OPERATOR'S MANUAL

1548 Haul Unit System

Haul Unit S/N: F21700F

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SERVICE • RELIABILITY • INNOVATION

Introduction

This operator's manual contains important safety, operation, and maintenance information for your 1548 Haul Unit System. This system includes the 1548 Haul Unit, Dirt Bucket, Haul Cart, and Track. You must read and understand this manual before you operate and maintain this equipment. Keep this manual with your Haul Unit at all times. Additional copies of this manual may be purchased from the Akkerman Aftermarket Support Department, or downloaded from the Akkerman web site at www.akkerman.com.

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

The use of second rate parts could affect the efficient performance of the Haul Unit System. ALWAYS use genuine Akkerman parts.

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

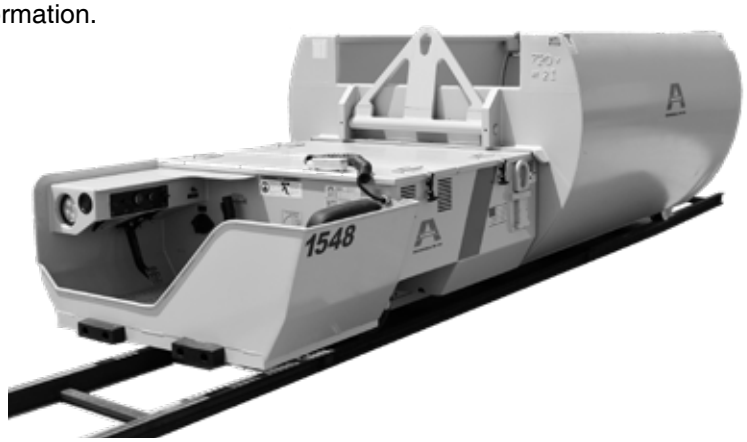
⚠DANGER Indicates an extremely hazardous situation which, if not avoided, WILL result in death or serious injury.

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

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

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

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



1548 Haul Unit with 720 Dirt Bucket

The 1548 Haul Unit System transports the spoils from the Tunnel Boring Machine back to the launch shaft. The typical Akkerman system is comprised of a haul unit, track and dirt bucket. Multiple-bucket train systems (utilizing the haul cart) are available to increase productivity on long tunnels or pushes.
The 1548 haul unit is electrically powered with a removable battery pack, and equipped with hydraulic disc brakes.

Dirt buckets are designed for maximum capacity based on the size of pipe or tunnel being installed. They are self-dumping when using a two-line crane or by attaching a stationary line.

The track sections are lightweight, yet sturdy. The tracks are quick to connect with a single bolt and wing nut. Storage racks are available for convenient shipping and handling.

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

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

Contents

Safety

BE ALERT FOR SAFETY INFORMATION

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

Read all safety information.

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

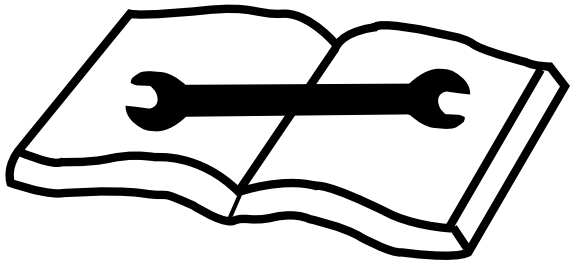
ATTENTION!
BECOME ALERT!
YOUR SAFETY IS INVOLVED!

READ OPERATOR'S MANUAL

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

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

Any unauthorized modifications will void the warranty.



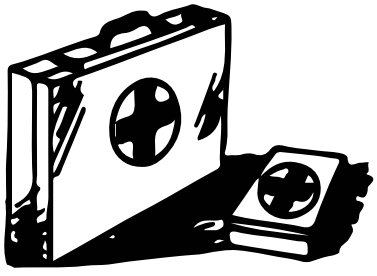
WEAR PROTECTIVE CLOTHING

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

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

KEEP FIRST-AID KIT ACCESSIBLE

Keep a first-aid kit handy and properly maintained. Call 9-1-1 for emergencies.



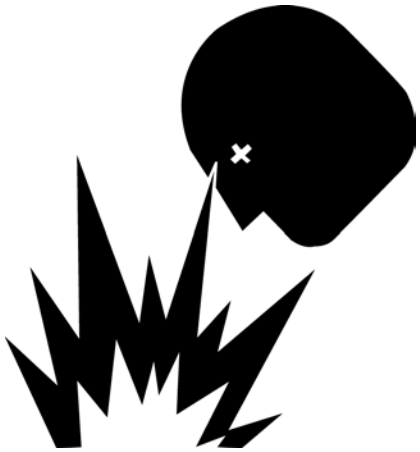
FIRE PREVENTION

⚠CAUTION Fires can cause injury or property damage.

Keep equipment clean. Remove all debris from equipment.

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

MAINTAIN BATTERY SAFELY



⚠WARNING Batteries produce explosive gases.

Wear eye protection and protective clothing during battery service.

Keep sparks, flames, and cigarettes away from batteries.

Contact with battery acid can cause severe burns. Flush immediately and thoroughly with clean water. Get medical attention immediately.

Charge a battery only in a well-ventilated area.

Never charge a frozen battery.

HYDRAULIC OIL/FLUIDS UNDER PRESSURE

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

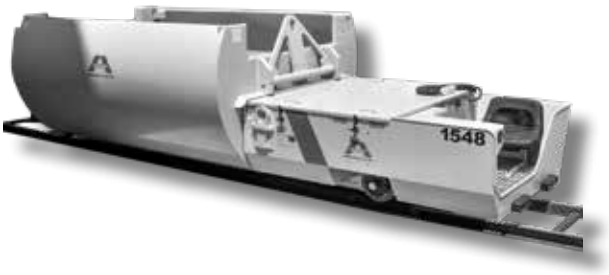
Release all pressure before performing maintenance or repairs. Never weld near pressurized fluid lines.

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

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

KEEP RIDERS OFF HAUL UNIT

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



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

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

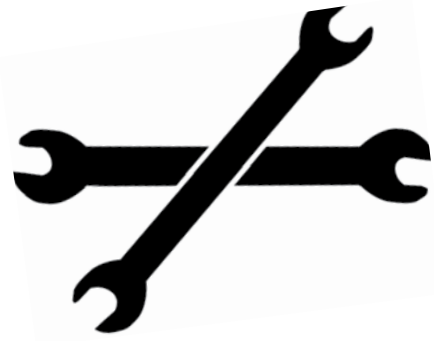
REGULARLY CLEAN AND INSPECT EQUIPMENT

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

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

PRACTICE SAFE MAINTENANCE

LOCKOUT TAGOUT power before performing any maintenance. Refer to Lockout Tagout Procedure Guideline in this section.



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

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

Do not service the machine while it is in motion.

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

BEWARE OF SUSPENDED LOADS

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

If a hydraulic hose, chain, or cable from the boom of a crane or excavator breaks, the boom and/or load can fall instantly.

Do not enter area under or around a load.

AVOID TUNNEL WALL CONTACT

⚠WARNING Contacting tunnel wall and boring head components can cause severe personal injury or death.

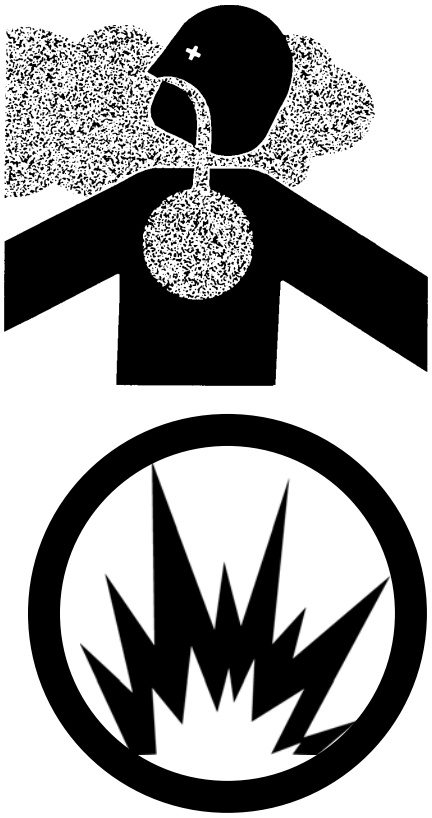
Keep all body parts on Haul Unit while Unit is moving.

NO SMOKING IN TUNNEL

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

Do not smoke in tunnel.

TEST TUNNEL VENTILATION



⚠WARNING Keep Boring Head and tunnel well ventilated at all times.

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

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

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

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

Gases must be removed before reentering tunnel.

DO NOT use Haul Unit to evacuate the tunnel. The electrical contacts with the unit can cause an explosion.

KEEP PERSONNEL AWAY FROM MOVING PARTS

⚠WARNING Crushing hazard.

Keep personnel away from inside of yoke, on skid, or behind pump unit when jacking or moving pump unit or yoke. Failure to do so could result in serious personal injury or death.

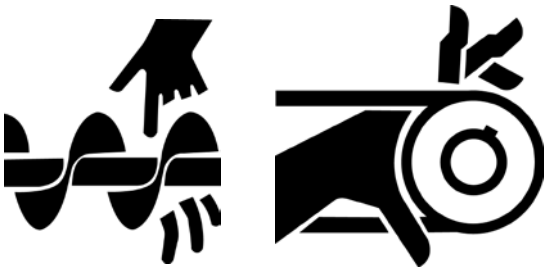
KEEP AWAY FROM CONVEYORS

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

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

Do not operate without covers and guards in place.

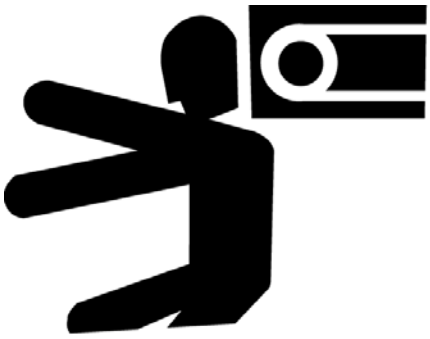
Lockout tagout power before servicing. Refer to Lockout Tagout Procedure Guideline in this section.



WATCH FOR CONVEYOR

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

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

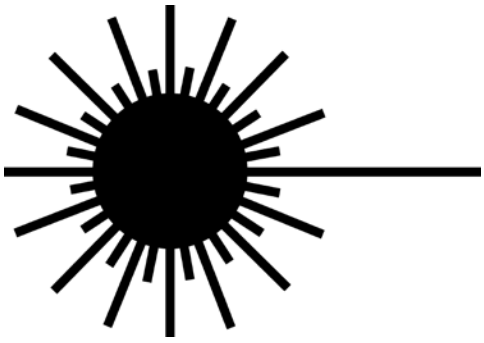


AVOID LASER LIGHT EXPOSURE

⚠DANGER Staring into laser light will cause severe injury.

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

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



KEEP JOB SITE CLEAN AND ORGANIZED

⚠WARNING Tripping can cause serious personal injury.

Be sure to keep job site clean and organized.

UNAUTHORIZED WELDING

⚠WARNING Unauthorized welding can cause structural failure and/or electrical system damage resulting in possible injury or death.

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

SLIPPERY WHEN WET

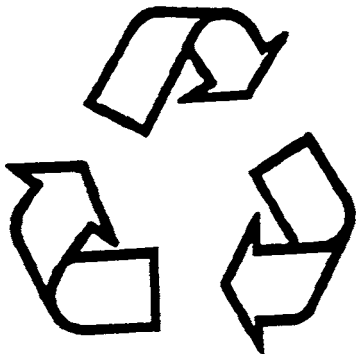
⚠WARNING Slips and falls can cause serious personal injury.

Ensure firm footing in wet or slippery conditions.

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

Remove any buildup of grease, oil, or debris.

RECYCLE WASTE

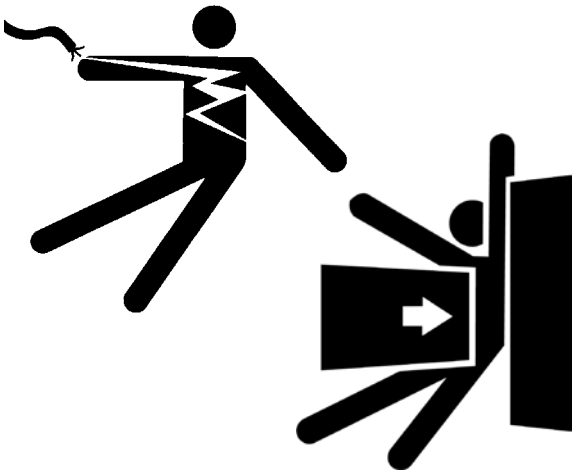


Follow local, state, federal, and international regulations when recycling or disposing of waste. Waste includes fluids/oil, fuel, filters, coolant, and batteries.

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

LOCKOUT TAGOUT PROCEDURE GUIDELINE

LOCKOUT TAGOUT power before attempting to make repairs, service, adjustments or daily shut down. Proper lockout tagout will prevent accidents and save lives. OSHA requires equipment placed in Lockout Tagout when the unexpected machine start up or release of stored energy could injure workers during cleaning, adjustments, repairing and servicing.



⚠DANGER Failure to lockout tagout power before servicing WILL cause severe personal injury or death.

Electrical repairs must be performed only by a certified electrician.

The contractor is fully responsible for the safety of all personnel on the job site. Use the following as a guideline for a lockout tagout procedure. The contractor must determine the best lockout tagout practices for their employees on the job site.

Follow all Federal, State and Local safety regulations and procedures.

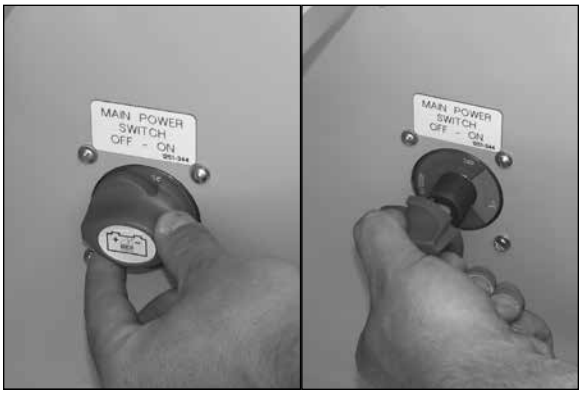
Be sure OSHA prescribed safety personal protective equipment is being worn by all personnel.

Be sure the area is safe for operation. Keep work site clean and organized.

LOCKOUT TAGOUT THE MAIN POWER SWITCH

1. Turn the Main Power Lockout Switch counterclockwise (CCW) to the OFF position.

2a. (SN F21700F-28 & Before) Rotate the knob past the OFF position and then pull knob out.



2a. SN F21700F-28 & Before

2b. (SN F21700F-29 & After) Install shackle of OSHA approved lock with tag through latch.

