly
15. Dirt Wing Cylinder
16. Bell End Ring
17. Push Block
18. Floor Assembly
19. Pressure Filter
20. Selector Speed Control
21. Flow Divider
22. Single/Dual Feed Control
23. Conveyor Safety Valve
24. Steering Cylinder (Bottom)
25. Steering Joint
26. Dirt Scoop
27. Dirt Paddle
28. Conveyor Lift
29. Steering Adjustment (Side to Side)
30. Steering Link
31. Gear Ring
32. Drum Roller
33. Idler Roller
34. Advance Slide Bracket
35. Advance Assembly
36. Advance Cylinder
37. Operator Seat

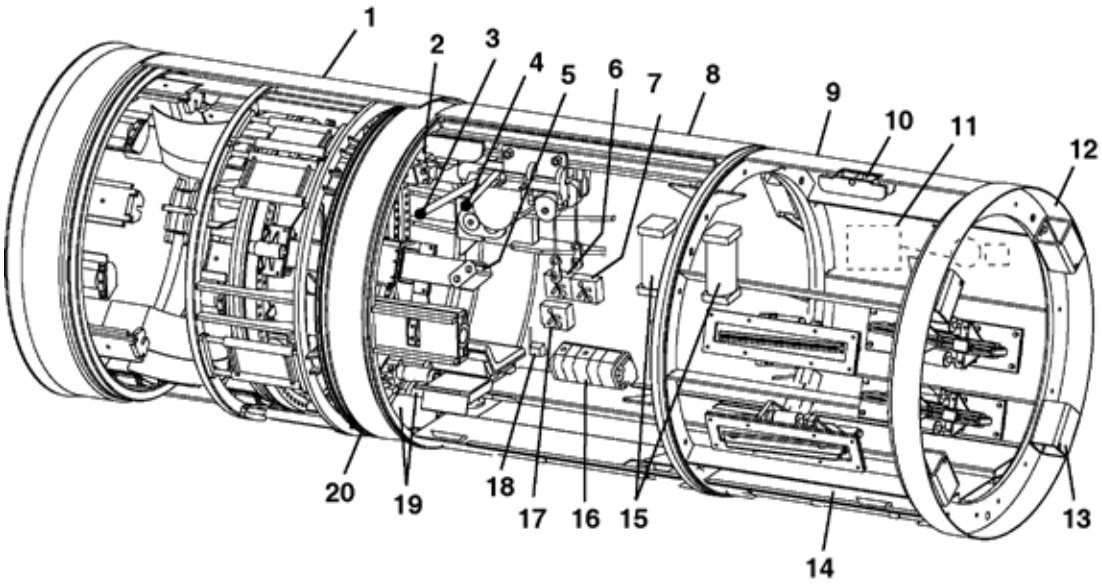
TUNNEL BORING MACHINE - 540 (SN BH18300-04 & AFTER)

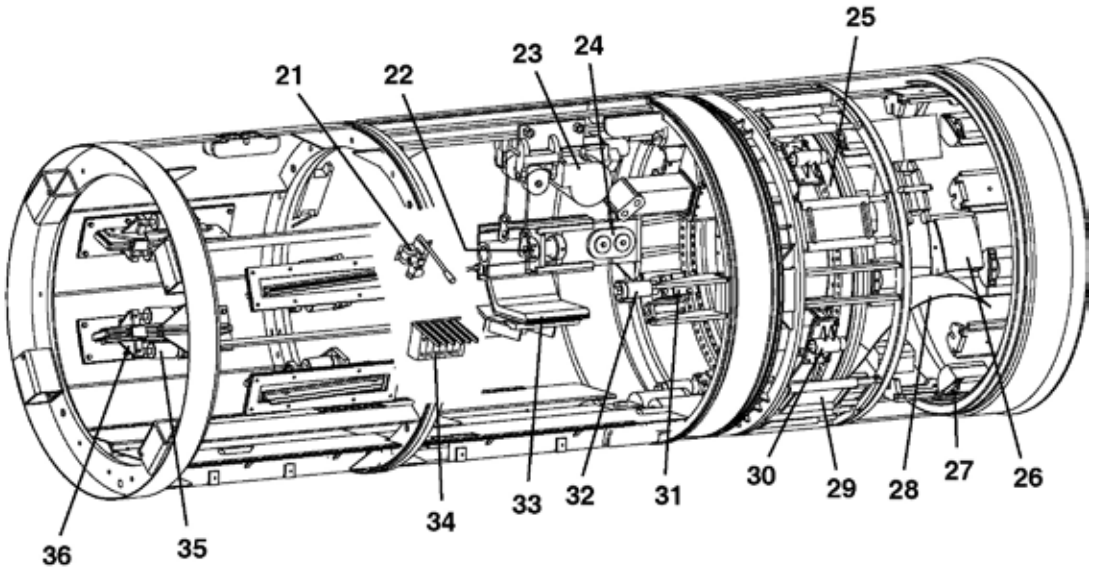




1. Front Drum & Drive Assembly
2. Steering Cylinders (Top)
3. Inner Drum Control
4. Drive Motor
5. Conveyor Drive Control
6. Conveyor Speed Control
7. Inner Drum Speed Control
8. Mid Drum Assembly
9. Dirt Wing Drum Assembly
10. Lift Pocket
11. Gas Detection System
12. Bell End Ring
13. Push Block
14.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

TUNNEL BORING MACHINE - 600 - 660 - 720 - 780

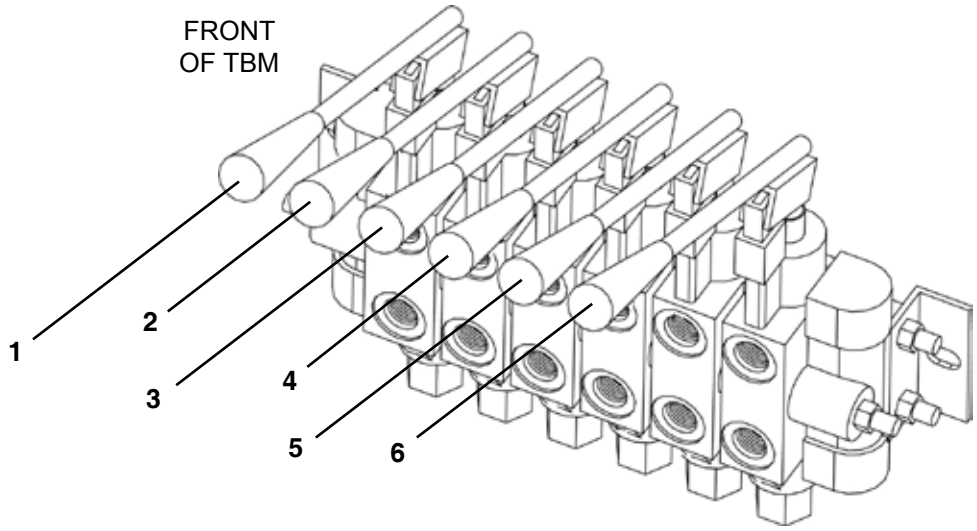




1. Front Drum & Drive Assembly
2. Steering Cylinders (Top)
3. Inner Drum Control
4. Conveyor Drive Control
5. Drive Motor
6. Inner Drum Speed Control
7. Conveyor Speed Control
8. Mid Drum Assembly
9. Dirt Wing Drum Assembly
10. Lift Pocket
11. Gas Detection System
12. Bell End Ring
13. Push Block
14.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

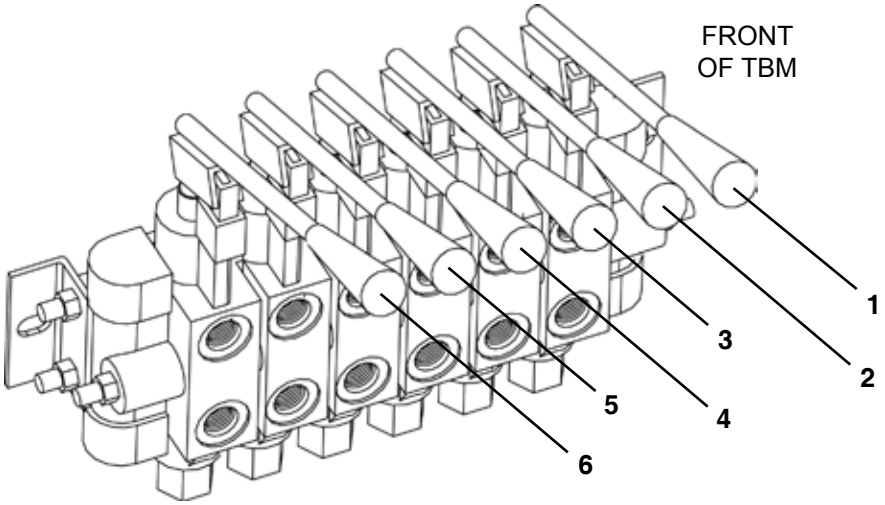
TBM CONTROL VALVE

360 - 48SC - 420 - 480 - 540 (sn BH18300-01 thru 03)



1. Inner Drum Advance
2. Conveyor Lift
3. Steering Cylinders
4. Auxiliary or Closed Face Attachment Doors
5. Dirt Wing Cylinders
6. Dirt Wing Cylinders

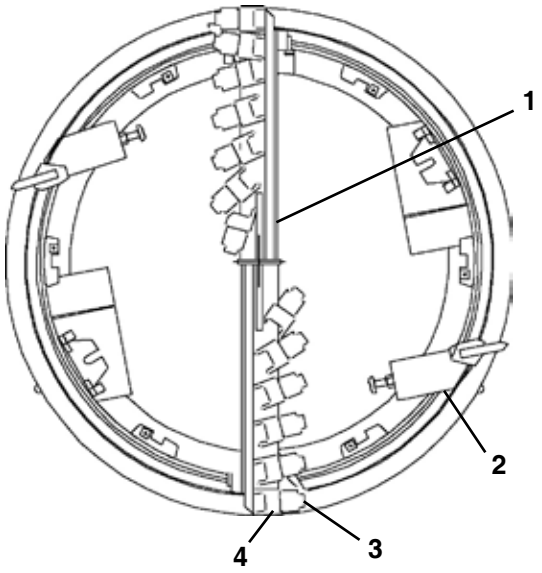
540 (sn BH18300-04 and after), 600, 660, 720, 780



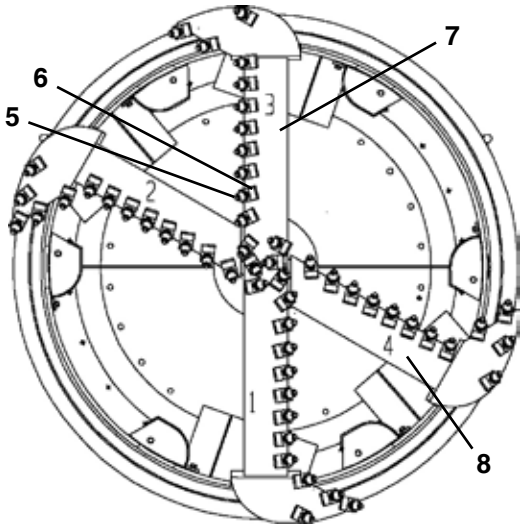
1. Inner Drum Advance
2. Conveyor Lift
3. Steering Cylinders
4. Auxiliary or Closed Face Attachment Doors
5. Dirt Wing Cylinders
6. Dirt Wing Cylinders

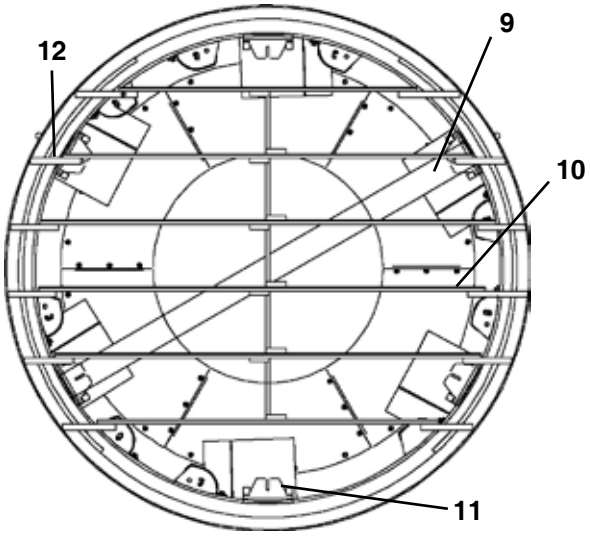
CUTTER HEAD ATTACHMENTS

Dirt Head

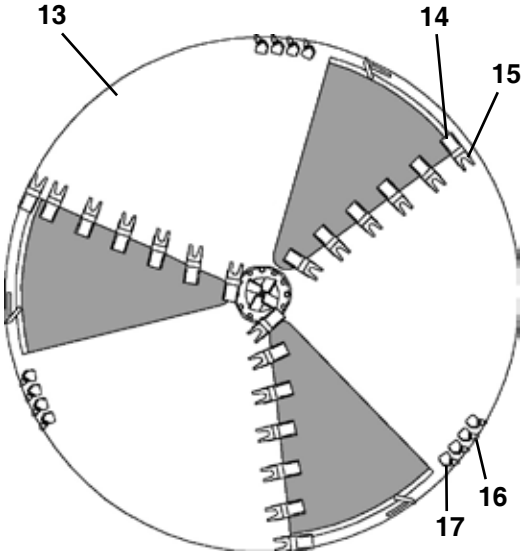


Quad Carbide Bar Head





Sand Head



Closed Face

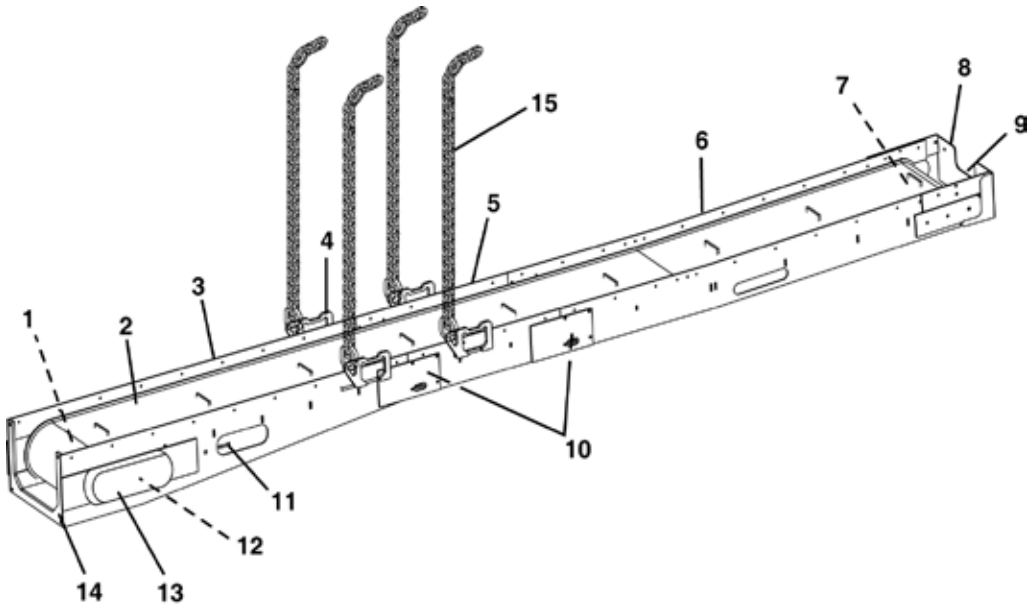
Dirt Cutter
1. Cutter Bar
2. Adjustable Cutter
3. Tooth Cutter
4. Tooth Pocket

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

Sand Head
9. Cutter Bar
10. Sand Shelf
11. Cutter Bar Mount
12. Sand Shelf Bracket

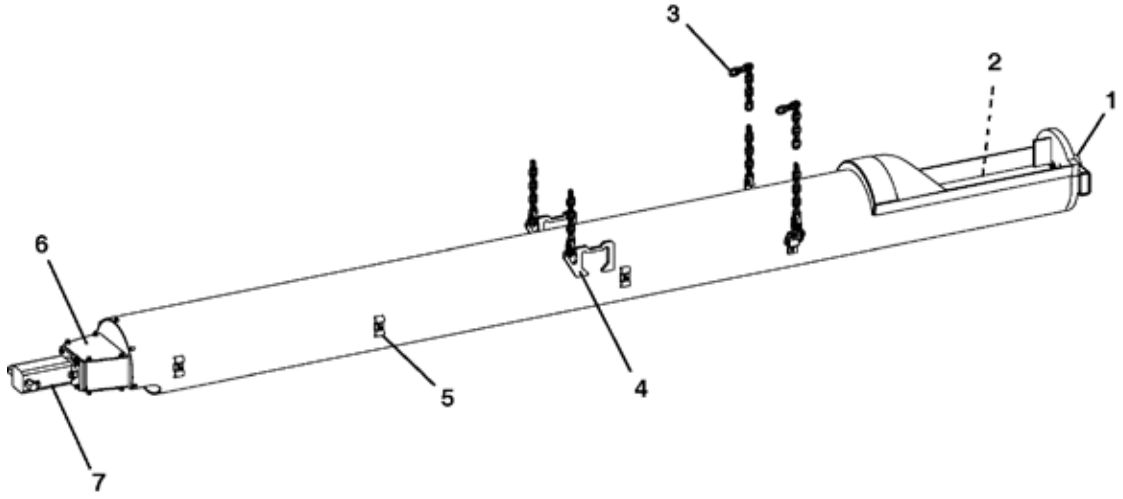
Closed Face
13. Closed Face
14. Cutter Tooth
15. Tooth Pocket
16. Cutter Bit
17. Bit Holder

CONVEYOR - BELT



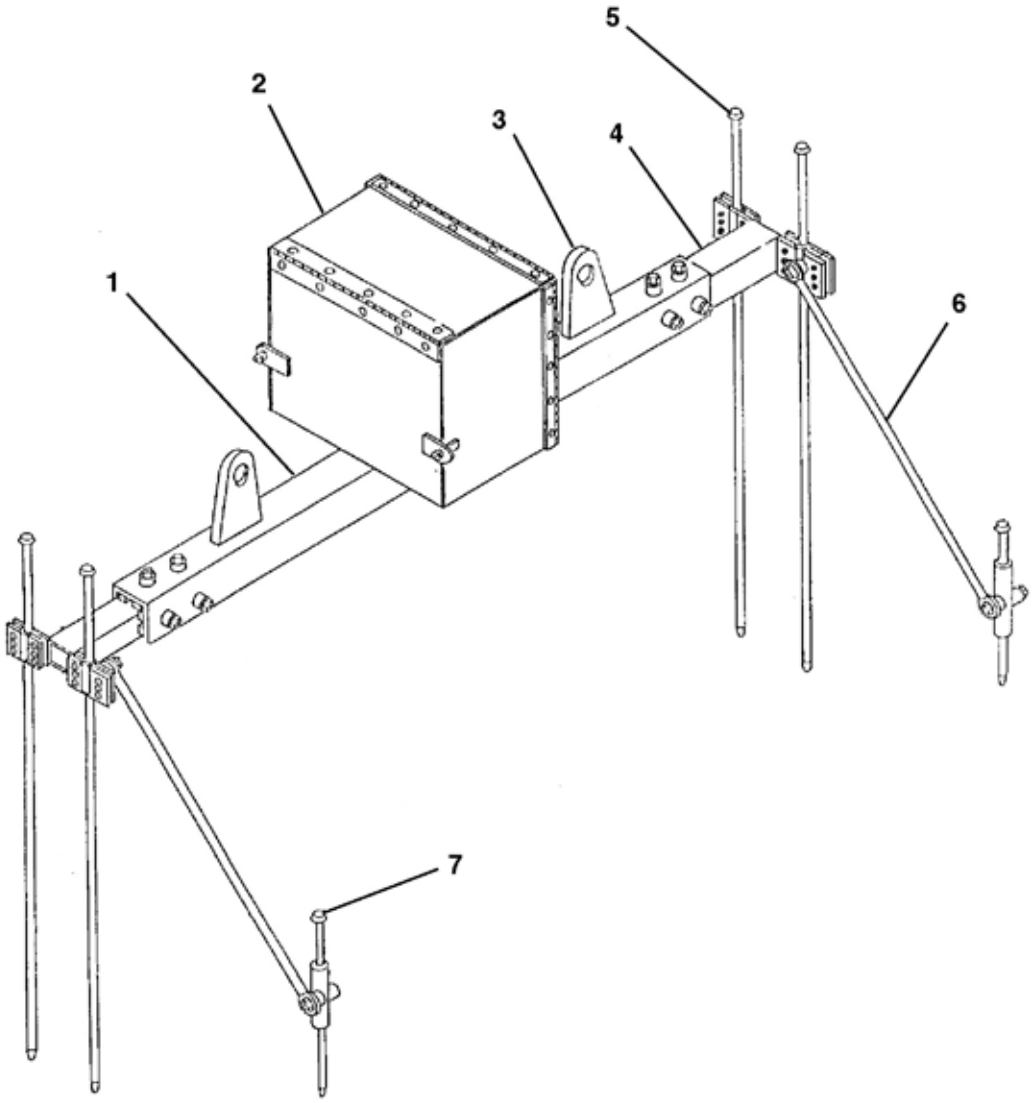
1. Drive Motor Frame Assembly
2. Belting
3. Drive Frame Assembly
4. Lift Bracket
5. Extension Frame Assembly
6. Feed Frame Assembly
7. Front Roller Assembly
8. Dirt Guard
9. Carrier Bearing
10. Idler Roller
11. Belt Tensioning Screw
12. Drive Motor & Roller Assembly
13. Conveyor Chain Cover
14. Drive Frame Free End Support
15. Safety Chain

CONVEYOR - SCREW



1. Carrier Bearing
2. Auger
3. Safety Chain
4. Lift Bracket
5. Hose Clamp
6. Motor Mount
7. Motor

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

NOTES

Controls & Instruments

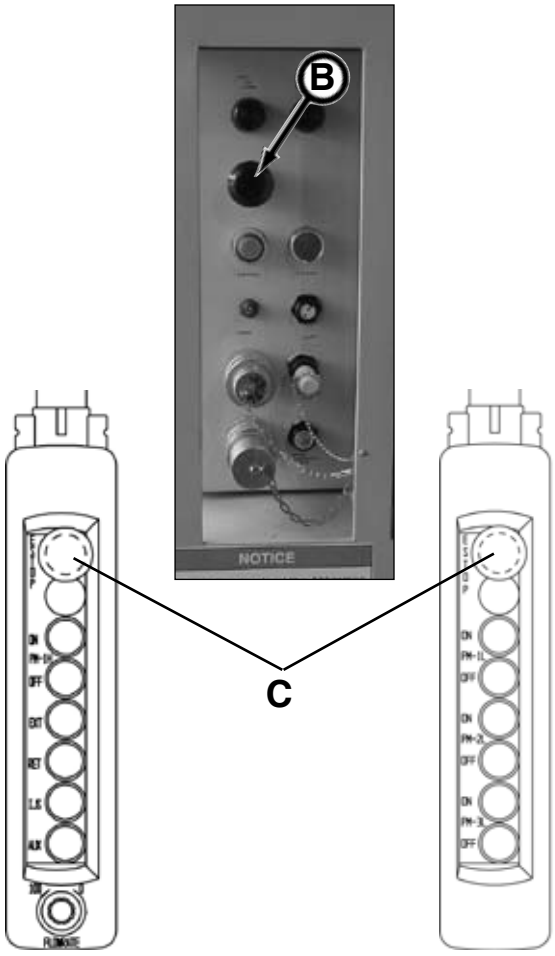
EMERGENCY STOP

5000 Pump Unit
The Emergency Stop button (A) is the main electrical emergency switch which will stop and start the electrical motor rotation. The TBM and 5000 Pump Unit operating lights will remain on when the emergency stop button is pushed IN to stop position.
The button functions as follows.

STOP - Push button IN
START - Pull button OUT

P400/P600 Power Packs
The Emergency Stop buttons on the Power Pack control panel (B), pendants (C), and any remote emergency stops will stop the electrical motor rotation and hydraulic power. The TBM and Power Pack operating lights will remain on when any of the emergency stop buttons are pushed IN to stop position.
The button functions as follows.

STOP - Push button IN
Power for Start Circuit - Pull button OUT



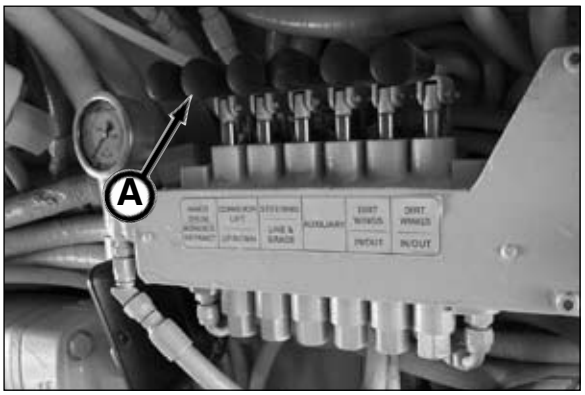
CONVEYOR CONTROLS

Conveyor Lift

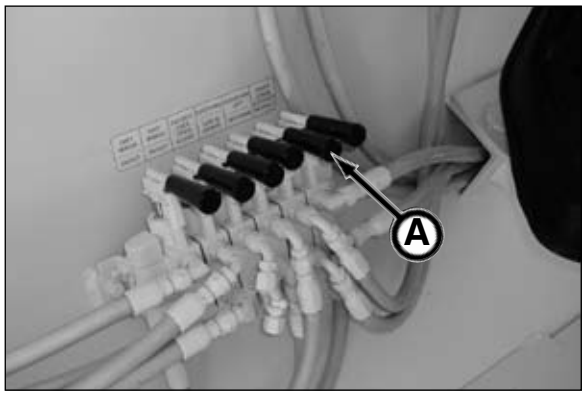
The conveyor lift control (A) on the TBM control valve raises or lowers the conveyor. Move the lever as follows:

UP - raises conveyor
DOWN - lowers conveyor

NOTICE Do not over-raise the conveyor. If conveyor is completely raised when the inner drum is retracted, damage will result to conveyor and/or conveyor cables.



360, 48SC, 420, 480, 540 (sn18300-1-3)

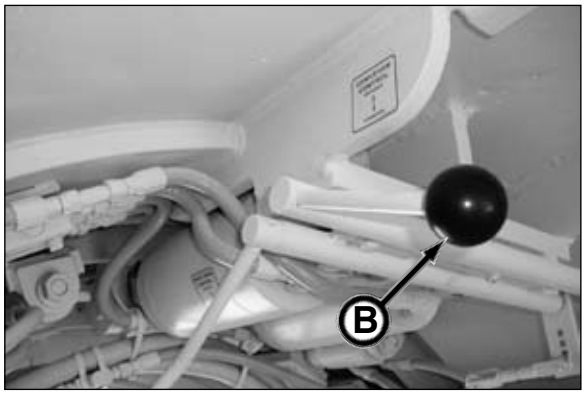


540 (sn18300-4 and after), 600, 660, 720, 780

Conveyor Drive

The conveyor drive lever (B) controls the forward and reverse direction of the belt or auger conveyor. Move the lever as follows:

UP - reverse (towards reception shaft)
DOWN - forward (towards launch shaft)



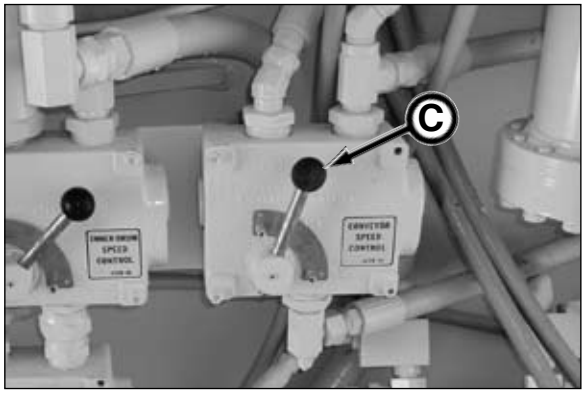
Conveyor Speed

The conveyor speed valve lever (C) controls the conveyor belt or auger speed. Move the lever as follows:

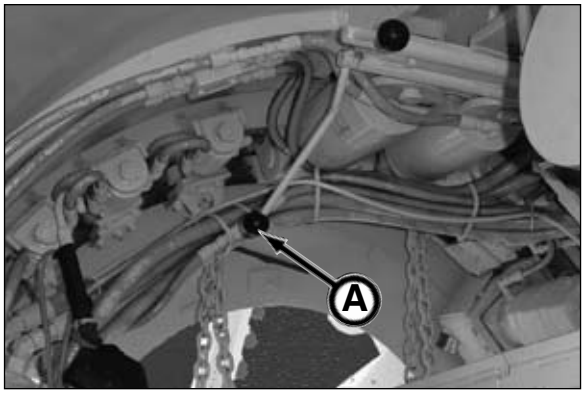
CW - increase speed
CCW- decrease speed

Control the speed of the conveyor so when the spoils drop on the conveyor, they do not pile up on the belt or in the auger. A change in TBM advancement rate or ground conditions will require an adjustment in the conveyor speed.

⚠WARNING Running the conveyor too fast can cause severe injury from flying debris and cause possible machine damage. Slow the conveyor speed so there is continual controlled movement of the spoils into the dirt bucket.



INNER DRUM CONTROLS

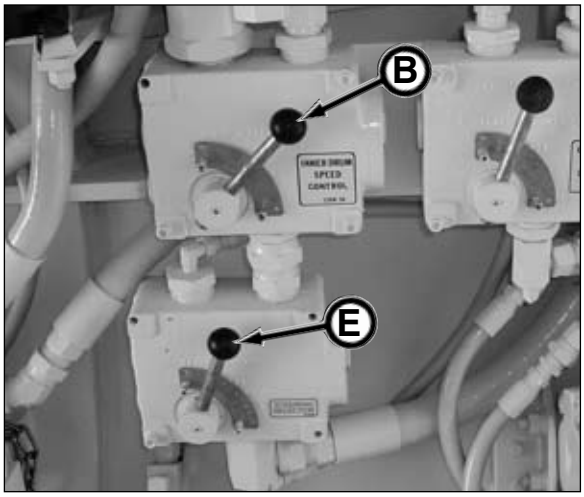


The Inner Drum Control lever (A) controls the inner drum and cutter head rotation. Move the lever as follows:

UP/Pull - reverse (CCW rotation*) direction
DOWN/Push - forward (CW rotation*) direction

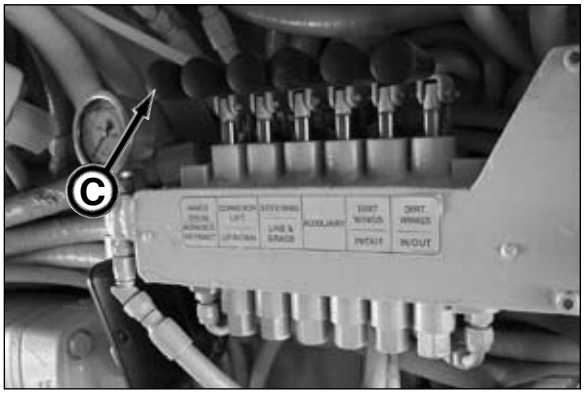
* as viewed from operator seat, inside TBM

NOTICE Verify the control direction before mining.



The Inner Drum Speed Control lever (B) controls the speed of the inner drum rotation. Move the lever as follows:

CW - increase speed
CCW - decrease speed



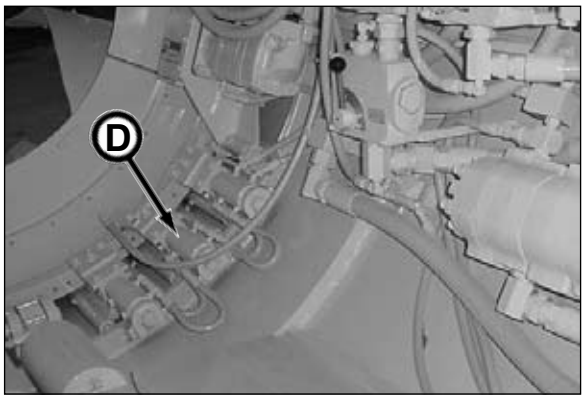
360, 48SC, 420, 480, 540 (sn18300-1-3)

The Inner Drum Advance Control lever (C) controls the inner drum advance cylinders (D). Move the lever as follows:

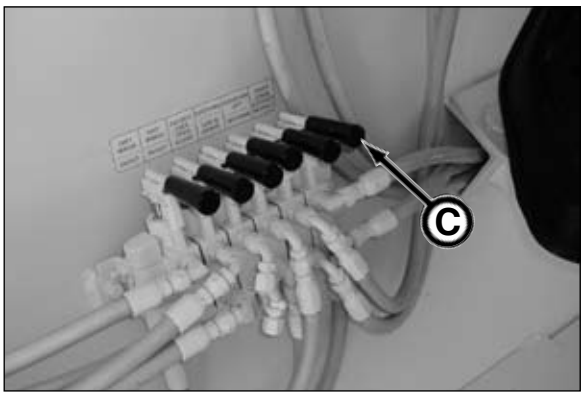
UP - advance
DOWN - retract

Use selector speed control (E) to adjust the speed of the inner drum advance cylinders. Move the lever as follows:

CW - increase speed
CCW - decrease speed



Inner Drum Advance Cylinder (D)



540 (sn18300-4 and after), 600, 660, 720, 780

GAS DETECTOR

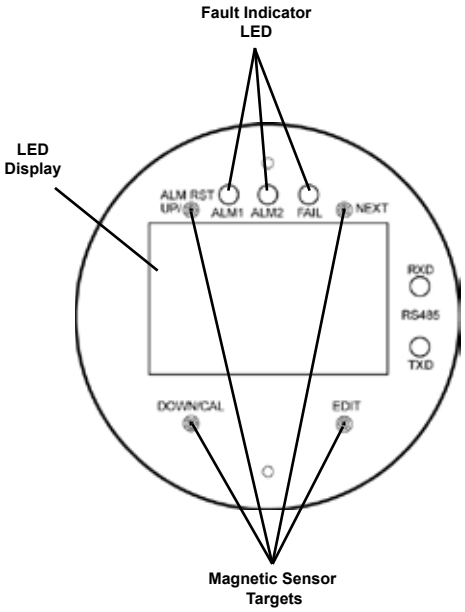
NOTICE Refer to Akkerman Gas Detection System Operation & Parts Manual for operation and maintenance procedures.

⚠ DANGER The gas detection system installed in the TBM, monitors only methane gas levels. **Monitoring of all 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 includes the following primary components; the gas sensor, and transmitter/relay. The Akkerman system also provides a power supply for the system, and an audible and visual alarm system.

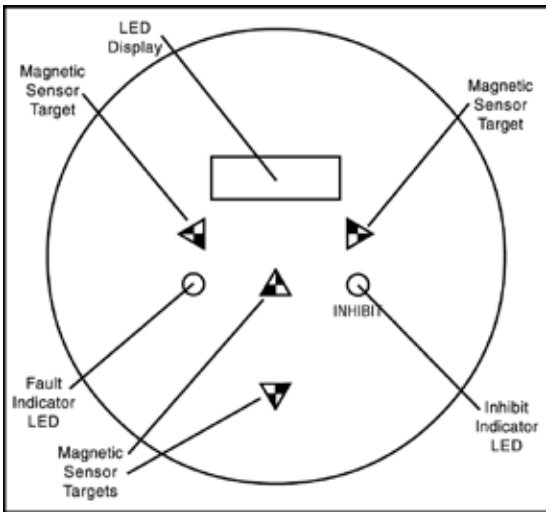
The transmitter has a LED/LCD display, depending upon the model of your gas detector. During normal operation, the current gas concentration is displayed. It is also used to display/scroll messages when in calibration mode or when a sensor fault is detected.

The four magnetic sensor controls are activated by a magnetic wand. Holding the magnetic wand over one of the magnetic sensor targets will activate that sensor. It may take several seconds for the magnetic sensor to activate. If the transmitter does not respond, remove the magnetic wand for several seconds and try again.



GDS GasMax II Transmitter Display

Zellweger Analytics



Zellweger Analytics Transmitter Display

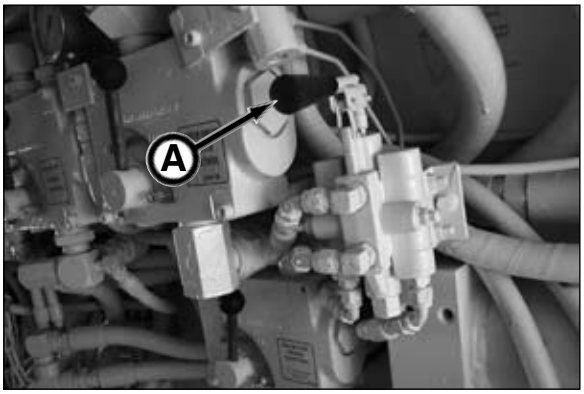
GDS GasMax II

GDS GasMax II Transmitter

STEERING CONTROLS

The steering controls include the steering selector, steering cylinder control, and steering adjustment nut.

When steering corrections are necessary, 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.



360, 48SC, 420, 480, 540 (sn18300-1-3)

Steering Selector
Use the steering selector (A) to select the grade or alignment adjustment.

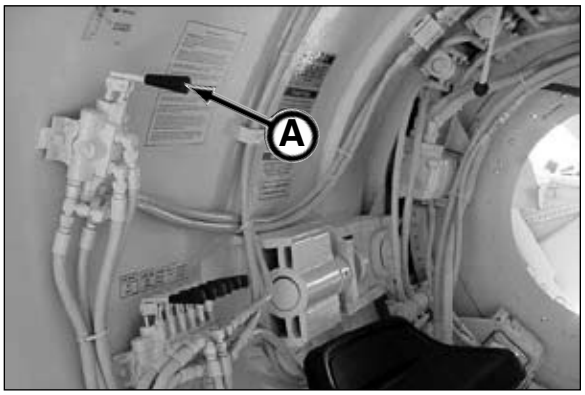
GRADE (up/down)
Move steering selector UP to select GRADE, then operate the steering cylinder control to adjust the steering cylinders. Once adjustment is made, move steering selector to Neutral position.

NEUTRAL
Move selector to middle position or Neutral to prevent accidental engagement of steering cylinders.

ALIGNMENT (left/right)
Move steering selector DOWN to select Alignment. Once adjustment is made, move steering selector to Neutral position.

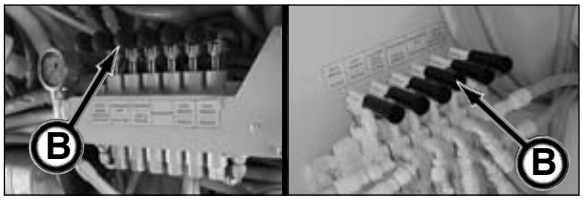
Left turn: operate the steering cylinder control (B) UP while turning steering adjustment nut (C) forward.

Right turn: operate the steering cylinder control (B) DOWN while turning steering adjustment nut back.



540 (sn18300-4 and after), 600, 660, 720, 780

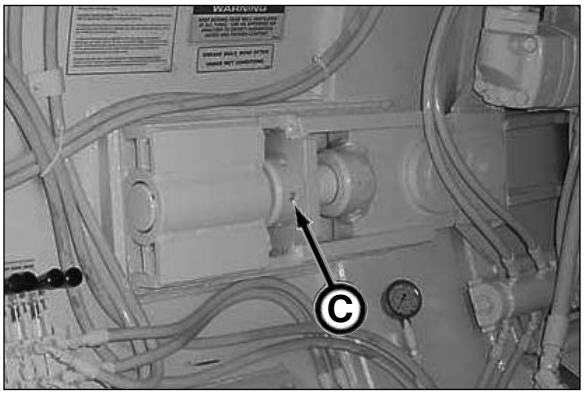
Steering Cylinder Control
The steering cylinder control lever (B) on the TBM control valve controls the extend and retract movement of the steering cylinders.



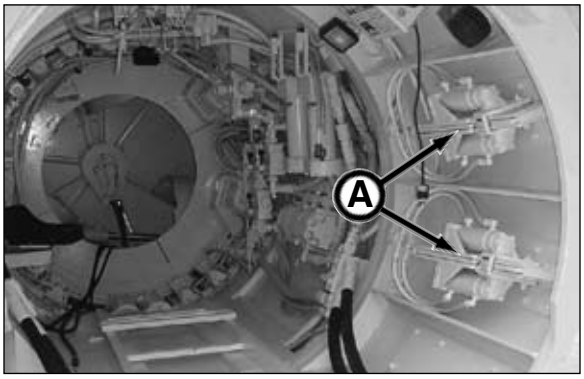
360, 48SC, 420, 480, 540 (sn18300-1-3)

540 (sn18300-4 and after), 600, 660, 720, 780

Steering Adjustment Nut Assembly
The steering adjustment nut assembly (C) provides right to left manual steering adjustments by rotating the nut forward or backwards.
A steering wrench may be used to rotate nut, otherwise relieve pressure on the nut by slightly moving steering cylinders and rotate nut by hand.



DIRT WINGS



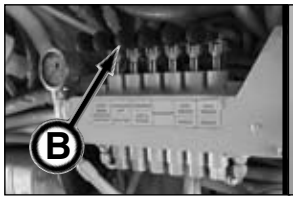
The dirt wings (A) are used to control the TBM roll. If the TBM rolls 1/4 to 1/2" (6.35 to 12.7 mm) from level, dirt wings need to be extended.

There are various dirt wing configurations available for installation on the TBM; bolt-on or hydraulic in clockwise or counter-clockwise direction and extensions. Typically, the 360 and 48SC TBMs do not use dirt wings, though optional bolt-on dirt wings are available, and the 420, 480, 540, 600, 660, 720, and 780 TBMs have four clockwise hydraulic dirt wings.

Extend Dirt Wings:
Push lever (B) UP until the dirt wings are fully extended. The dirt wings are fully extended when the system pressure reads 2,800 - 3,000 psi.

Retract Dirt Wings:
Pull lever (B) DOWN until dirt wings are fully retracted.

Keep the dirt wings extended until the TBM roll is back to level position.



360, 48SC, 420, 480, 540 (sn18300-1-3)

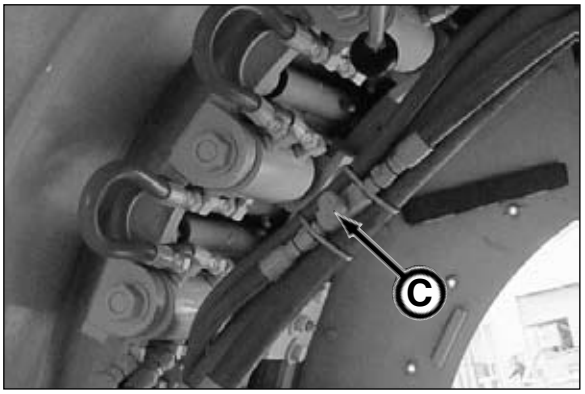
540 (sn18300-4 and after), 600, 660, 720, 780

GEAR RING OILER

Use the gear ring oiler (C) to lubricate the drive gear ring. Turn knob as follows:

CW - decrease/stop oil flow
CCW - increase oil flow

Close valve once drive gear is lubricated. Do not operate with valve open. Doing so will over lubricate drive gear.

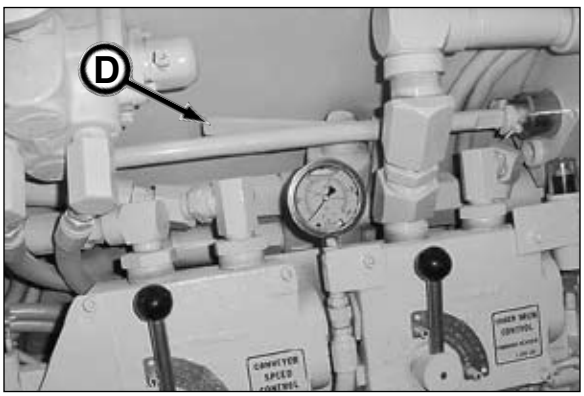


SINGLE / DUAL FEED CONTROL

On tunnel boring machines 360, 48SC, 420, 480 and 540 (sn BH18300-01 thru 03), there is a control lever (D) to switch the hydraulic flow from single feed (60 gpm) to dual feed (120 gpm).

The 540 (sn BH18300-04 and after), 600, 660, 720 and 780 tunnel boring machines require the switching of hoses (refer to Switching Single/Dual Feed Hydraulic Flow in section 6, Operation).

NOTICE If TBM is setup for dual feed hydraulic flow, and you do not move lever (D) to dual feed position, the conveyor will not operate.



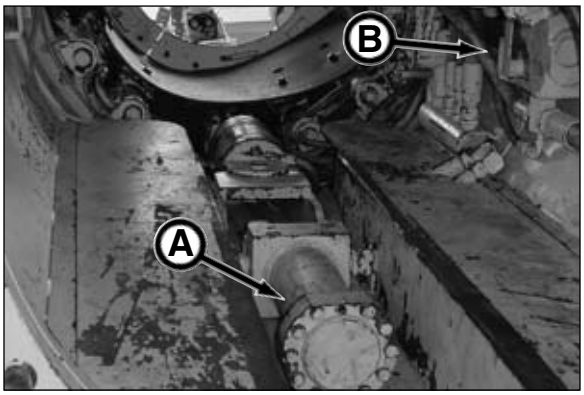
PRESSURE FILTER INDICATOR

To prevent under or over servicing of the hydraulic filter elements (A), a filter indicator (B) has been installed in your tunnel boring machine. Depending on the size of your TBM, your machine may have one or two filters.

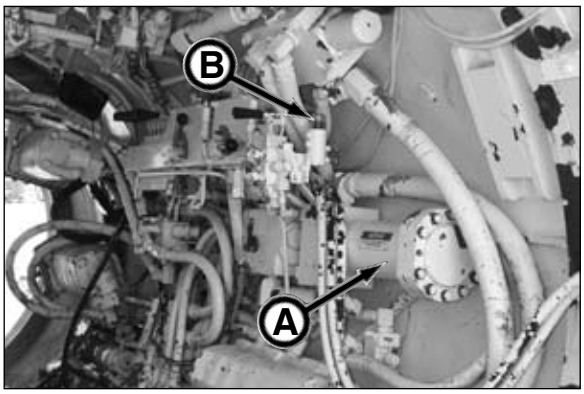
The yellow colored band indicates the filters are functioning properly.

When the filter indicator displays a red colored band, replace filter(s).

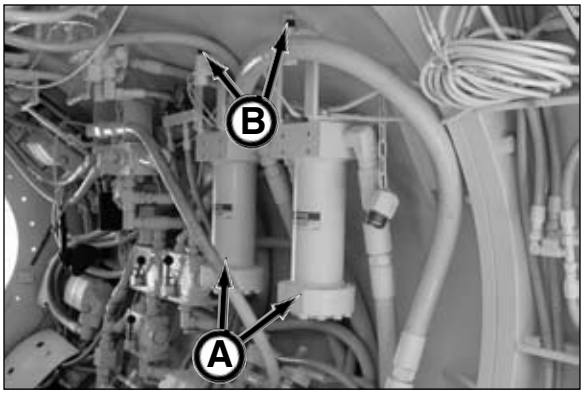
NOTICE The red indicator may display at initial start-up until the oil reaches normal operating temperature. If the red band continues to display after reaching normal operating temperature, replace filter to prevent contamination.



360



48SC, 420, 480, and 540 (sn18300-3 and before)



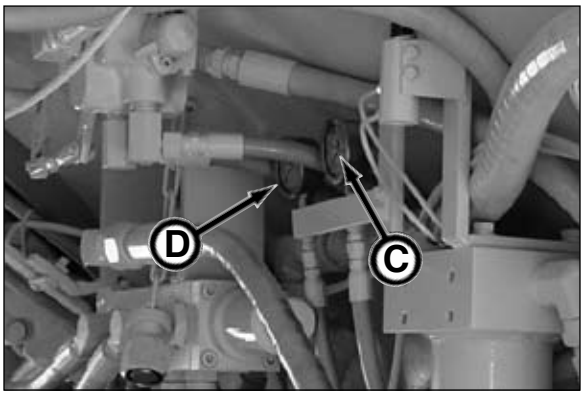
540 (sn18300-4 and after), 600, 660, 720, and 780

PRESSURE GAUGES

There are two hydraulic pressure gauges installed in your tunnel boring machine for observing the TBM pressures.

Gauge (C) displays the conveyor pressure. Gauge (D) displays the auxiliary pressure which includes: inner drum advance, conveyor lift, steering, dirt wings, and closed face attachment door pressure (if equipped).

The maximum pressure for each system is 2,800 - 3,000 psi.

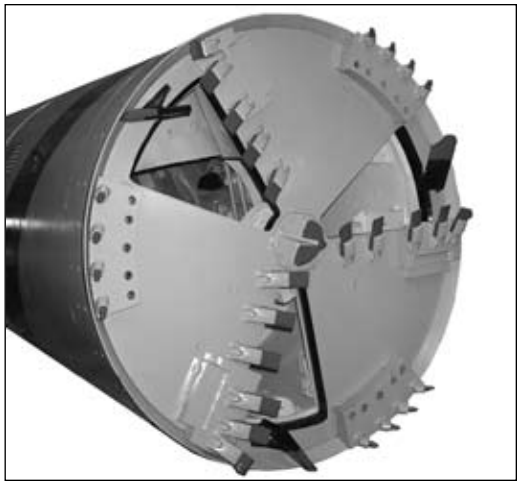


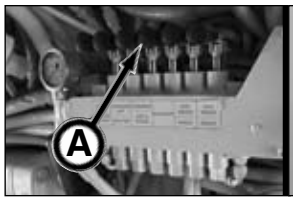
540 (sn18300-4 and after) Shown

CLOSED FACE OR AUXILIARY CONTROL

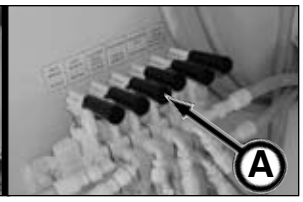
The Closed Face lever (A) controls the opening and closing of the doors on the optional closed face cutter head attachment. Used in unstable ground conditions, the hydraulically operated doors control subsidence of loose soil while excavating the ground.

A lubrication system (two water/lubrication ports on cutter head) is equipped on the closed face attachment to provide a method to lubricate the face if needed.





360, 48SC, 420, 480, 540 (sn18300-1-3)



540 (sn18300-4 and after), 600, 660, 720, 780

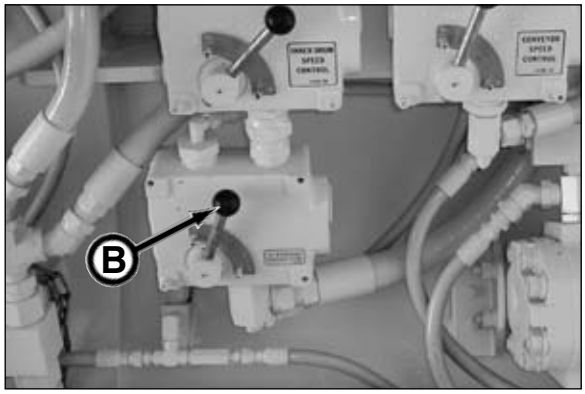
SELECTOR SPEED CONTROL

The Selector Speed lever (B) controls the speed of the inner drum advance, conveyor lift, steering, dirt wings, and closed face doors (if equipped).

Move the lever as follows:

CW - increase speed
CCW - decrease speed

It is recommended that the Selector Speed Control does not exceed position 3 on dial plate. Exceeding position 3 will restrict oil that should be used for the inner drum speed control. And exceeding position 3 may cause functions to operate too quickly for operator to handle, such as the conveyor lift. Typically this speed control pressure should not exceed 800 to 1,000 psi.



Pre-Start Inspection

⚠WARNING Do not operate this equipment until you read, study, and understand this manual and your haul unit, gas detection system, jacking frame, and power unit 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/tagout 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 unit for proper operation at the start of each shift.
	8. Test air monitoring and ventilation detectors for proper operation.
	9. Thoroughly inspect all equipment for damage, including loose or missing hardware. Repair or replace before operating.
	10. Be sure all covers and guards are in place before operation.
	11. Check electrical lines for frayed, damaged, or worn insulation or wires. Replace damaged or worn electrical lines/connections.
	12. Check for fluid leaks. Repair leak or replace components.
	13. Keep job site clean and organized.
	14. Perform all lubrication and maintenance procedures. Refer to Section 9, Periodic Maintenance.
	15. Test each function and control to ensure correct operation.
	16. Check hydraulic hoses and lines for leaks, wear and/or damage. Replace any defective hoses and/or lines.
	17. Check oil level in hydraulic oil reservoirs. Add as needed.
	18. Perform pre-start inspection on your equipment. Refer to your equipment’s operator’s manual.
	19. Conveyor MUST be secured with four safety chains to conveyor bracket in TBM, and cutter-head drive valve chain must be tethered to conveyor.
	20. Test the electrical motors for proper rotation prior to operating the pump unit or power pack.

NOTES

Operation

OPERATING GUIDELINES

⚠WARNING Do not operate this equipment until you read, study, and understand this manual and your haul unit, gas detection system, jacking frame, and power unit 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 worksite clean and orderly.

6. NEVER operate equipment if it has been engulfed with water. Contact your Akkerman Aftermarket 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. Once survey is complete, perform a general visual inspection of the survey line to make sure it is in the same direction as the project bore. If not, the survey must be remarked. A good survey is critical for proper line and grade.

9. Before operating, thoroughly inspect all equipment and repair equipment problems. Check hoses for cuts or bulges. Replace worn or damaged hoses.

10. Be sure the excavated launch and reception shafts are properly shored or braced to prevent slides or cave-ins.

11. Test air monitoring and ventilation detectors for proper operation. Never enter a tunnel without air monitoring and ventilation detectors.

12. A fully trained and qualified signal person must direct the excavator or crane operator when lifting and lowering equipment, pipe and supplies 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. Inform all job site personnel that the equipment will be starting up. Do not start until all unauthorized personnel are clear of the equipment.

19. After start-up, observe all gauges, meters, controls and warning devices to assure they are functioning properly and their readings are within the operating range.

(continued on next page)

Operating Guidelines (continued)

20. Never leave the operator's station without first releasing hydraulic pressure, performing daily system shutdown, and disconnecting the main power supply.

21. 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.

22. Check line and grade alignment often. Keep in mind if you are off one degree, the bore will be off nearly two feet per one hundred feet.

23. Keep hands, body, and objects clear of rotating conveyor or operating auger. Do not operate without covers and guards in place. Lockout power before servicing.

24. If this manual becomes lost, contact your Akkerman Aftermarket Support representative for a new manual or download this manual from the Akkerman web site at www.akkerman.com.

25. The operator must note and report any slow down of machine operating time that might be an early warning of future problems.

26. Do not make adjustments or repairs to any of the system components while in operation. All pressure must be released and electrical power must be locked out, tagged out.

27. High pressure hydraulics are used on the jacking system. Be sure all cover and guards are in place before operating.

28. Pressure peaks cause hoses to jump without notice. Keep all personnel away from hoses during operation of equipment.

29. 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.

30. Conveyor must not be started until all personnel have been moved away from the conveyor and have been warned that the conveyor is about to start up.

