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**Operation and
Maintenance Manual
Microtunneling
System**

TRENCHLESS EQUIPMENT SPECIALISTS

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1. Introduction

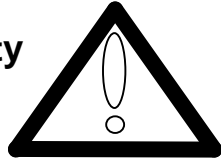
Akkerman Inc. has been in the pipe jacking and tunnel boring business for many years with manned entry equipment. Although very successful, the manned entry equipment has limitations. Small pipe sizes, unstable or hazardous ground conditions all present problems. For this reason Akkerman has developed a remotely controlled tunnel boring system called a microtunneling system. The basic parts of the system are: MTBM (Micro Tunnel Boring Machine) - to do the earth boring, Jacking System - to advance the pipe through the ground, Slurry System - circulates and removes the cut material from the MTBM, Control Container - operator interface for system control.

The latest technology has been used to make this equipment easy to use and reliable. In any electrically integrated system the most unreliable component is it's connectors. Special care must be used when connections are made to avoid damage.

The purpose of this manual is to provide you with the information to operate, maintain, and service Akkerman microtunneling equipment. **Please read and understand this manual before attempting to operate equipment.** To aid the operator, the operation section was arranged in the chronological order of daily events. The sections following the operation section should be read by personnel who need to become familiar with the equipment. The following is a list of the sections and their contents:

1. **Introduction** - This section
2. **Safety** - Some of the safety rules that any personnel who work around the machine should know.
3. **Operation** - Recommendations for site layout, set up of the equipment, and operational procedures.
4. **Machine Specifications** - General information about the machine.
5. **System Overview** - A detailed description of the parts of the system.
6. **Maintenance and Routine Checks** - Parts information and service intervals.
7. **Software Tools** - A description of software tools that can be used for maintenance, or gathering specialized information about the machine.
8. **Appendix** - Contains information on the use of Microsoft windows, how the logger works, copies of system files, computer hardware information, and other technical specifications.

2. Safety



Throughout this manual and on machine decals, you will find precautionary statements (“CAUTION”, “WARNING” and “DANGER”) followed by specific instructions. These instructions are intended for the personal safety of you and those working with you. Please take time to read them.

CAUTION: The word CAUTION is used where a safe behavioral practice, according to the operating and maintenance manual and common safety practices, will protect the operator and others from accidental involvement.

WARNING: The word WARNING denotes a potential or hidden hazard which has a potential for serious injury. It is used to warn operators and others to exercise every appropriate means to avoid a surprise involvement with machinery.

DANGER: The word DANGER denotes a forbidden practice in connection with a serious hazard.

Failure to follow the CAUTION, WARNING, and DANGER instructions may result in serious bodily injury or death.

The microtunneling system has hydraulic systems that can produce pressures up to 8,000 PSI, power cables that carry voltages up to 600 volts, heights of up to 50 feet or more from jacking shaft floor to ground level, and moving parts. All of which for normal operation is very safe, but carelessness could cause severe injury. The manufacturer has no direct control over machine application, operation, lubrication, or maintenance. It is, therefore, important to exercise proper safety practices in these areas and follow all system, company and governmental safety rules, and regulations.

It is your responsibility to read and understand this manual before operating this equipment.

Protect yourself.

Wear all the protective clothing and personal protective equipment issued to you by your employer or called for by job conditions. You may need:

1. A hard hat
2. Safety shoes
3. Safety glasses, goggles or face shield
4. Heavy gloves
5. Hearing protection
6. Reflective clothing
7. Wet weather gear
8. Air quality monitor
9. OSHA approved Commercial First Aid Kit
10. ABC rated fire extinguisher

Wear whatever is needed, don't take chances.

- ?? Do NOT wear loose clothing or any accessory -- flopping cuffs, dangling neckties and scarves, or jewelry and wrist watches -- that could catch on moving parts.
- ?? Be alert, know where to get assistance. Know how to use first aid kit and fire extinguisher / fire suppression system.
- ?? Be aware, take advantage of training programs offered.
- ?? Be careful, human error is caused by many factors: carelessness, fatigue, overload, preoccupation, unfamiliarity of operator with equipment, drugs and alcohol to name a few, but injury or death could be the lasting effect.
- ?? Encourage the safety of your coworkers.
- ?? Never remove or disconnect any safety device.
- ?? Never unplug energized power lines or cables.
- ?? Do not use or attempt to repair damaged hoses or cables.
- ?? Never disconnect hydraulic hoses when pumps are running or lines are pressurized.
- ?? Make sure all hoses and cable connectors are dry and connected properly.
- ?? Do not make modifications to any equipment without proper approval.
- ?? Make sure personnel are always clear of items being lifted.
- ?? Make sure all equipment is maintained in proper working order.
- ?? Stay clear of the jacking system when operation.
- ?? Abide by all local, state and federal laws.
- ?? Follow standard procedures and understand the operation of the machine before using it.
- ?? Wear the appropriate personal protective equipment at all times.

Be qualified.

For safe operation of this equipment, you must be a qualified and authorized operator. To be qualified, you must understand the written instructions supplied in this manual, have training, including actual operation of the equipment and know the safety rules and regulations for the jobsite.

- ?? Know the rules. Most employers have rules governing operation and maintenance of equipment. Before you start work at a new location, check with your supervisor or safety coordinator. Ask about rules you will be expected to obey.
- ?? Do not operate this equipment if you are under the influence of drugs so alcohol which may impair your alertness or coordination. An operator on prescription or over the counter drugs needs medical advice on whether or not they can safely operate machines.
- ?? Know the capacity, required clearances and operating characteristics of this equipment.
- ?? Never remove any part of the machine (except for service and reinstall before operating).
- ?? Never leave the operators position with the system energized.
- ?? Obey traffic laws.
- ?? Keep others away from your operation.
- ?? Know the purpose of all the controls, gauges and indicators.
- ?? Be aware that changes in ground conditions change the operating capabilities of your machine.
- ?? Study the DANGER, WARNING and CAUTION safety decals on your equipment and read the operators manual before attempting operation.

Start safely.

Before you begin your workday, you must inspect your equipment and have all systems in good operational condition. Do not operate the machine until all deficiencies are corrected.

- ?? Check for broken, missing or damaged parts. Make necessary repairs.
- ?? Check hoses for cuts or bulges. Replace badly worn or damaged hoses.
- ?? Check the emergency stop circuit for proper operation.
- ?? Perform all maintenance procedures outlined in this manual.
- ?? Clean the operators area, control knobs, switches and monitors. Oil, grease, debris or mud in these areas can cause you to slip and fall. Clean your boots and hands before entering the operator area.
- ?? Never fill the hydraulic system with the equipment in operation.
- ?? Check the hydraulic system. Have any leaks repaired.



WARNING: Hydraulic fluid under pressure can penetrate the skin or eyes and cause serious injury, blindness or death. Fluid leaks under pressure may not be visible. Use a piece of cardboard to find leaks, but do not use bare hand. Wear a face shield or safety goggles for eye protection. If fluid is injected into the skin, it must be removed within a few hours by a doctor familiar with this type of injury.

- ?? Before starting equipment, walk completely around the machine. Make sure no one is on or close to it. Let other workers and bystanders know you are starting up and don't start until everyone is clear of the equipment.
- ?? Start the equipment from the operators position only. Know the exact starting procedure listed later in this manual.
- ?? After startup, observe all gauges, controls and warning devices to assure they are functioning properly and their readings are within the operating range.
- ?? Do not use a machine that is not in proper operating condition. It is the OPERATORS RESPONSIBILITY to check the condition of all systems.
- ?? Test each function and control to ensure correct operation.

Work safely.

- ?? Never allow unqualified or untrained personnel to operate equipment.
- ?? Keep others away from your operation.
- ?? Never leave the operators position without first releasing hydraulic pressure, performing daily system shutdown and disconnecting the main power source.
- ?? Operate the equipment smoothly - gradually increase or decrease speed controls.
- ?? Do not operate with obstructed view of the work area.
- ?? Be alert, watch out for hazardous conditions.
- ?? Watch out for obstacles, be ready to reduce speeds and advance rates if an obstacle is encountered.
- ?? Do not use or attempt to repair damaged hoses or cables.
- ?? Never disconnect hydraulic hoses when pumps are running or lines are pressurized.
- ?? Make sure all hoses and cable connectors are dry and connected properly.

Perform maintenance safely.

- ?? Do not perform any maintenance work on equipment unless you are authorized - and qualified to do so.
- ?? If you have been authorized and are qualified to do maintenance, read and understand the operation and maintenance manual. Study the instructions; check the instruction messages on the machine and follow any special procedures carefully.
- ?? Be sure you have the necessary skill, information, correct tools and equipment to do the job correctly.
- ?? Do not attempt to make adjustments or repairs to equipment that is in operation.
- ?? Dissipate pressure in hydraulic circuits before service.



WARNING: Hydraulic fluid under pressure can penetrate the skin or eyes and cause serious injury, blindness or death. Fluid leaks under pressure may not be visible. Use a piece of cardboard to find leaks, but do not use bare hand. Wear a face shield or safety goggles for eye protection. If fluid is injected into the skin, it must be removed within a few hours by a doctor familiar with this type of injury. Perform daily shutdown, disconnect and lock out the main power source before service.

- ?? Lock out the main disconnect and attach a DO NOT OPERATE tag or similar warning tag to the main power disconnect before performing maintenance.
- ?? Prepare a clean, adequately spaced well lit area with proper ventilation and wear the appropriate personal protective equipment.
- ?? Safety glasses are always needed for eye protection. Rubber aprons and gloves are required for handling fluids or corrosive materials. Wear a helmet or goggles when you weld or cut with a torch.
- ?? Do not sand, grind, flame cut or weld without checking for flammable gasses and providing appropriate ventilation .
- ?? If welding is required on this equipment, consult the factory for proper procedures before doing so.



WARNING: Keep clear of all rotating components. Wrapping or entanglement may result in serious injury or death.

- ?? Keep hands clear of items that could drop. Handle heavy parts sensibly, with regard to yourself and other persons. Lower heavy items, do not drop them.
- ?? Keep pockets free of objects that could fall, short circuit or become entangled in machinery.
- ?? If adjustments must be made with the equipment running, always work as a 2-person team with one person sitting in the operators position while the other works on the machine.
- ?? Remove only guards or covers that provide access. Wipe away excess grease or oil.
- ?? Never leave guards or access covers off when unattended. Keep bystanders away if safety shields are removed.
- ?? Keep all guards, access covers and warning labels in place and in proper condition.
- ?? Disconnect, lock out and tag the main power source before opening any access cover where electricity is present. Use proper equipment to verify that all stored energy has been dissipated before service work begins.

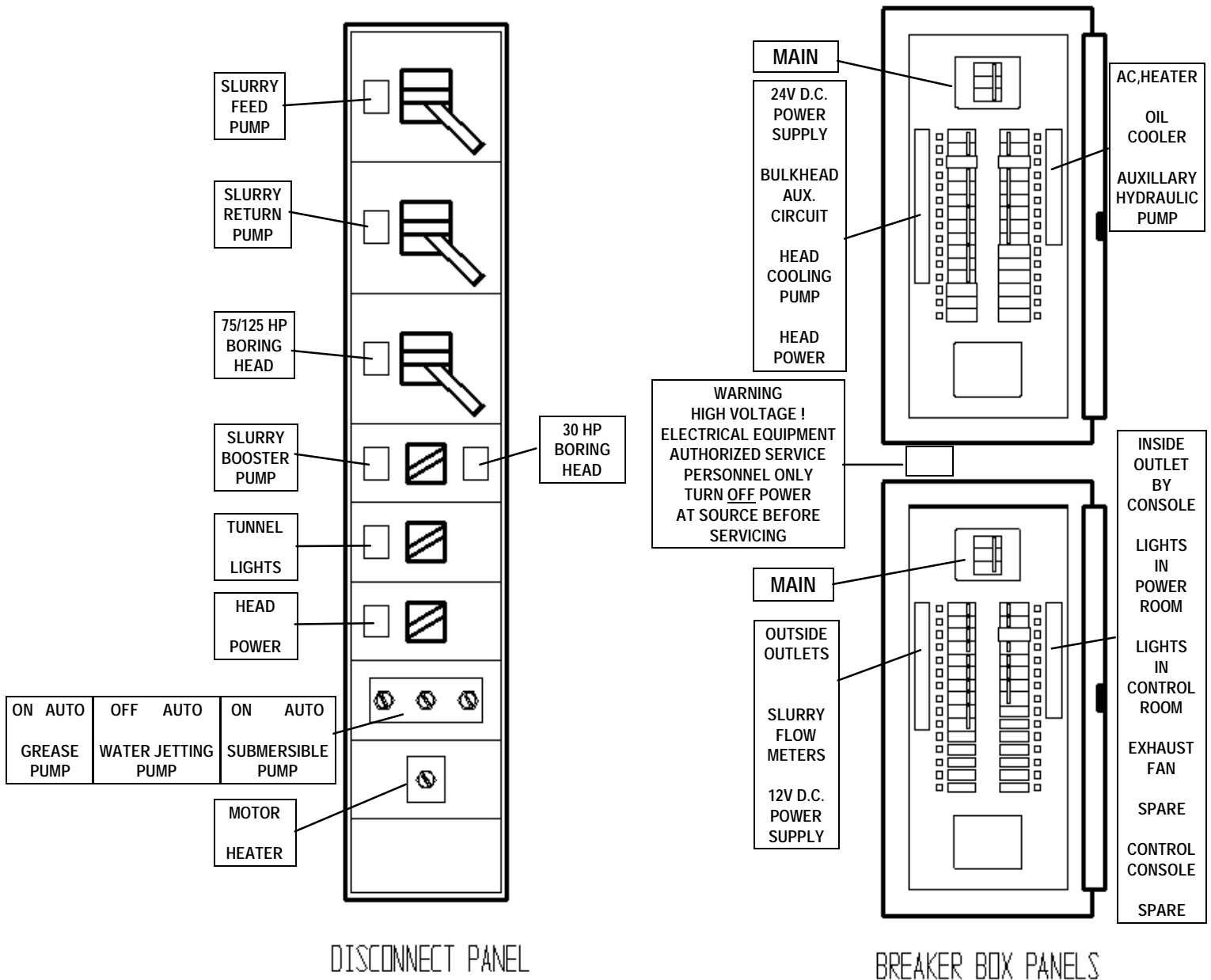


WARNING: Risk of electrical shock. Electrical shock can cause severe burns or death.

- ?? Never work on the electrical system unless you are a qualified electrician familiar with the system details and special handling requirements.
- ?? Always use a nonflammable solvent when you clean parts. Do not use gasoline, diesel fuel or other flammable liquids. Handle chemicals and solvents according to manufacturers instructions.

3. Decals

This page provides a sample of some of the decals used on the microtunneling system. It is extremely important to verify that all decals are in place as show in the illustrated parts manual for each individual piece of equipment. If any decals are worn out, removed, illegible, contact the factory immediately for replacements. Do not operate the microtunneling system if any of the decals are missing or you are unable to read them. Operation without proper decals could result in harm to the operating personnel or to the equipment.



Decal locations for the control container in the control room, panels behind the operators station. See illustrated parts manual for more decal locations

4. Operation

4.1. Site Planning

Before starting a job it is important to carefully review the site and make sure that it is arranged in the most effective manner possible. The following is a list of equipment that is typically needed for a job:

- ?? MTBM
- ?? Jacking frame
- ?? Control container
- ?? Slurry separation system or tanks
- ?? Slurry pumps - feed and return
- ?? Drive motor cooling water tank
- ?? Crane
- ?? Fork lift
- ?? Storage container with appropriate tools and hardware
- ?? Portable Toilet
- ?? Generator or power source
- ?? High Pressure Jetting Pump
- ?? Portable welders
- ?? Small generator or power source
- ?? Slurry reversing or bypass valves
- ?? Pipe lubrication (bentonite) pump
- ?? Spoil removal truck

Other sight considerations are:

- ?? Spoil removal truck access
- ?? Pipe unloading area
- ?? Fresh water supply
- ?? Launch shaft size
- ?? Hose interconnections
- ?? Electrical interconnections
- ?? Walkways
- ?? Pipe staging area
- ?? Jacking shaft access area
- ?? Any traffic or other physical restraints

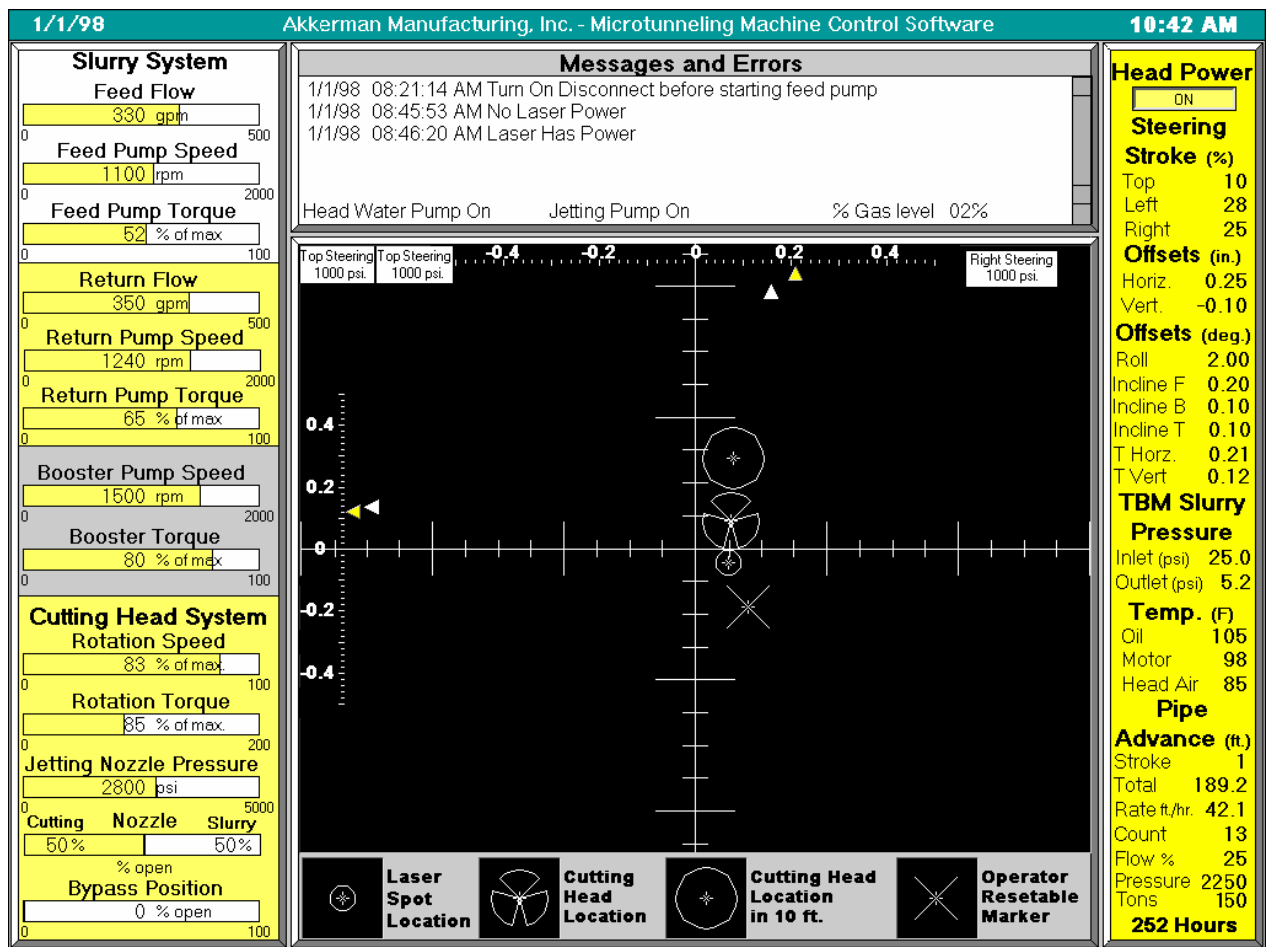
4.2. Site Preparation

1. Provide a firm, level jacking shaft floor with proper drainage. Use confined space entry techniques when entering the jacking shaft. Make sure the floor is at the proper elevation and grade. A gravel jacking shaft floor may be used, but concrete is more acceptable. Place steel plates on the jacking shaft floor for supporting the base of the jacking frame, MTBM and pipe.
2. Make a thrust block. Concrete generally works the best. Thrust blocks should be at least 5 feet square but will vary depending on the jacking loads expected. Space must be provided for the mounting of the laser behind the jacking frame.
3. Set in the jacking frame. The frame elevation can be adjusted to grade by the jacks on the bottom of the frame. Make sure there is at least 1/2 ft between the front of the jacking rails and where the launch seal will be. Connect the jacking frame hydraulic hoses, electrical cables and pit box. Pad sharp corners to prevent damage to the cables and hoses.
4. Make a mount for the laser. It must be mounted behind the jacking frame and isolated from the thrust forces. The mount must NOT be attached to the any part of the jacking shaft that may move under thrust load.
5. The main consideration for the placement of the return pump is to mount it as close as possible to the jacking frame so the booster pump does not have to generate excessive head (horse power). Provisions must be made for hose swing as the thrust ring travels on the jacking frame.
6. Place the control container on a firm, level surface a safe distance from the jacking shaft. It should be placed so the bottom of the jacking shaft is observable from either the side or end window in the control container. This is not always possible but should be an objective.
7. Put the main power source as far away from the control container as possible (a little less than 75 feet). This will reduce the noise to the operator and make it easier to communicate with others while operating.
8. Connect the power to the control container. Check for correct phase and proper grounding. A phase monitor is provided behind the door above the main disconnect switch. A red light will illuminate if the phase is wrong and a green light will illuminate when the phase is correct.
9. Put the slurry tank(s) on a stable, level surface close to the control container and a safe distance from the jacking shaft. Provisions should be made to drain water overflow away from the jacking shaft.
10. Place the feed pump near, or mount onto, the slurry tank and make hose connections.
11. Connect the cooling pump, jetting pump and lubrication system to the pit manifold.
12. Connect the high pressure jetting pump feed hose and drive motor cooling hose to the drive motor cooling tank.
13. Connect the cooling pump and jetting pump to the control container electrical bulkhead.
14. Connect the lubrication system cables (model ER-2250) to the control container electrical bulkhead.
15. Install the launch shaft seal and casing in the front of the jacking shaft.
16. Place the MTBM front section on the jacking frame and ensure alignment of the laser with the center of the target.
17. Place the MTBM trailing section near the launch shaft.
18. Connect all the electrical cables and hoses including the MTBM front and trailing section.
19. Connect the 150' starter hoses and cable between the MTBM starting and trailing sections.
20. Install the optional lighting booms, lights, and camera on the container as required.
21. Perform drive startup, see section (4.3).
22. Test the feed, return and booster pumps for proper rotation.
23. Test the jacking frame, cycle the cylinders several times to purge air from the lines and check for leaks.
24. Retract steering cylinders to the full retracted position and note readings, extend to full extend position and note readings.
25. Extend or retract steering cylinders to mid stroke position.

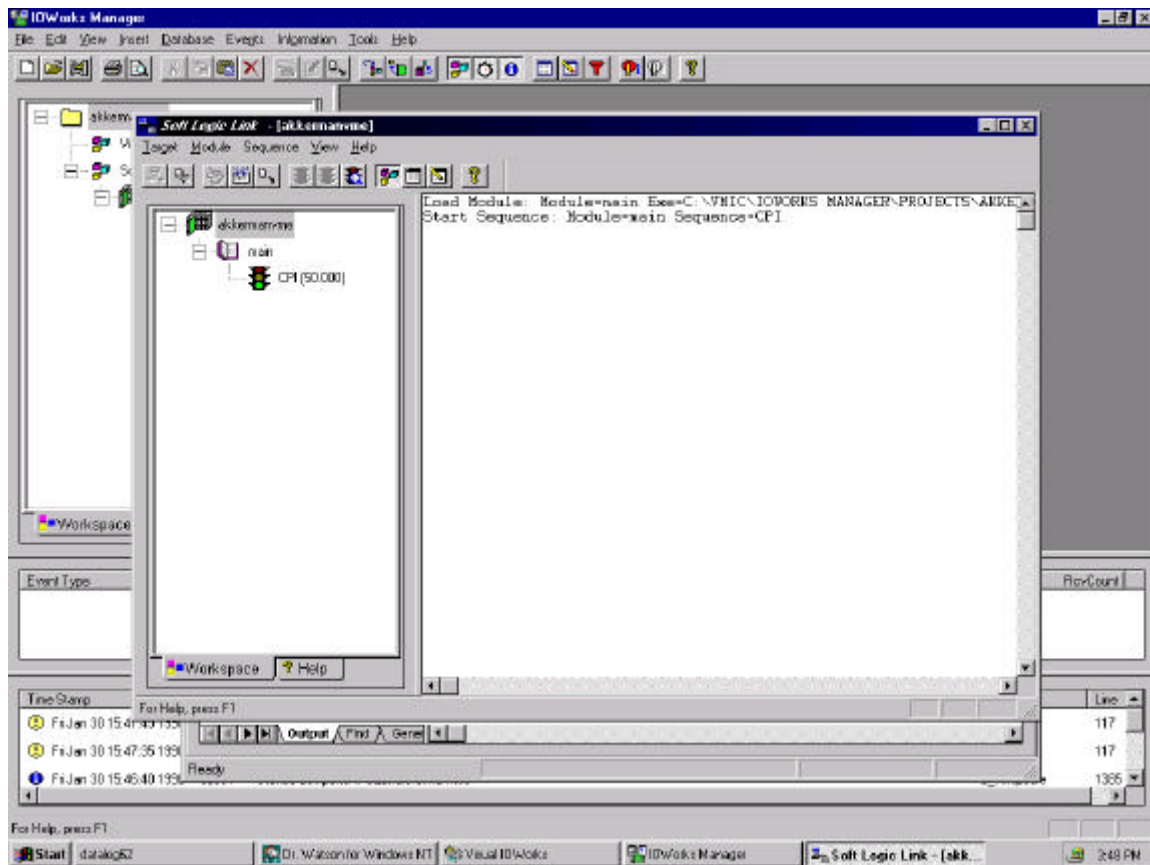
4.3. Drive Startup

4.3.1. Daily System Startup

1. Energize the main power source and turn on all circuit breakers and disconnect switches except those directly behind the operator.
2. Cycle the 24 Volt power breaker off and back on to reset the genius blocks.
3. Turn on the console key switch.
4. Wait for the 'Press CTRL + ALT + DEL' screen to appear.
5. Turn the keyboard selector switch to the 'Right Monitor' position. Press and hold down the CTRL, ALT, and DELETE keys.
6. When the logon box appears, press ENTER. Turn the keyboard selector switch to the left monitor and repeat logon procedure.



The Left monitor will enter (display) the 'target screen' as shown above.



The Soft Link program is designed to link the operator interface (switches) to the computer control program.

1. The right monitor will enter the 'Soft Logic Link' and 'Data Logger' programs as shown above.
2. Verify that the control system is in operation by pressing the 'Lamp Test' switch and checking if all console switch lamps illuminate.
3. Open the valves on the manifold in the launch shaft.
4. Continue drive startup or begin daily operation.

4.3.2. Start Drive

Execute the 'START DRIVE' program on the right monitor each time the boring machine is placed on the jacking frame for the start of a new drive.

