BI001639
A6474X235
August 2012

Operation Manual

SU488 L and SU488 Scoop

A6474X235 (Operation)

2 Your safety

maintenance, repair

Only persons who have and can demonstrate a special knowledge of hydraulics are allowed to work on the hydraulic system.

Avoid, whenever possible, servicing, cleaning or examining the machine in congested areas.

Avoid, whenever possible, servicing or providing maintenance to the unit unless the wheels are chocked and steering lockout device is connected to prevent accidental movement of the unit.

Do not alter the electrical or hydraulic settings from that indicated in this manual or as set at the factory.

Always replace damaged or lost decals and metal instruction plates.

Disconnect the battery when working with the electrical system, or when welding on the unit to prevent electrical shock.

Be sure the battery area is well ventilated (clear of fumes) when it is necessary to connect battery charger. Fumes from the battery could ignite from a spark and explode.

Always follow all safety procedures of each particular mine when performing maintenance.

It is important that any procedure not specifically recommended in this guide be thoroughly evaluated from the standpoint of safety before it is implemented.

Some illustrations in this manual show guards or cover panels removed for purposes of clarity. Never operate unit without guards or cover panels in place.

Carry out a visual inspection of all the hydraulic components at regular intervals. In particular check that:

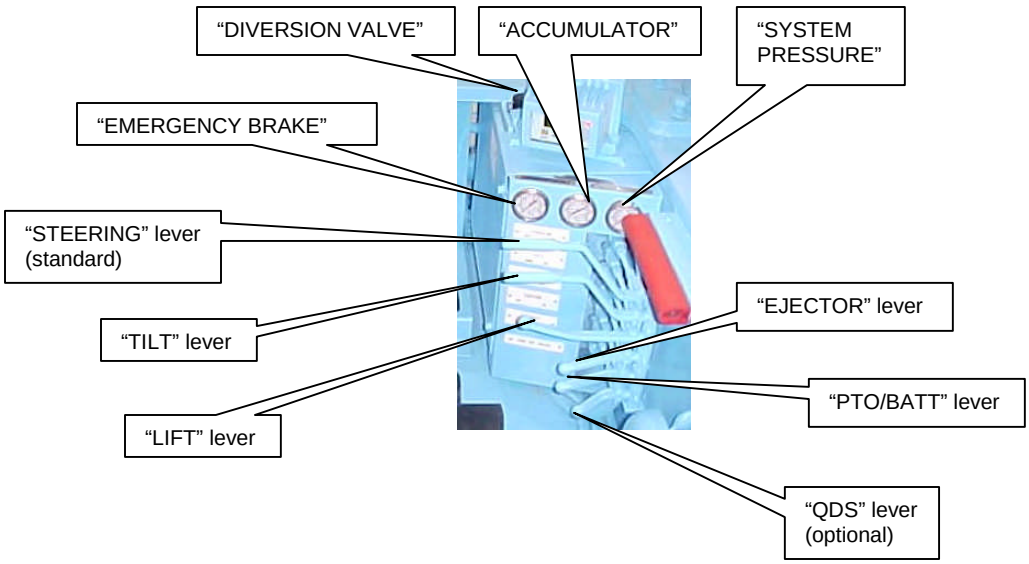
- the hoses are not pinched or trapped,
- the hoses have no bubbles or blisters,
- the hose or outer sheathes of the hose are not abnormally rigid or hard,
- the outer sheath of the hoses is not damaged,
- the connectors are securely inserted into the sockets, and
- the connections are leak-tight.

Ensure that no dirt enters the hydraulic system during repair work. Dirt in the hydraulic system can cause serious damage in the whole system! Flush out the hydraulic lines thoroughly before connecting.

4 Installation

5 Operation

Fig. 14: Hydraulic control system (with vertical lift and/or QDS)



Hydraulic control panel (with vertical lift and/or QDS)

The hydraulic control panel (Fig. 14), located to the left of the operator, has a group of switches that control the following:

IMPORTANT!
For more detailed control handle operating instructions, see Starting procedures in this chapter.

"STEERING"

The "STEERING" control lever is used to steer the machine. To steer left while moving forward (right when moving in reverse), push the steering control lever slowly away from the operator. To turn right while moving forward (left when moving in reverse), pull the steering control lever slowly toward the operator.

"TILT"

The "TILT" control lever is used to control the forks and/or the quick attach bucket. This control lever allows the operator to tilt the forks or bucket either forward or back. To tilt the attachment down, push the lever away from the operator. To tilt the attachment up, pull the lever towards the operator.

"LIFT"

The "LIFT" control lever is used to raise or lower the forks and/or the quick attach bucket. To lower the attachment, push the lever away from the operator. To raise the attachment, pull the lever towards the operator.

Starting procedure with control handle

After reading the previous descriptions and locating each control, the operator is ready to operate the machine. An experienced operator should monitor a new operator's indoctrination to the starting procedure.

CAUTION!
Use caution when traveling down grade, exceeding 5 mph (8 kph) with this machine will result in tram motor failure.

WARNING!
Check the battery connections and the battery covers. They must be in place and locked to be permissible.

WARNING!
Never operate any levers or pedals from outside the operator's compartment. All switches in the operator's compartment must be in the "OFF" position before the battery circuit breaker is moved to the "ON" position.

WARNING!
This unit is equipped with a cab or canopy. Be careful not to hit your head when entering or leaving the operator's compartment. This machine must not be operated without the canopy in place.

General

1. Disconnect the steering lockout device (Fig. 25).

2. Sit in the operator's seat and adjust the seat position relative to the foot and hand controls.

WARNING!
Be sure no one is in the Hazard zone (Fig. 23) before operating any levers or pedals.

Never try to adjust the operator's seat while the machine is in motion.

Do not operate the machine with any part of your body outside the operator's compartment to prevent having body parts caught between the unit and outside objects.

3. The tape panic strip (s) may be pressed at any time to trip the machine circuit breaker, set the park brake, and to de-energize the tram and pump motors.

4. Stop button "J3" may be pressed at any time to set the park brake, and to de-energize the tram and pump motors (Fig. 24).

Towing a disabled machine

WARNING!
It is not possible, within the scope of this guide, to anticipate all possible arrangements for towing a disabled vehicle, you must take all possible precautions to protect the operators and anyone around both vehicles from being injured by either the towing vehicle, the towing device used (cables, bars, etc.) and the towing vehicle (scoop, tractor, etc.) must be strong and heavy enough to maintain control of both vehicles through all bottom conditions to be encountered at all times. Safety chains or other safety devices must be used in case of failure of the primary towing device. All operators must be alert at all times to prevent either unit from running away or running out of control during towing. The vehicle to be towed must be securely coupled to the towing vehicle before the brakes are released on the disabled unit. The operator of the towing vehicle must be in place in the towing vehicle with the brakes applied before the brakes of the disabled vehicle are released.

- ☞ Couple the towing vehicle securely to the disabled vehicle.
- ☞ Close the valve to tank circuit that is on the hand pump to isolate the park brake solenoid from the circuit.
- ☞ Begin pumping the hand pump. The building pressure moves the shuttle valve and allows the Automatic (Park) Brake system to be pressurized.
- ☞ The Automatic (Park) Brake is released as indicated by the Brake Release gauge.

CAUTION!
For long distance towing, disconnect and remove front and rear drive lines.

WARNING!
At no time during towing should anyone ride in or on the vehicle being towed or stand in between the towing vehicle and the disabled vehicle.

- ☞ Begin towing the vehicle.
- ☞ Once the destination is reached, stop both vehicles and set the parking brake on the disabled vehicle before removing the towing devices. The disabled vehicle should be choked in both direction at all four wheels for additional stability. The brake is set by turning the valve handle on the hand pump to “NORMAL RE-APPLY”.