3. Secure lock by pushing shackle into body of the lock until the shackle is locked into the locking mechanism.

4. Turn key to lock shackle in place.

5. Remove key from lock.

6. Test to be sure shackle is fully secured into lock.

7. Sign “Equipment Locked Out” tag or equivalent.

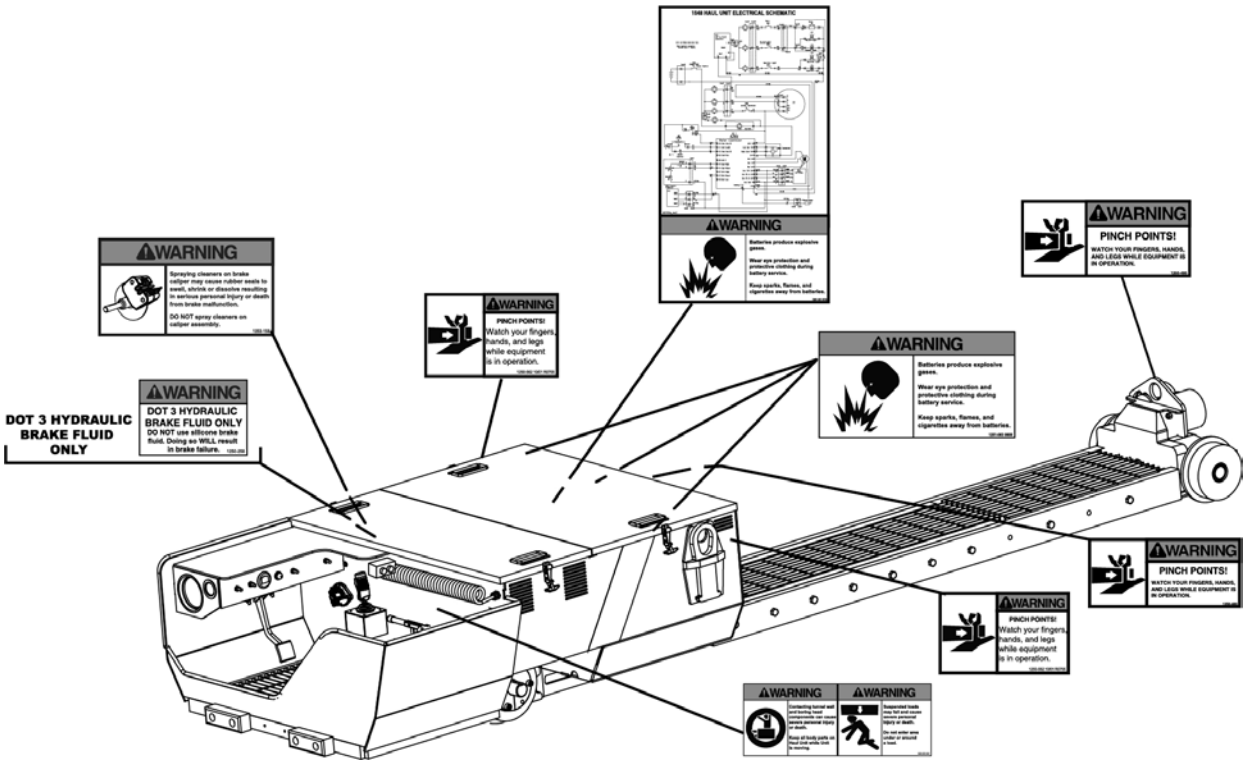
2b. SN F21700F-29 & After

Safety Decals

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

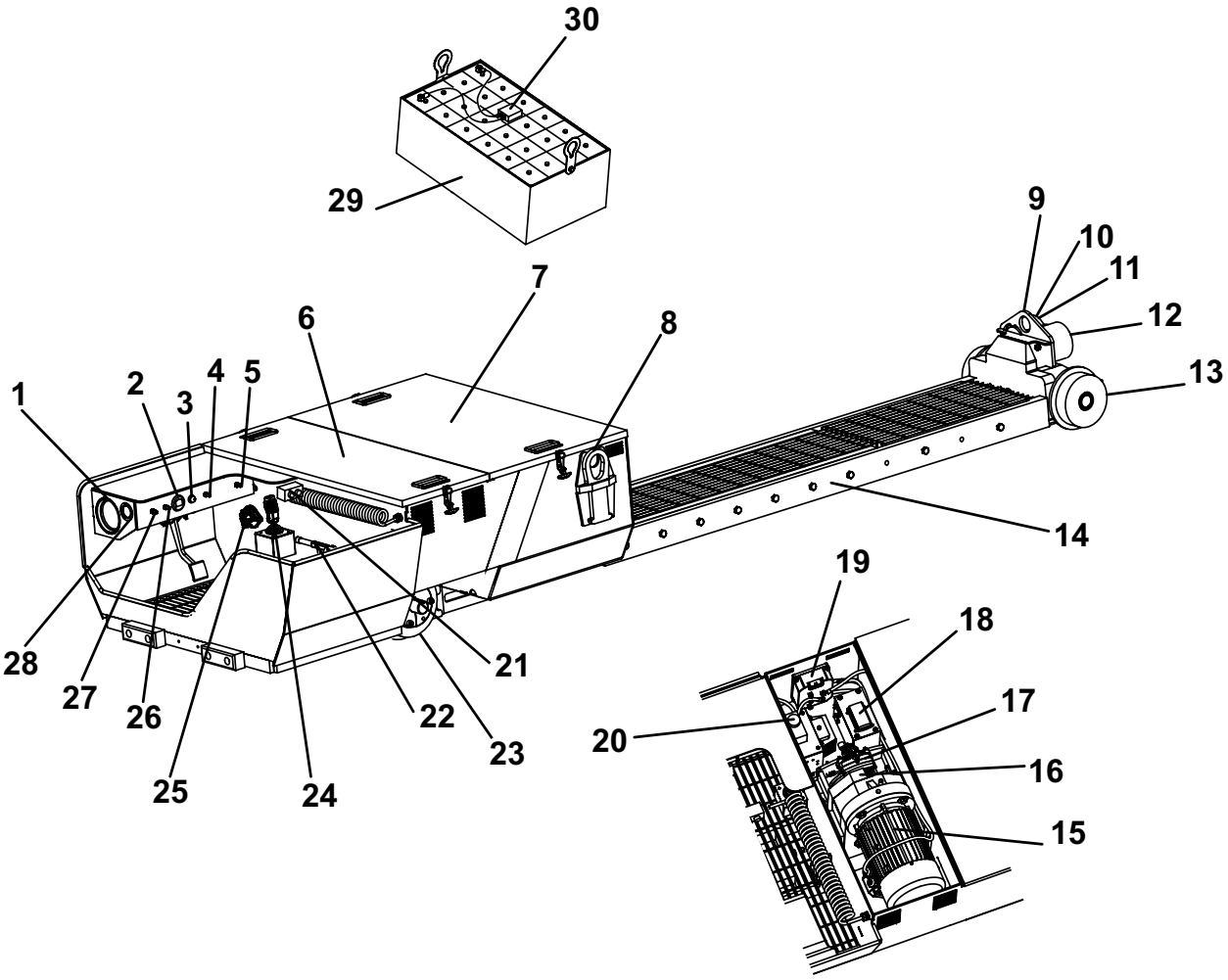
Serious injury or property damage can occur if safety instructions are not followed. Contact your Akkerman Aftermarket Support representative for free replacement safety decals.

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

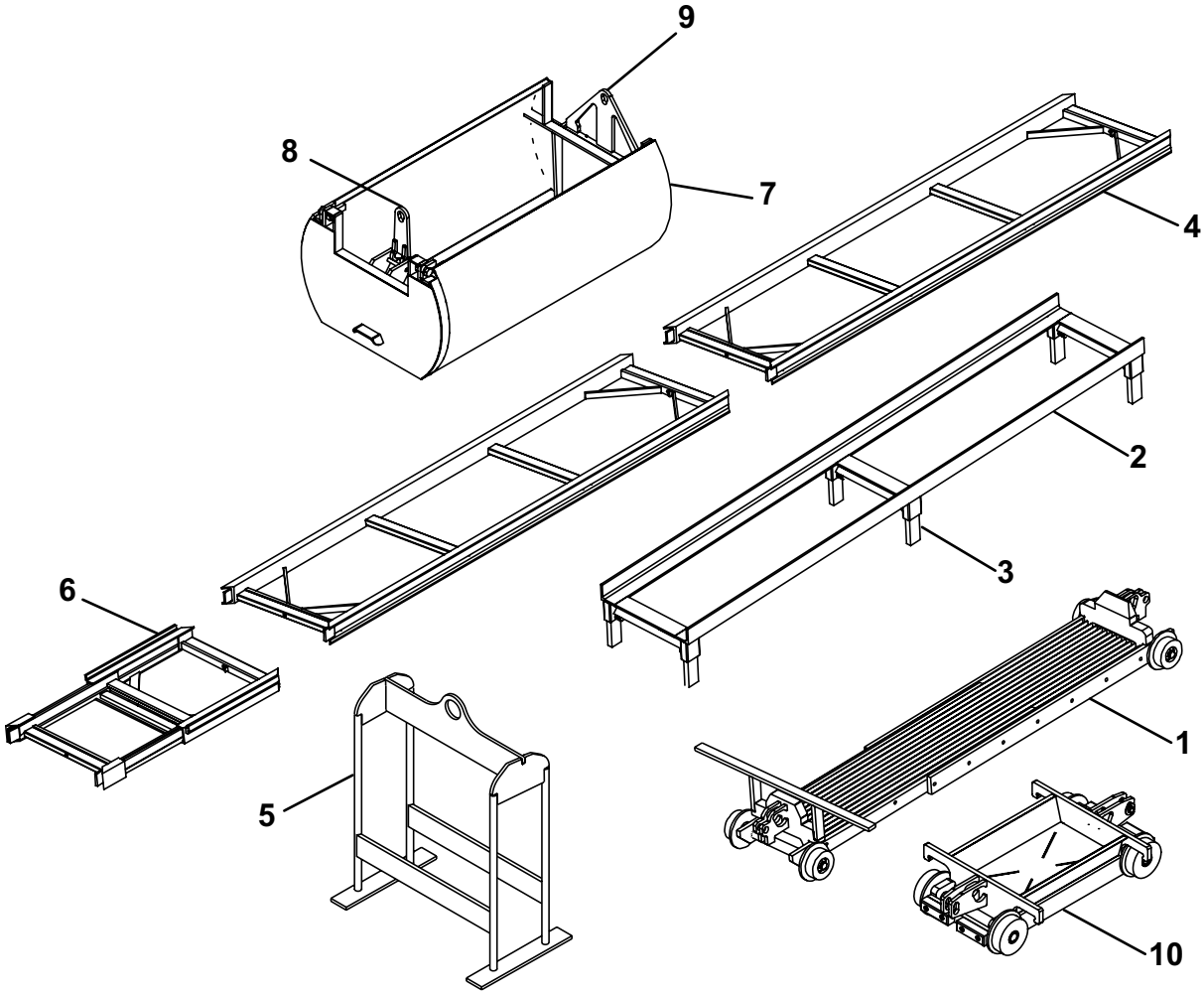


NOTES

Terminology



1. Front Light
2. Battery Gauge
3. Horn
4. Drive Motor Mode Selector Control
5. Drive Motor Control Switch
6. Drive Box Compartment
7. Battery Compartment
8. Lift Eye
9. Idler Assembly
10. Horn Assembly
11. Rear Beacon Light
12. Rear Light
13. Idler Wheel
14. Frame Assembly
15. 15 HP Electric Drive Motor
16. Gear Box
17. Brake Assembly
18. Drive Fuse Block
19. Drive Motor Controller
20. Hydraulic Brake Reservoir
21. Inching Control
22. Parking Brake
23. Drive Wheel
24. Direction/Speed Control
25. Main Power Lockout Switch
26. Rear Light Switch
27. Front Light Switch
28. Front Beacon Light
29. Battery Pack
30. Battery Harness



1. Haul Cart
2. Track Riser
3. Riser Bar
4. Track
5. Track Carrier
6. Sliding Track
7. Dirt Bucket
8. Bucket Lift Eye
9. Door Lift Eye
10. Inspection Cart

Controls & Instruments

MAIN POWER LOCKOUT SWITCH

⚠WARNING Failure to LOCKOUT TAGOUT power before servicing can cause severe personal injury or death. Refer to Lockout Tagout Procedure Guideline in the Safety section.

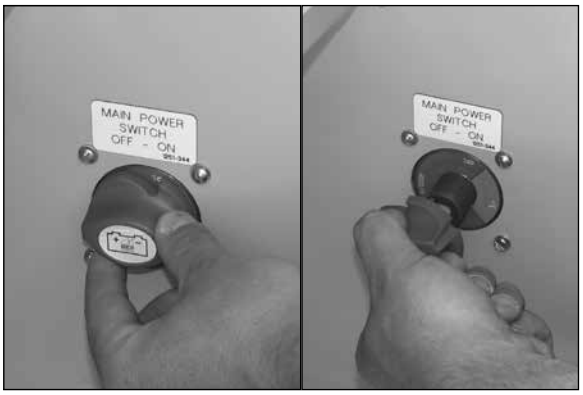
The Main Power Lockout Switch provides power to haul unit lights, horn and motor control switches.

To turn power ON: rotate the Main Power Lockout Switch clockwise (CW) to the ON position.

To turn power OFF: rotate the Main Power Lockout Switch counterclockwise (CCW) to the OFF position.

The Main Power Switch knob on SN F21700F-28 & before can also be completely removed to prevent any accidental powering on of haul unit by rotating the knob past the OFF position and then pulling the knob out.

Refer to Lockout Tagout Procedure Guideline in the Safety section.



SN F21700F-28 & Before

SN F21700F-29 & After

DRIVE MOTOR CONTROL SWITCH

The Main Power Lockout Switch must be ON for the Drive Motor Control Switch to be active.

The Drive Motor Control Switch provides power to the Direction and Speed Control lever, and also activates the Battery Gauge.

ON: Flip switch UP

OFF: Flip switch DOWN

BRAKES

⚠WARNING NEVER leave unattended haul unit without engaging parking brake. Failure to do so could cause severe injury or death from rolling haul unit.

⚠CAUTION Be careful when stopping the haul unit as the forward momentum can carry the unit past the point where the brake is applied.

DIRECTION & SPEED CONTROL/JOYSTICK
Use the direction/speed control joystick for braking the haul unit by moving the controller in the opposite direction of travel.

NOTICE When using the direction/speed control joystick as a brake for the haul unit, the haul unit battery charges with the regenerative brake motor system, increasing battery life between charges.

SN F21700F-28 & Before *SN F21700F-29 & After*

BRAKE PEDAL
Release or return the control handle to the center (neutral or detent) position and depress the brake pedal to stop the haul unit.

NOTICE (SN F21700F-03 thru 11)
When using the brake pedal, the haul unit battery charges with the regenerative brake motor system, increasing battery life between charges.

PARKING BRAKE
To park your haul unit or to avoid any unintended movement, engage the parking brake by pulling brake lever UP to the locked (vertical) position. To release parking brake, push lever down completely.

NOTICE The brake lever MUST be adjusted as follows: Disengage brake and turn adjustment knob (top of lever) as needed until brake lever locks in vertical position.

DIRECTION & SPEED CONTROLLER/JOYSTICK

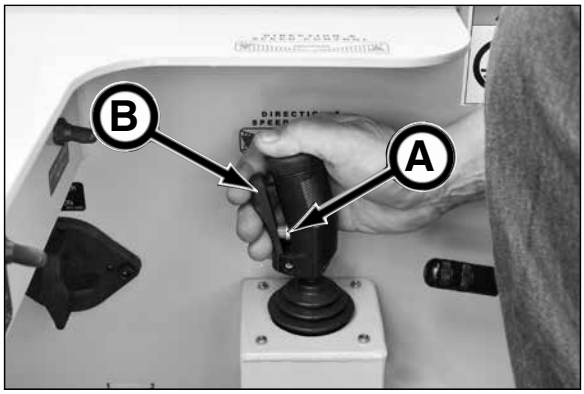
The controller controls the haul unit direction and speed of travel.

1. Activate the control by flipping the Drive Motor Control Switch UP to the ON position.

2a. (SN F21700F-28 & before) Move control lever to the left (out of neutral or detent position), then, to propel haul unit, slowly move the control lever forward or back for the desired direction of travel.

2b. (SN F21700F-29 & after) To propel haul unit, engage the operator presense switch (A) by squeezing the joystick lever (B), then slowly move the control lever forward or back to the desired direction of travel.

2a. SN F21700F-28 & Before



2b. SN F21700F-29 & After

These are proportional controllers/joysticks. The haul unit will propel faster the farther the control handle is moved away from the center or neutral position.

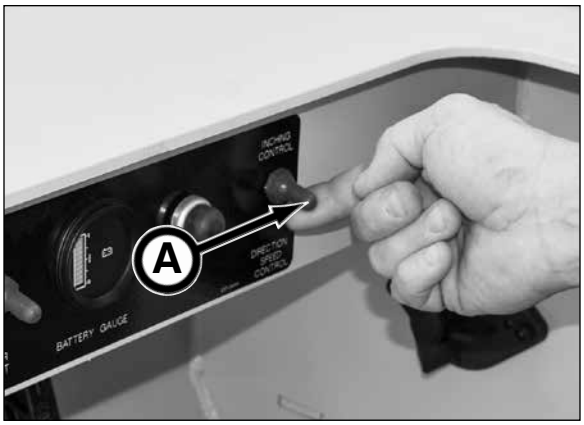
The controller/joystick is also self-centering and will return to neutral when handle is released.

NOTICE When using the direction/speed controller as a brake for the haul unit by moving the controller in the opposite direction of travel, the haul unit battery charges with the regenerative brake motor system. This will increase battery life between charges.