31. The area around conveyor loading and unloading points must be kept clear of obstructions during conveyor operation.

32. Conveyor must be stopped and the power source locked out and tagged out during maintenance, repair, or servicing.

33. The conveyor must be locked out and tagged out before attempting to remove a jam or overload.

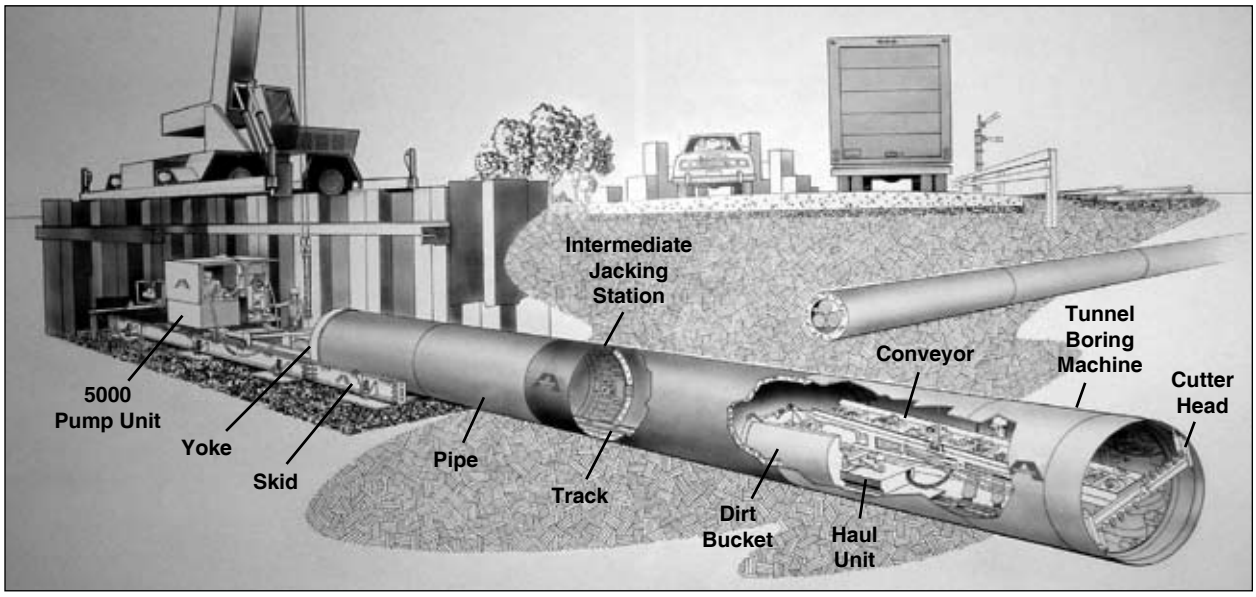
34. Before operating conveyor, all guards and/or safety devices must be in place and operable to prevent any contact with conveyor.

35. Wear reasonably close fitting clothing and remove jewelry to prevent an entanglement hazard.

36. While cutterhead and conveyor are operating, the operator must remain seated in normal operating position.

37. BEFORE operating conveyor, the cutterhead drive dump valve MUST be tethered to conveyor AND ALL FOUR safety chains MUST be secured to conveyor.

SYSTEM OVERVIEW



Tunnel Boring Machine (TBM)
The purpose of the TBM (boring head) is to excavate material at the cutter face and guide (steer) the pipe through the ground. As the TBM is advanced by the pipe jacking system, powerful hydraulic motors in the TBM 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 for removal from the pipe line.

Akkerman TBMs are articulated and hydraulically steerable in any direction. With the proper use of a laser, the strictest line and grade requirements can be maintained throughout the pipeline installation. An operator is positioned near the front of the machine to observe soil conditions and to monitor line and grade. A methane detection system is also standard equipment in Akkerman boring machines.

Pipe Jacking System
The pipe jacking system (pump unit/power pack, yoke and skid or jacking frame and optional intermediate jacking station) provide the horizontal thrust to push the TBM and pipe through the ground.

The *5000 Pump Unit* high pressure system supplies hydraulic oil for the two main jacking cylinders and all intermediate jacking stations. The low pressure system supplies oil via hydraulic lines for the boring head and conveyor. An optional Auxiliary Pump Unit may be easily installed to double the low pressure hydraulic flow.

When the 5000 Pump Unit is not used, the *P400 and/or P600 Power Packs* are used to provide low and high pressure hydraulics for the tunnel boring machine and jacking systems designed for small shaft or high capacity multiple cylinder jacking systems.

The *Yoke* is the frame that the main cylinders push against to advance the boring head and pipe. It is placed between the main thrust cylinders and the pipe, providing 360 degree surface contact against the pipe to minimize point pressure and reduce the chance of breakage. The yoke also acts as a dirt bucket unloading bay for the haul system.

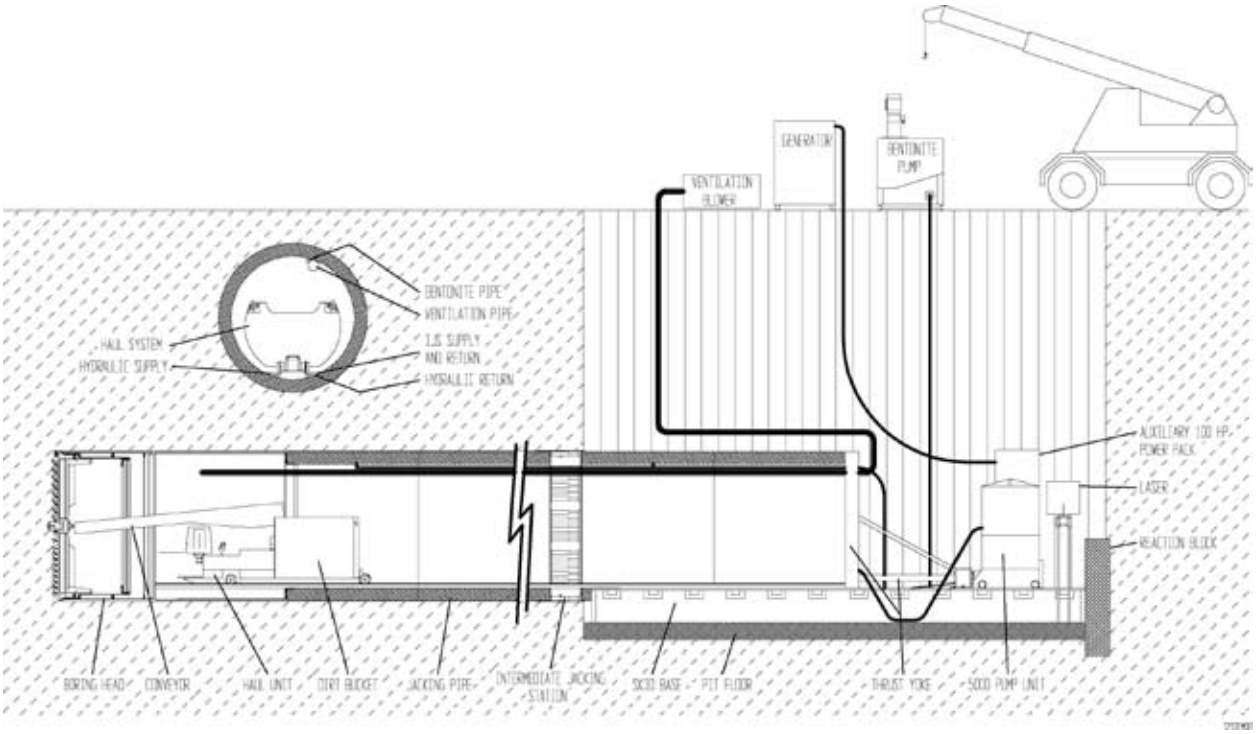
The *Skid* base is the foundation of the 5000 pump unit and yoke. It also acts as a guide for launching the boring head and pipe into the ground and transfers the main cylinder thrust rearward to the reaction block. Sectional skid base pieces are joined together for longer pipe joint lengths.

The *Intermediate Jacking Stations* are used to distribute the jacking forces throughout the pipe string. Each station consists of ram segments. Each 60-ton capacity segment has 5 rams (7 inch stroke). All stations are supplied oil by one set of lines from the power pack (pump unit) and operated from one point within the jacking shaft.

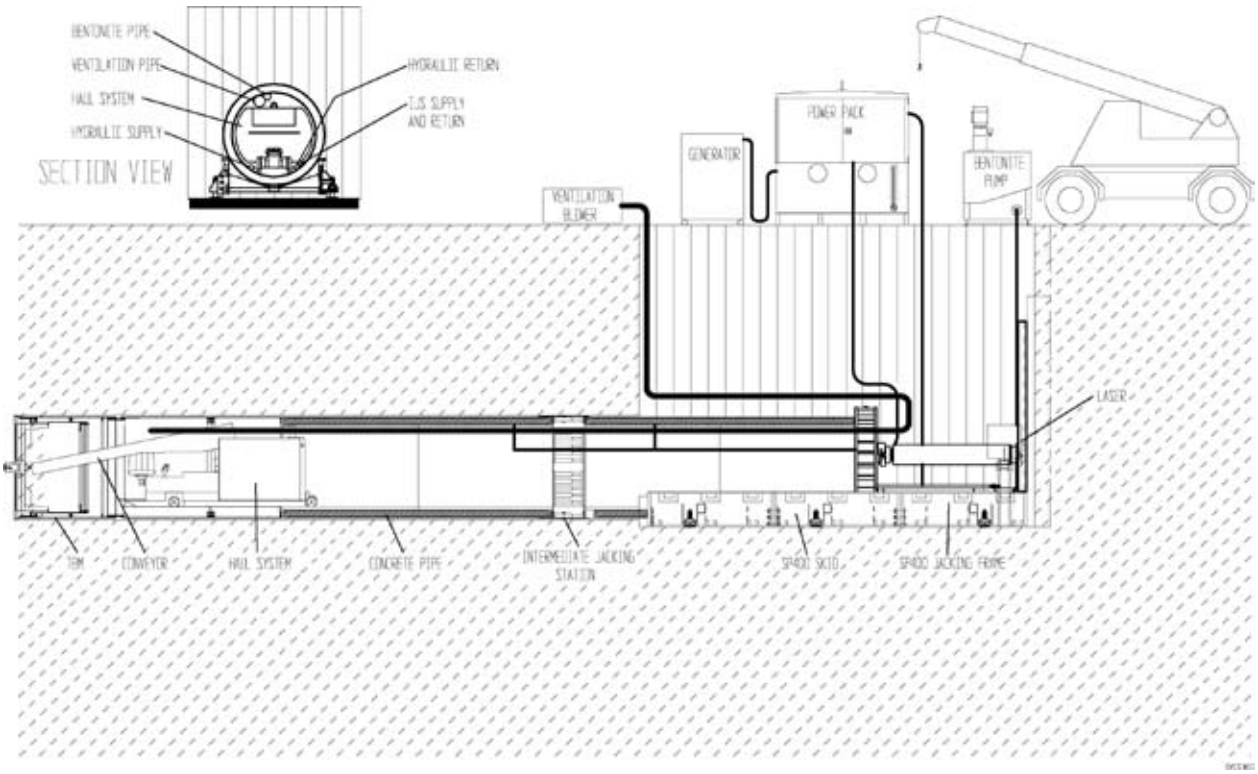
Conveyor
As the spoils are dropped onto the conveyor from the TBM inner drum, the conveyor carries the material to the dirt bucket on the haul unit. The conveyor transports the spoil from the front of the boring head to the dirt bucket on the haul unit. Conveyors are offered in several sizes to maximize the performance for each size boring head. A screw conveyor performs better in certain sticky or sloppy ground conditions.

Haul Unit System
The haul unit transports the spoils from the tunnel boring machine back to the launch shaft. A crane is then used to hoist the dirt bucket out of the shaft for unloading. The typical haul unit system is comprised of a haul unit, track, and dirt bucket.

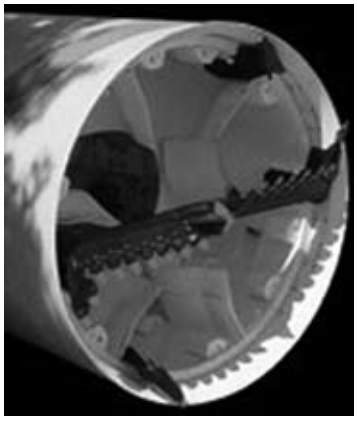
TYPICAL 5000 PIPE JACKING SYSTEM LAYOUT



TYPICAL POWER PACK/JACKING FRAME SYSTEM LAYOUT

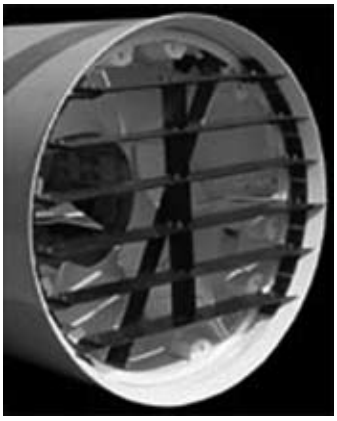


CUTTER HEADS



Dirt Bar Head

Carbide Quad Bar Head



Sand Shelves

Akkerman TBM wheel machines range in size from 44 inches (1,118 mm) to about 115 inches (2,921 mm) outside diameter.
Wheel machines are equipped with three cutter heads:

- Dirt Cutter Head (clay, silty sand, etc.)
- Carbide Cutter Head (soft to medium hard rock)
- Sand Shelves (loose unstable soil, but not flowing)

All three cutter heads may be interchanged underground.

A Closed Face Cutter Head is optional and used for boring in unstable ground conditions. The hydraulically operated doors control subsidence of loose soil while excavating the ground.

Optional Closed Face

RECOMMENDED TOOLS & EQUIPMENT

Below is a list of tools and equipment for most complex technical construction operations. Financial resources and equipment availability are as much of a deciding factor as immediate job site requirements in determining what items should be on hand. This list contains many items, some of which may only be needed in special situations.

1. Safety equipment, first-aid kit, fire extinguishers, and stokes-type stretcher.
2. Any other required safety gear, such as air monitoring and gas detection systems, including personal gas detectors.
3. Ventilation fan(s) and ducting.
4. Communications equipment and good quality flashlights.
5. Generator sized for the project's power requirements including an adequate fuel supply for the generator's minimum period of operation.
6. A crane sized to project requirements.
7. Adequate pumping capacity for launch and reception shaft sump, and process water overflow, potential storm event inflow, trash pump, and hoses.
8. Adequate job site lighting, crew safety vests, and traffic control devices/signage, and barricades.
9. Wash down hose and spray nozzle.
10. Measuring and surveying equipment; including sight level or theodolite, laser levels, plumb-bobs, string lines and 100' tape measure.
11. Secure tool and equipment storage.
12. Rubber-tired front-end loader with bucket and forks.
13. Skid steer loader.
14. Shovels, rakes, and brooms.
15. Bullfloat and trowels.
16. Concrete bucket, tremie hose and hopper.
17. Carpentry tools including circular saw, sawzall, extension cords, and cordless drill w/bits, and basic hand tools.
18. Hammer drill and masonry bits, small "rivet buster" type jackhammer, chisels.
19. Sledgehammer(s), pry and crowbars of all sizes, spud wrenches, and pick-bars.
20. Various sizes hydraulic bottle jack(s), railroad or house type jacks, portapower hydraulic jack cylinder kit.
21. Log chains, shackles and clevis'.
22. Chain or cable-type "come alongs."
23. Arc welder and cutting torch rigs, eye shields and required protective gear.
24. Disc and mini-disc grinders, and extra discs.
25. Mechanic's tools, including but not limited to; wrenches, sockets, allen wrenches, torque wrenches, pliers, screwdrivers, hammers, etc.
26. Grease gun.
27. Electrician's tools, including test meters, voltage indicator, ground fault indicator, and specialty hand tools.
28. Pipe wrenches, water pump pliers, pump packing removal kit.

SITE PLANNING

It is important to carefully review the site and make sure that it is arranged in the most effective manner possible. Here is a list of equipment and site considerations that are typically needed for a TBM project.

Equipment:

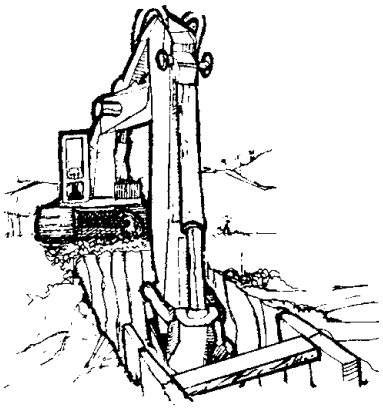
- TBM
- Power Unit or Power Pack
- Skid and Jacking Frame
- Yoke
- Crane
- Portable Welders
- Small Generator
- Generator Or Power Source
- Pipe Lubrication Pump
- Spoil Removal Truck
- Portable Toilet
- Fork Lift

Other site considerations:

- Spoil Removal Truck Access
- Launch Shaft Size
- Walkways
- Pipe Unloading area
- Hose Interconnections
- Pipe Staging Area
- Fresh Water Supply
- Electrical Interconnections
- Jacking Shaft Access Area
- Any Traffic or Other Physical Restraints

SITE PREPARATION

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.



AEM is the original author and publisher of the above illustration

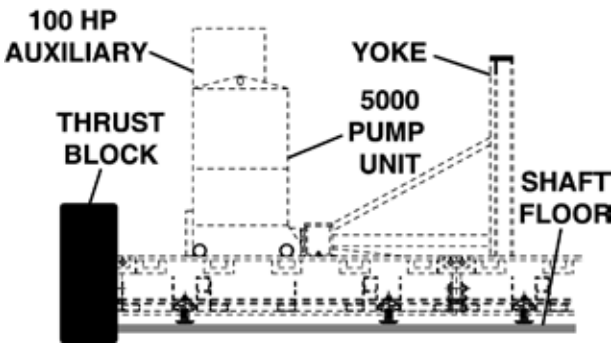
⚠WARNING Gases may be present during excavation and could cause severe personal injury or death. Use an approved air analyzer to detect hazardous gases on the job site and in the tunnel at all times.

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 skid, yoke, pump unit, jacking frame, 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 designed 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.



Set Up With 5000 Pump Unit

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

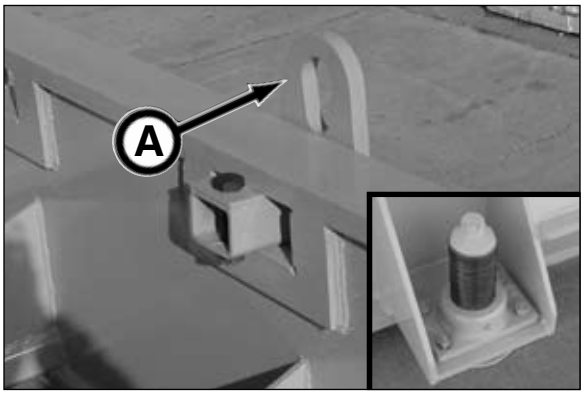
6. Proceed to Setting Up The Jacking System in this section.

SETTING UP THE JACKING SYSTEM

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

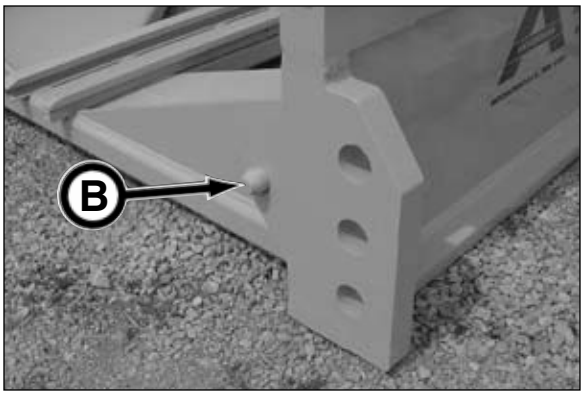
NOTICE Be sure the crane or excavator and all lifting equipment is rated to lift load. Remember, you may be able to lift the load in close at ground level, but as the load radius and elevation change, the lifting capacity of the crane or excavator or other lifting equipment decreases.

1. Lower skid assembly into launch shaft using lift eye assemblies (A) and place against the thrust block. Correct the skid assembly line and grade with leveling screws (see inset). Typically there should be at least 6 inches between the front of the jacking rails and the shaft wall to allow room for the cutterhead of the TBM.

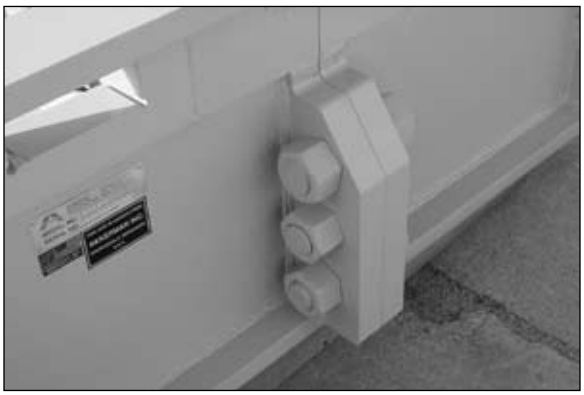


If necessary, lower other skid assembly(s) into launch shaft and mount to first skid assembly as follows:

a. Align the skid sections using the locator pin (B).



b. When skid assemblies are properly aligned, mount with six 2 in. bolts and nuts.



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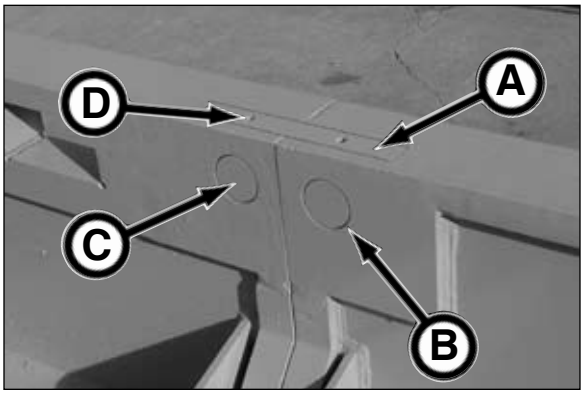
c. To complete mounting, install skid split bars (A) into side skid base assembly making sure the holes of the bar line up with the holes (B) in the skid assembly. Insert skid split pins (C) with slot of pin at the 12 o'clock position for set screw. Secure skid split pin with set screws (D).



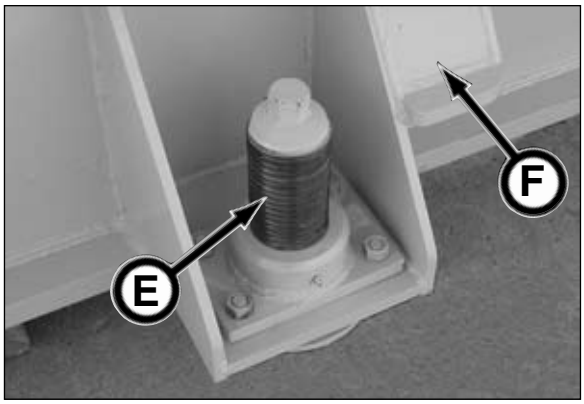
d. Continue mounting other skid sections, if required.

e. 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.

f. Once skid assemblies are properly joined, check for the proper line of the project bore. Adjust skid (s) as needed.

g. Once skid assemblies are in the proper line, correct the skid assembly grade with leveling screws (E). Due to the weight of the skid assemblies, place a hydraulic jack below the jack pad (F) to raise or lower skid as needed for ease of adjusting grade with leveling screws.

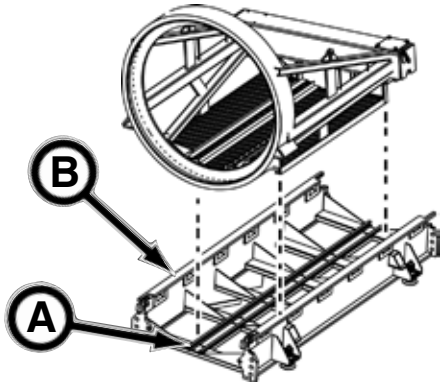


h. When completed, recheck line and grade and adjust as needed.

2. (Pump Unit, if equipped) Lower the pump unit onto skid assembly. Check to be sure the drive wheels are resting on the skid assembly top rails without bolster drag.

(continued on next page)

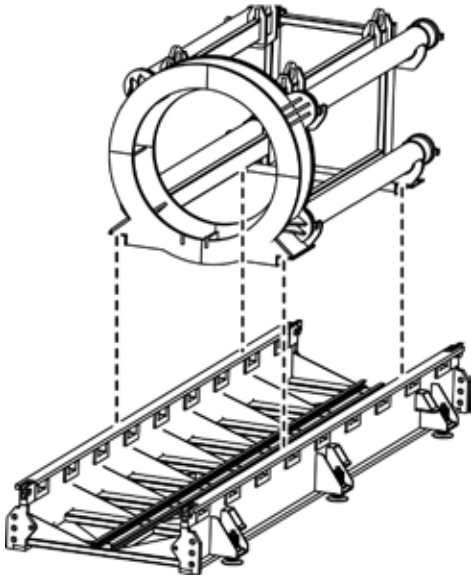
3. (Yoke, if equipped) Lower the yoke (in front of the pump unit) onto the lower skid assembly rails (A) , while making sure the yoke wheels are resting on the top skid assembly rails (B).



4. (If equipped with jacking frame) Recheck line and grade of skid assembly rails. Lower jacking frame onto skid assembly rails and make sure the frame is properly centered on the rails.

5. (If using Power Pack) Lower power pack on a level, solid foundation an appropriate distance from the edge of the shaft to prevent shaft cave-in.

6. Proceed to Setting Up The Tunnel Boring Machine in this section.



SETTING UP THE TUNNEL BORING MACHINE

1. Lower tunnel boring machine (TBM) onto the front of the skid assembly, making sure the cutter teeth on the TBM will not strike the skid assembly when the cutterhead is rotated.

2. Check TBM side to side level by placing level (C) on top steering cylinder bracket. If not level, have crane operator move the TBM until TBM side to side is level.

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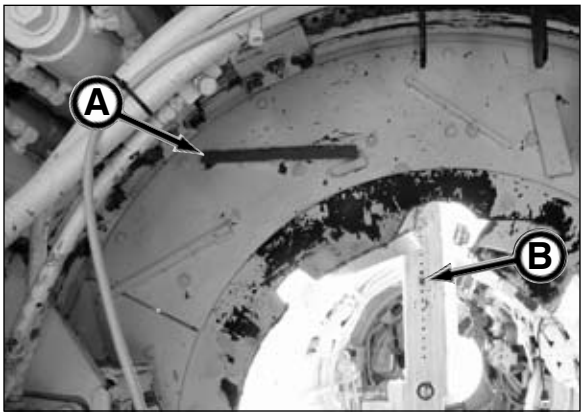


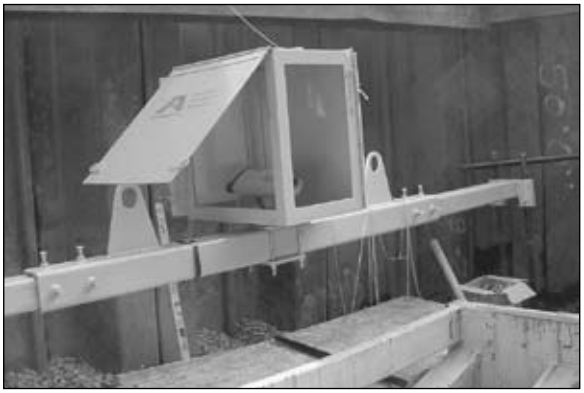
3. Place level on inner drum level bar (A) and rotate the inner drum as needed until level. This will position the target bolt (B) on the cutter bar in the proper location for setting the guidance system.

4. Check to be sure front drum is parallel with mid drum/dirt wing drum. Place a 4' level or other long straight edge between the front drum and mid drum sections (as shown). If mid section lines up with level or straight edge, then the front and back sections of the TBM are running parallel.

   If there is a gap between the two sections, the sections are not parallel. Move steering cylinders or if needed, move the steering adjustment nut until there is no longer a gap.

NOTICE The TBM line and grade MUST be steered parallel to the jacking system base.

5. Recheck jacking system base grade and alignment. Check machine elevation and make final pipe line calculations, allowing for cutter bit "over cut."



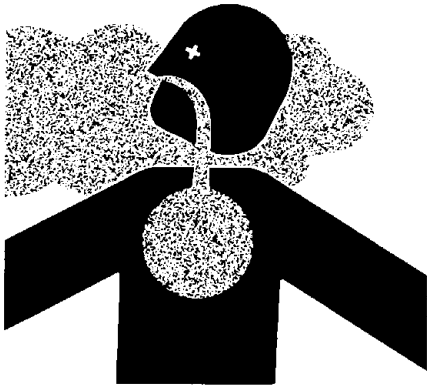
6. Lower the stand for the laser guidance system as close to the rear of the jacking shaft as possible without contacting skid assembly, jacking frame, pump unit or thrust block. Be sure the guidance system will not be affected by thrust applied to jacking system.

7. 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.

(continued on next page)

⚠WARNING NEVER operate tunneling equipment without proper operating gas detection systems. Severe personal injury or death can occur without proper gas detection systems in place due to accumulation of combustible and toxic gases, and depletion of oxygen.

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

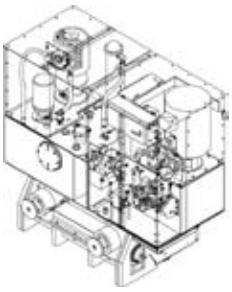


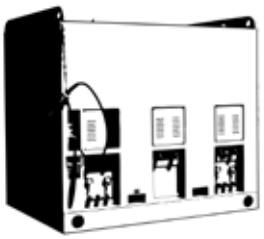
8. Connect the Pump Unit/P400/P600/jacking frame hydraulics and electrical connections.

   For the 5000 Pump Unit, refer to Preparing Pump Unit For Operation and Setting Up The 5000 Pump Unit - Start-Up Check in the Operation section of your 5000 Pump Unit Operator's Manual.

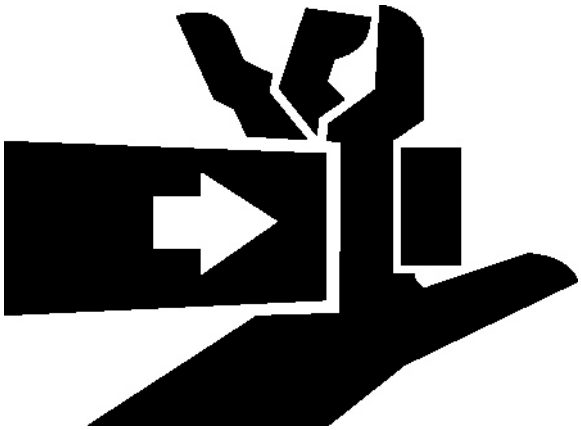
   For the P400/P600 Power Pack, refer to Setting Up The P400/P600 in this section.

9. Follow 5000 Pump Unit or P400/P600 Power Pack startup procedures in this section.





⚠WARNING PINCH POINTS! Watch your fingers, hands, and legs while equipment is in operation.



⚠CAUTION Pressure peaks cause hoses to jump without notice. Keep all personnel away from hoses during operation of equipment.

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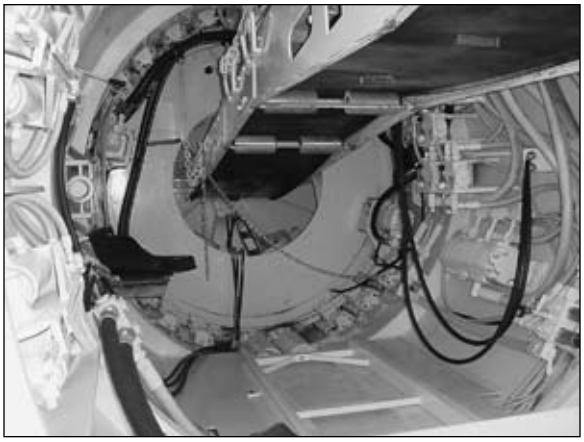
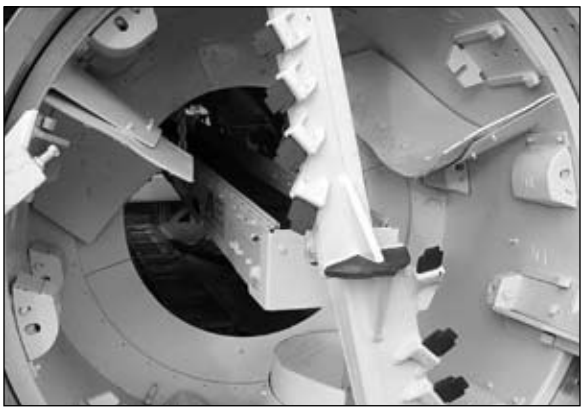
⚠WARNING Conveyor is heavy and could drop while installing or operating, resulting in severe personal injury or death. Conveyor must be fastened securely to supports while moving conveyor into position. Once conveyor is in position, lifting cables and ALL FOUR conveyor safety chains MUST be secured to conveyor.

10. Carefully install conveyor into the TBM and connect the lifting cables to the front lifting position on the conveyor lifting eyes.





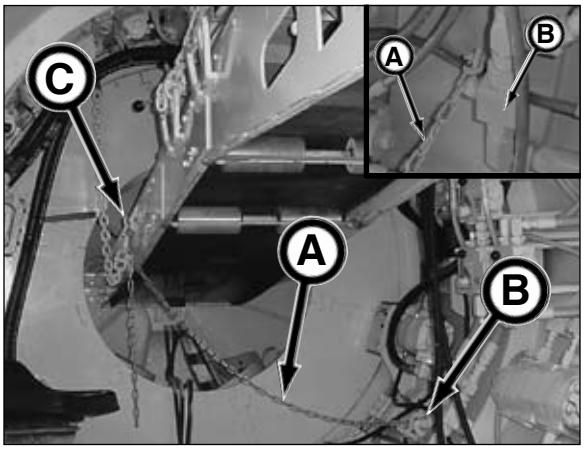
11. Lift the conveyor with the conveyor lift and slip bearing at the front of the conveyor onto the pin at the center of the cutter bar.

(continued on next page)

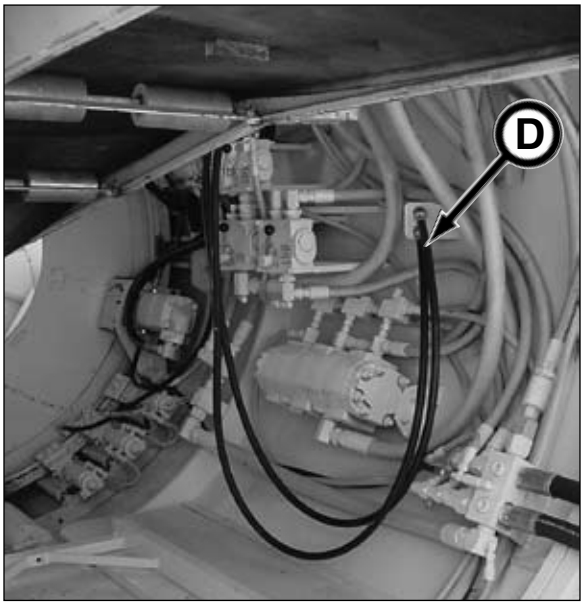
12. Connect the four safety chains to the conveyor and lower the conveyor lift just enough to provide adequate slack in the lift cables to move the lifting hooks to the rear (operating) position on the conveyor lifting eye.

⚠WARNING Conveyor can jam in rotating cutterhead causing conveyor to swing into operator, resulting in severe personal injury.

1. The conveyor safety valve (cutterhead drive dump valve) MUST be tethered to conveyor and the operation MUST be tested before starting the conveyor to insure proper operation.
2. ALL FOUR safety chains MUST be secured to conveyor.
3. Operator MUST remain seated in normal operating position.



13. Fasten chain (A) from conveyor safety valve (B) to conveyor hook (C).



14. Connect conveyor supply and return hydraulic hoses (D) to quick disconnects.

15. Proceed to TBM Hydraulic Setup - Single & Dual Feed in this section.

TBM HYDRAULIC SETUP - SINGLE & DUAL FEED

There are two hydraulic supply/return options available for setting up the 5000 Pump Unit/Auxiliary Pump Unit and the P400 or P600 Power Packs with the tunnel boring machine; single feed supply and dual feed supply.

The single feed option supplies 60 gpm of low pressure oil to the boring head, steering, and spoil conveyor.

The dual feed option supplies an additional 60 gpm of low pressure oil (total of 120 gpm) with the use of the Auxiliary Pump Unit on the 5000 Pump Unit or by using two low pressure modules on the P400 or P600 Power Pack. Typically the main boring head supply on the 5000 Pump Unit will run the boring head, and steering of the TBM, and the Auxiliary Pump Unit supplies power for the conveyor unit. Though the Auxiliary supply can power the conveyor and provide additional power to the boring head, using the TBM gear divider in the larger TBMs.

TBM HYDRAULIC SETUP

Single Feed (60 gpm of low pressure oil)
(360 - 48SC - 420 - 480 - 540 [sn BH18300-01 - 03])

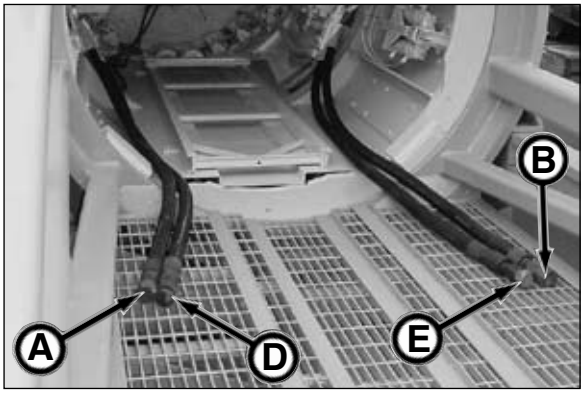
1. Connect main supply hose from 5000 Pump Unit or P400/P600 to supply hose (A) in TBM.

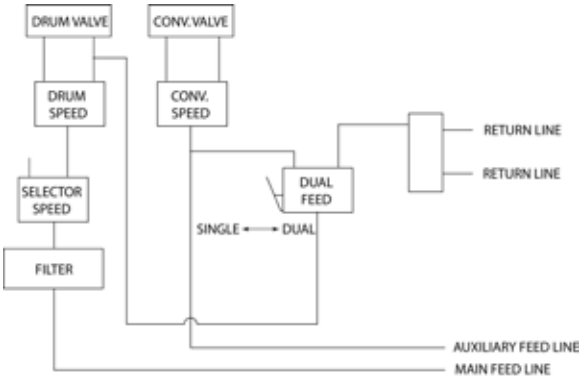
2. Connect main return hose from 5000 Pump Unit or P400/P600 to return hose (B) in TBM.

3. Select single feed position on dual feed control (C).

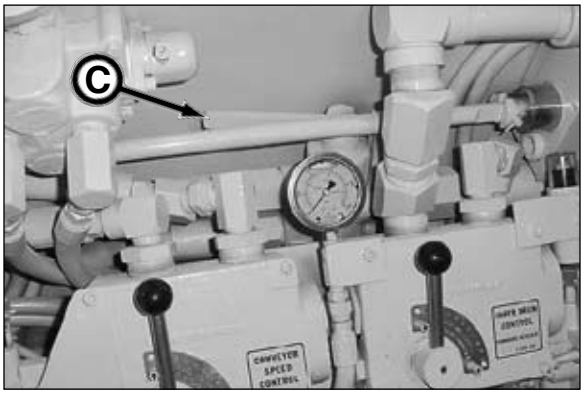
4. Be sure the other supply (D) and return (E) hoses in the TBM are capped.

5. For hydraulic power source connections, refer to the 5000 Pump Unit Hydraulic Setup or the P400/P600 Hydraulic Setup in this section.

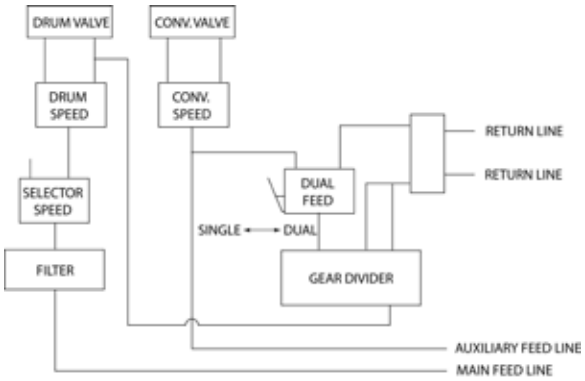




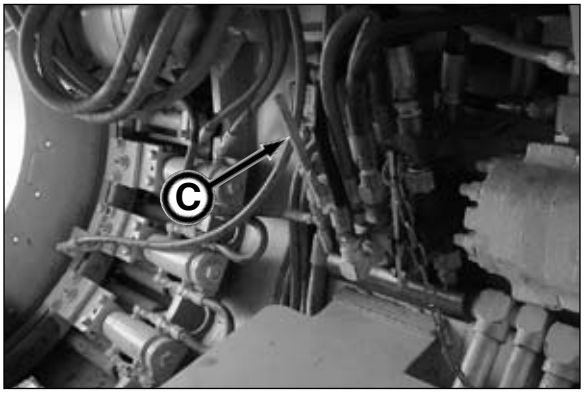
Single/Dual Feed Control Circuit
360 - 48SC - 420



Single/Dual Feed Control
360 - 48SC - 420



Single/Dual Feed Control Circuit
480 - 540 (sn BH18300-01 - 03)



Single/Dual Feed Control
480 - 540 (sn BH18300-01 - 03)

TBM HYDRAULIC SETUP (continued)
Dual Feed (120 gpm of low pressure oil)
(360 - 48SC - 420 - 480 - 540 [sn BH18300-01 - 03])

1. Connect main supply hose from 5000 Pump Unit or P400/P600 to supply hose (A) in TBM.

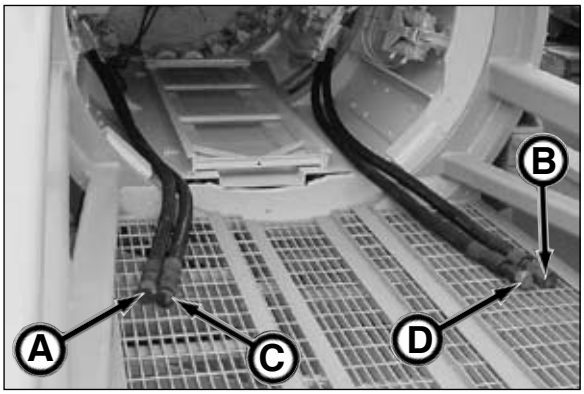
2. Connect main return hose from 5000 Pump Unit or P400/P600 to return hose (B) in TBM.

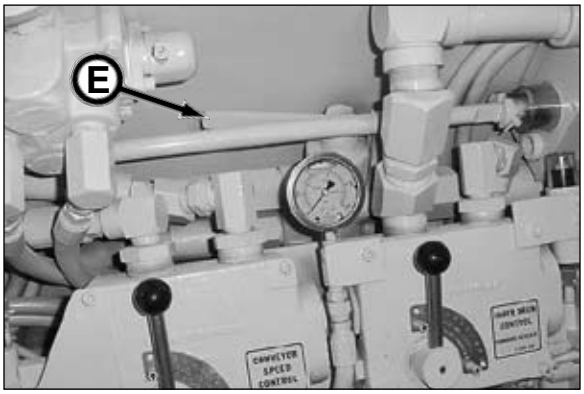
3. Connect auxiliary supply hose from 5000 Pump Unit or P400/P600 to supply hose (C) in TBM.

4. Connect auxiliary return hose from 5000 Pump Unit or P400/P600 to return hose (D) in TBM.

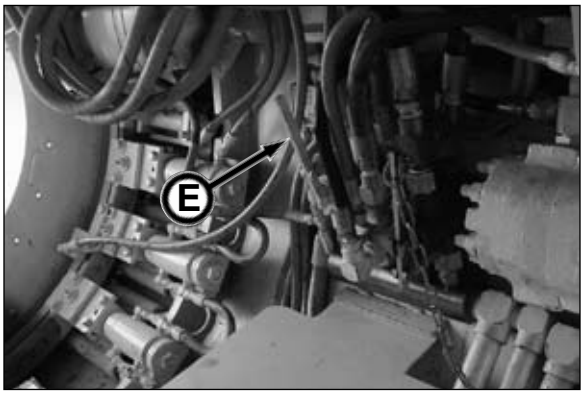
5. Select single feed position on dual feed control E).

6. For hydraulic power source connections, refer to the 5000 Pump Unit Hydraulic Setup or the P400/P600 Hydraulic Setup in this section.

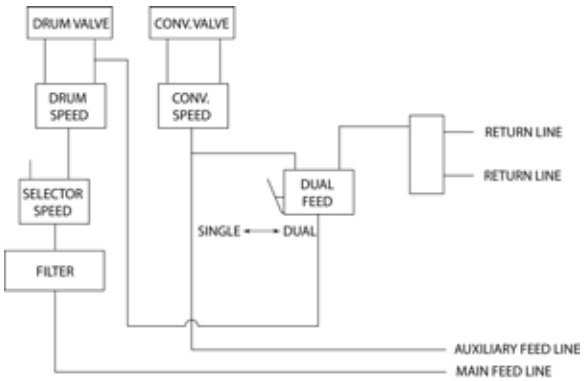




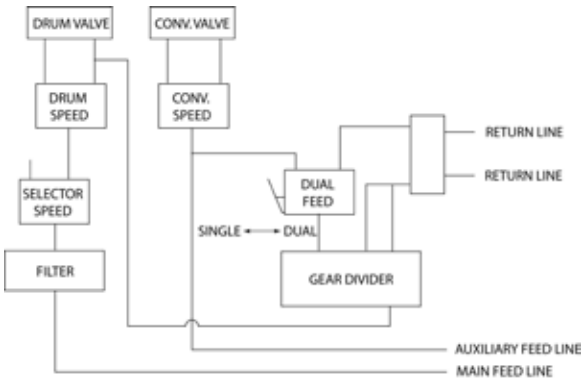
Single/Dual Feed Control
360 - 48SC - 420



Single/Dual Feed Control
480 - 540 (sn BH18300-01 - 03)



Single/Dual Feed Control Circuit
360 - 48SC - 420



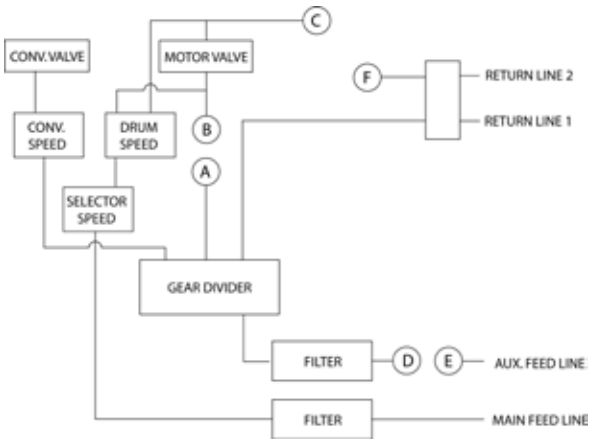
Single/Dual Feed Control Circuit
480 - 540 (sn BH18300-01 - 03)

(continued on next page)

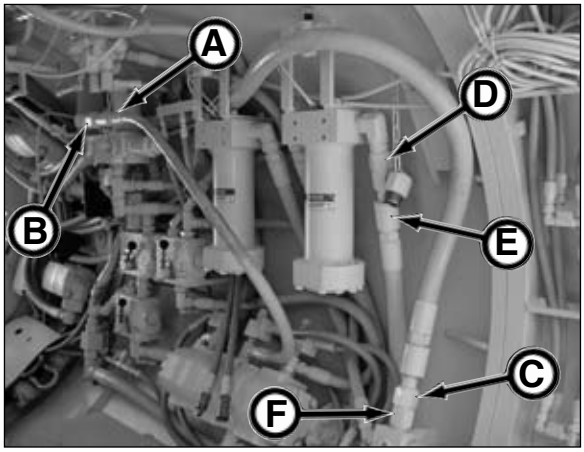
TBM HYDRAULIC SETUP (continued)
Single Feed (60 gpm of low pressure oil) & Dual Feed (120 gpm of low pressure oil) (540 [sn BH18300-04 & after] - 600 - 660 - 720 - 780)

In single feed supply, the main feed line runs all functions. The auxiliary feed line and return line 2 are not used.

1. Connect hose (A) to fitting (F).
2. Connect hose (C) to fitting (D).
3. Cap hose (E).
4. Cap fitting (B).
5. Connect main supply hose from 5000 Pump Unit or P400/P600 to supply hose (G) in TBM.
6. Connect main return hose from 5000 Pump Unit or P400/P600 to return hose (H) in TBM.
7. Be sure the other supply (I) and return (J) hoses in the TBM are capped.
8. For hydraulic power source connections, refer to the 5000 Pump Unit Hydraulic Setup or the P400/P600 Hydraulic Setup in this section.

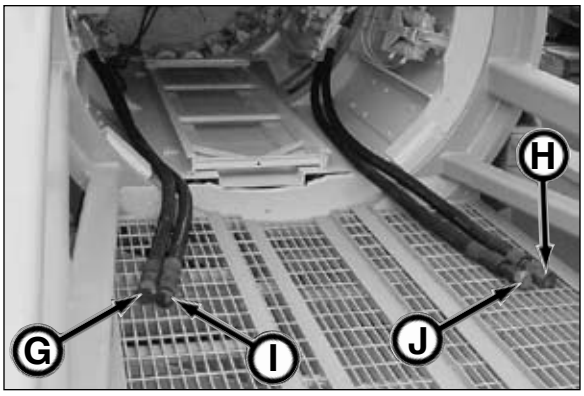


Single/Dual Feed Circuit
540 (sn BH18300-04 & after) - 600 - 660 - 720 - 780



In dual feed supply, the main feed line runs the cutter bar. The auxiliary feed line runs the conveyor and also adds 25 gpm to the cutter bar. The return lines 1 and 2 are used.

1. Connect hose (A) to fitting (B).
2. Connect hose (C) to fitting (F).
3. Connect hose (E) to fitting (D).
4. Connect main supply hose from 5000 Pump Unit or P400/P600 to supply hose (G) in TBM.
5. Connect main return hose from 5000 Pump Unit or P400/P600 to return hose (H) in TBM.
6. Connect auxiliary supply hose from 5000 Pump Unit or P400/P600 to supply hose (I) in TBM.
7. Connect auxiliary return hose from 5000 Pump Unit or P400/P600 to return hose (J) in TBM.
8. For hydraulic power source connections, refer to the 5000 Pump Unit Hydraulic Setup or the P400/P600 Hydraulic Setup in this section.



5000 PUMP UNIT HYDRAULIC SETUP

NOTICE For more information on the setup and operation of the 5000 Pump Unit and Auxiliary Pump Unit, refer to your 5000 Pump Unit Operator's Manual.

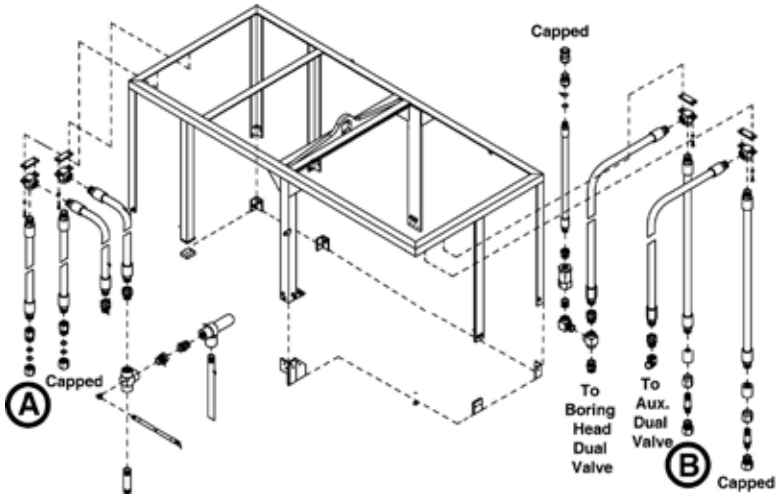
⚠WARNING Escaping oil or other fluids under pressure can penetrate your skin causing serious injury. Contact medical help immediately if any oil or fluid is injected into your skin.
ALWAYS switch power supply switches to the STOP position, move dual control valves to the OFF position, AND use gloves before connecting or disconnecting hydraulic oil hoses/lines.

BEFORE setting up the Pump Unit hydraulics, set up the 5000 Pump Unit. Refer to Setting Up The 5000 Pump Unit - Start-Up Check in the Operation section of your 5000 Pump Unit Operator's Manual.

***Single Feed* (60 gpm low pressure)**
Connect return line quick coupler (A) to the TBM return line quick coupler.

Connect supply quick coupler (B) to the TBM supply quick coupler.

Note the hoses that must be capped for the single feed option.

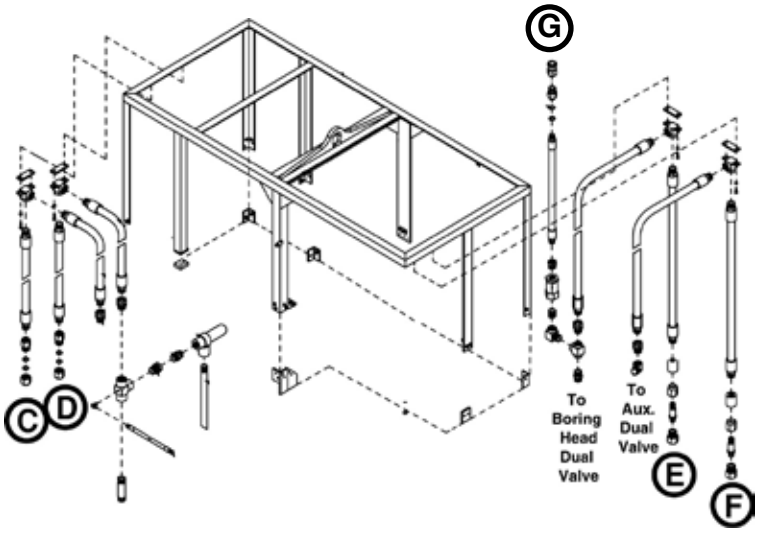


Dual Feed (90/120 gpm* low pressure)
Connect return line quick coupler (C) to the TBM return line quick coupler.

Connect return line quick coupler (D) to the conveyor/auxiliary return line quick coupler.

Connect supply quick coupler (E) to the TBM supply quick coupler.

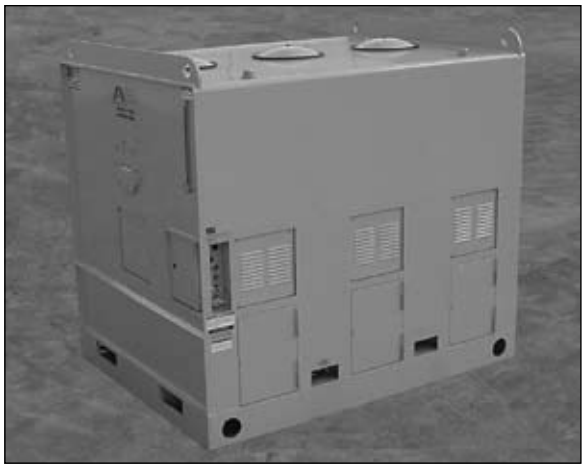
Connect supply quick coupler (F) to the conveyor/auxiliary supply quick coupler.



NOTICE For 30 gpm conveyor drive/90 gpm cutter drive, connect fitting (G) to the Auxiliary Unit as shown in Setting Up The Auxiliary Pump Unit in the 5000 Pump Unit Operator's Manual.

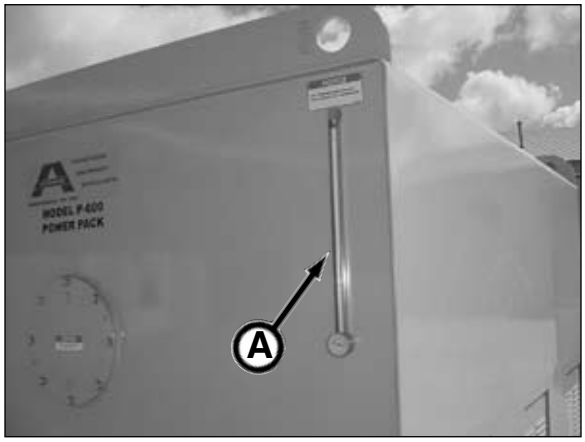
* In dual feed hydraulic supply, 90 gpm is available for the 360 - 48SC - 420 - 480 - 540 (sn 18300-01 - 03) while 120 gpm is available for the 540 (sn 18300-04 & after) - 600 - 660 - 720 - 780.