WARNING!
Failure to set the parking brake on the disabled vehicle before removing the towing device could allow the disabled vehicle to roll away uncontrolled.

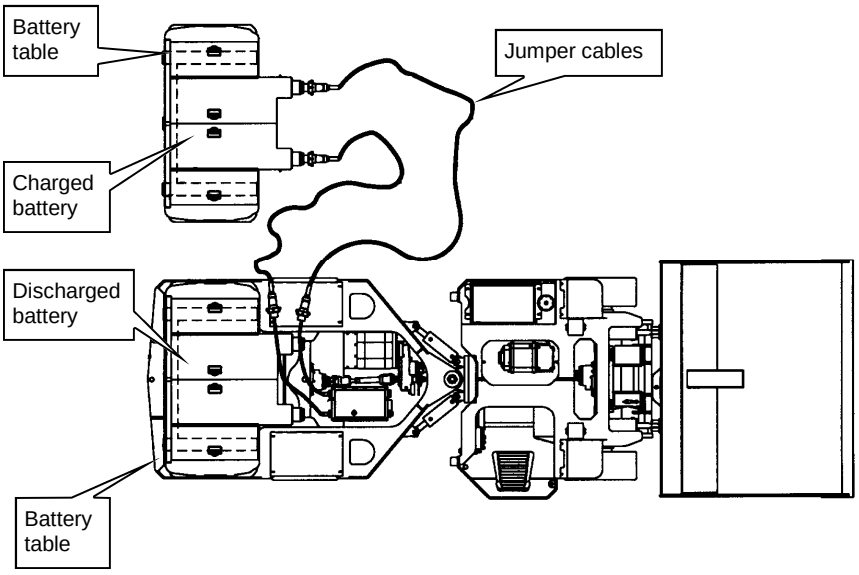
☞ Connect the jumper cable:

☞ Connect the receptacle end of the jumper cable to the machine and connect the plug end of the jumper cable to the fully charged battery (Fig. 39).

☞ Secure the jumper cable connections by using the threaded lock rings. These lock rings must be hand tight but do not have to be padlocked. One person should hold the jumper cable so it will not be damaged or run over when the machine is moved.

☞ Start the machine (see Starting procedure in this chapter).

Fig. 39: Battery change procedure (vertical lift)



Specific lubrication and maintenance procedures

Every shift

electrical cables and conduits
hydraulic hoses and fittings
tires and headlights

Inspect all electrical cables, conduits, hydraulic hoses, fittings, tires, and headlights for signs of wear or damage. Repair or replace any damaged item.

warning tags and reflectors

Visually inspect the condition and readability of all warning tags, labels, and reflectors. Replace all that are found missing or damaged.

tape switches (panic bars)

Check the tape switches (panic bars) located inside the operator's compartment (Fig. 46). Start the machine but do not tram. Strike the tape switch: the machine circuit breaker should trip and the machine should shut down. Repeat with the other tape switch.

Fig. 46: Tape switch (panic strip) location

hydraulic oil level

Check the hydraulic oil level by looking at the sight glass located on the oil tank (Fig. 47). If the oil level is low, add oil:
(Spec. 100-1, if equipped with John Deere or Axle Tech axles)
(Spec. 100-12, if equipped with Kessler axles)

Fig. 47: Hydraulic oil level

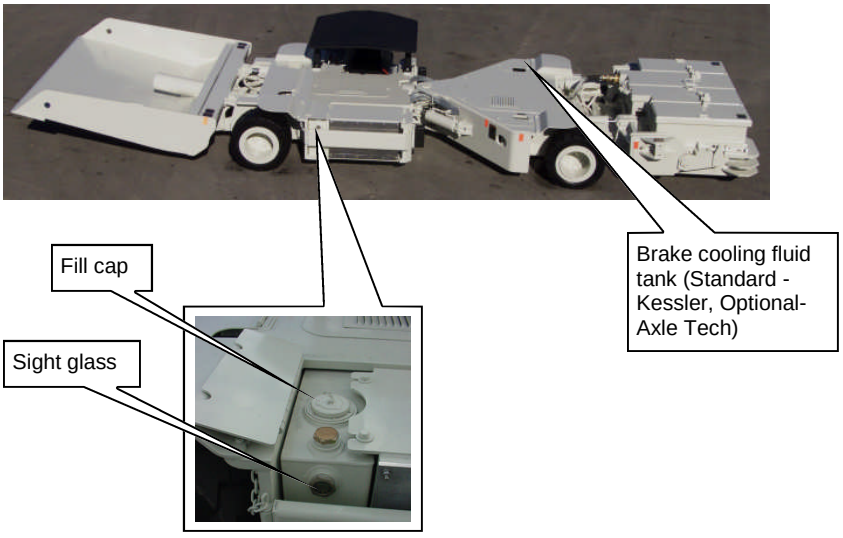
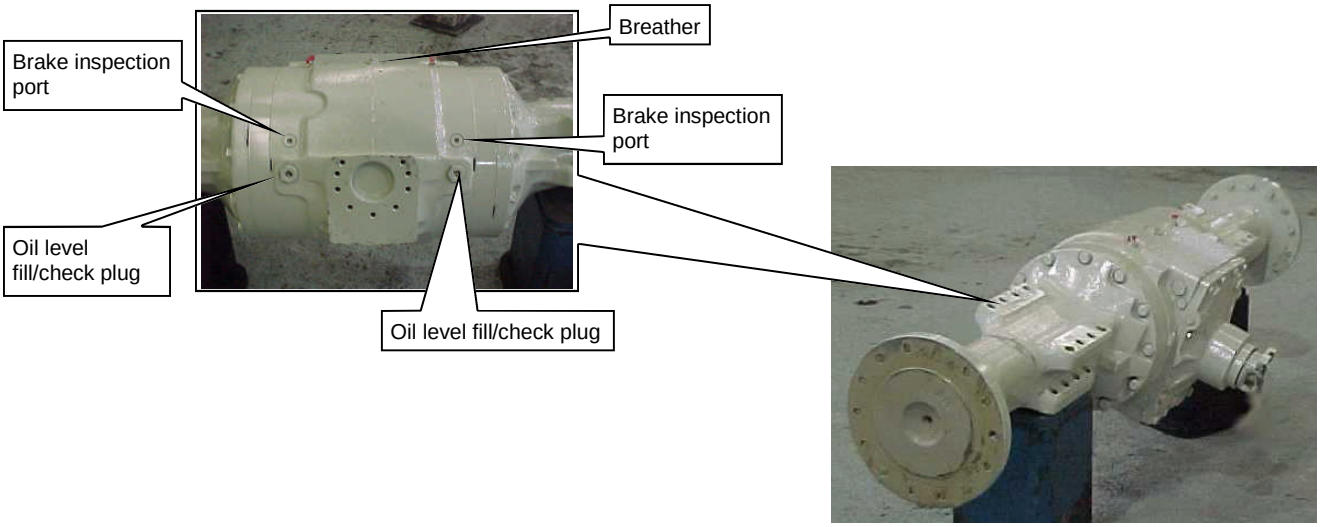


Fig. 64: Axle oil level (John Deere)

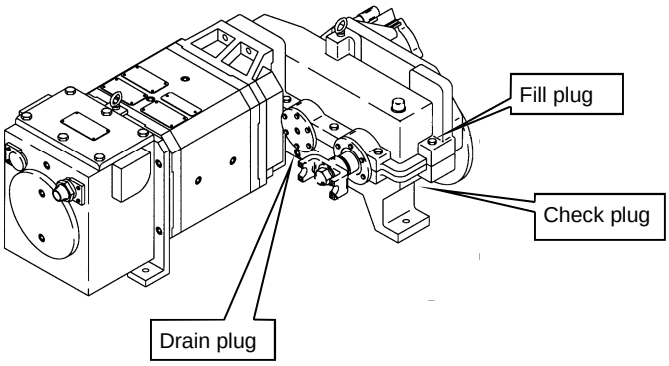


speed reducer (gear case) oil

Check the oil in both speed reducers (Fig. 65).