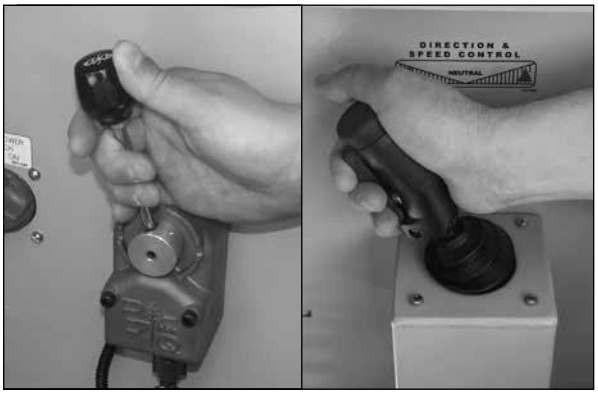
DRIVE MOTOR MODE SELECTOR CONTROL

Use the selector (A) to activate the desired Drive Motor Mode Selector Control, the Direction / Speed Control or the Inching Control. Flip the switch as follows:

UP - Inching Control
DOWN - Direction / Speed Control



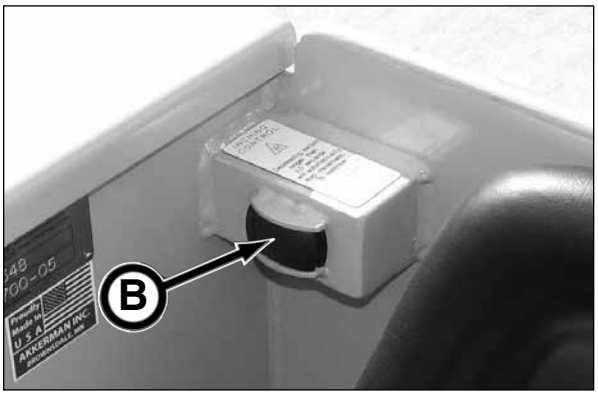
The Direction/Speed Control Joystick regulates the haul unit direction and speed of travel. The speed of travel varies with the movement of the joystick. In other words, the haul unit will propel faster the farther the control/joystick handle is moved away from the center or neutral position.



SN F21700F-28 & Before *SN F21700F-29 & After*

The Inching Control (B) also regulates the haul unit direction and speed of travel. However, the speed is very limited for precise control. If the Inching Control is depressed longer than 2.5 seconds, the haul unit movement will automatically stop. To continue movement, release switch and then depress switch.

The Inching Control is designed to slowly “inch” the haul unit/dirt bucket into position around the conveyor.



SN F21700F-11 & Before

NOTICE The Main Power Lockout Switch and the Drive Motor Control Switch must be ON for the Inching Control or Direction/Speed Control to function.

SN F21700F-12 & After

HORN

NOTICE The Main Power Lockout Switch must be ON for the horn to function.

Press switch button to sound horn.

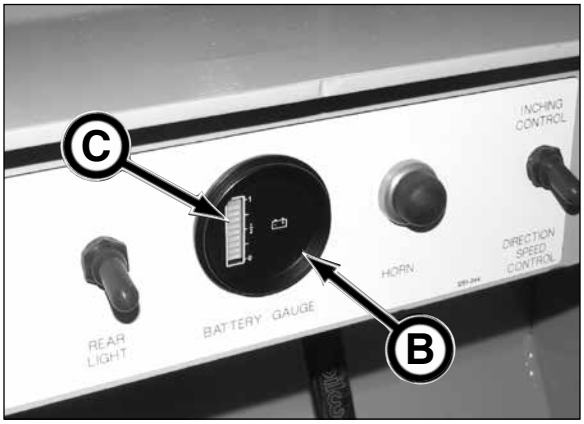
The horn (A) is located behind the blue beacon light.

BATTERY GAUGE

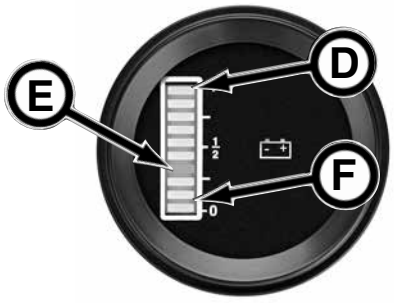
When the Main Power Lockout Switch is ON, the battery gauge (B) will briefly illuminate indicating there is power to the gauge.

Once the Main Power Lockout Switch AND the Drive Motor Control Switch are ON, the battery gauge will display the battery charge level.

BATTERY GAUGE
The battery gauge displays the battery charge level (C).



The top LED (D) is lit only when the battery is fully charged. As the battery charge decreases, successive LEDs illuminate one at a time.
Once the charge level decreases to a 30% reserve charge, the LED (E) will flash indicating the batteries will soon require a recharge.
The bottom two LEDs (F) will flash indicating that the haul unit batteries are low and should be recharged.

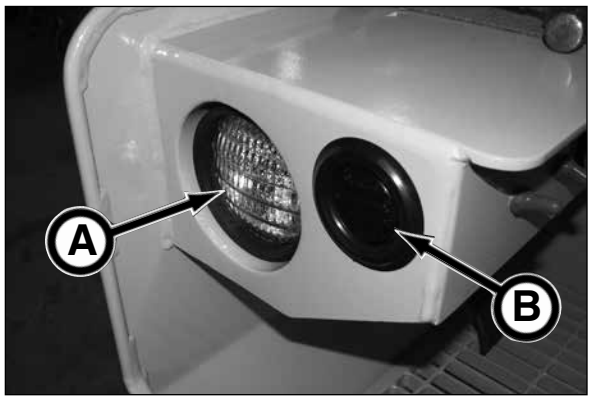


LIGHTS

NOTICE The Main Power Lockout Switch must be ON for the lights to function.

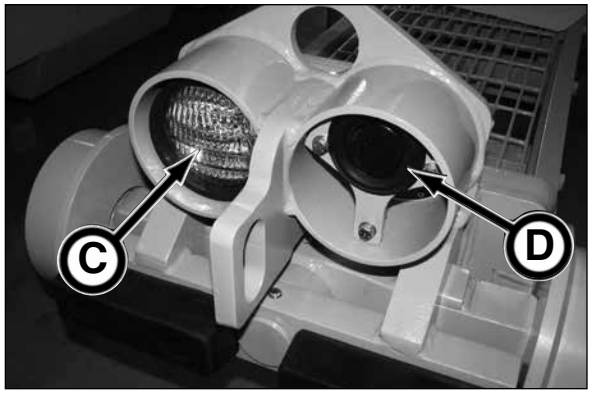
The 1548 Haul Unit is equipped with:

- a front headlight (A) and a flashing blue beacon light (B).



Front Lights

- a rear headlight (C) and a flashing blue beacon light (D).



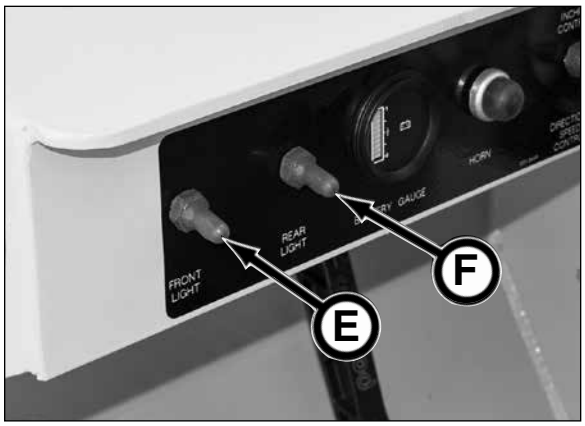
Rear Lights

Use the front light switch (E) and rear light switch (F) as follows to control the lights:

ON: Flip switch UP

OFF: Flip switch DOWN

Both the headlight and flashing blue beacon light will illuminate when the appropriate switch is flipped to the ON position.



FUSES

⚠WARNING Failure to LOCKOUT TAGOUT power before servicing can cause severe personal injury or death. Refer to Lockout Tagout Procedure Guideline in the Safety section.

Fuses protect an electrical circuit from current overload. If an overload should occur, the fuse will “blow” thus breaking the flow of current and preventing damage to the circuit.

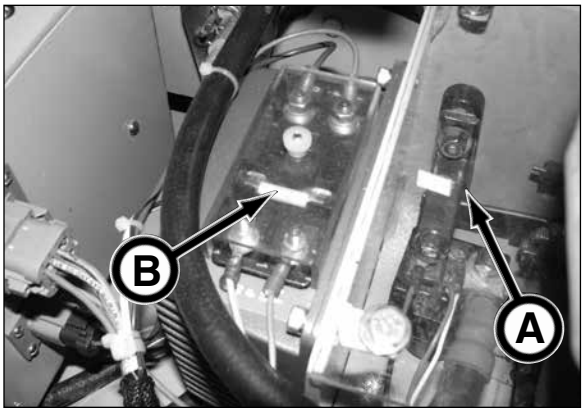
BEFORE replacing any fuse, the Main Power Lockout Switch MUST be off and the control knob (SN F21700F-28 & before) completely removed or in lock out tag out (SN F21700F-29 & after) to prevent accidental powering of the haul unit. Then remove guard, replace fuse and replace guard.

SN F21700F-28 & Before *SN F21700F-29 & After*

⚠WARNING ALWAYS INSTALL THE SAME AMPERAGE RATED AND TYPE FUSE AS THE ONE YOU ARE REPLACING. Never use a fuse with a higher amperage rating as damage will result to the circuit it is protecting.

FUSES

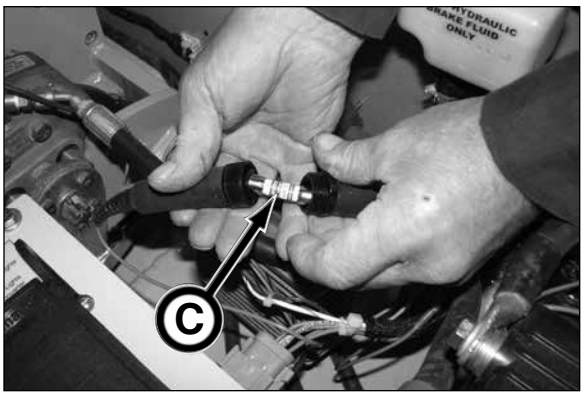
Main Fuse (A) ..... 350 AMP Type ANL
Power Supply Fuse (B) ..... 12 AMP Type 3AB
48V Auxiliary Fuse (C) ..... 20 AMP Type KLM



DRIVE FUSE BLOCK (D)

The Drive Fuse Block is located in the drive compartment of the haul unit. All fuses in the Drive Fuse Block are Type ATC fuses.

Fuse #	AMP	Component
1	3	Operator (Front) Lights
2	20	Horn
3	3	Bucket (Rear) Lights
18	10	DC to DC Converter
19	3	Drive Motor Control Switch
20	1	Hourmeter (SN 1 - 6 Only)



Fuse sockets 1 through 12 are for the 12 Volt system. Fuse sockets 13 through 20 are for the 48 Volt system.

NOTICE All other fuses in the Drive Fuse Block are spare fuses.

NOTES

Pre-Start Inspection

⚠WARNING Do not operate this equipment until you read, study, and understand this manual. A daily inspection of the equipment must be performed to prevent severe personal injury or death and equipment damage.

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

Use the following checklist ✓ as a guide for your daily pre-start inspection or shift change. Make a copy of this Pre-Start Inspection checklist. Once it is complete, check off, initial and date each item and file the copy as a record of maintenance.

	1. Use “ONE-CALL” notification to check for buried utility lines prior to tunneling.
	2. Contractor is responsible for all personnel to wear proper protective equipment on the job site. Replace equipment if defective.
	3. Check the excavated launch and reception shafts for proper shoring or bracing to prevent slides or cave-ins.
	4. Thoroughly clean equipment of mud and dirt.
	5. Remove combustible or flammable materials from equipment. Store materials properly.
	6. Test air monitoring and ventilation detectors for proper operation.
	7. Inspect track, haul unit, and dirt bucket for damage. Repair or replace as needed.
	8. Check to be sure each track section joint is properly fastened.
	9. Check haul unit drive wheels for damage. If damaged, replace wheels.
	10. Be sure all covers and guards are in place before operation.
	11. Check that the self-dumping dirt bucket door moves freely and operates correctly.
	12. Practice operating the haul unit to get the “feel” of the equipment. Check for speed and braking technique.
	13. Check to be sure the brake fluid in the master cylinder is properly filled. Use only DOT 3 Brake Fluid.
	14. Check to be sure pedal and parking brakes engage and release properly.
	15. Check to be sure direction and speed controller works properly before operating. Repair or replace as needed.
	16. Check controller for damage. Repair or replace as needed.
	17. Check battery electrolyte level. Refer to battery manufacturer instructions.
	18. Check for loose or missing hardware. Replace damaged or missing hardware.
	19. Check for worn, loose, or damaged wire connections. Repair or replace wiring.
	20. Tighten loose clamps or fittings.
	21. Check battery harness and contactor harness connectors for a secured connection.
	22. Check wire harnesses for frayed or worn insulation or wires. Replace damaged or worn harnesses.
	23. Check battery charge level on haul unit before operating.
	24. Check spare battery pack for full charge. Recharge, if needed.
	25. Check for fluid leaks. Repair leak or replace hoses or components.
	26. Keep job site clean and organized.
	27. Check equipment for proper lubrication. Refer to Section 9, Periodic Maintenance.

NOTES

Operation

OPERATING GUIDELINES

⚠WARNING Do not operate this equipment until you read, study, and understand this manual. Failure to do so, could result in severe personal injury or death.

1. Before operating, read and understand the Safety, Pre-Start Inspection, and Operation sections.

2. Do not operate this equipment while under the influence of alcohol, drugs, or medication.

3. Follow all Federal, State, and Local safety regulations and procedures.

4. Be sure OSHA prescribed safety protective equipment is being worn by all personnel.

5. Be sure the area is safe for operation. Keep worksite clean and orderly.

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

7. Have a fully charged fire extinguisher on the job site at all times.

8. Before operating, repair equipment problems.

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

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

11. Before operation, determine whether the job site has confined spaces. Follow OSHA regulations for proper training required for employees working in and around confined spaces.

12. A fully trained and qualified signal person must direct the excavator or crane operator when lifting and lowering the haul unit, dirt bucket, and other equipment.

13. Never walk or work under any part of the excavator or crane and suspended loads, such as pipe or dirt bucket.

14. Never operate the haul unit without being completely on the operator seat, unless the inching control is being used.

15. Practice operating the controls to make sure they work properly and to get the “feel” of the speed and braking of the haul unit.

16. When using haul unit to enter or exit a tunnel, watch out for personnel and do not run into obstacles.

17. No riders are allowed on the haul unit. Riders can fall from equipment or be injured by unexpected movement, resulting in severe injury or death. A rider may be allowed in an empty dirt bucket **(with contractor approval only)**, to transport personnel from the tunnel opening to the boring head. If allowed, the rider **MUST** be fully inside dirt bucket, including head and all other body parts, to avoid contact with obstructions. Also, rider cannot obstruct the operator’s view.

18. Beware of pinch points.

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

20. Do not operate this equipment on a grade higher than 5% unloaded or 2.5% loaded. The unloaded equipment grade can be visualized by a 1/2 foot (6 in.) drop or rise in a 10 foot distance. The loaded equipment grade can be visualized by a 1/4 foot (3 in.) drop or rise in a 10 foot distance.

21. Do not operate with loose objects on the operator platform, battery compartment cover and drive box cover, such as tools or parts.

SETTING UP THE HAUL UNIT

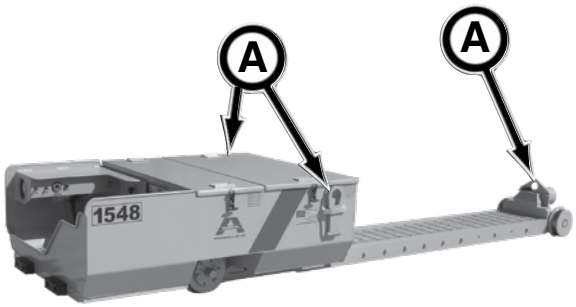
1. Once the Tunnel Boring Machine (TBM) has been setup with: power unit, jacking system, conveyor, and laser guidance system; install track and track risers as needed (see Installing Track in this section).

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

Do not enter area under or around a load.

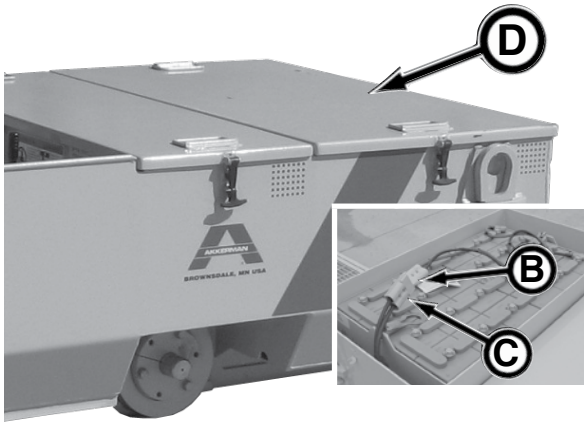
NOTICE In certain applications, the dirt bucket will need to be lowered into position behind the conveyor until the TBM has moved far enough forward to allow enough room to lower the haul unit.