P400/P600 POWER PACK SETUP



NOTICE For more information on the setup and operation of the P400/P600, refer to your P400/P600 Power Pack Operation and Maintenance Manual.

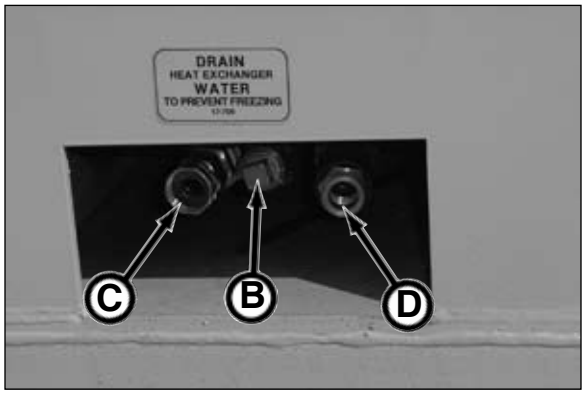
1. Power Pack must be placed on a level, solid foundation.



2. Check hydraulic on oil level gauge (A). If needed, add ISO-VG-46 20W Premium Hydraulic/Turbine Oil as necessary.

3. Install heat exchanger drain plug (B).

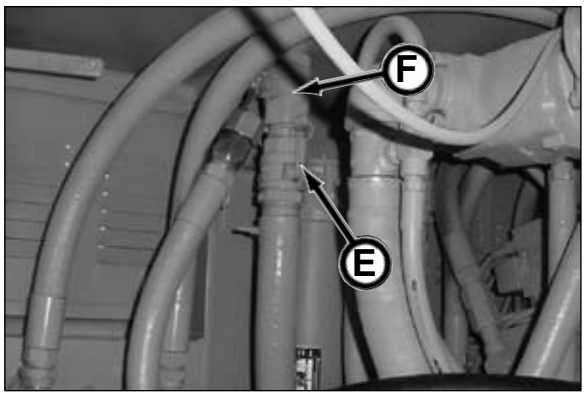
4. Connect a fresh, clean water supply hose with 15 GPM minimum to heat exchanger fitting (C). The water must be clean otherwise any sediment or debris in the water will plug heat exchanger.



⚠WARNING To avoid serious personal injury, the water discharge must not flow into any electrical or machine areas and must drain safety away from the pump unit or power pack.

5. Connect a water discharge hose (D) to heat exchanger.

   Be sure hoses do not come in contact with moving parts.



NOTICE Be sure to drain heat exchanger in cold weather. If heat exchanger freezes without being drained, damage will occur to the heat exchanger internal parts resulting in improper oil cooling and potential water contamination in the oil.

6. Check to be sure pump suction quick disconnect fittings (E) in all modules are securely connected.

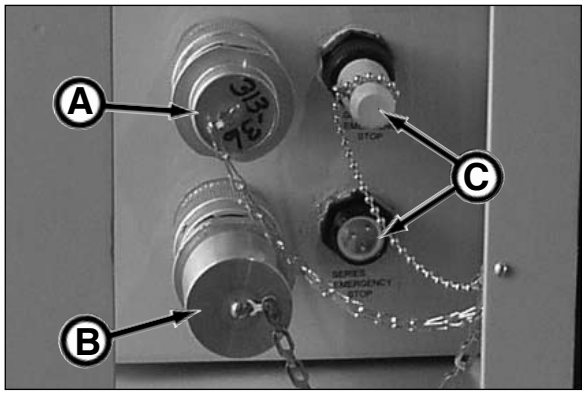
7. Open pump suction valves (F). Tie strap all valves open to prevent accidental closure of valves while operating.

(continued on next page)

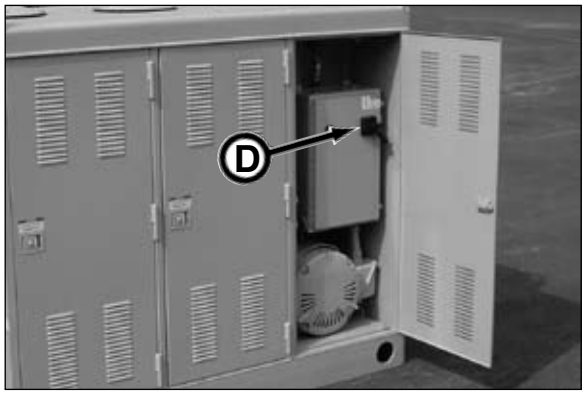
⚠DANGER Hazardous voltage. Disconnect and lock out power from source before connecting power leads. Only a certified electrician must connect the generator power leads to the power pack connections. Guards and shields must be in place at all times.

NOTICE Only a certified electrician must connect the generator power leads to the 480 Volt power module connections.

8. Connect generator power leads to Power Pack. Remove cover. Remove bolts and washers from power leads. Route generator power cords through panel and secure to power leads with bolts and washers previously removed.



9. Connect the control pendant(s) to the appropriate high pressure (A) or low pressure (B) receptacles on the Power Pack control panel.
10. Install plug on any unused control box pendant receptacles.
11. Install plug(s) on any unused control box series E-Stop receptacles (C).
12. Turn on main power source.



13. Flip module disconnect switches (D) to ON position.

(continued on next page)

14. Pull out all E-Stop buttons (A).

15. Start the 5-HP motor (B) with button (C) and check for proper motor rotation.

16. Stop 5-HP motor with button (D).

17. If the rotation is incorrect, have your certified electrician perform the following procedure. Depress E-Stop button, turn disconnect switch (E) OFF, and LOCKOUT the power source. Test to ensure no voltage is present, then have the electrician rewire for proper rotation. Then turn on main power source and disconnect switch, pull out E-Stop button, and repeat steps 15 through 17 to recheck for proper rotation.

18. Start the 5-HP motor.

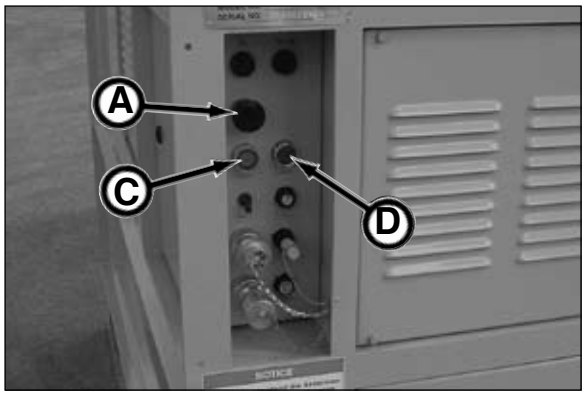
19. Check pilot pressure gauge (F) on high pressure module. Gauge should read approximately 350 psi.

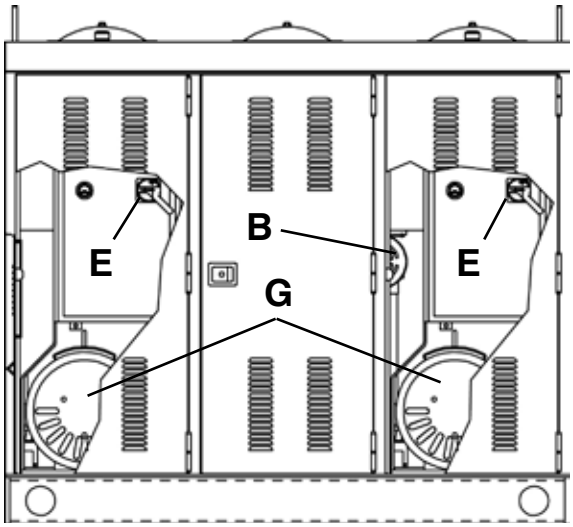
20. Test each E-Stop for proper operation. If any E-Stop button fails to operate properly, IMMEDIATELY turn disconnect switch OFF, LOCKOUT the power source and have a certified electrician repair the E-Stop before the equipment is operated.

21. With proper E-Stop operation, start the 100-HP motor (G) with button (H) on high pressure pendant and check for proper motor rotation.

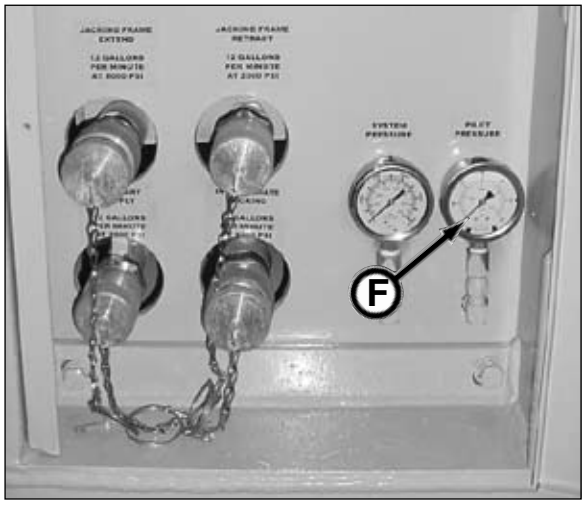
22. Stop 100-HP motor with button (I).

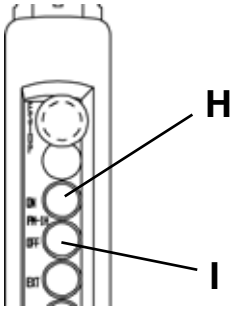
23. If the rotation is incorrect, have a certified electrician perform the following procedure. Depress E-Stop button, turn disconnect switch OFF, and LOCKOUT the power source. Test to ensure no voltage is present, then have the electrician rewire for proper rotation. Then turn on main power source and disconnect switch, pull out E-Stop button, and repeat steps 21 through 23 to recheck for proper rotation.





P600





High Pressure Pendant

P400/P600 POWER PACK HYDRAULIC SETUP

NOTICE **BEFORE** setting up the Power Pack hydraulics, set up the Power Pack. Refer to P400/P600 Power Pack Setup in this section.

⚠WARNING Escaping oil or other fluids under pressure can penetrate your skin causing serious injury. Contact medical help immediately if any oil or fluid is injected into your skin.
ALWAYS switch power supply switches to the STOP position, release hydraulic pressure, AND use gloves before connecting or disconnecting hydraulic oil hoses/lines.

Single Feed Hydraulic Supply
(60 gpm of low pressure oil)

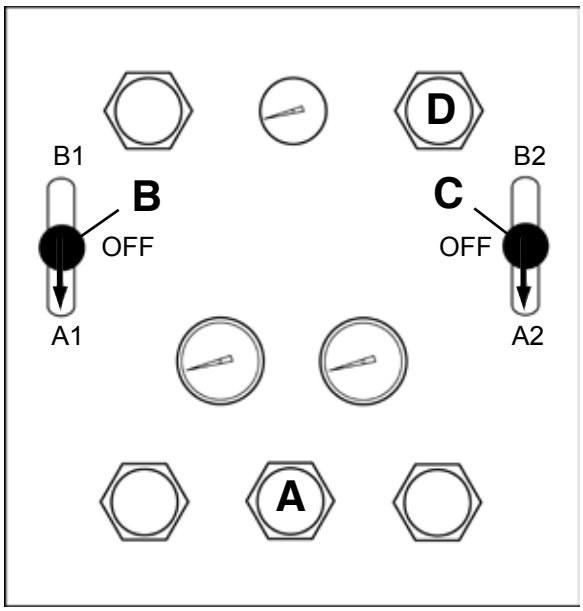
1. Connect the TBM main pressure supply hose to fitting (A) on P400/P600 low pressure module.

2. Move BOTH pump control levers (B and C) to position A1 and A2 respectively. This will supply 60 gpm to the TBM cutter head drive functions; inner drum advance and rotation, steering cylinders, conveyor lift, conveyor speed and dirt wings.

NOTICE Both pump controls must be activated to combine the flow to 60 gpm. Activating one pump control will produce only 30 gpm of oil.

3. Connect the TBM main return hose to fitting (D).

4. Setup TBM for single feed hydraulic connection (refer to TBM Hydraulic Setup - Single & Dual Feed in this section).



Dual Feed Hydraulic Supply
360 - 48SC - 420 - 480 - 540 (sn 18300-01 - 03)
(90 gpm of low pressure oil)

1. Connect the TBM main pressure supply hose to fitting (E) on P400/P600 low pressure module 1.

2. Move BOTH pump control levers (F and G) to position C1 and C2 respectively. This will supply 60 gpm to the TBM cutter head drive functions; inner drum advance and rotation, steering cylinders, conveyor lift, and dirt wings.

NOTICE Both pump controls must be activated to combine the flow to 60 gpm. Activating one pump control will produce only 30 gpm of oil.

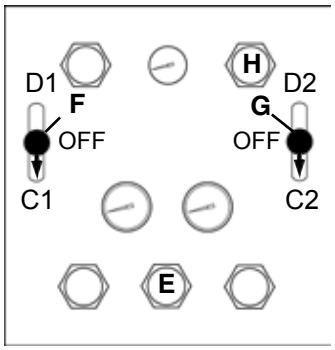
3. Connect the TBM main return hose to fitting (H).

4. On P400/P600 low pressure module 2, connect the TBM conveyor supply hose to fitting (I).

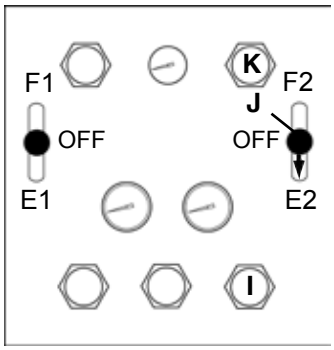
5. Move pump control lever (J) to position E2. This will supply 30 gpm to the TBM conveyor drive.

6. Connect the TBM conveyor return hose to fitting (K).

7. Setup TBM for dual feed hydraulic connection (refer to TBM Hydraulic Setup - Single & Dual Feed in this section).



Low Pressure Module 1 - 60 gpm to cutter head drive



Low Pressure Module 2 - 30 gpm to conveyor drive

Dual Feed Hydraulic Supply
540 (sn 18300-04 & after) - 600 - 660 - 720 - 780
(120 gpm of low pressure oil)

1. Connect the TBM main pressure supply hose to fitting (A) on P400/P600 low pressure module 1.

2. Move BOTH pump control levers (B and C) to position A1 and A2 respectively. This will supply 60 gpm to the TBM cutter head drive functions; inner drum advance and rotation, steering cylinders, conveyor lift, and dirt wings.

NOTICE Both pump controls must be activated to combine the flow to 60 gpm. Activating one pump control will produce only 30 gpm of oil.

3. Connect the TBM main return hose to fitting (D).

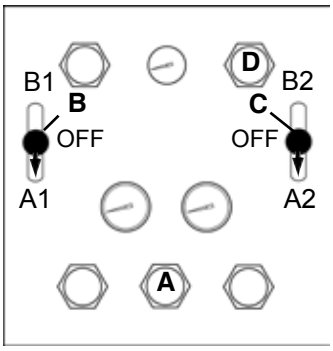
4. On P400/P600 low pressure module 2, connect the TBM conveyor supply hose to fitting (E).

5. Move BOTH pump control levers (F and G) to position C1 and C2 respectively. This will supply 60 gpm to the TBM conveyor drive.

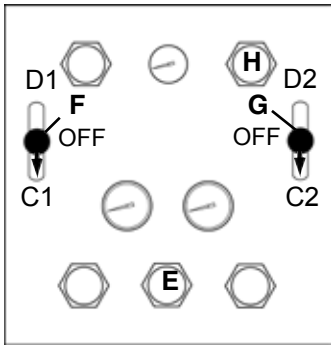
6. Connect the TBM conveyor return hose to fitting (H).

7. Setup TBM for dual feed hydraulic connection (refer to TBM Hydraulic Setup - Single & Dual Feed in this section).

8. Proceed to Checkout Equipment Prior To Start-Up in this section..



Low Pressure Module 1 - 60 gpm to cutter head drive



Low Pressure Module 2 - 60 gpm to conveyor drive

CHECKOUT EQUIPMENT PRIOR TO START-UP

1. Perform equipment maintenance as shown in Periodic Maintenance section.

2. Connect clean water supply hoses with 15 GPM minimum to heat exchanger in pump unit or power pack.

3. Check the oil level in the pump unit or power pack hydraulic reservoir. Add oil if necessary.

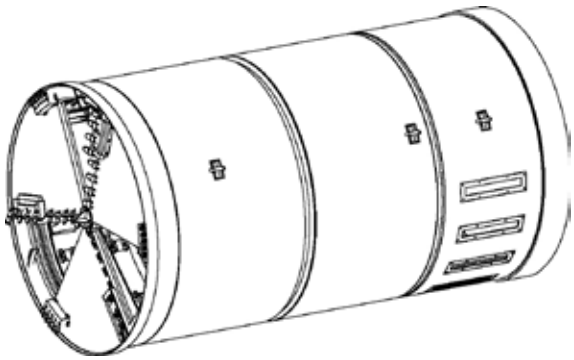
4. Inspect conveyor lift cables daily and replace immediately at the first sign of wear or damage.

5. Check to be sure all suction valves are open and tie strapped to prevent accidental closing of valves.

6. Inspect all hoses and electrical lines for damage. Replace before operating.

7. Be sure all hydraulic hoses and electrical lines are properly installed.

8. Refer to your haul unit, gas detection system, power unit, and jacking frame operation manuals for pre-start checks.\



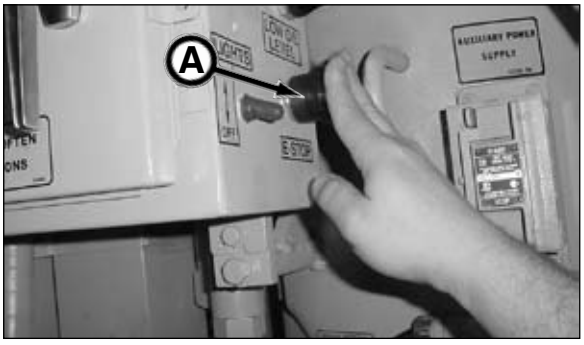
USING EMERGENCY STOP

Be sure to check the operation of ALL E-Stop buttons before operating TBM.

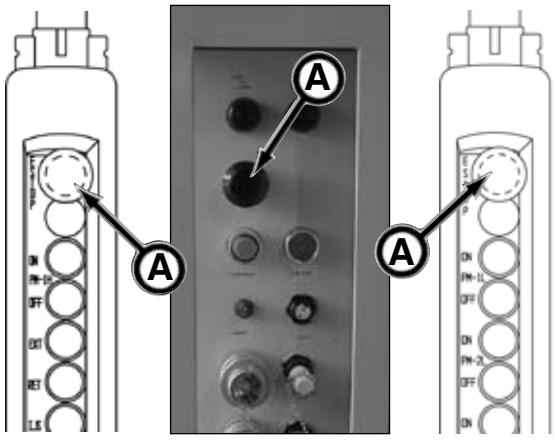
Push Emergency Stop button (A) IN to stop the electrical motor rotation and hydraulic flow.

This button must be pulled out to restart operation.

The operating lights will remain on.



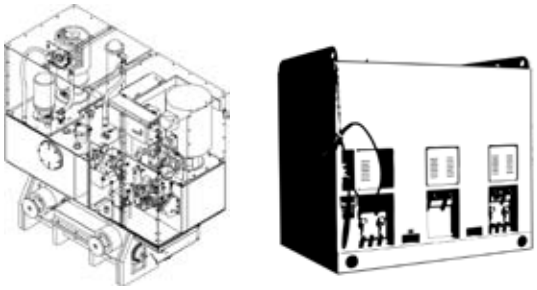
5000 Pump Unit



P400 / P600 Power Pack

TBM START-UP PROCEDURE

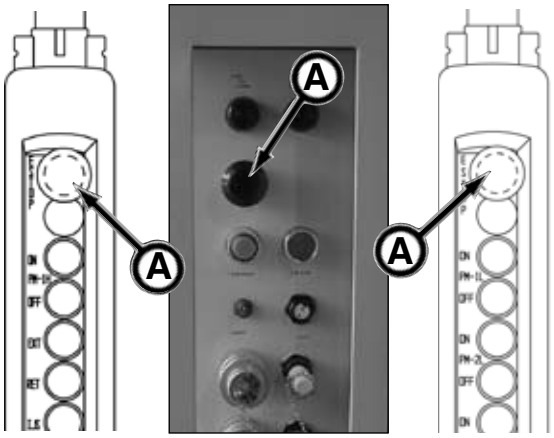
1. The 5000 Pump Unit or P400/P600 Power Pack start-up procedure must be performed prior to TBM start-up.



2. Connect the TBM hydraulic hoses to the power unit or power pack.

3. Connect electrical connections to TBM.

4. Test ALL E-Stop switches (A) for proper operation.



(continued on next page)

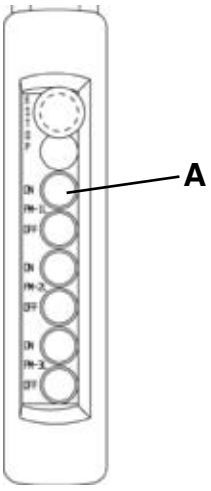
5. Move all TBM control valve handles to the OFF position.

6. Cycle hydraulic supply ON and OFF several times to purge air from system.

(5000 Pump Unit)
a. Turn Boring Head Power Supply ON.

b. Move Boring Head Dual Valve ON and OFF several times to purge air from system.

c. Move Boring Head Dual Valve to OFF and turn Boring Head Power Supply to OFF position.



(P400/P600 Power Pack)
d. Press low pressure module 1 ON with button (A).

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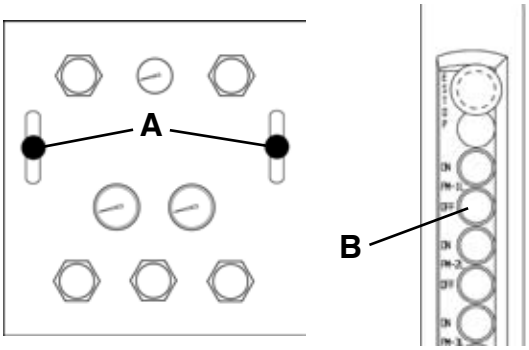
e. Move pump control levers (A) ON and OFF several times to purge air from system.

f. Press button (B) to shut off module 1.



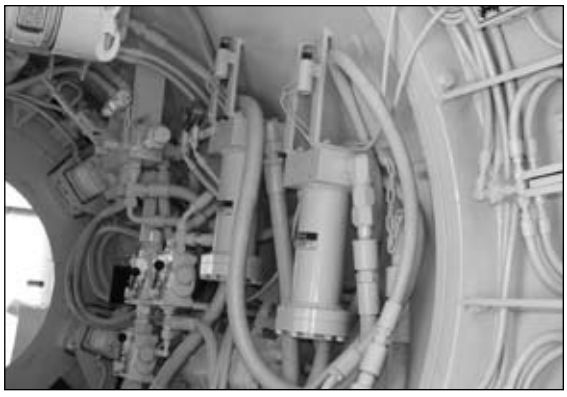
7. Check gas detection systems for proper operation and gas level. Refer to your Gas Detection System Operation manual for more information.

8. Be sure conveyor lift safety chains are connected to conveyor.

9. Check filter element indicator(s). Replace if needed.

10. Check all hoses and fittings for leaks.

11. Be sure all guards are in place and securely fastened.



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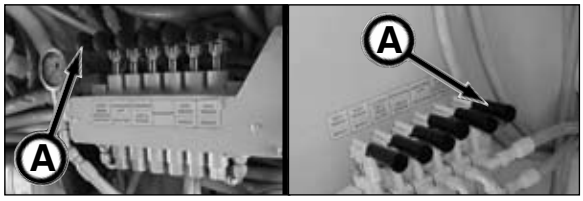
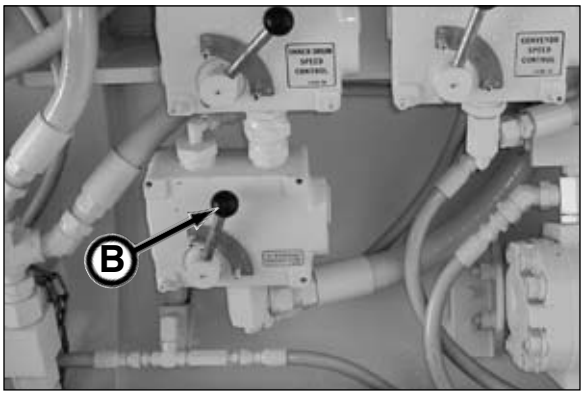
12. Operate Inner Drum Advance control (A) and adjust speed with control (B) to a moderately slow advancement rate.

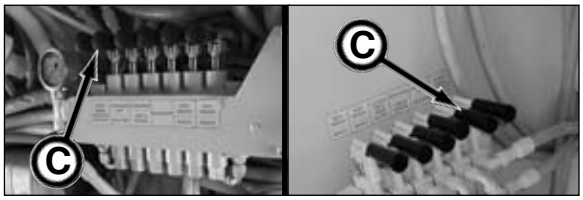


360, 48SC, 420, 480, 540 (sn18300-1-3) *540 (sn18300-4 and after), 600, 660, 720, 780*



13. Operate Conveyor Lift control (C) and adjust speed with control (B) to a moderate speed.

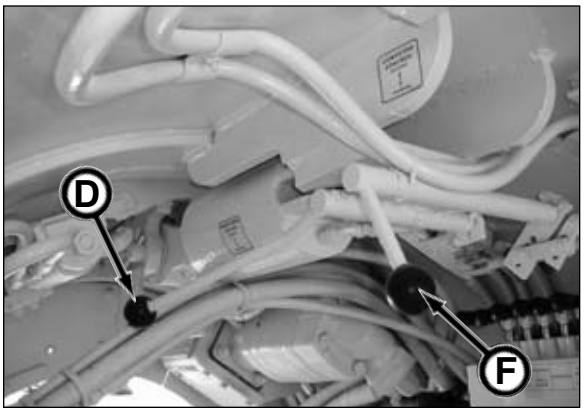
⚠WARNING Adjusting the lift speed too quickly for the operator to handle could cause severe injury or machine damage.

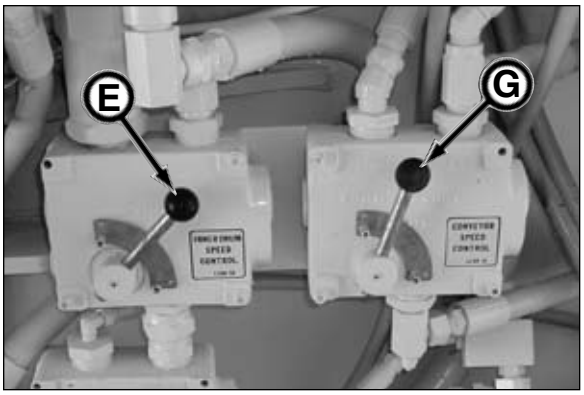


360, 48SC, 420, 480, 540 (sn18300-1-3) *540 (sn18300-4 and after), 600, 660, 720, 780*

14. Operate the Inner Drum Control (D) and adjust speed with Inner Drum Speed Control (E) to desired speed.

15. Operate Conveyor Control (F) and adjust speed with Conveyor Speed Control (G) to desired speed.





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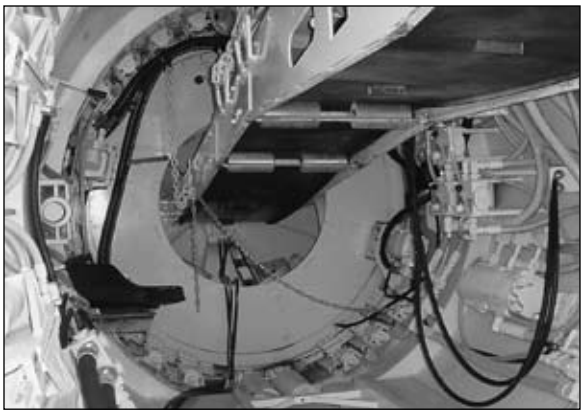
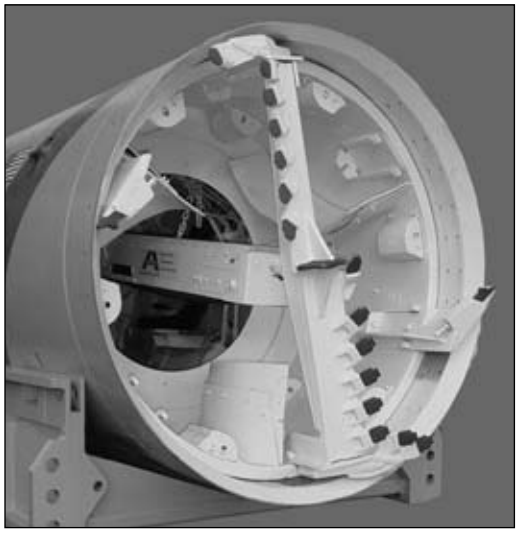


16. Be sure conveyor safety valve chain is connected to conveyor and test operation by pulling conveyor toward operator.



17. Check that the cutter bar mounting bolts are securely fastened.

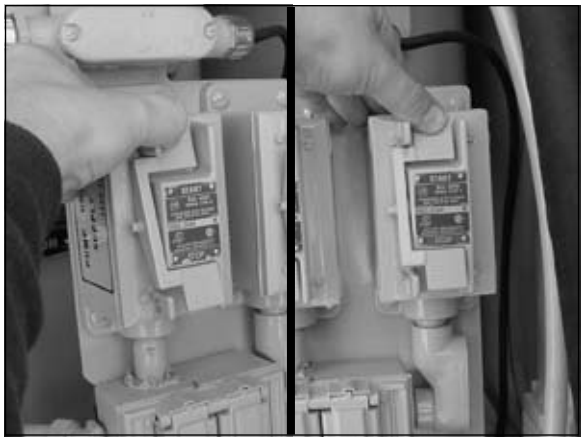
18. Verify that the TBM operator is able to quickly evacuate the TBM in the event of an emergency.

19. Proceed to Launching The TBM in this section.

5000 PUMP UNIT START UP PROCEDURES

1. With hydraulic hoses and electrical cables properly installed and generator or power source ON, turn main disconnect switch ON and auxiliary disconnect switch (if used) ON.

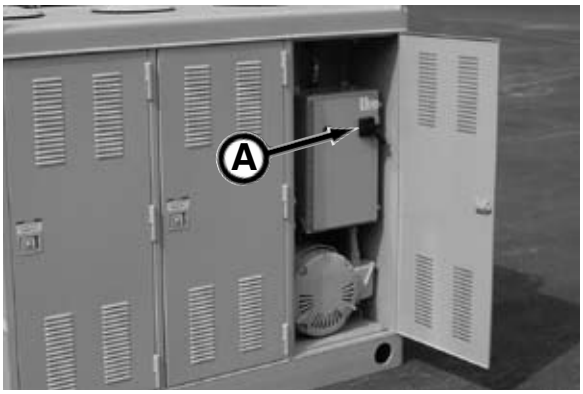
2. Pull out E-Stop button. This will operate the 5 HP motor.
3. Check 5 HP motor for proper rotation.



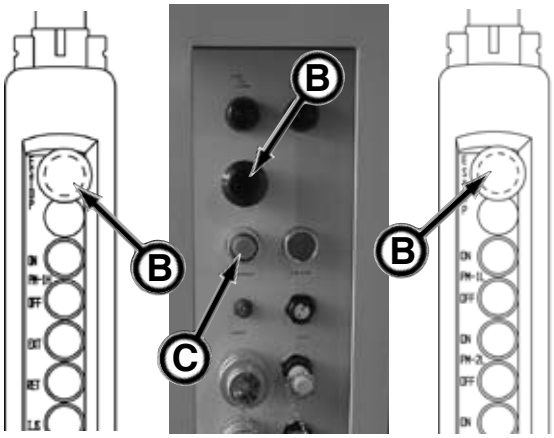
4. Turn the Pump Unit and Boring Head motors on one at a time to prevent electrical overload on generator or power source by pressing the START buttons.
5. Check motors for proper rotation.
6. Check hoses for leaks. Replace as needed.

7. Check filter indicators. Replace filters as needed.
8. Be sure all air is purged from system by operating boring head dual valves on and off several times.
9. Proceed to TBM Start-Up Procedure in this section.

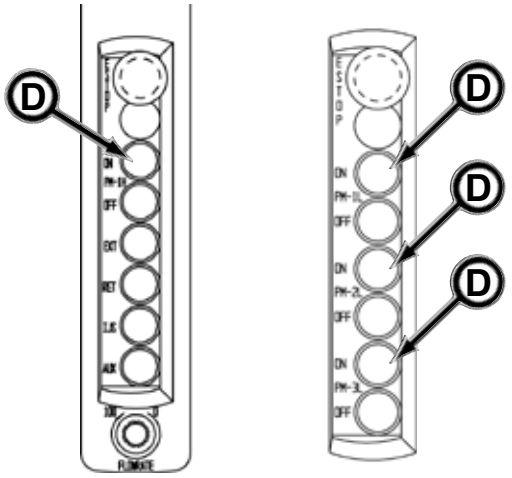
P400/P600 START UP PROCEDURES



1. With hydraulic hoses and electrical cables properly installed and generator or power source ON, turn module disconnect switches (A) ON.



2. Pull out all E-Stop buttons (B).
3. Turn on 5 HP motor by pressing START button (C) on power pack.
4. Check motor for proper rotation.



High Pressure Pendant

Low Pressure Pendant

5. Turn the high pressure and low pressure motors on one at a time to prevent overload by pressing the appropriate module(s) ON button (D) and check motor rotation.
6. Check hoses for leaks. Replace as needed.

7. Check filter indicators (E). Replace filters as needed.
8. Be sure all air is purged from system.
9. Proceed to TBM Start-Up Procedure in this section.

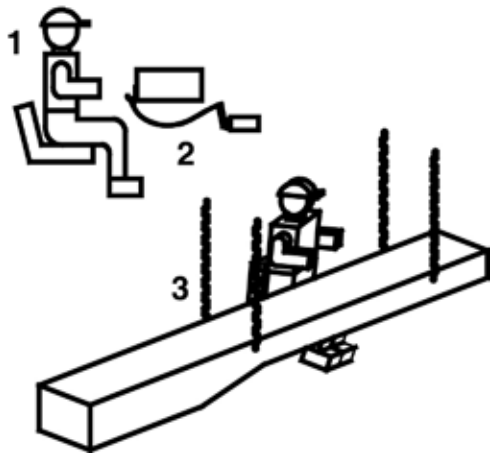
LAUNCHING THE TUNNEL BORING MACHINE

Refer to your 5000 Pump Unit Operator's Manual for proper operation during TBM launch.

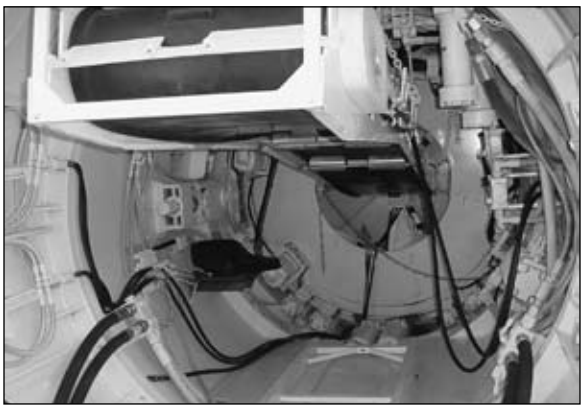
NOTICE Perform TBM Start-Up Procedure BEFORE launching TBM.

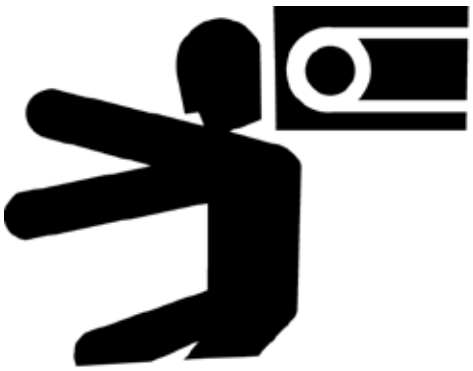
⚠WARNING Conveyor can jam in rotating cutterhead causing conveyor to swing into operator, resulting in severe personal injury. While cutterhead is rotating:

1. Operator MUST remain seated in normal operating position.
2. The conveyor safety valve (cutterhead drive dump valve) MUST be tethered to conveyor and the operation MUST be tested before starting the conveyor to insure proper operation.
3. ALL FOUR safety chains MUST be secured to conveyor.



1. Move the conveyor to the operating position where spoils will fall into dirt bucket.





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

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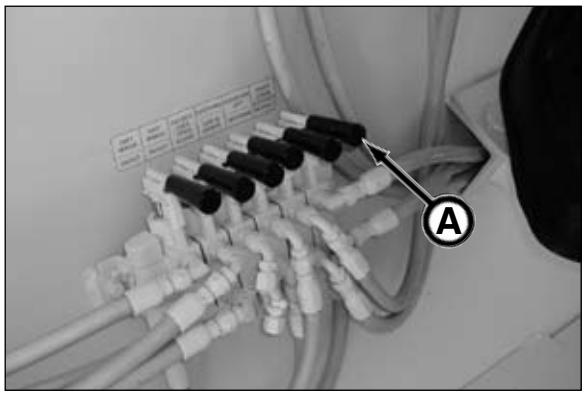
NOTICE NEVER operate equipment if it has been engulfed with water. Contact your Akkerman Aftermarket Support representative for proper procedures on how to restore equipment for operation.

2. Fully extend inner drum advance cylinders with the Inner Drum Advance control (A) and then retract approximately a 1/2” (13 mm).

NOTICE When using sand shelves, do not extend advance cylinders.

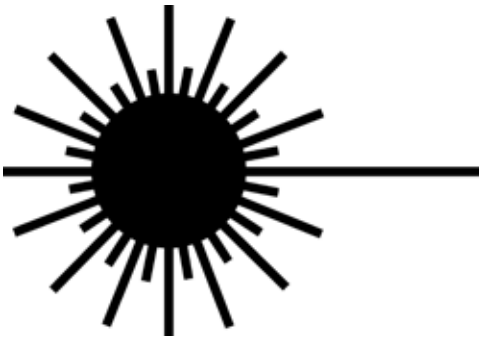


540 (sn18300-4 and after), 600, 660, 720, 780

⚠WARNING Be sure that forward pull exists on the conveyor lifting cables and safety chains throughout the full advance travel. Failure to do so may cause severe injury from conveyor slipping out of the cutter bar center pin.

3. Return the conveyor to the down (maintenance) position.

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



4. Set laser guidance system to grade and alignment, and be sure the laser beam has a clear path to the cutter bar target bolt.

NOTICE For proper guidance system installation, refer to your laser manufacturer’s installation requirements.

NOTICE Typically after TBM is leveled and prior to launching the TBM, some operators steer 1/2” to 3/4” (13 to 19 mm) up to compensate for the ground conditions at start up. The TBM has a tendency to dip once launched into ground. This steering adjustment is dependent upon ground conditions.

(continued on next page)

5. Move the conveyor into the operating position.

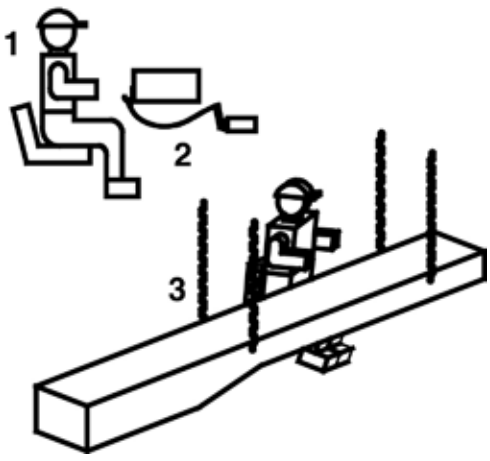
6. Lower dirt bucket into position behind the conveyor. Do not install the haul unit at this time.

⚠WARNING Conveyor can jam in rotating cutter head causing conveyor to swing into operator, resulting in severe personal injury. While cutter head is rotating:

1. Operator MUST remain seated in normal operating position.

2. The conveyor safety valve (cutterhead drive dump valve) MUST be tethered to conveyor and the operation MUST be tested before starting the conveyor to insure proper operation.

3. ALL FOUR safety chains MUST be secured to conveyor before operating inner drum.



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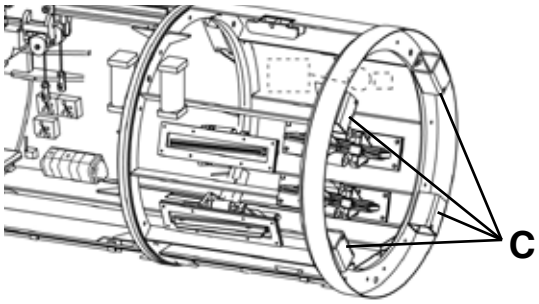
⚠DANGER Contact with rotating auger conveyor or belt conveyor rollers will cause severe injury or death.
Keep hands, body, and objects clear of operating auger and conveyor. Do not operate without covers and guards in place. Lockout power before servicing.

NOTICE Refer to Operating The Conveyor in this section for more information.

7. Turn on the conveyor with control (A), rotate inner drum with control (B) and apply forward thrust to the TBM from pump unit or jacking frame.

NOTICE Before rotating the cutter head, be sure the cutter teeth will not interfere with jacking system frame.

NOTICE Use push blocks (C) to push TBM forward so yoke does not damage outside ring of TBM. Remove push blocks before installing first pipe.



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8. When the dirt bucket is full, flip the bucket lift eye up.

⚠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. With a crane or excavator, check for clearances and carefully lift dirt bucket out of unloading area and move to dumping site.

10. Unload dirt bucket. The dirt bucket is self-dumping when using a two-line crane or when attaching a stationary line.

(continued on next page)

11. Check if TBM over cut is sufficient to allow steering corrections, but does not exceed job specifications. Readjust over cut (outside cutters are adjustable-refer to Adjusting Overcut in this section) and check tooth wear daily and more often in severe conditions.

12. Check and adjust grade and alignment often (after each dirt bucket at a minimum) to avoid excessive jacking pressure. Refer to Making Steering Adjustments and Adjusting TBM Roll in this section.

13. Continue operation until the TBM has been advanced forward enough to lower the trailing section of the TBM or the first pipe into place.

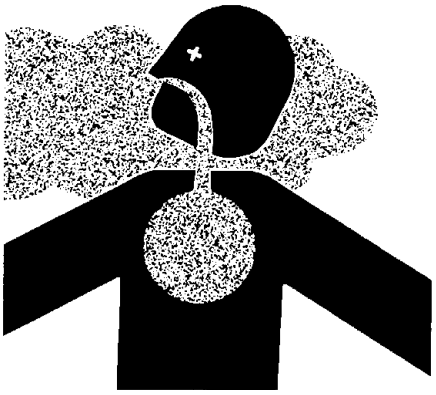
14. Stop the TBM and the 5000 Pump Unit or P400/ P600 Power Pack. Return all controls to the OFF position.

⚠WARNING Escaping oil or other fluids under pressure can penetrate your skin causing serious injury. Contact medical help immediately if any oil or fluid is injected into your skin. ALWAYS switch power supply switches to the STOP position, move all control valves to the OFF position AND use gloves before connecting or disconnecting hydraulic oil hoses/lines.

15. Disconnect and cap the TBM supply and return hoses.

(continued on next page)

⚠DANGER The Akkerman gas detection system only monitors methane gas levels. Monitoring of gas levels is the responsibility of the contractor. This includes accumulation of combustible and toxic gases, and depletion of oxygen. The contractor must keep the tunnel ventilated with fresh air AT ALL TIMES.



16. Disconnect the ventilation, electrical and communication lines and reconnect quickly by routing lines through next pipe.

17. Start the high pressure pump on the 5000 Pump Unit or P400/P600 and retract the jacking system far enough to lower the first pipe on the jacking system base (skid).

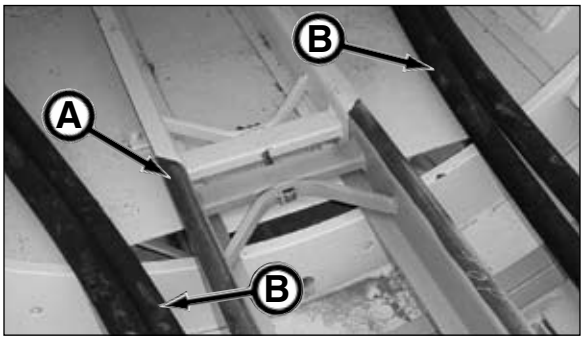
⚠WARNING Suspended loads may fall and cause severe injury or death. Do not allow anyone to enter area under or around a suspended load.

18. Stop the Pump Unit/Power Pack and lower the first pipe onto the jacking system base.

(continued on next page)

19. Start the jacking system and apply forward thrust until the first pipe mates with the TBM.

20. When the first pipe has been set, install the first haul system track (A) and secure to TBM. Refer to Installing Track in the Operation section of your Haul Unit Operator's Manual for track installation.



NOTICE Be sure there is always track connecting the pipeline to the rear of the jacking frame/yoke for the haul unit and the loading and unloading of the dirt bucket.

21. Reconnect the TBM supply and return hoses (B) (adding hoses as necessary) and turn the TBM supply pump ON.

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

22. Lower haul unit onto the track with the operator end of the haul unit installed towards the front of the TBM.

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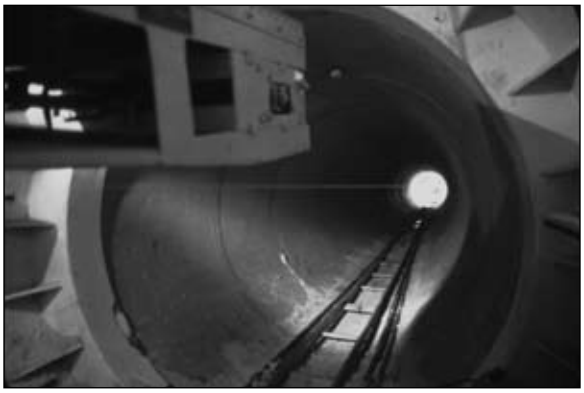
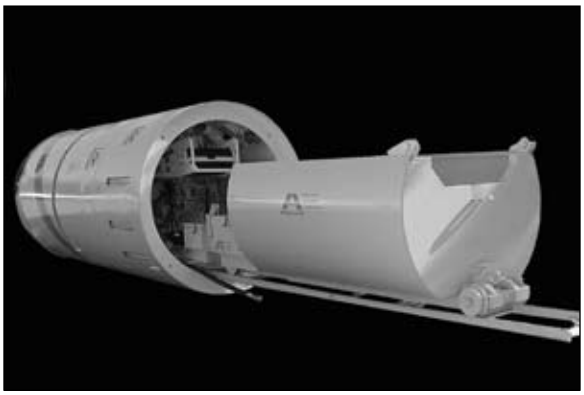
23. Recheck laser guidance system accuracy often (both with and without forward thrust applied) to avoid making improper steering corrections. In most situations, the conveyor must be lowered to check line and grade target.



NOTICE The more often the target position is checked, the less adjustment that will be required.

NOTICE Relevel inner drum every time the target position is checked.

24. Lower dirt bucket into place on the haul unit.



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

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

(continued on next page)

NOTICE For information on operating the haul unit, refer to Operating The Haul Unit in the Operation section of your Haul Unit Operator's Manual.

25. Move the haul unit to the front of the tunnel until dirt bucket is in position to catch spoils from conveyor.

NOTICE Haul Unit track can get slippery. Therefore when operating the haul unit, GO SLOW! Also, remember that the haul unit forward momentum will carry the haul unit past the point where the brake is applied.

26. Continue pipe jacking process for each additional pipe section (adding hydraulic hose and track as necessary, refer to Adding New Pipe in this section) until pipe line is complete. When pipe line is complete, refer to Removing Jacking System in this section.

NOTICE If there is a possibility that the maximum jacking capability will exceed the maximum jacking force of your jacking system or pipe, intermediate jacking stations should be installed (refer to Using Intermediate Jacking Stations in this section).

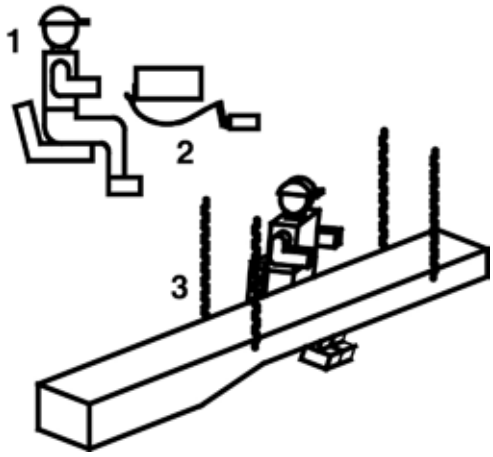
OPERATING THE CONVEYOR

⚠WARNING Conveyor can jam in rotating cutterhead causing conveyor to swing into operator, resulting in severe personal injury. While cutterhead is rotating:

1. Operator MUST remain seated in normal operating position.

2. The conveyor safety valve (cutterhead drive dump valve) MUST be tethered to conveyor and the operation MUST be tested before starting the conveyor to insure proper operation.

3. ALL FOUR safety chains MUST be secured to conveyor.



Conveyor Operation Guidelines:

1. Check conveyor for damage before operating. Repair or replace damage or wear before operating.
2. Operator MUST remain seated in normal operating position.
3. Cutter head drive dump valve cable (stop cord) MUST be tethered to conveyor.
4. ALL FOUR safety chains MUST be secured to conveyor before operating inner drum.
5. Avoid contact with conveyor.
6. Keep hands, body, and objects clear of operating conveyor.
7. Do not operate without covers and guards in place.
8. Lockout power before performing maintenance or repairs on conveyor.
9. NEVER perform maintenance to conveyor while the conveyor is running.
10. While conveyor is running, DO NOT try to dislodge material from pulleys.
11. NEVER use a shovel, or other hand tool to clean material buildup while the conveyor is running.
12. Before operating conveyor, check to be sure the belt is properly tensioned.

360, 48SC, 420, 480, 540 (sn18300-1-3) *540 (sn18300-4 and after), 600, 660, 720, 780*

1. With conveyor properly installed and all guards in place, inform all personnel in tunnel that the conveyor is going to start up and to stay clear of the conveyor.

2. Lower conveyor into operating position with conveyor lift control (A) and adjust lift speed with selector speed control (B) to a moderate speed

⚠WARNING Adjusting the lift speed too quickly for the operator to handle could cause severe injury or machine damage.

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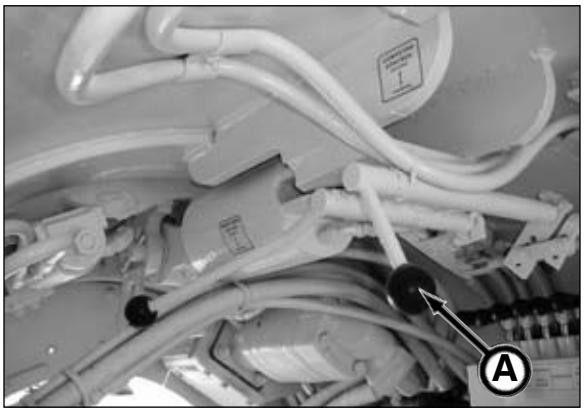
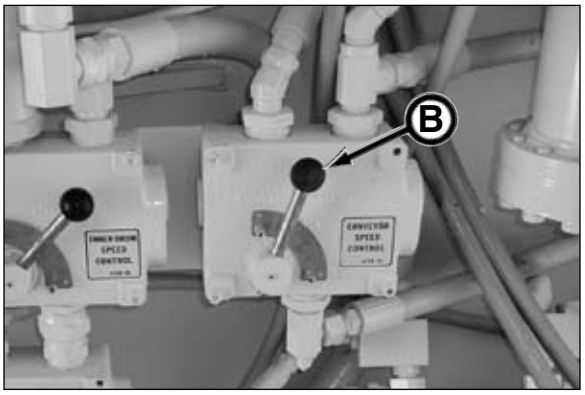
3. Move dirt bucket into position to catch spoils from conveyor.



⚠WARNING Running the conveyor too fast can cause severe injury from flying debris and cause possible machine damage. Slow the conveyor speed so there is continual controlled movement of the spoils into the dirt bucket.

4. Operate conveyor control (A) and adjust speed with conveyor speed control (B) to desired speed.



NOTICE Control the speed of the conveyor so when the spoils drop on the conveyor, they do not pile up on the belt or in the auger. A change in ground conditions will require periodic adjustments to the conveyor speed.

MAKING STEERING ADJUSTMENTS

NOTICE Steering adjustments are typically made when the dirt bucket is removed from the launch shaft, then the conveyor is lowered to expose the laser beam on the target bolt area.

NOTICE The more often the target position is checked, the less steering adjustments will be required.

When steering corrections are necessary, be sure to make ONLY minor adjustments. Making more extreme steering adjustments will increase the jacking forces due to the front and trailing sections not in parallel.

Use the steering selector (A) to select the grade or alignment adjustment.

GRADE (up/down):
Move steering selector (A) UP to select Grade, then operate the steering valve (B) on the TBM control valve up or down to adjust the two steering cylinders accordingly. This will move the front drum up or down. DO NOT use steering nut for grade adjustment.

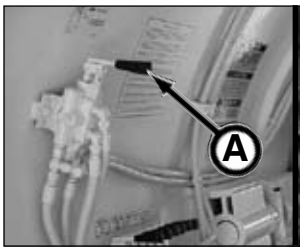
ALIGNMENT (left/right):
Move steering selector (A) DOWN to select Alignment.

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

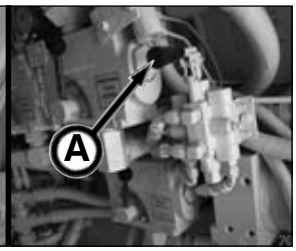
Right Turn: operate the steering cylinder valve (B) on the TBM control valve down while turning steering nut back.

NOTICE If steering nut is hard to turn, tap the steering cylinder lever to relieve pressure.

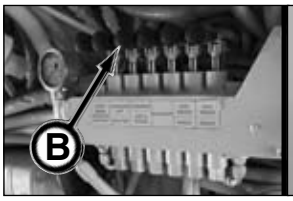
NOTICE Move steering nut simultaneously with steering cylinder so that no excessive force is on the nut.



360, 48SC, 420, 480 540 (sn18300-1-3)

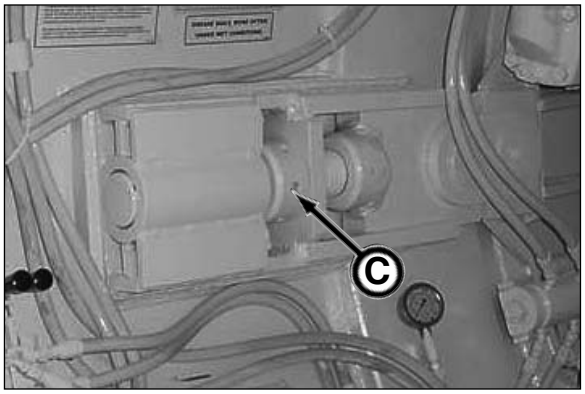


540 (sn18300-4 & after), 600, 660, 720, 780



360, 48SC, 420, 480, 540 (sn18300-1-3)

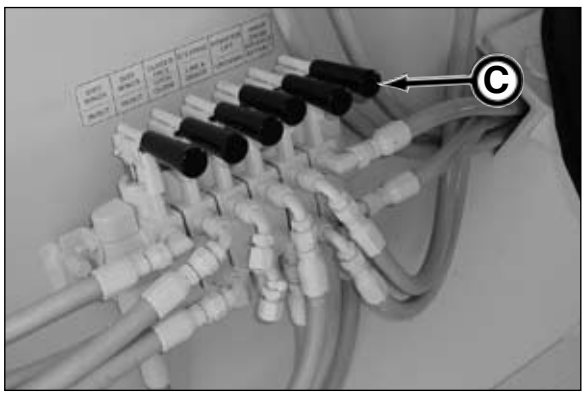
540 (sn18300-4 and after), 600, 660, 720, 780



ACCESING FRONT OF TBM / ENCOUNTERING AN OBSTRUCTION

To access the front of the machine and the face of the bore, retract the inner drum advance cylinders with control lever (C). Be sure to perform the lock out, tag out procedure before accessing the front of the TBM.