- ☞ Park the machine on solid level ground.
- ☞ Remove the check plug from the speed reducer (gearbox). The oil level should be kept at the level of the check plug.
- ☞ Should it be necessary to add oil, add the oil (Spec. 100-6) through the fill plug hole slowly until oil flows from the check plug hole. Do not overfill speed reducer.
- ☞ Replaced the check and fill plugs.

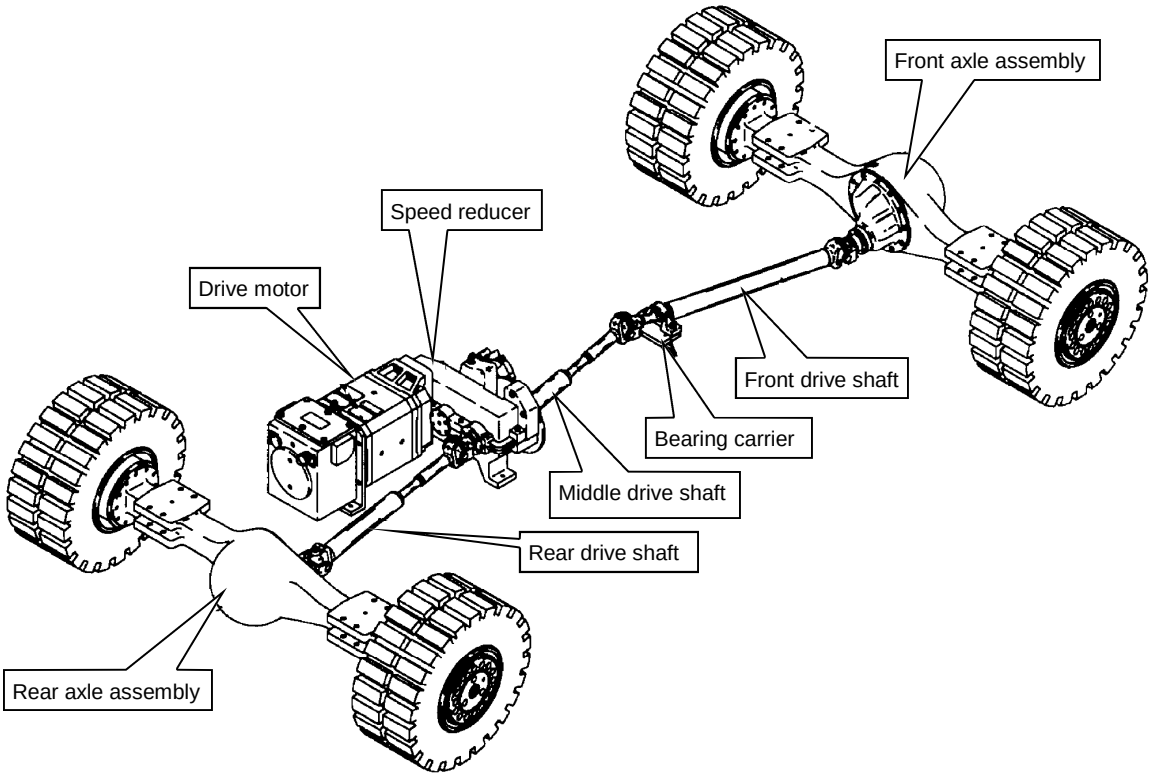
Fig. 65: Speed reducer (gear case) oil



Drive motor/gearbox (speed reducer) removal and replacement

WARNING!
Power must be removed by unplugging the battery plugs before servicing the motor.

Fig. 77: Drive train components



The following procedures reference Fig. 77.

Drive motor

- ☞ Remove the motor inspection cover and disconnect the power cables to the motor. Unpack the motor gland and completely remove the wiring and conduit from the motor.
- ☞ Attach a crane or hoist, capable of lifting the motor, to the eyebolt on top of the motor and take up any slack in hoist chain.
- ☞ Remove the four (4) bolts that attach the motor to the gearbox.
- ☞ Lift the motor out of the unit.
- ☞ Cover the reducer opening to prevent foreign matter from entering the gearbox.

Brakes

Table 6: Brakes troubleshooting

Trouble, symptom or cause	Probable cause	Test, check and/or remedy
brakes slow to apply	☞ No gas charge in accumulator.	☞ Check gas charge.
	☞ Defective brakes.	☞ Check brakes.
	☞ Hydraulic lines or fittings leaking.	☞ Check for leaks and repair.
	☞ Pedal linkage out of adjustment.	☞ Adjust linkage.
	☞ Damaged hydraulic brake lines.	☞ Check lines for dents that restrict flow of oil.
brakes won't release	☞ Pedal linkage out of adjustment or binding.	☞ Check for proper adjustment and binding.
	☞ Defective brakes.	☞ Check brakes .
	☞ Defective brake valve.	☞ Replace brake valve.
insufficient brakes	☞ No oil or low level in tank.	☞ Check oil level in tank.
	☞ Pedal linkage out of adjustment.	☞ Adjust linkage.
	☞ Brake line mashed.	☞ Check lines and replace.
	☞ No gas charge in accumulator.	☞ Check gas charge.
	☞ Defective brakes.	☞ Check brakes.
	☞ Brake valve defective.	☞ Replace valve.
brakes will not release completely	☞ Defective brakes.	☞ Check brakes.
	☞ Pedal linkage out of adjustment.	☞ Adjust pedal linkage.
	☞ Air in brakes.	☞ Bleed brakes.
	☞ Defective brake valve.	☞ Replace brake valve.
	☞ Back pressure on return line too high.	☞ Remove restriction.
excessive braking	☞ Defective brakes.	☞ Check brakes.
	☞ Defective brake valve.	☞ Replace brake valve.

Tightening torques

IMPORTANT!
Due to the application of fasteners being subject to great stresses and heavy or extreme vibration, it is imperative that all bolts be applied with an adequate amount of torque. For this reason this list of recommended torque settings for different types and sizes of fasteners used has been compiled.
The tightening torques stated in the spare parts lists have to be observed, as well, for installation and maintenance.

Set screws

Table 10: Set screws (Socket long-lok)

Nominal diameter	Recommended torque setting
#6	6 in-lbs
#8	9 in-lbs
#10	13 in-lbs
¼”	30 in-lbs
5/16”	5 ft-lbs
3/8”	8 ft-lbs
7/16”	11 ft-lbs
½”	16.7 ft-lbs

Table 11: Set screws (Socket standard steel)

Nominal diameter	Recommended torque setting
#6	9 in-lbs
#8	16 in-lbs
#10	30 in-lbs
¼”	6 ft-lbs
5/16”	12 ft-lbs
3/8”	18 ft-lbs
7/16”	29 ft-lbs
½”	43 ft-lbs
5/8”	100 ft-lbs
¾”	146 ft-lbs
7/8”	199 ft-lbs
1”	262 ft-lbs

Table 22: Invert emulsion hydraulic fluid (Spec. 100-5)