2. Using the lifting eyes (A), lower the haul unit without the battery pack, onto the jacking system rails or track. The operator platform end of the haul unit should be positioned towards the TBM.

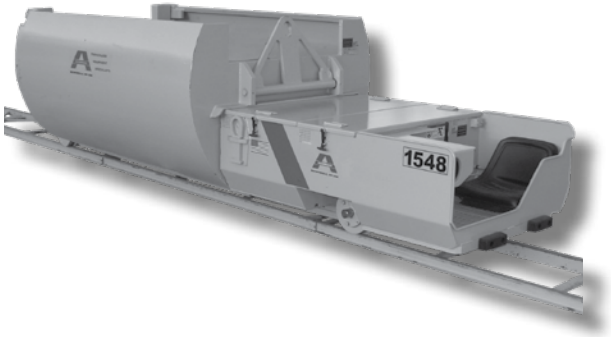


3. Inspect the area for clearance between the haul unit frame and the dirt bucket unloading area.

4. Open battery compartment cover. Lower the battery pack into the haul unit and connect the battery harness (B) with the contactor harness (C). Replace battery compartment cover (D).



5. Lower the dirt bucket onto the haul unit.



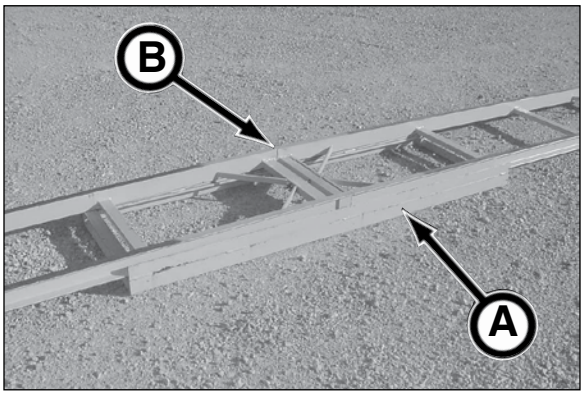
INSTALLING TRACK

1. Track sections are easily connected with a single bolt and wing nut. The first track section should be installed to the TBM.

   Install additional track after the trailing pipe has been lowered on the jacking system base and mates with the leading pipe.

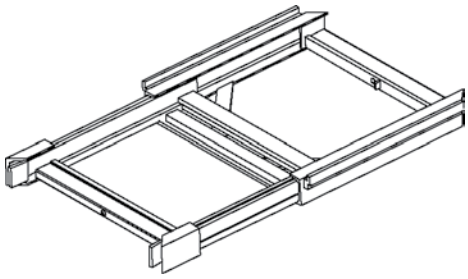
NOTICE Periodically inspect track bolts and wing nuts for tightness and damage. Retighten track bolts/wing nuts as necessary. If damaged, replace with new.

2. If track risers (A) are required, center the track risers under each track connection (B).



NOTICE Track risers are used to retain the track height from the TBM to the yoke.

3. The sliding track will slide in and out with the movement of the intermediate jacking station (IJS). Be sure no track joints are in the IJS.



OPERATING THE HAUL UNIT

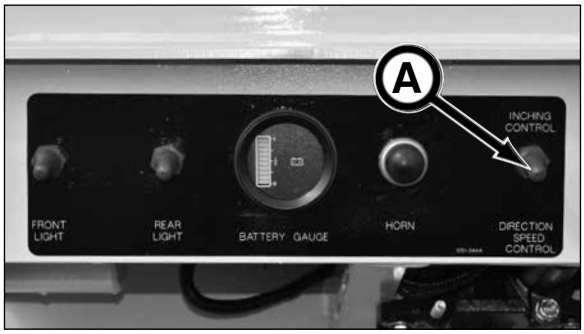
⚠WARNING Contacting tunnel wall and boring head components can cause severe injury or death. Keep all body parts on Haul Unit while Unit is moving.

⚠WARNING Wear reasonably close fitting clothing before operating this equipment. This will help prevent the danger of catching them in moving parts or controls when getting in and out of the haul unit operator platform.

1. Mount the haul unit operator platform, sit on seat and keep all body parts within the platform area.

2. Clear all personnel from the bucket unloading area and pipeline travel area.

3. Flip Drive Motor Mode Selector Control (A) down to the Direction/Speed Control.



4. Release the parking brake by pushing lever down.

5. With the Main Power Lockout Switch to the ON position, turn ON Drive Motor Control Switch.

6a. (SN F21700F-28 & Before) Start travel into the pipeline by slowly moving direction/speed control.

NOTICE The haul unit will propel faster the farther the control handle is moved away from the center or neutral position.

6a. SN F21700F-28 & Before

(continued on next page)

6b. (SN F21700F-29 & After) Start travel into the pipeline by applying the operator presense switch and slowly moving the direction/speed control joystick while pressing the operator presence switch.

6b. SN F21700F-29 & After

NOTICE The haul unit will propel faster the farther the control handle is moved away from the center or neutral position.

7. When approaching destination, move the direction/speed control to the opposite direction of travel or depress brake pedal as needed to stop the haul unit. Keep in mind that forward momentum will carry the haul unit past the point where the brake is applied.

NOTICE As the haul unit is approaching the conveyor in the front of tunnel, stop the haul unit and flip the selector switch to Inching Control. Then use the Inching Control for precise propulsion control when positioning the haul unit and dirt bucket to the conveyor.

8. Apply the parking brake to prevent unintended haul unit movement.

9. To move haul unit out of tunnel, release parking brake, and slowly move the direction/speed control as needed. Then slowly move the haul unit into the bucket unloading area on the yoke or other jacking frame. Use the brake pedal and parking brake as needed.

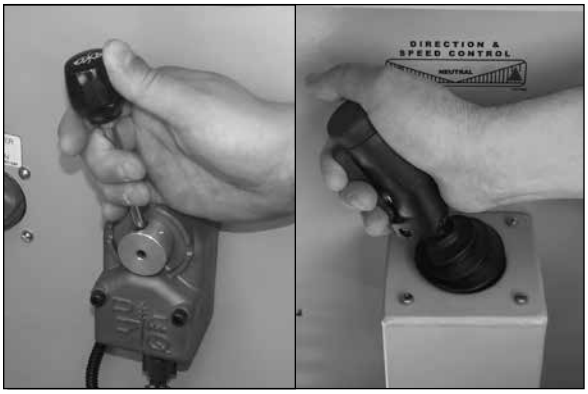
NOTICE Do not attempt to propel unit with the parking brake in the locked position. Damage to the brake system can occur.

STOPPING THE HAUL UNIT

⚠CAUTION Be careful when stopping the haul unit as the forward momentum can carry the unit past the point where the brake is applied.

There are two methods to stop the movement of the haul unit:

1. Move the direction/speed controller in the opposite direction of travel as needed to stop the haul unit.



SN F21700F-28 & Before *SN F21700F-29 & After*

2. Depress the brake pedal to stop the haul unit.

NOTICE When using the direction/speed controller as a brake for the haul unit, the haul unit battery charges with the regenerative brake motor system, increasing battery life between charges.

PARKING THE HAUL UNIT

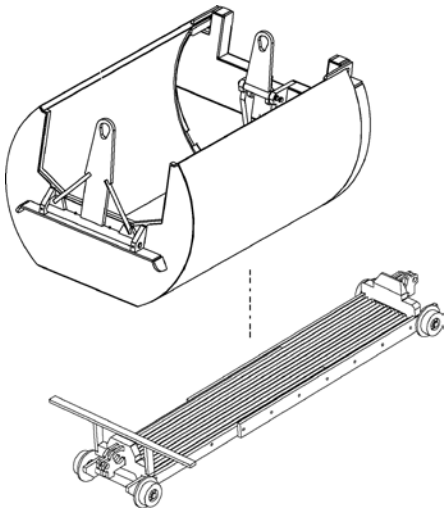
With the haul unit stopped, pull the parking brake lever UP into the locked (vertical) position.

NOTICE If the brake lever does not lock into position, the lever MUST be adjusted as follows: Disengage brake and turn adjustment knob (top of lever) as needed until brake lever locks in vertical position.

NOTICE Do not attempt to propel unit with the brake in the locked position. Damage to the brake system can occur.

USING THE HAUL CART

Increase your haul unit productivity on long tunnels with a multiple-dirt bucket train system by pinning the haul cart (with dirt bucket) to the 1548 Haul Unit.



NOTICE If utilizing a multiple-dirt bucket train system, note that the extra load will reduce the operational grade, and the haul unit will take longer to start and stop.

If you need to switch the haul cart from standard to the extended dirt bucket configuration, or vice versa, simply remove all bolts, lock washers, and nuts, slide frame to desired standard (60”) or extended (90”) dirt bucket size, and replace the hardware.

MOVING THE FRAME EXTENSION FOR STANDARD & EXTENDED DIRT BUCKET CONFIGURATION

NOTICE The grate (A) is used only with the extended dirt bucket (90”) configuration. The grate is stored when the haul unit is configured for the standard dirt bucket (60”).

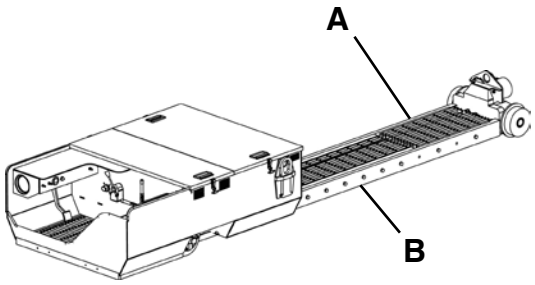
1. Securely support haul unit frame so the frame extension (B) can be slid forward or back depending on whether you are switching to the standard or extended dirt bucket.

2. Remove all bolts from frame extension. Retain hardware for later use.

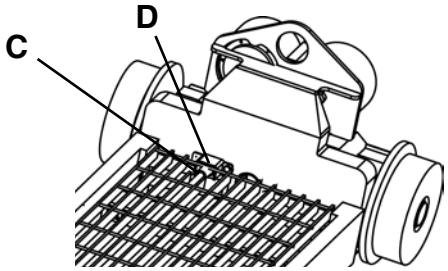
For Extended Bucket, continue to step 3.
For Standard Bucket, continue to step 4.

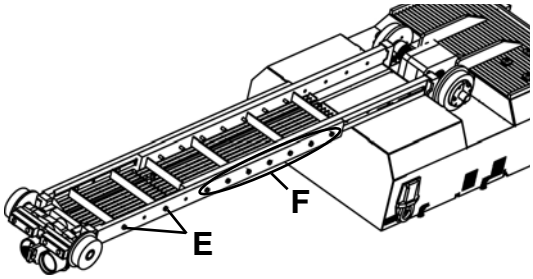
3. (For Extended Bucket)
- Disconnect power cable (C) from frame extension connector (D).
- Slide frame extension forward or away from haul unit so the 90” dirt bucket will fit properly on the frame.
- Place grate (A) onto frame extension and secure with four 5/8 UNC x 3 in. bolts and nuts (E).
- Secure frame extension to haul unit frame with fourteen 5/8 UNC x 4 in. bolts (F).
- Carefully route power cable (C) through grating and reconnect power cable to extension frame connector (D). If necessary, secure power cable to prevent it from getting tangled or caught with tunnel components or obstructions.

4. (For Standard Bucket)
- Remove and store grate (A) and hardware for future extended bucket configuration.
- Disconnect power cable (C) from frame extension connector (D).
- While sliding frame extension back towards haul unit frame, carefully route power cable through tube (G) and into motor compartment.
- Secure frame extension to haul unit frame with fourteen 5/8 UNC x 4 in. bolts (F).
- Reconnect power cable (C) to frame extension connector (D). Secure excess power cable in motor compartment with tie straps as needed to prevent it from getting tangled or caught with tunnel components or obstructions.

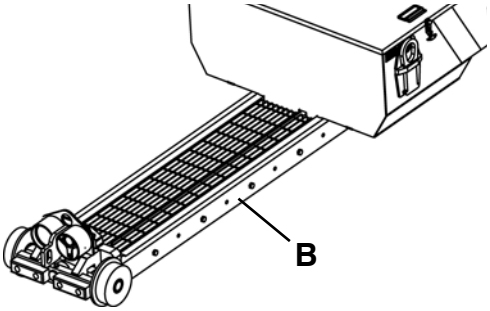


Extended Haul Unit - Top View

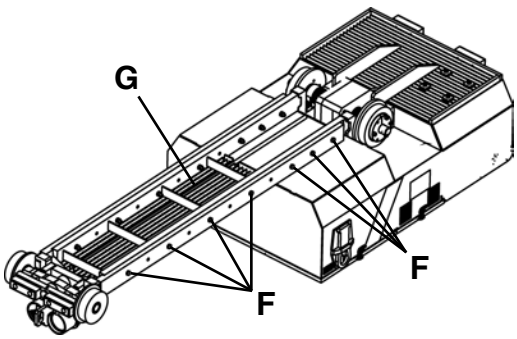




Extended Haul Unit - Bottom View



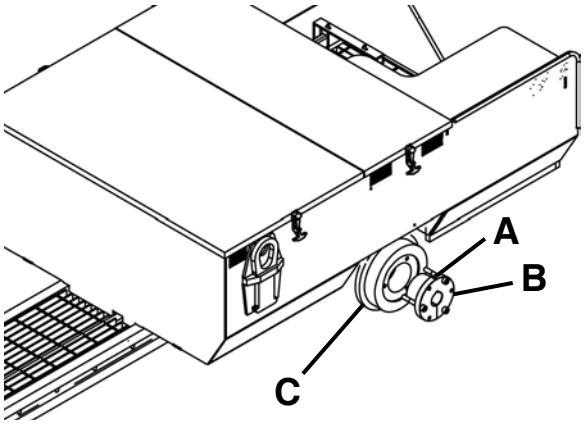
Standard Haul Unit - Top View



Standard Haul Unit - Bottom View

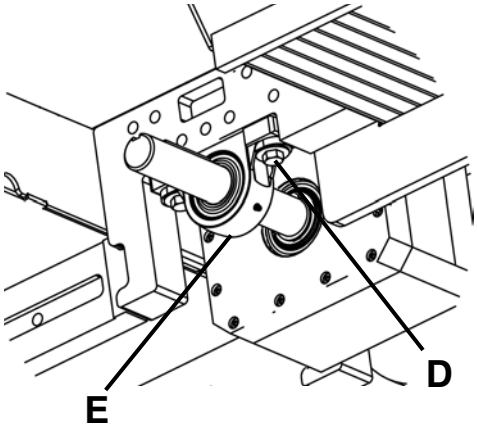
ADJUSTING HAUL UNIT TRACK GAGE

The 1548 Haul Unit standard track gage width is 20” (508 mm). A track gage kit (021716A) is available to change the track gage to 24” (610 mm).

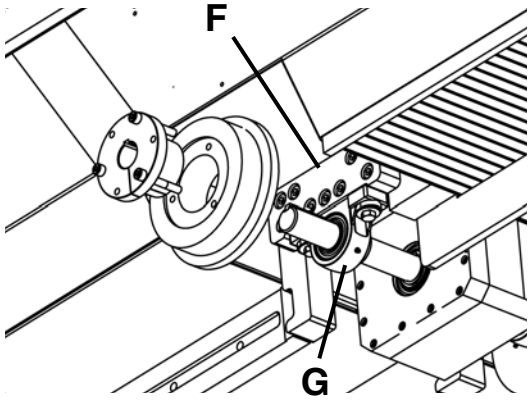


Adjusting Haul Unit from 20” to 24” Track Gage

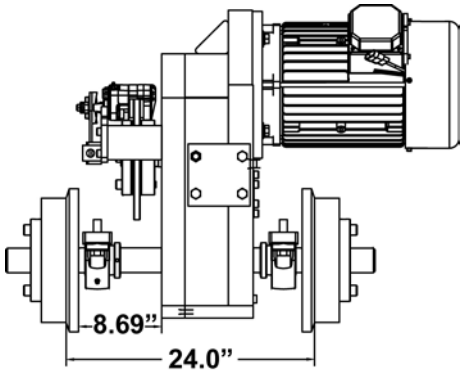
1. Securely support haul unit frame so the wheels and hubs can be removed.
2. Loosen hub set screw (A).
3. Remove hub (B), wheel (C) and key (not shown). Retain for later use.