This feature allows for the removal of large obstructions, whether planned or unexpected and makes it easy to perform routine maintenance and repairs.



540 (sn18300-4 and after), 600, 660, 720, 780 Shown

ADJUSTING TBM ROLL

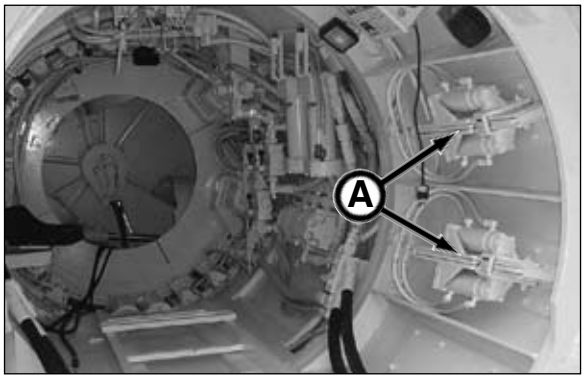
If the TBM rolls 1/4” to 1/2” (6 to 13 mm) from level, the dirt wings need to be extended. The dirt wings (A) are fully extended when the system pressure reads 2,800 - 3,000 psi.

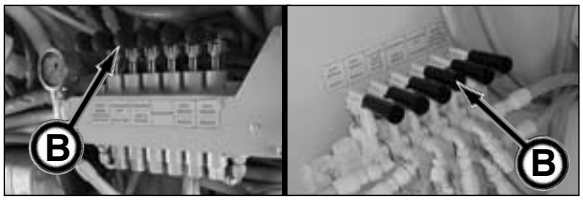
Control the TBM roll with lever (B) as follows:

Operator side is low: extend dirt wings
Operator side is high: retract dirt wings

Keep the dirt wings extended until the TBM roll is back to level position.

If needed, bolt-on and hydraulic clockwise and counterclockwise dirt wings, and extensions are available. Contact your Akkerman Aftermarket Support representative for more information.





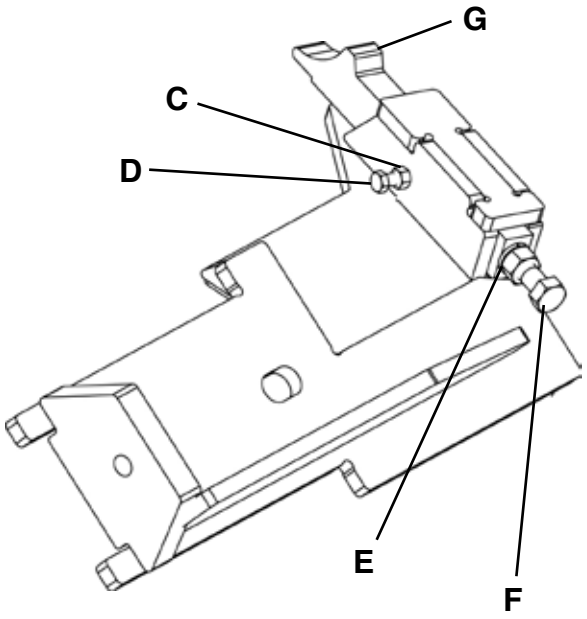
360, 48SC, 420, 480, 540 (sn18300-1-3)

540 (sn18300-4 and after), 600, 660, 720, 780

ADJUSTING OVERCUT

The typical overcut is 1.50” (38 mm) larger than the product pipe diameter, which allows space for steering and the addition of bentonite. Keep in mind that too large of an overcut can lead to uncontrollable steering. Contact your Akkerman Aftermarket Support representative if your desired overcut is more than 1.50” (38 mm).

1. Loosen nut (C), set screw (D), and nut (E).
2. Readjust bolt (F) to move cutter (G) to desired overcut.
3. Retighten nut (E).
4. Retighten set screw (D).
5. Retighten nut (C).



USING GAS DETECTOR

Refer to your Gas Detection System Operation & Parts Manual for properly operating the 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 methane gas levels. **Monitoring of all 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.

Zellweger Analytics System

GDS GasMax II System

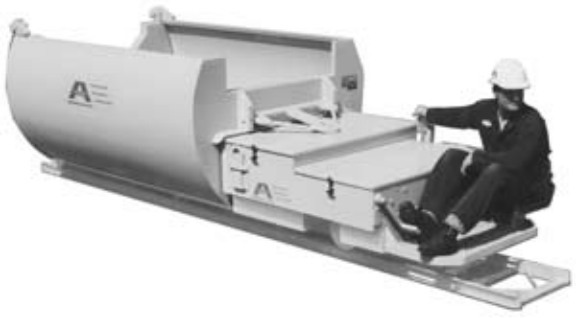
USING HAUL UNIT

⚠WARNING Contacting tunnel wall and boring head components can cause severe injury or death. Keep all body parts on Haul Unit while unit is moving.

Refer to your Haul Unit Operator's Manual for the proper safety, operation, and maintenance information.

Keep all tooling or other support equipment off of the haul unit.

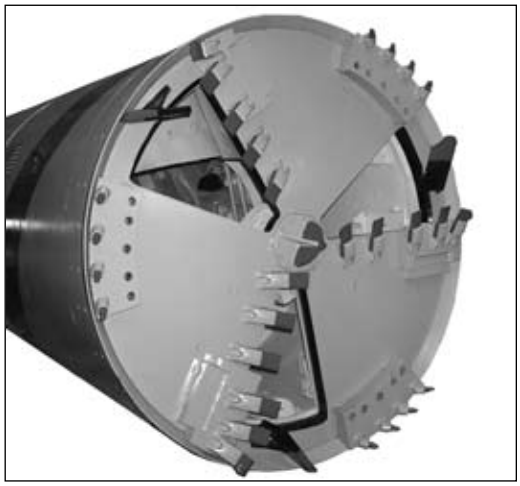
524 Haul Unit With Dirt Bucket



1448 Haul Unit With Dirt Bucket

USING CLOSED FACE OR AUXILIARY CONTROL

The Closed Face lever (A) controls the opening and closing of the doors on the optional closed face cutter head attachment. Used in unstable ground conditions, the hydraulically operated doors control subsidence of loose soil while excavating the ground.



Move the lever as follows:

UP - open doors
DOWN - close doors

A lubrication system (two water/lubrication ports on cutter head) is equipped on the closed face attachment to provide a method to lubricate the face if needed.

360, 48SC, 420, 480, 540 (sn18300-1-3)

540 (sn18300-4 and after), 600, 660, 720, 780

Operating Guidelines:

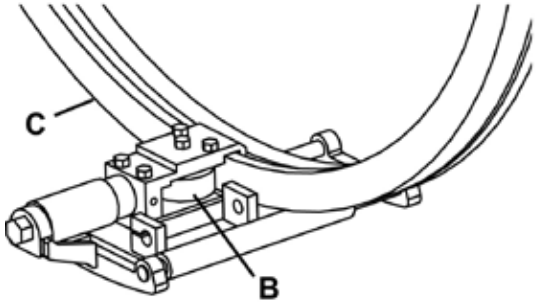
1. Advance inner drum cylinders only enough to turn the inner drum.

2. Open doors only as needed while advancing to prevent over excavating.

3. Connect water/lubrication hose to 1/2” fitting on closed face attachment to lubricate clay or abrasive materials.

4. When retracting advance cylinders for closure of closed attachment to TBM cutter ring, monitor auxiliary pressure gauge (located next to inner drum speed control) for pressure spike indicating closed face closure.

   Continuing to retract beyond this point, may result in damage to thrust rollers (B) and gear ring (C).



5. At each shift change, or at the end of the day, retract inner drum and close doors to prevent material flow into the TBM.

ADDING NEW PIPE

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

1. Retract jacking system cylinders.
2. Turn all switches to OFF.
3. Turn all control valves to the OFF position.
4. Shut down power source and perform lock out, tag out procedure.
5. With power locked out, relieve hydraulic pressure and disconnect TBM hydraulic pressure and return hoses, vent supply, 110V electrical line, bentonite hoses (if used), and IJS hydraulic hoses and cable (if used). Make sure all of the electrical lines, hose connections and cables are in a clean, dry location and are out of the way of the next pipe.
6. Disconnect track from pipeline.

7. Perform a visual machine inspection by checking the following items: all fluid levels, leaks, and machine damage. Make repairs before operating.
8. Lower the next pipe into shaft and wipe off and lubricate the sealing ring to ensure proper sealing before setting pipe.
9. Clean electrical and hose connections before reinstalling.
10. Reinstall TBM hydraulic pressure and return hoses, vent supply, 110V electrical line, bentonite hoses (if used), IJS hydraulic hoses and cable (if used) and communication lines. Check to be sure all connections are properly connected and secured.
11. Once it is communicated to all job site personnel that the power and machine operation will be resumed, start up power source.
12. Perform TBM and Power Unit/Power Pack system start-up.
13. Slowly advance the new pipe with the launch shaft jacking frame/yoke until pipe is set.
14. Install new pipe track to pipeline track. 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/yoke for the haul unit and the loading and unloading of the dirt bucket.
15. After start-up, check target to be sure the laser was not bumped in the launch shaft.
16. Repeat installation for subsequent pipe.

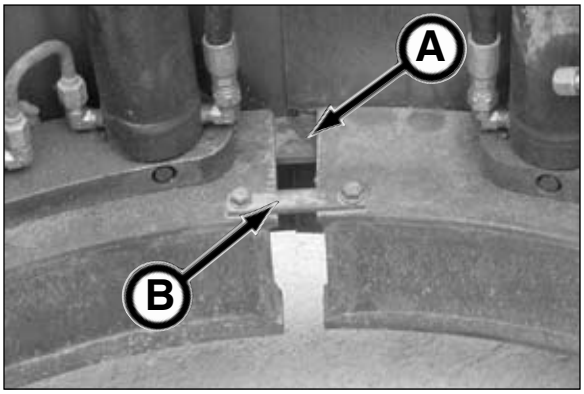
USING INTERMEDIATE JACKING STATIONS (IJS)

Intermediate Jacking Stations (IJS) are generally used when the thrust pressure reaches one third of the maximum pressure capacity of the pump unit or one half of the thrust capacity of the IJS, which ever occurs first. Contact the Akkerman Sales Department for more information on the proper setup and usage of IJS.

INSTALLING IJS

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

1. Lower IJS with the inner ring towards the front of the tunnel, between the leading pipe and the trailing pipe.



NOTICE IJS configurations may vary depending upon project requirements.

2. With the IJS lowered onto the skid assembly, cut inner ring flange (A), located at seam of sleeve, with torch and unbolt plate (B) before mating pipe with IJS.

⚠WARNING Pinch Points! Watch your fingers, hands, and legs while installing IJS sleeve.

3. SLOWLY jack until the trailing pipe slides into IJS sleeve and the IJS sleeve slides over leading pipe.

4. Use a winch or turn-buckle to squeeze the IJS sleeve until it mates with the leading and trailing pipe.

5. Tack weld seam.

6. Torch off lifting eyes.

7. Completely weld seam. Reweld flange (A) if possible.

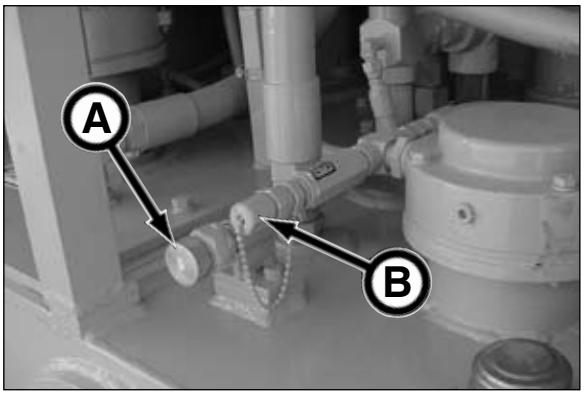
8. Install track and sliding track. Be sure no track joints are in IJS opening.

(continued on next page)

9. (5000 Pump Unit)
   Connect hydraulic hoses to Pump Unit.

   a. Connect quick coupler (A) to intermediate jacking station valve pressure port. Use hose rated for 8,000 psi working pressure ONLY.

   b. Connect coupler (B) to the IJS tunnel return line.

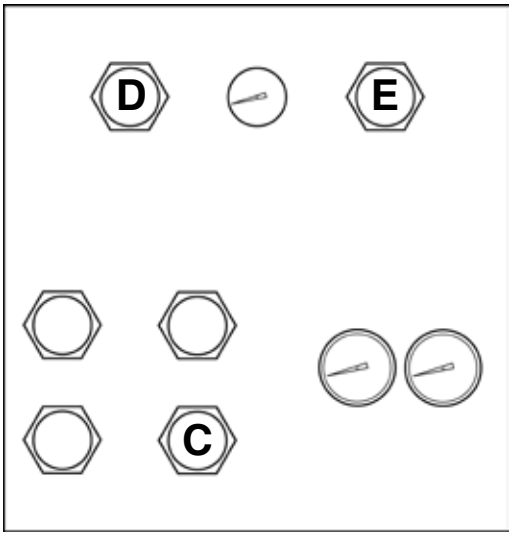


5000 Pump Unit IJS Connections

10. (P400/P600 Power Pack)
    Connect hydraulic hoses to Power Pack.

    a. Connect intermediate jacking station valve pressure port hose to quick coupler (C). Use hose rated for 8,000 psi working pressure ONLY.

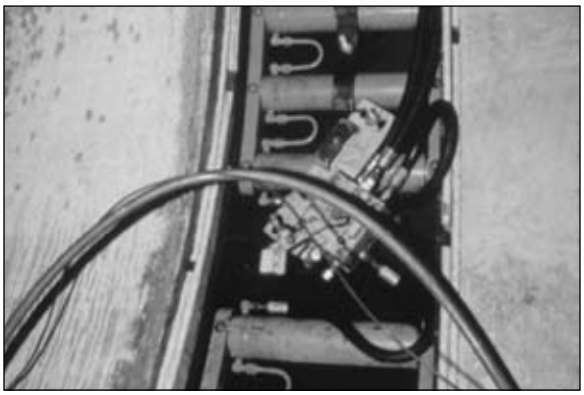
    b. Connect IJS tunnel return hose to coupler (D or E).

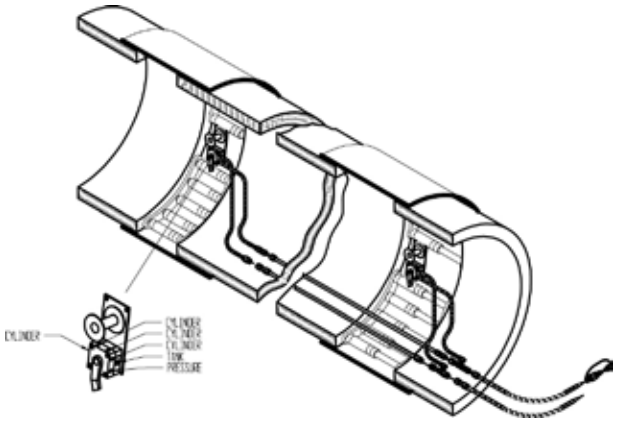


P400/P600 - IJS Connections

11. Mount the IJS valve between cylinder segments.

12. Connect hydraulic hoses to IJS valve:
    a. Pressure to port P
    b. Return to port T
    c. Connect cylinders to C ports





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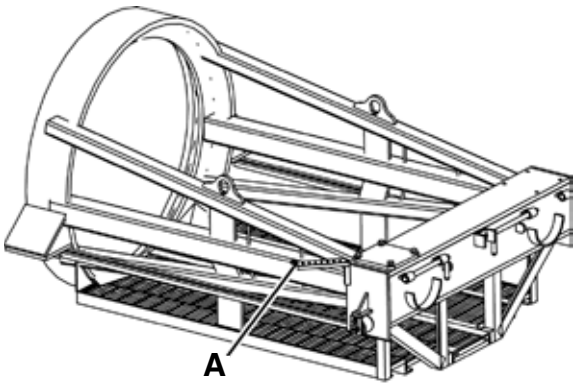
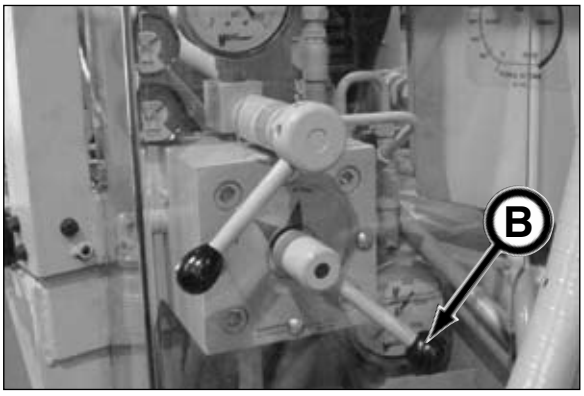
13. Secure cable weight to IJS line holder (A) on yoke or jacking frame.



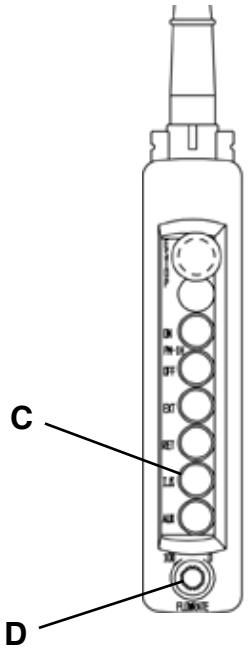
OPERATING IJS

14. (5000 Pump Unit) With the Pump Unit running, set selector valve (B) to Intermediate Jack (as shown).

15. (5000 Pump Unit) Be sure pressure release valve is closed.



16. (P400/P600 Power Pack) With the power pack running, depress the IJS button (C) on the high pressure pendant while adjusting flow rate with control (D).



P400/P600 High Pressure Pendant

(continued on next page)

17. Pull cable for IJS #1 to open valve and operate stroker control (5000 Pump Unit) or depress IJS (A) on pendant while adjusting flow rate (P400/P600). Operate the boring head the same as if the TBM is being jacked with the main ram cylinders (5000 Pump Unit) or jacking frame cylinders (P400/P600 Power Pack).

18. When the IJS cylinders are at full extension, the pressure should start to climb rapidly. Maximum pressure is 8,000 psi.

19. Release cable and stroker control (5000 Power Unit) or release pendant IJS button (P400/P600).

20. Pull cable for IJS #2 to open and operate stroker control (5000 Pump Unit) or depress IJS on pendant (P400/P600) to close IJS #1. When the IJS cylinders are at full extension, the pressure should start to climb rapidly.

NOTICE **Do not** operate TBM cutterhead when using IJS #2, IJS #3, etc. or when closing final IJS. Doing so could result in a pipe joint separation.

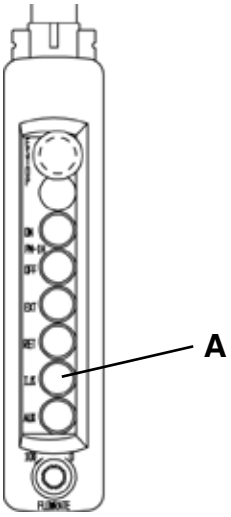
21. Release cable and stroker control (5000 Pump Unit) or release pendant IJS button (P400/P600).

22. Pull cable for IJS #3 to open and operate stroker control (5000 Pump Unit) or depress IJS button on pendant (P400/P600) to close IJS #2. When the IJS cylinders are at full extension, the pressure should start to climb rapidly.

23. Release cable and stroker control (5000 Pump Unit) or release pendant IJS button (P400/P600).

24. Repeat this opening and closing process for any additional IJS.

5000 Pump Unit - Cable Stroker Control

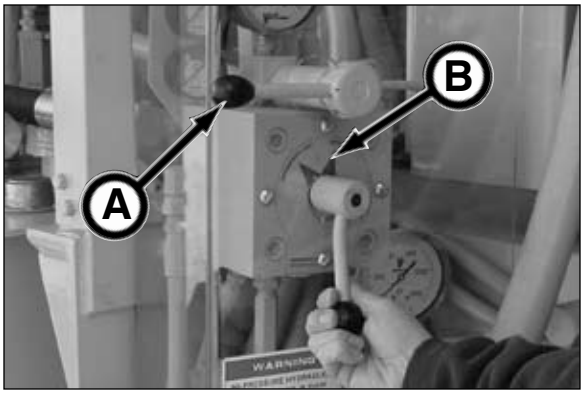


P400/P600 - High Pressure Pendant

(continued on next page)

25. (5000 Pump Unit) Release selector valve pressure by moving pressure release lever (A) CW. After pressure is released, move the pressure release valve CCW to close the valve.

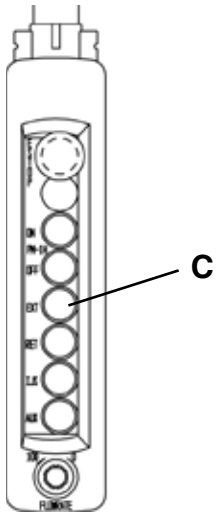
26. (5000 Pump Unit) Set selector valve to Extend position (B).



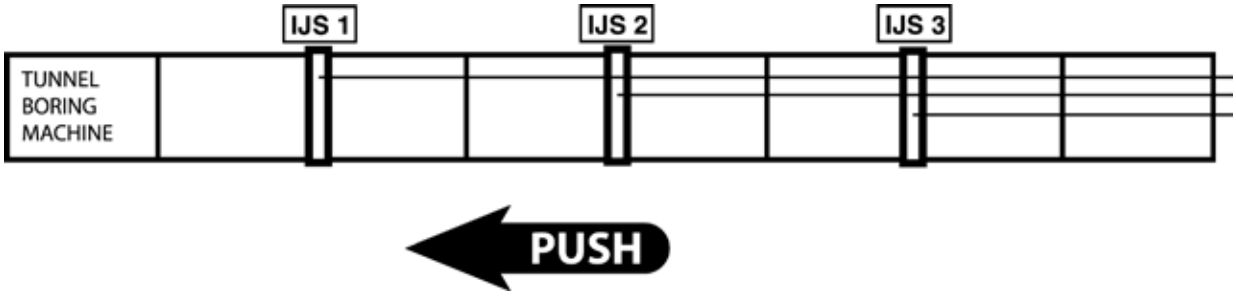
27. Continue jacking with main rams using the stroker control (5000 Pump Unit) or depress Extend button (C) on pendant (P400/P600) to close the last IJS.

5000 Pump Unit - Cable Stroker Control

NOTICE Keep in mind when using the Intermediate Jacking Stations, you are only mining with IJS #1, then closing IJS #1 with IJS #2, closing IJS #2 with IJS #3, and closing IJS #3 with main rams (5000 Pump Unit) or jacking frame rams (P400/P600).



P400/P600 - High Pressure Pendant



Intermediate Jacking Station Sequence

USING LINER CAN

Use the following procedure as a general guideline when using a liner can.

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 to power pack.

2. Move all TBM controls to the OFF position.

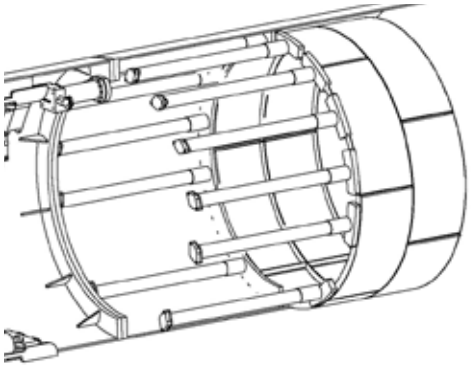
3. Turn on cooling water supply to power pack heat exchanger.

4. Pull out E-Stop button to start power. Recheck motor rotation.

5. Turn on power pack power to run the steering, auxiliary, and conveyor functions.

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

6. Set laser guidance system to grade and alignment. Be sure the laser beam can be easily seen on the cutter bar target bolt when the cutter bar is level.



7. Retract liner can cylinders with liner can cylinder control.

8. Assemble liner plate rings in TBM.

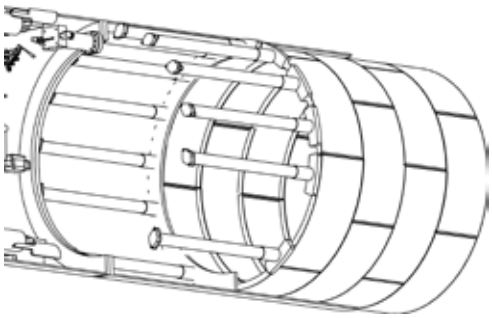
9. Once the liner plate rings are assembled in liner can of TBM, extend the liner can cylinders. The cylinders apply pressure to the liner plate which applies pressure to the thrust block or other support structure, pushing the TBM forward. Excavate cut face as necessary.

10. When the liner can cylinders are completely extended, retract the cylinders.

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

11. Place the dirt bucket into position behind the conveyor; do not install the haul unit at this time.

12. Operate the conveyor control and adjust speed with conveyor flow control.



13. Load the spoils on the conveyor by rotating inner drum.

14. Check and adjust grade and alignment (more often if necessary) after each dirt bucket removal to avoid excessive jacking pressure.

15. Continue assembling liner plate rings (per manufacturer instructions) until TBM has been advanced forward enough to lower haul unit into TBM.

16. Remove dirt bucket.

17. On power pack, press E-Stop button IN to shut down TBM power and shut off all jacking system power.

18. Perform lock out, tag out procedure on generator or other power source, and power pack.

(continued on next page)

19. Install the first track section. Refer to your Haul Unit Operator's Manual for track installation. Sections of track will need to be added as new liner plate sections are assembled. Also, there must always be track connecting the pipeline to the rear of the skid assembly for the haul unit loading and unloading of the dirt bucket.

20. Lower haul unit onto track. Refer to your Haul Unit Operator's Manual for haul unit installation.

21. Lower dirt bucket into place on haul unit. Move the haul unit into the pipeline until the dirt bucket is underneath the conveyor.

22. Perform system start up procedure.

23. Retract liner can cylinders with liner can cylinder control.

24. Shutdown system and perform lock out, tag out procedure.

25. Assemble liner plate rings in TBM.

26. Once the liner plate rings are assembled in liner can of TBM, perform startup procedure and extend the liner can cylinders and excavate face as necessary.

27. When the liner can cylinders are completely extended, retract the cylinders.

28. Load the spoils on the conveyor.

29. Unload the dirt bucket once it is full by moving it to the unloading/loading zone in the launch shaft with the haul unit.

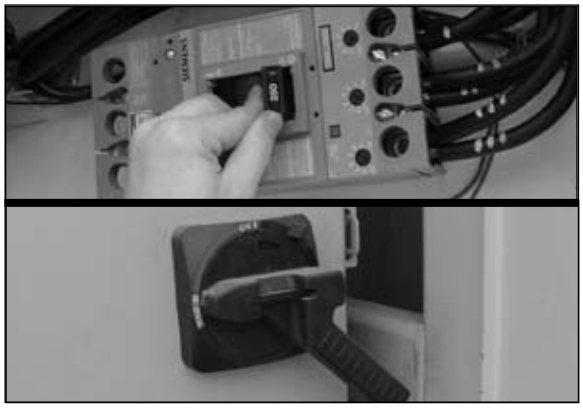
30. Recheck laser guidance system accuracy often, with and without forward thrust applied, to avoid making improper steering corrections.

31. Continue to install additional liner plate, by following steps 23 through 30 until the pipeline is complete.

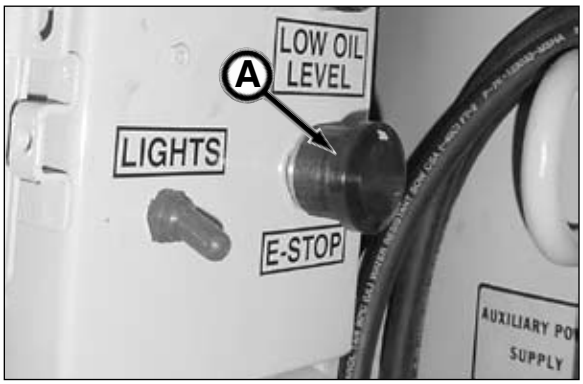
DAILY SHUT DOWN

1. Stop jacking frame hydraulics.

2. Turn all controls and/or switches to OFF position.



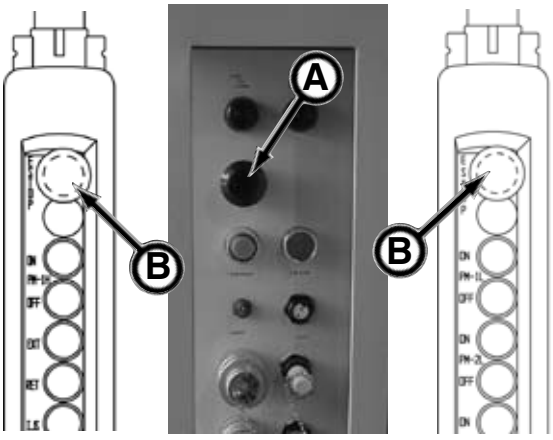
3. Push in ALL E-Stop buttons (5000 Power Unit, or P400/P600 Power Pack (A), power pack pendants (B), and launch or reception shaft E-stops to shut down power.



4. Shut off water supply to power unit/power pack heat exchanger. Drain water if freezing temperatures are possible.

5. Shut off main power source and perform lock out, tag out procedure.

6. Perform a visual system inspection by checking the following items: all fluid levels, leaks, and machine damage. Make repairs before operating. Also check to be sure all connections are properly connected and secured.



NOTICE Contractors often choose to remove the 5000 Pump Unit to prevent flooding of the pump unit in the launch shaft.

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REMOVING TBM AND JACKING SYSTEM

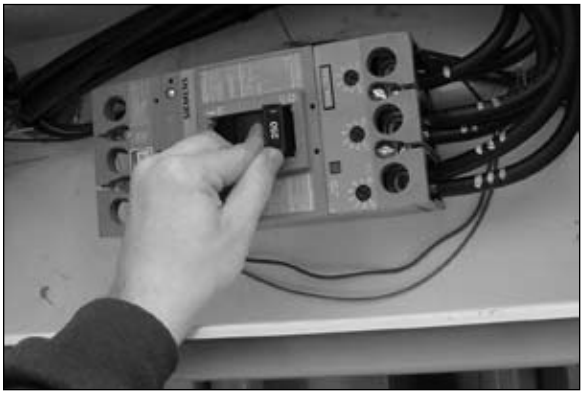
⚠WARNING Any electrical work completed on the jacking system MUST be performed by a certified electrician.

When pipe line is complete and TBM is in reception shaft, remove the TBM and jacking system as follows:

1. LOCKOUT power source(s). Push in ALL E-Stops.

5000 Pump Unit Shown

(5000 Pump Unit) Turn Disconnect Switch OFF on Pump Unit and Auxiliary Pump Unit (if used). Disconnect electrical connections to Disconnect switches.



(P400/P600 Power Pack) Turn Disconnect Switch OFF on modules. Disconnect electrical connections to Disconnect switches.

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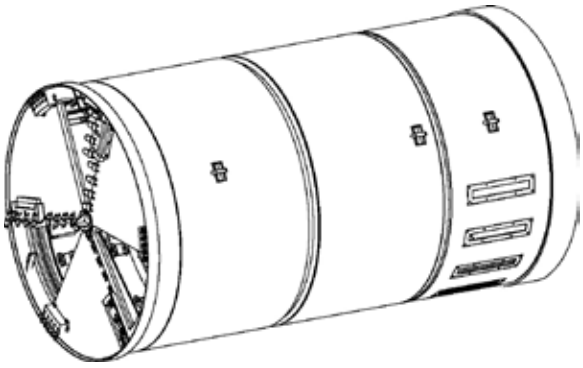
⚠WARNING Escaping oil or other fluids under pressure can penetrate your skin causing serious injury. Contact medical help immediately if any oil or fluid is injected into your skin.

ALWAYS use gloves when connecting or disconnecting hydraulic oil hoses/lines.



2. Relieve hydraulic pressure from all TBM and power unit or power pack hydraulic hoses.

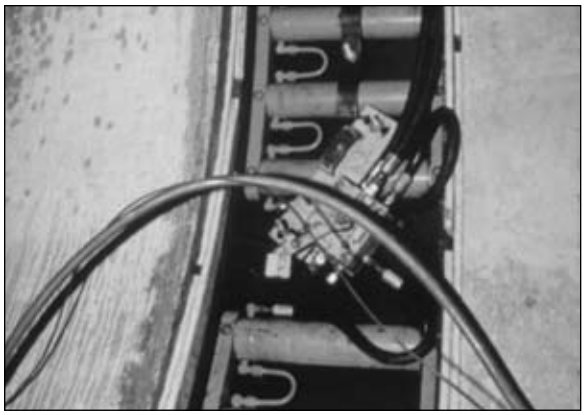
3. Disconnect hydraulic hoses and electrical lines from inside of TBM and cap hoses.

NOTICE Reclaim oil from hydraulic hoses.

NOTICE If using Intermediate Jacking Stations (IJS), the outer shell will remain in pipe line.

4. If IJS are used:

a. remove IJS #1 valve, cylinder segments, and cap hoses, lines, valve and cylinder ports. Cut off valve and cylinder segment bolts. Close IJS #1 gap by operating IJS #2.



b. remove IJS #2 valve, cylinder segments, and cap hoses, lines, valve and cylinder ports. Cut off valve and cylinder segment bolts. Close IJS #2 gap by operating IJS #3.

c. remove IJS #3 valve, cylinder segments, and cap hoses, lines, valve and cylinder ports. Cut off valve and cylinder segment bolts. Close IJS #31 gap by operating main rams (5000 Pump Unit) or jacking frame rams (P400/P600) (if IJS #3 is the last IJS).

(continued on next page)

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

5. Remove TBM.

6. Remove track.

7. Remove Pump Unit, haul unit, yoke, and skid(s).

NOTES

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. Secure all loose items.

NOTES

Lubricants

NOTICE Use of inferior lubricants can affect the efficient performance of your tunnel boring machine, pump unit/power pack and haul unit. Always use high quality lubricants as specified in this section. Refer to the Periodic Maintenance section for proper lubrication quantity, maintenance intervals, and procedures.

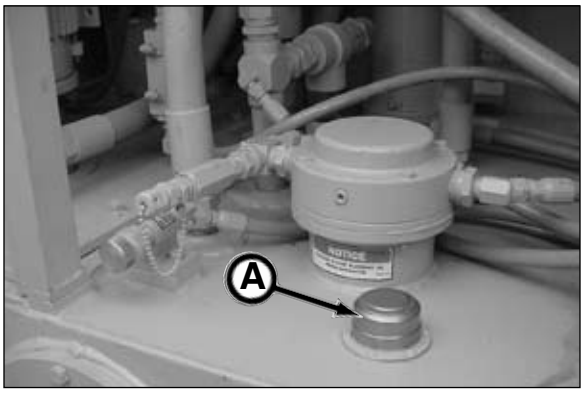
HYDRAULIC RESERVOIR LUBRICANT

The 5000 Pump Unit, P400 and P600 Power Packs and 1448 Haul Unit reservoirs are filled with ISO-VG-46 20W Premium Hydraulic/Turbine Oil.

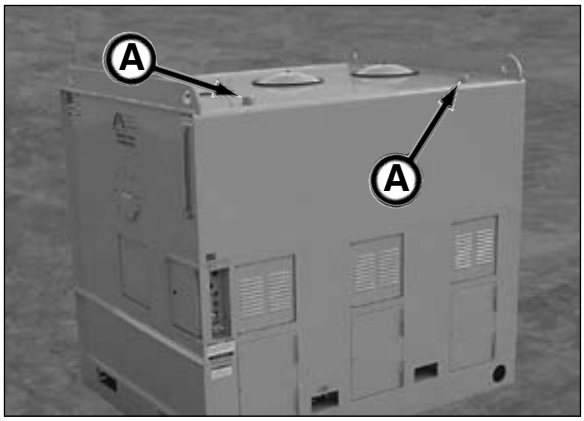
Use an API GL-1/GL-2 or equivalent when adding or changing lubricant. Replace fill cap (A).

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.

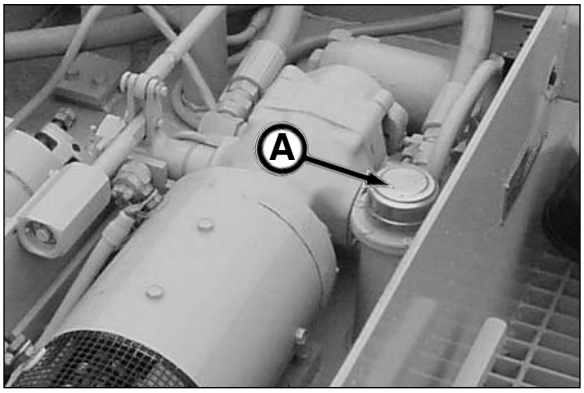
Hydraulic Oil Reservoir Capacity:
5000 Pump Unit - 275 gal. (1,041 L)
P400 Power Pack - 400 gal. (1,514 L)
P600 Power Pack - 600 gal. (2,271 L)
1448 Haul Unit - 10 gal. (37.8 L)



5000 Pump Unit



P400/P600 Power Pack



1448 Haul Unit

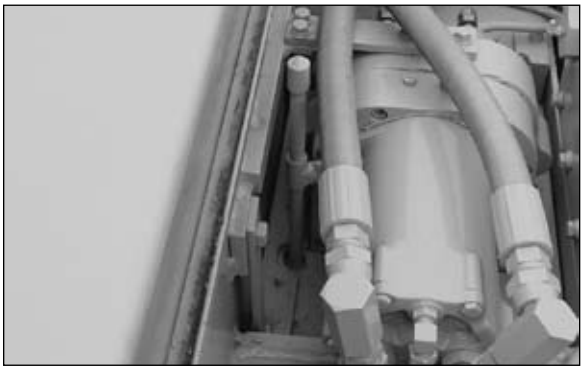
HAUL UNIT GEAR BOX LUBRICANT

The gear box is filled with Mobil SHC 630 Synthetic Bearing and Gear Oil

Use Mobil SHC 630 or equivalent when adding or changing lubricant.

NOTICE The Mobil SHC 630 Synthetic Bearing and Gear oil is a synthetic oil specifically designed for this application. If you change to a different oil, use a reputable oil supplier to meet or exceed the Mobil SHC 630 oil specification. Do not mix oil manufacturers or grades.

524 Haul Unit Gear Box



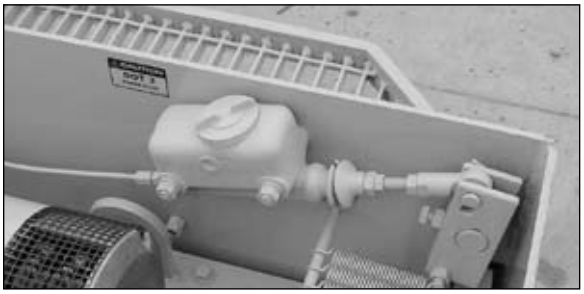
1448 Haul Unit Gear Box

HAUL UNIT BRAKE FLUID

The master cylinder is filled with a DOT 3 brake fluid.

Use ONLY a DOT 3 brake fluid when adding or changing fluid.

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.



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 contaminates.

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.

Use the hourmeters (A) on the 5000 Pump Unit or P400/P600 Power Pack (B) to help determine proper maintenance intervals.

The hourmeters register in full hours and 1/10ths hours.

BEFORE PERFORMING MAINTENANCE

1. Push IN all 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.

LOCKOUT POWER BEFORE SERVICING - 5000 PUMP UNIT

⚠WARNING Severe personal injury or death can result from unexpected power startup 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.

1. Disconnect the power source from the pump unit and the auxiliary pump unit (if used).

2. Push E-STOP button in.

3. On the 5000 Pump Unit, open disconnect switch enclosure and turn disconnect switch OFF. Close and securely fasten disconnect switch enclosure cover (inset).

4. On the Auxiliary Pump Unit, open small enclosure and turn disconnect switch OFF. Close and securely fasten small enclosure cover (inset).

5. Lockout/tagout all power sources.

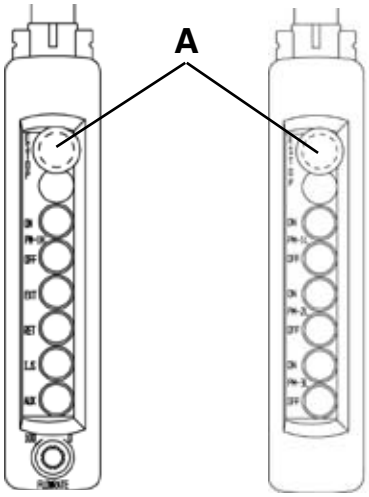
LOCKOUT POWER BEFORE SERVICING - P400/P600 POWER PACK

⚠WARNING Severe personal injury or death can result from unexpected power startup 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.

1. Disconnect the power source from the power pack.

2. Push all E-STOP buttons (A) IN including all remote E-STOP buttons.



High Pressure *Low Pressure*
Pendants

3. Rotate power disconnect switches on ALL power modules to the OFF position.

4. Lockout/tagout all power sources.

HYDRAULIC OIL/FLUIDS UNDER PRESSURE

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

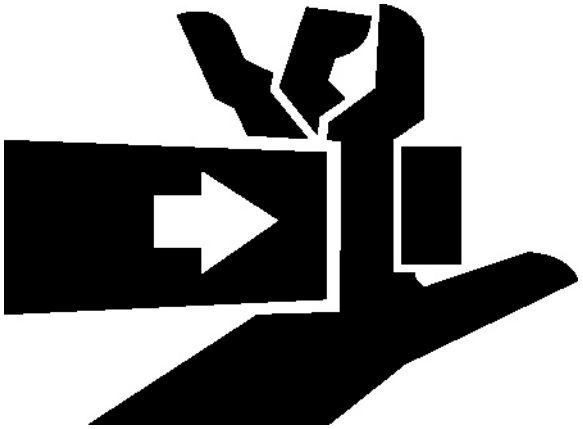
Release all pressure before performing maintenance or repairs. Never weld near pressurized fluid lines.

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

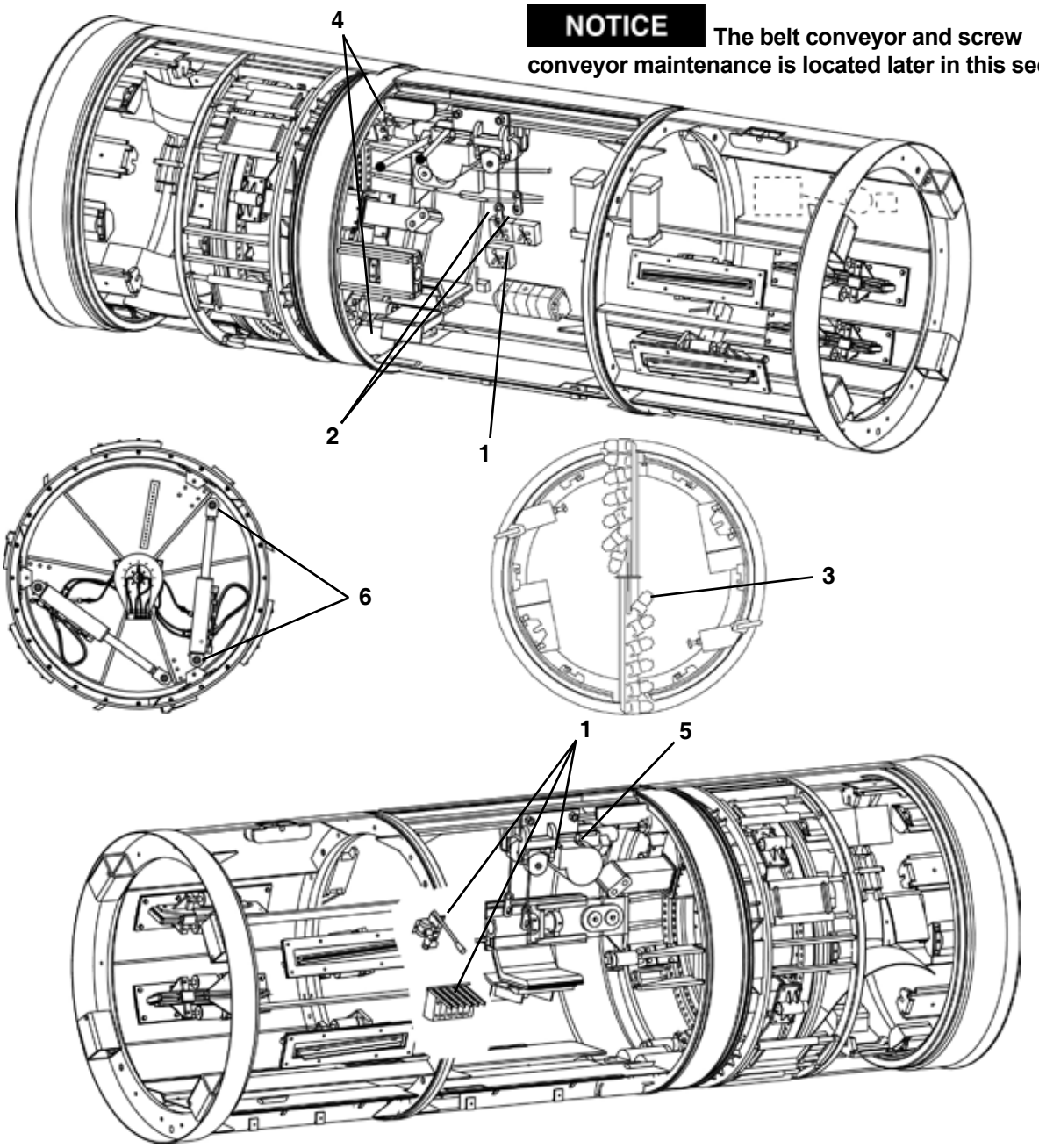
⚠WARNING Unauthorized welding can cause structural failure resulting in possible injury or death.

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

MAINTENANCE CHARTS - TBM

Use the item number in the chart to refer to the detailed maintenance procedures later in this section.

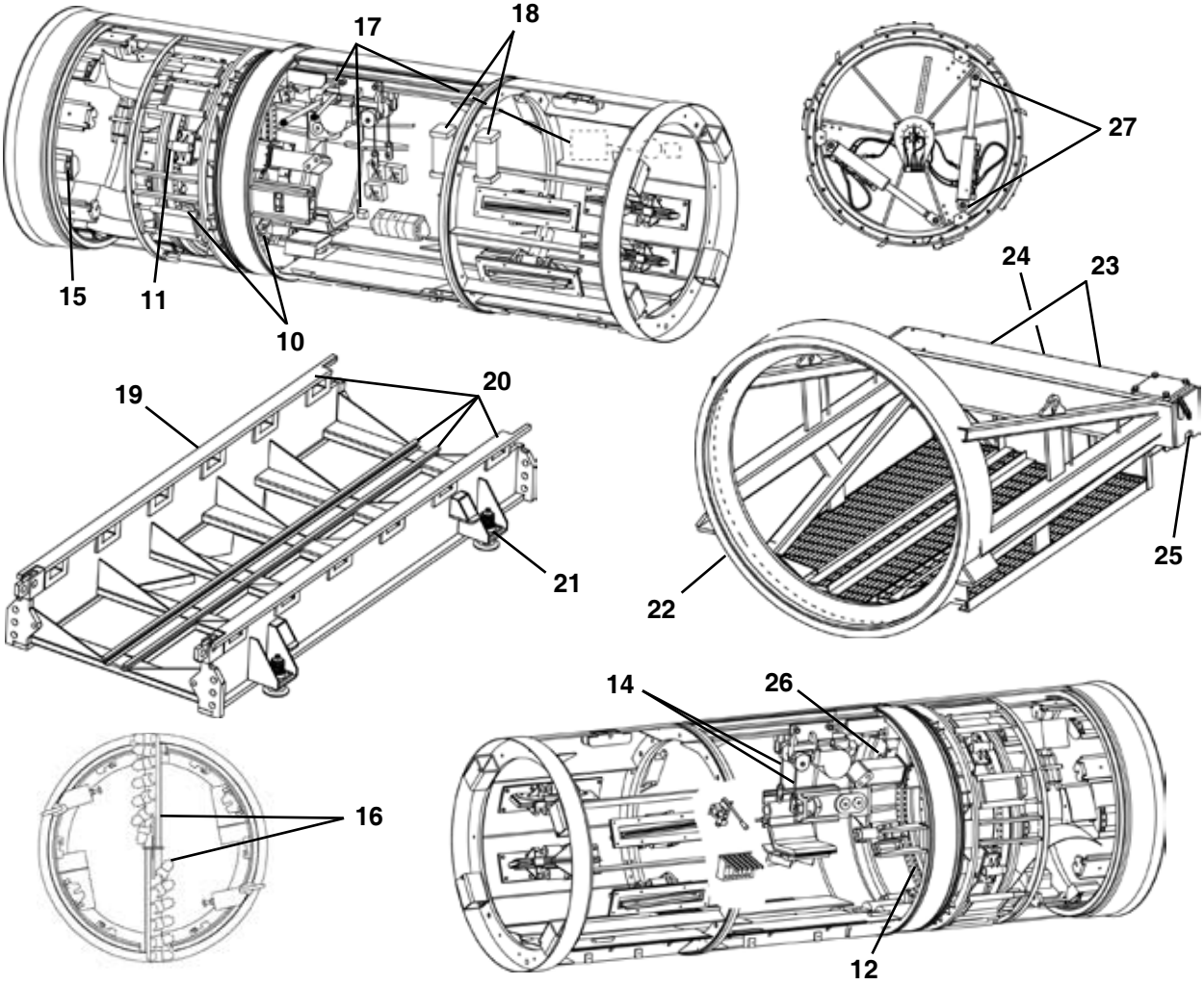
NOTICE **The belt conveyor and screw conveyor maintenance is located later in this section.**



PRIOR TO EACH JOB LAUNCH

ITEM	COMPONENT	SERVICE	REQUIREMENT	MATERIAL
1.	Controls	Check Operation		
2.	Gauge	Check Operation		
3.	Cutter Teeth	Check	Replace if damaged.	
4.	Steering	Check Line & Grade		
5.	Conveyor Lift	Lubricate (4 places)	Lubricate until grease is forced out.	Mobil XHP222
*6.	Closed Face	Lubricate	Lubricate until grease is forced out.	Mobil XHP222
**7.	Hydraulic Hoses	Inspect	Replace if cracks/wear visible.	
**8.	Decals	Inspect	Must be legible. Replace as needed.	
**9.	Haul Unit, Pump Unit & Jack Frame	Perform Maintenance	Refer to your machine's maintenance manual.	