	Supplier	Brand name
1	Unocal 76	FR Fluid
2	Conoco Inc.	FR Hydraulic Fluid
3	Atlantic Richfield Company	Duro FR-HD
4	Brooks Oil Company	Brooks Fire Resistant Hydraulic Fluid B
5	Cincinnati – Vulcon Company	Vulcon FR Fluid #1
6	Cities Service Oil Company	Citgo Pacemaker Invert FR Fluid
7	Century Oils Limited	Aquacent Light
8	Fiske Bros. Refining Company	Lubriplate HO-Retard
9	Getty Oil Company (Veedol, Tidewater)	Veedol Auburn FRH
10	Gulf Oil Company	FR Fluid
11	E.F. Houghton	Houghto-Safe 5046 Houghto-Safe 5046W
12	Century Lubricating Oils	Hulsafe 600
13	Imperial Oil and Grease	Astrol 587
14	Mobil Oil Corporation	Pyrogard D
15	National Oil and Chemical Co.	Erifon 1, 2, and 3
16	Pennzoil	Maxmul FRP/G
17	Quaker Chemical Company	Quintolubric 958 Series Quintolubric 958 Series
18	Henery E. Sanson and Sons MFGE Company	Hydra-Mul Premium Emulsion Fluid
19	Southwest Grease and Oil Company, Inc.	Invert Emulsion Fire Resistant Hydraulic Fluid
20	Southwest Petroleum Corp.	Swepco Fire Resistant Hydraulic oil #718
21	Standard Oil Company of Ohio (Boron Sohio)	Staysol FR
22	Sun Oil Company	Sunsafe F
23	Tower Oil Company	Safoil Anti-Wear Hydraulic Fluid
24	Wynn Oil Company	Hydra-Safe Heavy Medium
25	Lubrication Engineers	6455 Monolec Fire Resistant Hydraulic Fluid
26	Hydrotex	HY-Guard

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Operation and Troubleshooting Manual

HiPAC 10 Controller

Variable Frequency Drive (VFD) for Battery Powered Equipment (Hardwired System)

2 Your safety

Operation

This chapter contains important information on the operation of the HiPAC 10 variable frequency drive.

Read this chapter carefully and thoroughly. In particular, observe the safety instructions in Chapter 2 “Your safety”.

History

In the early 1970's, solid state peed controls for battery powered underground mining equipment were introduced. Solid state controls increased the range and reliability of the battery powered vehicles along with providing smooth, stepless acceleration. However, even with solid state speed control, direction change was achieved with the use of electromechanical contactors. These contactors provided an endless source of maintenance problems and consumed excessive amounts of valuable controller enclosure space. In addition, most solid state controllers of the past utilized an electromechanical "bypass" contactor to connect the motor directly to the batteries, which resulted in more contactor problems.

In the 1980’s, a contactorless motor controller (X90) was developed. The X90 system used a dual-field motor in combination with SCRs (Silicone Controlled Rectifiers) to achieve solid state direction change.

In the 1990’s, the BUC2000 motor controller was developed. The BUC2000 system used Insulated Gate Bipolar Transistors (IGBTs) to achieve motor control and direction change. Unlike an SCR, an IGBT is turned on and off via a gating electronic signal, eliminating commutating capacitor banks and coils. The microprocessor based BUC2000 logic card provided complete motor control and drove both a diagnostic dashboard display and a handheld calibrator/diagnostic unit.

During the early 2000’s, the successful HiPAC 10 motor controller system was developed. The HiPAC 10 system consists of highly efficient AC 3-phase induction motors and variable frequency drives. The HiPAC 10 system provides increased efficiency, higher torque capabilities, increased machine speeds, and has no motor brushes or brush holders.

Innovative Motor Control

The speed of rotation of AC induction motors is directly dependent upon the frequency of the applied AC voltage. Therefore, In order to control the speed of AC induction motors, the motor must be supplied with a voltage of variable magnitude and frequency. Ideally, this voltage is sinusoidal.

Fig. 11: Voltage cutbacks for a 240-Volt system

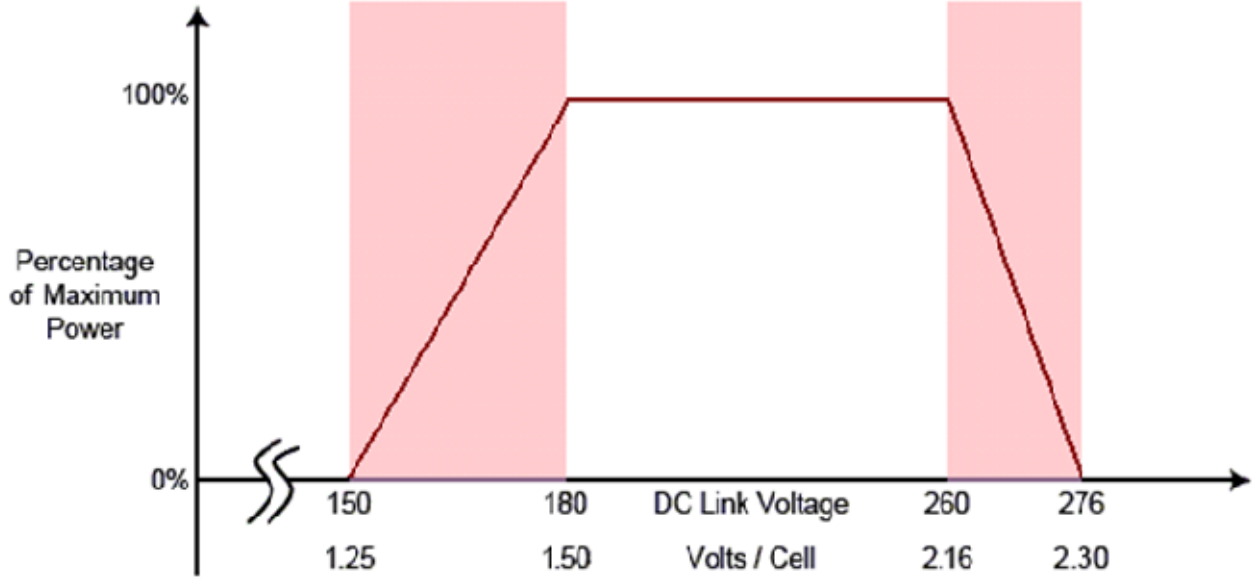


Fig. 12: Voltage cutbacks for a 128-Volt system

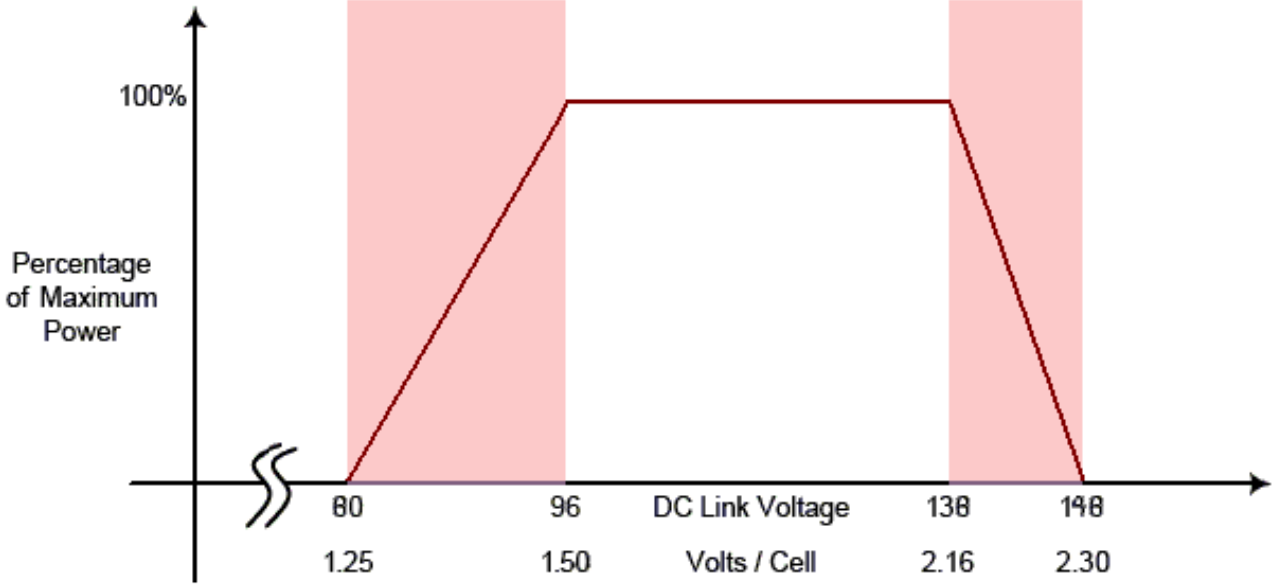


Table 13: Supervisor - Front Traction VFD (Node 1), connector "C" (VT680)