Ver 5.0	DRIVE DATA		
Drive Nbr: <input style="width: 100px;" type="text"/>	Length: <input style="width: 100px;" type="text" value="In feet"/>	Ground Condition: <input style="width: 150px;" type="text"/>	
Job Comments: <input style="width: 600px; height: 30px;" type="text"/>			

PIPE DATA	SHIFT SUPERVISORS
Pipe OD: <input style="width: 100px;" type="text" value="In inches"/>	First: <input style="width: 150px;" type="text" value="Name"/>
Pipe ID: <input style="width: 100px;" type="text" value="In inches"/>	Second: <input style="width: 150px;" type="text" value="Name"/>
Pipe Length: <input style="width: 100px;" type="text" value="In feet"/>	Third: <input style="width: 150px;" type="text" value="Name"/>
Pipe Kind: <input style="width: 100px;" type="text" value="Type"/>	Project Length: <input style="width: 100px;" type="text" value="In feet"/>
Number Used: <input style="width: 100px;" type="text" value="For drive"/>	

JOB DATA	EQUIPMENT USED
Date Started: <input style="width: 100px;" type="text"/>	Head: <input style="width: 100px;" type="text" value="24 in MTBM v"/>
Estimate Completion: <input style="width: 100px;" type="text"/>	Slurry: <input style="width: 100px;" type="text" value="Separation 1 v"/>
Boring Contractor: <input style="width: 200px;" type="text" value="Your Company"/>	Jacking: <input style="width: 100px;" type="text" value="SP 400 v"/>
Prime Contractor: <input style="width: 200px;" type="text"/>	Bentonite: <input style="width: 100px;" type="text" value="Bentonite 1 v"/>
Engineer: <input style="width: 200px;" type="text" value="Special Consultants"/>	Container: <input style="width: 100px;" type="text" value="Container 1 v"/>
Who For: <input style="width: 200px;" type="text" value="Your City"/>	Project Name: <input style="width: 150px;" type="text"/>
Job Description: <input style="width: 600px; height: 30px;" type="text"/>	
<input style="width: 100px;" type="button" value="Update Drive Data"/>	<input style="width: 100px;" type="button" value="Update Equipment"/>
<input style="width: 150px;" type="button" value="Exit Without Updating"/>	<input style="width: 40px;" type="text" value="7/97"/>

Minimize the I/O Works, I/O Works Manager and Soft Link programs by clicking the left mouse button on the - sign in the upper right corner of the screen. Fill out the information on the screen for setup of drive, pipe and job data, select equipment from the pull down arrows in the 'equipment used', then click on the 'Update Database' button. This will save the settings that have been entered. The most critical information on this screen is the equipment used. This list is used to calibrate the control system. If incorrect, the system will not function properly. The other items on the screen are for the print-out header or for future reference. Every entry does not have to be filled out but it is a good idea to fill out as many as possible.

4.3.3. Equipment Checkout

- ?? Grease pump in the MTBM should be filled.
- ?? Fill the drive motor cooling tank with fresh water and verify float switch operation.
- ?? Check the MTBM hydraulic power pack oil level, fill as necessary.
- ?? Check the MTBM main drive bearing oil level.
- ?? Check the MTBM gear reducer oil level.
- ?? Test the MTBM submersible pump float switch.
- ?? Check the container power pack hydraulic oil level.
- ?? Fill the slurry tank(s) with water.
- ?? Check the oil level in slurry pumps.
- ?? Verify the full load amperage setting for boring head starter, booster pump starter, boring head VFD, booster pump VFD.

4.3.4. MTBM Launch Sequence

MTBM starting section should be placed on the jacking frame, ([4.1 Site Planning](#) through [4.3.3 Equipment Checkout](#) completed).

1. Press 'OPEN' bypass valve and 'CLOSE' stop valve until buttons remain illuminated.
 - ?? Always make sure that one valve or the other is open. Closing both will block the slurry lines.
2. Place the slurry function selector switch in the 'SEQUENCE' position.
 - ?? The sequence of operation for the bypass and stop valves will now be automatic.
3. 'START' slurry feed pump, booster pump (if in slurry circuit), and return pump.
 - ?? Set flow rates to low (approximately 100 GPM) and check for leaks.
 - ?? Verify that the slurry lines are open and the separation equipment is working properly. Leave the pumps running on a low flow rate.
 - ?? Feed flow should equal return flow at this time on the 'target screen' meters.
4. Lubricate the launch shaft seal.
5. Start jacking by pressing main pump 'START', switch function selector switch to 'EXTEND', and setting about a 20% hydraulic flow with main pump rate control 'INCREASE' and 'DECREASE'.
6. Slowly push the MTBM cutter face through the launch shaft seal.
 - ?? [see section 4.4.4](#) Jacking for more details.
 - ?? Be careful not to damage the seal and to ensure proper alignment.
7. Continue advancing the jacking frame until the cutter face is in contact with the ground.
 - ?? Stop jacking if pressures rise quickly.
 - ?? With the steering cylinders in the half stroke position, write down the readings on all the inclinometers and target position. The laser should still be centered on the target.
 - ?? Make sure the pipe count is set to 0 and on manual until the first pipe is on the jacking frame, then set to automatic and set the count to 1.
 - ?? The jacking length should also be set to 0 and set to manual until the pipe advancement wheel is in position then set to automatic and set the length to the total length of the MTBM.
8. Press the stop valve 'OPEN'.
 - ?? The valves automatically sequence to stop valves open and bypass valve closed.
 - ?? Keep close attention on the launch shaft seal. Water leaks should be kept to a minimum.
9. Set cutting head speed at about 10%. Press cutting head 'LEFT' or 'RIGHT'
 - ?? After the cutter head has started rotation, increase speed to about 80%.
 - ?? The high pressure jetting pump should be turned 'OFF' while jacking front section.

10. Slowly increase the slurry feed and return pump speeds. As the MTBM is pushed into the ground, launch shaft seal leakage will occur at the steering joint and access covers. Adjust feed and return pump flows to prevent getting too much flow or slurry pressure at this time.
11. Use [4.4 Daily Operations](#) to jack the entire MTBM front section into the ground removing the lifting eyes and installing hole plugs as the machine is pushed in.
12. Follow [4.4.6 Pipe Change](#) to place the MTBM trailing section in the jacking frame.
 - ?? Exchange the 61 pin 150' TBM starter cable with a 9.5' or 5.5' cable as applicable.
 - ?? Remove MTBM hydraulic starter hoses, reconnect lines.
 - ?? Connect slurry return lines to the slurry booster pump.
 - ?? While jacking the trailing section, the high pressure jetting pump may be used if shaft seal leakage does not occur.
13. Advance the MTBM trailing section using [4.4 Daily Operations](#).
14. Install the pipe length indicator (wheel counter) and set length reading to the entire MTBM length.
15. Follow [4.4.6 Pipe Change](#) to place the first pipe in the jacking frame.
 - ?? When connecting the pipe make sure the O ring seals are not damaged.
 - ?? The first pipe needs to have slurry hose assemblies used instead of steel slurry lines.
16. Install subsequent pipe installation using [4.4 Daily Operations](#).

4.4. Daily Operation

4.4.1. Advancing the MTBM

To begin tunnel excavation:

1. With slurry stop valves closed and bypass valve open, 'START' slurry feed pump, booster pump, and return pump. Too much slurry flow will cause over excavation. The booster pump speed should be increased until the torque is about 90%. The slurry feed and return flow is a balancing act. Too much flow will cause too much pressure at the boring head. Over excavation is possible and also water leaking past the over cut and launch shaft seal or slurry water leakage to the surface. Too little flow will not transport the cuttings back from the head.
2. Press slurry stop 'OPEN'.
3. Press cutting head 'LEFT' or 'RIGHT' and set cutting head speed (see [4.4.3 Cutter Head](#) for more detail).
4. Advance jacking frame forward by pressing main pump 'START', switch on 'EXTEND', and setting a hydraulic flow rate with main pump rate control 'INCREASE' and 'DECREASE' (see [4.4.4 Jacking](#) for more detail).

4.4.1.1. To pause tunneling:

1. Place jacking function switch in 'STOP' or press main pump rate 'STOP'.
2. Press cutting head 'STOP'.
3. Press bypass valve 'OPEN'.

4.4.2. Slurry flow rates

1. Slurry Flows

Pipe Size (inches)	Minimum GPM	Maximum GPM
2	80	110
3	200	300
4	300	450
5	500	700
6	700	1000

- ?? Stay within the ranges specified above. If return flow falls below minimum, solids may settle out and clog the slurry line. If the flows rise above maximum, excessive over-cutting at the face may occur.
- 2. Typically the slurry booster pump is set at a speed higher than the return pump. The return pump is normally operated slightly faster than the feed pump. Slurry pump speeds vary with soil condition. A starting point would be to increase the pump speeds until the booster pump torque is at about 90%.
- 3. Use cutting nozzle 'OPEN' to direct more water to the face and less water to the chamber of the MTBM in clays. Use slurry nozzle 'OPEN' to direct more of the water to the slurry chamber and less water to the cutting nozzle in sands.
- 4. Operate the machine so that the slurry outlet pressure is less than 5 PSI above the ground water pressure. In MTBM's that have the slurry outlet pressure transducer mounted between the slurry chamber and the stop valve, the ground water pressure is measured by shutting off the slurry pumps, closing the stop valve and reading the slurry outlet pressure. The water table should provide a pressure of about 1/2 PSI per foot. Therefore, multiply the PSI times 2 to get the height of the water table above the machine. This is a simple check to see if the reading is reasonable.
- 5. Slurry flows and pressures vary for different machines and for different ground conditions. It is the responsibility of the operator to determine through experience, the operating parameters for the machine in specific soil conditions.

4.4.2.1. Slurry Bypass

Switch to slurry bypass when:

- ?? Tunneling is halted for more than 5 seconds.
 - ?? Return flow is difficult to maintain at levels near the feed flow while tunneling (bypass for at least 30 seconds). This is due to excessive material in the return lines.
 - ?? End of pipe (bypass at least 30 seconds).
 - ?? Beginning of pipe to check for leaks before starting cutter head or jacking.
1. Place jacking function switch in 'STOP' or press main pump rate 'STOP'.
 2. Press 'STOP' cutting head.
 3. Press 'OPEN' bypass valve.
 - ?? Slurry stop valves will close since function selector switch is in 'SEQUENCE'.
 4. Operate slurry feed pump, booster pump, and return pump at normal operating flows.
 - ?? If after 30 seconds the feed flow and return flow have not returned to normal values, then the slurry lines are clogged. See [4.4.2.2 Clearing Clogged Slurry Lines](#).

4.4.2.2. Clearing Clogged Slurry Lines

The slurry lines are clogged if [4.4.2.1 Slurry Bypass](#) does not result in normal flow rates after approximately 30 seconds.

A restriction in the head has occurred if switching to bypass brings slurry flows back to normal and normal operation results in low return flow. Also the inlet pressure will be high, the outlet pressure low and little return flow when slurry stop valves are open. Operate the slurry in bypass long enough to clear any cuttings out of the return lines. While this is being done, operate the chamber valve to 100% then sequence the stop/bypass and watch inlet pressure. If inlet pressure does not rise, operate the jetting nozzles to 100% and note if the slurry pressure rises. When the source of the pressure is found, reverse slurry flow [4.4.2.3](#) will be required.

A restriction in the return lines will cause inlet and outlet pressures to be high when the bypass is open. First stop all the pumps and shut off ball valves (slurry) in the jacking shaft. Then disconnect slurry hoses in the launch shaft at the trunk lines, connect them together, open ball valves and try clearing the lines with the feed and return pumps (do not operate the booster pump at this time). If this does not clean the lines, then check the feed and return hoses for lodged obstacles.

If the restriction is not in the hose external to the tunnel, the restriction must be in the return trunk line. Reconnect the hoses to the trunk lines, try flushing in bypass. If this does not clear the restriction, reverse flush the trunk lines with the bypass valve open.

4.4.2.3. Reverse Slurry Flow in MTBM

Reverse slurry flow to flush out the crushing chamber, slurry chamber, and MTBM slurry lines. Reverse slurry flow must be done when:

- ?? [4.4.2.1 Slurry Bypass](#) and [4.4.2.2 Clearing Clogged Slurry Lines](#) failed to achieve high flow rates.
 - ?? High flow rates are achieved in slurry bypass, but return flow rate is low during tunneling (slurry chamber, crushing chamber, or slurry lines between bypass valve and slurry chamber are clogged).
1. Stop jacking frame advancement, cutter head rotation and open the bypass valve.
 - ?? Slurry stop valves will close since function selector switch is in 'SEQUENCE'.
 2. Press 'STOP' slurry return pump, booster pump, and feed pump.
 3. Close the two slurry ball valve handles on the jacking frame.
 4. Disconnect both slurry hoses from the bottom of the slurry valves on the jacking frame.
 5. Reconnect slurry hoses to opposite slurry valve on the jacking frame (swap connections).
 - ?? A male-male and female-female pipe adapter will be needed.
 6. Open the two slurry valves on the jacking frame.
 7. 'START' feed pump and return pump, set flow rates to normal operation flows.
 8. Do NOT start booster pump.
 9. Allow slurry lines to flush for no more than 30 seconds
 - ?? Open the chamber or jetting valve, which ever was found to be clogged to about 75%
 - ?? If lines are clogged at this point, cycle the feed and return pump 'START' and 'STOP' buttons several times with bypass valve open in order to pressure shock the restriction loose.
 10. Press slurry stop 'OPEN'.
 - ?? The crushing chamber and slurry chamber are now being flushed.
 - ?? Minimize time that the slurry stop valves are open. Since jacking does not occur, any material excavated by the slurry water will form cavities in front of the MTBM.

11. Reconnect the slurry lines to their normal operating position and resume normal operation when the restriction has been cleared.

4.4.2.4. Using Above Ground Bypass Valve

This is typically done during a pipe change when using a mechanical slurry separation system which allows the slurry system to continue cleaning. If slurry separation is accomplished using a settlement tank, this procedure would normally not be required.

1. Press 'STOP' cutting head.
2. Place jacking function switch in 'STOP'.
3. 'STOP' slurry return pump, booster pump, and feed pump.
4. Open the slurry above ground bypass valve.
5. Close the shaft slurry stop valves on the jacking frame.
6. Push 'START' slurry feed pump, do NOT start the booster or return pumps.
 - ?? The flow path goes from the settlement tank to the feed pump, followed by the slurry feed flow meter and the above ground bypass, then return flow meter and back to the settlement tank.

4.4.3. Cutter Head

1. Jacking flow rates can be increased until the drive torque is between 80% and 100%. 90% is a good operating point. Reduce jacking speed to reduce torque.
2. The cutter head works equally well in both directions.
3. Watch for machine roll. If it exceeds 5 degrees, reverse the cutting head rotation. Extending the stabilizer cylinder (dirt wing) will help minimize roll, however, jacking forces will increase slightly.
4. Cutter head rotation can be reversed without pressing cutting head 'STOP'.
5. Operate cutter head at high speeds in stable ground, lower speeds in unstable ground.

4.4.3.1. Releasing a Seized Cutting Face

1. Retract the main jacking cylinders slightly to release the jacking pressure.
2. Place jacking function switch in 'STOP' or press main pump rate 'STOP'.
3. 'START' slurry feed pump, booster pump, and return pump.
4. Press 'OPEN' stop valve.
5. Switch high pressure jetting to 'AUTO'.
6. Reverse rotation several times by pressing cutting head 'LEFT' and 'RIGHT'.
 - ?? If unsuccessful, press cutting head 'STOP' and bypass valve 'OPEN'.
7. Make note of top, left and right steering cylinder positions.
8. Press 'EXTEND' top cylinder, left cylinder, and right cylinder until fully extended.
9. Press 'RETRACT' top cylinder, left cylinder, and right cylinder until fully retracted.
10. Press 'OPEN' stop valve.
11. Reverse rotation several times by pressing cutting head 'LEFT' and 'RIGHT'.
 - ?? If cutter head becomes free, return steering cylinders to their previous positions while cutter head is rotating.
 - ?? If unsuccessful, press cutting head 'STOP' and bypass valve 'OPEN' and repeat steps 3 - 11.

4.4.4. Jacking

1. Never exceed maximum jacking thrust rating of the pipe. Consult pipe manufacturer to obtain this rating.
2. Use lowest jacking pressures and lowest cutting head torque possible (below 100%), while maintaining high production rates.
3. Increase main pump rate to increase cutter head torque, jacking speed and jacking pressure.
4. Decrease main pump rate to decrease cutter head torque, jacking speed and jacking pressure.
5. Maintaining proper grade and alignment of the tunnel to ensure low jacking pressure.
6. Using lubrication (Bentonite/polymer) may, in certain ground conditions, lower jacking pressure.
7. Do not allow steering pressures to rise above 3000 PSI for soft ground. Reduce advancement rate, increase cutting nozzle flow or increase cutter head rotation speed to reduce pressure.

Jacking Frame

While any of the Akkerman pipe jacking systems may be used for microtunneling, the MT series described below is specifically designed for microtunneling. While other pipe jacking systems will not have all of the features listed, the theory of operation will remain the same.

Features:

- ?? Designed to minimize jacking shaft size. The jacking frame has full travel distance from front of frame to back.
- ?? Operator monitoring and control of the jacking system from the console.
- ?? Mounting base on top of the frame for slurry, high pressure jetting water, drive motor cooling water, and bentonite shut off valves. This bulkhead area reduces clutter in the jacking shaft which increases safety and reduces pipe set-up time.
- ?? Optional position sensors verify the jacking system advancement rate.
- ?? Extensions can be added to the frame for longer pipe lengths.
- ?? Console displays jacking system hydraulic pressure, cylinder extension, hydraulic flow rate, pipe advance rate, total tunnel distance, and number of pipe completed.

Capable of up to 300,400 or 800 tons of thrust, depending on the model used.

The jacking frame base has upper and lower rails. The locking ring, which has an adapter to mate to the pipe and an open center for access into the pipe line, travels on sets of rollers on the upper and lower rails of the jacking frame base. Two jacking cylinders are mounted rigid to the frame's right and left sides. The cylinder's rod end is mounted to a thrust arm with a series of rectangular pockets. Cylinders are extended out, the ring is then held in position, the locking blocks disengaged and the cylinders are fully retracted. The thrust ring locking blocks are then engaged into the next available pockets. The holding mechanism is released and jacking can resume.

4.4.4.1. Model MT-340, MT-460 and MT-866 Jacking Frame Operation

1. Place jacking function selector switch in 'STOP' and press main pump 'START'.
?? The oil cooler pump will start automatically.
2. Place function selector switch in 'RETRACT' position.
?? Fully retract the jacking frame cylinders each time retract is selected. This will allow the locking blocks to engage into the pockets as far forward as possible in the thrust ring locking guide and ensure locking guide cylinder timing.
3. Set hydraulic flow rate at 50% to start jacking cylinder retraction. Switch function selector to 'STOP' when jacking cylinders are fully retracted.
?? Press and release main pump rate control 'INCREASE' once to return flow rate to previous value.
?? Set flow rate to 50% by depressing main pump rate control 'INCREASE' or 'DECREASE' buttons as required.
4. By communicating with jacking shaft worker, ensure that all position locking blocks (dogs) align with pockets of an equal relationship on either side of the frame.
5. Thrust forward by placing function selector switch in 'EXTEND' and setting a hydraulic flow rate to desired speed.
?? Refer to [4.4.4 Jacking](#) to help determine a proper hydraulic flow rate.
?? Monitor jacking pressures, if pressures near 50% of the system capacity are noted, intermediate jacking stations may be required. Refer to [4.4.4.3 Intermediate Jacking Stations \(IJS\)](#).
?? Jacking may be paused by pushing main pump rate control 'STOP' or placing function selector switch in 'STOP'.
6. [Pause tunneling \(4.4.4.1\)](#) and Move function selector switch to 'STOP' once the jacking cylinders have reached full extension.
7. Repeat steps 2 thru 6 for the entire length of the pipe and the locking ring is at the end of the jacking frame.
8. To retract the locking ring, release thrust pressure by selecting 'RETRACT' position and set flow rate to 50%. Put the jacking selector switch in the 'STOP' position when retraction is completed, release and pin position locks and press the 'WINCH' button to provide flow to the locking ring travel valve. Press the increase or decrease to desired speed. The manual valve on the jacking frame is then used to travel the locking ring to the back of the jacking frame. Use caution when retracting the locking ring away from the pipe joint to prevent pipe damage.
9. Press main pump 'STOP'.
?? Oil cooler pump 'STOP' may be pressed if hydraulic oil temperature is below 120° F.
10. Remove the pins from the position locks, install pipe per [4.4.6 Pipe Change](#) and repeat the above procedures.

4.4.4.2. Model MT-400BB Jacking Frame Operation

1. Place jacking function selector switch in the 'STOP' and press main pump 'START'.
?? The oil cooler pump will start automatically.
2. Press 'LOCK' staging grippers. Wait for button to illuminate.
3. Press 'UNLOCK' position locks until illuminated.
?? All four locking blocks (dogs) are now retracted.
4. Place function selector switch in the 'RETRACT' position.
?? Fully retract the jacking frame cylinders each time retract is selected. This will allow the locking blocks to engage into the pockets as far forward as possible in the thrust ring locking guide and ensure locking guide cylinder timing.
5. Set hydraulic flow rate to 50% to start jacking cylinder retraction. Switch function selector to 'STOP' when jacking cylinders have fully retracted.
?? Press and release main pump rate control 'INCREASE' once to return flow rate to previous value.
?? Set flow rate to 50% by depressing main pump rate control 'INCREASE' or 'DECREASE' buttons as required.
6. By communicating with jacking shaft worker, align position locking blocks (dogs) with holes as far forward as possible in the thrust ring locking guide.
?? Jog jacking frame cylinders forward or back by placing function selector switch in 'EXTEND', 'RETRACT' or 'STOP' and setting a 50% flow rate.
7. Press 'LOCK' position locks until button illuminates.
8. Verify that all of the position locks are fully engaged in the frame pockets.
9. Press 'UNLOCK' staging grippers. Wait for button to illuminate.
10. Thrust forward by placing function selector switch in 'EXTEND' and setting a hydraulic flow rate to desired speed.
?? Refer to [4.4.4 Jacking](#) to help determine a proper hydraulic flow rate.
?? Monitor jacking pressures, if pressures near 50% of the system capacity are noted, intermediate jacking stations may be required. Refer to [4.4.4.3 Intermediate Jacking Stations \(IJS\)](#).
?? Jacking may be paused by pushing main pump rate control 'STOP' or placing function selector switch in 'STOP'.
11. Move function selector switch to 'STOP' and pause tunneling ([4.4.4.1](#)) when the jacking cylinders have reached full extension.
12. Repeat steps 2 thru 11 for the entire length of the pipe and the locking ring is at the end of the jacking frame.
13. To retract the locking ring, release thrust pressure by selecting 'RETRACT' position and set flow rate to 50%. Put the jacking selector switch in the 'STOP' position, press 'UNLOCK' position locks until button is illuminated, press 'UNLOCK' staging grippers until button is illuminated and press the 'WINCH' button. Press the increase or decrease to desired speed. This provides flow to the winch control valve. The manual valve on the winch assembly is then used to control the winch. Make sure position locks and grippers are both unlocked. Use caution when retracting the locking away from the pipe joint to prevent pipe damage. If the winch is not used to pull back the locking ring, the jacking cylinders can be used. Reverse the jacking procedure until the locking ring is back.
14. Connect retraction winch cable to the locking ring and use hand operated valve to pull the locking ring back. Press 'STOP' retraction winch once locking ring is in desired location.
?? An alternate method is to push the locking ring back manually.
15. Retract the jacking frame cylinders as in step 4.
16. Press main pump 'STOP'.
?? Oil cooler pump 'STOP' may be pressed if hydraulic oil temperature is below 120° F.

4.4.4.3. Intermediate Jacking Stations (IJS) (optional system)

Intermediate jacking stations (IJS) are hydraulic rams placed between pipe joints at intervals throughout the tunnel. They distribute the pipe jacking thrust to the pipeline, reducing thrust loading on the pipe at the jacking frame. A steel housing or band fits around the joint of the pipe to prevent the intrusion of ground. This component is non-recoverable. Cylinders are installed within the housing, between the pipe joints during pipe change and are extended to thrust the pipe line forward.

Features:

- ?? Operator controls IJS system from the console.
- ?? Control container comes standard with 5 IJS connection ports in the hydraulic access panel. Five more can be added. Up to 10 IJS stations can be operated by the control system.

Sealed IJS housings are available.

Use IJS when:

- ?? Jacking pressure is expected to become too high while extending jacking frame.
- ?? Planned jacking safety factor

Operation:

1. Pause tunneling (see 4.4.1.1).
2. Set intermediate jack selector to '1'.
3. 'START' slurry feed pump, booster pump, and return pump.
4. Press main pump 'START'.
5. Press slurry stop 'OPEN'.
6. Press cutting head 'LEFT' or 'RIGHT' and set cutting head speed.
7. Move function selector switch to 'IJS'. Set a hydraulic flow rate with main pump rate control 'INCREASE' and 'DECREASE'.
8. Switch function selector to 'STOP' when the ram is fully extended.
9. Pause tunneling.
10. Set intermediate jack selector to '2'.
11. Repeat steps 3 thru 9.
12. Set intermediate jack selector to next highest number. Repeat procedure until all intermediate jacking stations have been extended.
 - ?? Reset intermediate jack selector to '0' when completed.
13. Extend jacking frame.
14. Repeat the above procedures.

4.4.5. Steering

1. Steering should be carefully executed with small corrections made over many feet.
2. Watch the inclinometers to get an idea of their values for a straight run and set the pointers on the side of the target.
3. To steer up, extend the right and left the same amount or retract the top cylinder.
4. To steer right, extend the left and then the top, 1/2 the amount of the left.
5. To steer left, extend the right and then the top, 1/2 that amount of the right.
6. To steer down, extend the top cylinder or retract the bottom cylinders.

4.4.6. Pipe Change

After the pipe has been advanced the full length of the jacking frame, (locking ring at end of jacking frame) proceed as follows.

1. Press cutting head control 'STOP'.
2. Perform [4.4.2.1 Slurry Bypass](#).
3. Press 'STOP' slurry return pump, booster pump, and feed pump.
 - ?? If slurry flow through a mechanical separation system is required during the pipe change see [4.4.2.4 Using Above Ground Bypass Valve](#).
4. Turn 'OFF' disconnects for the slurry pumps, boring head, head power, and tunnel light.
5. Close the slurry, cooling water, Bentonite, and high pressure jetting valves on the jacking frame manifold.
6. Disconnect all the hoses and cables going into the pipe being jacked.
 - ?? Make sure all the cables and hose connections are in a clean, dry location and out of the way of the next pipe.
7. Retract jacking frame ([refer to 4.4.4.1 or 4.4.4.2](#)).
8. Lower the next pipe into position and lubricate the sealing ring.
9. Clean connections and connect slurry lines between the pipes.
10. Install cables and hoses through the new pipe.
11. Clean connections and connect cables and hoses.
12. Open the slurry, cooling water, Bentonite, and high pressure jetting valves on the jacking frame.
 - ?? Stop feed pump and close above ground bypass valve if open.
13. Slowly advance the new pipe until it is seated in position ([refer to 4.4.4.1 or 4.4.4.2](#)).
14. Turn 'ON' disconnects for the slurry pumps, boring head, head power, and tunnel light.
15. Press 'START' slurry feed pump, booster pump, and return pump.
 - ?? Check slurry lines for leaks and the separation system for proper operation.
16. Repeat [4.4 typical operation](#) for subsequent pipe installation.