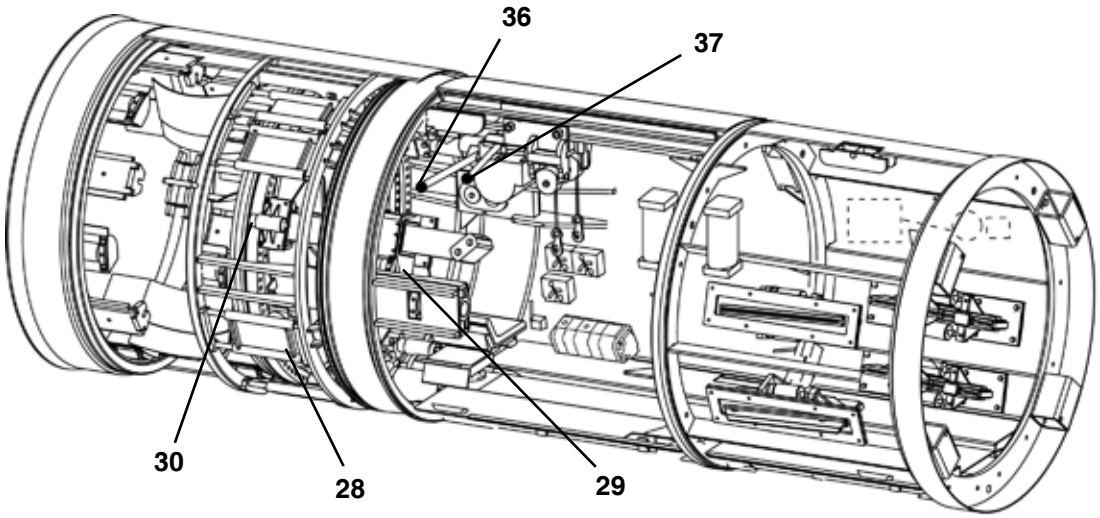
** If equipped ** Not Shown

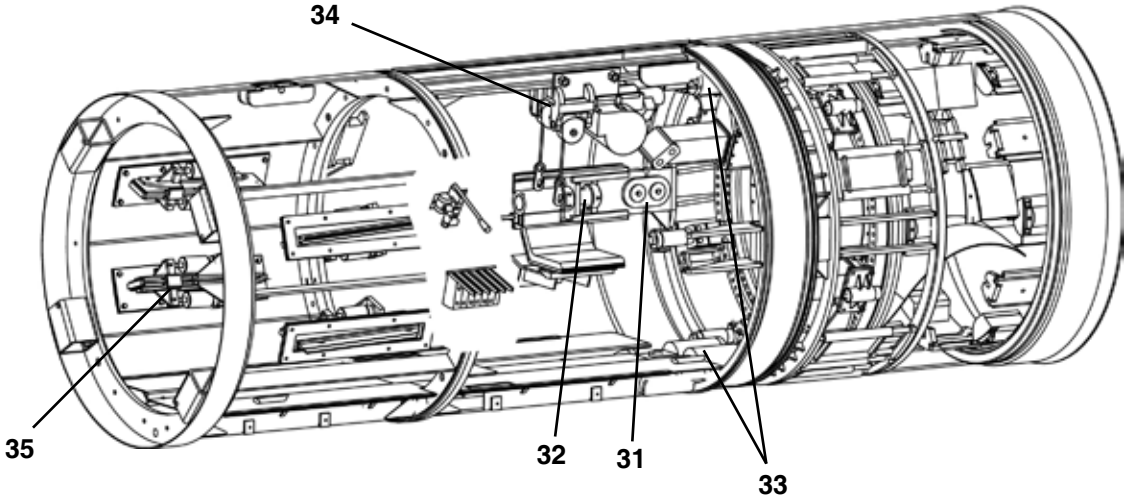


DAILY OR EVERY 10 HOURS OF OPERATION OR SHIFT CHANGE

ITEM	COMPONENT	SERVICE	REQUIREMENT	MATERIAL
10.	Thrust Roller	Lubricate	Lubricate until grease is forced out.	Mobil XHP222
11.	Idler Roller	Lubricate	Lubricate until grease is forced out.	Mobil XHP222
12.	Drive Gear Roller & Bolts	Inspect	Roller spools must rotate freely & replace bolts/rollers when worn > 1/8"	
*13.	Hoses	Inspect	Replace if damaged before operating.	
14.	Conveyor Lift Cable	Inspect	Replace at first sign of wear or damage.	
15.	Drum Roller	Lubricate	Lubricate until grease is forced out.	Mobil XHP222
16.	Cutter Bar & Teeth	Inspect & Adjust	Adjust over cut and replace worn or damaged teeth.	
17.	Controls	Check For Proper Operation		
18.	Pressure Filter	Check	Replace filter(s) per indicator.	Filter Element
19.	Skid Base	Inspect	If damaged, repair or replace.	
20.	Rails	Inspect	If damaged, repair or replace.	
21.	Leveling Screws	Lubricate	Lubricate generously.	Mobil XHP222
22.	Yoke Frame	Inspect	If damaged, repair or replace.	
23.	Ram Retaining Pins	Inspect	If damaged, repair or replace.	
24.	Retaining Pin Stop	Inspect	If damaged, repair or replace.	
25.	Yoke Wheels	Lubricate	Lubricate until grease is forced out.	Mobil XHP222
26.	Gear Ring	Lubricate	Maintain lubrication to gear ring.	
**27.	Closed Face	Lubricate	Lubricate until grease is forced out.	Mobil XHP222

* Not Shown ** If equipped

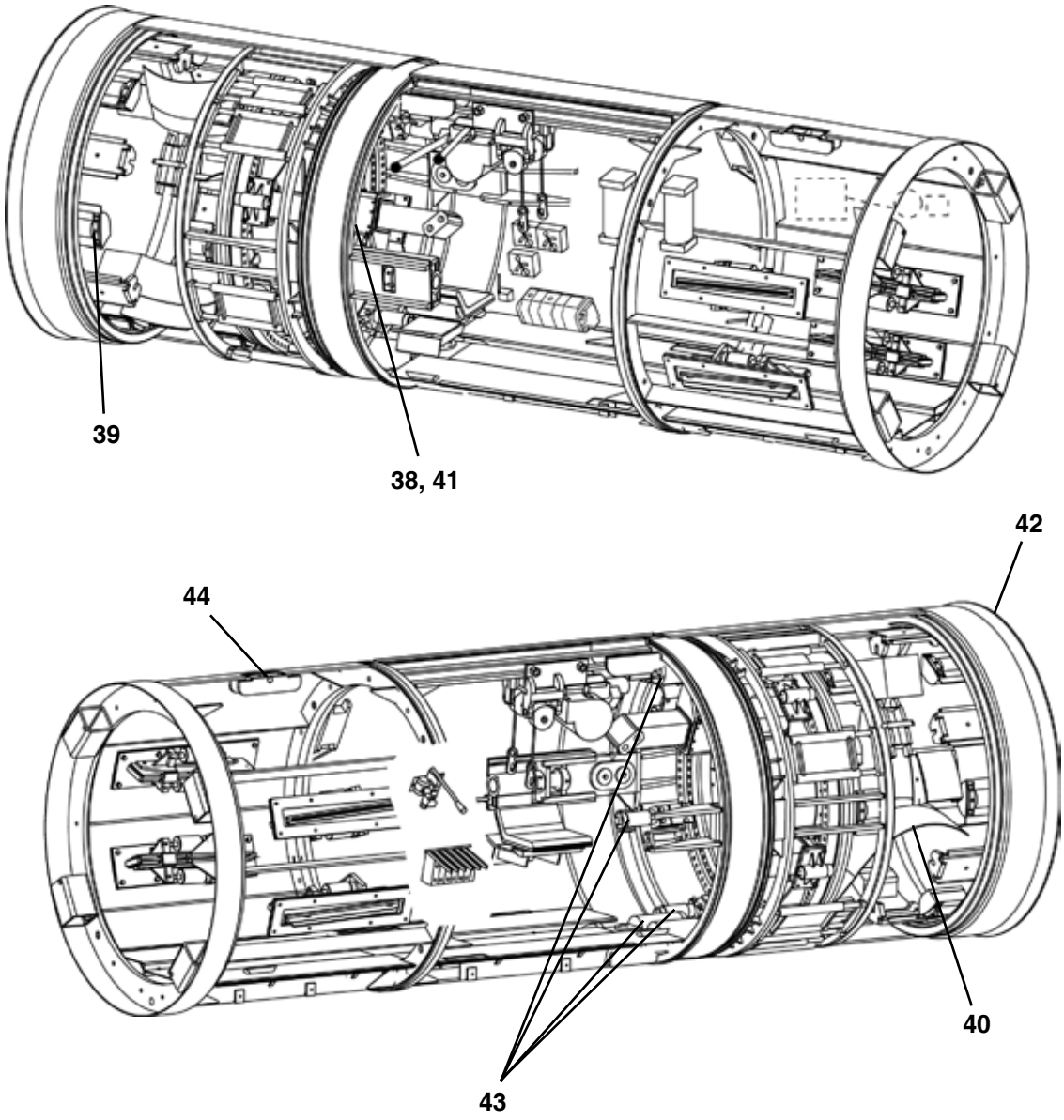




WEEKLY OR EVERY 50 HOURS OF OPERATION

ITEM	COMPONENT	SERVICE	REQUIREMENT	MATERIAL
28.	Thrust Bracket Guides & Cyl Pin	Lubricate and check pin for damage.	Lubricate until grease is forced out.	Mobil XHP222
29.	Motor Bracket Pivot Pin	Lubricate	Lubricate until grease is forced out.	Mobil XHP222
30.	Drive Motor To Gear	Check Clearance	1/16” to 1/8” max. clearance	
31.	Steering Link	Check for elongation.	Replace if > 3/16”.	
32.	Steering Link	Lubricate nut & threads.	Lubricate thoroughly.	Anti seize lube
33.	Steering Cylinder	Lubricate	Lubricate until grease is forced out.	Mobil XHP222
34.	Conveyor Lift	Lubricate	Lubricate until grease is forced out.	Mobil XHP222
35.	Dirt Wing Pins	Lubricate	Lubricate until grease is forced out.	Mobil XHP222
36.	Inner Drum Control	Lubricate	Lubricate until grease is forced out.	Mobil XHP222
37.	Conveyor Control	Lubricate	Lubricate until grease is forced out.	Mobil XHP222

* Not Shown
** If equipped



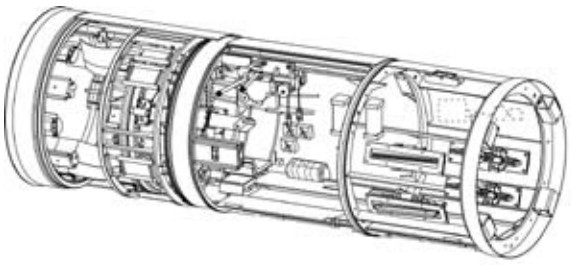
AFTER EACH DRIVE

ITEM	COMPONENT	SERVICE	REQUIREMENT	MATERIAL
38.	Motor Sprocket	Inspect	Replace when flat is < 3/8”.	
39.	Drum Roller	Inspect	If worn, replace. Bearing spins freely, no play.	
40.	Dirt Paddles	Inspect	Replace if damaged.	
41.	Motor Bracket	Inspect & Tighten Bolts	If damaged, repair or replace.	
42.	Cutter Ring	Inspect For Damage		
43.	Steering Cylinders	Inspect	If damaged, repair or replace.	
44.	Lifting Eye	Inspect	Repair if damaged before lifting.	

PRIOR TO EACH JOB LAUNCH

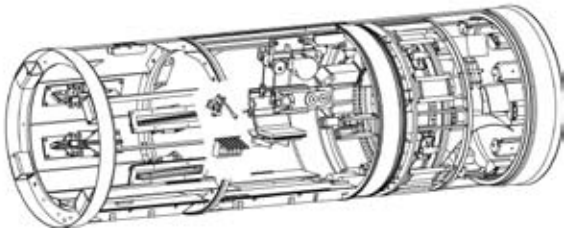
1. CHECK CONTROL OPERATION

Before launching TBM, be sure to check all TBM, Power Unit/Power Pack, haul unit controls and other supporting equipment for proper operation. If controls do not function properly, repair or replace BEFORE operation.



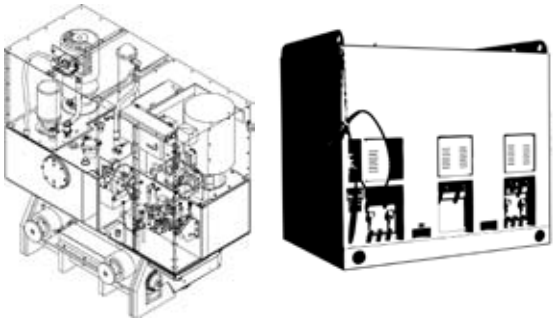
CHECK THE FOLLOWING CONTROLS FOR PROPER OPERATION:

ALL E-Stops, and gas detectors:
  check for proper operation



Conveyor Controls:
  conveyor lift - up and down
  conveyor drive - forward and reverse
  conveyor safety valve - MUST stop inner drum (CW) rotation
  conveyor speed controls - speed adjustable

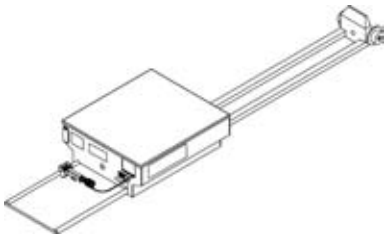
Inner Drum Controls:
  inner drum rotation - CW and CCW rotation
  inner drum advance cyl. - extend and retract
  inner drum speed control - speed adjustable



Steering Controls:
  steering selector - up/down and left/right selection
  steering cylinder - extend and retract
  steering adjustment - steering nut adjustable

Dirt Wing Controls
  cylinder control - extend and retract

Auxiliary or Closed Face Controls
  check control operation



TBM Gear Ring Oiler Control
  oiler - valve open and close

Selector Speed Control

Pump Unit/Power Pack Controls

Haul Unit Controls

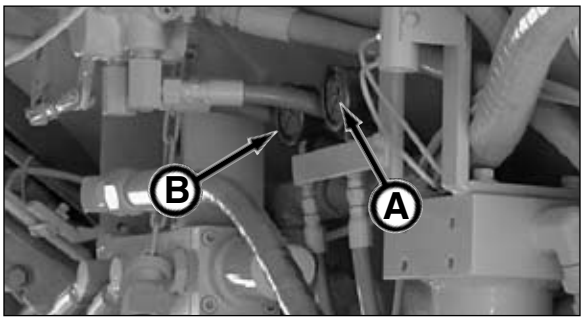
Jacking Frame/IJS Controls

Lights

2. CHECK GAUGE OPERATION

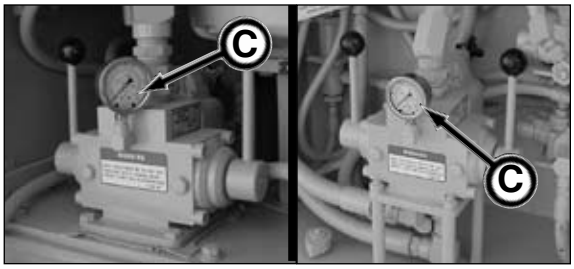
Check system pressures for proper operation.
If systems are not functioning properly, repair or replace system components BEFORE operation.

TBM
Conveyor pressure (A) ..... 2,800 - 3,000 psi
Auxiliary pressure (B) ..... 2,800 - 3,000 psi

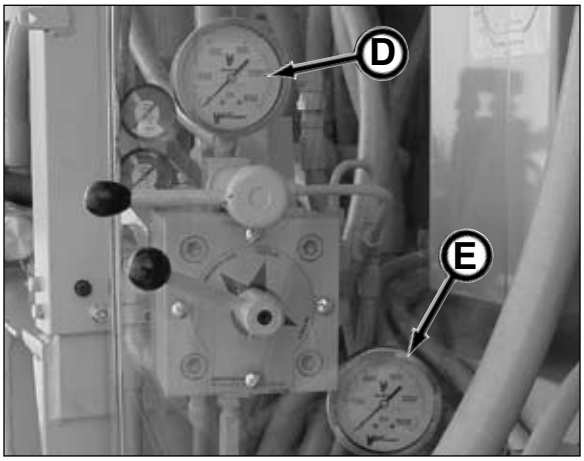


Shown 540 (sn18300-4 and after)

5000 Pump Unit
System low pressure (C) ..... 2,800 - 3,000 psi
System/IJS high pressure (D) ..... 8,000 - 9,000 psi
Main Ram Cylinder Extension High Pressure (E)
..... 8,000 - 8,400 psi

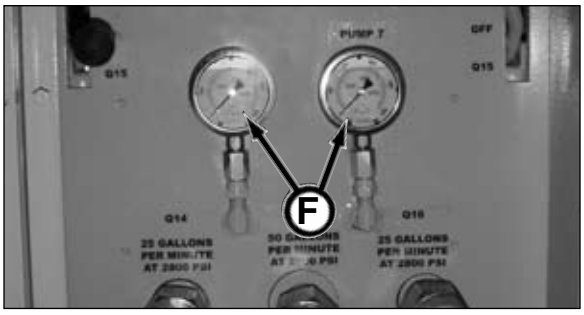


5000 Pump Unit - Low Pressure

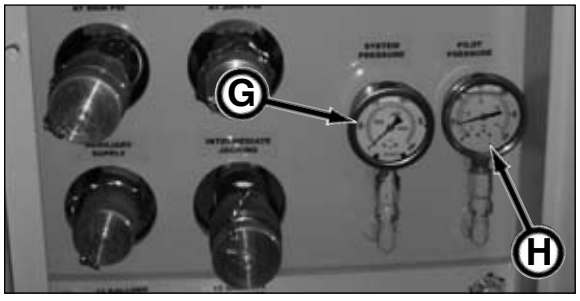


5000 Pump Unit - High Pressure

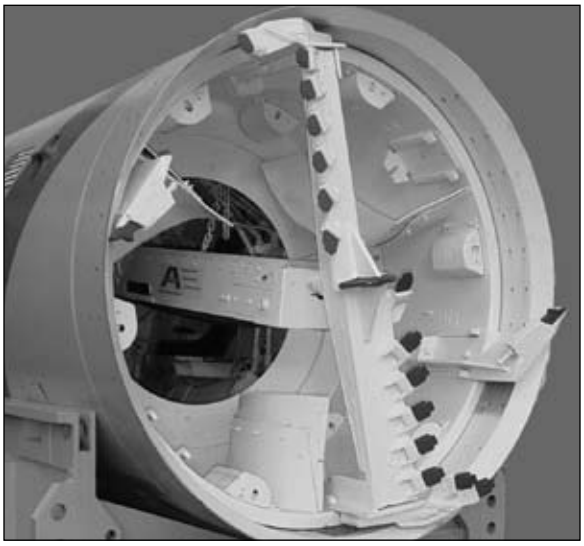
P400/P600 Power Pack
System low pressure (F)..... 2,800 - 3,000 psi
System high pressure (G) ..... 8,000 - 9,000 psi
Pilot Pressure (H) ..... 250 - 350 psi



P400/P600 - Low Pressure



P400/P600 - High Pressure



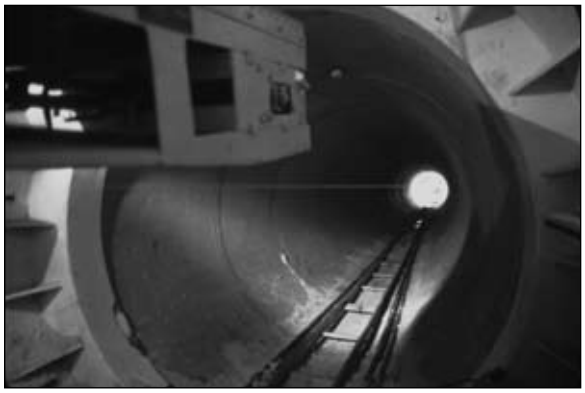
3. CHECK CUTTER TEETH/SAND SHELVES

Check all cutter teeth or sand shelves. Repair or replace as necessary.

4. CHECK LINE & GRADE

Check line and grade before launching. Adjust as needed using the steering cylinders and steering adjustment assembly.

Be sure to check line and grade alignment often, with and without forward thrust applied. Keep in mind if you are off one degree, the bore will be off nearly two feet per one hundred feet.

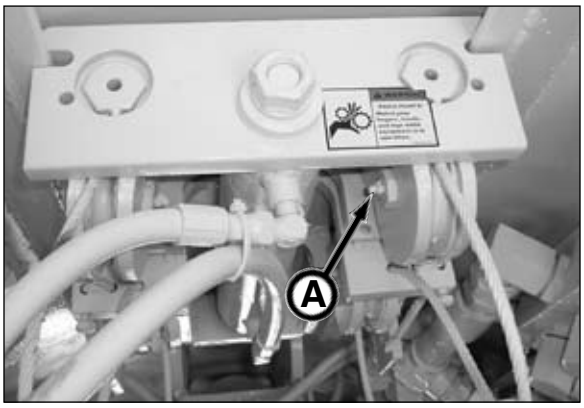


5. LUBRICATE CONVEYOR LIFT

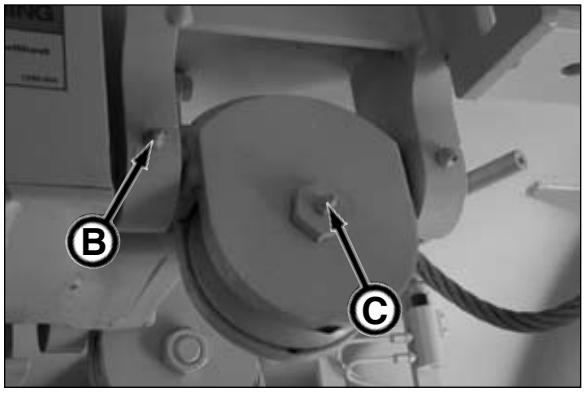
Lubricate conveyor lift with Mobilgrease® XHP222 or equivalent until grease is forced out.

TBM 360 - 540: 4 places
Cable pulley bearing (A) - 4 places

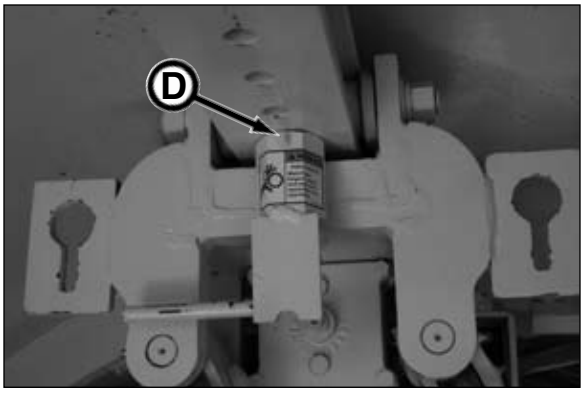
TBM 600 - 780: 7 places
Trolley bracket pins (B) - 4 places
Cable pulley bearing (C) - 2 places
Adjustment pin (D) - 1 place



TBM 360 - 540



TBM 600 - 780



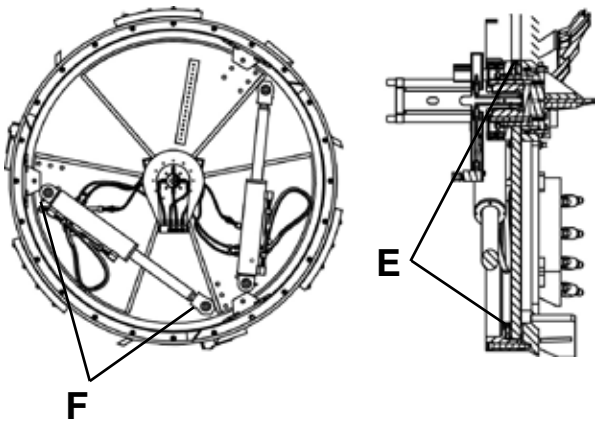
TBM 600 - 780

6. LUBRICATE CLOSED FACE CYLINDERS & DOORS (IF EQUIPPED)

Lubricate closed face doors (E) with Mobilgrease® XHP222 or equivalent until grease is forced out.

Lubricate closed face cylinders (F) with Mobilgrease® XHP222 or equivalent until grease is forced out.

The number of cylinders vary depending upon the size of the TBM.



7. INSPECT HYDRAULIC HOSES

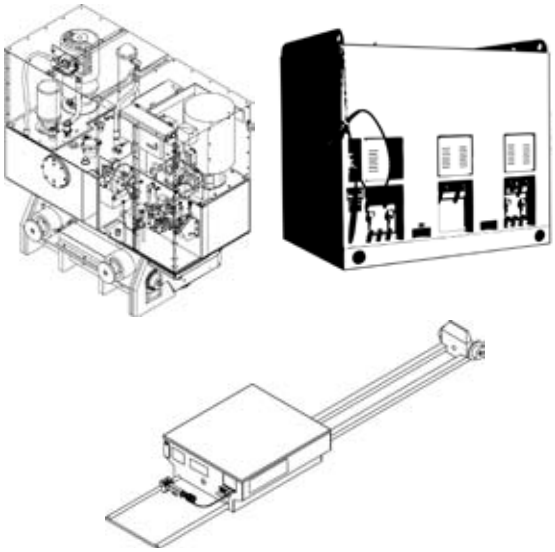
Inspect ALL hydraulic hoses for wear or damage. Repair or replace BEFORE operation.

8. INSPECT DECALS

Inspect ALL decals, operational and safety decals to be sure they are 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 will damage decals. Replace decals immediately if they are damaged, missing, or hard to read.

Before applying a new decal, be sure the surface is clean and dry.



9. PERFORM MAINTENANCE ON ALL SUPPORTING EQUIPMENT

Be sure all TBM supporting equipment such as the haul unit, pump unit/power pack, jacking frame, and generator are properly maintained and are operating properly. Be sure to repair or replace equipment before operating TBM. Refer to the operation and maintenance manuals of the equipment.

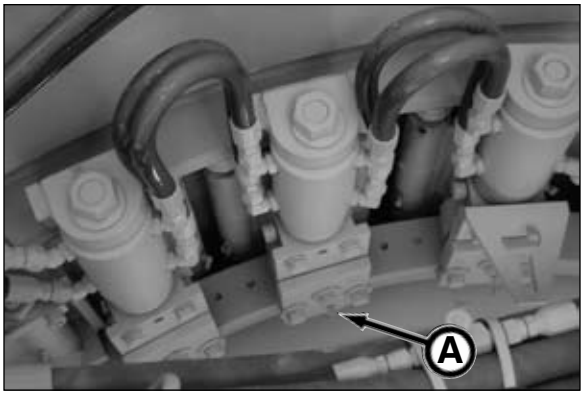
DAILY OR EVERY 10 HOURS OF OPERATION OR SHIFT CHANGE

10. LUBRICATE THRUST ROLLERS

Lubricate all thrust rollers (A) with Mobilgrease® XHP222 or equivalent until grease is forced out.

The rollers should be lubricated more often if subjected to wet conditions.

The number of thrust rollers vary depending upon the size of the TBM.

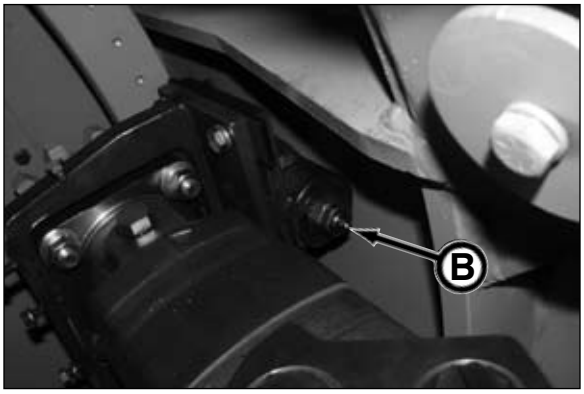


11. LUBRICATE IDLER ROLLERS

Lubricate idler rollers (B) with Mobilgrease® XHP222 or equivalent until grease is forced out.

The rollers should be lubricated more often if subjected to wet conditions.

The number of idler rollers vary depending upon the size of the TBM.

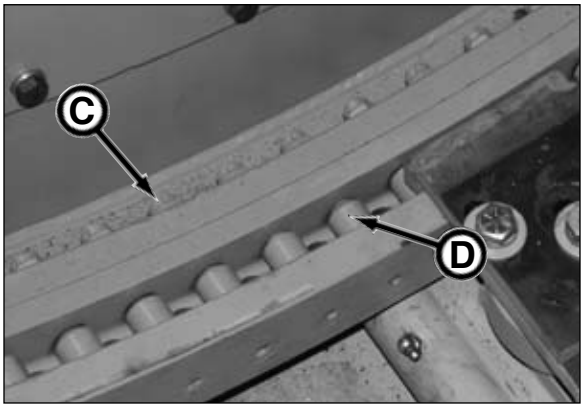


12. INSPECT DRIVE GEAR ROLLER & HARDWARE

Inspect drive gear bolts and nuts (C) for damage. Replace if worn or damaged.

Check that roller spools (D) rotate freely. If not replace roller.

If roller spools are worn more than 1/8” (3 mm), the spools and bolts/nuts must be replaced.



13. INSPECT HYDRAULIC HOSES

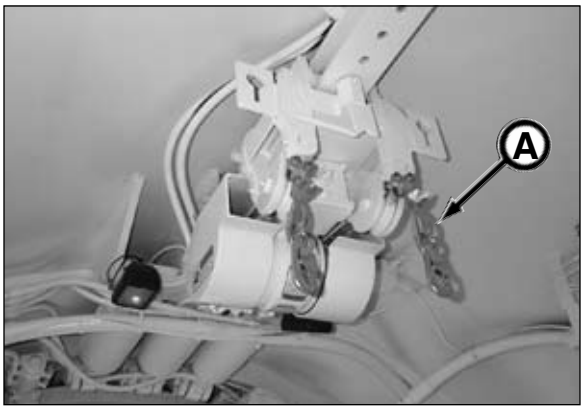
Inspect ALL hydraulic hoses for wear or damage. Repair or replace BEFORE operation.

14. INSPECT CONVEYOR LIFT CABLES

Inspect conveyor lift cables, hooks, protective sleeves and cable clamps (A) for wear or damage.

Replace cables, hooks, protective sleeves and cable connectors as a set at the first sign of wear or damage.

NOTICE TBMs 360 - 540 use a crimp-on cable clamp while the 600 - 780 TBMs use bolt-on cable clamps.



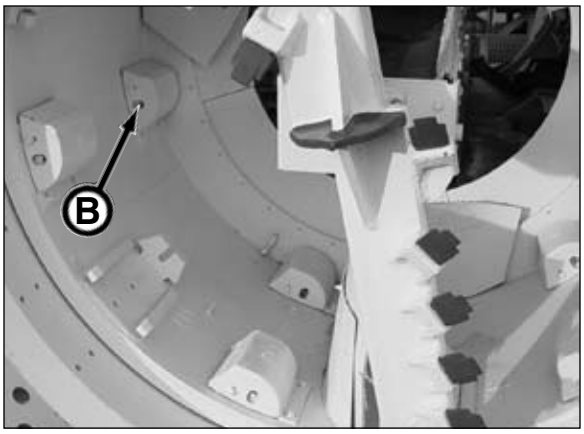
TBM 600 - 780 Shown

15. LUBRICATE DRUM ROLLERS

Lubricate drum rollers (B) with Mobilgrease® XHP222 or equivalent until grease is forced out.

The rollers should be lubricated more often if subjected to wet conditions.

The number of drum rollers vary depending upon the size of the TBM.

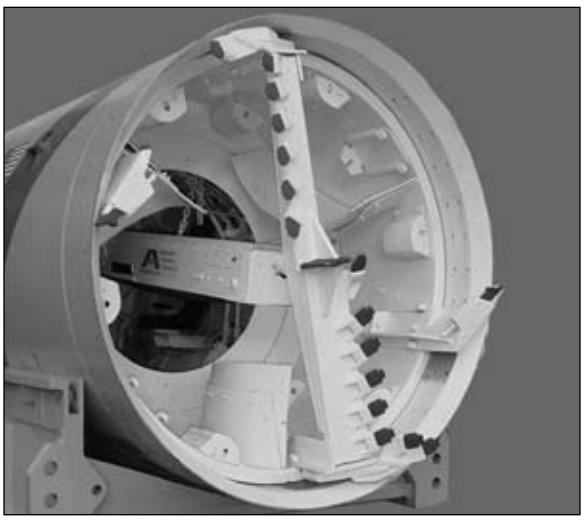


16. INSPECT CUTTER BAR/TEETH OR SAND SHELVES

Inspect cutter bar, teeth, and/or sand shelves for wear or damage. Repair or replace as needed.

Check overcut and adjust accordingly as described below.

The typical overcut is 1.50” which allows space for steering and the addition of bentonite. Keep in mind that too large of an overcut can lead to uncontrollable steering.



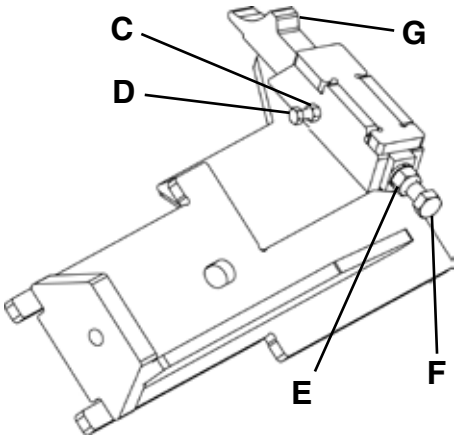
1. Loosen nut (C), set screw (D), and nut (E).

2. Readjust bolt (F) to move cutter (G) to desired overcut.

3. Retighten nut (E).

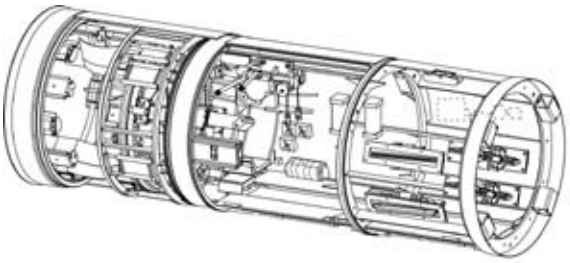
4. Retighten set screw (D).

5. Retighten nut (C).



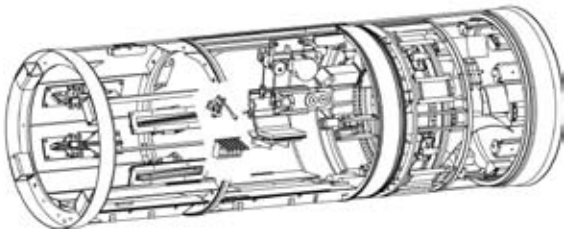
17. INSPECT CONTROLS FOR PROPER OPERATION

Before operating TBM or at each shift change, be sure to check all TBM, Power Unit/Power Pack, haul unit controls and other supporting equipment for proper operation. If controls do not function properly, repair or replace BEFORE operation.



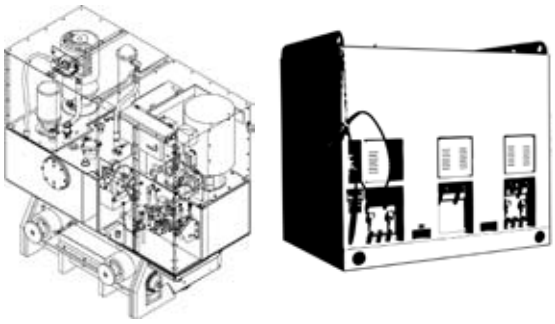
CHECK THE FOLLOWING CONTROLS FOR PROPER OPERATION:

ALL E-Stops, and gas detectors:
  check for proper operation



Conveyor Controls:
  conveyor lift - up and down
  conveyor drive - forward and reverse
  conveyor safety valve - MUST stop inner drum (CW) rotation
  conveyor speed controls - speed adjustable

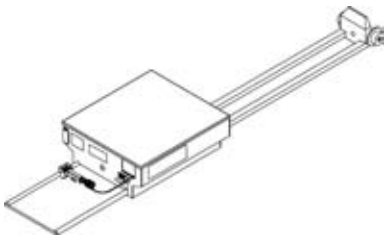
Inner Drum Controls:
  inner drum rotation - CW and CCW rotation
  inner drum advance cyl. - extend and retract
  inner drum speed control - speed adjustable



Steering Controls:
  steering selector - up/down and left/right selection
  steering cylinder - extend and retract
  steering adjustment - steering nut adjustable

Dirt Wing Controls
  cylinder control - extend and retract

Auxiliary or Closed Face Controls
  check control operation



TBM Gear Ring Oiler Control
  oiler - valve open and close

Selector Speed Control

Pump Unit/Power Pack Controls

Haul Unit Controls

Jacking Frame/IJS Controls

Lights

18. CHECK FILTER INDICATORS

To prevent under or over servicing of the hydraulic filter elements (A), a filter indicator (B) has been installed in your TBM.

The yellow band indicates that the filter(s) are functioning properly.

Replace filter(s) when the filter indicator has a red

NOTICE The red indicator may display at initial start-up until the oil reaches normal operating temperature. If the red band continues to display after reaching normal operating temperature, replace filter to prevent contamination.

The filter(s) require replacement if any of the following situations occur:

- A major component fails.
- Any sign of water contamination from an oil analysis or if oil is milky or foaming.
- A hydraulic oil sample indicates large particle contamination.

1. With power LOCKED OUT, clean and dry area around filter(s).

2. Remove filter by removing filter cover. Dispose of filter properly.

3. Remove filter o-rings if stuck in filter housing or cover.

4. Install new o-ring and backup o-ring with a light coat of clean hydraulic oil. Check to be sure the o-rings are not twisted and that they are correctly in place.

5. Install new filter until gasket makes contact with filter head.

6. Replace filter cover and secure with ten 1/2 UNC x 2-1/2 bolts and lock washers.

7. Check for leaks as follows:

   a. Enable power source to pump unit/power pack.

   b. Pull E-stop button OUT.

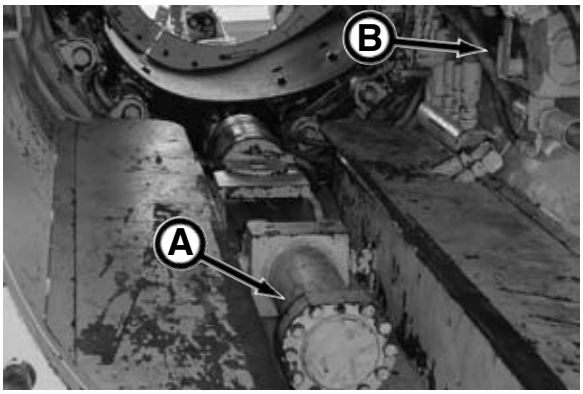
   c. Start the low pressure circuit on the power unit/ power pack.

   d. Allow system to reach a minimum of 75°F (24°C) and then run for 5 minutes. Check for leaks.

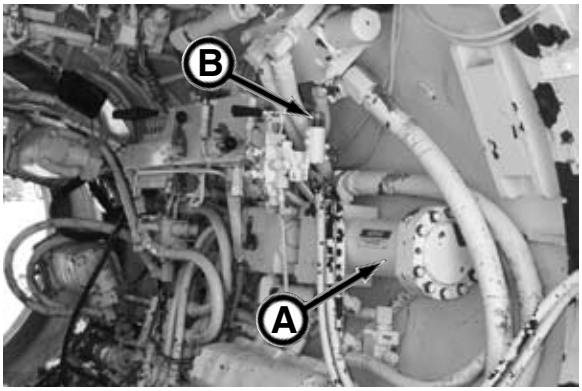
   e. Stop low pressure circuit.

   f. Push E-Stop button IN.

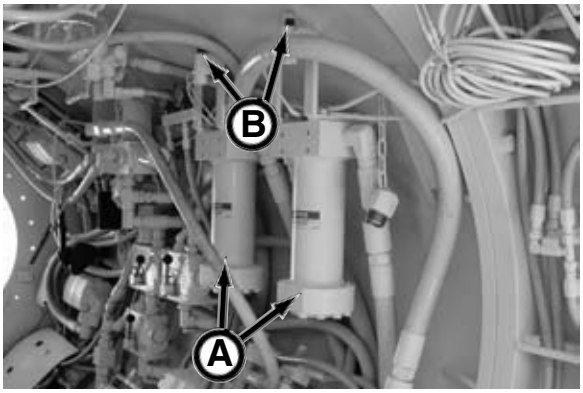
   g. LOCKOUT power source to pump unit/power pack.



360



48SC, 420, 480, and 540 (sn18300-3 and before)

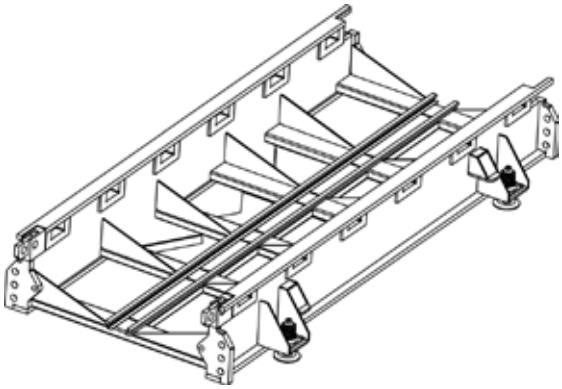


540 (sn18300-4 and after), 600, 660, 720, and 780

19. INSPECT SKID BASE

Visually inspect skid base for cracks or other damage. Also check for damaged, loose, or missing hardware. Replace with new.

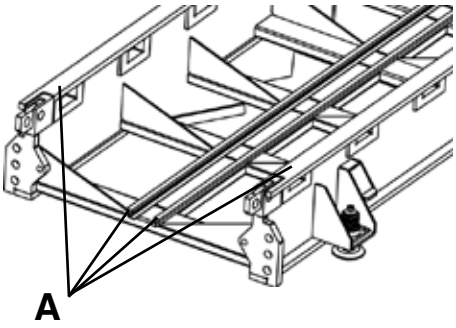
If cracks or damage are present, contact your Akkerman Aftermarket Support representative for authorized repair or replacement procedures.



20. INSPECT RAILS

Clean and inspect rails (A) for cracks or other damage.

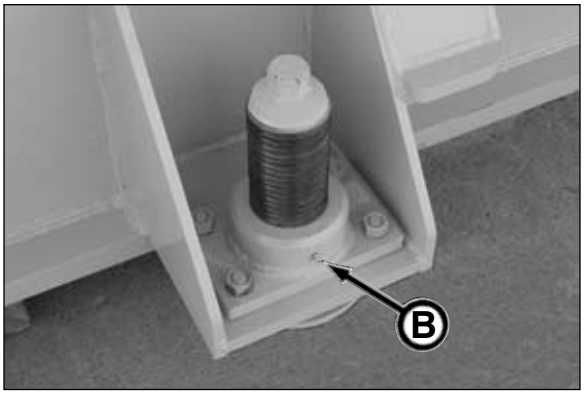
If cracks or damage are present, contact your Akkerman Aftermarket Support representative for authorized repair or replacement procedures.



21. LUBRICATE LEVELING SCREWS

Lubricate leveling screws (B) with Mobilgrease® XHP222 Premium Lubricating Grease or equivalent.

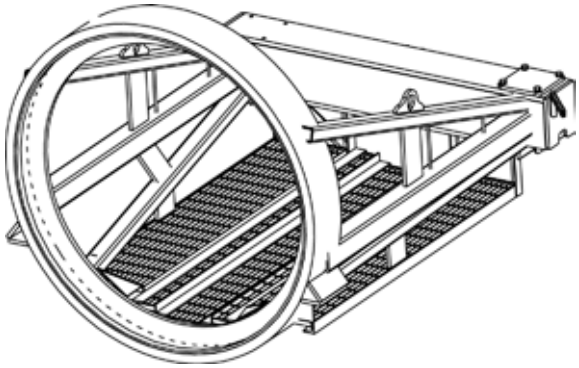
Lubricate threads thoroughly.



22. INSPECT YOKE FRAME

Visually inspect yoke for cracks or other damage. Also check for damaged, loose, or missing hardware. Replace with new.

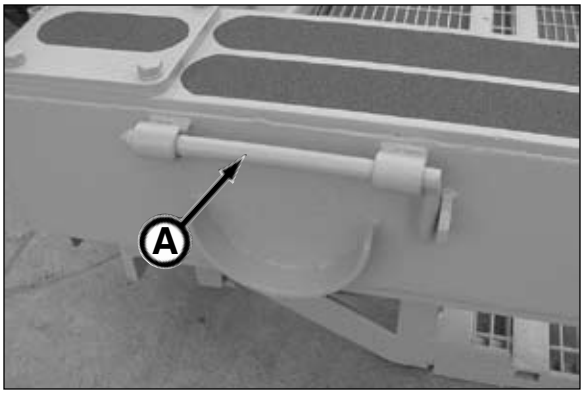
If cracks or damage are present, contact your Akkerman Aftermarket Support representative for authorized repair or replacement procedures.



23. INSPECT RAM RETAINING PINS

Visually inspect retaining pins (A) (2 places) for damage.

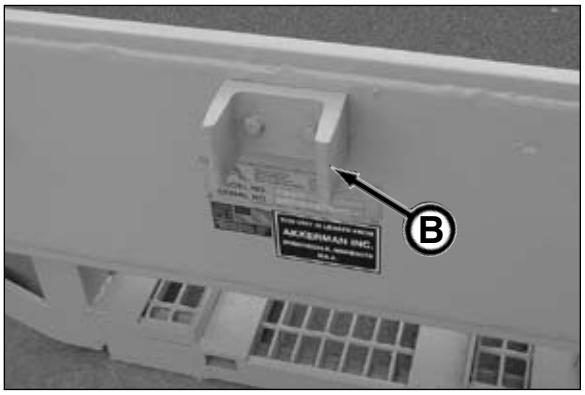
If damage is present, replace with new.



24. INSPECT RAM RETAINING PIN STOP

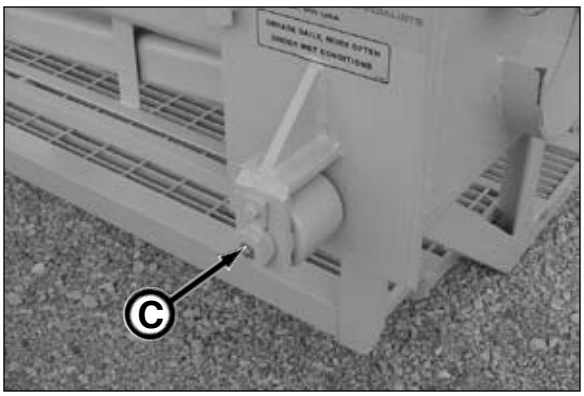
Visually inspect stop (B) or hardware for damage.

If damaged or missing, replace with new.



25. LUBRICATE YOKE WHEELS

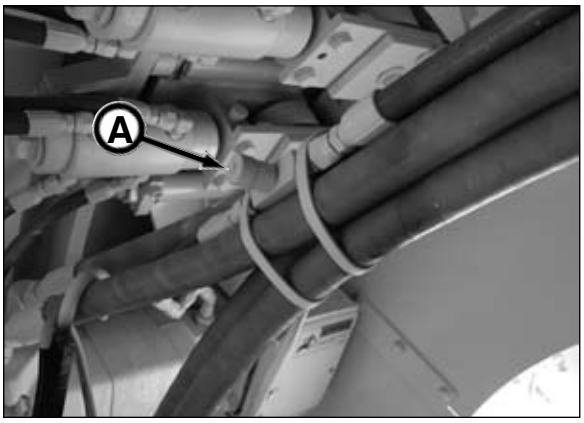
Lubricate yoke wheels (C) with Mobilgrease® XHP222 Premium Lubricating Grease or equivalent.



26. LUBRICATE GEAR RING

Lubricate gear ring by opening oiler valve (A) to maintain lubrication to gear ring. Once the gear ring is lubricated, close oiler valve.

The gear ring oiler uses the drive motor case drain oil to lubricate the gear ring.

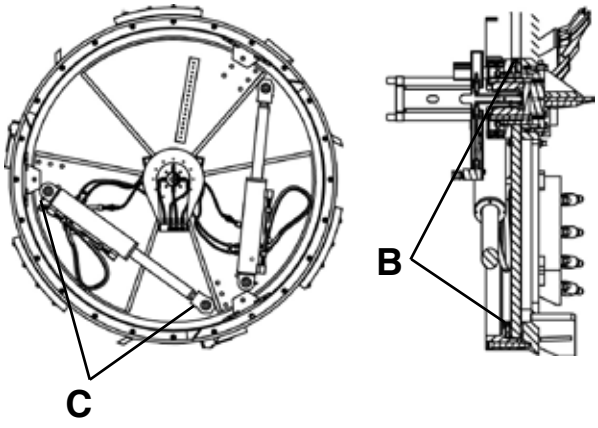


27. LUBRICATE CLOSED FACE CYLINDERS & DOORS (IF EQUIPPED)

Lubricate closed face doors (B) with Mobilgrease® XHP222 or equivalent until grease is forced out.

Lubricate closed face cylinders (C) with Mobilgrease® XHP222 or equivalent until grease is forced out.

The number of cylinders vary depending upon the size of the TBM.

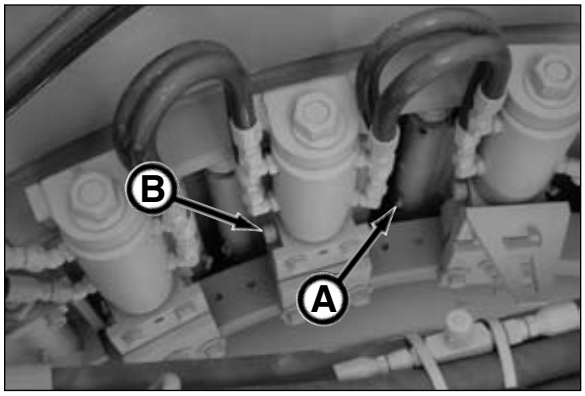


WEEKLY OR EVERY 50 HOURS OF OPERATION

28. LUBRICATE THRUST BRACKET GUIDES & CYLINDER PIN

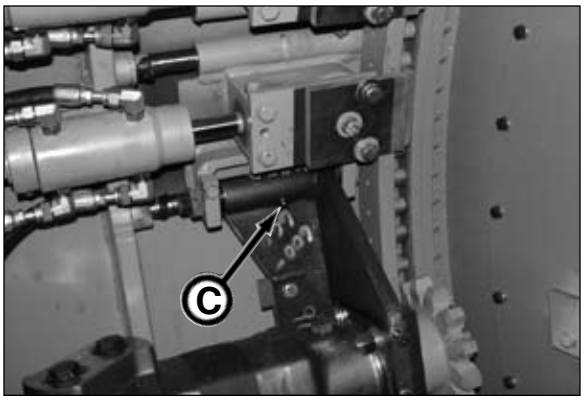
Lubricate thrust bracket guides (A) with Mobilgrease® XHP222 Premium Lubricating Grease or equivalent until grease is forced out.

Check cylinder pins (B) for wear or damage. Repair or replace before operating.



29. LUBRICATE MOTOR BRACKET PIVOT PIN

Lubricate pivot pin (C) with Mobilgrease® XHP222 Premium Lubricating Grease or equivalent until grease is forced out.



30. CHECK DRIVE MOTOR TO GEAR RING CLEARANCE (BACKLASH)

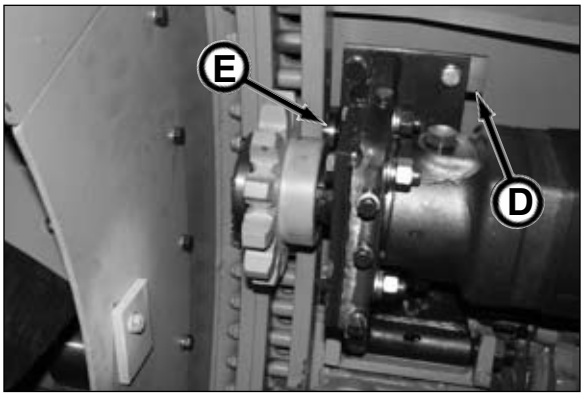
Check clearance (play or backlash) between drive motor assembly and gear ring. The clearance should be 1/16” - 1/8” (1.5 - 3 mm).

Check clearance by pushing drive motor. If there is not enough clearance (1/16” - 1/8” [1.5 - 3 mm]), use shims (D) as needed. If the clearance cannot be achieved, the idler roller shaft (E) must be replaced.

If the clearance between the drive motor assembly and gear ring is too loose, premature wear will result on gear ring spools and sprocket.

If the clearance between the drive motor assembly and gear ring is too tight, premature wear will result on idler roller shaft or cause shaft failure.

Be sure to replace motor guard before operating TBM.



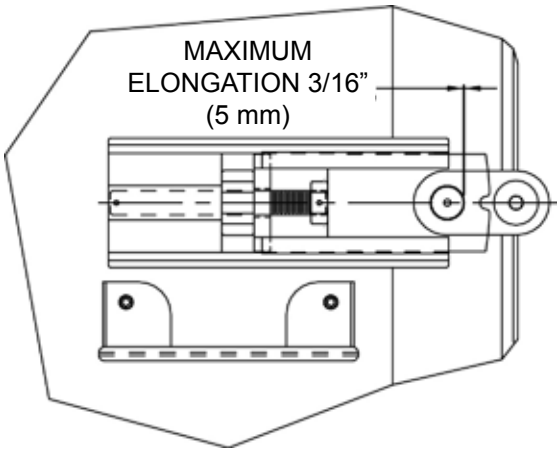
31. CHECK STEERING LINK FOR ELONGATION

Remove bolt and washer from steering link and check for elongation.

The maximum elongation is 3/16” (5 mm). If elongation exceeds 3/16” (5 mm), the steering link and new hardware must be replaced.

If link or hardware is damaged, replace with new.

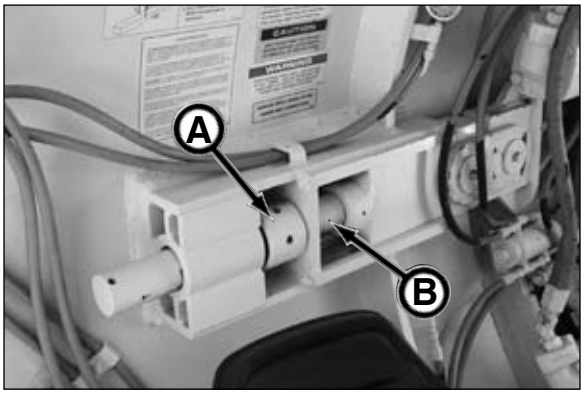
Repeat inspection on other steering link.



32. LUBRICATE STEERING LINK

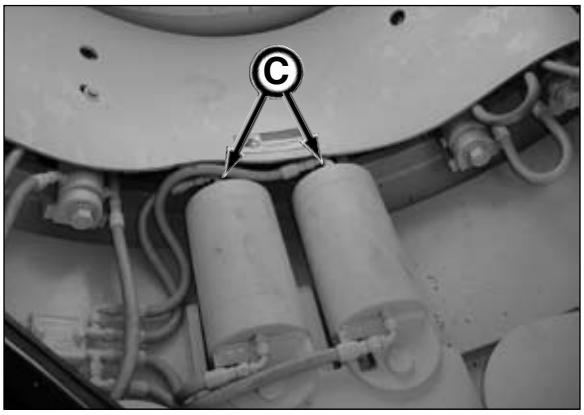
Lubricate steering link nut (A) and threads (B) with WD-40® or equivalent anti seize lubricant.

Lubricate threads thoroughly.



33. LUBRICATE STEERING CYLINDERS

Lubricate all steering cylinders (C) with Mobilgrease® XHP222 Premium Lubricating Grease or equivalent until grease is forced out.

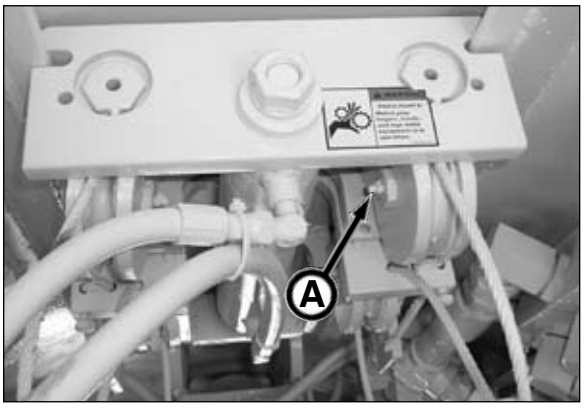


34. LUBRICATE CONVEYOR LIFT

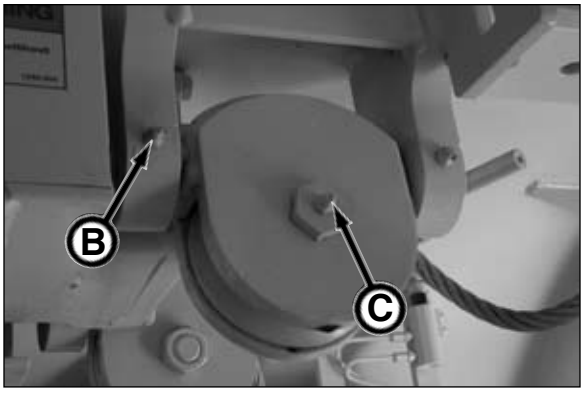
Lubricate conveyor lift with Mobilgrease® XHP222 or equivalent until grease is forced out.

TBM 360 - 540: 4 places
Cable pulley bearing (A) - 4 places

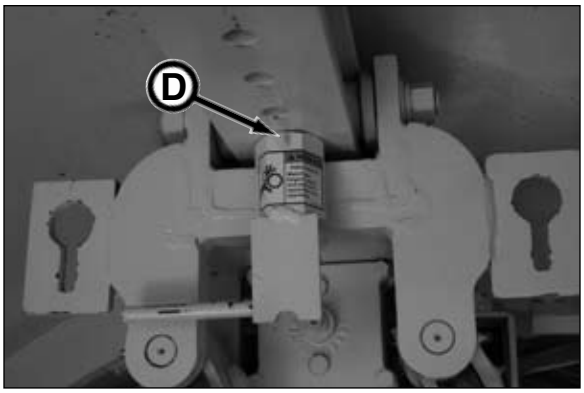
TBM 600 - 780: 7 places
Trolley bracket pins (B) - 4 places
Cable pulley bearing (C) - 2 places
Adjustment pin (D) - 1 place



TBM 360 - 540



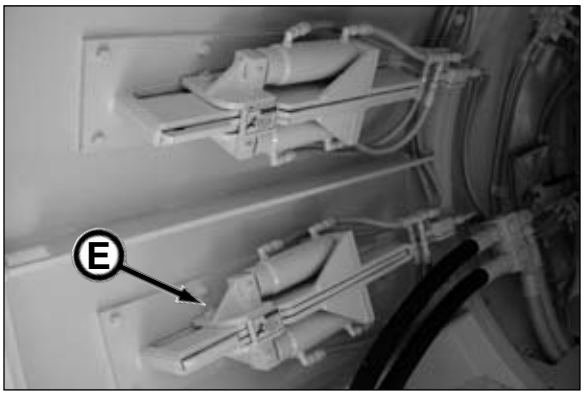
TBM 600 - 780

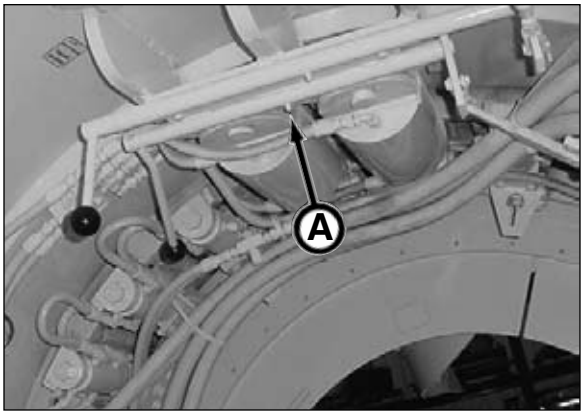


TBM 600 - 780

35. LUBRICATE DIRT WING PINS

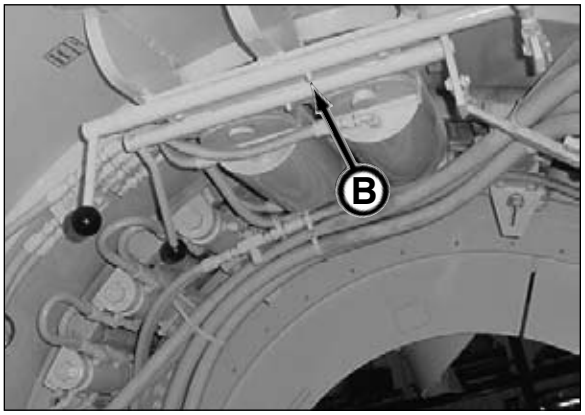
Lubricate all dirt wing pins (E) with Mobilgrease® XHP222 Premium Lubricating Grease or equivalent until grease is forced out.