Input Description	Connector/Pin
+24VDC Supply input	C1
(reserved for service brake)	C2
UVR driver (24VDC common)	C3
Park brake solenoid driver (24VDC common)	C4
Breaker "ON" for headlight relay driver (24VDC common)	C5
Not Used	C6
Not Used	C7
Not Used	C8

Table 14: Supervisor - Front Traction VFD (Node 1), connector "D" (VT680)

Input Description	Connector/Pin
Not Used	D1
Pre-Charge Feed from B+	D2
Not Used	D3
Not Used	D4
Not Used	D5
Not Used	D6
Not Used	D7
Not Used	D8

Control System Operation

Controller Start-up

The VFDs are supplied control power from a 24V DC-DC converter and power up when the operator manually closes the battery circuit breaker on the battery assembly (if equipped) and releases the emergency stop push button in the operator's compartment.

A valid start-up sequence is described as follows:

1. Turn the battery circuit breaker and/or disconnect switch (if equipped) to the "ON" position.

2. Press and hold the diagnostics momentary switch. The VFDs energize the pre-charge circuit and the controller start-up device checks are performed (checks are done within a matter of seconds). If all checks are okay, the supervisor traction VFD will energize the main circuit breaker UVR Coil (Pin C3) and the display will signal the operator that it is OK to close the main machine circuit breaker.

3. Release the diagnostics momentary switch.

4. Close the main machine circuit breaker supplying full battery power to the VFDs.

Once the main machine circuit breaker is determined closed by the supervisor VFD through the use of the circuit breaker auxiliary switch (Pin A12 on supervisor VFD), the system is ready for pump motor operation.

Note: Once the main machine circuit breaker is closed, the Diagnostics momentary switch becomes the button to change screens on the display.

See the machine operation manual for machine operation.

NOTICE!
MSHA requirements limit the maximum machine tram speed to 6 mph. This occurs automatically through the VFD software and correct hardwired configuration inputs.

IMPORTANT!
If the operator selects FS1 before selecting a direction, a SRO fault will be produced and direction selection inhibited.

individual inputs monitor screen

Individual inputs can be monitored from the Vehicle Inputs Monitor screen (Fig. 19), which can be very helpful for troubleshooting.

Note: The payload speed limit, oil level, hydraulic filter, and payload counter switches and inputs are not available on single motor systems.

Fig. 19: Vehicle Inputs Monitor screen

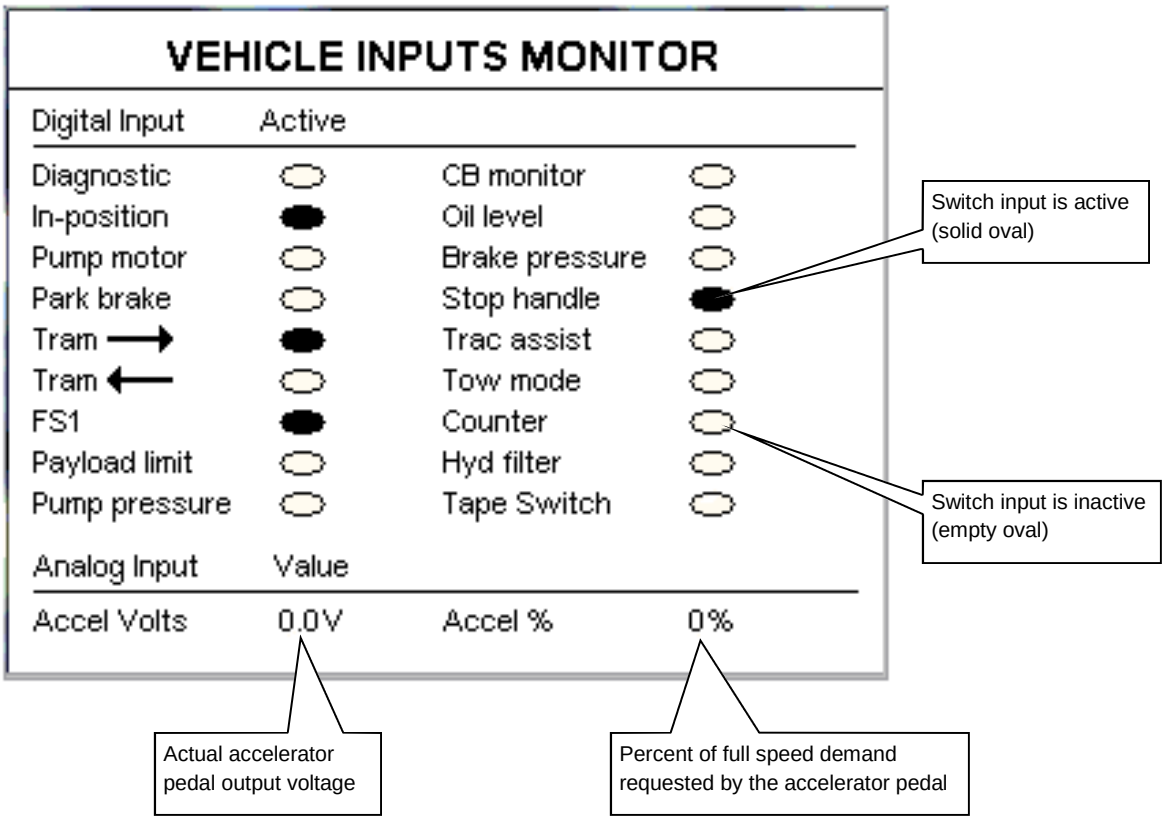


Table 27: Fault information codes, continued

Fault ID	Severity	Fault Description	Fault Help
4f01	3	CANbus configuration fault	Node has difficulty communicating via CAN. Confirm all drives have unique node ID. Check that all other drives are connected and powered up. Check configuration wiring.
4f02	3	CAN hardware fault	Node has difficulty communicating via CAN. Confirm all drives have unique node ID. Check toroids on CAN bus wires. Look for noise or breaks in CAN wiring. Check configuration wiring.
4f41	5	Internal software fault	Potential configuration error on drive. Recycle power. If fault does not clear, check firmware and configuration.
4f42	5	Internal software fault	Potential configuration error on drive. Recycle power. If fault does not clear, check firmware and configuration.
4f43	5	Internal software fault	Potential configuration error on drive. Recycle power. If fault does not clear, check firmware and configuration.
4f44	5	Internal software fault	Potential configuration error on drive. Recycle power. If fault does not clear, check firmware and configuration.
4f45	5	Internal software fault	Potential configuration error on drive. Recycle power. If fault does not clear, check firmware and configuration.
4f46	5	Internal software fault	Potential configuration error on drive. Recycle power. If fault does not clear, check firmware and configuration.
4f47	5	Internal software fault	Potential configuration error on drive. Recycle power. If fault does not clear, check firmware and configuration.
4f48	5	Internal software fault	Potential configuration error on drive. Recycle power. If fault does not clear, check firmware and configuration.
4f49	5	Internal software fault	Potential configuration error on drive. Recycle power. If fault does not clear, check firmware and configuration.
4f4a	5	Internal software fault	Potential configuration error on drive. Recycle power. If fault does not clear, check firmware and configuration.
4f4b	5	Internal software fault	Potential configuration error on drive. Recycle power. If fault does not clear, check firmware and configuration.
4f4c	5	Internal software fault	Potential configuration error on drive. Recycle power. If fault does not clear, check firmware and configuration.
4f4d	5	Internal software fault	Potential configuration error on drive. Recycle power. If fault does not clear, check firmware and configuration.
4f4e	5	Internal software fault	Potential configuration error on drive. Recycle power. If fault does not clear, check firmware and configuration.