4.4.7. High Pressure Jetting Pump

The high pressure jetting pump can increase production in clays and other sticky material. The pump should not be used in other ground conditions except to be turned on periodically to keep the nozzles clean.

- ?? The switch is located at the bottom of the disconnect panel behind the operator.
- ?? 'AUTO' position - high pressure jetting pump energizes only when cutting head 'LEFT' or 'RIGHT' is illuminated. The message 'JETTING PUMP ON' appears on the primary screen.
- ?? 'OFF' position - high pressure jetting pump always off.
- ?? The high pressure jetting pump and drive motor cooling pump automatically turn off if the water tank level drops below minimum.

4.4.8. Lubrication (Bentonite/Polymer) Pumping System (optional)

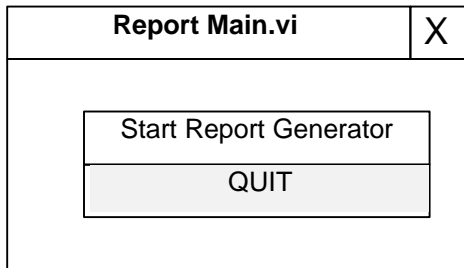
Refer to the Bentonite pump owners manual for operation and specifications.

4.4.9. Daily Shut-Down

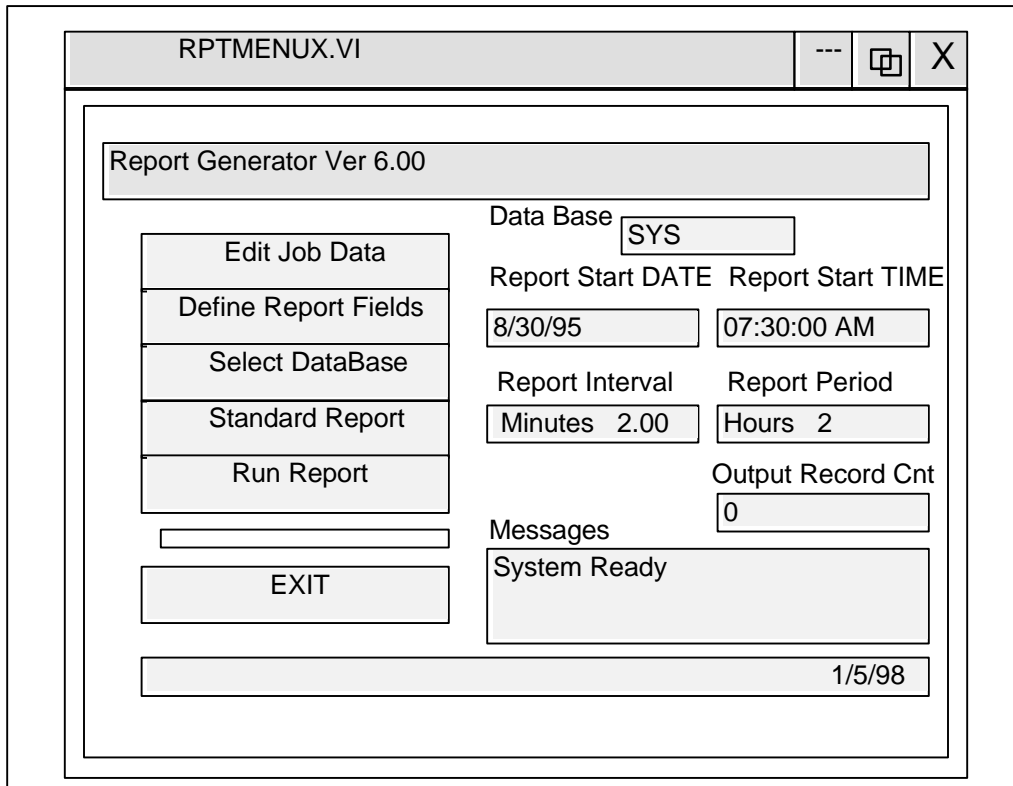
1. Stop jacking frame extension, turn off the MTBM drive motor.
2. Open the MTBM bypass valve and close the stop valves.
3. Flush water through the lines until clear.
4. Shut off the slurry pumps.
5. Close the valves on the manifold at the jacking frame and possibly the supply tanks.
6. Install paper in the printer and print reports.
7. Turn off head power.
8. Shut off all disconnects located across the aisle from console.
9. Turn the console switch to off.
10. Wait for the display to read 'it is now safe to turn off your computer'.
11. Shut off main power disconnect located across aisle from hydraulic pump or turn off the main power source.

4.4.10. Report Printing

1. Before report printing can begin, the printer must be loaded with paper and the 'on line' lamp illuminated.
2. Double click on the Report generator icon.



3. Select 'Start Report Generator'.



4. If a custom Header is desired for a **single report**, select 'Edit Job Data' (shown below) to define the report header information.

JOB Header			
Starting	<input type="text"/>	Ending	<input type="text"/>
Boring	<input type="text"/>	Head:	<input type="text"/>
Prime	<input type="text"/>	Slurry:	<input type="text"/>
Project	<input type="text"/>	Jacking:	<input type="text"/>
Length:	<input type="text"/>	Bentonite:	<input type="text"/>
Drive	<input type="text"/>	Container:	<input type="text"/>
Drive	<input type="text"/>	Job Description:	<input type="text"/>
Pipe	<input type="text"/>		
Number of Pipes	<input type="text"/>		
Pipe Type:	<input type="text"/>	Comments:	<input type="text"/>
Pipe Size	<input type="text"/>		
Pipe Size	<input type="text"/>		
DONE		CANCEL	

5. Select 'Done' after header information has been changed, or select cancel to exit without making changes. If job header changes are desired for all reports, run the Start Drive program ([see section 4.3.2](#)).

- For first drive setup, select 'Define Report Field' (shown below) to obtain the report format desired.

Report Format Editor
Ver 2.0

Column Data Selectors

None None None None None None None None

None None None None None None None None

Column Data Selectors

None None None None None None None None

None None None None None None None None

GET Format SAVE Format DONE

- Select 'get format', select the 'standard format' and customize the report fields by selecting and changing the desired options from the pull down menus shown above.
- Save the format as 'Standard Format'. Select 'Done'.
- When the 'RPTMENUX.VI' returns, fill the boxes for the report date, time, intervals of report and report period hours (length) of report to be printed.
- Select Standard Report.
- Wait for reports to print.

The report is **COMPLETE**
are you **DONE** with the Report Generator?

YES, I'm Done NO, I'M NOT Done

- Select 'Yes I'm Done to exit the report generator program.
- If an error appears while exiting the program, select 'OK'.
- Exit the 'RPTMENUX.VI' program (select Quit) after the reports have been printed.

4.5. End of Drive Shut-Down

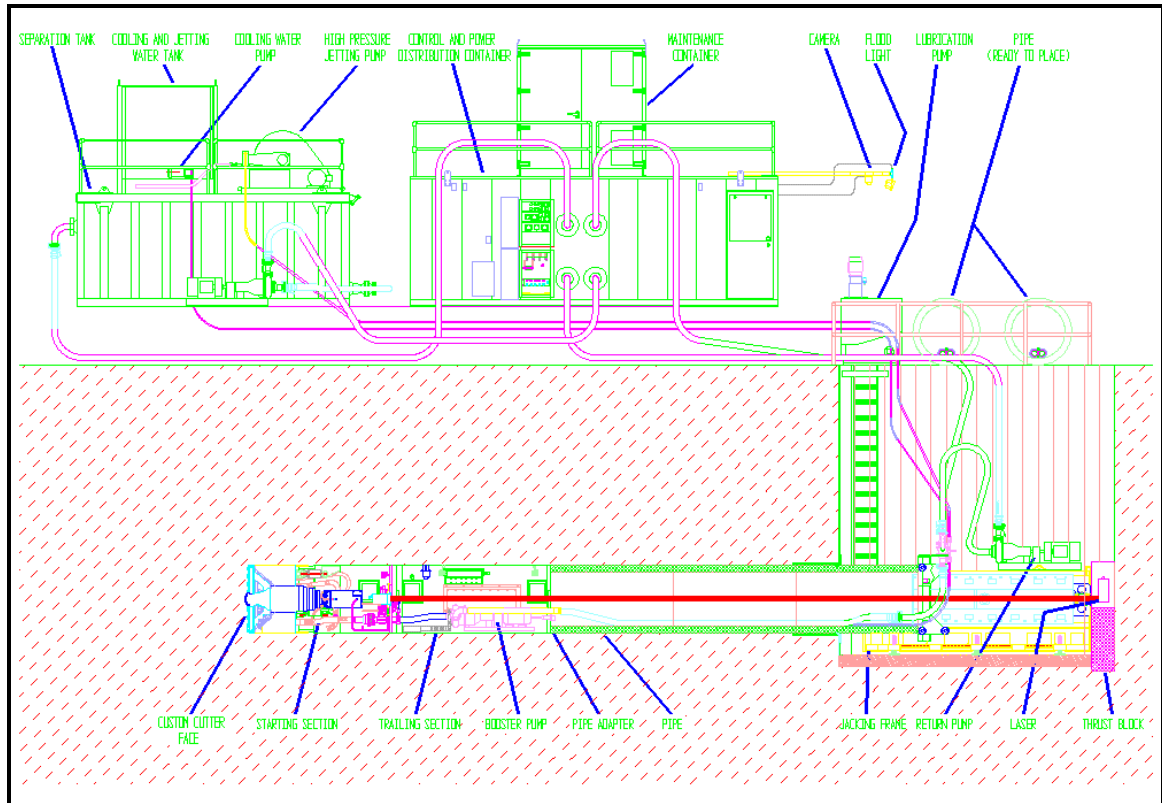
ENDJOB.VI	X
End of Drive	
Ground Condition: <input style="width: 150px;" type="text"/> Date Completed: <input style="width: 100px;" type="text"/>	
Drive Length: <input style="width: 100px;" type="text"/> Number of Pipe Used: <input style="width: 100px;" type="text"/>	
Comments: <input style="width: 300px; height: 40px;" type="text"/>	<input type="button" value="UpdateHeader Information"/>
Drill Series: <input style="width: 50px; text-align: center;" type="text" value="0"/> Drive Number: <input style="width: 50px; text-align: center;" type="text" value="10"/>	
<input type="button" value="Next Drill Series"/> <input type="button" value="Drive Completed"/> <input type="button" value="EXIT"/>	
<input type="button" value="Click before 'Drive Complete' at end on first drive."/> <input type="button" value="Click after a drive is finished."/> <input type="button" value="Without saving"/>	
NEXT DRILL SERIES: Increase drill series by 100. Resets drive number to 1.	
DRIVE COMPLETED: Creates a sequence file. If the drill series is 200 and the drive number is 3 then the sequence file is seq0203.mdb. This file would be saved as Q:\am-tbm\db\seq0203.mdb.	
<input type="button" value="1/98"/>	

1. Print all remaining drive reports desired before running the End Drive program.
2. Start the End Drive program.
3. If this is the end of the first drive of a new project, click on the 'Next Drill Series' button. Then click on 'Drive Complete'. This will save the drive data under the next available sequence number and end the program. This will ensure that the drive will start with a new series.
4. If this is NOT the first drive of a new project, start the End Drive program and select 'Drive Complete'.
5. Back up the records from the drive. Place a blank recordable c/d in the c/d drive. Copy the C:\AM-TBM\DB\seq0001.mdb or the seq with the most recent date (database) by clicking on the file with the left mouse to highlight it. Select EDIT - COPY. Select the c/d drive (D:), then select EDIT - PASTE.
6. Perform the daily shut-down (section 4.4.9)
7. Disconnect all hoses and cables.
8. Reverse the (4.2 Site Preparation) steps to disassemble the system.

5. Tunnel Boring Machine Specifications

See the customer books for complete details of your specific MTBM.

6. System Overview



Slurry Circulation System

The slurry circulation system removes spoil from the cutter face. This is accomplished by pumping clean slurry water to the MTBM, mixing spoil and slurry using valve controlled slurry paths in the MTBM, and pumping the slurry to the surface for separation.

The slurry system can consist of a slurry tank, feed pump, MTBM slurry valves, booster pump, and return pump. Mechanical slurry separation systems have been used successfully instead of settling tanks where needed. VFDs (Variable Frequency Drives) are commonly used on pumps to adjust the flow and pressure of the slurry for the ground conditions encountered.

Pipe Jacking System

The pipe jacking system (jacking frame and optional intermediate jacking) provide the horizontal thrust to push the MTBM and pipe through the ground.

There are several sizes of microtunneling jacking frames that are available. Each jacking frame has optional extensions available to optimize the jacking shaft size for the length of pipe used. The jacking frame can develop jacking forces of 300, 400 or 800 tons depending on model used. Each frame comes with a bulkhead to mount valves for slurry, bentonite and drive-motor cooling water. This simplifies turning off the fluids for disconnecting the lines when installing another pipe. An optional electrical box which contains connections for the wheel counter, laser power, jacking stop switch and MTBM methane system warning horn can also be provided.

Information and Control System

The information and control system monitors all inputs such as targeting data, pressures, temperatures, positions, speeds, torque's, and flows, and reports them to the operator. The control system also operates all outputs including valves, motors, pumps, etc.

The control container contains the control console, flow meters, power distribution, hydraulic power pack and VFDs for the slurry pumps and TBM drive motor. It also has a bulkhead panel for the electrical and hydraulic connections. The control console has a computer that interfaces to the operator and controls machine operations. Information is displayed on a monitor graphically as well as numerically for the operator. Data is logged on the project's progress and reports can be printed for contractor or engineering firm records.

6.1. Microtunneling Boring Machine (MTBM)

The purpose of the MTBM is to excavate material at the cutter face and guide (steer) the pipe through the ground. The MTBM is split in half (thirds on small diameter MTBM's) to minimize the size of launch shafts required. The front half of the MTBM is called the starting section. The starting section performs the excavation and steering. The second half of the MTBM is the trailing section. The trailing section features a small on-board hydraulic power pack, control system for the MTBM, camera, submersible pump, and torque fin (dirt wing). Larger diameter MTBM's may also include a slurry booster pump in the trailing section.

MTBM diameters may range in sizes from approximately 24 inches through 90 inches outer pipe diameter. Ground conditions can range from dry to saturated with water, fine-grained to gravel, and loose soil to soft rock. Although consistent ground conditions work the best, the MTBM will cut through layers of different types of soil. The machine will also tolerate soft rocks that are up to 1/3 the diameter of the machine.

6.1.1. Cutter Face

The cutter face and crushing chamber reduces excavated spoil down to a size capable of entering the slurry chamber through the spoil entrance screen. The mixing of the spoil and slurry water occurs in the slurry chamber. Spoil is then removed from the slurry chamber via the slurry return pump and optional slurry booster pump.

- ?? Soft rock of approximately 30% of the MTBM diameter can be crushed by the cutter face/crushing chamber. The tapered crushing chamber has wear bars and heat treatments to increase strength.
- ?? The cutter face uses carbide teeth and carbide hard facing to minimize wear.

6.1.2. High Pressure Jetting Nozzles

High pressure jetting nozzles can increase the MTBM production in clays. These nozzles are built into the crushing chamber. Ball valves in the MTBM select the number of high pressure nozzles that are active. Reducing the number of nozzles will increase pressure and vice versa. See [6.6.2 High Pressure Jetting](#) for more information.

6.1.3. Drive System

All MTBM's use a water-cooled electric motor and planetary gear reducer to power the cutter head. The cutter head can be rotated in either direction.

6.1.4. Drive Shaft

A drive shaft, splined on both ends, transfers power from the gear reducer to the cutter head.

6.1.5. Bearings

All Akkerman MTBM's have high capacity thrust bearings running in an oil bath and are protected by heavy duty seals.

6.1.6. Seals

A lip seal and a heavy metal shield are located in front of the thrust bearing mechanical seals. Grease is continually pumped through the lip seal to the crushing chamber. The drive motor water cooling supply is also used to flush between the front lip seal and the heavy metal shield. This purges contaminants from the seal surface.

O-ring seals at the steering cylinder joint allow movement of the articulated joint but prohibit intrusion of slurry water into the MTBM.

6.1.7. Gear Reducer

A planetary gear reducer transfers power from the drive motor to the cutter face. The gear reducer has an integral reservoir to hold lubricating oil.

6.1.8. Drive motor

Power for the cutter face comes from the electric drive motor which mounts to the gear reducer located behind the slurry chamber.

- ?? The electric drive motor is water cooled. Coolant exiting the water jacket is flushed into the slurry water.
- ?? A variable frequency drive (VFD) controls speed of the MTBM drive motor (0 - 1800 rpm). The motor is mounted to the planetary gear reducer. With varied ground conditions the operator can adjust cutter face speed and rotation direction to maximize production.
- ?? The VFD provides 150% - 200% overload capability to the cutter face (depending on MTBM diameter) and torque boost at startup.
- ?? Drive motor cooling water flow must be present while drive motor is in operation.

6.1.9. Grease Pump

The grease pump injects lubricant into the thrust bearing lip seal. This purges all contaminants from the sealing surface into the crushing chamber. It will pump for approximately 12 seconds every minute. Using this rate will ensure that grease is uniformly distributed throughout the entire length of the boring drive, a low level switch is used to warn the operator should the supply reservoir require refilling. The grease pump automatically cycles on and off when the drive motor is energized. The operator has manual control of the grease pump in the container. Typically manual control is used during MTBM maintenance to ensure that the grease cavities are full.

6.1.10. Hydraulic System

Hydraulic power for the MTBM is supplied by a 2 horsepower on-board hydraulic power pack. This hydraulic system operates the three steering cylinders, slurry bypass valve, slurry stop valve, slurry chamber/face modulating valve, and torque fin (dirt wing). The on board hydraulic pump has the following advantages.

- ?? No hydraulic lines are required through the tunnel.
- ?? Split flow system allows simultaneous operation of slurry valves and steering cylinders.
- ?? With all MTBM hydraulics on-board the MTBM hydraulic contamination will be minimal which results in improved reliability and longer component life.
- ?? Heat generation for this hydraulic system is negligible. The 2 HP hydraulic motor only energizes when actuating an MTBM hydraulic function.

6.1.11. Valves

The hydraulic valves for the three steering cylinders operate at pressures up to 7,200 psi. The slurry bypass valve, slurry stop valve, slurry chamber/face modulating valve, torque fin (dirt wing), and optional jack advance cylinders operate at pressures up to 3,500 psi. All hydraulic valve coils in the MTBM are 24 Volt DC.

6.1.12. Starter Hoses

Hydraulic starter hoses are used to connect the on-board hydraulic power pack in the trailing section with the MTBM starting section during a drive launch in which the MTBM sections need to be separated.

6.1.13. Steering

See [\(4.4.5 steering\)](#) for steering procedures.

Piloting the course of the MTBM is accomplished by extending or retracting one or more of the three hydraulic steering cylinders.

Steering corrections should be made gradually in small increments in order to minimize pipe jacking forces.

A sealed articulated joint which allows for steering corrections is located approximately 40% back from the front of the MTBM starting section.

6.1.14. Cylinders

Hydraulic steering cylinders are located at 12 o'clock, 4 o'clock, and 8 o'clock and are referred to as the top steering cylinder, right steering cylinder, and left steering cylinder respectively as viewed from the back of the MTBM.

6.1.14.1.Linear Transducers

Each steering cylinder has a linear transducer attached to it to measure the stroke position of the steering cylinder. Steering cylinder position is displayed in percent of stroke to the operator on the primary screen and is also used to calculate anticipated position of the MTBM for the target area of the primary screen.

6.1.14.2.Pressure Transducers

Each steering cylinder uses a pressure transducer to measure hydraulic pressure in the extend chamber of the cylinder. This information is used to calculate face pressure on the MTBM.

6.1.15. Inclinometers

Inclinometers are used to measure the vertical angle of the MTBM with respect to true level (not with respect to the laser).

- ?? One inclinometer is mounted between the cutter face and the steering joint to measure the incline forward of the steering cylinders.
- ?? A second inclinometer is mounted between the steering joint and the rear of the MTBM starting section to measure vertical angle behind the steering cylinders.
- ?? The vertical angles from the inclinometers aid the operator in steering the MTBM.
- ?? The inclinometers are housed in a NEMA 4X enclosure and are potted to protect the circuit from moisture.

6.1.16. Target

The water resistant target provides position and angle of the MTBM so that the operator can accurately guide the MTBM through the ground. The target is mounted at the back of the MTBM starting section.

The target measures and outputs:

- ?? MTBM horizontal angle with respect to the laser.
- ?? MTBM vertical angle with respect to the laser.
- ?? MTBM incline for back of the starting section. This value is redundant with a separate inclinometer mounted in the MTBM (see [6.1.15 Inclinometers](#) for more information).
- ?? MTBM X and Y coordinates with respect to the laser.
- ?? MTBM roll.
- ?? Anticipated position of the MTBM in 10 feet. This value is calculated using target positions, angles and steering cylinder position.

6.1.17. Submersible Pump

If water should happen to enter the MTBM, the submersible pump can be used to pump water out of the machine. Water in the machine is normally due to water spills during the installation of slurry pipe or possibly from jacking shaft ground water leakage into the pipe line.

- ?? Submersible pump automatically energizes when the MTBM power is on and the water level rises to the level switch. The operator may also use the momentary control switch to turn the pump on.
- ?? Discharge water is pumped into the slurry return lines.

6.1.18. Electronic Control

The control system monitors all inputs such as targeting data, pressures, temperatures, positions, speeds, torques, flows, and reports them to the operator. The control system also operates all outputs including valves, motors, pumps, etc.

- ?? The same control system can be used for all MTBM sizes.
- ?? System control processor is located in console. This processor communicates over a single pair of wires (reducing the number of conductors in the tunnel) to 'smart' input / output (I/O) blocks in the console and container. From the container, two pairs of wires (one for signals, one for redundancy) connect through the tunnel to the MTBM. In the MTBM the controller communicates with 'smart' I/O blocks and a programmable logic controller (PLC) to control MTBM functions and provide sensor data back to the operator.
- ?? The 'smart' I/O blocks automatically provide diagnostic information on device wiring, power conditions, loads, and circuits. The 'smart' I/O blocks also help identify the possible cause of problems when and if they occur. This information is displayed on the monitors in the console. If overloads or short circuits are detected, output circuits turn off immediately, protecting circuitry and wiring. The smart switch responds much faster than conventional fuses and can be reset automatically from remote locations.
- ?? The programmable logic controller (PLC) located in the MTBM includes analog to digital converters for pressures, temperatures, and positions and RS232 communications with the target.
- ?? Critical MTBM operations such as slurry valves opening and closing, steering cylinders extending and retracting, MTBM hydraulic pump and submersion pump are connected to both 'smart' I/O blocks and the PLC for redundancy. Example, if the 'smart' block fails to extend the top steering cylinder, the control system can attempt to extend the cylinder using the PLC. The value of this system is especially important in small diameter MTBMs where service is difficult.
- ?? Uses an industrial communication network that was originally designed for the harsh military environment with extreme electrical noise. This network is rated for 3,500 feet.

6.1.19. Slurry System

Inside the MTBM are the slurry stop valve, slurry bypass valve, and slurry chamber/cutting face modulating valve, and the optional slurry booster pump. See [6.2.3 MTBM Slurry](#) for more information.

6.1.20. Video Camera

The MTBM camera is used as a backup passive target or for maintenance purposes. On larger diameter MTBMs a camera with pan and tilt can be used.

6.1.21. Cables

6.1.21.1. Auxiliary Equipment Cable

The auxiliary equipment cable has 6 pins and 12 gauge wire.

- ?? Connects from the control container 'head power' receptacle through the tunnel to the MTBM trailing section. This provides 240 Volt, 3 Phase AC power for the MTBM information and control system, MTBM hydraulic pump, and MTBM submersible pump. In addition the 24 Volt DC MTBM maintenance light receives power from this cable.
- ?? This cable uses a pilot circuit which verifies that all cable connections have been made before the 240 Volt power is energized.
- ?? The same cable is used for drive motor cooling.

6.1.21.2.Main Control Cable

The main control cable has 16 pins and is shielded pair type cable.

- ?? Connects from the control container 'head control' receptacle through the tunnel to the MTBM trailing section.
- ?? One pair of wires in the cable is for the MTBM control system. A second pair serves as backup for the control system. The cable includes wire pairs for the MTBM video and audio.
- ?? All signals in the cable are low voltage.

6.1.21.3.TBM Cable

The TBM cable carries input and output signals from the PLC controller to junction boxes within the MTBM. It has 61 pins and is manufactured in 5.5 feet and 9.5 feet lengths. The length of cables used will vary by machine design. Each MTBM uses two TBM cables.

6.1.21.4.MTBM Starter Cable

The MTBM starter cable has 61 pins and is 150 feet in length. The MTBM starter cable is used to connect the MTBM electrical control box in the trailing section with the front electrical junction box during a drive launch if the MTBM sections need to be separated.

6.1.21.5.MTBM Drive Motor Cable

The MTBM drive motor cable connects from the control container 'cutting head drive' receptacle through the tunnel to the MTBM drive motor. The cable has a pilot circuit which verifies that all cable connections have been made before the drive motor is energized.

On small diameter MTBM's with smaller drive motors, the drive motor is powered by [6.1.16.6 Booster Pump Cable](#).

6.1.21.6.Booster Pump Cable

The booster pump cable connects from the control container 'slurry booster' receptacle through the tunnel to the slurry booster pump. The cable has a pilot circuit which verifies all cable connections have been made before the slurry booster pump is energized.

6.2. Slurry Circulation System

6.2.1. Feed Pump

During normal tunnel excavation, the slurry feed pump takes water from the settlement tank and pumps it (1) through a flow meter in the control container, (2) through the slurry above ground bypass, (3) through the shaft stop valves, and (4) through the tunnel to the front of the MTBM.

Different flow-paths may be selected if the operator desires to continue slurry flow during a pipe change (see [6.2.5 Slurry Above Ground Bypass](#)) or reverse the slurry flow direction in the MTBM (see [6.2.7 Shaft Stop Valves](#)).

All slurry pumps use variable frequency drives for speed adjustment. This is of great value as pump speed affects pressure of the slurry water at the cutter face. Excessive water delivered to the MTBM can cause excessive pressures and too much water returned can cause voids.

6.2.2. Return Pump

The slurry return pump takes water from the front of the MTBM (output of the slurry booster pump if applicable) and pumps it through a flow-meter in the control container, through the slurry above ground bypass, and finally to the slurry settlement tank.

6.2.3. MTBM Slurry

6.2.3.1. Bypass Valve

The bypass valve allows slurry water to flow through the tunnel and make a U-turn at the MTBM without entering the slurry chamber or cutting face. The bypass valve must be open if the stop valves are closed. During typical tunneling excavation the bypass valve is closed (stop valves open) to direct slurry water to the slurry chamber and cutter head. The bypass valve is opened (stop valves closed) to flush the pipelines of excavated spoil if build up should occur or when tunneling is paused.