4. Remove hardware (D) from pillow block (E). Retain hardware for later use.



5. Install bearing block (F) to frame with nine 3/4 UNC x 2 in. socket head cap screws (from kit). Tighten to 175 ft-lb. (240 N·m) torque.
6. Secure pillow block (G) to bearing block with hardware removed from step 4 and tighten to 175 ft-lb. (240 N·m) torque.



7. Replace key, wheel, and hub using dimensions shown in illustration to assure the drive wheels are aligned with the idler wheels. Secure with three 9/16 UNC x 3.625 in. bolts and tighten to 130 ft-lb. (175 N·m) torque.
8. Tighten set screw (A) in hub.
9. Repeat steps 2 through 8 for the opposite side of axle.

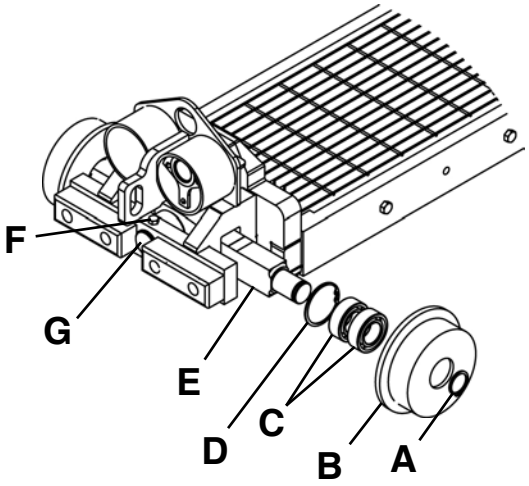
(continued on next page)

10. On the idler assembly end of the haul unit, remove snap ring (A) and wheel (B) from both ends of the idler axle (E). Retain for later use. The bearings (C) are contained within the wheel with snap ring (D).

11. Remove idler axle by removing one 1/2 UNC x 4 in. bolt (F) and axle pivot pin (G) from idler assembly. Retain for later use.

12. Install the 24" gage idler axle (from kit) to idler assembly with axle pivot pin and one 1/2 UNC x 4 in. bolt (removed from step 11) and tighten to 90 ft-lb. (120 N·m) torque.

13. Install wheel (with bearing and snap ring) and snap ring (removed in step 10) to each end of the axle assembly.

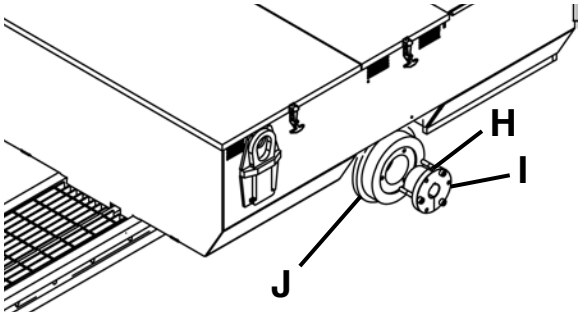


Adjusting Haul Unit from 24" to 20" Track Gage

1. Securely support haul unit frame so the wheels and hubs can be removed.

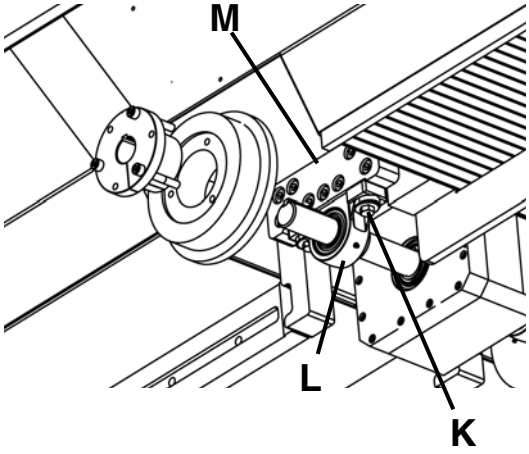
2. Loosen hub set screw (H).

3. Remove hub (I), wheel (J) and key (not shown). Retain for later use.

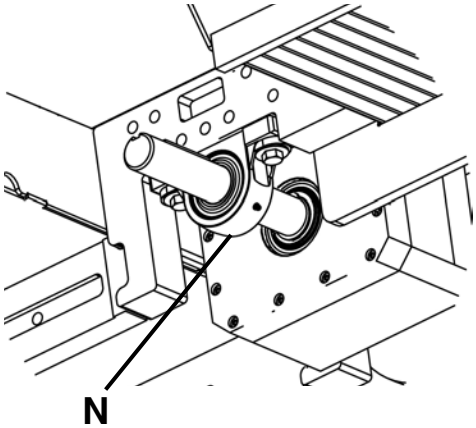


4. Remove hardware (K) from pillow block (L). Retain hardware for later use.

5. Remove bearing block (M) from frame and retain for future use.



6. Secure pillow block (N) to haul unit frame with hardware removed from step 4 and tighten to 175 ft-lb. (240 N·m) torque.



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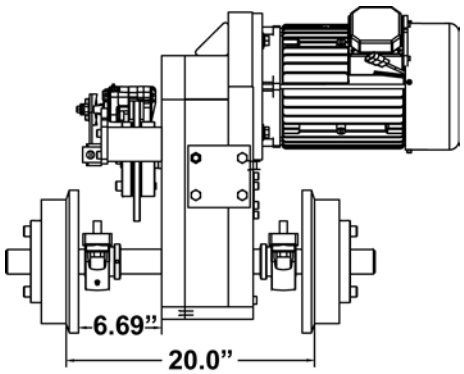
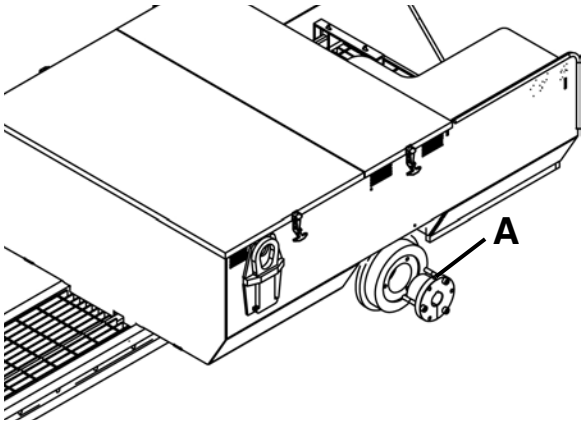
7. Replace key, wheel, and hub using dimensions shown in illustration to assure the drive wheels are aligned with the idler wheels. Secure with three 9/16 UNC x 3.625 in. bolts and tighten to 130 ft-lb. (175 N·m) torque.



8. Tighten set screw (A) in hub.

9. Repeat steps 2 through 8 for the opposite side of axle.

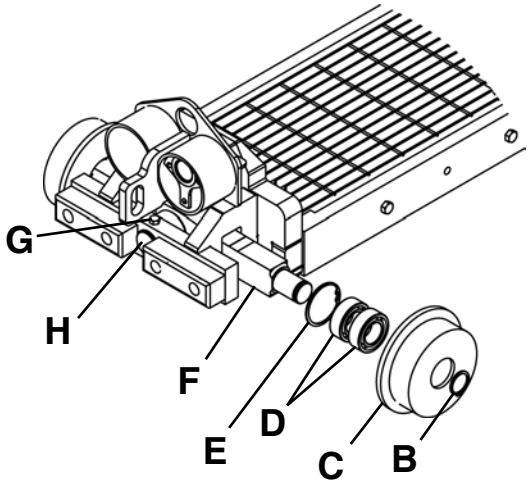


10. On the idler assembly end of the haul unit, remove snap ring (B) and wheel (C) from both ends of the idler axle (F). Retain for later use. The bearings (D) are contained within the wheel with snap ring (E).

11. Remove idler axle by removing one 1/2 UNC x 4 in. bolt (G) and axle pivot pin (H) from idler assembly. Retain for later use.

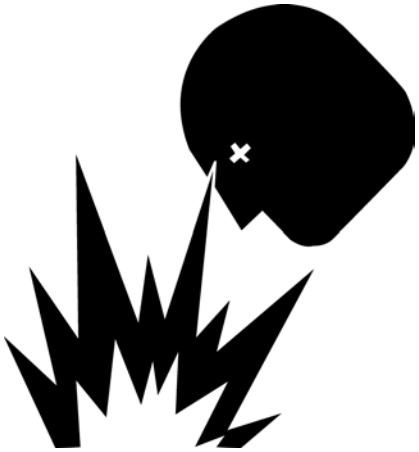
12. Install the 20" gage idler axle to idler assembly with axle pivot pin and one 1/2 UNC x 4 in. bolt (removed from step 11) and tighten to 90 ft-lb. (120 N·m) torque.

13. Install wheel (with bearing and snap ring) and snap ring (removed in step 10) to each end of the axle assembly.



RECHARGING THE BATTERY PACK - LESTRONIC II

⚠WARNING Batteries produce explosive gases. Wear eye protection and protective clothing during battery service. Keep sparks, flames, and cigarettes away from batteries.



If acid enters eye, IMMEDIATELY flush eye with running cold water for at least 15 minutes and get medical attention.

If battery acid contacts skin or clothing, wash immediately with soap and water.

Do not expose charger to rain or snow. Charge batteries only in a well ventilated area away from open flames and sparks.

The battery charger is a self-regulating charger. When the battery has reached its maximum state of charge, the circuitry will automatically turn the charger off.

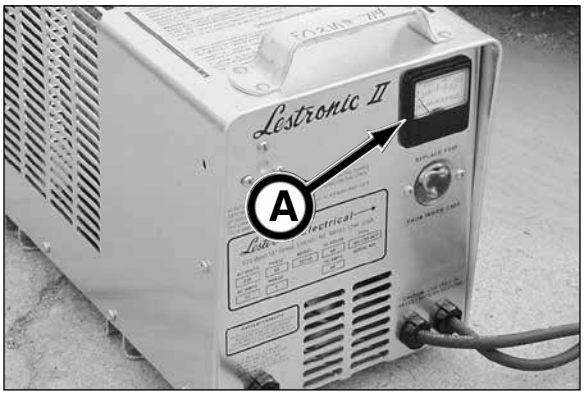
The batteries can be recharged while the battery pack is in the haul unit or at the spare battery pack.

RECHARGING AT HAUL UNIT

1. Before recharging battery, remove battery compartment cover to assure proper ventilation.

2. Check battery electrolyte level. Follow instructions from battery manufacturer.

3. Connect the charger DC output plug to battery harness plug.



4. Connect AC supply cord to a properly grounded single phase outlet of the proper voltage and frequency as specified on front of charger.

5. The charger will start after a short delay as indicated by the transformer hum and the ammeter movement (A).

6. After properly charged, ALWAYS disconnect AC cord from its outlet first.

7. Disconnect DC output plug from battery harness plug and secure battery compartment cover.

8. Store battery charger in a clean, dry area.

(continued on next page)

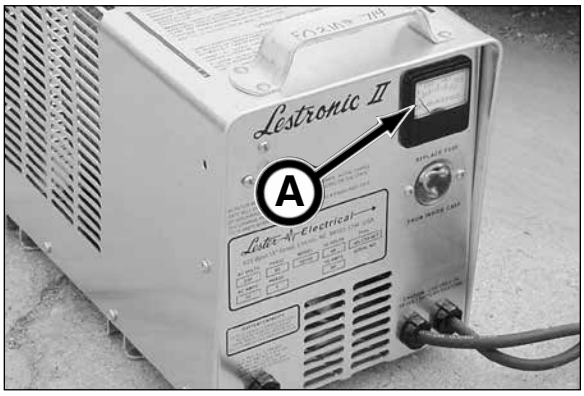
RECHARGING SPARE BATTERY PACK

1. Check battery electrolyte level. Follow instructions from battery manufacturer.

2. Connect the charger DC output plug to battery harness plug.

3. Connect AC supply cord to a properly grounded single phase outlet of the proper voltage and frequency as specified on front of charger.

4. The charger will start after a short delay as indicated by the transformer hum and the ammeter movement (A).



5. After properly charged, ALWAYS disconnect AC cord from the outlet first.

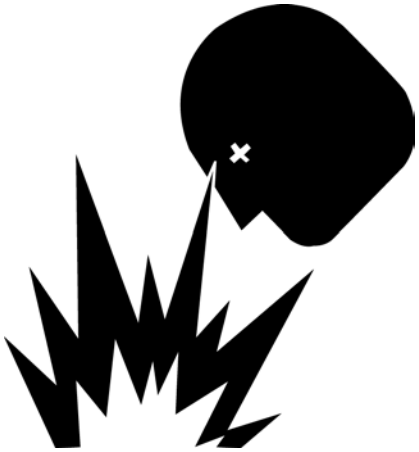
6. Disconnect DC output plug from battery harness plug.

7. Store battery charger in a clean, dry area.

For more information, refer to your Battery Charger Operation Manual.

RECHARGING THE BATTERY PACK - QUICK CHARGE™

⚠WARNING Batteries produce explosive gases. Wear eye protection and protective clothing during battery service. Keep sparks, flames, and cigarettes away from batteries.



If acid enters eye, IMMEDIATELY flush eye with running cold water for at least 15 minutes and get medical attention.

If battery acid contacts skin or clothing, wash immediately with soap and water.

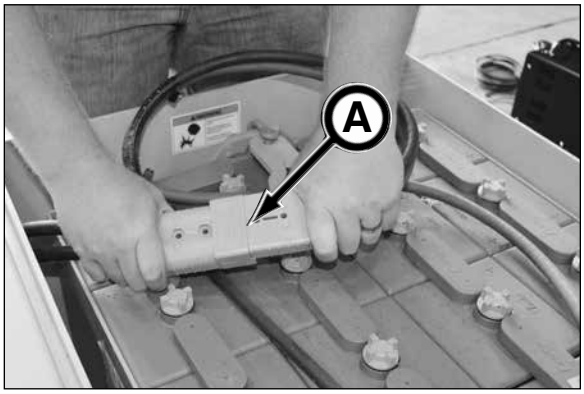
Do not expose charger to rain or snow. Charge batteries only in a well ventilated area away from open flames and sparks.

The battery charger is a self-regulating charger.

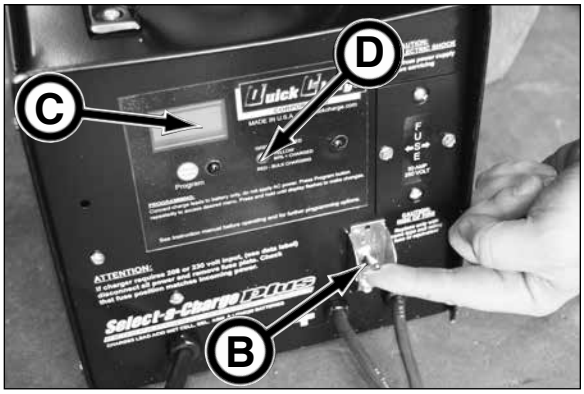
The batteries can be recharged while the battery pack is in the haul unit or at the spare battery pack.

RECHARGING AT HAUL UNIT

1. Before recharging battery, remove battery compartment cover to assure proper ventilation.
2. Check battery electrolyte level. Follow instructions from battery manufacturer.
3. Connect the charger DC output plug to battery harness plug (A).



4. Connect AC supply cord to a properly grounded single phase outlet of the proper voltage and frequency specified on the front of the charger.
5. Flip the switch to ON (B). The display (C) will detect and indicate the battery voltage and amps.
6. Charging will begin.
7. The LED indicator (D) will display RED until charge cycle is at 80%, YELLOW when the charging cycle 80% complete, and flash GREEN when fully charged.

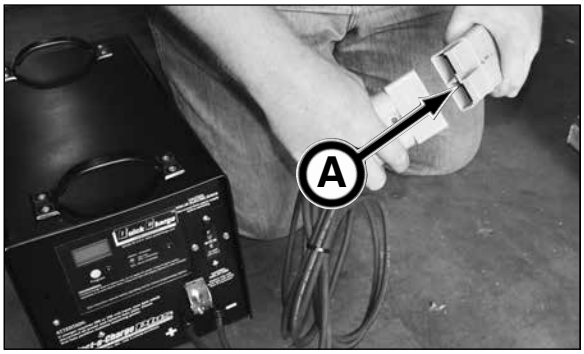


8. Once battery is fully charged, flip the switch to OFF (B).
9. After properly charged, ALWAYS disconnect AC cord from its outlet first.
10. Disconnect DC output plug from battery harness plug and secure battery compartment cover.
11. Store battery charger in a clean, dry area.