Test Measurements

If the cause of a fault remains unknown, simple meter checks can provide useful information to find it. While external measurements will not tell you exactly what is wrong “in the box”, they will often confirm if it is the VFD that has failed. Conversely, such test’s can “clear” a good VFD, saving both time and expense.

Tables 29, 30, 31, and 32 outline a series of tests that should prove useful in the troubleshooting process. All drives can be measured in the same way, regardless of node.

Table 29: Meter checks, “A” connector

Pin	Electrical Description	Expected measurements
A1	15 Volt Encoder Supply -	Zero Volt reference for A2.
A2	15 Volt Encoder Supply +	With 24V supply on, 13V to 15V, reference A1 or A3.
A3	15 Volt Encoder Supply -	Zero Volt reference for A2.
A4	Speed Encoder Input	With 24V supply on, should pulse between 0V and 12V when encoder spins. Reference to A1 or A3.
A5	Speed Encoder Input	With 24V supply on, should pulse between 0V and 12V when encoder spins. Reference to A1 or A3.
A6	Digital Input 1	With 24V supply on, 10V with open switch, 0V when switch is closed. Reference “A” pins 16, 25, 28, or 31.
A7	Digital Input 2	With 24V supply on, 10V with open switch, 0V when switch is closed. Reference “A” pins 16, 25, 28, or 31.
A8	Digital Input 3	With 24V supply on, 10V with open switch, 0V when switch is closed. Reference “A” pins 16, 25, 28, or 31.
A9	Digital Input 4	With 24V supply on, 10V with open switch, 0V when switch is closed. Reference “A” pins 16, 25, 28, or 31.
A10	Digital Input 5	With 24V supply on, 10V with open switch, 0V when switch is closed. Reference “A” pins 16, 25, 28, or 31.
A11	Digital Input 6	With 24V supply on, 10V with open switch, 0V when switch is closed. Reference “A” pins 16, 25, 28, or 31.
A12	Digital Input 7	With 24V supply on, 10V with open switch, 0V when switch is closed. Reference “A” pins 16, 25, 28, or 31.
A13	Digital Input 8	With 24V supply on, 10V with open switch, 0V when switch is closed. Reference “A” pins 16, 25, 28, or 31.
A14	Digital Input 9	With 24V supply on, 13V with open switch, 0V when switch is closed. Reference “A” pins 16, 25, 28, or 31.
A15	Digital Input 10	With 24V supply on, 13V with open switch, 0V when switch is closed. Reference “A” pins 16, 25, 28, or 31.
A16	Digital common	Zero Volt reference for Digital Inputs.
A17	Digital output	Zero Volts
A18	12 Volt supply +	With 24V supply on, 12V output. Reference “A” pins 16, 25, 28, or 31.
A19	5 Volt supply -	With 24V supply on, 5V output. Reference “A” pins 16, 25, 28, or 31.
A20	Motor thermal sensor input	With 24V supply on, 5V open circuit, drops to 2.5V when connected to PTC. Reference “A” pins 16, 25, 28, or 31.
A21	Motor temperature switch	With 24V supply on, 10V with open switch, 0V when switch is closed. Reference “A” pins 16, 25, 28, or 31.
A22	Towing Mode	With 24V supply on, 10V with open switch, 0V when switch is closed. Reference “A” pins 16, 25, 28, or 31.

The password may be entered by use of the control station diagnostics, screen select, and stop buttons.

- The Diagnostics switch acts as an “enter key” or acknowledgment key.
- The Screen Select button increments the display value up.
- The Stop button increments the display value down.

Once the password has been accepted, the display falls into the Initial Configuration screen (Fig. 30) From here, different menus and functions may be navigated and changed using the same three control box buttons - Diagnostics, Screen Select, and Stop. An example of a Parameter Change screen is on Fig. 31.

Fig. 30: Initial Configuration screen

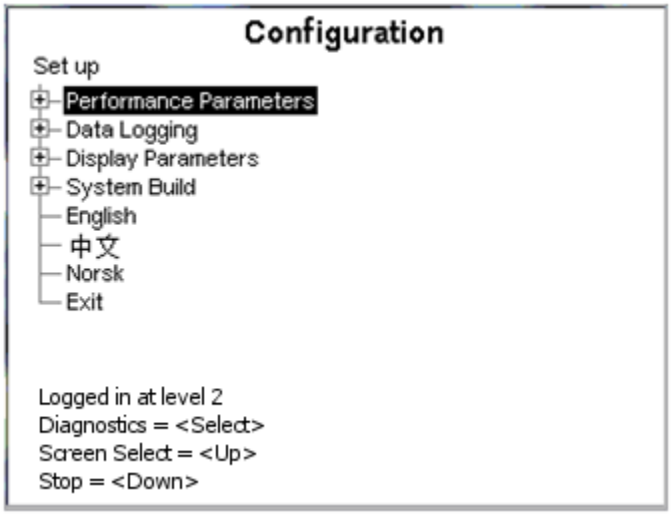
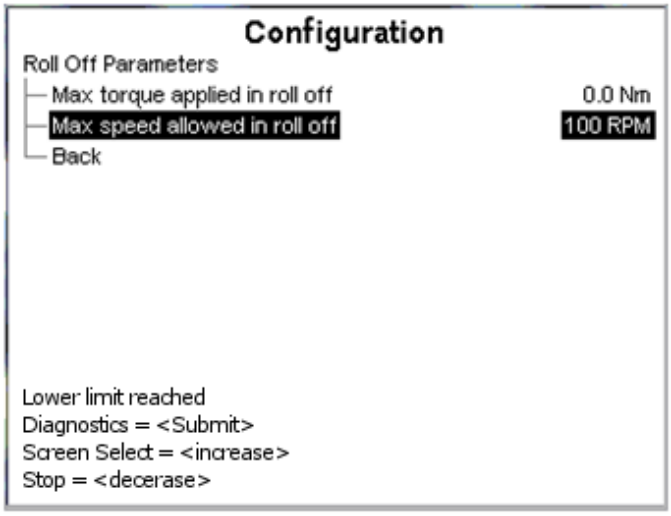


Fig. 31: Typical parameter change screen



Parts replacement

Removal and installation of VFDs

The following section outlines the removal and installation of VFDs.

CAUTION!
Before removing or installing a VFD, verify that the battery has been disconnected from the machine, that the circuit breakers are in the "OFF" position, and that the battery plug has been disconnected and locked/tagged out. Failure to do so may result in machine damage or injury to you or other personnel.

Connectors

Locking type connectors are used on the VFDs (Fig. 35).

To remove a connector:

1. Verify that the battery has been disconnected from the machine, that the circuit breakers are in the "OFF" position, and that the battery plug is disconnected and locked/tagged out.
2. Remove the cover from the machine.
3. Locate the VFD and identify the connectors, labeled "A", "B", "C", and "D".
4. The connectors are equipped with a screwdriver slot to release the latch (Fig. 36). Insert the screwdriver into the latch and lift up.
5. Pull up firmly to remove the connector.