On rare occasions it may be beneficial to partially open the bypass valve while tunneling (stop valves open). The benefit of doing this is to maintain a high slurry flow rate through the tunnel so that spoil remains suspended in the slurry water. However it should be noted that partially opening the bypass valve will decrease the slurry flow-rate to the slurry chamber and the cutter head,

6.2.3.2. Stop Valve

The slurry stop valves inhibit water from going to the front chambers of the MTBM and mixing with the spoil. The stop valves are operated fully open or fully closed. When the stop valves are closed, the slurry bypass valve must be open. The stop valves are opened when tunneling excavation is to occur.

6.2.3.3. Slurry Chamber/Cutting Face Modulating Valve

While tunneling, the operator can adjust the slurry chamber/cutting face modulating valve to change the ratio of slurry water entering the slurry chamber (for mixing with spoil) or entering the cutter face (for aiding in grinding). Different soil conditions require different ratios to maximize production.

Since this is a modulating valve, opening the valve to allow more slurry water to the cutter face will close the valve which lets slurry water into the slurry chamber. For example, if 60% of the slurry goes to the cutter face, then 40% is directed to the slurry chamber. Likewise, if 25% of the slurry goes to the cutter face, then 75% is directed to the slurry chamber, etc.

6.2.3.4. Booster Pump

During normal tunneling the optional slurry booster pump removes slurry water from the larger MTBM's slurry chamber and pumps it through the tunnel and the shaft stop valve to the slurry return pump. If the slurry stop valves are closed (bypass valve must be open), the slurry booster pump draws water from the feed pump and forces it to the return pump.

- ?? Booster pump is capable of up to 3" diameter solids.
- ?? Typically mounted in the MTBM trailing section.

6.2.4. Flow-Meters

The magnetic flow-meters measure flow-rate of slurry water being sent to and returning from the MTBM.

- ?? Measuring flow-rate is important since excessive water delivered to the MTBM can cause excessive pressure and too much water returned can cause voids.
- ?? The flow-meters are mounted in the container.
- ?? The flow-meters require no calibration or maintenance.

6.2.5. Slurry Above Ground Bypass

Opening the slurry above ground bypass, closing the shaft stop valves, and energizing the slurry feed pump is typically done during a pipe change when using a mechanical slurry separation system which requires a continuous slurry flow.

If slurry separation is accomplished using a settlement tank, this procedure would normally not be required.

6.2.6. Slurry Settlement Tank

Settlement tanks are used to either let the excavated material settle out of the return slurry or to catch the slurry water returning from a separation system. The baffles in the tank create separate compartments within the tank to aid in separation. Fittings for the feed pump and an input port are provided if needed.

- ?? The slurry settlement tanks are approximately 24' L x 8' H x 8.5' W.

6.2.7. Shaft Stop Valves

When closed the shaft stop valves prevent slurry water from entering the tunnel. The shaft stop valves are closed during a pipe change to prevent the slurry settlement tank from draining into the jacking shaft when the tunnel slurry lines are disconnected.

The shaft stop valves are typically mounted to the slurry/bentonite/water manifold on the jacking frame.

6.2.8. Slurry/Bentonite/Water Manifold

The slurry/bentonite/water manifold is used to shut off slurry, bentonite, and water supplies to the MTBM during a pipe change. The manifold has two shaft stop valves for slurry, a valve for bentonite, a valve for drive motor cooling water, and a valve for high pressure jetting water. The valves are attached to a steel framework that is normally mounted to the pipe jacking frame.

6.2.9. Hoses and Lines

Flexible hoses with quick coupling connections are used above ground, down in the shaft, in the tunnel at an intermediate jack station, and at the MTBM flexible joints.

Slurry water pipe (trunk line) carries slurry, bentonite and cooling water through the tunnel and are available in many common pipe lengths.

- ?? Features a self aligning quick connection.

6.3. Jacking System / Hydraulic Power Pack

The hydraulic power pack supplies hydraulic power to the jacking frame extension cylinders, optional systems such as jacking frame position locks, jacking frame staging grippers, intermediate jack stations, and winch.

- ?? Controlled from the operator console. Console displays flow %, filter condition, operating pressure, oil temperature, and oil level.
- ?? 100 HP AC motor.
- ?? 0 - 12 GPM with infinite control via remote proportional actuator.
- ?? 8,000 psi main jacking pressure.
- ?? 3,000 psi auxiliary functions.
- ?? 300 gallon oil reservoir.
- ?? 10 micron filtration.
- ?? Located in the control container.

6.3.1. Hydraulic Pump

Variable displacement piston pump with 0 - 12 GPM flow-rate which is controlled with a remote proportional actuator.

6.3.2. Remote Proportional Actuator

The electrically controlled remote proportional actuator varies the stroke of the 100 HP hydraulic pump thereby changing the hydraulic flow-rate.

6.3.3. Auxiliary Hydraulic Pump

The split flow auxiliary hydraulic pump provides 12 GPM flow through the oil cooler and 1 GPM flow for pilot pressure of the remote proportional actuator.

6.3.4. Oil Cooler

The air over oil cooler provides 60,000 BTU of cooling for hydraulic oil in the jacking system hydraulic power pack tank.

- ?? Oil cooler fan automatically starts when the auxiliary hydraulic pump is energized.
- ?? Louver covers on the exterior of the control container should be opened to allow hot air from the oil cooler to exit the building.

6.3.5. Resistance Temperature Detector

A resistance temperature detector (RTD) measures tank hydraulic oil temperature and relays the information to the control system. The RTD is located at the bottom center of the tank.

6.3.6. Pressure Gauges

Two pressure gauges are mounted on the top right of the tank.
The 10,000 PSI gauge monitors output pressure of the 100 HP pump.
The 600 PSI gauge monitors the output of the auxiliary hydraulic pump which provides pilot pressure for the remote proportional actuator.

6.3.6.1. Pressure Transducers

Each gauge in **6.3.5 Pressure Gauges** has a pressure transducer which converts pressure into electrical signals for use by the control system. It is this conversion which allow pressures to be displayed to the operator at the console. An additional pressure transducer is used to measure jacking cylinder extension pressure.

6.3.6.2. Sight Gauge

The sight gauge on the right side of the hydraulic tank provides visual inspection of oil level and color. Oil level is scaled in 55 gallon increments.

6.3.6.3. Level Transducer

An ultrasonic level transducer senses hydraulic oil level and provides an electrical signal to the control system which displays the information to the operator at the console. This transducer is a small cylinder (approximately 1" diameter x 4" long) located to the left of the pressure gauges.

6.3.7. Filters

The jacking return filter and jacking pump output filter both provide visual and electrical indication of filter condition. The filters achieve 10 micron filtration.

6.3.8. Optional Wheel Counter

The optional wheel counter measures the amount of pipeline installed. The wheel counter mounts to the jacking shaft wall near the top of the pipe seal and connects the pit box.

6.3.9. Jacking Frame Cable

The jacking frame cable has 16 pins. The male pin end of the cable and the female socket end both have a rotating coupling nut.

- ?? Used on model MT-400 jacking frames.
- ?? Connects from the control container 'jacking frame' receptacle to the jacking frame.
- ?? Cable wire pairs connect to the optional linear transducers in the jacking frame locking ring to report location of the position locks to the control system.
- ?? All signals in the cable are low voltage.
- ?? Cable is also used for [6.6.8.1 Pit Box Cable](#).

6.4. Lubrication (Bentonite) Pumping System (optional)

Refer to the Bentonite pump owners manual for operation and specifications.

Bentonite is a naturally occurring form of clay. Bentonite is pumped through ports in the pipe and enters the annulus between the outside of the pipe and the ground. Each Bentonite port typically has its own tunnel valve. Being a lubricant, Bentonite can reduce the jacking forces required to advance the MTBM and pipe in certain ground conditions. There are also several agents (polymers) that can be used to enhance bentonite properties. The Akkerman Model ER-2250 Bentonite pump features:

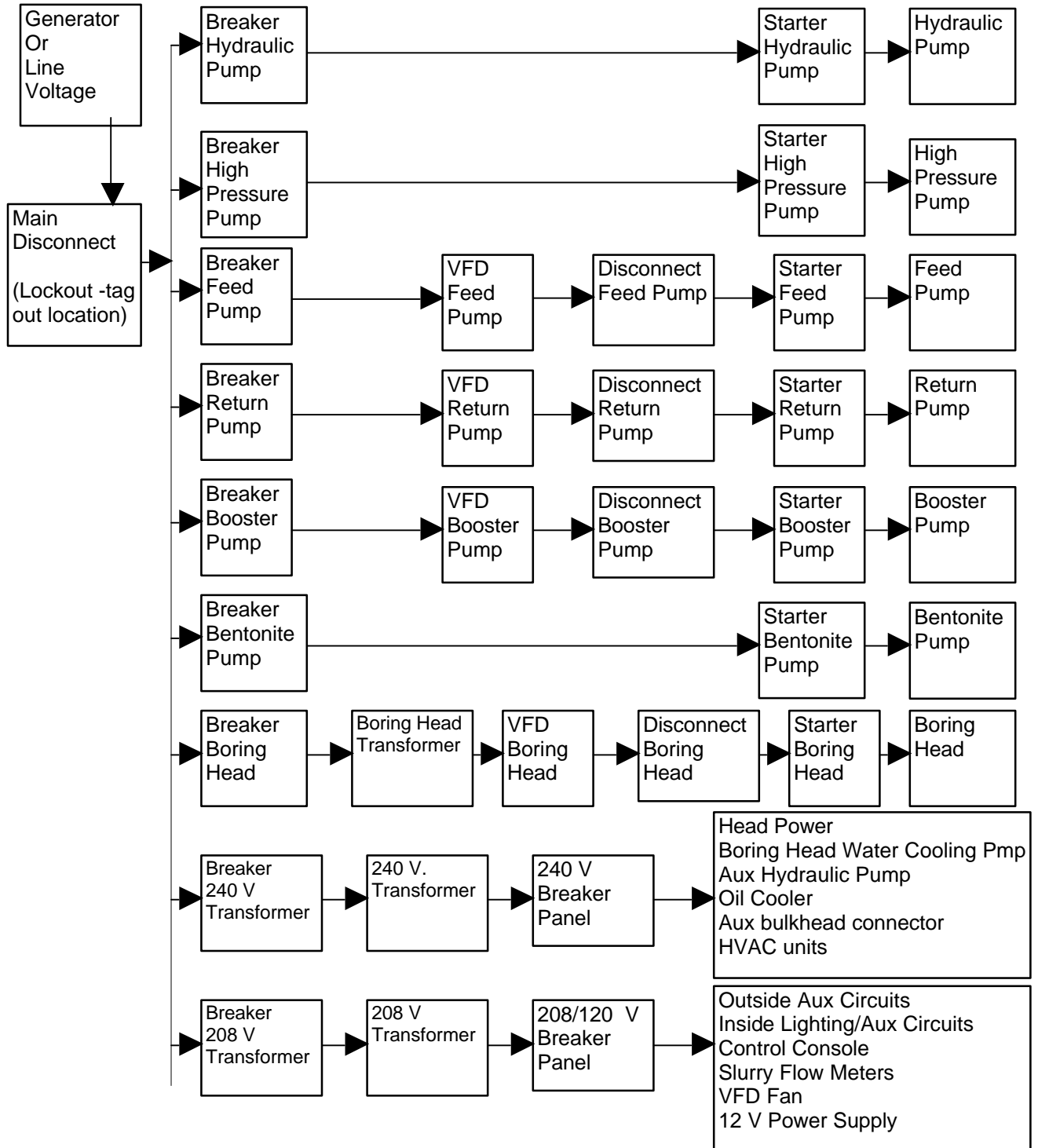
- ?? Independent remote operation of up to 8 Bentonite valves in the tunnel. This gives the operator control of specific locations that the Bentonite is to be injected, and hence lubrication of the entire pipe string will occur.
- ?? Optional control from the operator console or a remote enclosure.
- ?? Model ER2250 displays gallons per minute and total gallons pumped.
- ?? Model ER2250 will display tunnel valve condition (open or closed).
- ?? (2) 250 gallon tanks allow continuous mixing and pumping.
- ?? 0 to 26 gallons per minute at 225 PSI (infinitely variable).
- ?? Non-pulsating pump.
- ?? Independent control of mixers.
- ?? 10.5' L x 4' W x 7' H. (dimensions vary per model)

6.5. Information and Control System (Console)

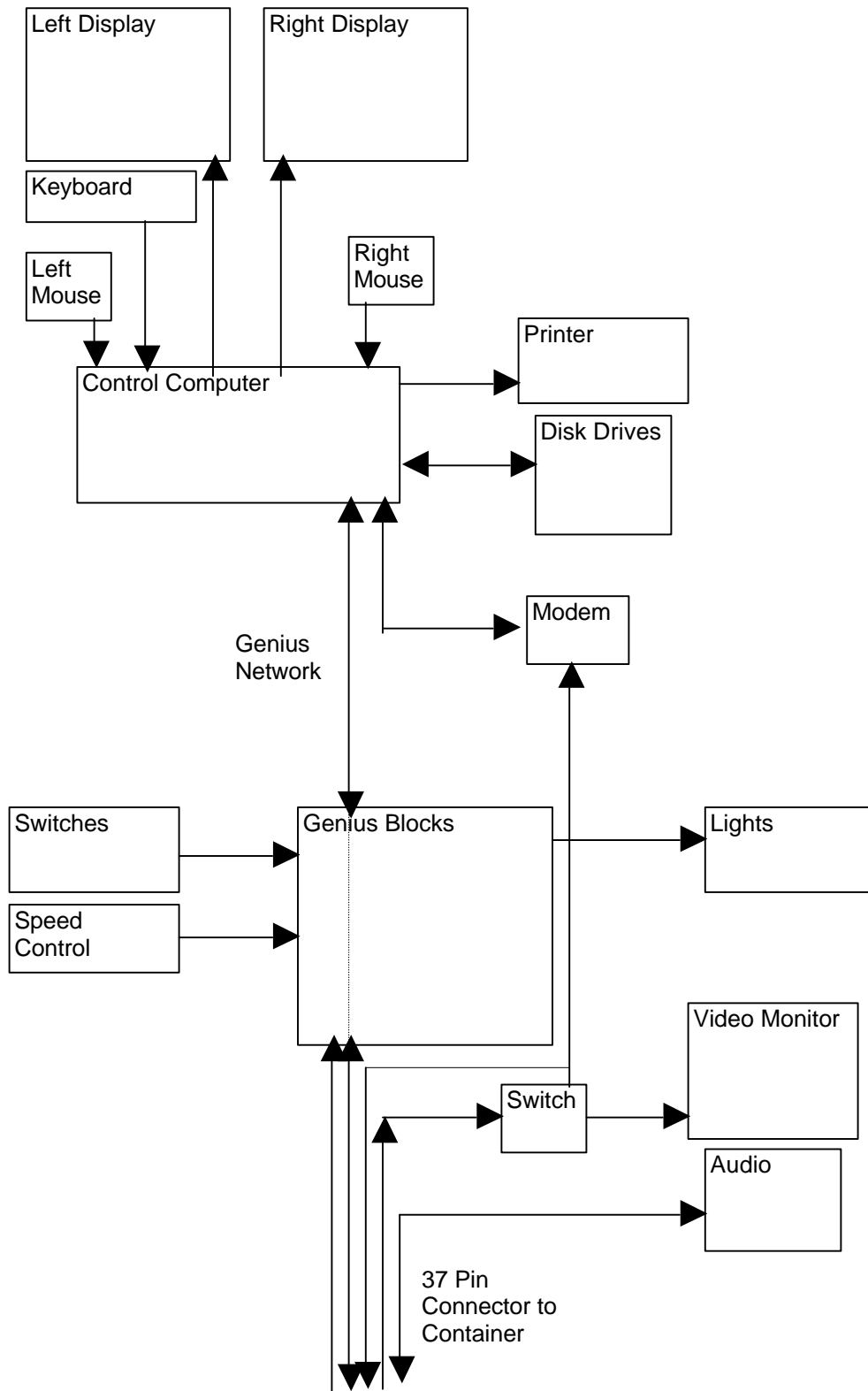
6.5.1. Electrical Overview

There are 2 areas of the electrical system: Power and Control. The following is a high level diagram of each system.

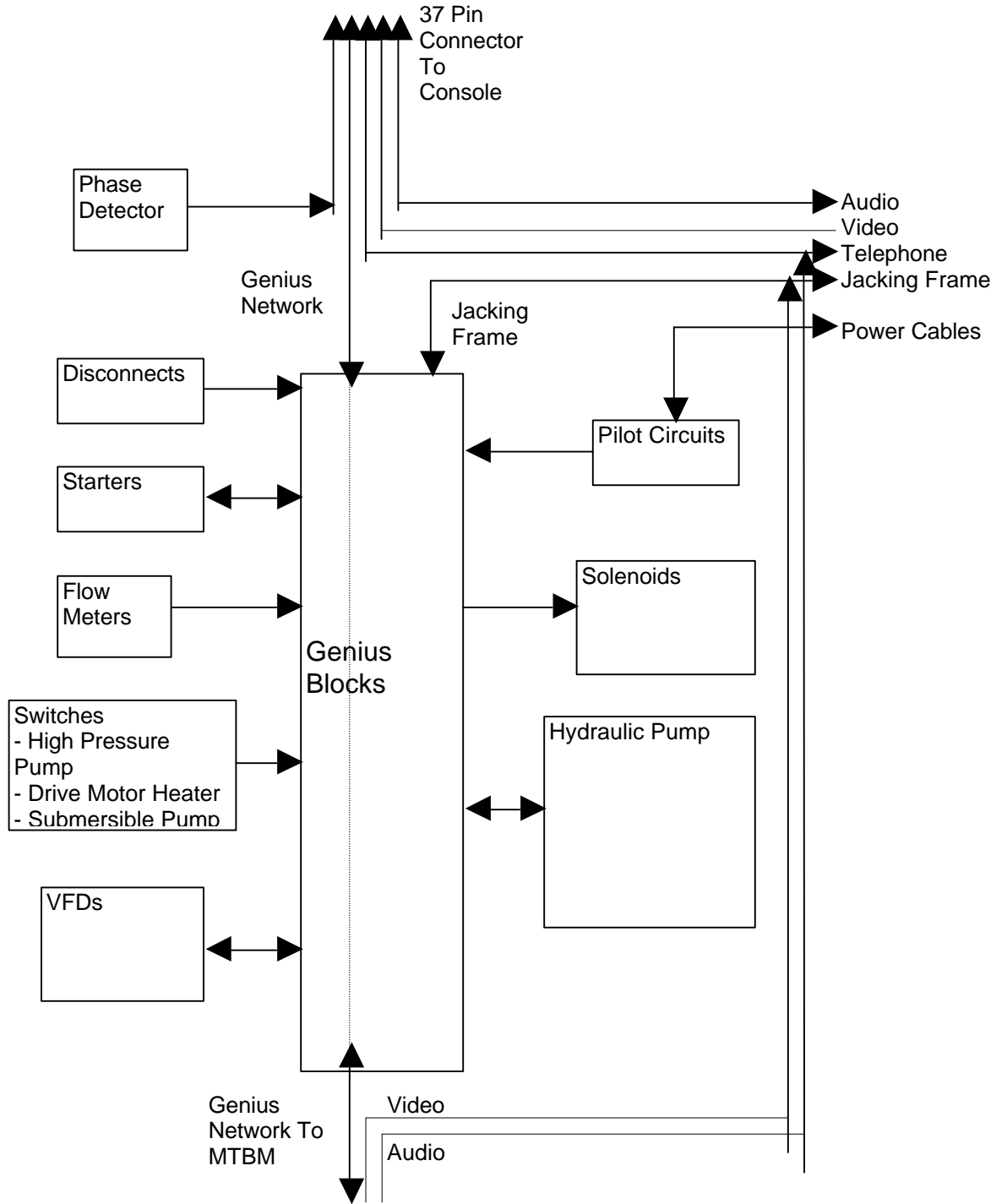
Block Diagram of the Power System



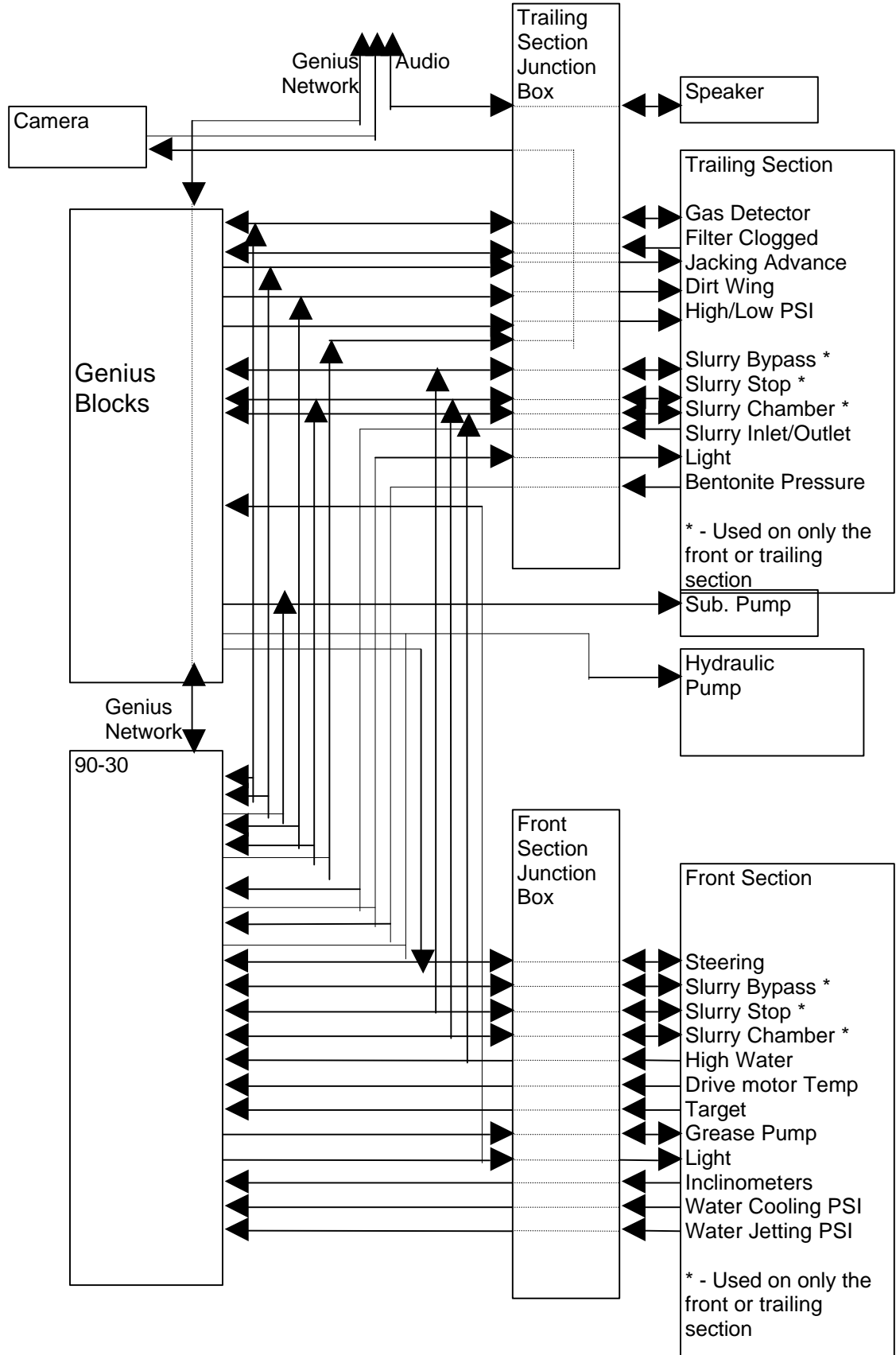
Block Diagram of The Console Control Circuit



Block Diagram of The Container Control Circuit



Block Diagram of The MTBM Circuit



6.5.2. Audio

6.5.2.1. Tunnel Mic/speaker - Microphone Volume

This adjusts the volume as heard by the control console operator.

6.5.2.2. Tunnel Mic/speaker - Speaker Volume

This adjusts the volume of the MTBM speaker.

6.5.2.3. Tunnel Mic/speaker - Push to talk

This button must be pressed for the console operator to speak to the person in the MTBM.

6.5.2.3.1. Optional Belt Packs

?? Volume Control adjusts the listening level of the incoming signal. The listening level has no effect on the outgoing 'talk' signal. It's range is from full off (counter-clockwise) to full on (clockwise).

?? Talk Button - turns on and off the microphone circuit. The button has dual action. If it is pressed and held, its action is momentary. The microphone circuit is turned on and remains on only until the button is released. If a locking action is desired, the talk button must be pushed and released twice in quick succession. This action will latch the microphone circuit on. It is released (turned off) by momentarily pressing and releasing button again.

?? Indicators - The green MIC ON LED indicates that the microphone circuit is on. The call indicator is a high intensity, multi-element, red LED that illuminates whenever a 'Call' signal is present on the respective intercom line.

6.5.2.3.2. Console Intercom System

?? A/B Channel Select - This toggle switch selects the channel on which the operator will communicate. Channel A and B have been tied together therefore the switch can be in either position. We prefer the B position.

?? Volume - This knob adjusts the listen-level for the speaker/headset.

?? Mic On/Off/(On) - This three-position toggle switch determines the activity of the microphone in the headset, handset, or gooseneck. When the switch is set to the top "on" position the microphone remains on. When in the middle position the microphone is off, The bottom "(on)" position is a momentary setting. For normal operation the switch should be left in the up position. The Call button is a black push-button and activates the visual signal circuit which is standard on Clear-Com intercoms.

6.5.3. Control of Display

6.5.3.1. Auxiliary Selector

The auxiliary selector or 'mouse' is the device that is mounted in the doors of the control console and is used to control the computer screen pointer and select functions. The left and right black switches represent the left and right mouse buttons. The round button, located between the left and right buttons is pressure and direction sensitive. To move the cursor in a direction, push the button in that direction. To move faster, push harder. The 'mouse' located on the left door will control the cursor on the left screen and the 'mouse' located on the right door will control the cursor on the right screen.

6.5.3.2. Keyboard Select

This selects if the keyboard to be used with the left monitor or the right monitor.

6.5.4. System Databases

The system database is created in Microsoft Access. Therefore all Access facilities can be used to work with the database. See Microsoft Access manuals for more details.

The name of the database used during runtime for logging and daily reports is:

Q:\am-tbm\db\sys.mdb

The programs that use the SYS.MDB data base are:

Start Drive

End Drive

Data Logger

Error Logger

DB editor

RPT Designer

Report Generator

The databases that contain data from previous drives has the form SEQJJDD where JJ is the Job sequence number starting at 0 and the DD is the drive sequence number starting at 01. The data for the third drive of the second project would be SEQ0103.MDB. If the job sequence number is incremented on the first job then the data base name would be SEQ0203.MDB. This gives a unique name to each drive. All of the c/d's containing data bases can be taken to the office and kept in a common place for future reference. In this manner any database for any drive and job can be found.