(continued on next page)

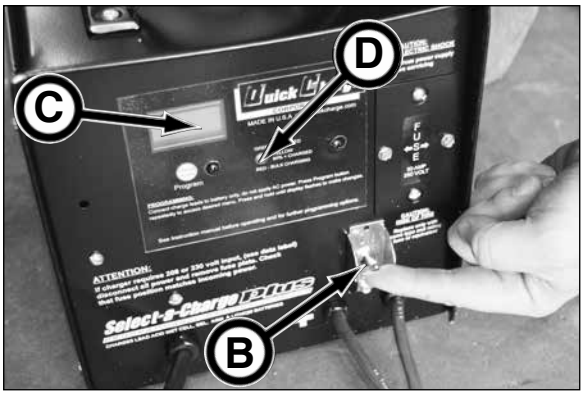
RECHARGING SPARE BATTERY PACK

1. Check battery electrolyte level. Follow instructions from battery manufacturer.



2. Connect the charger DC output plug to battery harness plug (A).

3. Connect AC supply cord to a properly grounded single phase outlet of the proper voltage and frequency specified on the front of the charger.

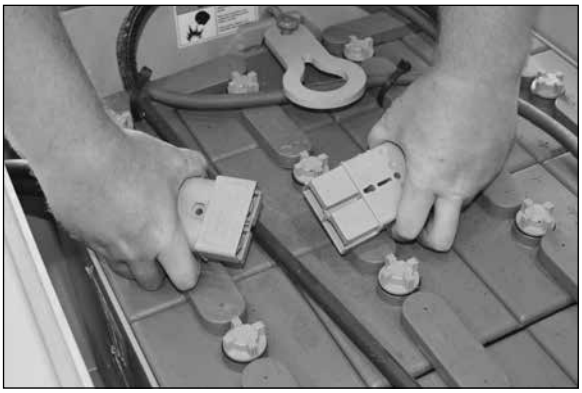


4. Flip the switch to ON (B). The display (C) will detect and indicate the battery voltage and amps.

5. Charging will begin.

6. The LED indicator (D) will display RED until charge cycle is at 80%, YELLOW when the charging cycle 80% complete, and flash GREEN when fully charged.

7. Once battery is fully charged, flip the switch to OFF (B).



8. After properly charged, ALWAYS disconnect AC cord from the outlet first.

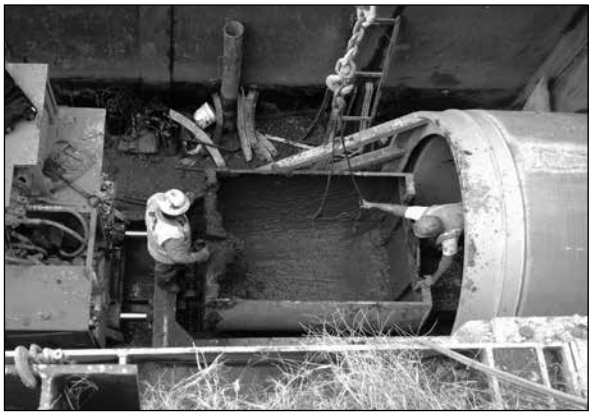
9. Disconnect DC output plug from battery harness plug.

10. Store battery charger in a clean, dry area.

For more information, refer to your Battery Charger Operation Manual.

USING THE DIRT BUCKET

NOTICE To switch haul unit frame for the standard or extended bucket, refer to Moving The Frame Extension For Standard & Extended Dirt Bucket Configuration in this section.



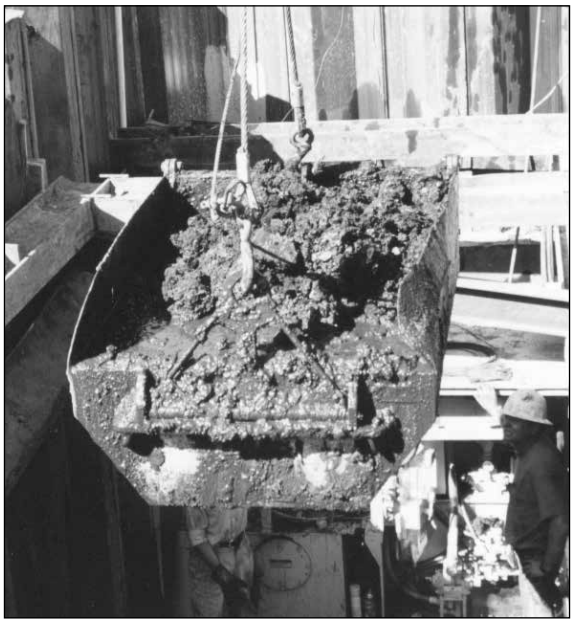
1. With the dirt bucket lowered onto the haul unit's rails, lower the bucket lift eye so it will not interfere with conveyor.

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

2. Move the haul unit into the tunnel. The dirt bucket must be positioned behind the conveyor to contain the spoil.

3. When the dirt bucket is full, move the haul unit/ dirt bucket out of the tunnel until the dirt bucket clears the tunnel wall to the unloading area.

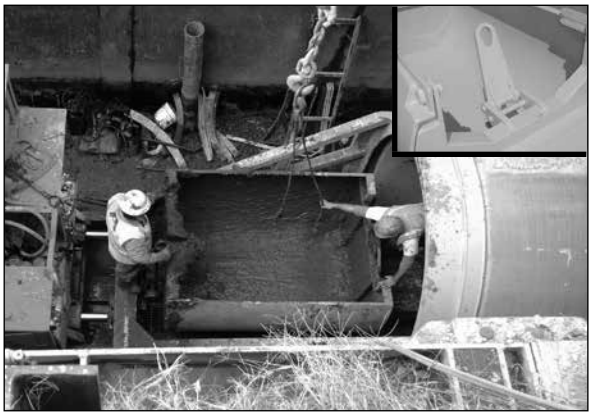
4. Flip the bucket lift eye up.



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

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

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



7. After dirt bucket is empty, move the dirt bucket to the unloading area and lower onto haul unit rails.

8. Lower bucket lift eye.

9. Follow steps 2 through 8 until the tunnel is complete.

10. After tunnel is complete, flip the bucket eye up (see inset), and lift the dirt bucket out of shaft or pit area.

Transporting

TRANSPORTING GUIDELINES

1. Know the local, state, and federal transportation regulations.

2. Obtain required permits for transporting.

3. Remove any obstacles from the trailer floor.

4. Load and unload on level ground.

5. It is best to lower haul unit onto blocks on trailer floor. This will make it easier when using fork lift to remove haul unit from trailer.

6. Do not use chain to fasten haul unit to trailer floor. Use straps to prevent damage to haul unit.

7. Lower spare battery pack into dirt bucket for transporting.

8. Be careful if using chains to secure dirt bucket. Travel vibration can cause chain hammering. If possible, use straps to secure dirt bucket to trailer floor.

NOTES

Lubricants

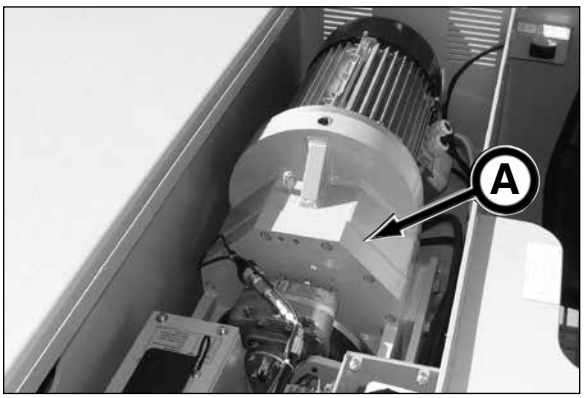
NOTICE Use of inferior lubricants can affect the efficient performance and life of your Haul Unit. Always use high quality lubricants as specified in this section.
Refer to the Periodic Maintenance section for proper lubrication quantity, maintenance intervals, and procedures.

GEAR BOX LUBRICANT

The gear box (A) is filled with Mobil SHC 626 Synthetic Bearing and Gear Oil.

Use Mobil SHC 626 or equivalent when adding or changing lubricant.

NOTICE The Mobil SHC 626 Synthetic Bearing and Gear oil is a synthetic oil specifically designed for this application. If you change to a different oil, use a reputable oil supplier to meet or exceed the Mobil SHC 626 oil specifications. Do not mix oil manufacturers or grades.



BRAKE FLUID

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

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

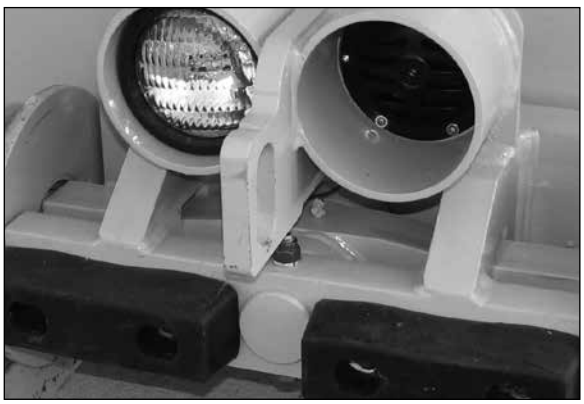
NOTICE Never mix different manufacturer's brake fluids since the fluids may be incompatible resulting in brake failure.

GREASE

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

The XHP222 grease is a multipurpose, high performance, high temperature, lithium grease.

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



STORING LUBRICANTS

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

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

Periodic Maintenance

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

The requirements for lubrication and maintenance are shown on the maintenance charts in this section. Intervals of maintenance are based on normal operating conditions. If operating under more difficult conditions, use a shorter time interval between maintenance.

LOCKOUT TAGOUT POWER BEFORE SERVICING

⚠WARNING Severe personal injury or death can result from unexpected haul unit startup or machine movement.

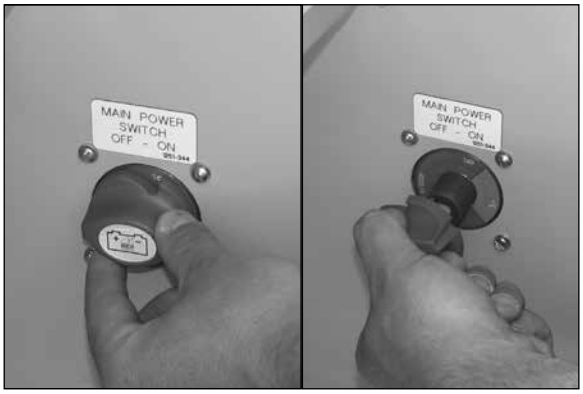
LOCKOUT TAGOUT power before attempting to make repairs or adjustments to this equipment, unless otherwise indicated. Proper lockout tagout will prevent accidents and save lives. Performing the lockout tagout will also prevent the equipment from moving unexpectedly.

Refer to Lockout Tagout Procedure Guideline in the Safety section.

LOCKOUT TAGOUT THE MAIN POWER SWITCH

1. Turn the Main Power Switch counterclockwise (CCW) to the OFF position.

2a. (SN F21700F-28 & Before) Rotate the knob past the OFF position and then pull knob out.



2a. SN F21700F-28 & Before

2b. (SN F21700F-29 & After) Install shackle of OSHA approved lock with tag through latch.

3. Secure lock by pushing shackle into body of the lock until the shackle is locked into the locking mechanism.

4. Turn key to lock shackle in place.

5. Remove key from lock.

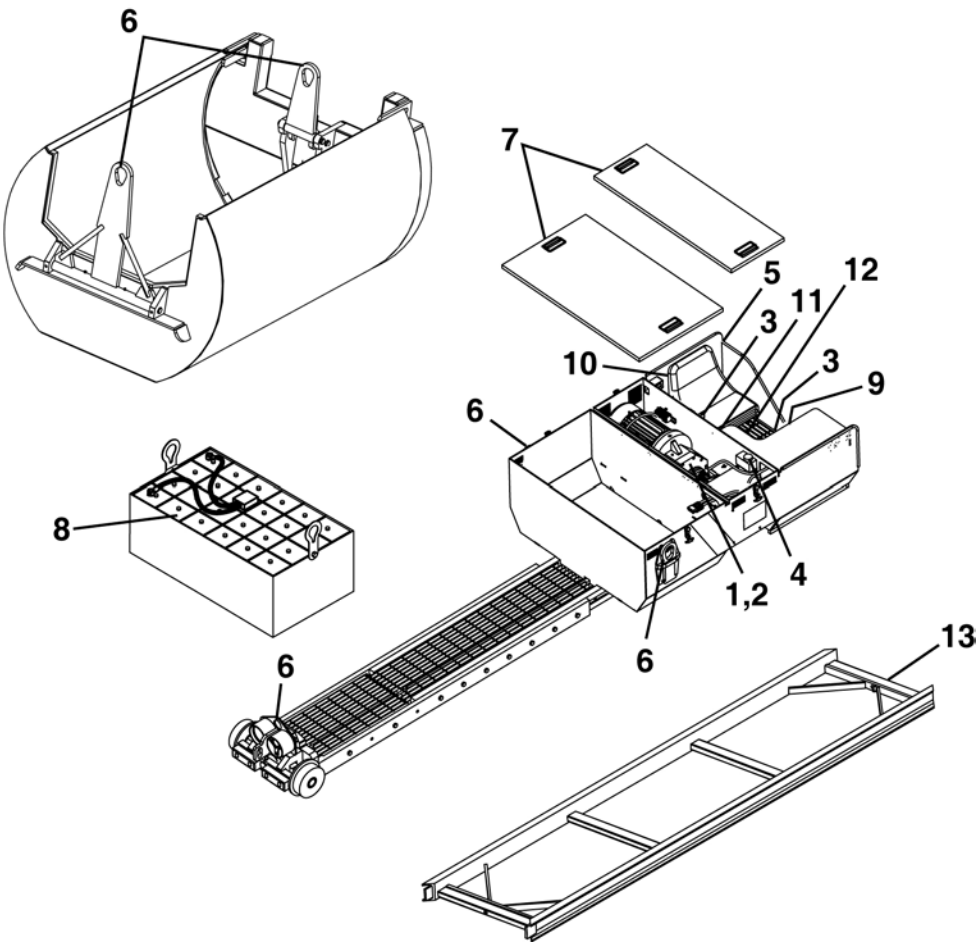
6. Test to be sure shackle is fully secured into lock.

7. Sign “Equipment Locked Out” tag or equivalent.

2b. SN F21700F-29 & After

MAINTENANCE CHARTS

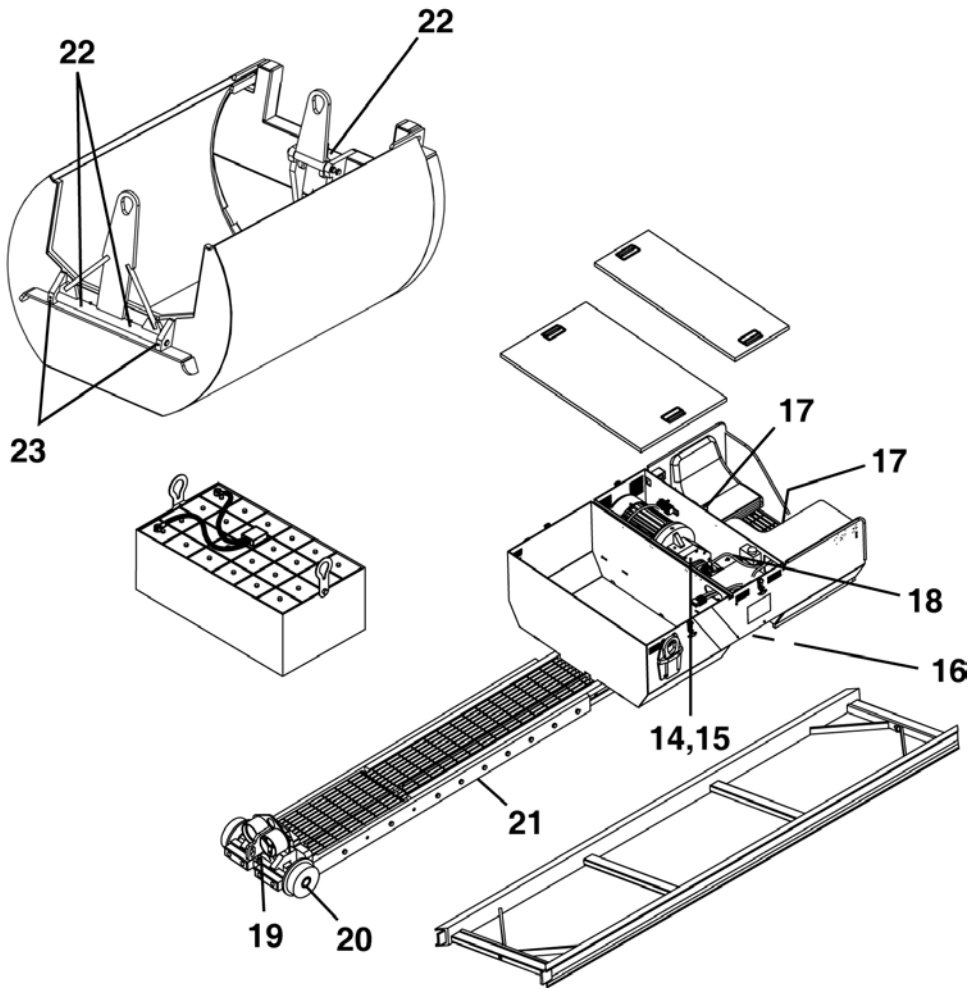
NOTICE Use the item number in the chart to refer to the detailed maintenance procedures later in this section.