To install a connector:

1. Verify that the correct connector, labeled "A", "B", "C", and "D", is selected.
2. Press connector down firmly to lock in place. Locking latch (Fig. 36) must be firmly fastened for mating.

Tightening torques

NOTICE!
Due to the application of fasteners being subject to great stresses and heavy or extreme vibration, it is imperative that all bolts be applied with the correct torque. The tightening torques stated in the spare parts lists have to be observed, as well, for installation and maintenance.

Controller terminal torque:	13.5Nm ± 10% (9 ft-lb ± 10%)
Controller mounting torque:	44 Nm ± 10% (32 ft-lb ± 10%)

Table of contents

6. Technical data

7. For your information

Your safety

This chapter provides vital information for your safety.
Pay special attention to this chapter. The safety instructions and rules of procedure will help you to avoid hazardous situations and to perform the necessary work as safely as possible.

state of the art

This battery has been manufactured in accordance with the state of the art and generally recognized safety standards and regulations.
You and others can nevertheless be exposed to dangerous situations e.g. as a result of environmental influences or battery damage.

Do not make any alterations or modifications which could impair the safety of the battery. All modifications and changes must be approved.

Use only original spare parts. Note that the use of parts from other manufacturers will void the guarantee.

In addition to this operating manual be sure to also observe the respective legal provisions and regulations in your country.

Observe the safety and accident prevention regulations:

- of the mine,
- of the Mine Inspector, and
- of the mining supervisory authorities.

while handling acids

- **The splashing of acid Into the eyes is the most dangerous condition encountered while handling sulfuric acid or electrolyte.** If this should happen, the eyes should immediately be gently flooded with clean, fresh, running water for at least 15 minutes, followed as quickly as possible with a physician's examination. If the person is wearing contact lenses, they should be removed before rinsing the eyes.

WARNING!
Do not use a buffering or neutralizing agent in the eyes without medical approval.

- Acid or electrolyte splashed onto the skin should be washed off under running water. Battery electrolyte will usually only cause irritation of the skin; if a burn develops, it should be treated medically.

- When electrolyte is splashed on clothing, use a weak solution of bicarbonate of soda, as soon as possible, to neutralize the acid.

- A carboy tilter or safety siphon should be provided for handling acid from a carboy container. Use the protective box when moving a carboy. Store acid in a cool place out of the direct rays of the sun. Use only glass, rubber, lead, or acid-resistant plastic containers when storing acid or electrolyte.

- When mixing acid to prepare electrolyte, always pour the acid slowly into the water and stir constantly to mix well. Never pour water Into acid. Never use sulfuric acid solutions which are over 1.400 specific gravity when adjusting battery acid.

- Apply a neutralizing solution, such as bicarbonate of soda and water, when acid is spilled on floor. Clean up affected area promptly. A mixture of one pound of soda to one gallon of water is recommended.

Unpacking upon receipt

Upon receipt of a mine power storage battery, perform the following:

- ☞ It is important first to examine the exterior of the packing for wet spots on bottom or sides which may indicate leaking jars. Inspect also for physical damage to battery package because the battery could be affected as well. Report any damage to your supervisor.
- ☞ Make certain that the package is right side up, with skid mounts resting firmly on floor.
- ☞ Use a forklift truck or crane of sufficient capacity to remove the packaged battery from the truck or freight car. If a crane is employed, be sure the sling is secured against the bottom of the skid and not around the skid mounts.

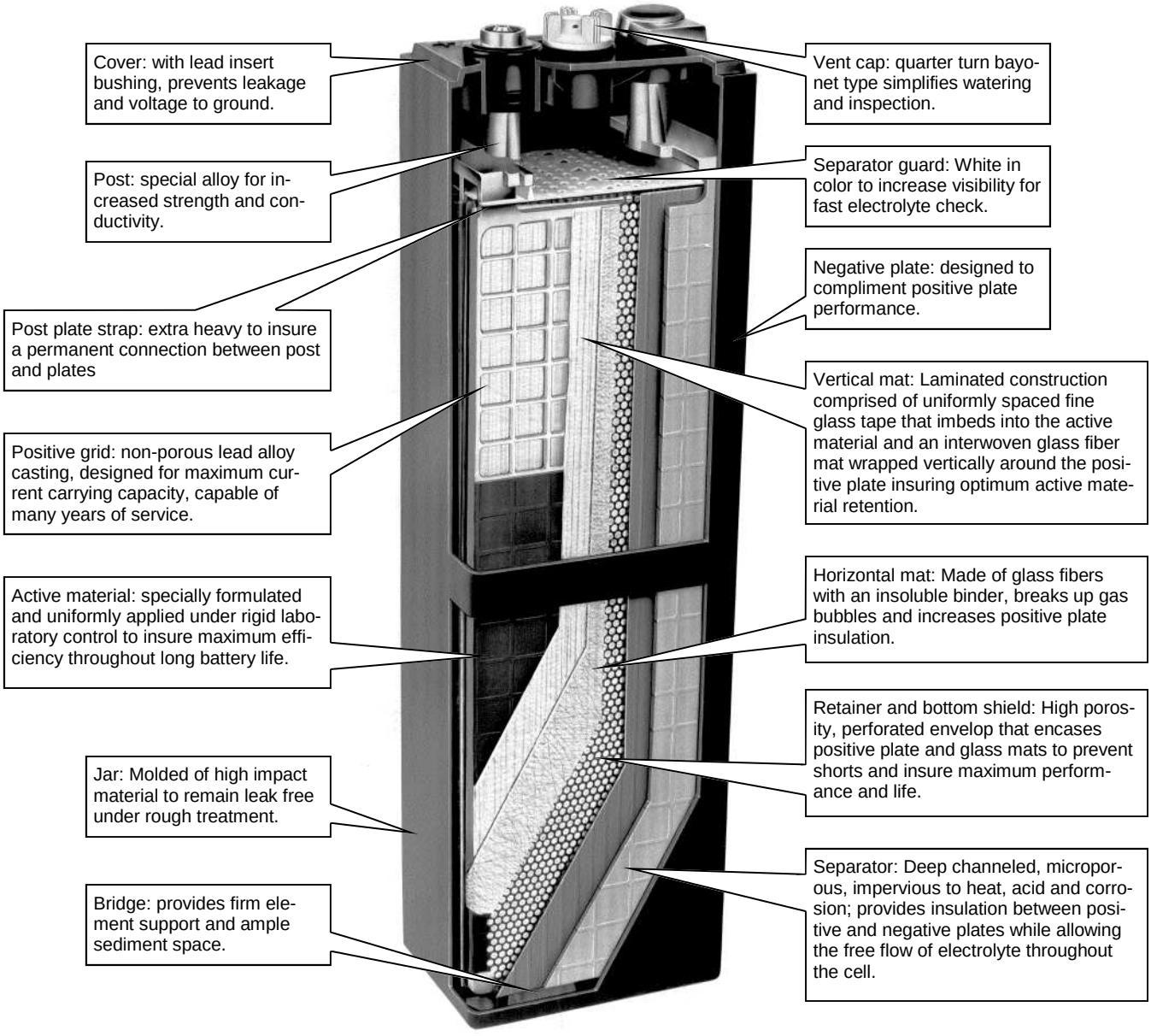
WARNING!
Lifting devices used to move batteries must be capable of carrying the weight stamped on the battery case. Keep all persons and body parts from under the batteries when they are lifted.

- ☞ Move the crated battery to the uncrating area and remove packaging, including any wrapping or other protection provided to the battery terminal cable connectors.
- ☞ Inspect battery and report any damage to your supervisor.
- ☞ Use a properly insulated lifting beam of adequate capacity to lift the battery, by means of an overhead hoist, from the battery skid.