36. LUBRICATE INNER DRUM CONTROL

Lubricate inner drum control (A) with Mobilgrease® XHP222 Premium Lubricating Grease or equivalent until grease is forced out.



37. LUBRICATE CONVEYOR CONTROL

Lubricate conveyor control (B) with Mobilgrease® XHP222 Premium Lubricating Grease or equivalent until grease is forced out.

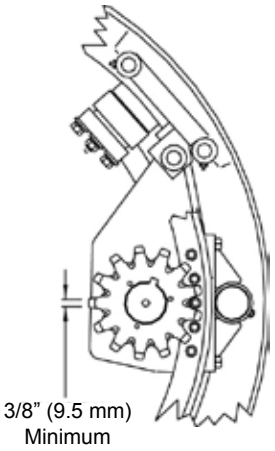
AFTER EACH DRIVE

38. INSPECT MOTOR SPROCKETS

Inspect motor sprocket for wear or damage. Remove guard and if sprocket tooth flat is less than 3/8” (9.5 mm), the sprocket must be replaced.

If sprocket is damaged, replace sprocket.

Replace covers before operation.

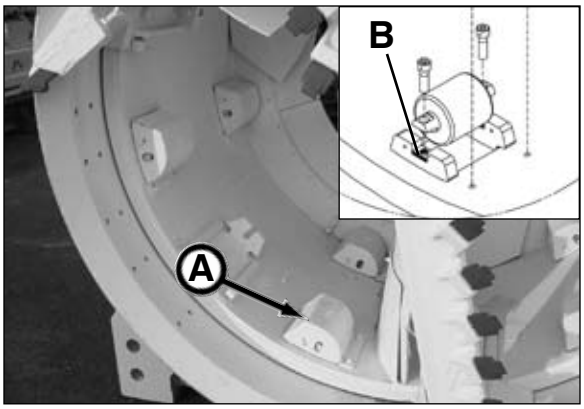


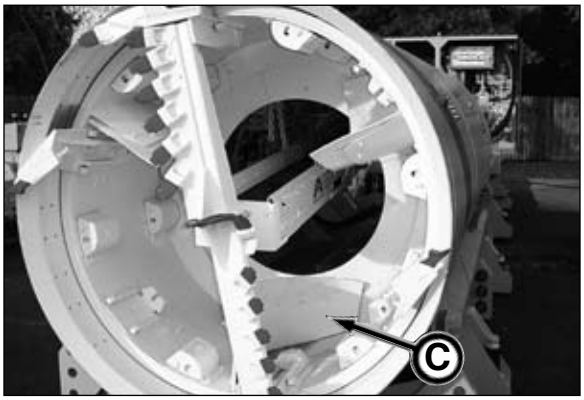
39. INSPECT DRUM ROLLERS

Inspect drum rollers (A) for wear. If roller bearing does NOT spin freely or has play, replace drum roller bearings.

The drum rollers should rotate from the 2 o’clock to 10 o’clock position. If the rollers rotate less than 2 to 10 o’clock, remove shims (B). If rollers rotate more than 2 to 10 o’clock, add shims.

Replace covers before operation.





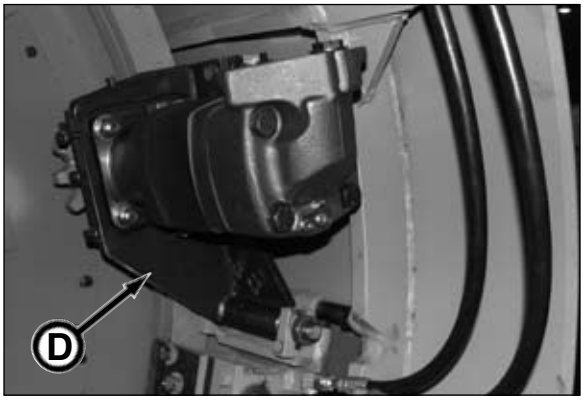
40. INSPECT DIRT PADDLES

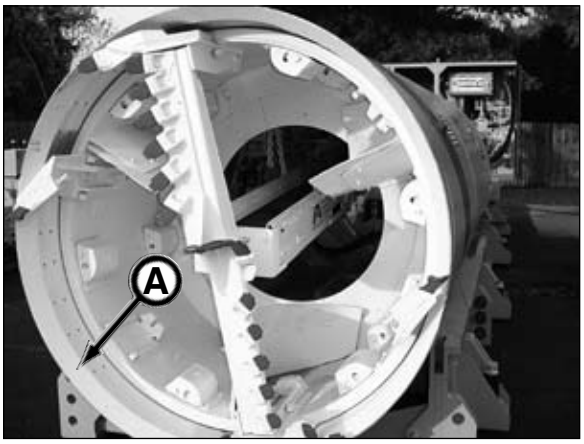
Inspect dirt paddles (C) for wear or damage. Replace dirt paddles as needed.

41. INSPECT MOTOR BRACKET

Inspect motor bracket (D) and hardware for wear or damage. Replace as needed.

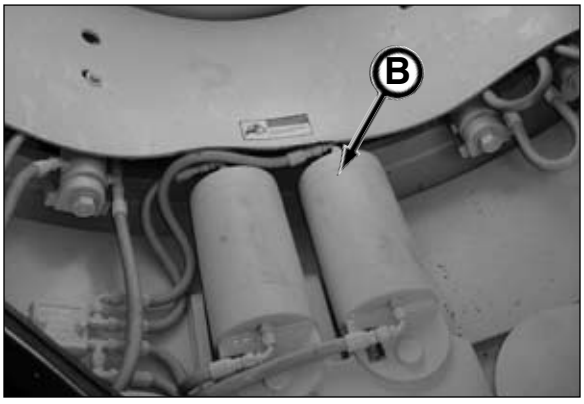
Replace covers before operation.





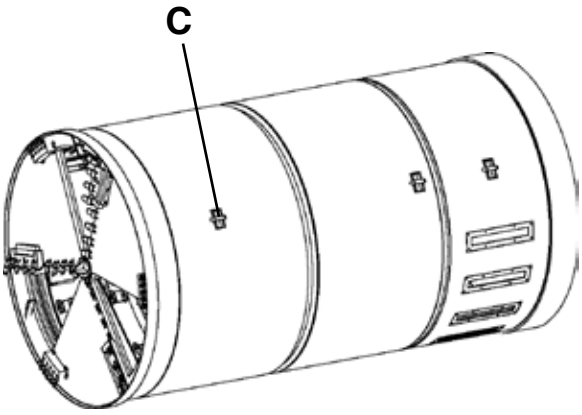
42. INSPECT CUTTER RING

Inspect cutter ring edge (A) for wear or damage. Cutter ring should not be dented, bent or flat. Repair as needed.



43. INSPECT STEERING CYLINDERS

Inspect steering cylinders (B) for wear or damage. Repair or replace before operating.

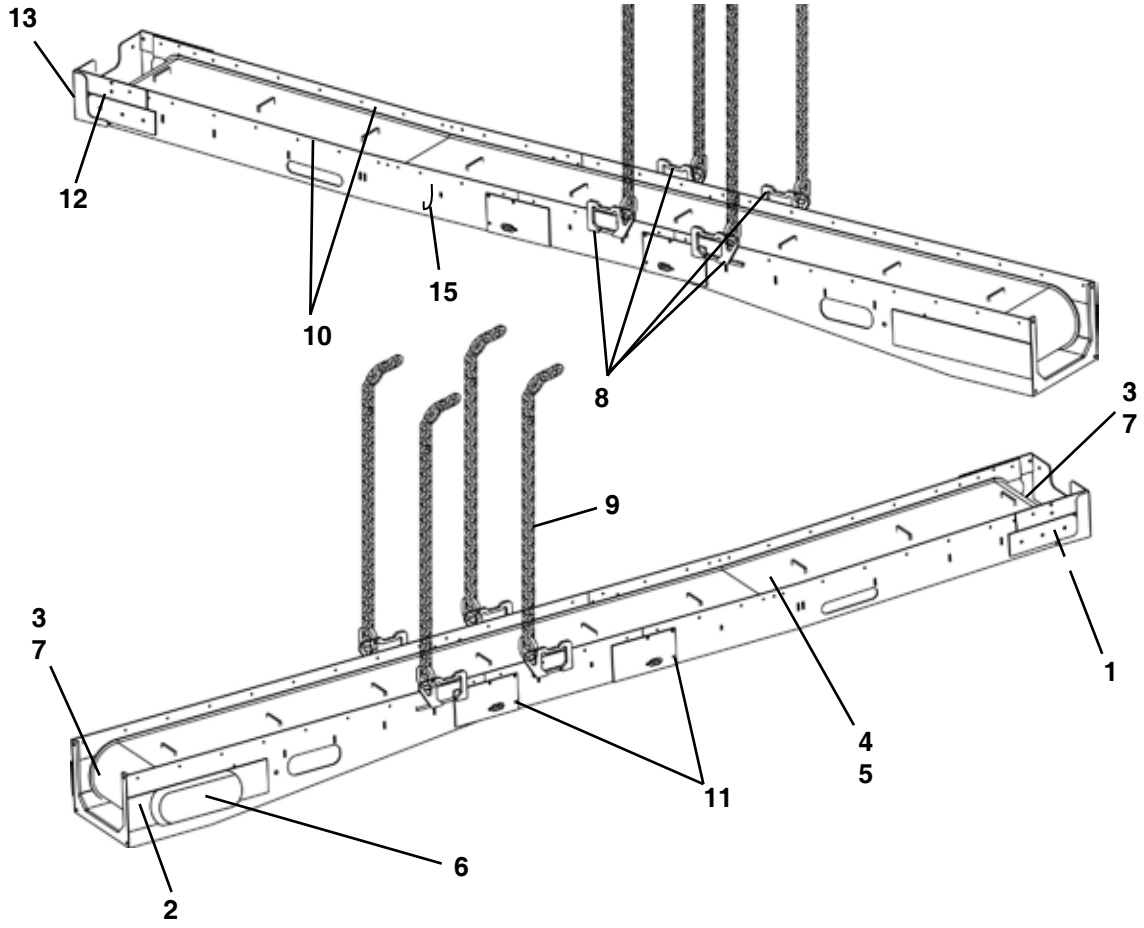


44. INSPECT LIFTING EYES

Inspect lifting eyes (C) for wear or damage. Worn or damaged lifting eyes MUST be replaced before lifting.

MAINTENANCE CHARTS - BELT CONVEYOR

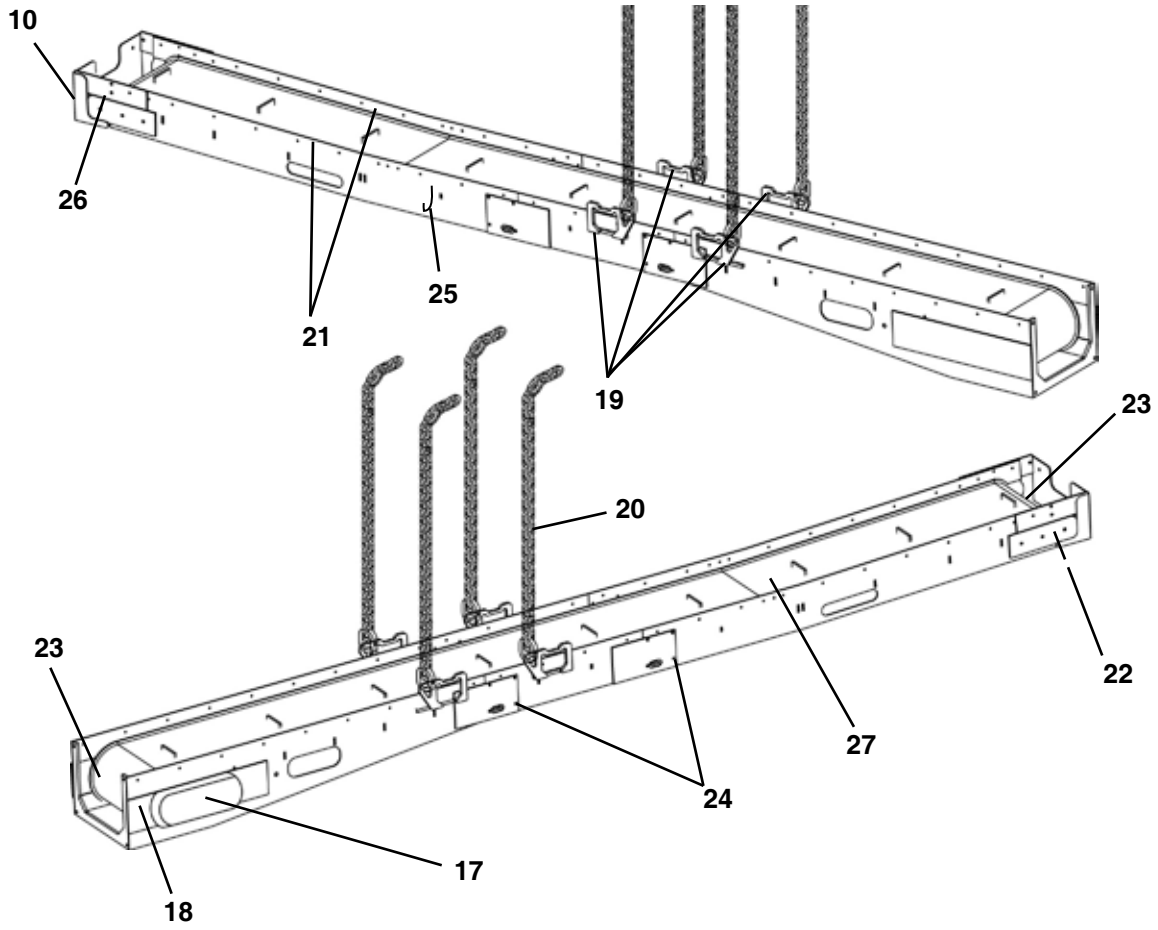
Use the item number in the chart to refer to the detailed maintenance procedures later in this section.



PRIOR TO EACH JOB LAUNCH

ITEM	COMPONENT	SERVICE	REQUIREMENT	MATERIAL
1.	Front Roller	Inspect & Lubricate	If damaged, replace with new.	Mobil XHP222
2.	Drive Roller & Brg.	Inspect & Lubricate	If damaged, replace with new.	Mobil XHP222
3.	Roller Scrapers	Inspect	If damaged, replace with new.	
4.	Belt	Inspect	Replace if worn, cracked or damaged.	
5.	Belt Tension	Check	At center, max. 6” deflection.	
6.	Drive Chain	Inspect & Lubrication	Check for wear and tightness.	Mobil XHP222
7.	Belt Scrapers	Inspect	If damaged, replace with new.	
8.	Lift Eyes	Inspect	If damaged, replace with new.	
9.	Lifting Chain	Inspect	If damaged, replace with new.	
10.	Spoils Guide	Inspect	If damaged, replace with new.	
11.	Idler Rollers	Inspect & Lubricate	If damaged, replace with new.	Mobil XHP222
12.	Nose Bracket & Brg.	Inspect & Lubricate	If damaged, replace with new.	Mobil XHP222
13.	Dirt Guard	Inspect	If damaged, replace with new.	
*14.	Hydraulic Hoses	Inspect	If worn or damaged, replace with new.	
15.	Safety Hook	Inspect	If damaged, replace with new.	
*16.	Decals	Inspect		

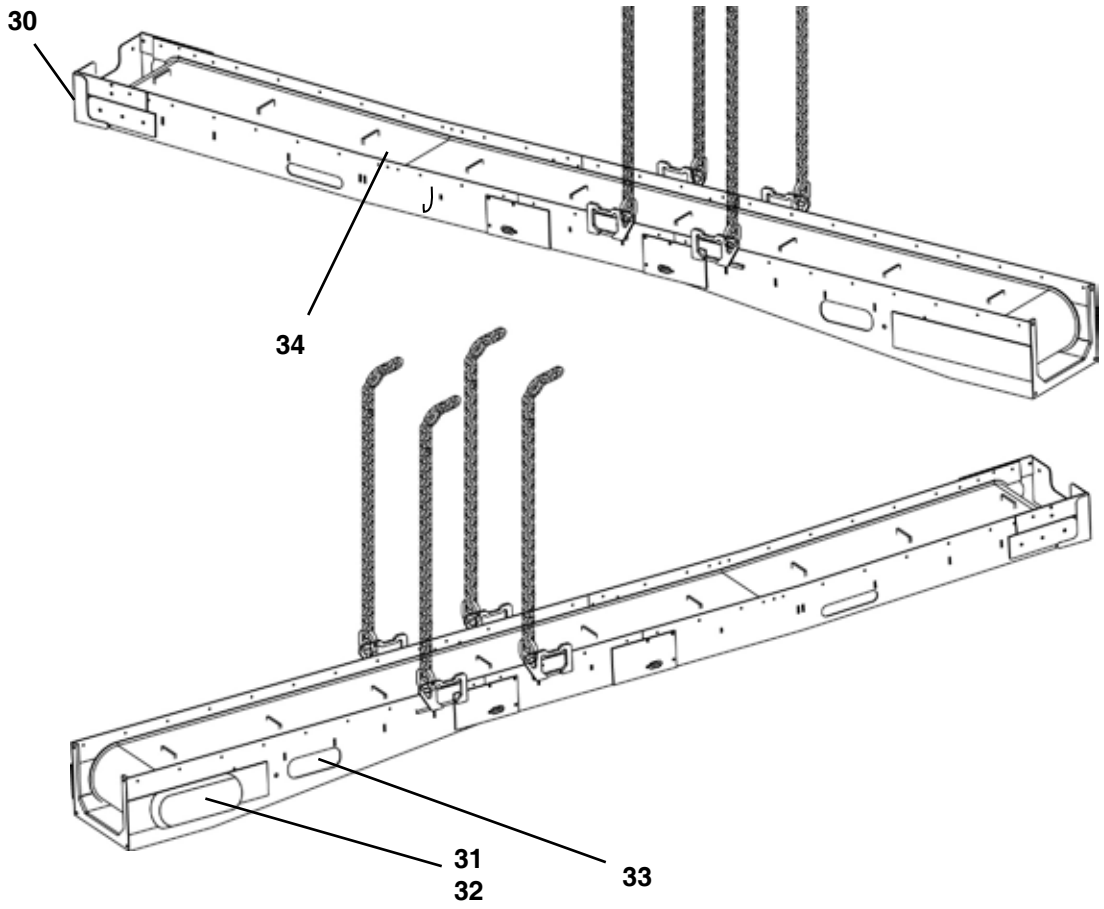
* Not Shown



DAILY OR EVERY 10 HOURS OF OPERATION OR EACH SHIFT CHANGE

ITEM	COMPONENT	SERVICE	REQUIREMENT	MATERIAL
17.	Drive Cover	Inspect	If damaged, replace with new.	
18.	Drive Roller & Brgs.	Inspect & Lubricate	Replace if cracks/wear visible	Mobil XHP222
19.	Lift Eyes	Inspect	If damaged, replace with new.	
20.	Lifting Chain	Inspect	If damaged, replace with new.	
21.	Spoils Guide	Inspect	If damaged, replace with new.	
22.	Front Roller	Inspect	If damaged, replace with new.	
23.	Belt Scrapers	Inspect	If damaged, replace with new.	
24.	Idler Rollers	Inspect & Lubricate	If damaged, replace with new.	Mobil XHP222
25.	Safety Hook			
26.	Nose Bracket & Brg	Inspect & Lubricate	If damaged, replace with new.	
27.	Belt	Inspect	Replace if worn, cracked or damaged.	
*28.	Decals	Inspect		
*29.	Hydraulic Hoses	Inspect	If worn or damaged, replace with new.	

* Not Shown



WEEKLY OR EVERY 50 HOURS OF OPERATION

ITEM	COMPONENT	SERVICE	REQUIREMENT	MATERIAL
30.	Dirt Guard	Inspect	If damaged, replace with new.	
31.	Drive Motor Bolts	Inspect for tightness	If damaged, replace with new.	
32.	Drive Chain	Inspect & Lubrication	Check for wear and tightness.	Mobil XHP222
33.	Belt Adjust Screw	Inspect & Lubricate		
34.	Belt Tension	Check	At center, max. 6” deflection.	

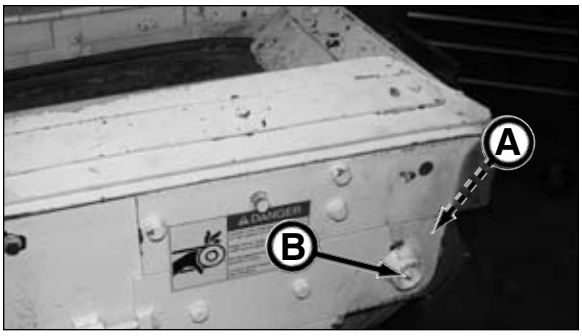
* Not Shown

PRIOR TO EACH JOB LAUNCH

1. INSPECT & LUBRICATE FRONT ROLLER

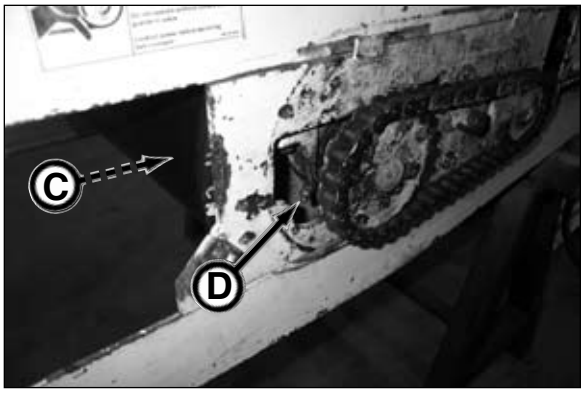
Inspect front roller (A) for wear or damage. If worn or damaged, replace with new.

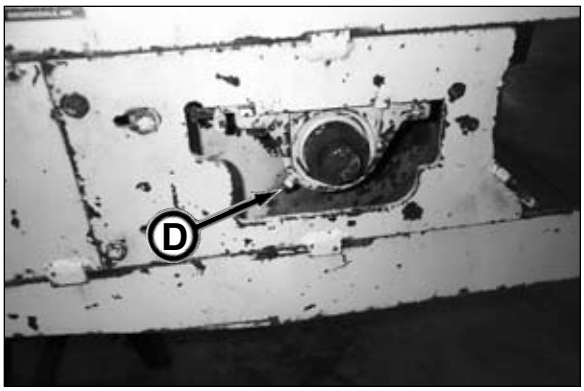
Lubricate front roller bearings (B) (2 places) with Mobilgrease® XHP222 Premium Lubricating Grease or equivalent until grease is forced out.



2. INSPECT & LUBRICATE DRIVE ROLLER & BEARING

1. Remove guard.
2. Inspect drive roller (C) for wear or damage. If worn or damaged, replace with new.
3. Lubricate drive roller pillow block bearings (D) (2 places) with Mobilgrease® XHP222 Premium Lubricating Grease or equivalent until grease is forced out.
4. Replace guard before operating conveyor.



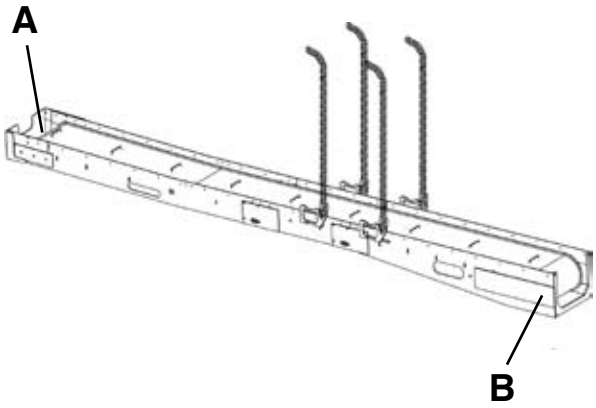


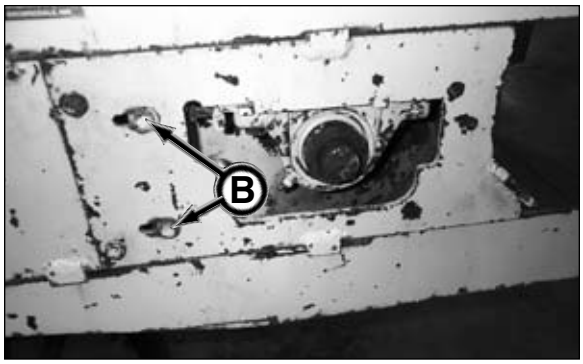
3. INSPECT ROLLER SCRAPERS

Inspect front roller (A) and the internal drive roller (B) scrapers for wear or damage. If worn or damaged, replace with new.

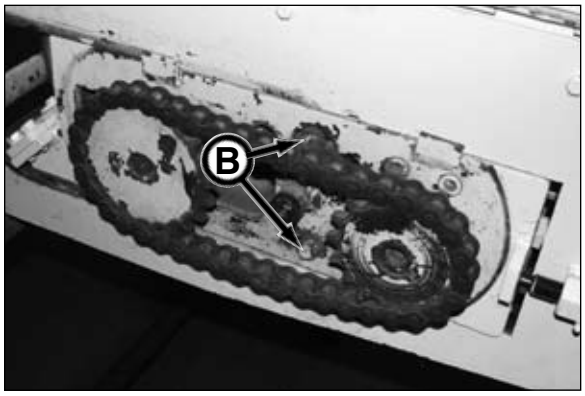
Check to be sure scrapers are adjusted so they are approximately 1/16 in. (1.5 mm) from the rollers.

Before operating conveyor, replace any cover/ guards that were removed for this inspection.





Internal Drive Roller Scraper Adjustment



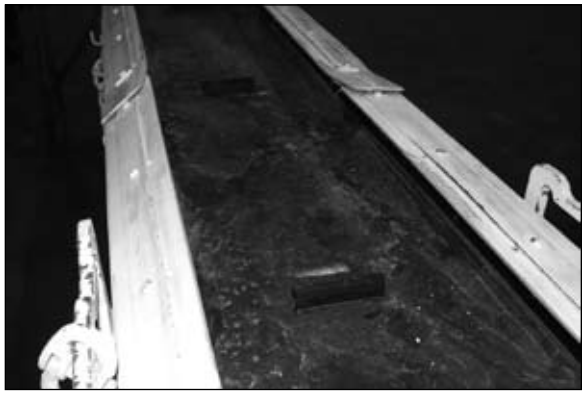
Internal Drive Roller Scraper Adjustment

4. INSPECT BELT

Inspect belt for cracks, wear, or damage. At the first sign of cracks, wear, or damage, replace conveyor belt.

Conveyor belt should be replaced if:

- The side ribs are worn to the point of no longer able to hold material.
- Cracks in the belt.
- Holes in the belt.
- Multiple belt lugs are missing.
- Belt can no longer be adjusted due to stretch in the belt.



5. CHECK BELT TRACKING & TENSION

Check the belt tracking as follows:

⚠WARNING Contact with rotating conveyor belt or rollers will cause severe injury or death. Keep hands, body, and objects clear or rotating conveyor.

1. Remove or rotate spoil guides up out of the way of belt.

2. With personnel away from conveyor, start the conveyor belt rotation.

3. Observe the belt tracking the entire length of the conveyor. The gap between the belt and the conveyor must be the same on both sides.

⚠WARNING NEVER adjust tracking while belt is rotating. Doing so can result in serious injury.

4. If the tracking requires adjustment, stop belt rotation and make small adjustments by using BOTH tracking adjustment bolts (A).

5. Start belt rotation and observe belt tracking. If further adjustment is needed, repeat steps 4 and 5 until the belt tracks straight on conveyor.

6. Once belt is tracking properly, stop belt rotation and lock out power to conveyor.

Check conveyor belt tension by:

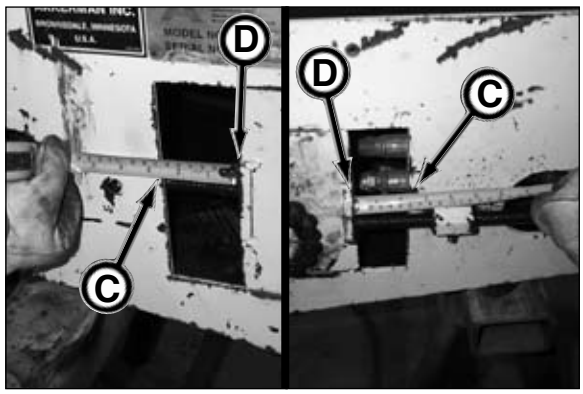
1. Remove or rotate spoil guides up out of the way of belt.

2. In the center of the conveyor, lift the belt (B) and measure the deflection. The deflection should be a maximum of 6 in. (152 mm).

NOTICE Be sure the center rib on the under side of the belt stays in the groove of pulley.

Adjusting conveyor belt tension:

1. Use BOTH adjustment screws to tighten belt to a 6 in. (152 mm) deflection in the center of the conveyor. Use a tape measure to measure the distance from the conveyor frame (C) to the drive motor frame (D). This distance must be the same on both sides of the conveyor.



NOTICE Be sure to tighten BOTH adjustment screws the same rate or distance. Failure to do so will cause premature wear in the belt due to the tension being different on each side of the belt.

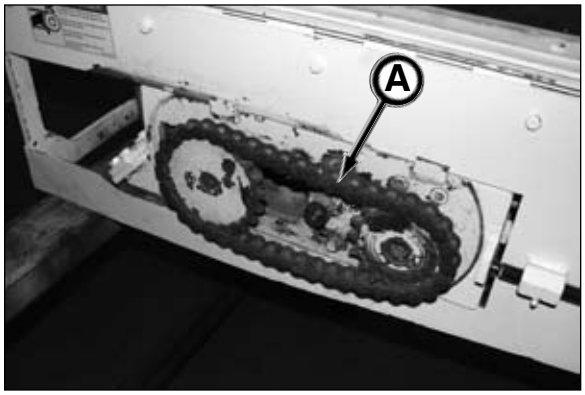
2. Once proper belt tension is achieved, the inner belt scrapers need to be readjusted for a 1/16 in. (1.5 mm) clearance.

6. INSPECT & LUBRICATE DRIVE CHAIN

Inspect drive chain (A). If worn or damaged, replace with new.

Thoroughly lubricate chain with Mobilgrease® XHP222 Premium Lubricating Grease or equivalent.

Replace cover before operating conveyor.



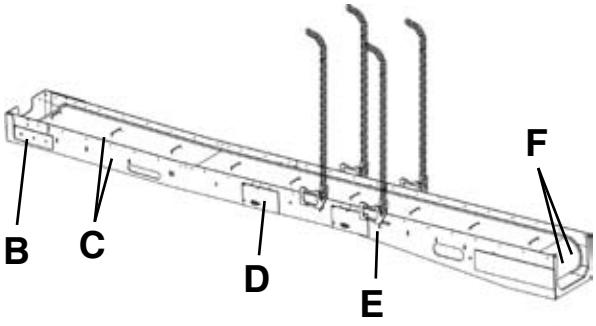
7. INSPECT BELT SCRAPERS

Inspect belt scrapers for wear or damage. If worn or damaged, replace with new.

Check to be sure scrapers are adjusted so they are approximately 1/16 in. (1.6 mm) from the belt.

⚠WARNING Contact with rotating conveyor belt or idler rollers will cause severe injury or death. Keep hands, body, and objects clear or rotating conveyor.

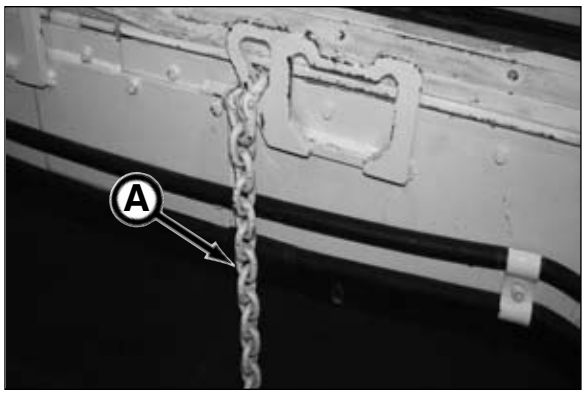
Once scrapers are adjusted, run the conveyor belt and make sure the scrapers do not contact the belt. If so, the scrapers MUST be readjusted. Once adjusted, stop belt rotation and lock out power to conveyor.



- B - Front End External Belt Scraper
- C - Inner Belt Scraper (2)
- D - Idler Roller Scraper for Extension Frame
- E - Idler Roller Scraper for Drive Frame
- F - External Belt Scraper (2)

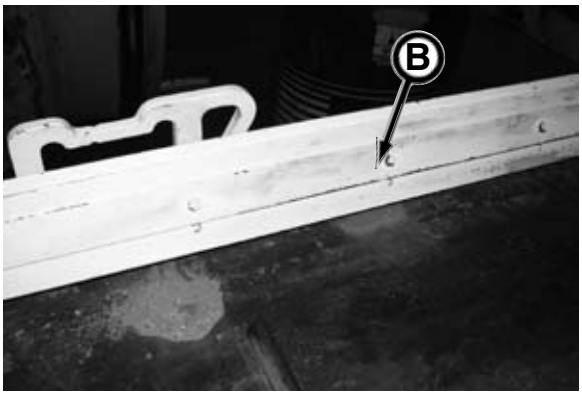
8. INSPECT LIFTING EYES

Inspect lifting eyes (G) for wear or damage. If worn or damaged, replace with new.



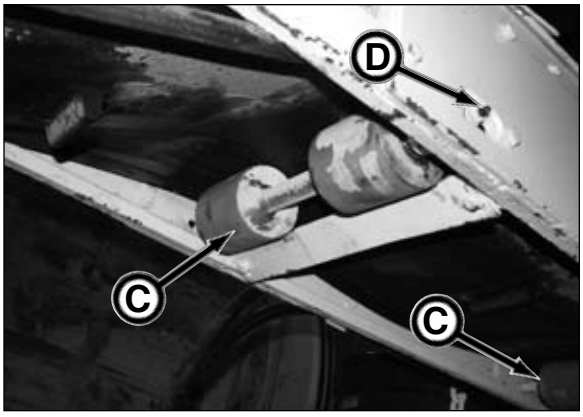
9. INSPECT LIFTING CHAINS

Inspect lifting chains (A) for wear or damage. If worn or damaged, replace with new.



10. INSPECT SPOILS GUIDES

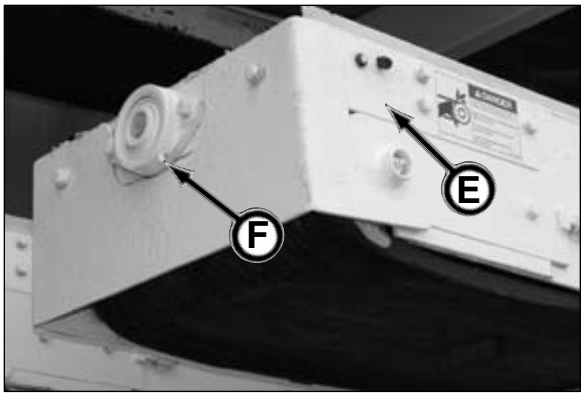
Inspect spoils guides (B) for wear or damage. If guide cannot be adjusted to within 1/4 in. (6.4 mm) of the belt, the guide should be replaced. Otherwise if damaged, replace with new.



11. INSPECT & LUBRICATE IDLER ROLLERS

Inspect idler rollers (C) for wear or damage. If worn or damaged, replace with new.

Lubricate idler roller bearings (D) (4 places) with Mobilgrease® XHP222 Premium Lubricating Grease or equivalent until grease is forced out.



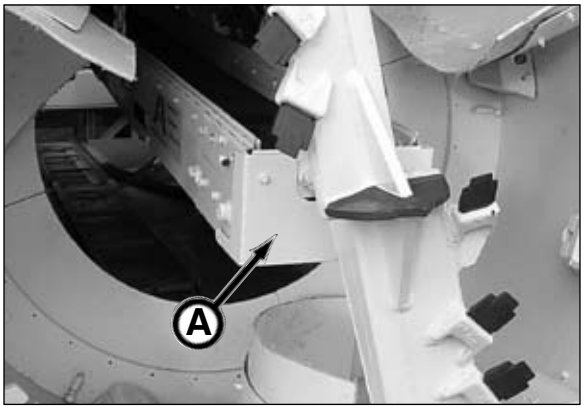
12. INSPECT & LUBRICATE NOSE BRACKET & BEARING

Inspect nose bracket (E) for wear or damage. If worn or damaged, replace with new.

Lubricate nose bearing (F) with Mobilgrease® XHP222 Premium Lubricating Grease or equivalent until grease is forced out.

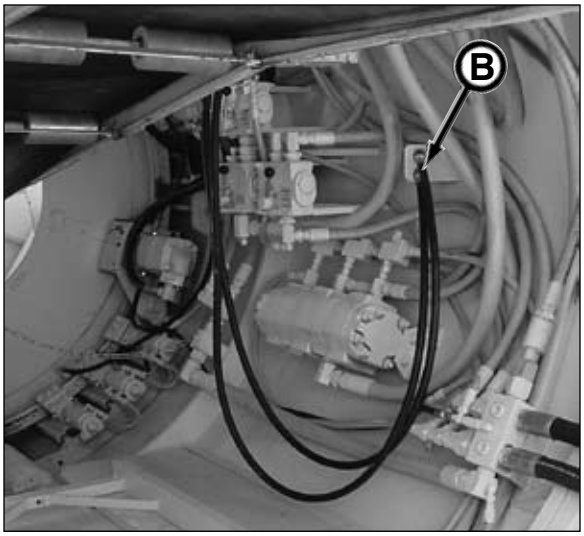
13. INSPECT DIRT GUARD

Inspect dirt guard (A) for wear or damage. If worn or damaged, replace with new.



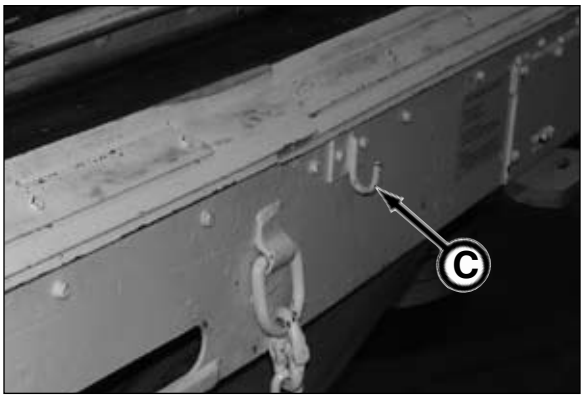
14. INSPECT HYDRAULIC HOSES

Inspect hydraulic hoses (B) for wear or damage. Repair or replace BEFORE operation.



15. INSPECT CONVEYOR SAFETY HOOK

Inspect hook (C) for wear or damage. If worn or damaged, replace with new.



16. INSPECT DECALS

Inspect ALL decals, operational and safety decals to be sure they are 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 will damage decals. Replace decals immediately if they are damaged, missing, or hard to read.

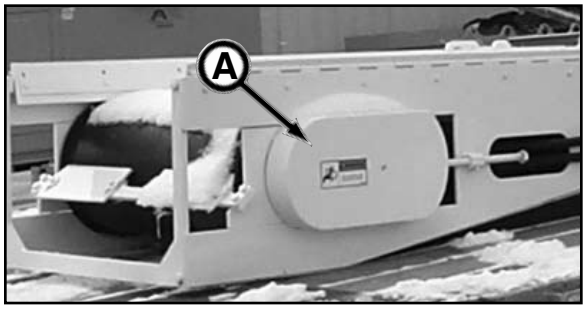
Before applying a new decal, be sure the surface is clean and dry.

DAILY OR EVERY 10 HOURS OF OPERATION OR EACH SHIFT CHANGE

17. INSPECT DRIVE CHAIN COVER

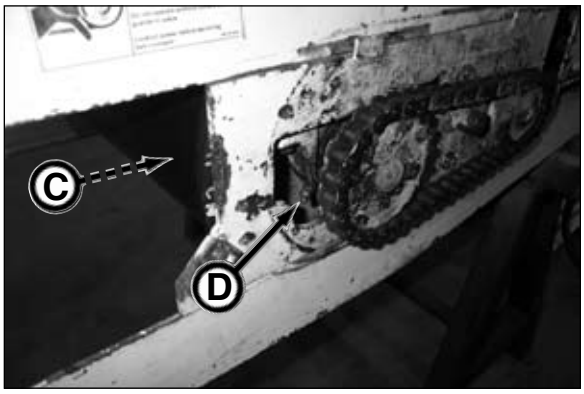
Inspect drive chain (A) for wear or damage. If worn or damaged, replace with new.

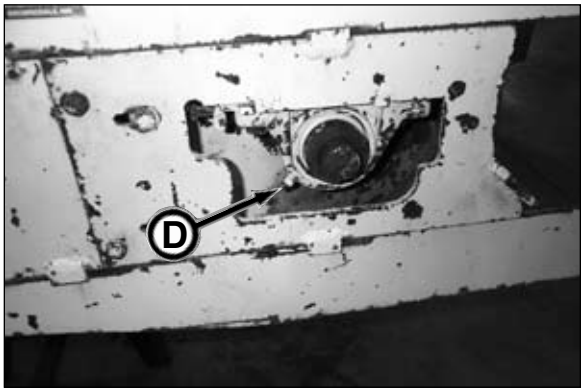
NEVER operate conveyor without cover in place.



18. INSPECT & LUBRICATE DRIVE ROLLER & BEARING

1. Remove guard.
2. Inspect drive roller (C) for wear or damage. If worn or damaged, replace with new.
3. Lubricate drive roller pillow block bearings (D) (2 places) with Mobilgrease® XHP222 Premium Lubricating Grease or equivalent until grease is forced out.
4. Replace guard before operating conveyor.



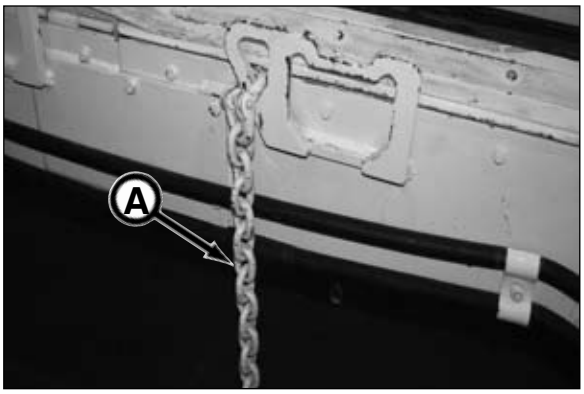


19. INSPECT LIFTING EYES

Inspect lifting eyes (E) for wear or damage. If worn or damaged, replace with new.

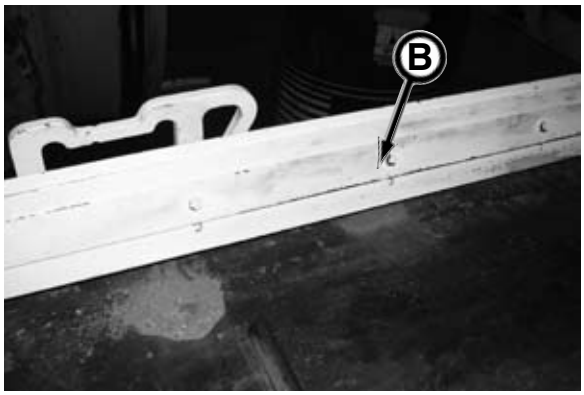
20. INSPECT LIFTING CHAINS

Inspect lifting chains (A) for wear or damage. If worn or damaged, replace with new.



21. INSPECT SPOILS GUIDES

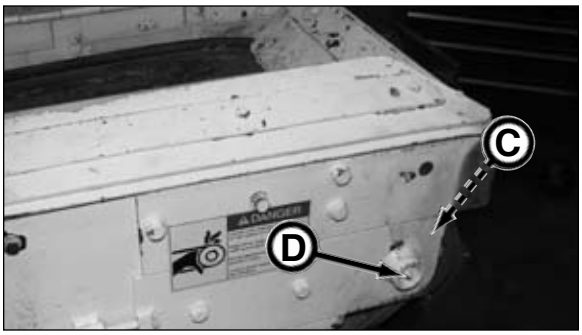
Inspect spoils guides (B) for wear or damage. If guide cannot be adjusted to within 1/4 in. (6.4 mm) of the belt, the guide should be replaced. Otherwise if damaged, replace with new.



22. INSPECT & LUBRICATE FRONT ROLLER

Inspect front roller (C) for wear or damage. If worn or damaged, replace with new.

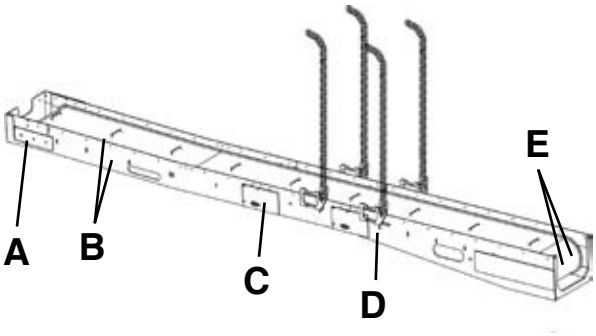
Lubricate front roller bearings (D) (2 places) with Mobilgrease® XHP222 Premium Lubricating Grease or equivalent until grease is forced out.



23. INSPECT BELT SCRAPERS

Inspect belt scrapers for wear or damage. If worn or damaged, replace with new.

Check to be sure scrapers are adjusted so they are approximately 1/16 in. (1.5 mm) from the belt.



⚠WARNING Contact with rotating conveyor belt or idler rollers will cause severe injury or death. Keep hands, body, and objects clear or rotating conveyor.

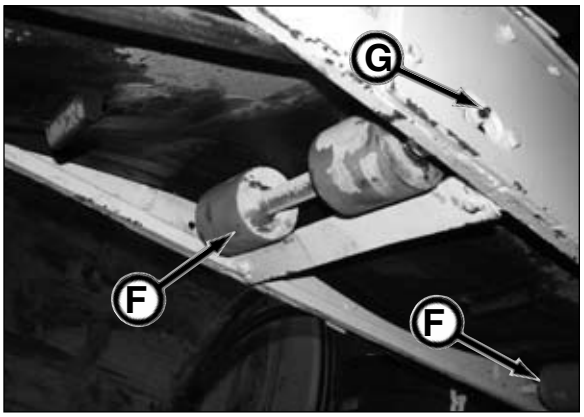
Once scrapers are adjusted, run the conveyor belt and make sure the scrapers do not contact the belt. If so, the scrapers MUST be readjusted. Once adjusted, stop belt rotation and lock out power to conveyor.

A - Front End External Belt Scraper
B - Inner Belt Scraper (2)
C - Idler Roller Scraper for Extension Frame
D - Idler Roller Scraper for Drive Frame
E - External Belt Scraper (2)

24. INSPECT & LUBRICATE IDLER ROLLERS

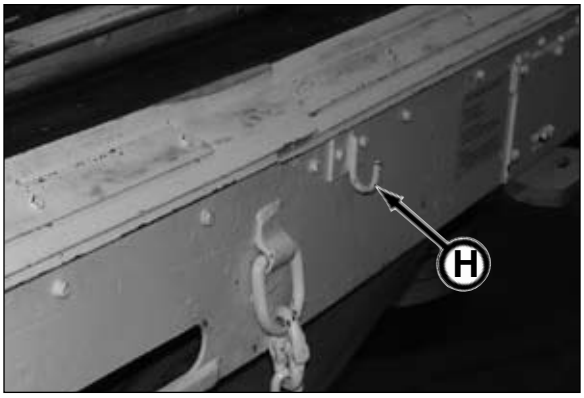
Inspect idler rollers (F) for wear or damage. If worn or damaged, replace with new.

Lubricate idler roller bearings (G) (4 places) with Mobilgrease® XHP222 Premium Lubricating Grease or equivalent until grease is forced out.

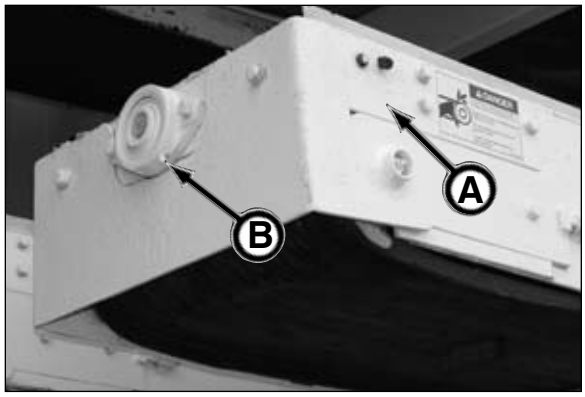


25. INSPECT CONVEYOR SAFETY HOOK

Inspect hook (H) for wear or damage. If worn or damaged, replace with new.



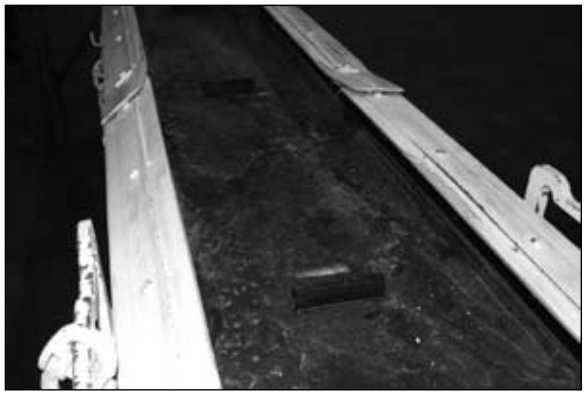
26. INSPECT & LUBRICATE NOSE BRACKET & BEARING



Inspect nose bracket (A) for wear or damage. If worn or damaged, replace with new.

Lubricate nose bearing (B) with Mobilgrease® XHP222 Premium Lubricating Grease or equivalent until grease is forced out.

27. INSPECT BELT



Inspect belt for cracks, wear, or damage. At the first sign of cracks, wear, or damage, replace conveyor belt.

Conveyor belt should be replaced if:

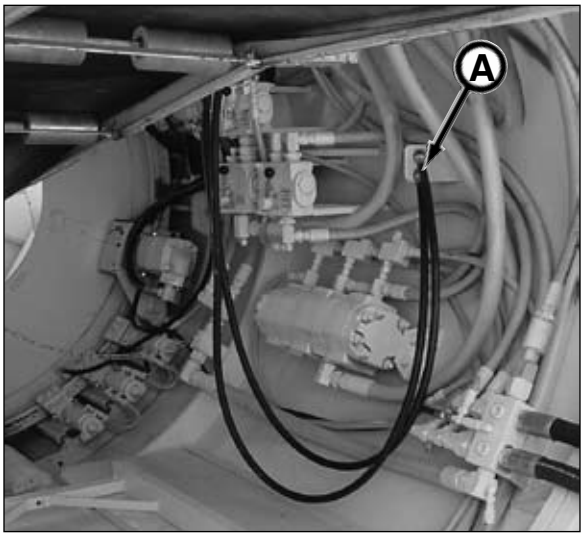
- The side ribs are worn to the point of no longer able to hold material.
- Cracks in the belt.
- Holes in the belt.
- Multiple belt lugs are missing.
- Belt can no longer be adjusted due to stretch in belt.

28. INSPECT DECALS

Inspect ALL decals, operational and safety decals to be sure they are 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 will damage decals. Replace decals immediately if they are damaged, missing, or hard to read.

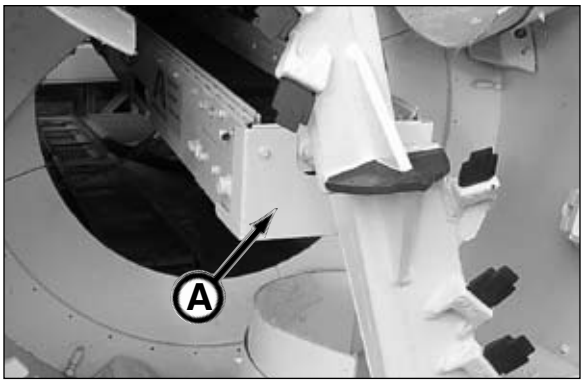
Before applying a new decal, be sure the surface is clean and dry.



29. INSPECT HYDRAULIC HOSES

Inspect hydraulic hoses (A) for wear or damage. Repair or replace BEFORE operation.

WEEKLY OR EVERY 50 HOURS OF OPERATION



30. INSPECT DIRT GUARD

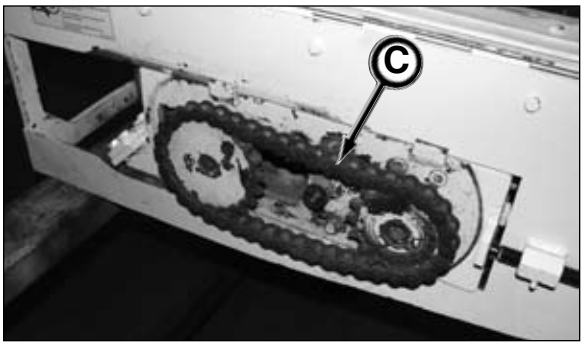
Inspect dirt guard (A) for wear or damage. If worn or damaged, replace with new.

31. CHECK DRIVE MOTOR BOLT TIGHTNESS

Check drive motor bolt (B) tightness. Tighten bolts to the following torque:

3/8 in.	40 ft-lb. (54 N·m)
1/2 in.	90 ft-lb. (122 N·m)

If bolt (s) do not hold torque, the bolts must be replaced with new.



32. INSPECT & LUBRICATE DRIVE CHAIN

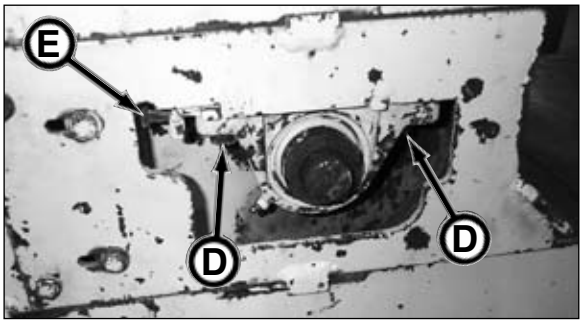
1. Inspect drive chain (C). If worn or damaged, replace with new.

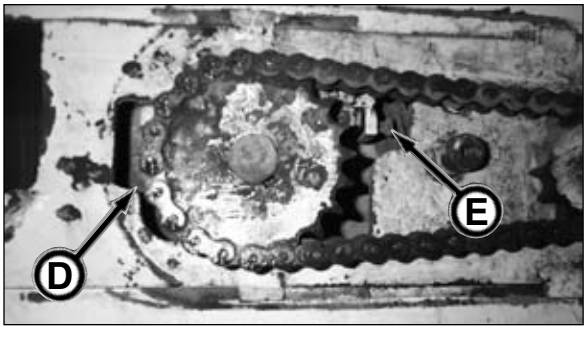
2. Check chain tension. The center of the chain should have a maximum deflection of 3/16 in. (4.8 mm).