6.5.5. AM-TBM Windows Program Group

The icons (pictures) for the most often used programs are on the monitor screen for easy access. The windows program group used for microtunneling is called 'AM-TBM'. This program is launched (started) with the startup programs. The startup programs are those that are started during the power up of the computer. Other less frequently used programs must be executed by double-clicking on an icon. In the startup group on the left monitor should be 'Akkerman AM-TBM' control software and the right monitor should be 'Data-log 62' and 'Visual IO Works Manager' and 'Soft Logic Link'. This leaves 'Report Dsgnr', 'Report Generator' 'Start Drive', 'End Drive', 'PC Anywhere' and 'PC Anywhere Auto Host' which must be started manually.

6.5.6. AM-TBM Screens during Operation

The Target Screen (see 4.3.1 Daily Startup) has Secondary screens in a pop down menu that can be accessed by clicking on the top line where it says 'Akkerman Inc. -...'. The options are:

Item	Description
Additional Meters Screen	Additional meters and camera control
Print Previous Days Report	Not Implemented
Print Report	Not Implemented
Job Start/End	Not Implemented
Add Comments to Database	Not Implemented
Repair/Compact Data Base	Not Implemented
Go To Parts Data Base	Not Implemented
Backup to Tape	Not Implemented
Quit	Exits Program

6.5.6.1. Primary Target Screen

The microtunneling control software or 'primary target screen' (see 4.3.1) provides the operator with most of the information needed to control the machine. It is normally run on the left monitor, but can also be run on the right monitor. The screen is divided into four areas: bar graph, numeric data, target animation, and messages and errors.

1. The bar graphs and numeric areas animate a bar meter for graphical / numerical display of the most dynamic pieces of information. The operator can pull down a menu by clicking on the meter desired and do the following:

Item	Description
Alarm Monitor	This has a menu that allows the operator to specify a condition, limit, audible, visible and color. The audible, visible and color indicate an action if the condition and limit are exceeded. Color and audible are easy to understand. When the condition and limit are exceeded the bar changes color and beeps. Visible operates the same way. By selecting visible the bar will be invisible if the condition and limit are not exceeded. When the limit is exceeded the meter becomes visible. If visible is not selected, then it is assumed the meter is to be displayed at all times.
History Trending	Display a graph which plots data in real time.

2. The Pipe Advance Total and Pipe Advance Count do not have the above options, instead they have the options to set to 'Automatic' - where the control system increments the values, or 'Manual' - where the operator must change the value, 'Set' - which will set the value to anything the operator inputs, 'Increment' - which increments the value by 1, and 'Decrement' - which decreases the value by 1.

In addition all the offsets have an option to input an adjustment. This will be added to the number that is displayed. This way the offsets can be made to read 0 when the machine is moving in a straight line with the laser. The adjustments (offsets) are not reflected in the printed reports.

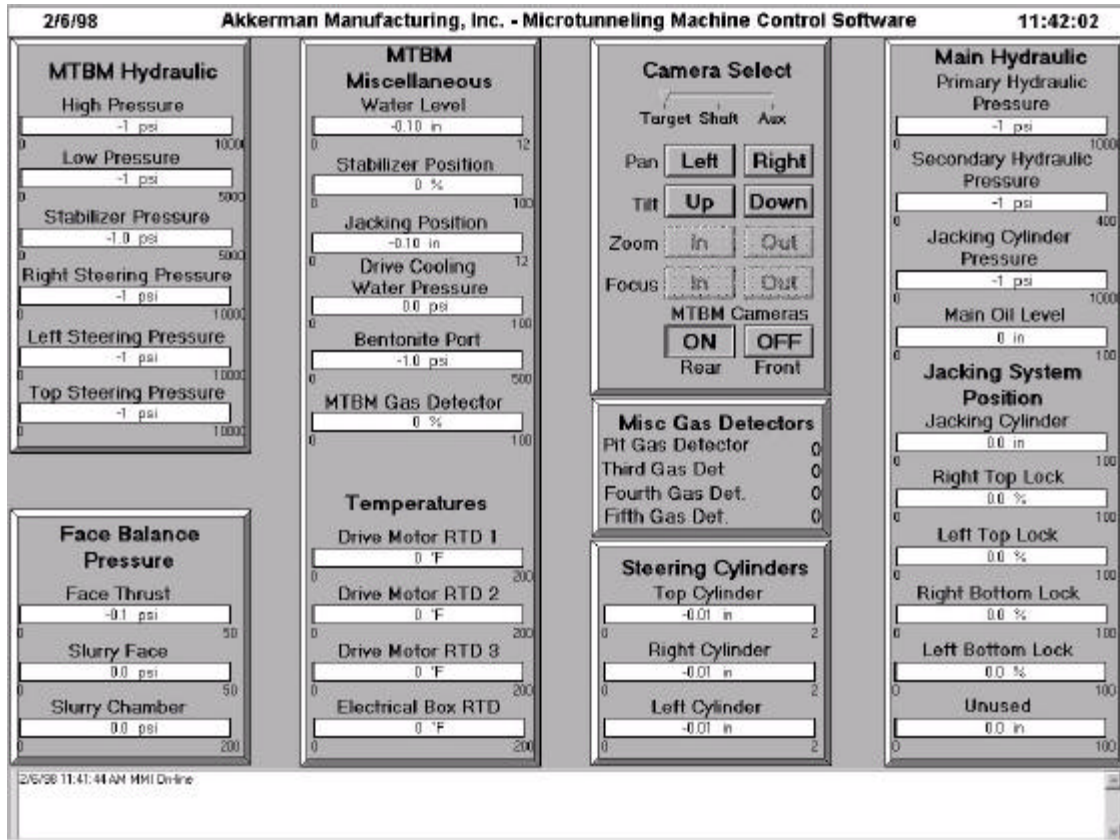
3. The center area of the target screen shows the position of the target, MTBM face, projected position, pitch (vertical angle) and yaw (horizontal angle) with respect to the laser. It also has a marker that can be set to the present laser position (pitch and yaw). This makes it easier to see how the MTBM is responding to steering. The target area can display the coordinates as either the center of the pipe (the red circle indicates the laser position), or the coordinates can be the laser position (the white circle indicates the pipe position). Note that both the color of the circle and the text in the legend change. To change coordinate systems, click on the legend text. The default can be set in the Target.INI file to use either coordinate system. Once a coordinate system has been decided upon do not leave the other coordinate system on the display. This can cause incorrect steering. When using the coordinate system as the center of the machine, steer to bring the coordinate system to the red circle. When using the coordinate system as the center of the laser, then steer to bring the white circle to the coordinate system.

To set the laser position, click on the text of the symbol 'Operator Resettable Marker' at the bottom of the screen. To set the pitch and yaw markers, move the cursor to the blue triangle and drag it with the mouse while holding down the left mouse button.

All four of the symbols can be removed or added to the target area by clicking on the symbol in the legend at the bottom of the target screen.

4. The messages and errors area displays all the messages and errors that come from the control system. Examples include: no laser power, boring head power cable not plugged in, contactor failed to close and operator errors. The bottom line contains messages about the status of the head water pump, jetting pump, gas level (optional) and drive motor heaters.
5. Note that the booster pump speed and torque graphs display cutter head speed and torque for MTBM's using a 30Hp cutter head drive motor.
6. Along the Right side of the display from top to bottom are 'head power', 'steering stroke', 'offsets (in.)', 'offsets (deg.)', 'TBM slurry pressure', 'temp', 'pipe advance' and 'hours'.
 - ?? The head power indicator displays the state of the 240 VAC power to the MTBM, either on or off.
 - ?? The steering stroke displays the MTBM steering cylinder stroke position, in percent, for the top, left and right cylinders.
 - ?? The horizontal and vertical offsets measure the deviation in inches of the laser spot with reference to the center of the target grid. Positive vertical deviation indicates that the laser spot is above the center of the target grid and positive horizontal deviation indicates that the laser spot is right of the center of the target grid.
 - ?? Roll indicates the degrees of clockwise roll of the MTBM, a negative reading indicates that the machine has rolled counter-clockwise as viewed from the rear of the MTBM.
 - ?? Incline F measures the degrees of incline with respect to level for the MTBM front section (in front of the steering band). A positive value indicates that the front (cutter bit) is higher than the back of the front section.
 - ?? Incline B measures the degrees of incline with respect to level for the MTBM front section (behind the steering band). A positive value indicates that the front (steering band) is higher than the back of the front section.
 - ?? Incline T measures the degrees of incline with respect to level for guidance target. A positive value indicates that the front (cutter bit end) of the target is higher than the back (lens) end.
 - ?? T horiz. measures the degrees of horizontal angle for the guidance target with respect to the laser beam. A positive value indicates that the front (cutter bit) end of the target is more to the right than the back (lens) end.
 - ?? T vert. Measures the degrees of vertical angle for the guidance target with respect to the laser beam. A positive value indicates that the front (cutter bit) end of the guidance target is higher than the back (lens) end.
 - ?? The slurry pressure, inlet and outlet, display the slurry pressure in Psi at the entrance and exit of the starting section.
 - ?? The oil temperature measures the main jacking hydraulic oil temperature.
 - ?? The motor temperature displays the internal temperature of the cutter bit drive motor.
 - ?? The head air temperature displays the ambient air temperature of the MTBM starting section.
 - ?? The pipe advance stroke displays, in feet, the optional stroke indicator of the jacking frame cylinders.
 - ?? The pipe advance total displays the total linear feet that have passed the pipe length wheel counter.
 - ?? The pipe advance rate measures the advancement rate, in feet per hour of the jacking frame.
 - ?? The pipe advance count displays the number of pipe that have been installed.
 - ?? The pipe advance flow displays the main jacking pump flow rate.
 - ?? The pipe advance pressure displays the extension pressure of the main jacking cylinders.
 - ?? The pipe advance tons displays the calculated tons of thrust that is being applied to the pipe by the jacking frame.
 - ?? The hours display indicates the total number of computer hours used.

6.5.6.2. Secondary Screen



Operational information that is not on the primary screen is displayed on the secondary meter screen. Bar graphs used have the same pull-down options as those on the primary screen. The camera control and selector switch must be set on the camera that is to be viewed. The mouse is used to operate pan, tilt, zoom or focus on cameras with advanced capabilities.

6.5.7. Camera

6.5.7.1. Camera Select - TBM/Target

Selects the camera receptacle in the MTBM to be displayed on the monitor.

6.5.7.2. Camera Select - Shaft

Selects the camera receptacle on the end of the container.

6.5.7.3. Camera Select - Auxiliary

Selects the camera receptacle on the side of the container to be displayed on the monitor.

6.6. Data Logging

In its simplest form, data logging is simply saving numbers in an organized manner for future retrieval. The important items to remember are: 1) What is the data being logged, 2) How is it to be used in the future and 3) Logging frequency.

6.6.1. Data-Logger

The data logger saves the important information about the drive in a database called SYS.MDB. The list of items that data logger saves is in a file called DATALOG.INI. This INI file can be changed by qualified personnel to save more or less data depending on the customer preferences. Factory settings are adequate in most cases.

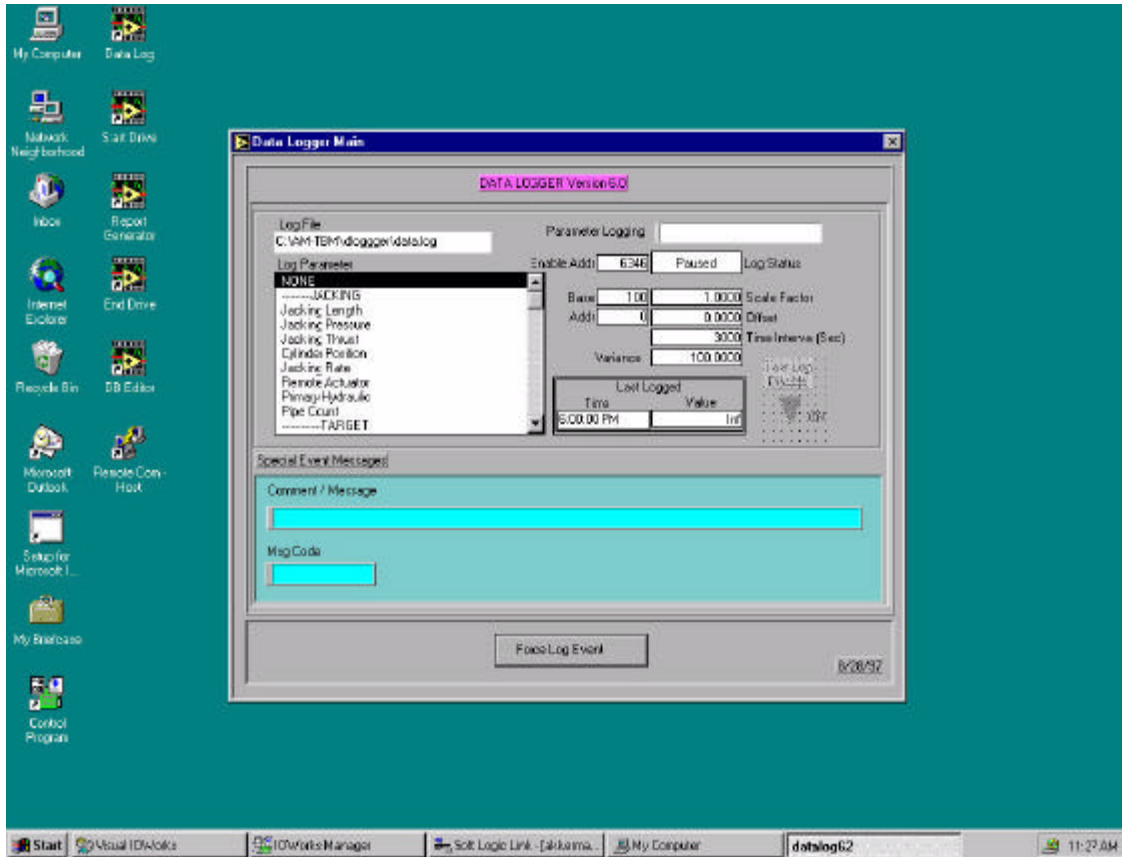
Logging frequency

The importance of the data and how fast the data is expected to change must be considered. For example, temperatures are not of great importance and do not change often. Logging them every 2 minutes would be sufficient. Head torque on the other hand would be logged quite frequently (about once per second) to get more information on the kind of soils that are being encountered. For example, a machine that is rotating at 10 RPM, and with a logging rate of once per second, would log 6 samples per revolution. For most things, slower (15 - 45 seconds) sampling rates are adequate. For example, if sampling is done on 15 second intervals on jacking pressure and the pipe is being pushed in at 1 ft per minute, then the samples would be logged every 4 inches. It is important to realize data that is logged is only the sample taken at the moment in time when logging occurs. Therefore, if something is logged every 2 minutes the time interval between the 2 minute samples is lost. If transients occur they will not be recorded. For this reason, it is important to log as much data of the critical data as storage and performance will allow. The system can also be set up to log a device only if the data has changed more than a specified amount. This greatly reduces the amount of data being logged. For example, a device can have a frequency of logging of 30 seconds yet only be logged a few times each hour if the data values remain fairly constant. When reports are printed, the data gets filled into the tables based on the logging frequency of 30 seconds. The control file C:\am-tbm\datalog.ini contains each parameters frequency to log and report significant change information.

The primary items on the Data Logger screen are:

Item	Description
Parameter Logging	This is the parameter that is being written to the database
Log Status	This tells whether data is being logged or the logger is waiting to log.
Last Logged Time	This is the time the last parameter was logged
Last Logged Value	This is the value of the last parameter that was logged
Log Parameter	List of parameters that are logged
Comment/Message	A message that can be input by the operator and logged. It will appear in the reports at the time it is logged. This is a good way to document events that can change the data. An example is the laser being bumped or a change in ground conditions. After the comment or message is input the button 'Force Log Event' must be clicked on.
MSG Code	This is not implemented in the reports yet but will in the future. When the reports are printed the operator will be able to input conditional statements on what range of error messages will be printed. An example would be any message below 10,000 would be for the boring contractor's information only.
Force Log Event	This forces any comment/message to be logged if one exists. It also forces all the log parameters to be logged.

When a report is printed with an interval greater than that being logged, the value that gets printed is the maximum value logged during that time period.



6.6.1.1. Error-Logger

The error logger saves the important error codes in a database called SYS.MDB. It is used to create a history of exceeded limits (over temperature for example) or possible errors within the system. It also provides a log for the service technician to help determine the series of events as they occur for trouble shooting.

6.6.1.2. Start Drive

See section 4.3.2 Start Drive for more details.

6.6.1.3. End Drive

See section 4.5 End of Drive for more details.

6.6.1.4. Report Printing

See section [4.4.10 Report Printing](#) for more details.

Item	Description
Edit Job Data	Modifies the header information for a single printed report. Changes can not be saved in the database. If the database needs to be changed, run the 'Start Job' program.
Define Report Fields	This is where the report gets designed. Select column by column what gets printed by holding the mouse button on the down arrow above each column. Then select the item that gets printed. The column heading is shown and can be modified. When done, select DONE and a menu will appear to ask if changes should be saved. If changes are to be saved, give a name to the file (standard report is recommended). The 'GET FORMAT' option at the bottom of the design screen is to get an existing format. Click here and select the format from the window.
Select Data Base	Select the database to be used for printing the report from the list of databases in the Dbase Selection window. If the database dates and times are known, click to remove the 'X' in 'Show Runs'. If the dates and times are not known, then leave the X. Then click on Select This Dbase. The date and start and stop times will be shown for each date data was logged in the database. Click on the date of the report that is to be printed, then click on DONE. Note that the date, time and report period will be filled in.
Standard Report	This will use the standard format and print the report for the date, time and interval listed on the screen. This is the default report format.
Run Report	This will print the report for the database, report format, date, time, interval, and period specified.
Exit	Exits the program
Start Date, Start Time	The start date and time of the report
Report Interval Minutes	The time between lines in the report.
Report Period Hours	How long the report is.

Edit Job Data

See section [4.4.10](#) for Edit Job Data screen.

This screen is used to edit the header information that will get put on a single report. This is used only for temporary modifications because the data can not be saved.

Report Format Editor

See section 4.4.10 for Report Format Editor screen.

This screen is used to define what data is printed in the report. The down arrows can be clicked on to bring up a list of all items in the database. Select the item desired and it will appear in the field by the down arrow. This is the title of the column on the report. It can be modified if desired. The two fields under the title can also be modified. The bottom one will show the units of the selected item. The SAVE button will save this form for future use. After clicking on the SAVE button, the next screen will ask for the name of the new form (standard report is recommended). The CANCEL button will exit the screen and not keep any changes. The DONE button will keep the data for printing. GET FORMAT will load an already defined report form. After clicking on this button a screen will come up that will display all the forms available. Click on the form desired.

Report Generator

The Run Report starts the report process. Make sure all the fields in the 'standard report' are filled in before selecting this button. It first gathers the information, formats the data, puts the data in a file and then prints the file. The default print file is called tmp.dat. If the option to send the data to file was selected a screen will come up asking for the file name to save the data. Input the name you want or select an existing name.

Starting Time is the starting time of the report. Hours, minutes, and seconds are required.

Report Interval is the interval that rows of data are printed. If a 2 minute interval is selected, then the time printed on a line is 2 minutes more than the previous line. Fractions of minutes are acceptable. For example, 2.5 minutes.

Output Record Count shows how many records have been processed.

Messages gives the status of the program. It will tell the operator if the program is busy processing a request or is ready for a request.

6.6.1.5.PCAnyWhere

This program is used for diagnostic communications between 2 computers via telephone. It can be used to diagnose a problem or demonstrate operation. To start the program, double click on the PCAnyWhere Host icon. The modem will enter receive mode and wait for an incoming call. Another computer with PCAnyWhere can then call into the system and start the communications.

6.6.2. Main System Control

6.6.2.1.Main System Control - Restart

Not implemented at this time.

6.6.2.2.Main System Control - Stop

Not implemented at this time.

6.6.2.3.Main System Control - Emergency Stop

When this button is depressed, all contactors are dropped out and the emergency switch lamp will illuminate. This will stop all motors. This button must be pulled out to restart operation.

6.6.2.4.Main System Control - Lamp Test

When depressed, all the lamps on the console will illuminate if the soft link program is running on the right monitor.

6.6.2.5.Main System Control - Key Lock - Standby

When in this position, the UPS is bypassed and power for the console is taken directly from the input power cord.

6.6.2.6.Main System Control - Key Lock - Stop

The UPS is turned off. The console will be powered down.

6.6.2.7.Main System Control - Key Lock - Run

This is the normal position of the key switch. All power that is used in the console will be going through the UPS. This provides maximum isolation between the computer equipment and the input line power. The UPS also prevents short term power outages.

6.6.3. Slurry Removal System

6.6.3.1.Slurry Removal System - Feed Pump

This adjusts the speed of the feed pump. When the speed is set to 0 the pump will stop.

6.6.3.2.Slurry Removal System - Feed Pump - Start

This will start the feed pump. The green light will illuminate when the feed pump contactor is pulled in.

6.6.3.3.Slurry Removal System - Feed Pump - Stop

This will stop the feed pump. The red lamp will illuminate when the feed pump contactor drops out.

6.6.3.4.Slurry Removal System - Auto

This is not used at this time.

6.6.3.5.Slurry Removal System - Sequence

When in this position the slurry stop and bypass valves will automatically sequence. It will force the slurry stop and bypass to be in opposite positions. When the stop valve is closed, the bypass will be open, when the stop valve is open the bypass valve will close.

6.6.3.6.Slurry Removal System - Manual

This will allow the slurry stop and bypass valves to be operated independently. When the selector is in this position, the operation of one valve does not effect the operation of the other.

6.6.3.7.Slurry Removal System - Slurry Stop - Open

Opening the stop valve allows slurry to the slurry chamber and cutting face. The open light will illuminate when the valve is fully open.

6.6.3.8.Slurry Removal System - Slurry Stop - Closed

Closing the slurry stop valve prevents slurry flow to the chamber and face. The closed light will illuminate when the valve is fully closed.

6.6.3.9.Slurry Removal System - Cutting Nozzle - Open

This opens the slurry valve allowing slurry to go to the cutting face. Opening this valve will close the slurry chamber valve by the same amount. The open light will illuminate when the valve is partially open.

6.6.3.10.Slurry Removal System - Cutting Nozzle - Closed

This stops slurry flow to the cutting face. Closing this valve will open the slurry chamber valve by the same amount. The close light will illuminate when the valve is fully closed.

6.6.3.11.Slurry Removal System - Slurry Nozzle - Open

Opens the slurry valve allowing slurry flow into the slurry chamber. Opening this valve will close the slurry cutting valve by the same amount. The open light will illuminate when the valve is partially open.

6.6.3.12.Slurry Removal System - Slurry Nozzle - Closed

Closes the slurry valve stopping slurry flow to the slurry chamber. Closing this valve will open the slurry cutting valve the same amount. The close light will illuminate when the valve is fully closed.

6.6.3.13.Slurry Removal System - Slurry Bypass - Open

Opening the bypass valve directs slurry flow from the feed line to the return line without entering the MTBM. The bypass valve must be full open or full closed. Momentarily pressing this button will cause the control system to open or close the valve all the way. The open light will illuminate once the valve is fully open.

6.6.3.14.Slurry Removal System - Slurry Bypass - Closed

Closes the bypass valve. Momentarily pressing this button will cause the valve to close all the way. The close light will illuminate when the valve is fully closed.

6.6.3.15.Slurry Removal System - Booster Pump

This adjusts the booster pump speed from 0 - 100%.

6.6.3.16.Slurry Removal System - Booster Pump - Start

Starts the booster pump. The green light illuminates when the booster pump contact is pulled in.

6.6.3.17.Slurry Removal System - Booster Pump - Stop

Stops the booster pump. The red light illuminates when the booster pump contact drops out.

6.6.3.18.Slurry Removal System - Return Pump

This adjusts the return pump speed from 0 - 100%.

6.6.3.19.Slurry Removal System - Return Pump - Start

Starts the return pump. The green light illuminates when the booster pump contact is pulled in.

6.6.3.20.Slurry Removal System - Return Pump - Stop

Stops the return pump. The red light illuminates when the return pump contact drops out.

6.6.4. Tunnel Boring Machine System

6.6.4.1. Steering Control - Top Cylinder - Extend

This extends the top steering cylinder. Holding the button depressed for a longer period of time will cause the cylinder to move further.

6.6.4.2. Steering Control - Top Cylinder - Retract

This retracts the top steering cylinder. Holding the button depressed for a longer period of time will cause the cylinder to move further.

6.6.4.3. Steering Control - Left Cylinder - Extend

This extends the left steering cylinder. Holding the button depressed for a longer period of time will cause the cylinder to move further.

6.6.4.4. Steering Control - Left Cylinder - Retract

This retracts the left steering cylinder. Holding the button depressed for a longer period of time will cause the cylinder to move further.

6.6.4.5. Steering Control - Right Cylinder - Extend

This extends the right steering cylinder. Holding the button depressed for a longer period of time will cause the cylinder to move further.

6.6.4.6. Steering Control - Right Cylinder - Retract

This retracts the right steering cylinder. Holding the button depressed for a longer period of time will cause the cylinder to move further.

6.6.4.7. Stabilizer Cylinder - Extend

This extends the stabilizer. Holding the button depressed for a longer period of time will cause the cylinder to move further.

6.6.4.8. Stabilizer Cylinder - Retract

This retracts the stabilizer. Holding the button depressed for a longer period of time will cause the cylinder to move further.

6.6.4.9. Drive Motor Cooling - Start

Starts the drive motor cooling pump. The green light illuminates when the contact is pulled in.

6.6.4.10. Drive Motor Cooling - Stop

Stops the drive motor cooling pump. The red light illuminates when the contact is dropped out.

6.6.4.11. Cutting Head Control - Speed

This adjusts the speed of the MTBM drive motor from 0 - 100%.

6.6.4.12. Cutting Head Control - Left

Starts the MTBM drive motor turning CCW (as viewed from back) also starts the drive motor cooling pump. If the drive motor is turning CW, rotation will reverse. The green left light illuminates when the motor contact pulls in.

6.6.4.13.Cutting Head Control - Stop

This will stop the MTBM drive motor and drive motor cooling pump. The red stop light illuminates.

6.6.4.14.Cutting Head Control - Right

Starts the MTBM drive motor turning CW (as viewed from back) also starts the drive motor cooling pump. If the drive motor is turning CCW, rotation will reverse. The green left light illuminates when the motor contact pulls in.

6.6.5. Pipe Jacking System

6.6.5.1.Main Pump - Start

This starts the main hydraulic pump, secondary hydraulic pump and the cooling fan. The respective green lights illuminate when the respective contact pulls in and the respective stop lights will go out.

6.6.5.2.Main Pump - Stop

This stops the main hydraulic pump motor. The stop light illuminates and the start light will go out.

6.6.5.3.Rate Select Mode - Manual

This puts the jacking system in manual rate select mode. The jacking rate is determined by the increase and decrease buttons. The manual light will illuminate.

6.6.5.4.Rate Select Mode - Automatic

This function is not supported at this time.

6.6.5.5.Oil Cooler Pump - Start

Starts the hydraulic oil cooling pump. The green start light will illuminate when the motor starts.

6.6.5.6.Oil Cooler Pump - Stop

Stops the hydraulic oil cooler pump. The red stop light will illuminate when the motor stops.