DAILY OR EVERY 10 HOURS OF OPERATION OR SHIFT CHANGE

ITEM	COMPONENT	SERVICE	REQUIREMENT	MATERIAL
1.	Gear Box	Inspect for Leaks		
2.	Gear Box	Check Oil Level	Oil level to fill plug.	Mobil SHC 626
3.	Brakes	Test Operation		
4.	Brake Fluid	Check Fluid Level	Refill master cylinder as needed.	DOT 3 Brk. Fluid
5.	Operator Platform	Clean and Inspect	If damaged, repair or replace.	
6.	Lifting Eyes	Inspect Pins and Hardware	If damaged, repair or replace.	
7.	Covers	Inspect	If damaged, repair or replace.	
8.	Battery	Clean and Inspect	Check electrolyte level. Fill if needed. Refer to Battery Mfr.	
9.	Battery Charge	Check	Recharge or replace if needed.	
10.	Seat	Check Seat Mounting	If damaged, replace immediately.	
11.	Controller	Clean and Test For Proper Operation		
12.	Main Power Lockout Switch	Check Switch Function		
13.	Track	Inspect	If damaged, repair or replace.	

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

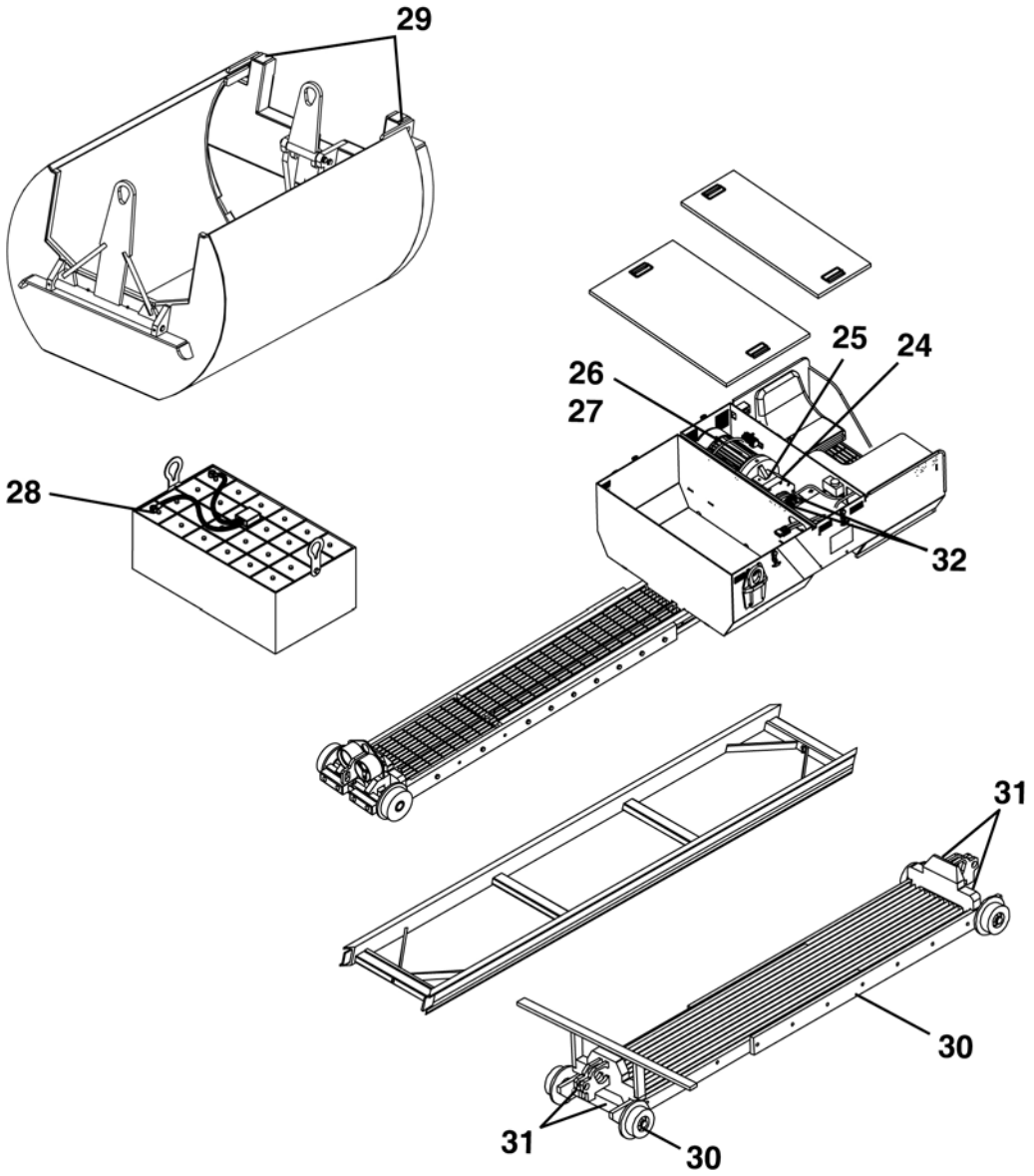


WEEKLY OR EVERY 50 HOURS OF OPERATION

ITEM	COMPONENT	SERVICE	REQUIREMENT	MATERIAL
14.	Gear Box	Check Mounting Hardware	1/2" - 90 ft-lbs, 5/8" - 175 ft-lbs	Torque Wrench
15.	Gear Box	Check Wheels & Bearings		
16.	Axle Pillow Block Bearings	Lubricate	*Lubricate with 2 shots of grease.	Mobil XHP222
17.	Brake/Parking Brake	Inspect	Repair or replace as needed.	
18.	Hoses & Cables	Inspect	If worn or damaged, replace with new.	
19.	Axle Pivot Pin	Lubricate	Lubricate until grease is forced out.	Mobil XHP222
20.	Idler Assembly	Inspect Wheels & Bearings	If damaged, replace with new.	
21.	Frame Rails	Inspect	If damaged, contact factory.	
22.	Lift Eye/Bar Hinge	Lubricate (3 places)	Lubricate until grease is forced out.	Mobil XHP222
23.	Lift Eye/Bar Hinge	Check set screw (4 places)	Tighten.	

* Lubricate bearings daily if subjected to water or mud.

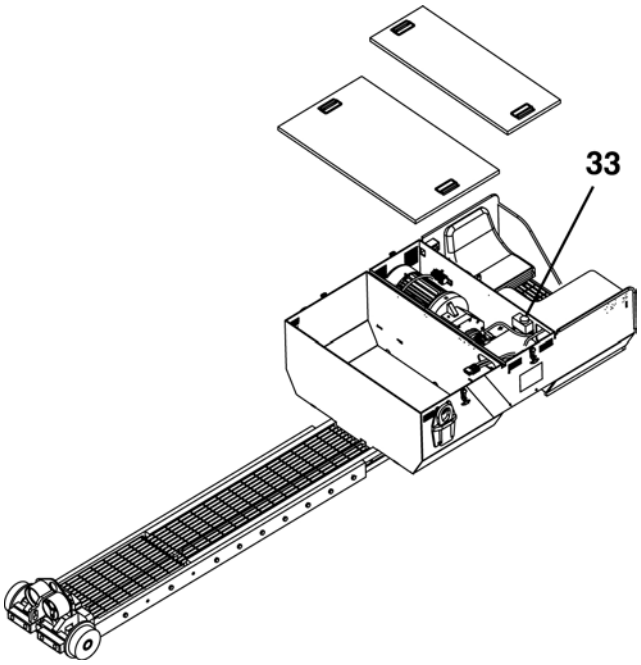
NOTICE Use the item number in the chart to refer to the detailed maintenance procedures later in this section.



MONTHLY OR EVERY 250 HOURS OF OPERATION

ITEM	COMPONENT	SERVICE	REQUIREMENT	MATERIAL
24.	Gear Box	Drain and Fill	5 qt. (4.7L)	Mobil SHC 626
25.	Gear Box Relief	Inspect	If damaged, replace with new.	
26.	Motor, Electric	Inspect	Keep vent holes clear & vanes clean.	
27.	Motor, Electric	Inspect Mounting Bolts	If loose, tighten to 80 ft-lb (27 N·m)	Torque Wrench
28.	Batteries	Inspect and Clean		Baking Soda Solution
29.	Bucket Door Pivot	Inspect	If damaged, replace with new.	
30.	Haul Cart	Inspect Frame & Wheel Bearings	If damaged, repair or replace.	
31.	Haul Cart Wheels	Lubricate Wheel Bearings	Lubricate until grease is forced out.	Mobil XHP222
32.	Brake Caliper Pins (4)	Apply Light Coat of Anti-Sieze	**DO NOT ALLOW LUBE TO CONTACT DISC BRAKE!!!**	Anti-Sieze

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

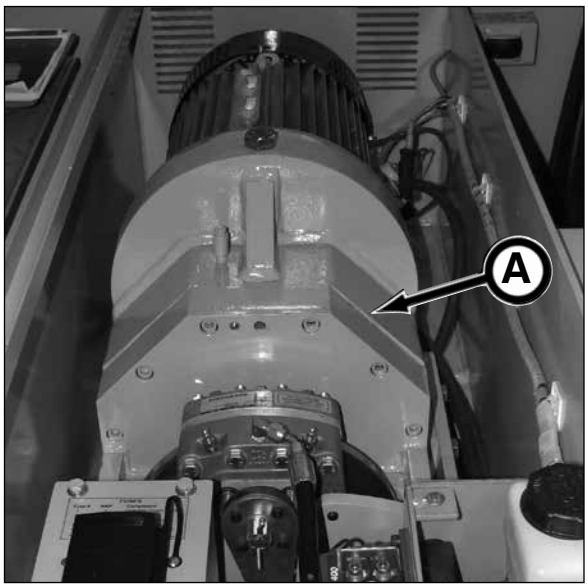


ANNUALLY OR EVERY 2000 HOURS OF OPERATION

ITEM	COMPONENT	SERVICE	REQUIREMENT	MATERIAL
33.	Master Cylinder Reservoir	Drain & Fill	Fill to MAX level on reservoir & bleed brakes before use.	DOT 3

DAILY OR EVERY 10 HOURS OF OPERATION OR SHIFT CHANGE

1. INSPECT GEAR BOX



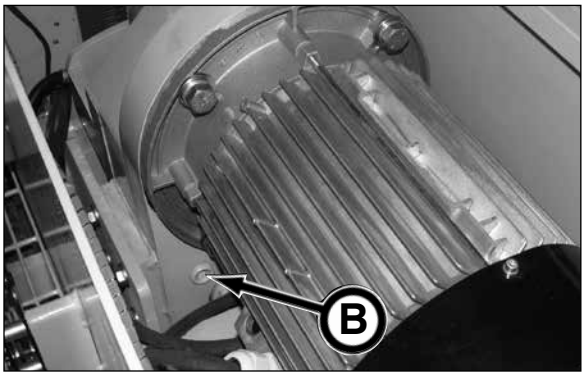
1. Remove drive box cover to gain access to gear box (A).

2. Visually check gear box for leaks. If any leaks are present, determine the cause and repair gear box before operating haul unit.

3. If necessary, add oil. See “2. Check Gear Box Fluid Level” in this section for proper oil type and refilling procedure.

4. Secure drive box cover.

2. CHECK GEAR BOX FLUID LEVEL



1. With haul unit on level ground, open drive box cover to gain access to the gear box. Clean area around check/fill plug (B).

2. Remove check/fill plug.

3. If fluid is not at the check/fill plug hole, add Mobil SHC 626 or equivalent until oil is at the hole level. DO NOT OVERFILL.

NOTICE The Mobil SHC 626 Synthetic Bearing and Gear oil is a synthetic oil specifically designed for this application. If you change to a different oil, use a reputable oil supplier to meet or exceed the Mobil SHC 626 oil specifications. Do not mix oil manufacturers or grades.

4. Replace check/fill plug. Secure drive box cover.

3. TEST BRAKE OPERATION

⚠WARNING If the haul unit fails to brake properly, the brake system MUST be repaired before operating the haul unit in the pipeline. Failure to do so could cause severe injury or death.

Before operating haul unit, test the brake operation of the brake pedal and the parking brake as follows.

BRAKE PEDAL
With the parking brake released (unlocked) depress the brake pedal to stop the haul unit.

PARKING BRAKE (Hand Brake)
Engage the parking brake by pulling brake lever UP to the locked (vertical) position.
To release parking brake, push lever down completely.

NOTICE The brake lever MUST be adjusted as follows: Disengage brake and turn adjustment knob (top of lever) as needed until brake lever locks in vertical position.

Check parking brake cable for damage. If damaged, replace with new.

4. CHECK MASTER CYLINDER BRAKE FLUID LEVEL

1. With the haul unit on a level surface, remove drive box cover to gain access to the master cylinder reservoir (A).

2. Clean area around the master cylinder reservoir.

3. Check if fluid level is between the MIN and MAX marking on reservoir.

4. If fluid is needed, remove fill cap and fill reservoir ONLY with new brake fluid that meets or exceeds DOT 3 specifications to the MAX marking on reservoir.

5. Replace fill cap.

5. INSPECT OPERATOR PLATFORM

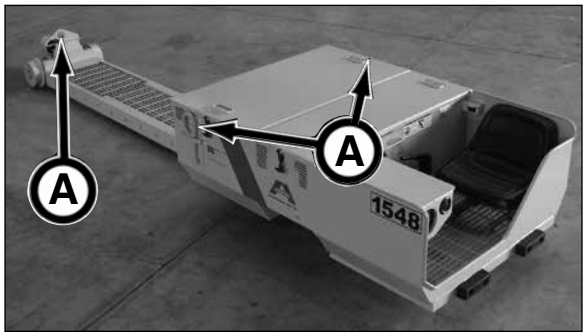
Clean and inspect operator platform for cracks or other damage.

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

6. INSPECT HAUL UNIT, DIRT BUCKET & BATTERY PACK LIFTING EYES, PINS & HARDWARE

HAUL UNIT
Inspect haul unit lifting eyes (A) for cracks or other damage. Repair or replace before lifting.

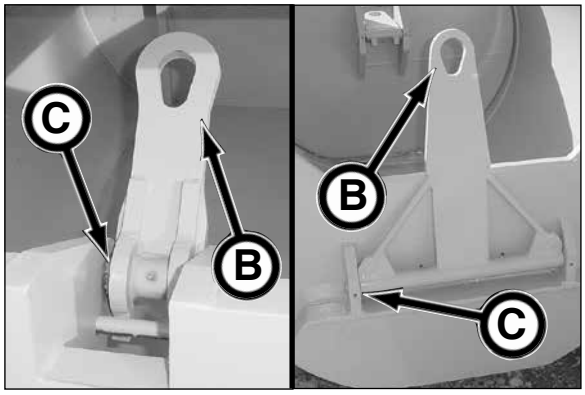
Check hardware for damage. If damaged, replace with new.



Haul Unit Lifting Eyes

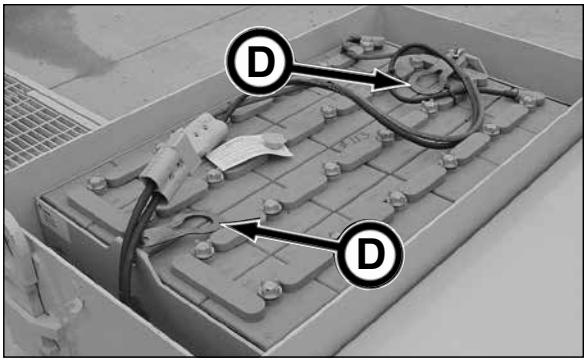
DIRT BUCKET
Inspect dirt bucket lifting eyes (B) for cracks or other damage. Repair or replace before lifting.