   To adjust chain tension, loosen bolts (D) on pillow block bearings and tighten chain adjustment bolt (E) until the 3/16 in. (4.8 mm) deflection is achieved. Then retighten pillow block bearing bolts.

3. Thoroughly lubricate chain with Mobilgrease® XHP222 Premium Lubricating Grease or equivalent.

   Replace cover before operating conveyor.





33. INSPECT & LUBRICATE BELT ADJUSTMENT SCREW

Inspect belt adjustment screw for wear or damage. If worn or damaged, replace with new.

Lubricate belt adjustment screw (2 places) with one shot of Mobilgrease® XHP222 Premium Lubricating Grease or equivalent.

34. CHECK BELT TRACKING & TENSION

Check the belt tracking as follows:

⚠WARNING Contact with rotating conveyor belt or rollers will cause severe injury or death. Keep hands, body, and objects clear or rotating conveyor.

1. Remove or rotate spoil guides up out of the way of belt.

2. With personnel away from conveyor, start the conveyor belt rotation.

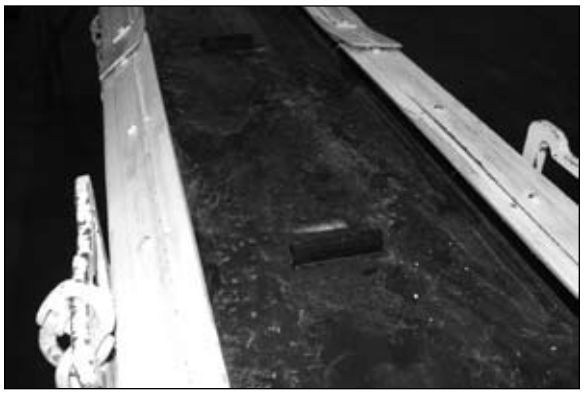
3. Observe the belt tracking the entire length of the conveyor. The gap between the belt and the conveyor must be the same on both sides.

⚠WARNING NEVER adjust tracking while belt is rotating. Doing so can result in serious injury.

4. If the tracking requires adjustment, stop belt rotation and make small adjustments by using BOTH tracking adjustment bolts (A).

5. Start belt rotation and observe belt tracking. If further adjustment is needed, repeat steps 4 and 5 until the belt tracks straight on conveyor.

6. Once belt is tracking properly, stop belt rotation and lock out power to conveyor.



(continued on next page)

Check conveyor belt tension by:

1. Remove or rotate spoil guides up out of the way of belt.

2. In the center of the conveyor, lift the belt (A) and measure the deflection. The deflection should be a maximum of 6 in. (152 mm).

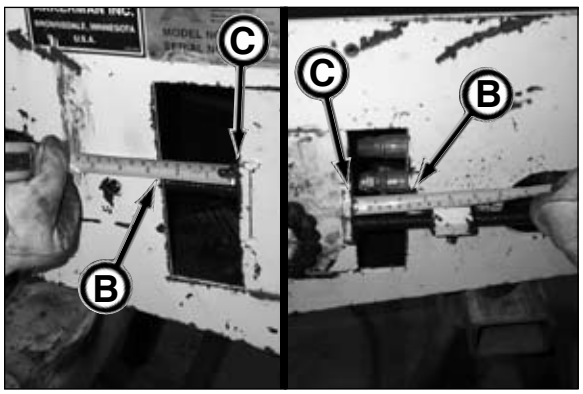
NOTICE Be sure the center rib on the under side of the belt stays in the groove of pulley.

Adjusting conveyor belt tension:

1. Use adjustment screws (2 places) to tighten belt to a 6 in. (152 mm) deflection in the center of the conveyor. Use a tape measure to measure the distance from the conveyor frame (B) to the drive motor frame (C). This distance must be the same on both sides of the conveyor.

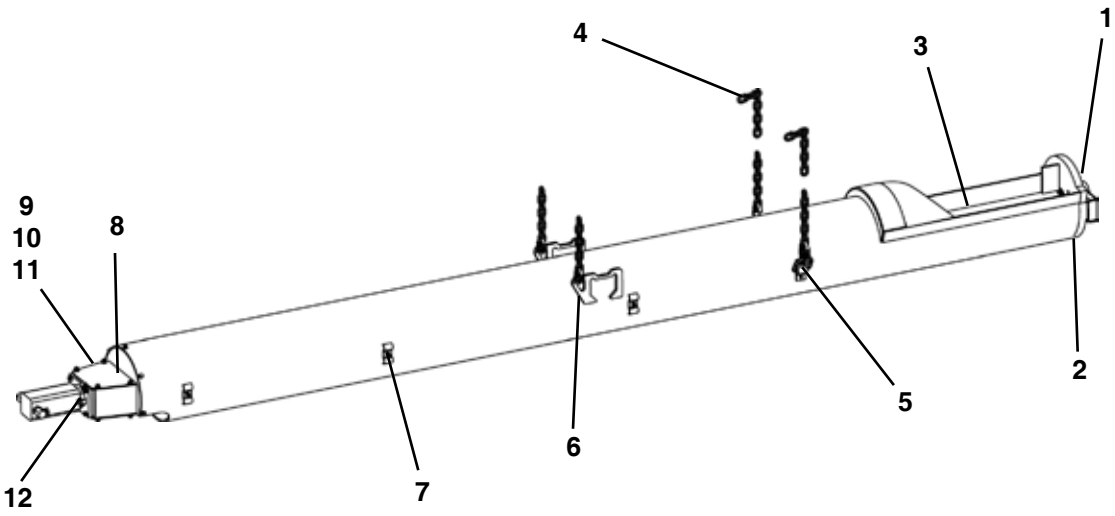
NOTICE Be sure to tighten BOTH adjustment screws the same rate or distance. Failure to do so will cause premature wear in the belt due to the tension being different on each side of the belt.

2. Once proper belt tension is achieved, the inner belt scrapers need to be readjusted for a 1/16 in. (1.5 mm) belt clearance.



MAINTENANCE CHARTS - SCREW CONVEYOR

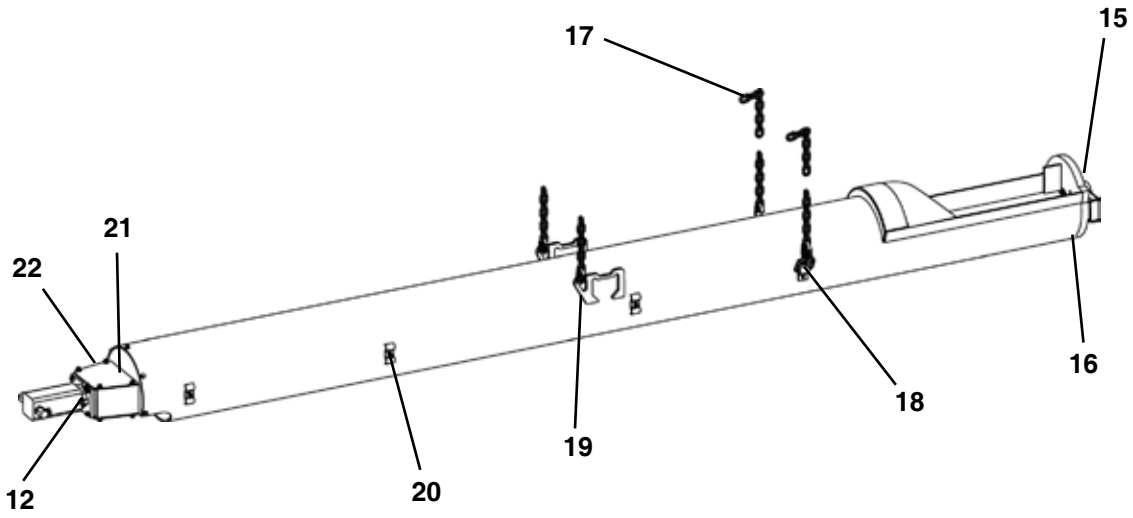
Use the item number in the chart to refer to the detailed maintenance procedures later in this section.



PRIOR TO EACH JOB LAUNCH

ITEM	COMPONENT	SERVICE	REQUIREMENT	MATERIAL
1.	Nose Bearing	Lubricate	Lubricate until grease is force out.	Mobil XHP222
2.	Tail End Inner Brg.	Lubricate	Lubricate until grease is force out.	Mobil XHP222
3.	Auger	Inspect	If damaged, repair or replace.	
4.	Lifting Chain	Inspect	If damaged, replace with new.	
5.	Lift D-Ring	Inspect	If damaged, replace with new.	
6.	Lift Eyes	Inspect	If damaged, replace with new.	
7.	Line Clamp	Inspect	If damaged, replace with new.	
8.	Drive End Inner Brg.	Lubricate	Lubricate until grease is force out.	Mobil XHP222
9.	Drive Chain	Lubricate	Lubricate thoroughly.	Mobil XHP222
10.	Drive Sprockets	Inspect	If damaged, replace with new.	
11.	Drive Guard	Inspect	If damaged, repair or replace.	
12.	Motor Bolts	Inspect	Tighten to 95 ft-lb (129 N·m)	
*13.	Hydraulic Hoses	Inspect	If worn or damaged, replace with new.	
*14.	Decals	Inspect	If damaged, replace with new.	

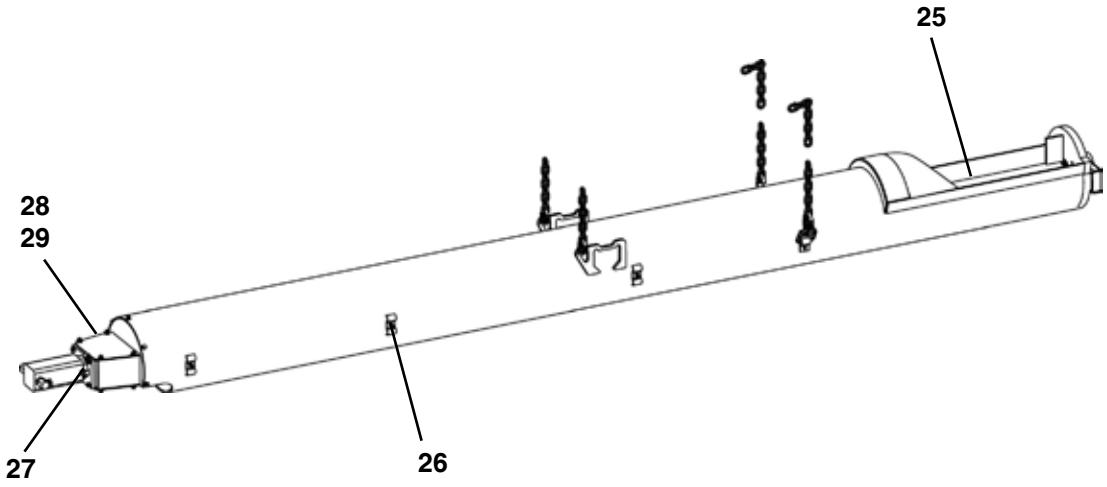
* Not Shown



DAILY OR EVERY 10 HOURS OF OPERATION OR EACH SHIFT CHANGE

ITEM	COMPONENT	SERVICE	REQUIREMENT	MATERIAL
15.	Nose Bearing	Lubricate	Lubricate until grease is force out.	Mobil XHP222
16.	Tail End Inner Brg.	Lubricate	Lubricate until grease is force out.	Mobil XHP222
17.	Lifting Chain	Inspect	If damaged, replace with new.	
18.	Lift D-Ring	Inspect	If damaged, replace with new.	
19.	Lift Eyes	Inspect	If damaged, replace with new.	
20.	Line Clamp	Inspect	If damaged, replace with new.	
21.	Drive End Inner Brg.	Lubricate	Lubricate until grease is force out.	Mobil XHP222
22.	Drive Guard	Inspect	If damaged, replace with new.	
*23.	Hydraulic Hoses	Inspect	If worn or damaged, replace with new.	
*24.	Decals	Inspect	If damaged, replace with new.	

* Not Shown

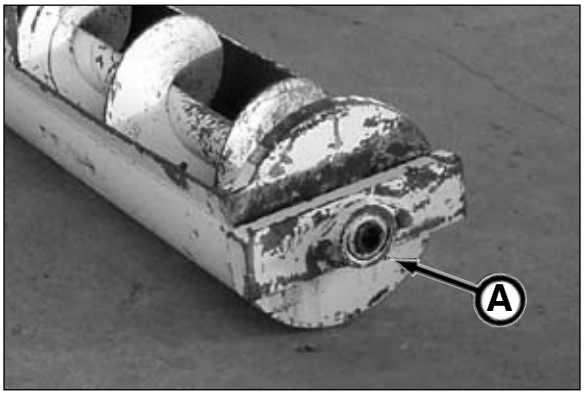


WEEKLY OR EVERY 50 HOURS OF OPERATION

ITEM	COMPONENT	SERVICE	REQUIREMENT	MATERIAL
25.	Auger	Inspect	If damaged, repair or replace.	
26.	Line Clamp	Inspect	If damaged, replace with new.	
27.	Motor Bolts	Inspect for tightness	Tighten to 95 ft-lb (129 N·m)	
28.	Drive Sprockets	Inspect	If damaged, replace with new.	
29.	Drive Chain	Lubrication	Lubricate thoroughly.	Mobil XHP222

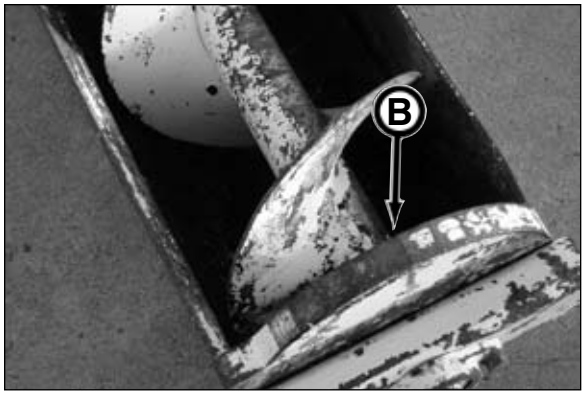
* Not Shown

PRIOR TO EACH JOB LAUNCH



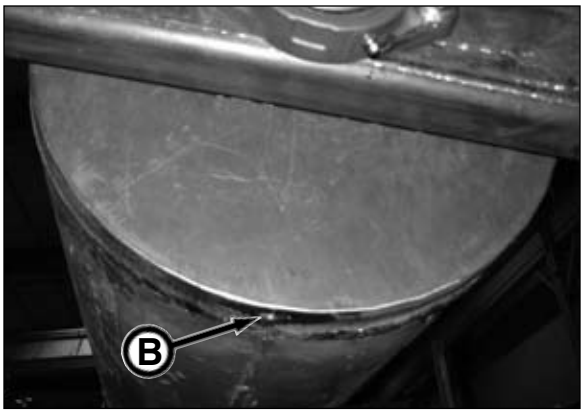
1. LUBRICATE NOSE BEARING

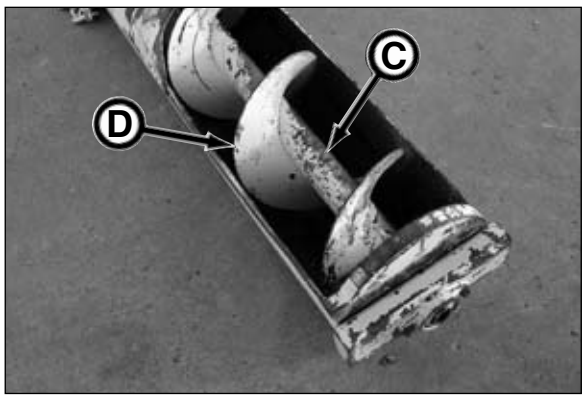
Lubricate nose bearing (A) with Mobilgrease® XHP222 Premium Lubricating Grease or equivalent until grease is forced out.



2. LUBRICATE TAIL END INNER BEARING

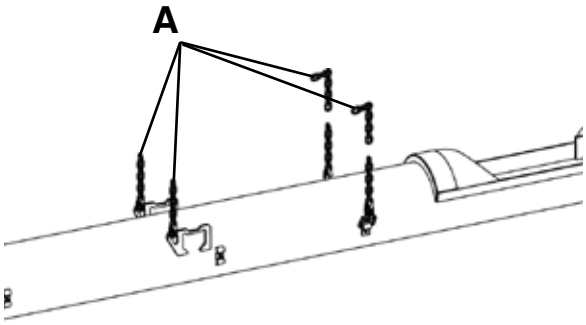
Lubricate inner bearing (B) (grease fitting located at bottom of conveyor) with Mobilgrease® XHP222 Premium Lubricating Grease or equivalent until grease is forced out.





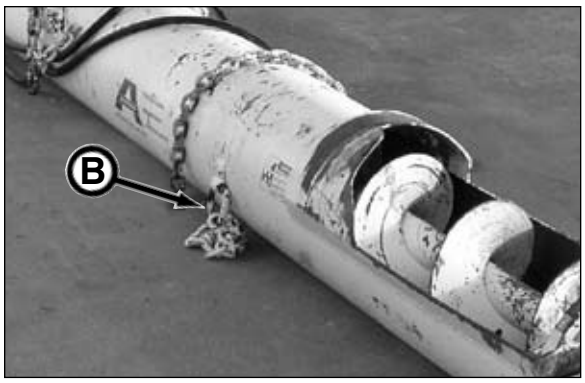
3. INSPECT AUGER

Inspect auger shaft (C) and flighting (D). If damaged, repair or replace with new.



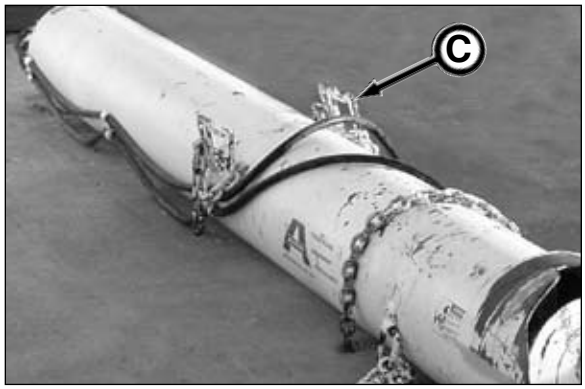
4. INSPECT LIFTING CHAINS

Inspect lifting chains (A) for wear or damage. If worn or damaged, replace with new.



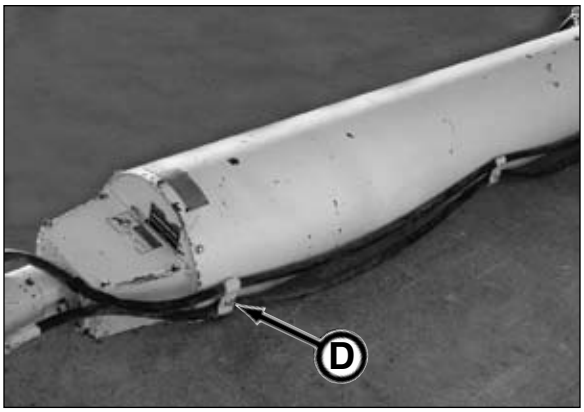
5. INSPECT LIFT D-RINGS

Inspect lift D-rings (B) for wear or damage. If worn or damaged, replace with new.



6. INSPECT LIFTING EYES

Inspect lifting eyes (C) for wear or damage. If worn or damaged, replace with new.



7. INSPECT LINE CLAMPS

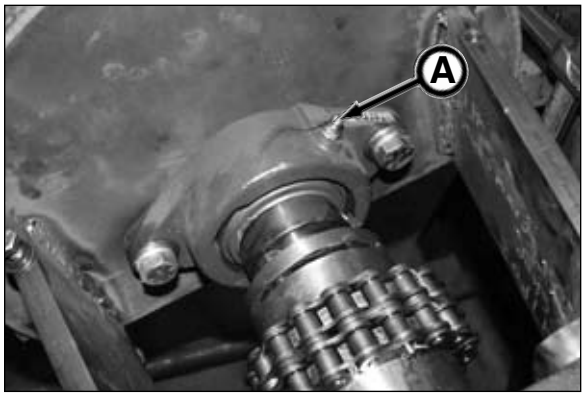
Inspect line clamps (D) for wear or damage. If worn or damaged, replace with new.

8. LUBRICATE DRIVE END INNER BEARING

1. Remove drive guard.

2. Lubricate inner bearing (A) with Mobilgrease® XHP222 Premium Lubricating Grease or equivalent until grease is forced out.

3. Replace drive guard before operating.



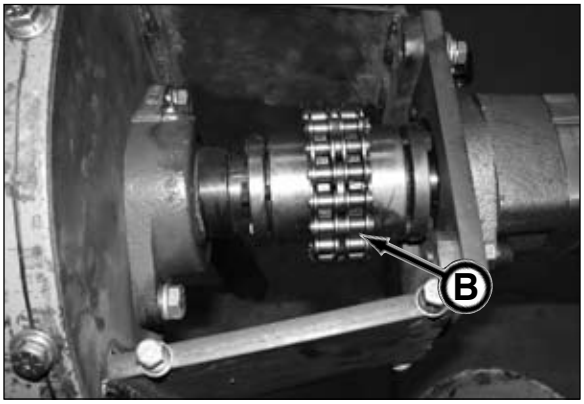
9. INSPECT & LUBRICATE DRIVE CHAIN

1. Remove drive guard.

2. Inspect drive chain (B). If worn or damaged, replace with new.

3.Thoroughly lubricate chain with Mobilgrease® XHP222 Premium Lubricating Grease or equivalent.

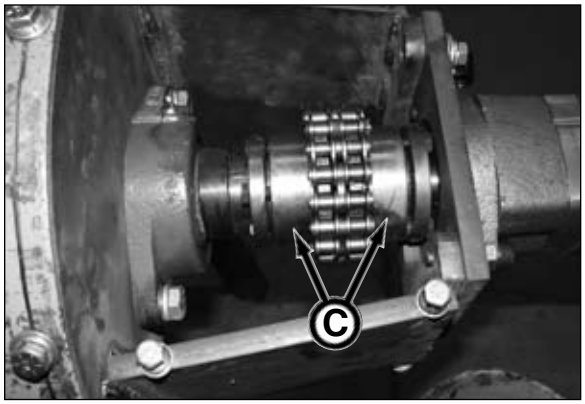
4. Replace drive guard before operating.



10. INSPECT DRIVE SPROCKETS

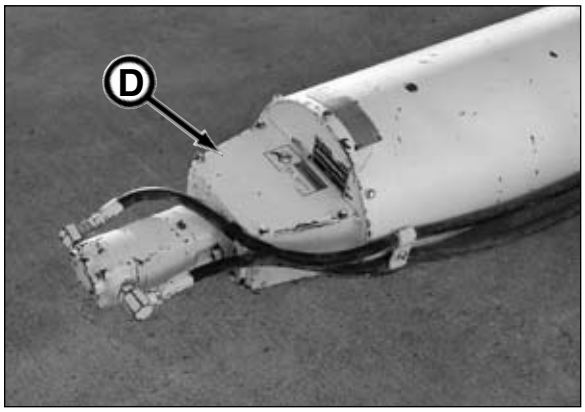
1. Inspect drive sprockets (C). If worn or damaged, replace with new.

2. Replace drive guard before operating.



11. INSPECT DRIVE GUARD

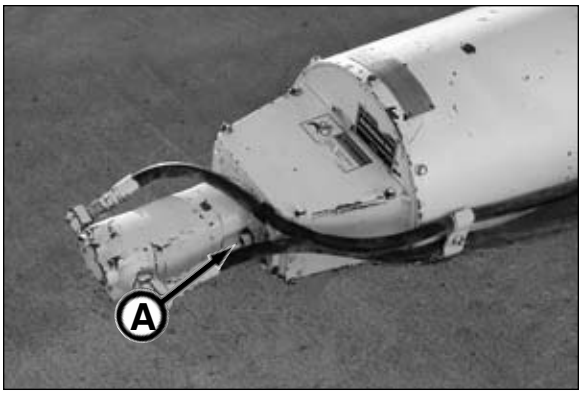
Inspect drive guard (D). If worn or damaged, replace with new.



12. CHECK DRIVE MOTOR BOLT TIGHTNESS

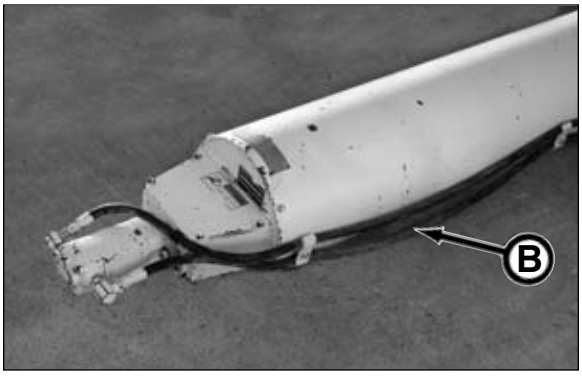
Check drive motor bolt (A) tightness. Tighten bolts to the 95 ft-lb (129 N·m) torque.

If bolts do not hold torque, replace bolts with new.



13. INSPECT HYDRAULIC HOSES

Inspect hydraulic hoses (B) for wear or damage. Repair or replace BEFORE operation.

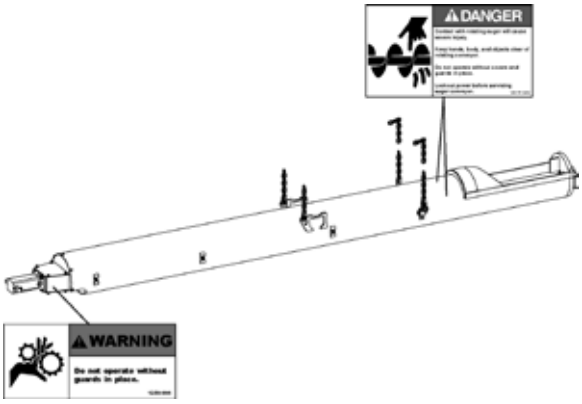


14. INSPECT DECALS

Inspect ALL decals, operational and safety decals to be sure they are 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 will damage decals. Replace decals immediately if they are damaged, missing, or hard to read.

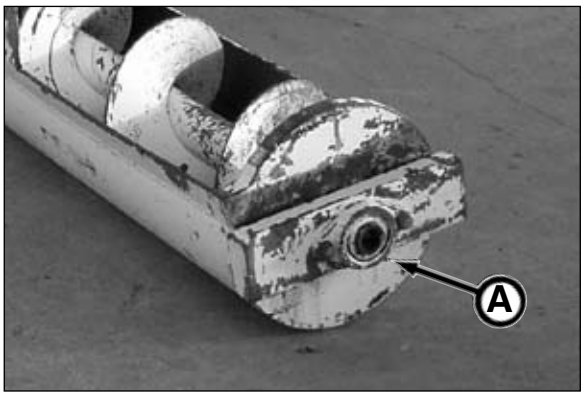
Before applying a new decal, be sure the surface is clean and dry.



DAILY OR EVERY 10 HOURS OF OPERATION OR EACH SHIFT CHANGE

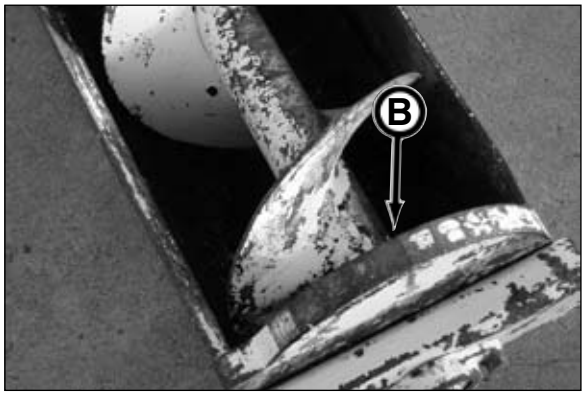
15. LUBRICATE NOSE BEARING

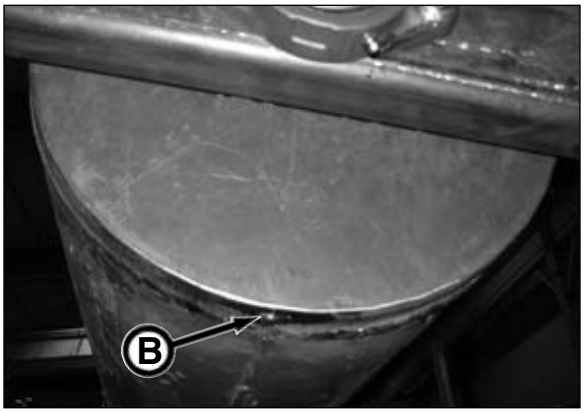
Lubricate nose bearing (A) with Mobilgrease® XHP222 Premium Lubricating Grease or equivalent until grease is forced out.



16. LUBRICATE TAIL END INNER BEARING

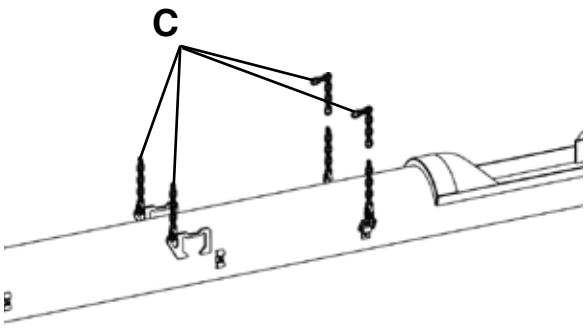
Lubricate inner bearing (B) (grease fitting location at bottom of conveyor) with Mobilgrease® XHP222 Premium Lubricating Grease or equivalent until grease is forced out.





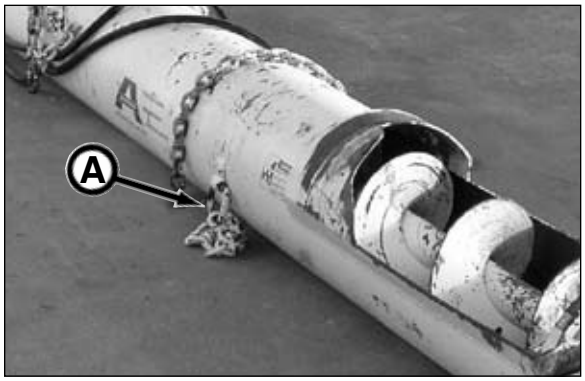
17. INSPECT LIFTING CHAINS

Inspect lifting chains (C) for wear or damage. If worn or damaged, replace with new.



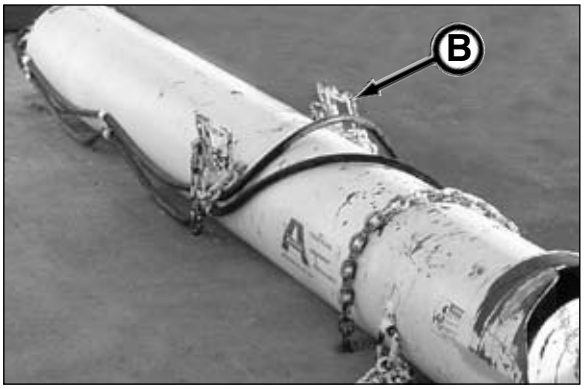
18. INSPECT LIFT D-RINGS

Inspect lift D-rings (A) for wear or damage. If worn or damaged, replace with new.



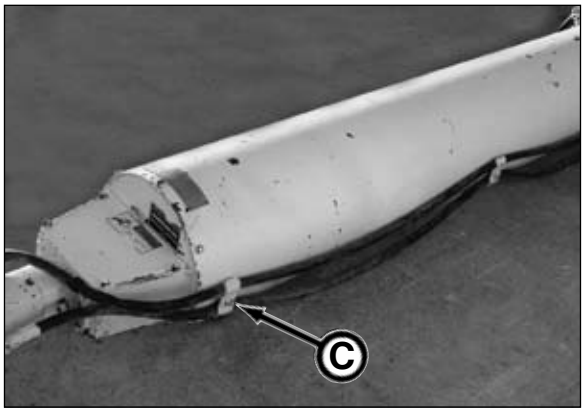
19. INSPECT LIFTING EYES

Inspect lifting eyes (B) for wear or damage. If worn or damaged, replace with new.



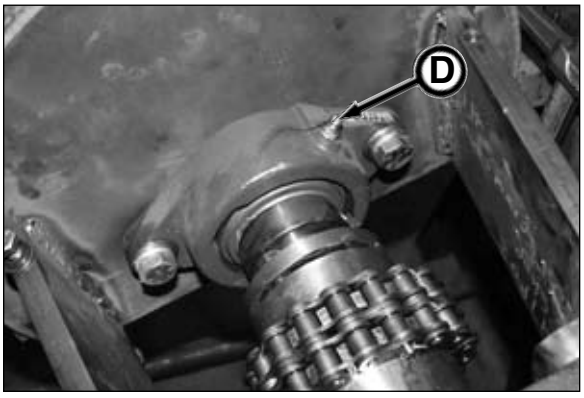
20. INSPECT LINE CLAMPS

Inspect line clamps (C) for wear or damage. If worn or damaged, replace with new.



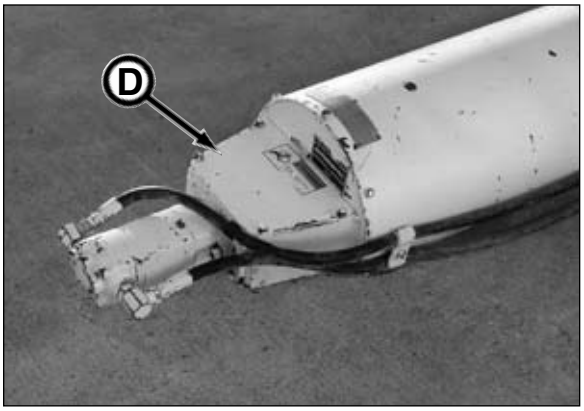
21. LUBRICATE DRIVE END INNER BEARING

1. Remove drive guard.
2. Lubricate inner bearing (D) with Mobilgrease® XHP222 Premium Lubricating Grease or equivalent until grease is forced out.
3. Replace drive guard before operating conveyor.



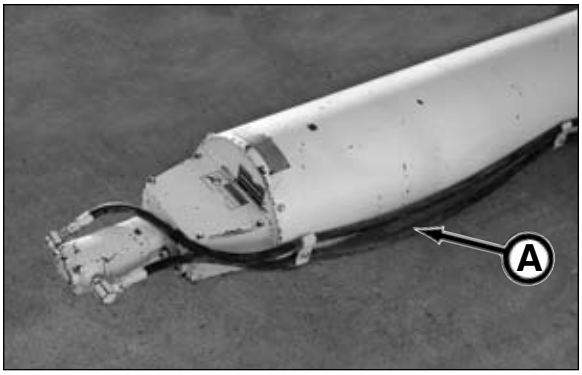
22. INSPECT DRIVE GUARD

Inspect drive guard (D). If worn or damaged, replace with new.



23. INSPECT HYDRAULIC HOSES

Inspect hydraulic hoses (A) for wear or damage. Repair or replace BEFORE operation.

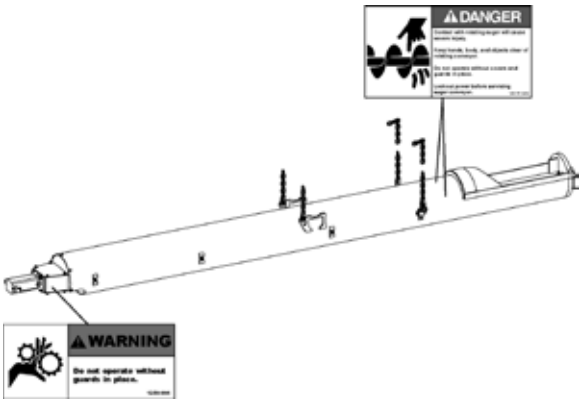


24. INSPECT DECALS

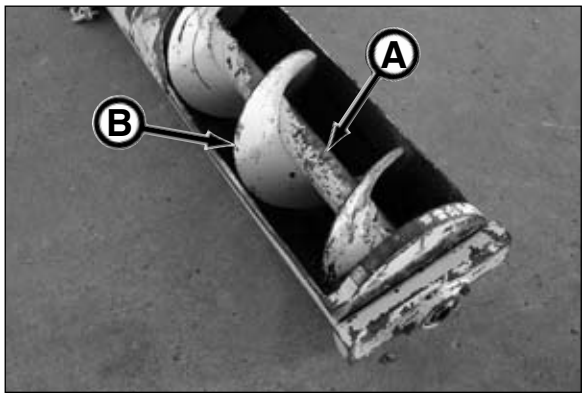
Inspect ALL decals, operational and safety decals to be sure they are clean and readable.

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 will damage decals. Replace decals immediately if they are damaged, missing, or hard to read.

Before applying a new decal, be sure the surface is clean and dry.

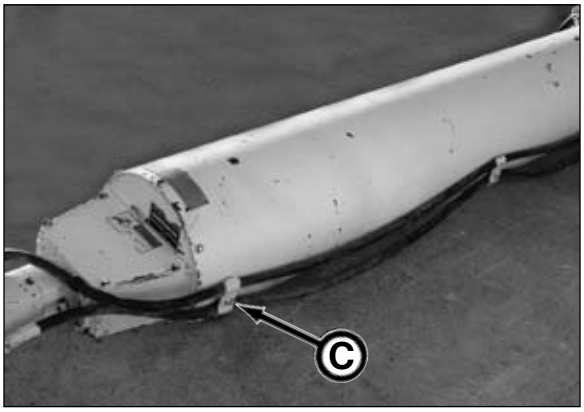


WEEKLY OR EVERY 50 HOURS OF OPERATION



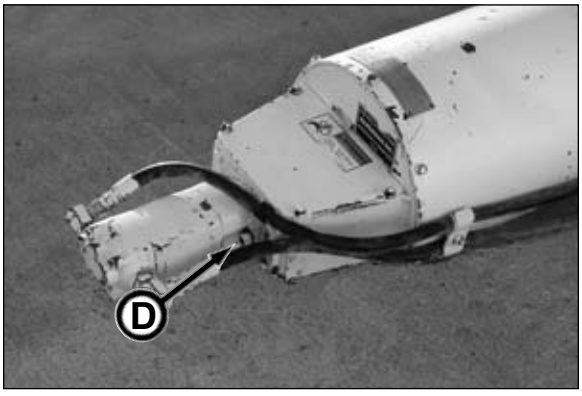
25. INSPECT AUGER

Inspect auger shaft (A) and flighting (B). If damaged, repair or replace with new.



26. INSPECT LINE CLAMPS

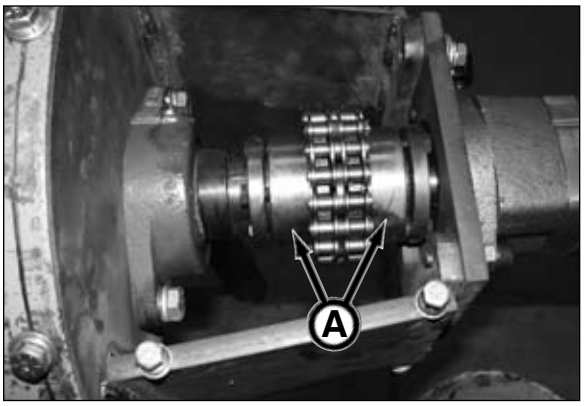
Inspect line clamps (C) for wear or damage. If worn or damaged, replace with new.



27. CHECK DRIVE MOTOR BOLT TIGHTNESS

Check drive motor bolt (D) tightness. Tighten bolts to the 95 ft-lb (129 N·m) torque.

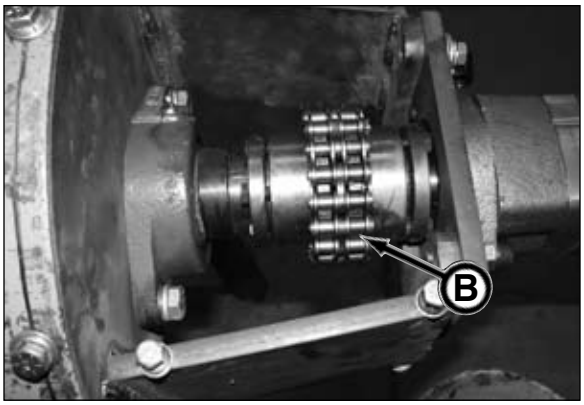
If bolts do not hold torque, replace bolts with new.



28. INSPECT DRIVE SPROCKETS

1. Inspect drive sprockets (A). If worn or damaged, replace with new.

2. Replace drive guard before operating.



29. INSPECT & LUBRICATE DRIVE CHAIN

1. Remove drive guard.

2. Inspect drive chain (B). If worn or damaged, replace with new.

3.Thoroughly lubricate chain with Mobilgrease® XHP222 Premium Lubricating Grease or equivalent.

4. Replace drive guard before operating.

NOTES

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 equipment 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. Drain heat exchanger.
8. Wipe up lube spills. Dispose of rags and trash properly. Store oily rags and other flammable material in protective containers.
9. If possible, store equipment under cover and out of the weather in a ventilated area.
10. Do not smoke in areas where flammable materials are stored.
11. Store fuels and lubricants in properly marked containers.
12. Loosen belt on belt conveyor.

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. Tighten belt tension on belt conveyor.
10. Review this Operator's Manual.

NOTES

Troubleshooting

TBM

Problem	Cause	Solution
No hydraulic power at boring head:		
1. Check pressure reading at Power Unit - Gauge reads 0 psi.	Power unit rotation incorrect or power unit not running.	Power up power unit and/or correct motor rotation.
	Supply valves not turned on at power unit.	Turn on power unit supply valves.
	Power unit oil level too low.	Fill reservoir to proper oil level.
2. Check pressure reading at Power Unit - Gauge reads approximately 500 psi.	Flow controls in boring machine set too low.	Increase speed on flow control.
	Methane system does not have power source connected.	Connect power to gas detection system.
	Conveyor safety valve is in bypass position.	Reset safety valve.
	Power unit supply valves not in full ON position.	Turn on power unit supply valves completely.
3. Check pressure reading at Power Unit - Gauge reads 2800 psi.	Pressure or return lines to boring head not connected.	Connect lines.
	Flow controls in boring head set too high.	Lower flow control settings.
	Control valve in boring head stuck in the ON position.	Repair or replace control valve.
	Supply or return hose blockage.	Inspect hoses.
	Conveyor hoses disconnected.	Connect hoses.

Problem	Cause	Solution
TBM Cutter Bar Stalling:		
Pressure reading at power unit with drum stalled:		
1. Gauge reads 0 psi.	(Refer to: No Hydraulic Power At Boring Head in this section.)	
2. Gauge reads approximately 500 psi.	**No** (Refer to: No Hydraulic Power At Boring Head in this section.)	
	Yes:	
	Inner drum speed flow control set too low.	Increase speed.
	Safety valve tripped.	Reset.
	Inner drum control valve not being operated or linkage is disconnected.	Check linkage.
3. Gauge reads more than 500 psi but less than 2000 psi.	Check if inner drum advance makes gauge reads 2800 psi when valve is held on and cylinders reach the end of travel.	
	YES:	
	a: Check if case drain flow from inner drum drive motors.	
	1. If flow is more than 1 GPM per motor with motor control valve actuated: worn or damage drive motor(s).	Repair or replace drive motors.
	2. If flow is less than 1 GPM per motor with motor control valve actuated.	
	- Worn or damaged motor control valve.	Repair or replace motor control valve.
	- Worn or damaged flow control valve.	Repair or replace flow control valve.
	- Improperly adjusted motor control valve linkage.	Adjust linkage.
	3. Power unit pump weak.	Test/replace pump.
	NO:	
	Power unit control valves not in the full on position.	Move valve lever to full on position.
	Leaking control valve.	Repair valve.
	Incorrect setting at power unit relief valve.	Contact Akkerman Aftermarket support representative.
	Worn or damaged pump in power unit.	

(Continued on next page)

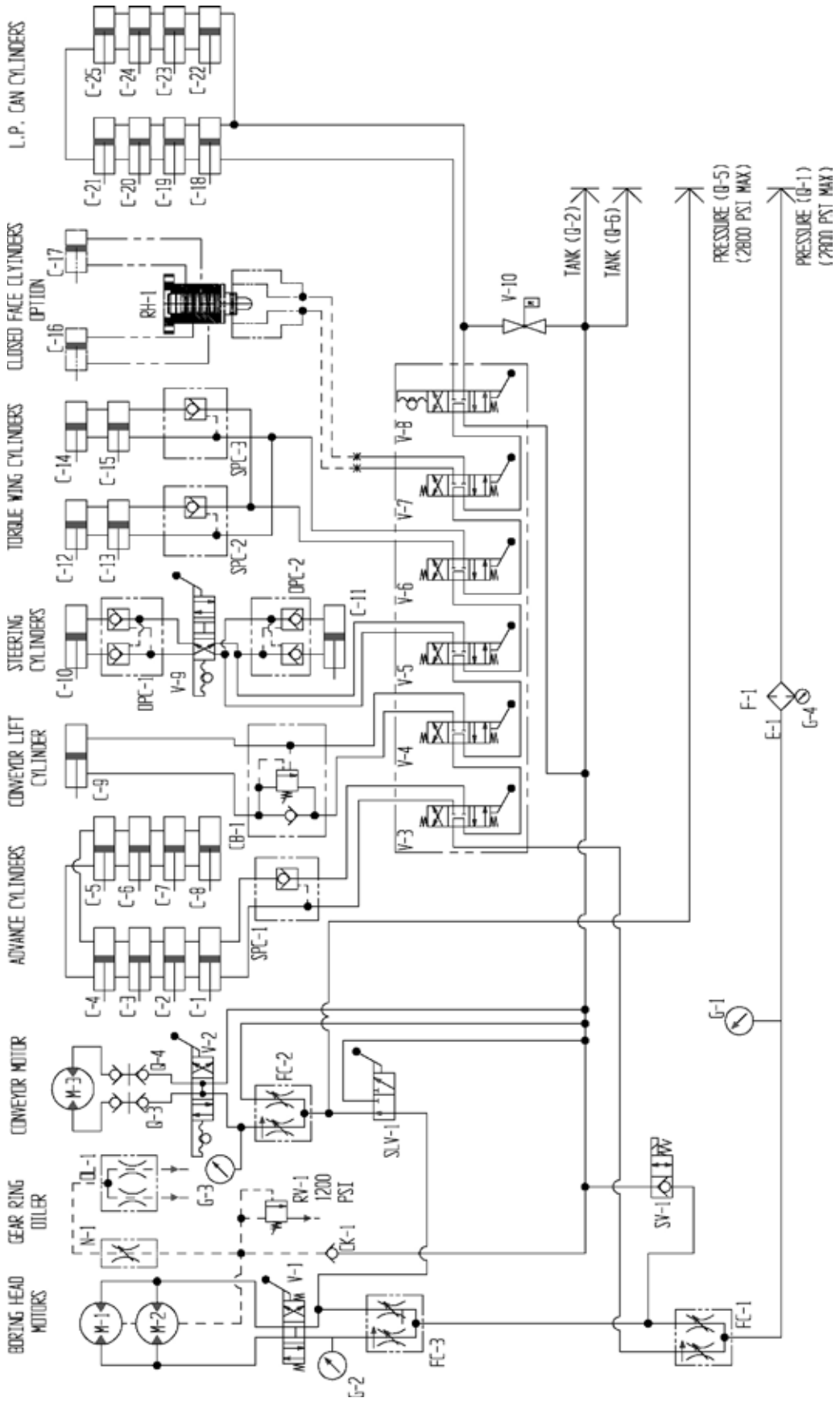
Problem	Cause	Solution
TBM Cutter Bar Stalling: (continued)		
4. Check pressure reading at Power Unit - Gauge reads 2800 psi.	Obstacle in cut path.	Remove obstacle.
	Drive motor sprocket incorrectly engaged in drive gear.	Check gear wear and drive motor to gear ring clearance (backlash).
	Machine advancement rate too fast.	Slow advancement rate.
	Incorrect cutter teeth for ground condition.	Change to correct teeth.
	Insufficient number of drive motors installed.	Add drive motors.
	Inner drum advanced or retracted too far.	Advance fully, then retract 2.5”.
	Motor(s) hydraulic hoses connected for wrong rotation on one or more motor.	Disengage all motors and test rotation.
TBM Dirt Wing will not extend/retract.		
1. Check pressure reading at Power Unit - Gauge reads less than 2,000 psi.	Flow control valve set too low.	Increase flow.
	Worn or damaged cylinder seal.	Replace seals.
1. Check pressure reading at Power Unit - Gauge reads 2,800 psi.	Material build up or obstruction in ramp travel area.	Remove dirt wing, disassemble and clean.
TBM Drum Advance, Conveyor Lift or Steering does not operate.		
1. Check pressure gauge in boring head - Gauge reads 0-500 psi.	Flow control valve set too low.	Increase flow typically 2.5 to 3.0.
	Worn or damaged cylinder seal.	Replace seal.
2. Check pressure gauge in boring head - Gauge reads 2800 psi.	Obstacle in travel area.	Remove obstacle.
	Flow control valve set too high.	Decrease flow.
	Valve handle stuck in the ON position.	Repair valve.
	Check valve did not release.	Replace check valve.

Problem	Cause	Solution
TBM Steering cylinder(s) collapse when forward thrust applied.	Worn or damaged check valve.	Replace check valve.
	Faulty cylinder seals.	Replace seals.
	Obstruction against cutter ring.	Remove obstruction.
	Insufficient over-cut clearance.	Readjust over-cut.
	Worn or damaged steering link adjustment screw.	Replace adjustment screw.
	Excessive thrust pressure.	Reduce thrust pressure.
	Faulty check valve.	Replace check valve.
TBM will not steer up/down.	Line/Grade selector valve not in correct position.	Up for grade. Down for line.
	Flow control valve set too low.	Increase flow.
	Worn or damaged cylinder seals.	Replace seals.
	Check valve not releasing.	Replace check valve.
TBM will not steer left/right.	Steering link nut not being rotated to maintain free travel of shield.	Keep nut free while steering left or right.
	Steering links stretched.	Replace steering link.
TBM inner drum will not advance/retract.	Flow control valve set too low.	Increase flow.
	Material build up in travel area.	Remove build up.
	Worn or damaged cylinder seal.	Replace seal.
	Cutting face resistance too high.	Rotate inner drum while advancing.
	Sand shelves installed.	Operate in retracted position with sand shelves.
TBM inner drum cylinders collapse when forward thrust is applied.	Check for faulty valve.	Replace valve.
	Worn or damaged cylinder seal.	Replace seal.
	Faulty check valve.	Replace valve.
	Excessive thrust load.	Reduct thrust.
	Damaged thrust roller pins.	Replace pins.

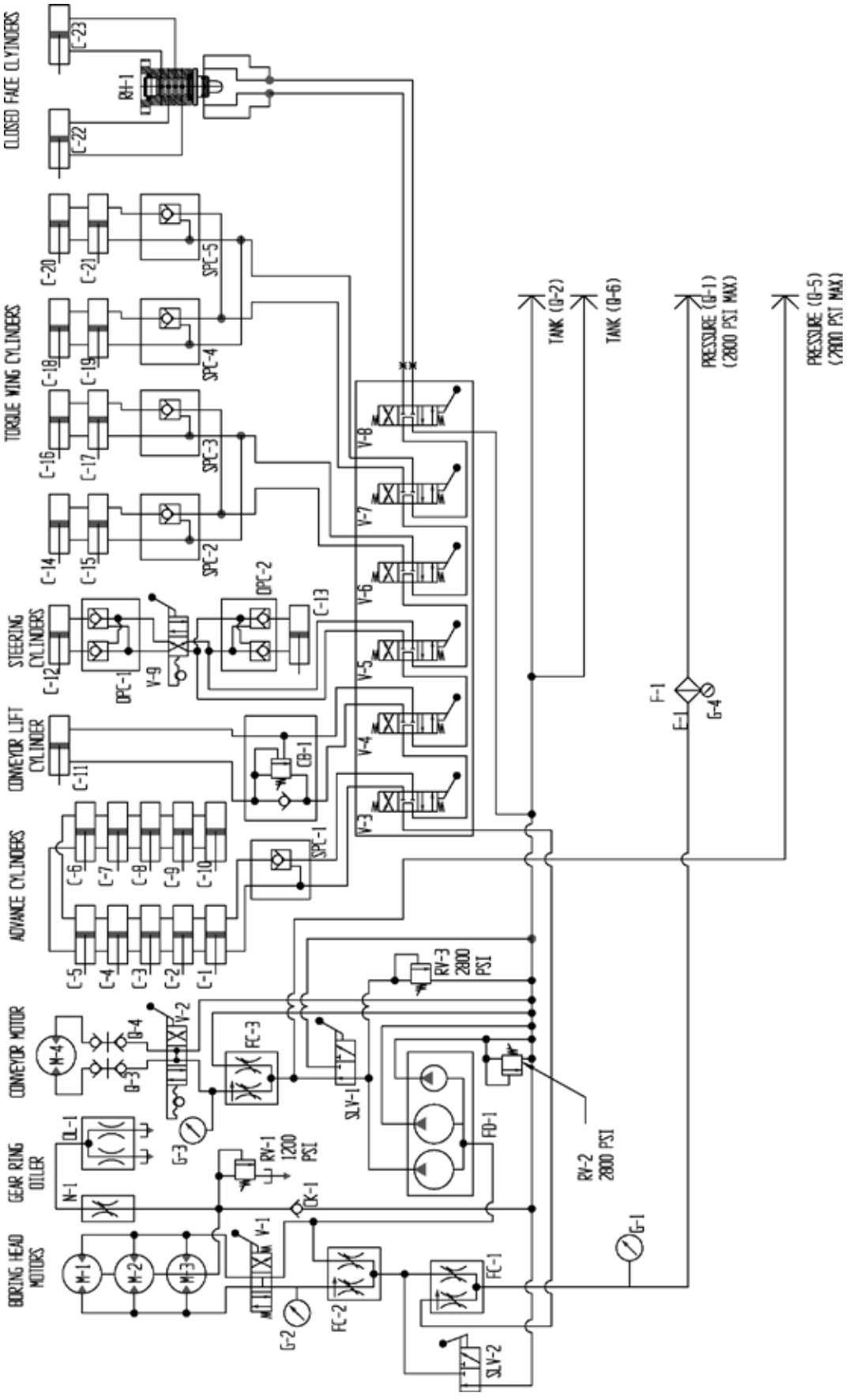
Problem	Cause	Solution
Conveyor Stalls:		
1. Check conveyor operating pressure gauge - Gauge reads 500 - 1000 psi.		
TEST: Disconnect conveyor hoses, turn valve on and read pressure gauge, turn valve off.		
a. Gauge reads 2800 psi.	Low belt tension.	Tighten belt tension.
	Broken drive chain.	Replace drive chain.
	Worn or damaged conveyor drive motor.	Replace motor.
	Wet conveyor belt.	Tighten under belt scrapers.
b. Gauge reads less than 1500 psi.	Conveyor valve not in full ON position or linkage not adjusted.	Turn valve to full ON position.
	Worn or damaged conveyor valve.	Replace valve.
	Safety valve tripped.	Reset.
	Single/dual feed valve not in correct position.	Set in correct position.
	Power unit supply valves not in full ON position.	Turn valve to full ON position.
	Worn or damaged supply pump (dual feed only)	Switch to other supply and retest.
	Faulty or misadjusted relief valve on gear divider.	Replace relief.
	Clogged hydraulic filter element.	Replace filter element.
2. Check conveyor operating pressure gauge - Gauge reads 2800 psi.		
	Obstacle lodged in belt or drive chain.	Remove obstacle. Check belt and drive chain for damage.
	Single/dual feed valve in wrong position.	Check/switch valve.
	Conveyor quick coupler faulty or not properly connected.	Properly connect coupler or replace.
	Damaged bearing on conveyor.	Replace bearing.
TBM inner drum turns too slowly (can build 2800 psi).	Flow control valve set too low in boring head.	Increase flow.
	Power unit valve not ON.	Turn ON both valves.
	Aux. power unit motor not running.	Turn ON power unit motor.