6.6.5.7.Auxiliary 1 - Extend

This turns on the auxiliary extend valve if the function select switch is in the stop position. The valve remains on only while the button is depressed.

6.6.5.8.Auxiliary 1 - Retract

This turns on the auxiliary retract valve if the function select switch is in the stop position. The valve remains on only while the button is depressed.

6.6.5.9.Function Select - Auto

This is not supported at this time.

6.6.5.10.Function Select - Extend

Turns the jacking cylinder extend valve on.

6.6.5.11.Function Select - Stop

Stops flow to the jacking cylinders. Function select must be in the stop position to enable other hydraulic functions.

6.6.5.12.Function Select - IJS

Provides hydraulic flow to the intermediate jacking valve bank. The IJS selector switch, [6.6.5.16](#) then is used to select the station desired.

6.6.5.13.Function Select - Retract

This will retract the jacking cylinders. Cylinders should be fully retracted whenever possible to maintain cylinder timing.

6.6.5.14.Retract Winch - Start

This will start the retraction of the winch. The valve will remain on until the stop switch is pressed. The light illuminates when the valve is on.

6.6.5.15.Retract Winch - Stop

This will stop the retraction of the winch.

6.6.5.16.Intermediate Jack Station Select - 0 to 10

This will extend the jacking station that is selected. 0 represents no station selected. Must be used with [6.6.5.12 function select](#).

6.6.5.17.Main Pump Rate Control - Stop

This stops the flow of oil from the hydraulic pump. If increase is pressed, the rate will return to the same value it was before the stop switch was depressed. If the flow is to start at 0, the stop switch must be depressed twice.

6.6.5.18.Main Pump Rate Control - Increase

If the stop button is lit, pressing the increase button will return hydraulic flow to the rate that was flowing when the stop button was depressed. If the increase button is lit, depressing the button will increase flow 1%. Holding the increase button depressed longer than 1/2 second will increase flow 10% for each 1/2 second up to 5 seconds, then the rate will increase by 20% until it reaches 100%. The time and increment values are factory defaults and can be changed to meet customer requirements.

6.6.5.19.Main Pump Rate Control - Decrease

If the stop button is lit, pressing the decrease button will return hydraulic flow to the rate that was flowing when the stop button was depressed. If the decrease button is lit, depressing the button will decrease flow 1%. Holding the decrease button depressed longer than 1/2 second will decrease flow 10% for each 1/2 second up to 5 seconds, then the rate will decrease by 20% until it reaches 0%. The time and increment values are factory defaults and can be adjusted to customer requirements.

6.6.5.20.Position Locks -Lock (Some Jacking Frame Models)

With the Function Select switch in the stop position, depressing this switch will set the oil flow to 30% and lock the position locks. It will also release the staging grippers. The staging grippers will continue to unclamp, after the button is released, until the hydraulic pressure reaches 1000 PSI (this is adjustable to customer application). The position locks will only move when the button is depressed. The lock light will come on when all 4 position locks are in position.

6.6.5.21.Position Locks - Unlock (Some Jacking Frame Models)

With the Function Select switch in the stop position, depressing this switch will set the oil flow to 30 % and unlock the position locks. It will also clamp the staging grippers. The staging grippers will continue to clamp, even after the button is released, until the hydraulic pressure reaches 1000 PSI (this is adjustable to customer application). The position locks will only move when the button is depressed. The unlock light will come on when all 4 position locks are in position.

6.6.5.22.Staging Grippers Lock (Some Jacking Frame Models)

With the Function Select switch in the stop position, depressing this switch will set the oil flow to 30 % and clamp the gripper locks. The staging grippers will continue to clamp, even if the button is released, until the hydraulic pressure reaches 1000 PSI (adjustable to customer application). The lock light will come on when the pressure reaches 1000 PSI.

6.6.5.23.Staging Grippers Unlock (Some Jacking Frame Models)

With the Function Select switch in the stop position, depressing this switch will set the oil flow to 30 % and unclamp the gripper locks. The staging grippers will continue to unclamp, even if the button is released, until the hydraulic pressure reaches 1000 PSI (adjustable to customer application). The unlock light will come on when the pressure reaches 1000 PSI.

6.6.5.24.Variable Frequency Drives (VFD)

6.6.5.24.1.Resetting

To reset a VFD, press the button on the front panel of the VFD that has a circle with a vertical line through it

6.6.5.24.2.Displaying Parameters

To display the operating parameters of an ABB variable frequency drive, press the left arrow key until a number appears on the screen that does not have a decimal point. Then use the up and down arrows to scroll to the desired parameter. The following is a list of operating parameters.

1. Output Frequency
2. Speed
3. Motor Current
4. % Rated Torque
5. % Rated Power
6. DC Bus Voltage
7. Output Voltage
8. Drive Temperature
15. Run Time
16. Kilowatt Hours
17. Last Rec'd Fault
18. Second Rec'd Fault
19. First Rec'd Fault

6.6.5.24.3.Changing Parameters

To change an operating parameter, qualified personnel should refer to the ABB programming manual.

6.6.6. Other Controls

6.6.6.1.High Pressure Jetting

The high pressure jetting switch, located on the bottom of the disconnect panel behind the operator, is used to disable the jetting pump (Off), or allow the jetting pump to operate in unison with the MTBM drive motor (Auto). A message will appear in the message area of the target screen whenever the pump is on.

6.6.6.2.Grease Pump

The grease pump switch, located on the bottom of the disconnect panel behind the operator, is used to momentarily turn on the grease pump (On), or allow the grease pump to operate in unison with the MTBM drive motor (Auto). A message will appear in the message area of the target screen whenever the pump is on.

6.6.6.3.Submersible Pump

The submersible pump switch, located on the bottom of the disconnect panel behind the operator, is used to momentarily turn on the submersible pump (On), or allow the pump to be controlled by the water level float switch in the MTBM (Auto). A message will appear in the message area of the target screen whenever the pump is on.

6.6.6.4.Drive Motor Heater

The drive motor heater switch, located on the bottom of the disconnect panel behind the operator, is used to turn the motor heater On or Off. A message will appear in the message area of the target screen whenever the motor heater is on.

6.7. Other Features

6.7.1. UPS

The quality of the power supplied to the system is unknown. For this reason an Uninterruptable Power Supply (UPS) was used to supply power to the computer system in the console. It will provide approximately 15 minutes of power when the incoming power is lost. To prevent drain on the batteries in the UPS, the Key Lock switch should always be turned off before the main power source or console power. During long periods of non use, the console should have power supplied to it. A cable can be used to plug the back of the UPS into a 240V outlet.

6.7.2. High Pressure Jetting (Optional)

A high pressure water pump supplies flow through the tunnel to nozzles in the MTBM providing a high pressure stream of water to the MTBM cutter face to break up clays and other very sticky material. The high pressure jetting switch, located on the bottom of the disconnect panel behind the operator, is used to disable the jetting pump (Off), or allow the jetting pump to operate in unison with the MTBM drive motor (Auto). A message will appear in the message area of the target screen whenever the pump is on.

6.7.2.1.MTBM Water Cooling/Jetting Tank

This tank stores fresh water for the drive motor cooling pump and the high pressure jetting pump. A low level switch is provided within the tank to stop the pumps when the level falls too low.

6.7.2.2. Drive Motor Cooling System

The drive motor cooling system dissipates heat from the MTBM electric drive motor. The drive motor cooling pump draws clean water from the MTBM water cooling/jetting tank. This water is pumped through a valve on the jacking frame and thru the tunnel into the water jacket surrounding the electric drive motor. Heated water is then expelled past the front lip seals into the slurry water.

6.7.2.3. Slurry/Bentonite/Water Manifold

The Slurry/Bentonite/Water manifold is used to shut off slurry, bentonite, and water supplies to the MTBM during a pipe change. The manifold has two valves for slurry, a valve for Bentonite, a valve for drive motor cooling water, and a valve for high pressure jetting water. The valves are attached to a steel framework that is typically mounted to the jacking frame. This configuration reduces clutter in the jacking shaft and reduces pipe change time.

6.7.2.4. Auxiliary Equipment Cable

- ?? The auxiliary equipment cable connects from the control container 'water cooling' receptacle to the water cooling/jetting tank. The water cooling/jetting tank level switch uses a pair of wires in this cable. The switch causes the drive motor cooling pump and the high pressure jetting pump to automatically turn off if the tank water level drops below minimum.
- ?? The same cable is used for MTBM 240 Volt power (see [6.1.16.1 Auxiliary Equipment Cable](#)).

6.7.3. Genius LAN Network

The genius network ties the entire control system together. All information to or from every device must travel over this network. This includes but is not limited to the console lights, console switches, VFD's, pumps, valves, inclinometers, linear transducers, pressure transducers, and temperature sensors. The main advantage of using the genius network is to simplify the wiring. All communications on the genius network pass along a single pair of wires. Also, the control modules can be placed near the devices they are controlling. The control modules have lamps for diagnostic purposes.

6.7.4. Power Distribution

6.7.4.1. Input Power

Input power is supplied to the control container through a panel behind the main disconnect switch. Four buss-bars are provided to attach the incoming power. A phase detector is provided in the container above the main disconnect switch on a panel behind the door. If the red light is illuminated, the phase is incorrect and must be changed.

- ?? As with any electrical work, use only qualified electrical personnel
- ?? 460 Volt 3 phase AC at 60 Hertz. 400 kVA recommended power source (may vary with MTBM specification).
- ?? Use 500 MCM or larger size cable for power connections to the control container.
- ?? Ground the control container using 1/0 AWG or larger wire.
- ?? Input current and voltage can be monitored on gauges located above the main power disconnect.
- ?? A phase monitor is located on a panel behind the door for the ammeter and voltmeter.

6.7.4.2. Circuit Breakers

Input power travels from the buss-bars through the main disconnect switch and fuses to the following nine molded case circuit breakers. These circuit breakers are for the following 460 Volt loads:

- ?? Boring head VFD and MTBM drive motor transformer
- ?? 460/240 Volt transformer
- ?? 460/(208,120) Volt transformer
- ?? Hydraulic pump
- ?? High pressure jetting pump
- ?? Slurry feed pump
- ?? Slurry return pump
- ?? Slurry booster pump
- ?? Bentonite power

Circuit breakers provide an electrical disconnecting means and short circuit protection. All 240 Volt loads and 208/120 Volt loads have circuit breakers mounted in two panels located across the aisle from the operator console.

6.7.4.3. Disconnects

The disconnect switches behind the operator console control power to the receptacles on the bulkhead area. Electrical power for all power cables going through the tunnel must be turned off during the addition of a new pipe. In addition, electrical power can be cut off for the three slurry pumps in this same location. These disconnect switches should always be turned off when cables are being unplugged.

6.7.4.4. Contactors

All the motor starters (contactors) are together in a single cabinet. They are turned on and off by the Genius modules. All the motor contactors have built in thermal overloads.

6.7.4.5. Ground Fault Protection

All electrical power exiting the control container is ground fault protected.

- ?? The slurry booster pump, slurry feed pump, slurry return pump, and MTBM drive motor have ground fault protection incorporated into their variable frequency drives.
- ?? Bentonite power, all 240 Volt loads, and the high pressure jetting pump have ground fault protection included with their circuit breakers.
- ?? All of the 120 Volt receptacles on the control container exterior are ground fault protected.

6.7.4.6. Special Features

- ?? All electrical power exiting building is interrupted if operator pushes emergency stop.
- ?? All power cables going through tunnel have pilot circuits. These pilots circuits require the cables to be connected before they can be energized.

6.7.5. Variable Frequency Drive (VFD)

Variable frequency drives (VFD) provide infinitely adjustable speed control for motors and torque boost for start up. VFD's are used on the three slurry pump motors and the MTBM drive motor. The VFD's protect these motors from over current, ground fault, stalling, over & under voltage.

- ?? Controlling the MTBM drive motor speed and rotation direction will maximize production of the cutter face with varied ground conditions.

- ?? The drive motor VFD provides 150% - 200% overload capability to cutter face (depending on MTBM diameter).

6.7.6. Outside Lighting and Camera System (Optional)

Booms, lights and cameras can be mounted to the top of the container. There are several camera outlets along the top of the container to plug in the camera. Generally two cameras are used. One over the jacking shaft and a second looking around the site area or at the slurry separation equipment.

6.7.7. Pit Box

The pit box is mounted to the jacking frame and provides 12 Volt DC power for the laser, an audio receptacle, methane gas warning horn, connector for the pipe advance wheel counter, connector for the jacking frame cylinder position sensor (optional), and a jacking frame stop switch.

6.7.7.1. Pit Box Cable

The pit box cable has 16 pins and a shiny black outer covering on the cable. The male pin end of the cable and the female socket end both have a rotating coupling nut.

- ?? Connects from the control container 'pit cable' receptacle to the pit box.
- ?? Cable has pairs of wires for 12 Volt DC laser power, audio, methane gas warning horn, pipe advance wheel counter, jacking frame extension, and jacking frame stop switch.
- ?? All signals in the cable are low voltage.
- ?? Same cable is used for the Jacking Frame Cable.

7. Maintenance and Routine Checks

7.1. MTBM

7.1.1. Guidance System

- ?? To prevent damage to the guidance target remove it from the MTBM after the completion of each drive and keep it in the storage box until the start of the next drive.
- ?? Clean the lens as necessary with a mild, abrasive free cleaning solution and scratch free cloth.

7.1.2. Steering

- ?? Extend and retract the steering cylinders several times to purge air from the system.
- ?? Scaling of the linear transducers should be performed before each new drive. Stroke should read 0% - 100 % for each cylinder.
- ?? [Steering joint seal should be cleaned, checked for leaks and seal wear](#)
- ?? [Inspect steering cylinders for damage.](#)

7.1.3. Drive Seals

- ?? The cutter bit, lip seal retaining ring and lip seals should be removed and inspected after each drive. When the seals are removed, the water flushing ports should be flushed and the area thoroughly cleaned and lubricated before the seals are re installed.
- ?? The seal mating surface should also be inspected for wear.

7.1.4. Gear Reducer

- ?? The gear reducer oil should be changed after each drive. If an unusually large amount of debris is found, the gear reducer and an oil sample should be returned to the factory for inspection.

7.1.5. Drive Bearings

- ?? The main drive bearing oil should be changed after each drive. If an unusually large amount of debris is found, the drive should be disassembled and inspected by qualified personnel and an oil sample should be returned to the factory for inspection.
- ?? If water or slurry contamination is found, the bearing cavity must be thoroughly flushed and the drive seals must be replaced.

7.1.6. Drive motor

- ?? Water cooling passages should be flushed after each drive.
- ?? Water jacket must be thoroughly drained to prevent freezing.
- ?? Grease bearings annually, more often in wet conditions.

7.1.7. Submersible Pump

- ?? Check float switch operation.
- ?? Check pump shut off time delay operation, more delay is necessary for down grade bores.
- ?? Test control container switch operation.
- ?? Clean water inlet holes of the submersible pump.

7.1.8. Control Valves

- ?? Extend and retract the steering cylinders and verify that each will hold pressure.
 - ?? Verify that the on screen values agree with the cylinder position.
- ?? Open and close the stop, bypass and chamber / cutting nozzle valves.
 - ?? Verify that the on screen values agree with the cylinder position.
 - ?? Test in manual and sequence position.
- ?? Extend and retract the stabilizer cylinder and verify that it will hold pressure.

7.1.9. Grease Pump

- ?? Fill reservoir with grease before each drive and test pump output.

7.1.10. Hydraulic Pump

- ?? Check the hydraulic pump reservoir oil level.
- ?? Check the high and low pressure relief settings.

7.1.11. Video / Audio

- ?? Test the camera selector switch operation.
- ?? Test camera control functions (pan, tilt...).
- ?? Test audio operation and controls.

7.1.12. Lamps

- ?? Test lamp operation in the starting and trailing sections.
- ?? Test the operation of the maintenance lamp from the container switch.

7.1.13. Inclinometers

- ?? Verify incline reading against a digital level.

- ?? Check roll incline, should be 0 with the machine hanging from the lifting eyes.
 - ?? C.C.W. as viewed from the rear is negative (-) roll.
 - ?? Note readings may change with 150' cable length, use the 5.5' or 9' cable to calibrate.

7.1.14. Methane Detector

- ?? Check the display reading and check if the fault lamp is illuminated.
- ?? Calibrate the system often to prevent the possibility of errors.
- ?? Follow detector manufacturers operation / maintenance recommendations.

7.1.15. Power Supplies

- ?? Check if both 24 volt power supplies are properly functioning, the input on pin 9 of block 3 should be on.

7.1.16. High Pressure Jetting

- ?? Clean high pressure strainer.
- ?? Check nozzle flow and pressure for each nozzle.

7.2. Slurry Circulation System

7.2.1. Slurry Pumps

- ?? Check oil level in all slurry pump drives.
- ?? Check impellers, vortex rings and stuffing boxes for wear.
- ?? Check shaft seals.
- ?? Flush and drain to prevent freezing.

7.2.2. Slurry Hoses

- ?? Remove a slurry return hose in the MTBM and check the hose for wear.
 - ?? If wire is exposed inside the hose, all hoses in the MTBM should be replaced.
- ?? Inspect all banding clamps for wear, replace as necessary.
- ?? Flush and drain all slurry ports, lines, hoses and pumps to prevent freezing.

7.2.3. Flow Meters

- ?? Compare flow meter readings while running above ground bypass.
- ?? Inspect linings and electrodes for wear.

7.3. Pipe Jacking System

7.3.1. Jacking Frame

- ?? Lubricate frame slide rails and travel ring assembly daily.
- ?? Lubricate locking blocks (dogs) daily.
- ?? Check travel ring chain tension periodically, adjust as necessary.
- ?? Do not allow build up to occur in the jacking frame base.

7.4. Information and Control System

- ?? Copy drive database (see sections 4.5 and 6.5.4) to C/D after each drive to prevent accidental data loss.
- ?? Check hard disk space. A minimum of 10% free space is required.

- ?? Check for Genius communication to the MTBM over both lan A and lan B.
- ?? Check Genius blocks for faults, forces and errors.
- ?? Check VFD settings before each drive and verify that they match the motor that is to be controlled.
- ?? Check / adjust overload relay setting for any motor that had the VFD setting modified.
- ?? Verify motor rotation for all electric motors.
- ?? Verify that the equipment selections are correct in 'Start Drive' program.

7.5. Miscellaneous

7.5.1. Jetting Pump

- ?? Do not operate jetting pump without fresh water supply.
- ?? Drain to prevent freezing.
- ?? Maintain proper belt tension.

7.5.2. Boring Head Cooling Pump

- ?? Do not operate cooling pump without fresh water supply.
- ?? Drain to prevent freezing.
- ?? Maintain 200 Psi relief setting.

7.5.3. Cables

- ?? Check for contamination in pin / socket area before mating, clean and dry as necessary.
- ?? Inspect cable outer jacket (shell) for damage. Discontinue use and replace immediately if damage occurs.
- ?? Inspect cable ends for chipping, flaking or pin / socket damage. Replace if damage is noted.
- ?? Do not pull or strain cables as cable damage may result.
- ?? Check cable for continuity and shorting before each use.

7.6. Transducer Calibration

Calibration is done at the factory and should not be required in the field. There are cases when adjustment to the calibration is required in the field. When this happens the following procedure can be used:

1. Calibrate with another device that has the following or better accuracy - 1% for Pressure transducers and flow meters, and 0.01 inches for linear transducers. Hook up the calibrating device in the circuit. Results from this device are called the calibrating value.
2. Go the appendix of this document. Find the item being calibrated in ether the 'Scaling Transducers' or the 'Analog' section at the end of 'Genius I/O list Block Configuration'.
3. Make sure the block or 90-30 has the values listed in the table. The value for column D - 'Low PT A/D' may vary depending on what it takes to get the zero or initial value. This value can be obtained by putting the transducer at the minimum and reading the A/D value in the 90-30 or Hand Held Monitor.
4. Now put the transducer at the maximum value, read the A/D value in the Hand held monitor or 90-30. Put this value in as the multiplier in the 90-30 or 'High PT A/D' in the Block.
5. Verify the new values. If they are not correct, repeat the above procedure.

8. Software Tools

8.1. Access

See the Microsoft booklet for complete information on Microsoft Access.

8.2. Excel

See the Microsoft booklet for complete information on Microsoft Excel.

9. Appendix

9.1. Basics of Windows

See the Microsoft booklet for complete information on Microsoft Windows.

9.2. Genius I/O List and block configuration

Block	I/O Pin	Description	A	B	C	D	E	F
		A - I/O B - Report Fault (Y/N) C - Hold Last State (Y/N) D - Default Output State (On/Off) E - Report No Load (Y/N) F - Overload Shutdown (Y/N)						
TBM								
2	1	Spare	I	Y	X	X	X	X
	2	High Water Level	I	Y	X	X	X	X
	3	Open Cutting Nozzle	O	Y	N	O	Y	Y
	4	Close Cutting Nozzle	O	Y	N	O	Y	Y
	5	Open Slurry Bypass Valve	O	Y	N	O	Y	Y
	6	Close Slurry Bypass Valve	O	Y	N	O	Y	Y
	7	Open Slurry Stop Valve	O	Y	N	O	Y	Y
	8	Close Slurry Stop Valve	O	Y	N	O	Y	Y
	9	Extend Stabilizer Cylinder Retract	O	Y	N	O	Y	Y
	10	Stabilizer Cylinder	O	Y	N	O	Y	Y
	11	Extend Jacking Advance	O	Y	N	O	Y	Y
	12	Retract Jacking Advance	O	Y	N	O	Y	Y
	13	Front TV Camera	O	Y	N	O	Y	Y
	14	Submersion pump	O	Y	N	O	Y	Y
	15	High Pressure	O	Y	N	O	Y	Y
	16	Low Pressure	O	Y	N	O	Y	Y
3	1	Genius Bus Switching Module						
	2	Extend Top Steering Cylinder	O	Y	N	O	Y	Y
	3	Retract Top Steering Cylinder	O	Y	N	O	Y	Y
	4	Extend Right Steering Cylinder	O	Y	N	O	Y	Y
	5	Retract Right Steering Cylinder	O	Y	N	O	Y	Y
	6	Extend Left Steering Cylinder	O	Y	N	O	Y	Y
	7	Retract Left Steering Cylinder	O	Y	N	O	Y	Y
	8	Hydraulic Pump	O	Y	N	O	Y	Y
	9	Open						
	10	Grease Pump	O	Y	N	O	Y	Y
	11	Head Motor Over Temperature Switch	I	Y	X	X	X	X

	12	Filter Clogged	I	Y	X	X	X	X
	13	Submersion Pump Relay Closed	I	Y	X	X	X	X
	14	Hydraulic Pump Relay Closed	I	Y	X	X	X	X
	15	Out of Grease	I	Y	X	X	X	X
	16	Gas Detect Fault	I	Y	X	X	X	X
Container								
4	1	Bus Switching Module for L1 L2	O	Y	N	O	N	Y
	2	Genius network termination	O	Y	N	O	N	Y
	3	Secondary Hydraulic Pump	O	Y	N	O	Y	Y
	4	Secondary Hydraulic Pump Relay closed	I	Y	X	X	X	X
	5	Jacking Auxiliary Filter	I	Y	X	X	X	X
	6	Jacking Return Filter	I	Y	X	X	X	X
	7	Jacking Pump Output Filter	I	Y	X	X	X	X
	8	Secondary Pressure Control Valve	O	Y	N	O	Y	Y
	9	Extend Jacking Frame	O	Y	N	O	Y	Y
	10	Retract Jacking Frame	O	Y	N	O	Y	Y
	11	Jacking Frame Auxiliary hydraulics	O	Y	N	O	Y	Y
	12	IJS	O	Y	N	O	Y	Y
	13	IJS9	O	Y	N	O	Y	Y
	14	IJS10	O	Y	N	O	Y	Y
	15	Jack Forward switch Light	O	Y	N	O	Y	Y
	16	Jack Backup switch Light	O	Y	N	O	Y	Y
5	1	IJS1	O	Y	N	O	Y	Y
	2	IJS2	O	Y	N	O	Y	Y
	3	IJS3	O	Y	N	O	Y	Y
	4	IJS4	O	Y	N	O	Y	Y
	5	IJS5	O	Y	N	O	Y	Y
	6	IJS6	O	Y	N	O	Y	Y
	7	IJS7	O	Y	N	O	Y	Y
	8	IJS8	O	Y	N	O	Y	Y
	9	Thrust Lock (Position)	O	Y	N	O	Y	Y
	10	Thrust Unlock (Position)	O	Y	N	O	Y	Y
	11	Ring Lock (Position)	O	Y	N	O	Y	Y
	12	Ring Unlock (Position)	O	Y	N	O	Y	Y
	13	Winch start	O	Y	N	O	Y	Y
	14	Winch reverse	O	Y	N	O	Y	Y
	15	Aux Extend	O	Y	N	O	Y	Y
	16	Aux Retract	O	Y	N	O	Y	Y
6	1	Boring Head Motor	O	Y	N	O	Y	Y
	2	Booster Pump	O	Y	N	O	Y	Y
	3	Return Pump	O	Y	N	O	Y	Y
	4	Feed Pump	O	Y	N	O	Y	Y
	5	Bentonite Power	O	Y	N	O	Y	Y
	6	Boring Head Cooling Pump	O	Y	N	O	Y	Y
	7	200 hp boring head motor contactor	O	Y	N	O	Y	Y
	8	Head Power Relay	O	Y	N	O	Y	Y
	9	Boring Head Motor Relay Closed	I	Y	X	X	X	X
	10	Booster Relay Closed	I	Y	X	X	X	X
	11	Return Pump Relay Closed	I	Y	X	X	X	X
	12	Feed Pump Relay Closed	I	Y	X	X	X	X
	13	Bentonite Pump Relay Closed	I	Y	X	X	X	X
	14	Boring Head Cooling Pump Relay Closed	I	Y	X	X	X	X
	15	200 hp boring head relay closed	I	Y	X	X	X	X
	16	Head Power Relay Closed	I	Y	X	X	X	X