When lifting batteries, always use a device which exerts a vertical pull on the lifting eye or tab. If a chain must be used, it should be in combination with a lifting beam with provision for adjusting lifting hook centers to the exact length of the tray. Any method of lifting which tends to squeeze or stretch the battery tray may distort it and could damage jars or disturb cell seals.

A piece of rubber sheet or other insulating material, temporarily laid on the battery while lifting, will prevent any possible short circuits from chains or hooks. As an additional precaution against accidental shorting, the lifting beam hooks should be electrically insulated from each other.

Fig. 1: Cell



Mine batteries incorporate every feature required by today's mines. They are designed by engineering technology and built by master battery craftsmen according to strict quality control guidelines.
These batteries are the finest available to meet today's mining requirements, and our precision construction provides new equipment performance throughout a long life.

Preparation for Use

Establishing battery requirements

The number of batteries required for service depends primarily upon the number of 8-hour shifts in effect. Normally, for operation on a single-shift basis, the minimum number of batteries required will be the same as the number of operating machines and the batteries need not be removed from the unit for charging. For operation on a 2- or 3-shift basis, the minimum number of batteries required will be twice the number of operating machines and it will, therefore, be necessary to exchange discharged batteries for charged batteries at the end of each work shift. Whenever possible, it is recommended that more than the minimum number of batteries be available for multiple-shift operation, providing at least an 8-hour cooling period after charging. In an emergency, any one battery can be used for two 8-hour shifts during a 24-hour period, but this procedure, repeated regularly, will cause high electrolyte temperatures and could seriously affect service life. Therefore, where 3-shift operation is normal, 3 batteries will be required per machine.

Acid to water proportions

Sulfuric acid to water proportions required to make electrolyte are given in Table 3.

Charged and wet batteries

Charged and wet batteries are shipped with cells filled and fully charged. Prepare these batteries for use as follows:

WARNING!
Proper eye and body protection must be worn at all times when servicing batteries to prevent electrical shock and contact with battery acid. Clean and neutralize any acid spill immediately.

- ☞ Examine battery to see if electrolyte has been accidentally spilled. If so, clean and neutralize any spillage with a cloth that has been dipped in a bicarbonate of soda solution. Rinse area with clear water.

- ☞ Remove vent caps and check the electrolyte level in each cell. Measure and record the specific gravity, electrolyte temperature, and individual open circuit voltage of each cell. Note any irregularities.

- ☞ Check to make sure that all cells are properly connected and that terminal connections are tight. If there are irregularities in the electrolyte levels or specific gravity readings, or if the battery has been in storage for more than 30 days, it should be given a freshening charge to assure that every cell is at a fully charged state.

- ☞ Recheck electrolyte levels after charging and after gassing has stopped. Again, measure and record specific gravity and electrolyte temperatures. If irregularities in electrolyte specific gravity readings still exist, call your service representative.

Troubleshooting

In addition to the required routine maintenance, storage batteries may, at some time during their service life, require more extensive or unusual care. Such care should be given as soon as it has been determined that a problem exists or that trouble may be developing. This section deals with the means of identifying existing or impending problems and offers possible solutions.

The Troubleshooting Chart, Table 6, defines the most common problems which could occur during a battery's lifetime. If the suggested operational remedies are ineffective, it may be assumed that there is an internal problem and it will be necessary to disassemble the cell or cells to inspect the elements and sediment well. If the cause of the problem can only be corrected by completely replacing cells or the battery, this information should be reported to the person in authority.

Table 6: Storage battery troubleshooting chart

Symptoms	Probable Cause	Possible Remedy
battery overheats during charge	☞ 1. Malfunctioning charging equipment.	☞ 1. Replace or repair defective charger parts (timer, voltage sensitive relay, control board, etc.)
	☞ 2. Charging equipment out of adjustment.	☞ 2. Adjust start or finish charging rates.
	☞ 3. Defective or weak cell(s).	☞ 3. Replace/repair problem cells.
	☞ 4. Battery worn out and beyond economical repair.	☞ 4. Replace battery.
	☞ 5. High resistance connection within battery.	☞ 5. Check for hot wires, cells, intercell connectors, charging plugs, etc. Repair or replace defective component(s).
	☞ 6. Low electrolyte level.	☞ 6. Add water to just cover separator protector when discharged.
	☞ 7. Battery charge in the vehicle with battery compartment closed or the tray cover closed.	☞ 7. Open compartment during charge or charge battery of the unit with the tray cover opened.
	☞ 8. Battery of 100° F when placed on charge.	☞ 8. Allow battery to cool below 90° F before charging.

- ☞ Raise the element to clear the top of the jar. Do not, unless absolutely necessary, expose an element to air longer than five minutes. Oxygen in the air combines with the active material in the negative plates, causing them to oxidize and heat. If the exposure persists, negative plates will discharge.

  - ☞ While the element is out of the jar, check the sediment well in the bottom of the jar. If it is full of shed material, the cell will probably have to be replaced.

  - ☞ Inspect plate and separator edges while the element is suspended. A more thorough inspection of separators, plate insulation, grids, and active materials may be indicated. If so, proceed as follows:

    - ☞ Remove the element from the jar.

    - ☞ Lay the element on its side on a clean non-metallic surface with the plates at right angles to the table surface so the element can be fanned slightly to permit the removal of separators, always on negative side.

    To reinstall the separator:

    - ☞ Make certain that the flat side of the separator is against the negative plate and the ribbed side is facing the positive.

    - ☞ Push up until they are flush with the bottom of the element and they project equally on each side of the plates.

- ☞ Before installing an element in a previously used jar, wash out any sediment which may have accumulated in the bottom of the jar and clean all compound from around the inside of the top edge.

- ☞ Clamp the element, if necessary, when reinstalling it in the jar. Make certain that the element is entering the jar properly and that the plates are at right angles to the plate support ribs in the bottom. When installing an element with a cell cover attached, use a putty knife to guide the lip of the cover past the top edges of the jar.

Table 13: Untreated screw, black finish (Fine thread)

Property class	Torque	Recommended torque setting	Nominal diameter	
	Ma	M8 X 1	M10 X 1.25	M12 X 1.25
8.8	Nm	27	52	95
	Ft-lbs	19	38	70
10.9	Nm	38	73	135
	Ft-lbs	28	53	99
12.9	Nm	45	88	160
	Ft-lbs	33	64	118

Table 13: Untreated screw, black finish (Fine thread, continued)

Property class	Torque	Recommended torque setting	Nominal diameter	
	Ma	M14 X 1.5	M16 X 1.5	M18 X 1.5
8.8	Nm	150	225	325
	Ft-lbs	110	165	239
10.9	Nm	210	315	460
	Ft-lbs	154	232	339
12.9	Nm	260	380	550
	Ft-lbs	184	280	405

Table 13: Untreated screw, black finish (Fine thread, continued)

Property class	Torque	Recommended torque setting	Nominal diameter	
	Ma	M20 X 1.5	M22 X 1.5	M24 X 2
8.8	Nm	399	610	780
	Ft-lbs		449	575
10.9	Nm	640	860	1100
	Ft-lbs	472	634	811
12.9	Nm	770	1050	1300
	Ft-lbs	567	774	958

TABLE OF CONTENTS

REMOVE personal metal items such as rings, bracelets, necklaces, and watches when working with a battery. A battery can produce a short circuit current high enough to weld a ring or the like to metal, causing a severe burn.

NEVER charge a frozen battery.

If it is necessary to remove the battery connections, always remove the grounded terminal from the battery first. Make sure all loads are disconnected and unit is off, so as not to cause an arc.

Be sure the area around the battery is well ventilated while the battery is being charged.
When cleaning battery terminals, be careful to keep corrosion from coming in contact with the eyes.

Study all the battery manufacturer's specific precautions such as do not remove cell caps while charging, recommended rates of charge, and maintenance procedures.