Problem	Cause	Solution
TBM cutter head will not make full revolution.	Obstruction in cut path.	Remove obstruction.
	Sand cutter bar advanced into sand shelf.	Operate with full retract when using sand shelves.
	Worn or damaged bolt or bushing in drive gear.	Replace damaged part.
	Foreign material built up in drive gear area.	Remove build up. Check gear area for damage.
	Incorrect backlash in drive motor.	Adjust motor to gear ring clearance (backlash).
	Material build up under inner drum in roller ring area.	Remove build up. Check roller ring area for damage.

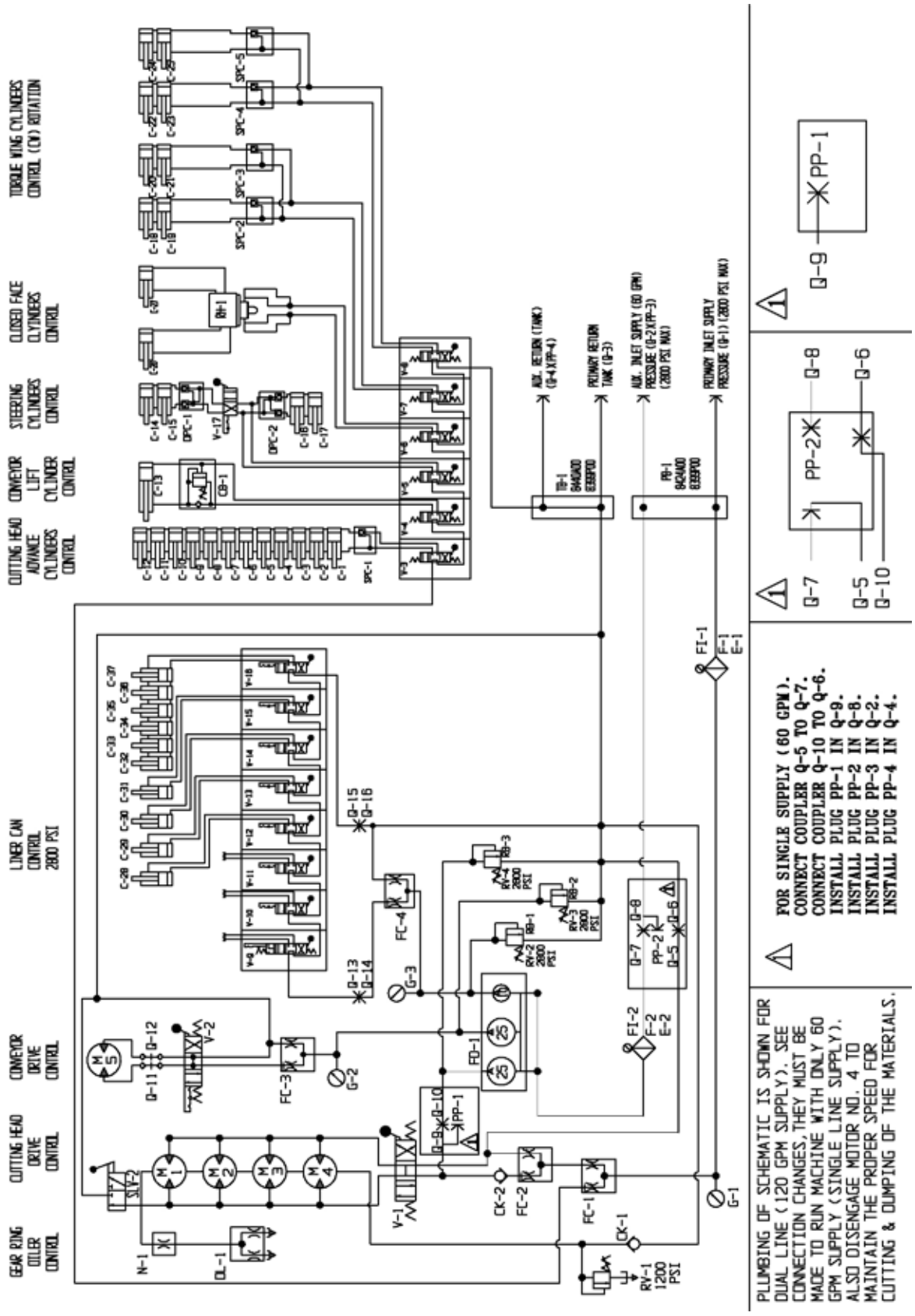
TBM HYDRAULIC SCHEMATIC - 360-48SC-420



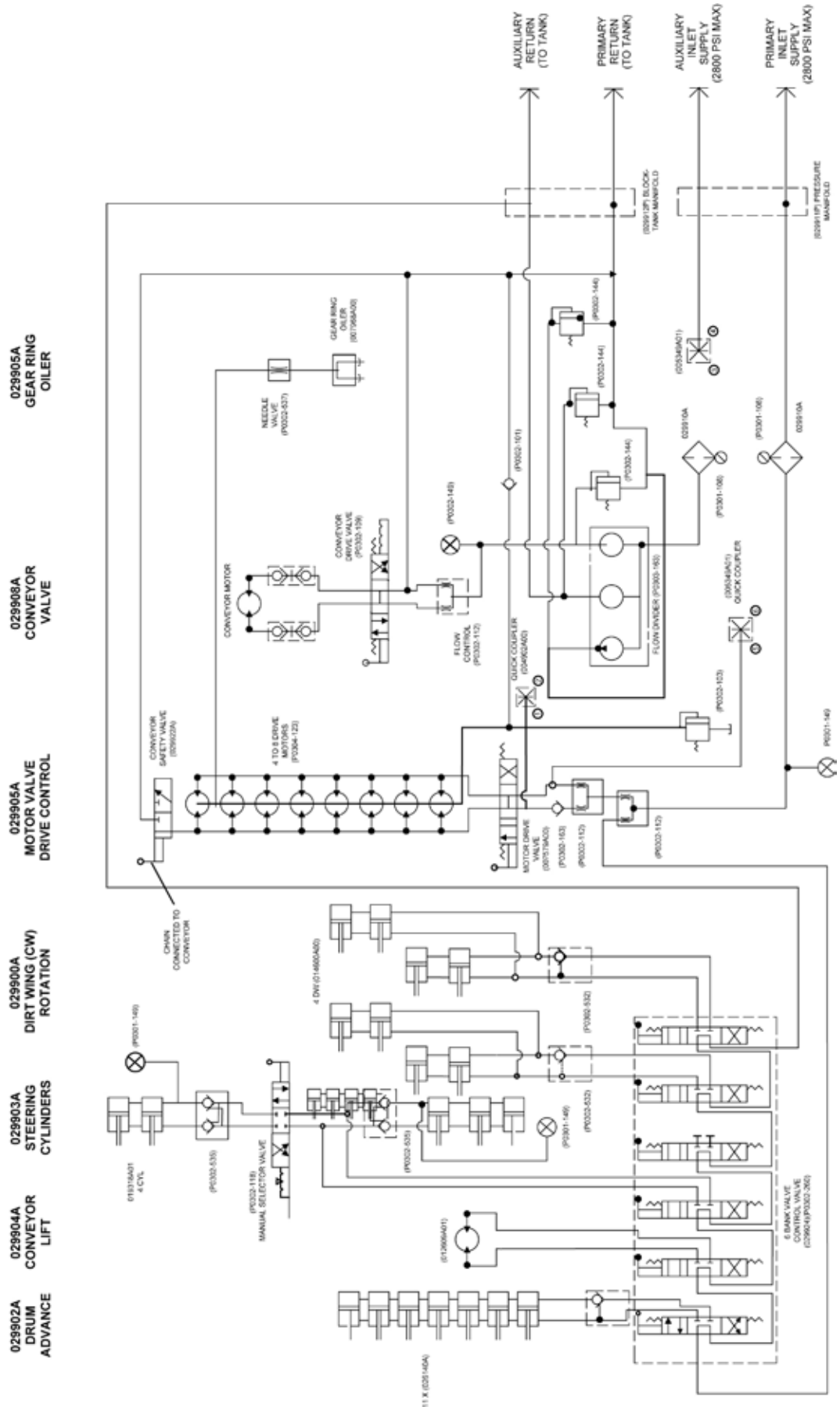
TBM HYDRAULIC SCHEMATIC - 480-540 (SN BH18300-01-03)



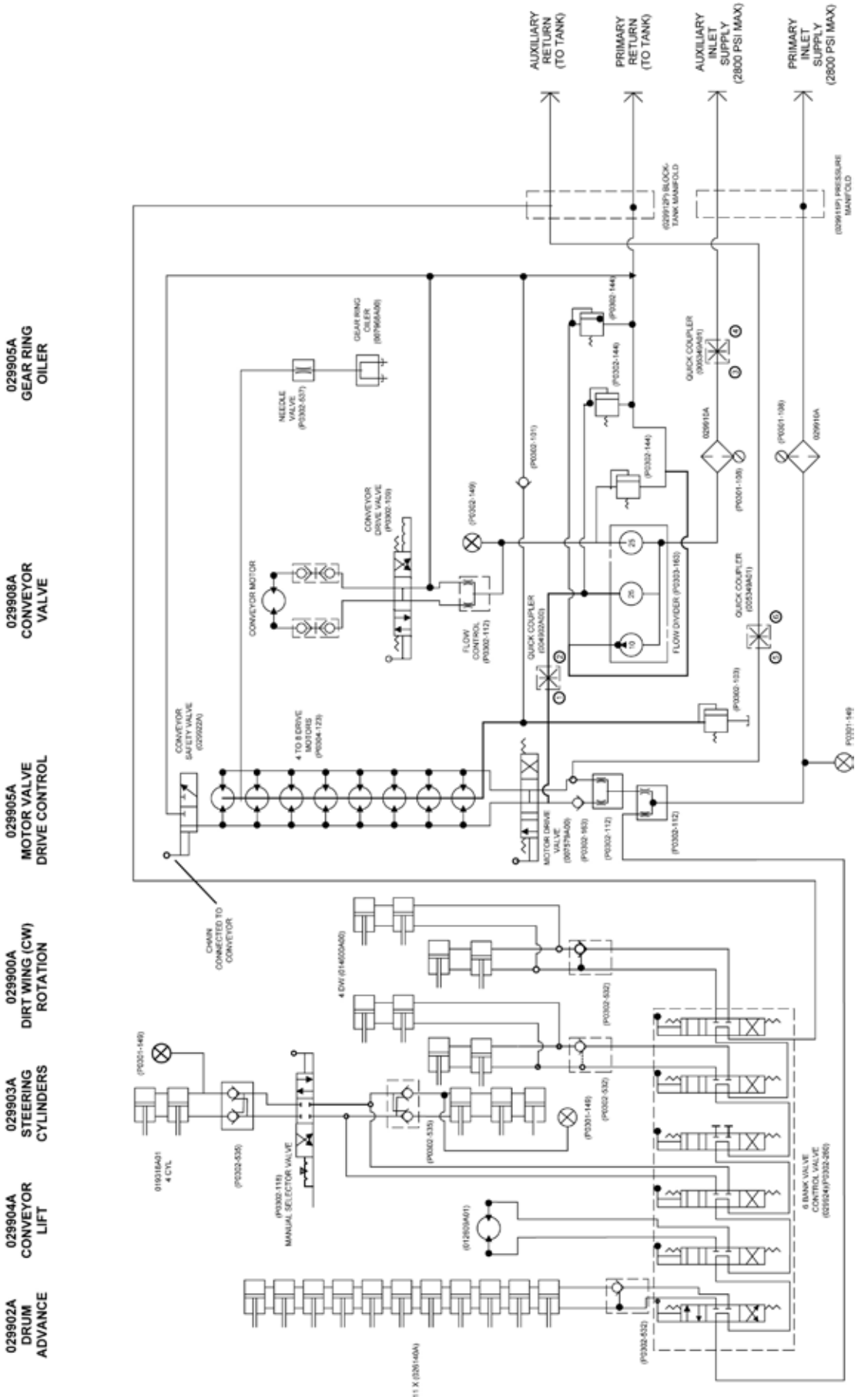
TBM HYDRAULIC SCHEMATIC - 540 (SN BH18300-04 & AFTER)



TBM HYDRAULIC SCHEMATIC - 600-780 - SINGLE FEED SUPPLY



TBM HYDRAULIC SCHEMATIC - 600-780 - DUAL FEED SUPPLY



5000 PUMP UNIT

Problem	Cause	Solution
Pump Unit push cylinders stall at less than 500 psi.	Cylinders at full extension.	Retract cylinders or redog pump unit.
	Pressure release valve is open.	Close pressure release valve.
	Worn or damaged cylinder seals.	Replace seals.
	Worn or damaged control valve seals.	Replace seals.
	Cylinder piston relief leaking.	Repair or replace.
	Worn or damaged hydraulic pump.	Test IJS pressure. Repair or replace pump.
	If cylinders continue to stall, contact your Akkerman Aftermarket Support Representative.	
Pump Unit cylinder(s) collapse when forward thrust is stopped or intermediate jacks are used.	Pilot operated check valve leaking.	Repair or replace.
	Worn or damaged cylinder seals.	Replace seals.
	Cylinder relief valve leaking.	Repair or replace valve.
	Cylinder piston relief leaking.	Repair relief.
	Pressure release valve is leaking.	Repair or replace valve.
	If cylinders continue to collapse, contact your Akkerman Aftermarket Support Representative.	
Jacking pressure gauge pressure drops when forward thrust is stopped.	Low cylinder load.	Avoid over excavation at tunnel face.
	Worn or damaged cylinder seals.	Replace seals.
	Pilot operated check leaking.	Repair or replace check valve.
	If jacking pressure gauge continues to drop, contact your Akkerman Aftermarket Support Representative.	
The 5 HP, 50 HP, and 100 HP motors will not start.	Emergency stop switch is depressed.	Pull E-STOP button out.
	Main disconnect tripped or not turned ON.	Turn disconnect ON.
	Generator or power supply faulty.	Repair or replace.
	Low oil level.	Add hydraulic oil as needed.
	15 amp fuse tripped.	Replace fuse.
	6-1/4 amp fuse tripped.	Replace fuse.
	Faulty low oil level switch, cable or relay.	Replace.
	Faulty 480 VAC to 110 VAC transformer.	Repair by qualified technicians or replace with new.
	If motors will still not start, contact your Akkerman Aftermarket Support Representative.	

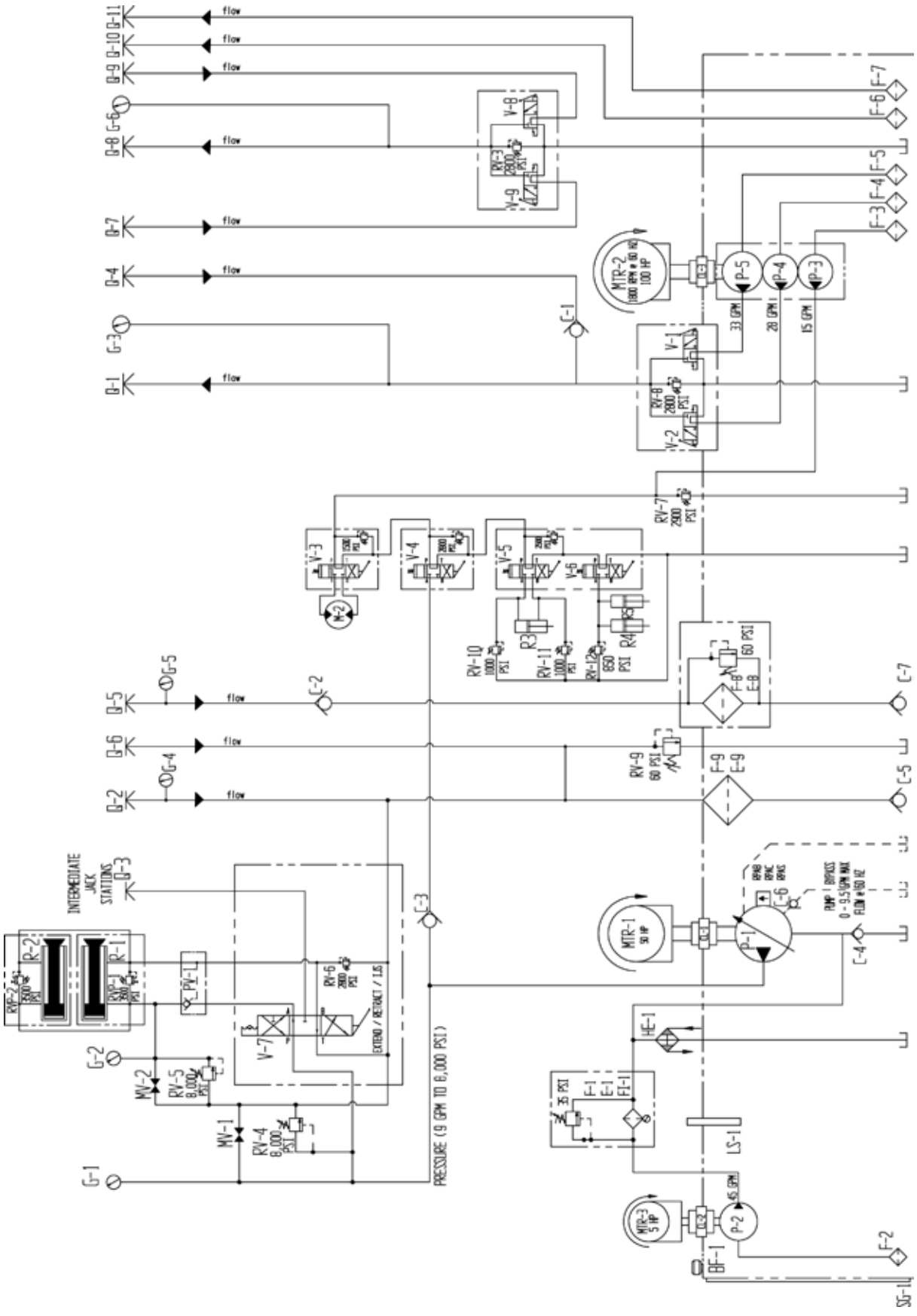
Problem	Cause	Solution
100 HP motor will not start.	Circuit heaters tripped.	Reset.
	175 amp fuse(s) blown.	Replace fuses.
	Faulty Start/Stop switch.	Replace switch.
	Low oil level.	Fill reservoir with oil.
	Faulty low oil level switch or relay.	Replace switch.
	If 100 HP motor will still not start, contact your Akkerman Aftermarket Support Representative.	
Hydraulic oil temperature gauge exceeds 150 degrees.	Heat exchanger water supply not adequate.	Water supply must be a minimum of 15 gpm.
	5 HP circuit fuse heaters tripped.	Reset.
	Excessive hydrauic circuit pressure to boring machine.	Reduce steering flow control.
		Replace boring head filters.
	Hydraulic circuit disconnected causing a safety relief valve to be activated.	Connect hoses.
	Excessive ambient temperature.	Provide fresh, clean, cold water source.
	Excessive horsepower required by boring machine or jacking operation.	Reduce advancement rate or install IJS.
	Heat exchanger water passages plugged.	Clean heat exchanger.
Boring head supply gauge frequently reaches 2,800 psi.	Too few cutter bar drive motors.	Reduce advancement rate or install additional motors, if possible.
	Single feed supply to boring head	Change to dual feed supply.
	Incorrect cutter bar selected for ground condition.	Change cutter head.
	Pipe advancement rate too fast.	Slow main ram thrust.
	Worn or damaged TBM inner drum thrust roller bearings.	Replace bearings.
	Worn or damaged TBM inner drum rollers.	Replace rollers.
	One of motors connected in reverse rotation.	See TBM troubleshooting.
	If boring head supply gauge continues to frequently reach 2,800 psi, contact your Akkerman Aftermarket Support. Representative.	

Problem	Cause	Solution
Pump Unit motors start but no oil pressure is available.	Incorrect motor rotation.	Rewire motor for proper rotation.
	Low oil level.	Add hydraulic oil as needed.
	Control valve not turned on.	Make sure the control valves are in the proper position.
	Faulty relief valve.	Replace valve.
	Flow rate turned too low.	Readjust cable stroker volume stop. Readjust TBM flow rate.
	Worn or damaged hydraulic pump.	Repair or replace pump.
	If oil pressure continues to be unavailable, contact your Akkerman Aftermarket Support Representative.	DO NOT operate for extended periods. Doing so may cause pump failure.
Intermediate jacks do not operate.	*TEST: Select IJS position on control valve and close pressure release valve. Operate Cable Stroker Control and read system pressure gauge. Gauge reads 0 - 1,000 psi.*	
	Intermediate jack valve not in full ON position.	Pull cable completely to ON position.
	Worn or damaged control valve seals.	Replace seals.
	Faulty relief valve.	Repair or replace valve.
	Flow rate turned too low.	Readjust cable stroker volume stop.
	Oil leak in tunnel.	Repair leak.
	Worn or damaged hydraulic pump.	Repair or replace pump.
	If intermediate jacks still do not operate, contact your Akkerman Aftermarket Support Representative.	

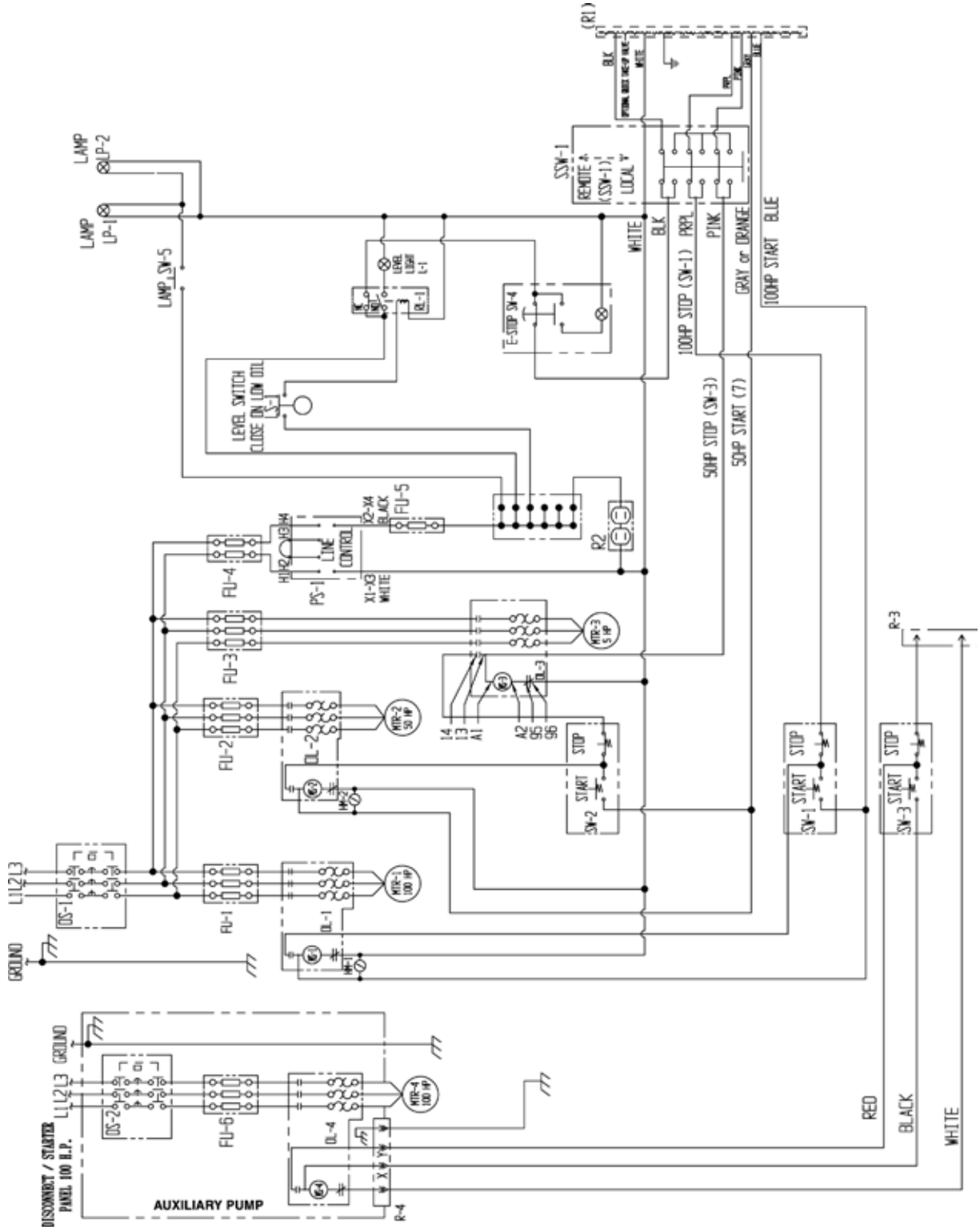
Problem	Cause	Solution
Pump Unit boring head supply will not produce 2,800 psi.	*TEST: Connect flow meter to outlet hose of supply valve (Q-10* or Q-5*). Oil temperature should be approximately 120 degrees.* *1) Turn on left supply handle, (facing pressure gauge).* *Test output flow at 0 psi (approx. 32 gpm)* *Test output flow at 2,000 psi (approx. 30 gpm)* *Test output flow at 2,700 psi (approx. 29 gpm)* *2) Turn off left supply handle and turn on right handle.* *Test output flow at 0 psi (approx. 28 gpm)* *Test output flow at 2,000 psi (approx. 26 gpm)* *Test output flow at 2,700 psi (approx. 25 gpm)* *If flow specifications are close to the above, refer to Cutter Bar Stalling in your TBM operation manual.* *If flow specifications are not close to the above, troubleshoot as follows:* 1. Replace control valve seals and repeat test. 2. Replace control valve relief and repeat test. 3. Disconnect output hose from 1 pump section (inside reservoir). 4. Connect flow meter to pump section. **⚠WARNING Do not shut off flow meter restriction valve at any time during test as serious personal injury or pump damage will result.** 5. Repeat above test procedure to determine flow capacity. 6. Repeat procedure for 2nd pump section.	
	If flow specifications are now close to the above specifications:	Replace control valve.
	If flow specifications are not close to the above specifications:	Replace pump.

* Refer to 5000 Pump Unit Hydraulic Schematic in this section.

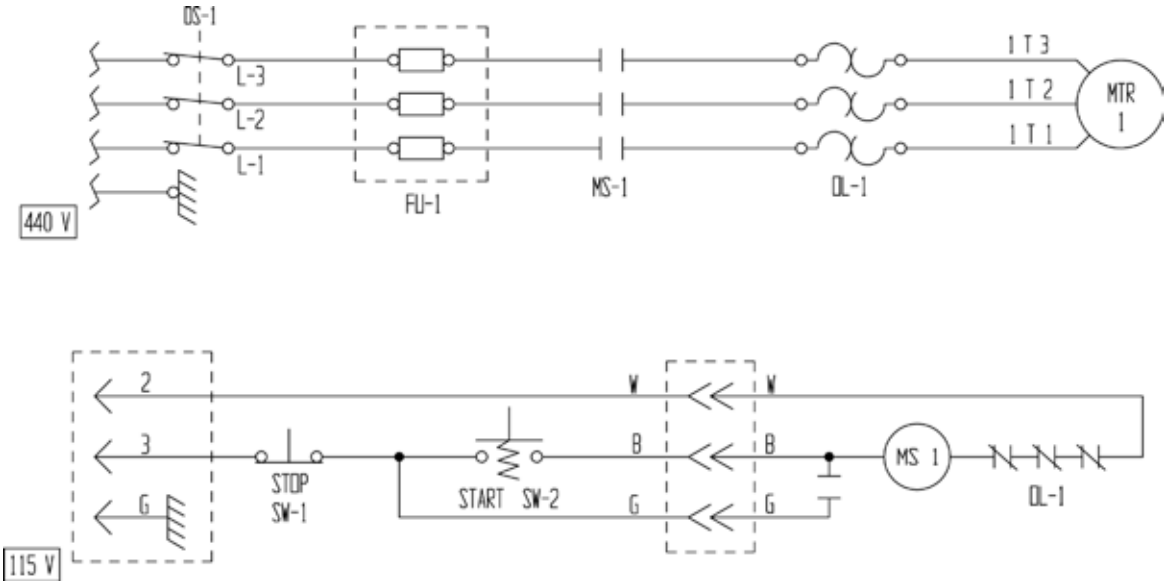
5000 PUMP UNIT HYDRAULIC SCHEMATIC



5000 PUMP UNIT ELECTRICAL SCHEMATIC - STANDARD



AUXILIARY PUMP UNIT ELECTRICAL SCHEMATIC



P400-P600 POWER PACK

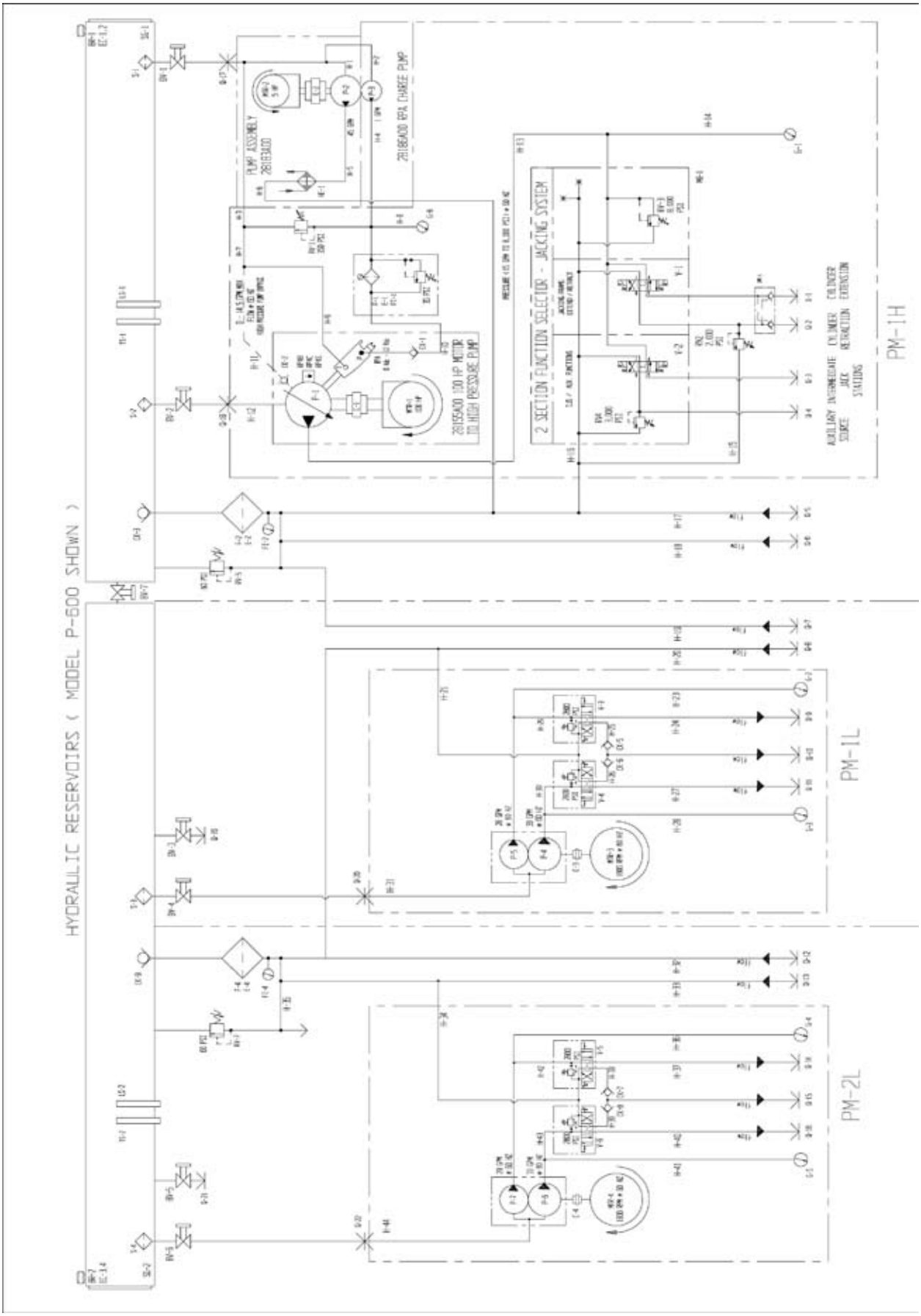
Problem	Cause	Solution
Pump unit push cylinders stall at less than 500 psi.	Cylinder at full extension	Retract.
	Worn or damaged cylinders seals.	Replace seals.
	Worn or damaged control valve seals.	Replace seals.
	Cylinder piston relief leaking.	Replace relief.
	Faulty pendant controller switch.	Replace switch.
	Faulty pendant extension cable.	Remove cable and re-test, repair cable.
	Worn or damaged pump compensator.	Contact your Aftermarket support representative.
	Worn or damaged hydraulic pump.	Test/replace pump.
Pump unit cylinder(s) collapse when forward thrust is stopped or intermediate jacks are used.	Pilot operated check valve leaking.	Replace valve.
	Worn or damaged cylinder seals.	Replace seals.
	Cylinder piston relief leaking.	Replace relief.
Jacking pressure gauge pressure drops when forward thrust is stopped.	Low cylinder load.	Avoid over excavation at tunnel face.
	Worn or damaged cylinder seals.	Replace seals.
	Pilot operated check leaking.	Replace valve.
100 HP motor will not start.	Circuit fuse heaters tripped.	Reset.
	150 amp fuse(s) blown.	Replace fuse(s).
	Faulty Start/Stop switch.	Replace switch.
	Low oil level.	Fill reservoir with oil.
	Faulty low oil level switch or relay.	Replace switch or relay.
	Oil has reached over temperature.	Check cooling water supply and allow time for circuit to reset.
	5 HP pilot pressure pump not operating (High pressure module only).	Reset 5 HP overload relay and check fuses.

Problem	Cause	Solution
No pump unit motor will start.	Emergency stop switch is depressed.	Release E-Stop.
	Main disconnect tripped or not turned ON.	Turn ON main disconnect.
	Generator or power supply faulty.	Repair or replace.
	Pendant controller not connected.	Connect pendant.
	Faulty pendant extension cable.	Test without extension cable, repair cable.
	Shorting pin plug not installed on unused pendant receptacle.	Install jumper plug.
	Shorting pin plug not installed on unused E-stop receptacle.	Install jumper plug.
	Low oil level.	Add oil.
	15 amp circuit breaker tripped.	Reset breaker.
	6 amp circuit breaker tripped.	Reset breaker.
	Faulty low oil level switch, cable or relay.	Replace switch, cable or relay.
	Faulty E-stop cable, switch or relay.	Replace switch, cable or relay.
	Faulty 480 VAC to 110 VAC transformer.	Repair by qualified technicians or replace with new.
	Head E-Stop power cable disconnected or faulty.	Connect cable or replace.
Temperature gauge exceeds 150 degrees.	Heat exchanger water supply not adequate.	Water supply must be a minimum of 15 gpm.
	Oil supply to heat exchanger turned off.	Turn on oil supply.
	5 HP circuit fuse heaters tripped.	Reset.
	15 amp circuit breaker tripped.	Reset breaker.
	Excessive hydraulic circuit pressure to boring machine.	Reduce steering flow control. Replace boring head filters.
	Hydraulic circuit disconnected causing a safety relief to be activated.	Connect hoses.
	Excessive ambient temperature.	Provide fresh, clean, cold water source.
	Excessive horsepower required by TBM or jacking operation.	Reduce advancement rate or install IJS.
	Heat exchanger water passages plugged.	Clean heat exchanger.

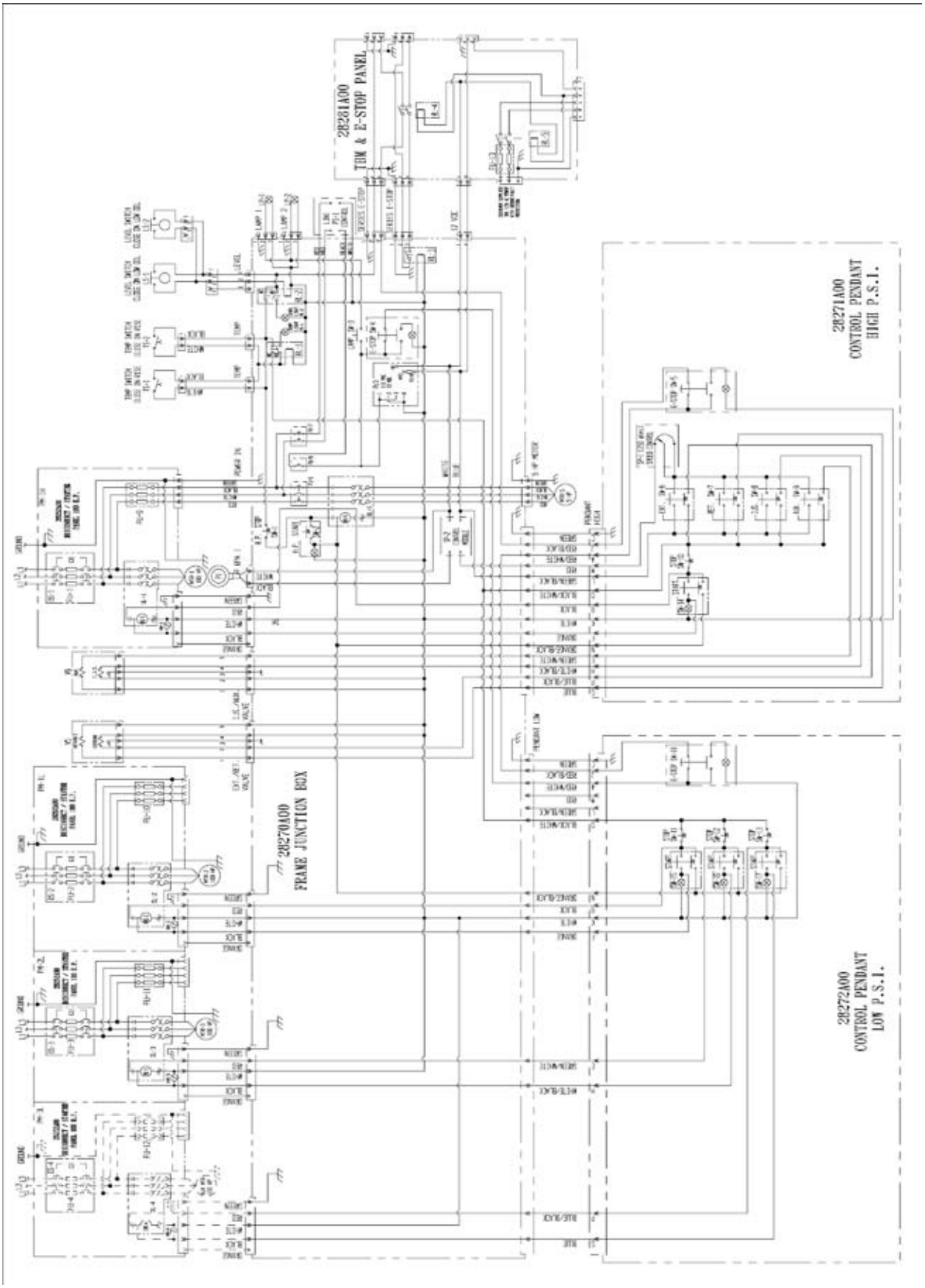
Problem	Cause	Solution
Pump Unit boring head supply will not produce 2,800 psi.	*TEST: Connect flow meter to outlet hose of supply valve (Q-10* or Q-5*). Oil temperature should be approximately 120 degrees.* *1) Turn on left supply handle, (facing pressure gauge).* *Test output flow at 0 psi (approx. 25 gpm)* *Test output flow at 2,000 psi (approx. 24 gpm)* *Test output flow at 2,700 psi (approx. 22 gpm)* *2) Turn off left supply handle and turn on right handle.* *Test output flow at 0 psi (approx. 25 gpm)* *Test output flow at 2,000 psi (approx. 26 gpm)* *Test output flow at 2,700 psi (approx. 22 gpm)* *If flow specifications are close to the above, refer to Cutter Bar Stalling in this section.* *If flow specifications are not close to the above, troubleshoot as follows:* 1. Replace control valve relief and repeat test. 2. Disconnect output hose from 1 pump section (inside reservoir). 3. Connect flow meter to pump section. **⚠WARNING Do not shut off flow meter restriction valve at any time during test as serious personal injury or pump damage will result.** 4. Repeat above test procedure to determine flow capacity. 5. Repeat procedure for 2nd pump section.	
	If flow specifications are now close to the above specifications:	Replace control valve.
	If flow specifications are not close to the above specifications:	Replace pump.
Boring head supply gauge frequently reaches 2,800 psi.	Too few cutter bar drive motors.	Reduce advancement rate or install additional motors, if possible.
	Plugged TBM filters.	Replace filters.
	Single feed supply to boring head dual feed supply.	Change to dual feed supply.
	Incorrect cutter bar selected for ground condition.	Change cutter head.
	Pipe advancement rate too fast.	Slow main ram thrust.
	Worn or damaged TBM inner drum thrust roller bearings.	Replace bearings.
	Worn or damaged TBM inner drum rollers.	Replace rollers.
	If boring head supply gauge continues to frequently reach 2,800 psi, contact your Akkerman Aftermarket Support Representative.	

Problem	Cause	Solution
Intermediate jacks do not operate.	*TEST: Select IJS position on control pendant, operate stroke and read system pressure gauge. Gauge reads 0 - 1,000 psi.*	
	Faulty control switch.	Replace switch.
	Intermediate jack valve not in full ON position.	Turn valve fully ON.
	Worn or damaged control valve seals.	Replace seals.
	Intermediate jack valve previously operated not in full OFF position.	Check valve, turn valve fully OFF.
	Worn or damaged hydraulic pump.	Repair or replace pump.
	Faulty pendant exterior cable.	Repair or replace cable
	If intermediate jacks still do not operate, contact your Akkerman Aftermarket Support Representative.	
Pump Unit motors start but no oil pressure available.	**NOTICE** DO NOT operate for extended periods with this condition. Doing so will result in pump damage.	
	Incorrect motor rotation.	Rewire motor for proper rotation.
	Low oil level.	Add hydraulic oil as needed.
	Closed pump suction valve.	Open valve.
	Control valve not turned ON.	Turn control valve ON.
	Faulty control valve switch.	Repair or replace switch.
	Flow rate turned too low.	Readjust flow rate.
	Faulty SP-2 control module.	Rplace module.
	Worn or damaged hydraulic pump.	Repair or replace pump.

P400 - P600 HYDRAULIC SCHEMATIC & MAJOR PARTS

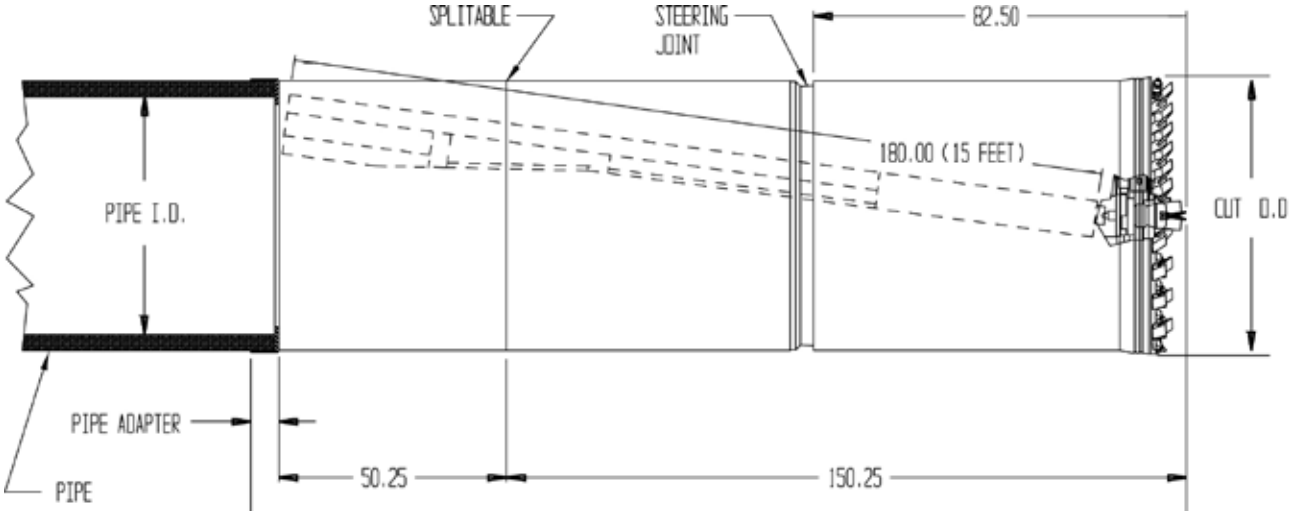


P400 - P600 ELECTRICAL SCHEMATIC



Specifications

TUNNEL BORING MACHINE



TBM Model	Wall Thickness	Pipe ID	Machine OD	Cutting Diameter	Drive Motors (57 CID)	Cutting Torque (ft-lbs)	Cutting Speed
360	B	36”	44”	45.5”	2	21,190	0-23 rpm w/60gpm
360	C	36”	45.5”	47”	2	22,140	0-23 rpm w/60gpm
48SC	*	N/A	48”	49.5”	2	22,140	0-23 rpm w/60gpm
420	B	42”	51”	52.5”	2	26,660	0-19 rpm w/60gpm
420	C	42”	52.5”	54”	2	26,660	0-19 rpm w/60gpm
480	B	48”	58”	59.5”	3	47,400	0-11 rpm w/60gpm
480	C	48”	59.5”	61”	3	47,400	0-11 rpm w/60gpm
540	B	54”	65”	66.5”	3	52,890	0-15 rpm w/120gpm
540	C	54”	66.5”	68”	3	52,890	0-15 rpm w/120gpm
600	B	60”	72”	73.5”	3	59,980	0-13 rpm w/120gpm
600	C	60”	73.5”	75”	3	59,980	0-13 rpm w/120gpm
660	B	66”	79”	80.5”	3	66,425	0-11 rpm w/120gpm
660	C	66”	80.5”	82”	3	66,425	0-11 rpm w/120gpm
720	B	72”	86”	87.5”	4	96,588	0-8 rpm w/120gpm
720	C	72”	87.5”	89”	4	96,588	0-8 rpm w/120gpm
780	B	78”	93”	94.5”	4	105,760	0-7 rpm w/120gpm
780	C	78”	94.5”	96”	4	105,760	0-7 rpm w/120gpm

* steel casing wall thickness is typically 1/2”

Increaser kits are available to match specific pipe OD

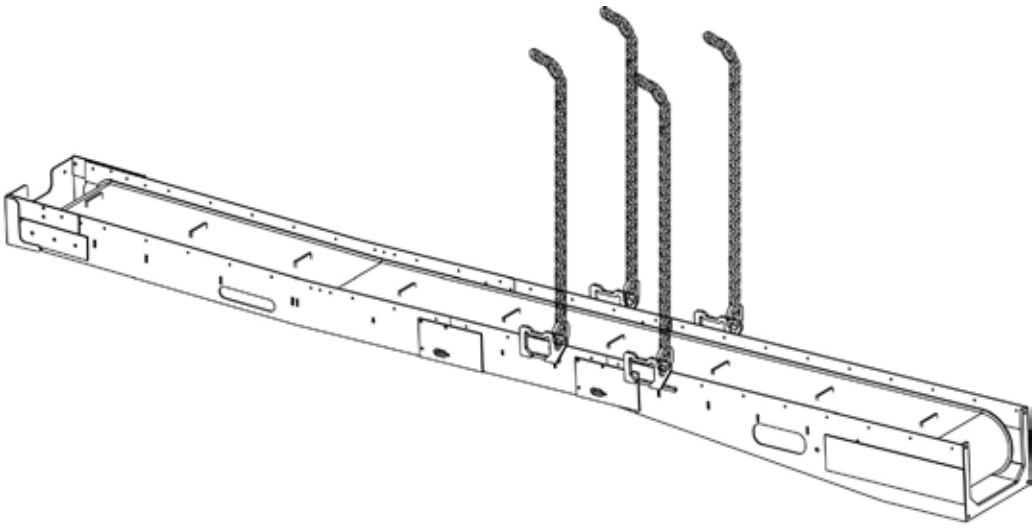
Operating Pressure (Maximum) ..... 2,800 psi

OD - Outside Diameter ID - Inside Diameter

Standard Cutter Heads:
- dirt cutter bar
- carbide cutter bar
- sand shelves

Optional Cutter Head:
- closed face

CONVEYORS



BELT CONVEYOR

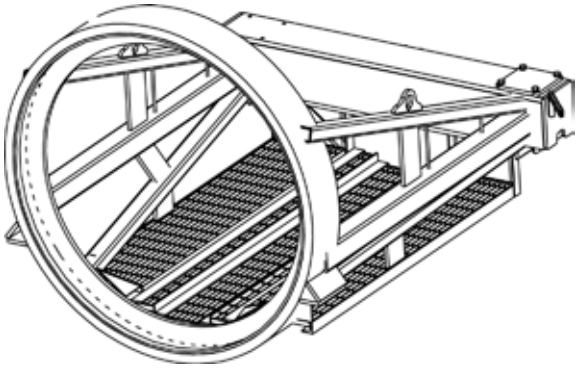
Model	Belt Size	Length	Use With TBM
1015	10”	15’	360, 48SC
1215	12”	15’	48SC, 420
1615	16”	15’	480, 540
2415	24”	15’	600, 660, 720, 780

SCREW CONVEYOR

Model	Auger Diameter	Length	Use With TBM
120	12”	15’	360, 48SC, 420, 480, 540
140	14”	15’	540, 600, 660
160	16”	15’	720, 780

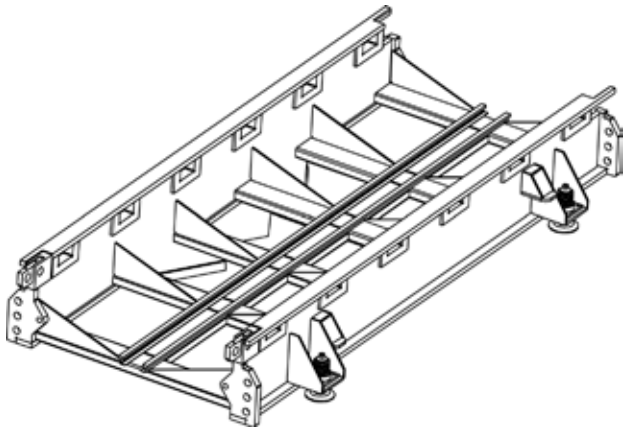
Equipped with:
Hydraulic drive motor, four point safety chains, and guards.

YOKES



Model	Width	Length	Height
360	72.75” (1,848 mm)	91.5” (2,324 mm)	44” (1,118 mm)
420	72.75” (1,848 mm)	93.5” (2,375 mm)	51” (1,295 mm)
480	72.75” (1,848 mm)	93.5” (2,375 mm)	58” (1,473 mm)
540	72.75” (1,848 mm)	93.5” (2,375 mm)	65” (1,651 mm)
540 Ext	72.75” (1,848 mm)	123.5” (3,137 mm)	65” (1,651 mm)
600	77.5” (1,969 mm)	93.75” (2,381 mm)	72.5” (1,829 mm)
600 Ext	77.5” (1,969 mm)	123.75” (3,137 mm)	72” (1,829 mm)
660	79” (2,007 mm)	93.75” (2,381 mm)	79” (2,007 mm)
720	86” (2,184 mm)	93.75” (2,381 mm)	86” (2,184 mm)
720 Ext	86” (2,184 mm)	123.75” (3,137 mm)	86” (2,184 mm)
780	93” (2,362 mm)	123.75” (3,137 mm)	93” (2,362 mm)

SKIDS



Model	Width	Length	Height	Weight
2.5 ft	80” (2,032 mm)	30” (762 mm)	25.5” (648 mm)	1,500 lbs. (680 kg)
7.5 ft	91” (2,311 mm)	90” (2,286 mm)	25.5” (648 mm)	4,200 lbs. (1,905 kg)
15 ft	91” (2,311 mm)	180” (4,572 mm)	25.5” (648 mm)	8,400 lbs. (3,810 kg)
22.5 ft	91” (2,311 mm)	270” (6,858 mm)	25.5” (648 mm)	12,600 lbs. (5,715 kg)

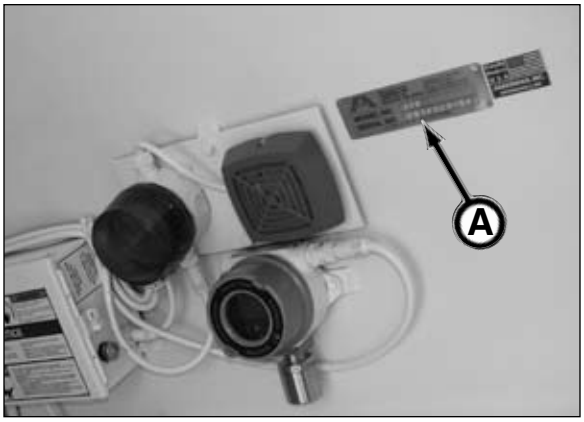
Identification Numbers

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 _____

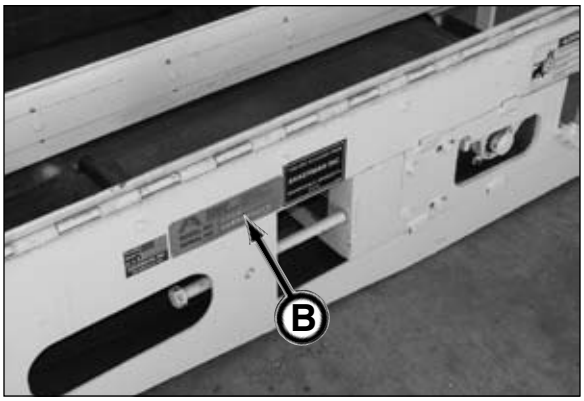
Serial Number _____



BELT CONVEYOR (B)

Model Number _____

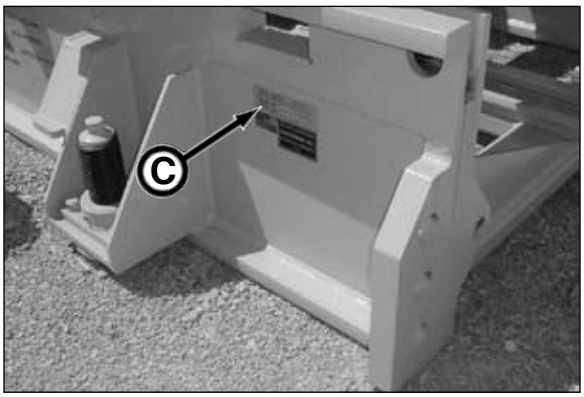
Serial Number _____



SKID (C)

Model Number _____

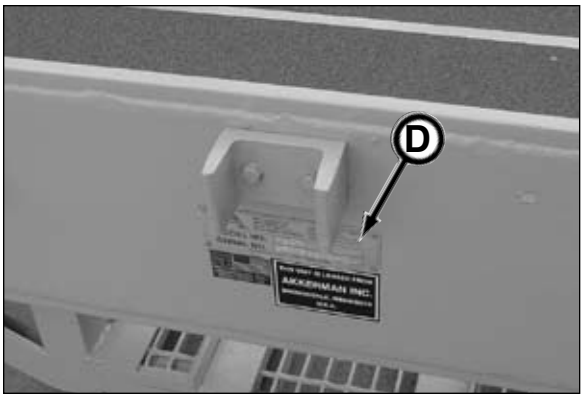
Serial Number _____



YOKE (D)

Model Number _____

Serial Number _____



NOTES

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 Aftermarket 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.

NOTES

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.

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