7	1	Oil Cooler Motor	O	Y	N	O	Y	Y
	2	Grease pump switch	I	Y	X	X	X	X
	3	Submersible pump switch	I	Y	X	X	X	X
	4	240V 3 PH Auxiliary Circuit	O	Y	N	O	Y	Y
	5	Hydraulic Pump	O	Y	N	O	Y	Y
	6	75 hp motor heater switch	I	Y	X	X	X	X
	7	High Pressure Water Nozzle switch	O	Y	X	X	X	X
	8	Pipe Advancement Wheel CH A	I	Y	X	X	X	X
	9	Pipe Advancement Wheel CH B	I	Y	X	X	X	X
	10	High Pressure Nozzle Relay Closed	I	Y	X	X	X	X
	11	Oil Cooling Relay Closed	I	Y	X	X	X	X
	12	Jacking frame stop switch	I	Y	X	X	X	X
	13	200 hp boring head VFD direction	O	Y	N	O	Y	Y
	14	240 V 3 PH Relay Closed	I	Y	X	X	X	X
	15	Hydraulic Pump Relay Closed	I	Y	X	X	X	X
	16	200 hp boring head VFD start	O	Y	N	O	Y	Y
13	1	Yard Camera Pan Left			N	O		
	2	Yard Camera Tilt Down			N	O		
	3	Yard Camera Zoom In			N	O		
	4	Yard Camera Focus In			N	O		
	5	Yard Camera Pan Right			N	O		
	6	Yard Camera Tilt Up			N	O		
	7	Yard Camera Zoom Out			N	O		
	8	Yard Camera Focus Out			N	O		
	9	Shaft Camera Pan Left			N	O		
	10	Shaft Camera Tilt Down			N	O		
	11	Shaft Camera Zoom In			N	O		
	12	Shaft Camera Focus In			N	O		
	13	Shaft Camera Pan Right			N	O		
	14	Shaft Camera Tilt Up			N	O		
	15	Shaft Camera Zoom Out			N	O		
	16	Shaft Camera Focus Out			N	O		
14	1	Slurry Feed Auxiliary Disconnect contacts	I	Y	X	X	X	X
	2	Slurry Return Auxiliary Disconnect Contacts	I	Y	X	X	X	X
	3	Boring Head Auxiliary Disconnect Contacts	I	Y	X	X	X	X
	4	Booster Auxiliary Disconnect Contacts	I	Y	X	X	X	X
	5	Head Power Auxiliary Disconnect Contacts	I	Y	X	X	X	X
	6	Tunnel Lights Auxiliary Disconnect Contact	I	Y	X	X	X	X
	7	Boring Head Cooling Power Pilot Relay Contact	I	Y	X	X	X	X
	8	Pit Horn	O	Y	N	O	Y	Y
	9	Start Booster drive	O	Y	N	O	Y	Y
	10	Start Feed drive	O	Y	N	O	Y	Y
	11	Start Return drive	O	Y	N	O	Y	Y
	12	Start 125 hp drive	O	Y	N	O	Y	Y
	13	125 hp drive forward/reverse	O	Y	N	O	Y	Y
	14	Boring Head Pilot Relay Contact	I	Y	N	O	Y	Y
	15	Head Power Pilot Relay Contact	I	Y	N	O	Y	Y
	16	Drive motor booster reverse	O	Y	N	O	Y	Y

Console								
21	1	Start Jacking Pump Switch	I	Y	X	X	X	X
	2	Stop Jacking pump Switch	I	Y	X	X	X	X
	3	Jacking Rate Select Automatic	I	Y	X	X	X	X
	4	Jacking Rate Select Manual Switch	I	Y	X	X	X	X
	5	Extend Stabilizers Switch	I	Y	X	X	X	X
	6	Retract Stabilizer Switch	I	Y	X	X	X	X
	7	Extend Jack	I	Y	X	X	X	X
	8	Retract Jack	I	Y	X	X	X	X
	9	Automatic Jacking	I	Y	X	X	X	X
	10	Intermediate Jack Select	I	Y	X	X	X	X
	11	Stop Jacking Cylinder Switch	I	Y	X	X	X	X
	12	Spare2111	I	Y	X	X	X	X
	13	Extend Left steering Cylinder Switch	I	Y	X	X	X	X
	14	Retract Left Steering Cylinder Switch	I	Y	X	X	X	X
	15	Extend Right Steering Cylinder Switch	I	Y	X	X	X	X
	16	Retract Right Steering Cylinder Switch	I	Y	X	X	X	X
22	1	Intermediate Jack 0	I	Y	X	X	X	X
	2	Intermediate Jack 1	I	Y	X	X	X	X
	3	Intermediate Jack 2	I	Y	X	X	X	X
	4	Intermediate Jack 3	I	Y	X	X	X	X
	5	Intermediate Jack 4	I	Y	X	X	X	X
	6	Intermediate Jack 5	I	Y	X	X	X	X
	7	Intermediate Jack 6	I	Y	X	X	X	X
	8	Intermediate Jack 7	I	Y	X	X	X	X
	9	Intermediate Jack 8	I	Y	X	X	X	X
	10	Intermediate Jack 9	I	Y	X	X	X	X
	11	Intermediate Jack 10	I	Y	X	X	X	X
	12	Start Drive Motor Cooling Pump	I	Y	X	X	X	X
	13	Stop Drive Motor Cooling Pump	I	Y	X	X	X	X
	14	Extend Top Steering Cylinder Switch	I	Y	X	X	X	X
	15	Retract Top Steering Cylinder Switch	I	Y	X	X	X	X
	16	Spare 2215	I	Y	X	X	X	X
23	1	Start Jacking Pump Light	O	Y	N	O	Y	Y
	2	Stop Jacking Pump Light	O	Y	N	O	Y	Y
	3	Jacking Rate Select Automatic Light	O	Y	N	O	Y	Y
	4	Jacking Rate Select Manual Light	O	Y	N	O	Y	Y
	5	Extend Stabilizers Light	O	Y	N	O	Y	Y
	6	Retrace Stabilizers Light	O	Y	N	O	Y	Y
	7	Start Drive Motor Cooling Light	O	Y	N	O	Y	Y
	8	Stop Drive Motor Cooling Light	O	Y	N	O	Y	Y
	9	Auxiliary Extend Light	O	Y	N	O	Y	Y
	10	Auxiliary Retract Light	O	Y	N	O	Y	Y
	11	Thrust Ring Position Lock Light	O	Y	N	O	Y	Y
	12	Thrust Ring Position Unlock Light	O	Y	N	O	Y	Y
	13	Staging Grippers Lock Light	O	Y	N	O	Y	Y
	14	Staging Grippers Unlock Light	O	Y	N	O	Y	Y
	15	Keyboard Relay	O	Y	N	O	Y	Y
	16	Keyboard Switch (off)	I	Y	N	O	Y	Y
24	1	Emergency Stop	I	Y	X	X	X	X
	2	Lamp Test	I	Y	X	X	X	X
	3	Keylock locked	I	Y	X	X	X	X
	4	Keylocked Run	I	Y	X	X	X	X
	5	Extend Auxiliary	I	Y	X	X	X	X
	6	Retract Auxiliary	I	Y	X	X	X	X
	7	Spare	I	Y	X	X	X	X

	8	Spare	I	Y	X	X	X	X
	9	Main Control Restart	I	Y	X	X	X	X
	10	Main Control Stop	I	Y	X	X	X	X
	11	Select Target Camera (Head)	I	Y	X	X	X	X
	12	Select Shaft Camera	I	Y	X	X	X	X
	13	Select Auxiliary Camera	I	Y	X	X	X	X
	14	Emergency Stop Light	O	Y	X	X	X	X
	15	Main Control Restart Light	O	Y	N	O	Y	Y
	16	Main Control Stop Light	O	Y	N	O	Y	Y
26	1	Retraction Winch Switch Start	I	Y	X	X	X	X
	2	Retraction Winch Switch Stop	I	Y	X	X	X	X
	3	Slurry Feed Pump Start Switch	I	Y	X	X	X	X
	4	Slurry Feed Pump Stop Switch	I	Y	X	X	X	X
	5	Slurry Manual	I	Y	X	X	X	X
	6	Slurry Sequence	I	Y	X	X	X	X
	7	Slurry Auto	I	Y	X	X	X	X
	8	Open Slurry Stop Valve	I	Y	X	X	X	X
	9	Close Slurry Stop Valve	I	Y	X	X	X	X
	10	Slurry Return Pump Start Switch	I	Y	X	X	X	X
	11	Slurry Return Pump Stop Switch	I	Y	X	X	X	X
	12	Spare 2611	I	Y	X	X	X	X
	13	Thrust Ring Position Locked	I	Y	X	X	X	X
	14	Thrust Ring Position Unlocked	I	Y	X	X	X	X
	15	Staging Gripper Lock	I	Y	X	X	X	X
	16	Staging Gripper Unlock	I	Y	X	X	X	X
27	1	Slurry Booster Pump On Switch	I	Y	X	X	X	X
	2	Slurry Booster Pump Off Switch	I	Y	X	X	X	X
	3	Slurry Bypass Valve Open Switch	I	Y	X	X	X	X
	4	Slurry Bypass Valve Close Switch	I	Y	X	X	X	X
	5	Slurry Nozzle Open Switch	I	Y	X	X	X	X
	6	Slurry Nozzle Close Switch	I	Y	X	X	X	X
	7	Cutting Nozzle Open Switch	I	Y	X	X	X	X
	8	Cutting Nozzle Close Switch	I	Y	X	X	X	X
	9	Jacking Rate Speed Stop	I	Y	X	X	X	X
	10	Jacking Rate Speed Increase	I	Y	X	X	X	X
	11	Jacking Rate Speed Decrease	I	Y	X	X	X	X
	12	Oil Cooler Pump Start	I	Y	X	X	X	X
	13	Oil Cooler Pump Stop	I	Y	X	X	X	X
	14	Head Control Left Switch	I	Y	X	X	X	X
	15	Head Control Stop Switch	I	Y	X	X	X	X
	16	Head Control Right Switch	I	Y	X	X	X	X
28	1	Slurry Feed Pump Start Light	O	Y	N	O	Y	Y
	2	Slurry Feed Pump Stop Light	O	Y	N	O	Y	Y
	3	Spare2802	O	Y	N	O	Y	Y
	4	Spare2803	O	Y	N	O	Y	Y
	5	Slurry Stop Valve Opened Light	O	Y	N	O	Y	Y
	6	Slurry Stop Valve Closed Light	O	Y	N	O	Y	Y
	7	Slurry Nozzle Open Light	O	Y	N	O	Y	Y
	8	Slurry Nozzle Close Light	O	Y	N	O	Y	Y
	9	Cutting Nozzle Open Light	O	Y	N	O	Y	Y
	10	Cutting Nozzle Close Light	O	Y	N	O	Y	Y
	11	Head Control Left Light	O	Y	N	O	Y	Y
	12	Head Control Stop Light	O	Y	N	O	Y	Y
	13	Head Control Right Light	O	Y	N	O	Y	Y
	14	Spare2813	O	Y	N	O	Y	Y
	15	Slurry Return Pump Start Light	O	Y	N	O	Y	Y
	16	Slurry Return Pump Stop Light	O	Y	N	O	Y	Y

29	1	Slurry Booster Pump Start Light	O	Y	N	O	Y	Y
	2	Slurry Booster Pump Stop Light	O	Y	N	O	Y	Y
	3	Slurry Bypass Valve Open Light	O	Y	N	O	Y	Y
	4	Slurry Bypass Valve Close Light	O	Y	N	O	Y	Y
	5	Increase Jacking Speed Light	O	Y	N	O	Y	Y
	6	Stop Jacking Light	O	Y	N	O	Y	Y
	7	Decrease Jacking Speed Light	O	Y	N	O	Y	Y
	8	Oil Cooler Pump Start Light	O	Y	N	O	Y	Y
	9	Oil cooler Pump Stop Light	O	Y	N	O	Y	Y
	10	Retraction Winch Start Light	O	Y	N	O	Y	Y
	11	Retraction Winch Stop Light	O	Y	N	O	Y	Y
	12	Spare2910	O	Y	N	O	Y	Y
	13	Spare2911	O	Y	N	O	Y	Y
	14	Spare2912	O	Y	N	O	Y	Y
	15	Spare2913	O	Y	N	O	Y	Y
	16	Spare2914	O	Y	N	O	Y	Y

ANALOG Blocks			A	B	C	D	E
BLK	I/O	Description A - Report Fault B - Range/channel active C - Low Pt Engineering D - Low Pt A/D E - High Pt Engineering The high Pt A/D is obtained when calibrating transducer, Alarm input mode N, input filter 16ms, alarm low -2,000, Alarm high 15,000					
8	1	Spare=6050	N	0-10	0	0	10,000
	2	Left Jacking Position	N	0-10	0	0	10,000
	3	Right Bottom Position Locks	N	0-10	0	0	10,000
	4	(dogs)	N	0-10	0	0	10,000
	5	Left Bottom Position Locks (dogs)	N	0-10	0	819	10,000
	6	Slurry Booster Speed control Slurry Feed speed control	N	0-10	0	819	10,000
9	1	Right Top Position Locks (dogs)	N	0-10	0	0	10,000
	2	Left Top Position Locks (dogs)	N	0-10	0	0	10,000
	3	Jack Pressure	N	4-20	0	819	10,000
	4	Oil Level	N	4-20	3,200	1,073	0
	5	Slurry Return Speed control	N	4-20	0	819	10,000
	6	Slurry Boring Head Speed control	N	4-20	0	819	10,000
10	1	Primary Hydraulic Pressure	N	4-20	0	819	10,000
	2	Secondary Hydraulic Pressure	N	4-20	0	819	3,000
	3	Slurry Feed Flow	N	4-20	0	819	3,448
	4	Slurry Return Flow	N	4-20	0	819	3,448
	5	Remote Proportional Actuator	N	0-10	0	0	10,000
	6	200 hp boring head speed control	N	4-20	0	819	10,000
11	1	Transformer Temperature L1	Y	Y	PT	.00385	
	2	Transformer Temperature L2	Y	Y	PT	.00385	
	3	Transformer Temperature L3	Y	Y	PT	.00385	
	4	Hydraulic Oil Temperature	Y	Y	PT	.00385	
	5	Spare RTD 1104	N	N	PT	.00385	
	6	Spare RTD 1105	N	N	PT	.00385	
17	1	Booster Pump Current	N	Y	0	4,000	10,000
	2	Feed Pump Current	N	Y	0	4,000	10,000

	3	Return Pump Current	N	Y	0	4,000	10,000
	4	Boring Head Current	N	Y	0	4,000	10,000
	5	200 hp boring head current	N	Y	4,000	4,000	20,000
	6	Spare analog input	N	Y	4,000	4,000	20,000
25	1	Feed pump Speed Control	N	0-10	0	0	10,000
	2	Booster Pump Speed Control	N	0-10	0	0	10,000
	3	Return Pump Speed Control	N	0-10	0	0	10,000
	4	Head Cutter Speed Control	N	0-10	0	0	10,000
	5	Spare analog output	N	0-10	0	0	10,000
	6	Spare analog output	N	0-10	0	0	10,000

90-30 In Head							
1		Module 4					
	1	Motor Temperature Winding #1					
	2	Motor Temperature Winding #2					
	3	Motor Temperature Winding #3					
	4	Pipe Air Temperature					
	5	Electrical Box Temperature					
	6	Spare Temperature					
		Module 5					
	7	Jacking Advance Position					
	8	Slurry Bypass Valve Position					
	9	Slurry Stop Valve Position					
	10	Stabilizer Position					
	11	Spare Trailing section connector					
	12	Slurry Cutting Nozzle Position					
	13	Up/Down Acceleration					
	14	In/Out Acceleration					
	15	Sideways Acceleration					
	16	Top Steering Cylinder Position					
	17	Right Steering Cylinder Position					
	18	Left Steering Cylinder Position					
	19	Grade Inclination Target					
	20	Rotational Angle Target					
	21	Back Section Incline					
	22	Front Section Incline					
		Module 6					
	23	Gas Detector					
	24	Stabilizer Pressure					
	25	Hydraulic Low Pressure					
	26	Hydraulic High Pressure					
	27	Open					
	28	Slurry Chamber Input Line Pressure					
	29	Slurry Chamber Output Line Pressure					
	30	Top Steering Cylinder Pressure					
	31	Right Steering Cylinder Pressure					
	32	Left Steering Cylinder Pressure					
	33	Drive Motor Cooling Water Pressure					
	34	High Pressure cutting nozzle Pressure					
	35	Spare 0134					
	36	Bentonite Pressure					
	37	Module 7					
		1. Spare					
		2. Front Light Relay					
		3. Open Cutting Nozzle					
		4. Close Cutting Nozzle					

		5. Open Slurry Bypass Valve					
		6. Close Slurry Bypass Valve					
		7. Open Slurry Stop Valve					
		8. Close Slurry Stop Valve					
		9. Extend Stabilizer Cylinder					
		10. Retract Stabilizer Cylinder					
		11. Extend Jack Advance					
		12. Retract Jack Advance					
		13. Motor Heater Relay					
		14. Submersion Pump					
		15. High Pressure					
		16. Low Pressure					
	38	Module 8					
		1. Open					
		2. Extend Top Steering Cylinder					
		3. Retract Top Steering Cylinder					
		4. Extend Right Steering Cylinder					
		5. Retract Right Steering Cylinder					
		6. Extend Left Steering Cylinder					
		7. Retract Left Steering Cylinder					
		8. Hydraulic Pump with 90-30					
		9. Head Camera Pan Left					
		10. Head Camera Tilt Down					
		11. Reserved					
		12. Reserved					
		13. Head Camera Pan Right					
		14. Head Camera Tilt Up					
		15. Reserved					
		16. Reserved					
	39	Front Target X Position Horizontal					
	40	Front Target Y Position Vertical					
	41	X Angle Horizontal					
	42	Y Angle Vertical					
	43	Target error code					
	44	Watch dog timer					
	45	Received Command					
	46	Received Data					

9.3. Transducer scaling

Transducer	Genius or 90-30 multiplier	Scaling (Scale * SM = value)	units	Register
TBM				
TBM Roll	200	0.001	Degrees	952
Horiz Deviation		0.01	Inches R/Left	
Vert Deviation		0.01	Inches Up/Down	
Horiz Angle		0.001	Degrees R/Left	
Vert Angle		0.001	Degrees Up/Down	
Target incline	10,000	0.001	Degrees	946??
Grade Front	10,000	0.001	Degrees	
Grade Back	10,000	0.001	Degrees	
Grade Target	10,000	0.001	Degrees	
Top Position	10,000	0.01	% Max Stroke	830
Right Position	10,000	0.01	% Max Stroke	834
Left Position	10,000	0.01	% Max Stroke	838
Top Pressure	10,000	1	PSI	918
Right Pressure	10,000	1	PSI	924
Left Pressure	10,000	1	PSI	930
Top Thrust		0.1	Tons 0.1	
Right Thrust		0.1	Tons	
Left Thrust		0.1	Tons	
Slurry Inlet PSI	10,000	0.01	PSI	894
Slurry Out PSI	10,000	0.01	PSI	898
Slurry Nozzle Position	10,000	0.1	% Open	842
Bypass Position	10,000	0.1	% Open	850
Stop Valve Position	10,000	0.1	% Open	854
Hydraulic Balance Pressure		0.1	PSI	
Slurry Balance Pressure		0.01	PSI	
Jetting Nozzle PSI	10,000	1	PSI	942
TBM Cutting Nozzle Position	10,000		% Open	846
Accel up/down	1	0.01	G	910
Accel In/Out	1	0.01	G	914
Accel Sideways	1	0.01	G	906
TBM Drive Motor Speed		0.1	% Max Speed	
TBM Motor Current	100	0.01	I	
TBM Drive Motor Temp		1.0	Degrees F.	
Cutter Head Speed	10,000	0.1	RPM	09-06
Cut Head Torque		0.01	K FT-LB	
TBM Drive Cooling Press	30,000	0.01	PSI	936
TBM L1 Temperature	45	1.0	Degrees	
TBM L2 Temperature	45	1.0	Degrees	
TBM L2 Temperature	45	1.0	Degrees	
Pipe Temperature	45	1.0	Degrees	
Electrical Box Temperature	45	1.0	Degrees	
TBM Jacking Advance	10,000	0.1	Inches	862
TBM Stabilizer Position	10,000	0.1	% Max Stroke	858
TBM Stabilizer Pressure	10,000	1.0	PSI	870

TBM Low Hydraulic Press	10,000	1.0	PSI	886
TBM High Hydraulic Pressure	10,000	1.0	PSI	890
TBM Gas Detector	10,000	0.01	% Gas	882
TBM Bentonite Pressure	30,000	1.0	PSI	962
200 HP drive Speed				10-06
200 Hp drive Current				17-06
Jacking				
Jacking Length		0.1	Feet	
Jacking Pressure		1.0	PSI	09-03
Jacking Thrust		1.0	K Tons	
Jacking Cylinder Position		0.1	Inches	08-02
Jacking Rate		0.1	Ft/Hr	
Remote Actuator		0.01	% Max Flow	10-05
Primary Hydraulic		1.0	PSI	10-01
Secondary Hydraulic		1.0	PSI	10-02
Right Bottom Position Lock			% Max Position	08-03
Left Bottom Position Lock		0.01	% Max Position	08-04
Right Top Position Lock		0.01	% Max Position	09-01
Left Top Position Lock		0.01	% Max Position	09-02
Oil Level		0.01	inches	09-04
Oil Temperature		0.1	Degrees F.	11-04
Slurry				
Booster Speed		0.1	% Max Speed	08-05
Feed Speed		0.1	% Max Speed	08-06
Return Speed		0.1	% Max Speed	09-05
Booster Current		0.01	% Max I	17-01
Feed Current		0.01	% Max I	17-02
Return Current		0.01	% Max I	17-03
Feed Flow		0.1	GPM	10-03
Return Flow		0.1	GPM	10-04
Console				
Feed pump Speed Pot		0.01	RPM	25-01
Booster pump speed pot		0.01	RPM	25-02
Return pump speed pot		0.01	RPM	25-03
Cutting head speed pot		0.01	RPM	25-04

9.4. ABB Drive Configurations

BOLD PARAMETERS altered by Akkerman from ABB default settings. 30 HP drive motor settings for ABB variable frequency drive DC3.

START-UP DATA

A language
 B applications
 C applic. Restore
 D supply voltage
 E user display scale
 F motor current - fla
 G motor power hp
 H motor power factor
 I motor base freq
 J motor base rpm
 K motor nom. Voltage

ENGLISH
FACTORY
 NO
480 V
100
40
30
0.79
 60
1760
460

10.5 Analog Inputs

10.5.1 minimum AI1
 10.5.2 maximum AI1
 10.5.3 RC filter on AI1
 10.5.4 invert AI1
 10.5.5 minimum AI2
 10.5.6 maximum AI2
 10.5.7 RC filter on AI2
 10.5.8 invert AI2

2V / 4mA
 10V / 20mA
 0.1 s
 NO
 0V / 0mA
 10V / 20mA
 0.1 s
 NO

10.6 Relay Outputs

10.6.1 relay RO1 output
 10.6.2 relay RO2 output
 10.6.3 relay RO3 output

READY
 RUN
 FAULT (-1)

20.5 Critical Frequencies

20.5.1 crit freq select
 20.5.2 crit freq low 1
 20.5.3 crit freq high 1
 20.5.4 crit freq low 2
 20.5.5 crit freq high 2
 20.5.6 crit freq low 3
 20.5.7 crit freq high 3
 20.5.8 crit freq low 4
 20.5.9 crit freq high 4
 20.5.10 crit freq low 5
 20.5.11 crit freq high 5

OFF
 0 Hz
 0 Hz
 0 Hz
 0 Hz
 0 Hz
 0 Hz
 0 Hz
 0 Hz
 0 Hz

OPERATING DATA

1 output
 2 speed
 3 motor current
 4 % rated torque
 5 % rated power
 6 DC bus voltage
 7 output voltage
 8 drive temperature
 9 control location
 10 keypad ref 1
 11 keypad pi (ref 2)
 12 ext ref 1 or 2
 13 external ref 1
 14 external ref 2
 15 run time
 16 kilowatt hours
 17 last-recd fault
 18 second-recd fault
 19 first-recd fault
 20 parameter lock

KEYPAD R1
 REF 1

10.7 Analog Outputs

10.7.1 analog output 1
 10.7.2 scale AO1
 10.7.3 minimum AO1
 10.7.4 RC filter on AO1
 10.7.5 invert AO1
 10.7.6 analog output 2
 10.7.7 scale AO2
 10.7.8 minimum AO2
 10.7.9 RC filter on AO2
 10.7.10 invert AO2

NOT USED
 100%
 0 mA
 2 s
 NO
 OUT CURR
50%
4 mA
0.5 s
 NO

20 Drive Parameters

20.1 Freq/Current Limit

20.1.1 min frequency
 20.1.2 max frequency
 20.1.3 frequency range
 20.1.4 current limit

0 Hz
 60 Hz
 0 - 120 Hz
50.16 A

20.2 Start / Stop

20.2.1 start function
 20.2.2 torq boost current
 20.2.3 stop function
 20.2.4 brake chopper
 20.2.5 DC hold
 20.2.6 DC hold voltage
 20.2.7 DC brake voltage
 20.2.8 DC brake time

TORQ BOOST
50.92 A
RAMP
 NO
 OFF
 0.01 x V_N
 0.01 x V_N
 0 s

20.3 Accel / Decel

20.3.1 acc/dec 1 or 2 sel
 20.3.2 ac/dec ramp shape
 20.3.3 accel time 1
 20.3.4 decel time 1
 20.3.5 accel time 2
 20.3.6 decel time 2

DI 4
 LINEAR
 3 s
1 s
 60 s
 60 s

20.4 Motor Control

20.4.1 switching freq
 20.4.2 max output voltage
 20.4.3 V/Hz ratio
 20.4.4 field weak point
 20.4.5 IR compensation
 20.4.6 IR comp voltage
 20.4.7 IR comp range
 20.4.8 slip compensation
 20.4.9 nominal slip
 20.4.10 voltage limit

3 kHz
460 V
 LINEAR
 60 Hz
AUTO
 0.01 x V_N
 0 Hz
ON
2.2%
 ON

30 Protection/Information

30.1 Fault Function

30.1.1 serial fault function
 30.1.2 AI < min function
 30.1.3 mot temp fault func
 30.1.4 motor thermal time
 30.1.5 motor load curve
 30.1.6 zero speed load
 30.1.7 break point
 30.1.8 stall function
 30.1.9 stall current
 30.1.10 stall time/frequency
 30.1.11 underload function
 30.1.12 underload time
 30.1.13 underload curve

STOP
 NO
NO
 700 s
125%
125%
 60 Hz
FAULT
57 A
 20 s/25 Hz
 NO
 600 s
 1

30.2 Automatic Reset

30.2.1 number of resets
 30.2.2 time window
 30.2.3 time bet res attempt
 30.2.4 overvoltage
 30.2.5 undervoltage
 30.2.6 overcurrent
 30.2.7 AI signal < min

2
 30 s
 0
 NO
 YES
 NO
 NO

30.3 Supervision

30.3.1 output freq 1 function
 30.3.2 output freq 1 limit
 30.3.3 output freq 2 function
 30.3.4 output freq 2 limit
 30.3.5 current function
 30.3.6 current limit
 30.3.7 ref 1 function
 30.3.8 ref 1 limit
 30.3.9 ref 2 function
 30.3.10 ref 2 limit
 30.3.11 supervis messages

NO
 0
 NO
 0
 NO
 0 x I_N
 NO
 0 Hz
 NO
 0%
 ON

30.4 Information

30.4.1 CRI prog version
 30.4.2 MC prog version
 30.4.3 test date

(version)
 (version)
 (date)

10 Control Connections

10.1 Strt/Stop/Direction

10.1.1 ext 1 strt/stp/dir
 10.1.2 ext 2 strt/stp/dir
 10.1.3 loc/ext direction

DI 1,2
 NOT SEL
REQUEST

10.2 External Ref Select

10.2.1 ext 1/ext 2 select
 10.2.2 external ref 1 sel
 10.2.3 ext ref 1 minimum
 10.2.4 ext ref 1 maximum
 10.2.7 external ref 2 sel
 10.2.8 ext ref 2 minimum
 10.2.9 ext ref 2 maximum

OP DATA 12
 AI1
 0 Hz
 60 Hz
 OP DATA 14
 0 Hz
 60 Hz

10.3 Preset Speeds

10.3.1 preset speed sel
 10.3.2 preset speed 1
 10.3.3 preset speed 2
 10.3.4 preset speed 3

DI 5,6
 5 Hz
 10 Hz
 15 Hz

10.4 System Contr Input

10.4.1 run enable
 10.4.2 fault reset select
 10.4.3 param. Lock sel
 10.4.4 external fault

YES
 NOT SEL
 OP DATA 20
 NOT SEL

BOLD PARAMETERS altered by Akkerman from ABB default settings. 50 HP slurry feed pump settings for ABB variable frequency drive DC1.

START-UP DATA

A language
 B applications
 C applic. Restore
 D supply voltage
 E user display scale
 F motor current - fla
 G motor power hp
 H motor power factor
 I motor base freq
 J motor base rpm
 K motor nom. Voltage

ENGLISH
FACTORY
 NO
480 V
100
58
50
0.85
 60
1770
460

10.5 Analog Inputs

10.5.1 minimum AI1
 10.5.2 maximum AI1
 10.5.3 RC filter on AI1
 10.5.4 invert AI1
 10.5.5 minimum AI2
 10.5.6 maximum AI2
 10.5.7 RC filter on AI2
 10.5.8 invert AI2

2V / 4mA
 10V / 20mA
 0.1 s
 NO
 0V / 0mA
 10V / 20mA
 0.1 s
 NO

10.6 Relay Outputs

10.6.1 relay RO1 output
 10.6.2 relay RO2 output
 10.6.3 relay RO3 output

READY
 RUN
 FAULT (-1)

20.5 Critical Frequencies

20.5.1 crit freq select
 20.5.2 crit freq low 1
 20.5.3 crit freq high 1
 20.5.4 crit freq low 2
 20.5.5 crit freq high 2
 20.5.6 crit freq low 3
 20.5.7 crit freq high 3
 20.5.8 crit freq low 4
 20.5.9 crit freq high 4
 20.5.10 crit freq low 5
 20.5.11 crit freq high 5

OFF
 0 Hz
 0 Hz
 0 Hz
 0 Hz
 0 Hz
 0 Hz
 0 Hz
 0 Hz
 0 Hz
 0 Hz

OPERATING DATA

1 output
 2 speed
 3 motor current
 4 % rated torque
 5 % rated power
 6 DC bus voltage
 7 output voltage
 8 drive temperature
 9 control location
 10 keypad ref 1
 11 keypad pi (ref 2)
 12 ext ref 1 or 2
 13 external ref 1
 14 external ref 2
 15 run time
 16 kilowatt hours
 17 last-recd fault
 18 second-recd fault
 19 first-recd fault
 20 parameter lock

10.7 Analog Outputs

10.7.1 analog output 1
 10.7.2 scale AO1
 10.7.3 minimum AO1
 10.7.4 RC filter on AO1
 10.7.5 invert AO1
 10.7.6 analog output 2
 10.7.7 scale AO2
 10.7.8 minimum AO2
 10.7.9 RC filter on AO2
 10.7.10 invert AO2

NOT USED
 100%
 0 mA
 2 s
 NO
 OUT CURR
 100%
4 mA
0.5 s
 NO

20 Drive Parameters

20.1 Freq/Current Limit

20.1.1 min frequency
 20.1.2 max frequency
 20.1.3 frequency range
 20.1.4 current limit

0 Hz
 60 Hz
 0 - 120 Hz
58 A

20.2 Start / Stop

20.2.1 start function
 20.2.2 torq boost current
 20.2.3 stop function
 20.2.4 brake chopper
 20.2.5 DC hold
 20.2.6 DC hold voltage
 20.2.7 DC brake voltage
 20.2.8 DC brake time

TORQ BOOST
87 A
 COAST
 NO
 OFF
 0.01 x V_N
 0.01 x V_N
 0 s

20.3 Accel / Decel

20.3.1 acc/dec 1 or 2 sel
 20.3.2 ac/dec ramp shape
 20.3.3 accel time 1
 20.3.4 decel time 1
 20.3.5 accel time 2
 20.3.6 decel time 2

DI 4
 LINEAR
 3 s
 3 s
 60 s
 60 s

20.4 Motor Control

20.4.1 switching freq
 20.4.2 max output voltage
 20.4.3 V/Hz ratio
 20.4.4 field weak point
 20.4.5 IR compensation
 20.4.6 IR comp voltage
 20.4.7 IR comp range
 20.4.8 slip compensation
 20.4.9 nominal slip
 20.4.10 voltage limit

3 kHz
460 V
 LINEAR
 60 Hz
AUTO
 0.01 x V_N
 0 Hz
ON
1.4%
 ON

30 Protection/Information

30.1 Fault Function

30.1.1 serial fault function
 30.1.2 AI < min function
 30.1.3 mot temp fault func
 30.1.4 motor thermal time
 30.1.5 motor load curve
 30.1.6 zero speed load
 30.1.7 break point
 30.1.8 stall function
 30.1.9 stall current
 30.1.10 stall time/frequency
 30.1.11 underload function
 30.1.12 underload time
 30.1.13 underload curve

STOP
 NO
NO
 700 s
100%
100%
 60 Hz
FAULT
69.6 A
 20 s/25 Hz
 NO
 600 s
 1

30.2 Automatic Reset

30.2.1 number of resets
 30.2.2 time window
 30.2.3 time betw res attempt
 30.2.4 overvoltage
 30.2.5 undervoltage
 30.2.6 overcurrent
 30.2.7 AI signal < min

2
 30 s
 0
 NO
 YES
 NO
 NO

30.3 Supervision

30.3.1 output freq 1 function
 30.3.2 output freq 1 limit
 30.3.3 output freq 2 function
 30.3.4 output freq 2 limit
 30.3.5 current function
 30.3.6 current limit
 30.3.7 ref 1 function
 30.3.8 ref 1 limit
 30.3.9 ref 2 function
 30.3.10 ref 2 limit
 30.3.11 supervis messages

NO
 0
 NO
 0
 NO
 0 x I_N
 NO
 0 Hz
 NO
 0%
 ON

30.4 Information

30.4.1 CRI prog version
 30.4.2 MC prog version
 30.4.3 test date

(version)
 (version)
 (date)

10 Control Connections

10.1 Strt/Stop/Direction

10.1.1 ext 1 strt/stp/dir
 10.1.2 ext 2 strt/stp/dir
 10.1.3 loc/ext direction

DI 1
 NOT SEL
 FORWARD

10.2 External Ref Select

10.2.1 ext 1/ext 2 select
 10.2.2 external ref 1 sel
 10.2.3 ext ref 1 minimum
 10.2.4 ext ref 1 maximum
 10.2.7 external ref 2 sel
 10.2.8 ext ref 2 minimum
 10.2.9 ext ref 2 maximum

OP DATA 12
 AI1
 0 Hz
 60 Hz
 OP DATA 14
 0 Hz
 60 Hz

10.3 Preset Speeds

10.3.1 preset speed sel
 10.3.2 preset speed 1
 10.3.3 preset speed 2
 10.3.4 preset speed 3

DI 5,6
 5 Hz
 10 Hz
 15 Hz

10.4 System Contr Input

10.4.1 run enable
 10.4.2 fault reset select
 10.4.3 param. Lock sel
 10.4.4 external fault

YES
 NOT SEL
 OP DATA 20
 NOT SEL

BOLD PARAMETERS altered by Akkerman from ABB default settings. 60 HP slurry return pump settings for ABB variable frequency drive DC2.

START-UP DATA

A language
 B applications
 C applic. Restore
 D supply voltage
 E user display scale
 F motor current - fla
 G motor power hp
 H motor power factor
 I motor base freq
 J motor base rpm
 K motor nom. Voltage

ENGLISH
FACTORY
 NO
480 V
100
68
60
0.86
 60
1775
460

10.5 Analog Inputs

10.5.1 minimum AI1 ***2V / 4mA***
 10.5.2 maximum AI1 10V / 20mA
 10.5.3 RC filter on AI1 0.1 s
 10.5.4 invert AI1 NO
 10.5.5 minimum AI2 0V / 0mA
 10.5.6 maximum AI2 10V / 20mA
 10.5.7 RC filter on AI2 0.1 s
 10.5.8 invert AI2 NO

10.6 Relay Outputs

10.6.1 relay RO1 output READY
 10.6.2 relay RO2 output RUN
 10.6.3 relay RO3 output FAULT (-1)

20.5 Critical Frequencies

20.5.1 crit freq select OFF
 20.5.2 crit freq low 1 0 Hz
 20.5.3 crit freq high 1 0 Hz
 20.5.4 crit freq low 2 0 Hz
 20.5.5 crit freq high 2 0 Hz
 20.5.6 crit freq low 3 0 Hz
 20.5.7 crit freq high 3 0 Hz
 20.5.8 crit freq low 4 0 Hz
 20.5.9 crit freq high 4 0 Hz
 20.5.10 crit freq low 5 0 Hz
 20.5.11 crit freq high 5 0 Hz

OPERATING DATA

1 output
 2 speed
 3 motor current
 4 % rated torque
 5 % rated power
 6 DC bus voltage
 7 output voltage
 8 drive temperature
 9 control location
 10 keypad ref 1
 11 keypad pi (ref 2)
 12 ext ref 1 or 2
 13 external ref 1
 14 external ref 2
 15 run time
 16 kilowatt hours
 17 last-recd fault
 18 second-recd fault
 19 first-recd fault
 20 parameter lock

KEYPAD R1
 REF 1

10.7 Analog Outputs

10.7.1 analog output 1 ***NOT USED***
 10.7.2 scale AO1 100%
 10.7.3 minimum AO1 0 mA
 10.7.4 RC filter on AO1 2 s
 10.7.5 invert AO1 NO
 10.7.6 analog output 2 OUT CURR
 10.7.7 scale AO2 100%
 10.7.8 minimum AO2 ***4 mA***
 10.7.9 RC filter on AO2 ***0.5 s***
 10.7.10 invert AO2 NO

20 Drive Parameters

20.1 Freq/Current Limit

20.1.1 min frequency 0 Hz
 20.1.2 max frequency 60 Hz
 20.1.3 frequency range 0 - 120 Hz
 20.1.4 current limit ***68 A***

20.2 Start / Stop

20.2.1 start function ***TORQ BOOST***
 20.2.2 torq boost current ***102 A***
 20.2.3 stop function COAST
 20.2.4 brake chopper NO
 20.2.5 DC hold OFF
 20.2.6 DC hold voltage $0.01 \times V_N$
 20.2.7 DC brake voltage $0.01 \times V_N$
 20.2.8 DC brake time 0 s

20.3 Accel / Decel

20.3.1 acc/dec 1 or 2 sel DI 4
 20.3.2 ac/dec ramp shape LINEAR
 20.3.3 accel time 1 3 s
 20.3.4 decel time 1 3 s
 20.3.5 accel time 2 60 s
 20.3.6 decel time 2 60 s

20.4 Motor Control

20.4.1 switching freq 3 kHz
 20.4.2 max output voltage ***460 V***
 20.4.3 V/Hz ratio LINEAR
 20.4.4 field weak point 60 Hz
 20.4.5 IR compensation ***AUTO***
 20.4.6 IR comp voltage $0.01 \times V_N$
 20.4.7 IR comp range 0 Hz
 20.4.8 slip compensation ***ON***
 20.4.9 nominal slip ***1.4%***
 20.4.10 voltage limit ON

30 Protection/Information

30.1 Fault Function

30.1.1 serial fault function STOP
 30.1.2 AI < min function NO
 30.1.3 mot temp fault func ***NO***
 30.1.4 motor thermal time 700 s
 30.1.5 motor load curve ***100%***
 30.1.6 zero speed load ***100%***
 30.1.7 break point 60 Hz
 30.1.8 stall function ***FAULT***
 30.1.9 stall current ***81.6 A***
 30.1.10 stall time/frequency 20 s/25 Hz
 30.1.11 underload function NO
 30.1.12 underload time 600 s
 30.1.13 underload curve 1

30.2 Automatic Reset

30.2.1 number of resets 2
 30.2.2 time window 30 s
 30.2.3 time betw res attempt 0
 30.2.4 overvoltage NO
 30.2.5 undervoltage YES
 30.2.6 overcurrent NO
 30.2.7 AI signal < min NO

30.3 Supervision

30.3.1 output freq 1 function NO
 30.3.2 output freq 1 limit 0
 30.3.3 output freq 2 function NO
 30.3.4 output freq 2 limit 0
 30.3.5 current function NO
 30.3.6 current limit $0 \times I_N$
 30.3.7 ref 1 function NO
 30.3.8 ref 1 limit 0 Hz
 30.3.9 ref 2 function NO
 30.3.10 ref 2 limit 0%
 30.3.11 supervis messages ON

30.4 Information

30.4.1 CRI prog version (version)
 30.4.2 MC prog version (version)
 30.4.3 test date (date)

10 Control Connections

10.1 Strt/Stop/Direction

10.1.1 ext 1 strt/stp/dir ***DI 1***
 10.1.2 ext 2 strt/stp/dir NOT SEL
 10.1.3 loc/ext direction FORWARD

10.2 External Ref Select

10.2.1 ext 1/ext 2 select OP DATA 12
 10.2.2 external ref 1 sel AI1
 10.2.3 ext ref 1 minimum 0 Hz
 10.2.4 ext ref 1 maximum 60 Hz
 10.2.7 external ref 2 sel OP DATA 14
 10.2.8 ext ref 2 minimum 0 Hz
 10.2.9 ext ref 2 maximum 60 Hz

10.3 Preset Speeds

10.3.1 preset speed sel DI 5,6
 10.3.2 preset speed 1 5 Hz
 10.3.3 preset speed 2 10 Hz
 10.3.4 preset speed 3 15 Hz

10.4 System Contr Input

10.4.1 run enable YES
 10.4.2 fault reset select NOT SEL
 10.4.3 param. Lock sel OP DATA 20
 10.4.4 external fault NOT SEL

BOLD PARAMETERS altered by Akkerman from ABB default settings. 75 HP motor settings for ABB variable frequency drive DC4 (P0109-033, ACS504-125-6-00P2)

START-UP DATA

A language
 B applications
 C applic. Restore
 D supply voltage
 E user display scale
 F motor current - fla
 G motor power hp
 H motor power factor
 I motor base freq
 J motor base rpm
 K motor nom. Voltage

ENGLISH
FACTORY
 NO
575 V
100
70
75
 0.83
 60
1755
575

10.5 Analog Inputs

10.5.1 minimum AI1
 10.5.2 maximum AI1
 10.5.3 RC filter on AI1
 10.5.4 invert AI1
 10.5.5 minimum AI2
 10.5.6 maximum AI2
 10.5.7 RC filter on AI2
 10.5.8 invert AI2

2V / 4mA
 10V / 20mA
 0.1 s
 NO
 0V / 0mA
 10V / 20mA
 0.1 s
 NO

10.6 Relay Outputs

10.6.1 relay RO1 output
 10.6.2 relay RO2 output
 10.6.3 relay RO3 output

READY
 RUN
 FAULT (-1)

20.5 Critical Frequencies

20.5.1 crit freq select
 20.5.2 crit freq low 1
 20.5.3 crit freq high 1
 20.5.4 crit freq low 2
 20.5.5 crit freq high 2
 20.5.6 crit freq low 3
 20.5.7 crit freq high 3
 20.5.8 crit freq low 4
 20.5.9 crit freq high 4
 20.5.10 crit freq low 5
 20.5.11 crit freq high 5

OFF
 0 Hz
 0 Hz
 0 Hz
 0 Hz
 0 Hz
 0 Hz
 0 Hz
 0 Hz
 0 Hz
 0 Hz

OPERATING DATA

1 output
 2 speed
 3 motor current
 4 % rated torque
 5 % rated power
 6 DC bus voltage
 7 output voltage
 8 drive temperature
 9 control location
 10 keypad ref 1
 11 keypad pi (ref 2)
 12 ext ref 1 or 2
 13 external ref 1
 14 external ref 2
 15 run time
 16 kilowatt hours
 17 last-recd fault
 18 second-recd fault
 19 first-recd fault
 20 parameter lock

KEYPAD R1
 REF 1

10.7 Analog Outputs

10.7.1 analog output 1
 10.7.2 scale AO1
 10.7.3 minimum AO1
 10.7.4 RC filter on AO1
 10.7.5 invert AO1
 10.7.6 analog output 2
 10.7.7 scale AO2
 10.7.8 minimum AO2
 10.7.9 RC filter on AO2
 10.7.10 invert AO2

NOT USED
 100%
 0 mA
 2 s
 NO
 OUT CURR
50%
4 mA
0.5 s
 NO

20 Drive Parameters

20.1 Freq/Current Limit

20.1.1 min frequency
 20.1.2 max frequency
 20.1.3 frequency range
 20.1.4 current limit

0 Hz
 60 Hz
 0 - 120 Hz
80 A

20.2 Start / Stop

20.2.1 start function
 20.2.2 torq boost current
 20.2.3 stop function
 20.2.4 brake chopper
 20.2.5 DC hold
 20.2.6 DC hold voltage
 20.2.7 DC brake voltage
 20.2.8 DC brake time

TORQ BOOST
105 A
RAMP
 NO
 OFF
 0.01 x V_N
 0.01 x V_N
 0 s

20.3 Accel / Decel

20.3.1 acc/dec 1 or 2 sel
 20.3.2 ac/dec ramp shape
 20.3.3 accel time 1
 20.3.4 decel time 1
 20.3.5 accel time 2
 20.3.6 decel time 2

DI 4
 LINEAR
 2 s
1 s
 60 s
 60 s

20.4 Motor Control

20.4.1 switching freq
 20.4.2 max output voltage
 20.4.3 V/Hz ratio
 20.4.4 field weak point
 20.4.5 IR compensation
 20.4.6 IR comp voltage
 20.4.7 IR comp range
 20.4.8 slip compensation
 20.4.9 nominal slip
 20.4.10 voltage limit

3 kHz
575 V
 LINEAR
 60 Hz
AUTO
 0.01 x V_N
 0 Hz
ON
2.5%
 ON

30 Protection/Information

30.1 Fault Function

30.1.1 serial fault function
 30.1.2 AI < min function
 30.1.3 mot temp fault func
 30.1.4 motor thermal time
 30.1.5 motor load curve
 30.1.6 zero speed load
 30.1.7 break point
 30.1.8 stall function
 30.1.9 stall current
 30.1.10 stall time/frequency
 30.1.11 underload function
 30.1.12 underload time
 30.1.13 underload curve

STOP
 NO
NO
 700 s
150%
150%
 60 Hz
FAULT
105 A
***10 s/15 H**
 NO
 600 s
 1

30.2 Automatic Reset

30.2.1 number of resets
 30.2.2 time window
 30.2.3 time betw res attempt
 30.2.4 overvoltage
 30.2.5 undervoltage
 30.2.6 overcurrent
 30.2.7 AI signal < min

2
 30 s
 0
 NO
 YES
 NO
 NO

30.3 Supervision

30.3.1 output freq 1 function
 30.3.2 output freq 1 limit
 30.3.3 output freq 2 function
 30.3.4 output freq 2 limit
 30.3.5 current function
 30.3.6 current limit
 30.3.7 ref 1 function
 30.3.8 ref 1 limit
 30.3.9 ref 2 function
 30.3.10 ref 2 limit
 30.3.11 supervis messages

NO
 0
 NO
 0
 NO
 0 x I_N
 NO
 NO
 NO
 0%
 ON

30.4 Information

30.4.1 CRI prog version
 30.4.2 MC prog version
 30.4.3 test date

(version)
 (version)
 (date)

10 Control Connections

10.1 Strt/Stop/Direction

10.1.1 ext 1 strt/stp/dir
 10.1.2 ext 2 strt/stp/dir
 10.1.3 loc/ext direction

DI 1,2
 NOT SEL
REQUEST

10.2 External Ref Select

10.2.1 ext 1/ext 2 select
 10.2.2 external ref 1 sel
 10.2.3 ext ref 1 minimum
 10.2.4 ext ref 1 maximum
 10.2.7 external ref 2 sel
 10.2.8 ext ref 2 minimum
 10.2.9 ext ref 2 maximum

OP DATA 12
 AI1
 0 Hz
 60 Hz
 OP DATA 14
 0 Hz
 60 Hz

10.3 Preset Speeds

10.3.1 preset speed sel
 10.3.2 preset speed 1
 10.3.3 preset speed 2
 10.3.4 preset speed 3

DI 5,6
 5 Hz
 10 Hz
 15 Hz

10.4 System Contr Input

10.4.1 run enable
 10.4.2 fault reset select
 10.4.3 param. Lock sel
 10.4.4 external fault

YES
 NOT SEL
 OP DATA 20
 NOT SEL

BOLD PARAMETERS altered by Akkerman from ABB default settings. 125 HP drive motor settings for ABB variable frequency drive DC4 (P0109-033, ACS504-125-6-00P2)

START-UP DATA

A language	*ENGLISH*
B applications	*FACTORY*
C applic. restore	NO
D supply voltage	*600 V*
E user display scale	*100*
F motor current - fla	*140*
G motor power hp	*150*
H motor power factor	0.83
I motor base freq	60
J motor base rpm	*1185*
K motor nom. voltage	*600*

10.5 Analog Inputs

10.5.1 minimum AI1	*2V / 4mA*
10.5.2 maximum AI1	10V / 20mA
10.5.3 RC filter on AI1	0.1 s
10.5.4 invert AI1	NO
10.5.5 minimum AI2	0V / 0mA
10.5.6 maximum AI2	10V / 20mA
10.5.7 RC filter on AI2	0.1 s
10.5.8 invert AI2	NO

20.5 Critical Frequencies

20.5.1 crit freq select	OFF
20.5.2 crit freq low 1	0 Hz
20.5.3 crit freq high 1	0 Hz
20.5.4 crit freq low 2	0 Hz
20.5.5 crit freq high 2	0 Hz
20.5.6 crit freq low 3	0 Hz
20.5.7 crit freq high 3	0 Hz
20.5.8 crit freq low 4	0 Hz
20.5.9 crit freq high 4	0 Hz
20.5.10 crit freq low 5	0 Hz
20.5.11 crit freq high 5	0 Hz

OPERATING DATA

1 output	
2 speed	
3 motor current	
4 % rated torque	
5 % rated power	
6 DC bus voltage	
7 output voltage	
8 drive temperature	
9 control location	*EXTERNAL*
10 keypad ref 1	
11 keypad pi (ref 2)	
12 ext ref 1 or 2	REF 1
13 external ref 1	
14 external ref 2	
15 run time	
16 kilowatt hours	
17 last-recd fault	
18 second-recd fault	
19 first-recd fault	
20 parameter lock	OPEN

10.6 Relay Outputs

10.6.1 relay RO1 output	READY
10.6.2 relay RO2 output	RUN
10.6.3 relay RO3 output	FAULT (-1)

30 Protection/Information

30.1 Fault Function

30.1.1 serial fault function	STOP
30.1.2 AI < min function	NO
30.1.3 mot temp fault func	*NO*
30.1.4 motor thermal time	700 s
30.1.5 motor load curve	*150%*
30.1.6 zero speed load	*150%*
30.1.7 break point	60 Hz
30.1.8 stall function	*FAULT*
30.1.9 stall current	*187.5 A*
30.1.10 stall time/frequency	*10 s/15 Hz*
30.1.11 underload function	NO
30.1.12 underload time	600 s
30.1.13 underload curve	1

10.7 Analog Outputs

10.7.1 analog output 1	*NOT USED*
10.7.2 scale AO1	100%
10.7.3 minimum AO1	0 mA
10.7.4 RC filter on AO1	2 s
10.7.5 invert AO1	NO
10.7.6 analog output 2	OUT CURR
10.7.7 scale AO2	*58%*
10.7.8 minimum AO2	*4 mA*
10.7.9 RC filter on AO2	*0.01 s*
10.7.10 invert AO2	NO

30.2 Automatic Reset

30.2.1 number of resets	2
30.2.2 time window	30 s
30.2.3 time betw res attempt	0
30.2.4 overvoltage	NO
30.2.5 undervoltage	YES
30.2.6 overcurrent	NO
30.2.7 AI signal < min	NO

20 Drive Parameters

20.1 Freq/Current Limit

20.1.1 min frequency	0 Hz
20.1.2 max frequency	60 Hz
20.1.3 frequency range	0 - 120 Hz
20.1.4 current limit	*155 A*

20.2 Start / Stop

20.2.1 start function	*TORQ BOOST*
20.2.2 torq boost current	*210 A*
20.2.3 stop function	*RAMP*
20.2.4 brake chopper	NO
20.2.5 DC hold	OFF
20.2.6 DC hold voltage	0.01 x V _N
20.2.7 DC brake voltage	0.01 x V _N
20.2.8 DC brake time	0 s

30.3 Supervision

30.3.1 output freq 1 function	NO
30.3.2 output freq 1 limit	0
30.3.3 output freq 2 function	NO
30.3.4 output freq 2 limit	0
30.3.5 current function	NO
30.3.6 current limit	0 x I _N
30.3.7 ref 1 function	NO
30.3.8 ref 1 limit	0 Hz
30.3.9 ref 2 function	NO
30.3.10 ref 2 limit	0%
30.3.11 supervis messages	ON

10 Control Connections

10.1 Strt/Stop/Direction

10.1.1 ext 1 strt/stp/dir	*DI 1,2*
10.1.2 ext 2 strt/stp/dir	NOT SEL
10.1.3 loc/ext direction	*REQUEST*

10.2 External Ref Select

10.2.1 ext 1/ext 2 select	OP DATA 12
10.2.2 external ref 1 sel	AI1
10.2.3 ext ref 1 minimum	0 Hz
10.2.4 ext ref 1 maximum	60 Hz
10.2.7 external ref 2 sel	OP DATA 14
10.2.8 ext ref 2 minimum	0 Hz
10.2.9 ext ref 2 maximum	60 Hz

20.3 Accel / Decel

20.3.1 acc/dec 1 or 2 sel	DI 4
20.3.2 ac/dec ramp shape	LINEAR
20.3.3 accel time 1	3 s
20.3.4 decel time 1	*1 s*
20.3.5 accel time 2	60 s
20.3.6 decel time 2	60 s

10.3 Preset Speeds

10.3.1 preset speed sel	DI 5,6
10.3.2 preset speed 1	5 Hz
10.3.3 preset speed 2	10 Hz
10.3.4 preset speed 3	15 Hz

20.4 Motor Control

20.4.1 switching freq	3 kHz
20.4.2 max output voltage	*575 V*
20.4.3 V/Hz ratio	LINEAR
20.4.4 field weak point	60 Hz
20.4.5 IR compensation	*AUTO*
20.4.6 IR comp voltage	0.01 x V _N
20.4.7 IR comp range	0 Hz
20.4.8 slip compensation	*ON*
20.4.9 nominal slip	*2.5%*
20.4.10 voltage limit	ON

10.4 System Contr Input

10.4.1 run enable	YES
10.4.2 fault reset select	NOT SEL
10.4.3 param. lock sel	OP DATA 20
10.4.4 external fault	NOT SEL

30.4 Information

30.4.1 CRI prog version	(version)
30.4.2 MC prog version	(version)
30.4.3 test date	(date)