Check pins and hardware (C) for damage.
If damaged, replace with new.



Dirt Bucket Lifting Eyes

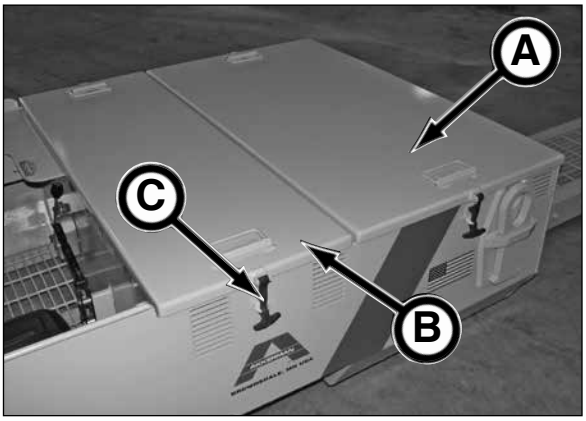
BATTERY PACK
Inspect battery pack lifting eyes (D) for cracks or other damage. Repair or replace before lifting.



7. INSPECT COMPARTMENT COVERS

Clean and inspect battery compartment cover (A) and drive box cover (B) for cracks or other damage. Repair or replace as required.

Check to make sure the rubber cover fasteners (C) will securely hold cover to haul unit. If not, replace as required.

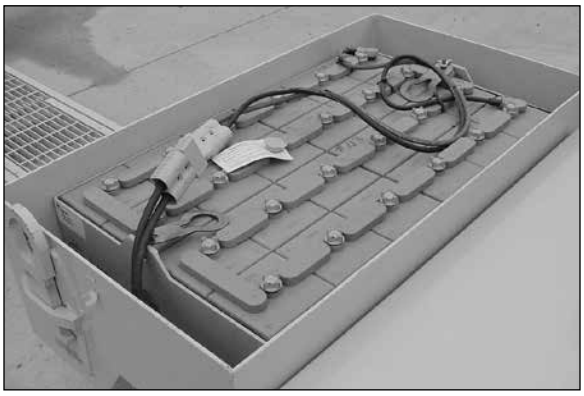


8. CLEAN & INSPECT BATTERY

Keep top of batteries clean.

Inspect battery for damage or leakage. Replace as needed.

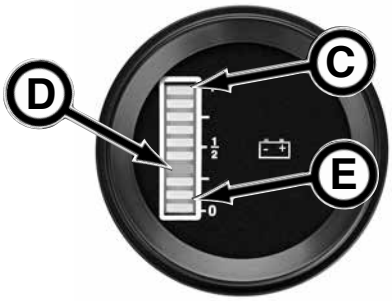
Check battery cables and clamps for damage. If damaged, replace with new.



9. CHECK BATTERY CHARGE

Periodically check the battery charge level.

With the Main Power Lockout Switch AND the Drive Motor Control Switch ON, the battery gauge displays the battery charge level.
The top LED (C) is lit only when the battery is fully charged. As the battery charge decreases, successive LEDs illuminate one at a time.
Once the charge level decreases to a 30% reserve charge, the LED (D) will flash indicating the batteries will need soon require a recharge.
The bottom two LEDs (E) will flash indicating that the haul unit batteries are low and should be recharged.



10. CHECK SEAT MOUNTING

Before each use, check seat mounting. Tighten loose hardware.

If cracks or rust occur, replace seat and mounting hardware immediately.

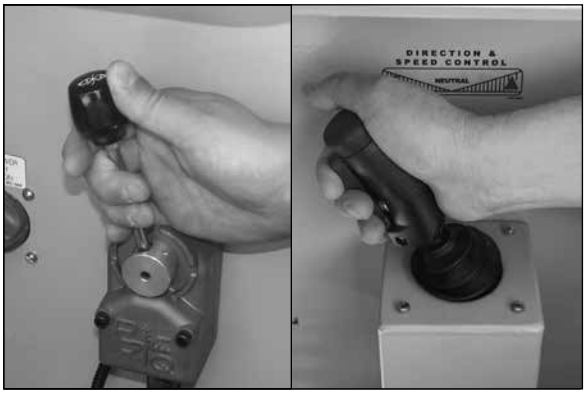
11. INSPECT CONTROLLER

Clean and inspect the controller for damage as follows:

1. Activate the control by flipping the Drive Motor Control Switch UP to the ON position.

2. Remove personnel from test area to prevent injury.

3. Test the controller functions for proper operation. If the controller fails to operate properly, the controller MUST be repaired before operating the haul unit in the pipeline.



SN F21700F-28 & Before *SN F21700F-29 & After*

12. CHECK MAIN POWER LOCKOUT SWITCH FUNCTION

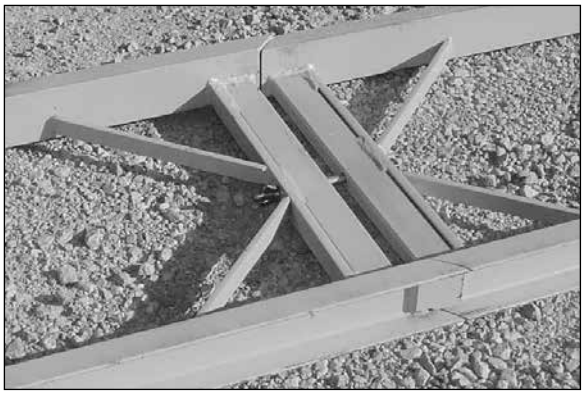
Check the Main Power Lockout Switch function. When the switch is in the OFF position, no powered functions should be able to operate. If the functions are powered with the switch in the OFF position, the switch must be repaired or replaced before operating the haul unit.

SN F21700F-28 & Before *SN F21700F-29 & After*

13. INSPECT TRACK

Check to be sure each track section is securely fastened.

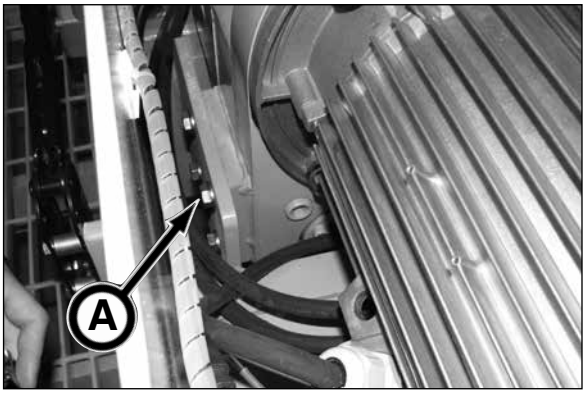
Inspect track for cracks or other damage. Repair or replace as required.



WEEKLY OR EVERY 50 HOURS OF OPERATION

14. CHECK GEAR BOX MOUNTING HARDWARE TORQUE

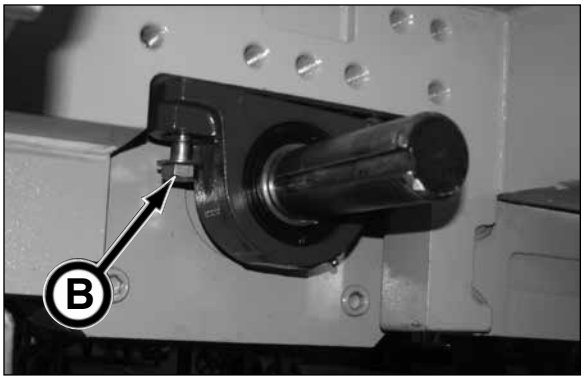
Check four 1/2 in. mounting bolts (A) on gear box for tightness. Tighten to 90 ft-lb. (120 N·m) torque.



NOTICE Hub and wheel are removed for photographic purposes only.

Check four 5/8 in. mounting bolts (B) on pillow blocks for tightness. Tighten to 175 ft.lb. (240 N·m) torque.

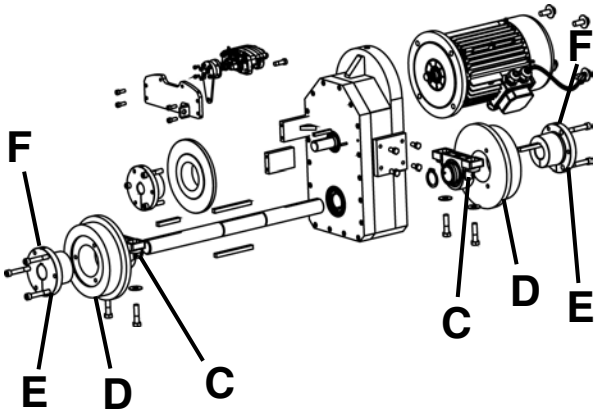
If bolts are damaged or do not hold torque, replace with new bolts and flat washers.



15. CHECK GEAR BOX WHEEL & BEARINGS

1. Check bearings (C), wheels (D), hubs (E) and set screws (F) for damage. If damaged, replace with new.

2. Check to be sure the drive wheels are in line with the idler wheels. If not, refer to section 6, Operation, Adjusting Haul Unit Track Gage.



16. LUBRICATE AXLE PILLOW BLOCK BEARINGS

Lubricate the bearings (D) (2 places) with 2 shots of Mobilgrease® XHP222 or equivalent.

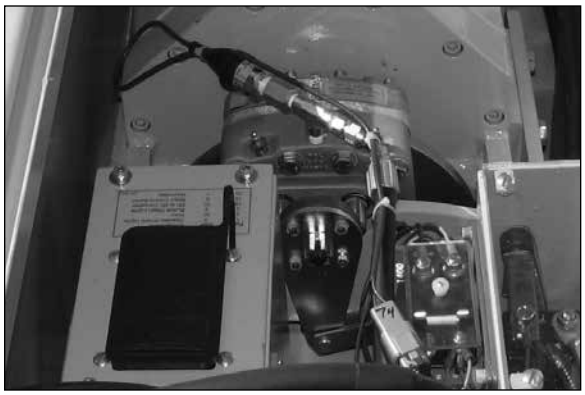
Lubricate daily if bearings are subjected to water and mud.

17. INSPECT BRAKE

⚠WARNING To prevent accidental contact with electrical components while performing brake maintenance, turn the main power switch to the OFF position.

⚠WARNING Spraying cleaners on brake caliper may cause rubber seals to swell, shrink or dissolve resulting in serious personal injury or death from brake malfunction. Do not use spray cleaners on caliper assembly.

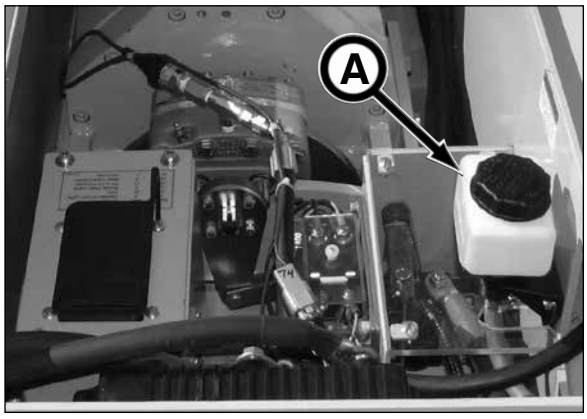
Inspect brake for any of the following conditions:



- build up on brake rotor
- leaking brake fluid
- build up of foreign matter in brake area
- spongy brake
- brake linkage binding
- damaged brake line
- any other unusual conditions

If any of these conditions occur, have your brake repaired IMMEDIATELY by a qualified brake technician.

⚠WARNING If any of these conditions exist, do not operate haul unit until the brake has been repaired, including bleeding of the brake (refer to bleeding brake procedure below). Failure to do so could cause severe injury or death.

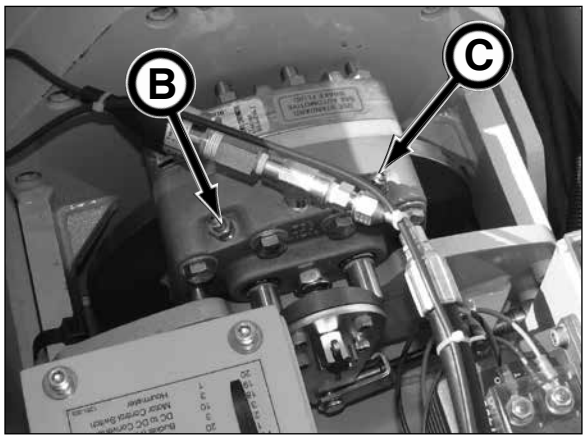


Bleeding the Hydraulic Brake

Bleed the hydraulic brake if the brakes are spongy, the brake system was opened such as replacing a damaged line or hose, or any other unusual conditions.

1. Make sure the master cylinder reservoir (A) is filled with DOT 3 brake fluid.

NOTICE The master cylinder reservoir may require refilling during the bleeding procedure.

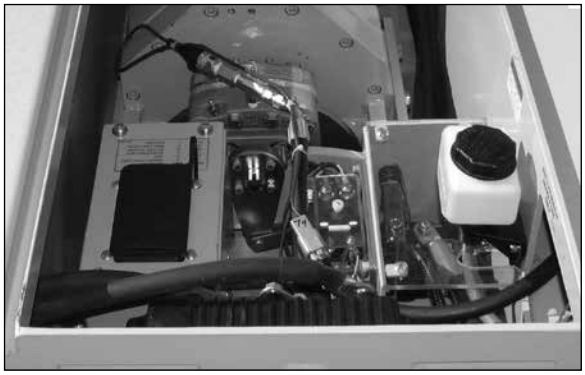


2. Attach one end of a transparent hose to a bleed screw (B) on one of the calipers. Route the other end of hose into the master cylinder reservoir.
3. Pump brake pedal until there is a resistance.
4. Apply pressure on brake pedal and loosen bleed screw with hose attached.
5. When brake pedal is fully depressed, tighten bleed screw.
6. Release brake pedal.
7. Repeat steps 3 through 6 until transparent hose is free of air bubbles.
8. Remove transparent hose.
9. Recheck master cylinder reservoir fluid level. Use only DOT 3 fluid.
10. Attach transparent hose to other bleed screw (C) and repeat steps 3 through 9.

18. INSPECT ALL HOSES & CABLES

Inspect all hoses or cables for wear or damage. Do not operate the haul unit until the worn or damaged hoses or cables are replaced.

If a hose or cable show signs of fraying, they must be replaced.



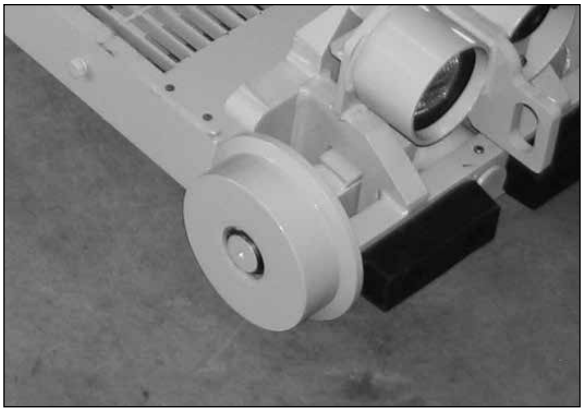
19. LUBRICATE IDLER AXLE PIVOT PIN

Lubricate the pivot pin with Mobilgrease® XHP222 or equivalent until grease is forced out.

Lubricate more often in wet or muddy conditions.

20. INSPECT IDLER ASSEMBLY WHEELS & BEARINGS

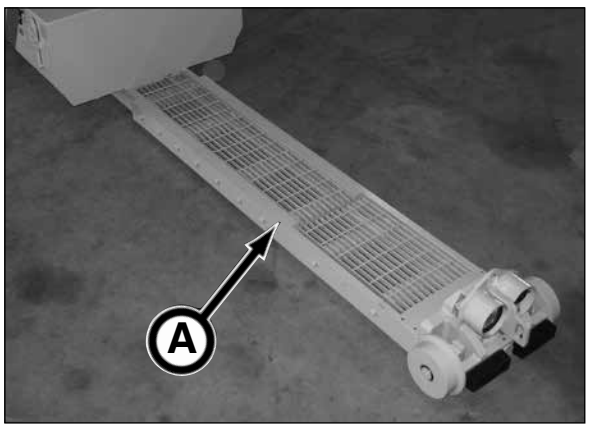
Inspect idler wheels and bearings for damage. If damaged, replace with new.

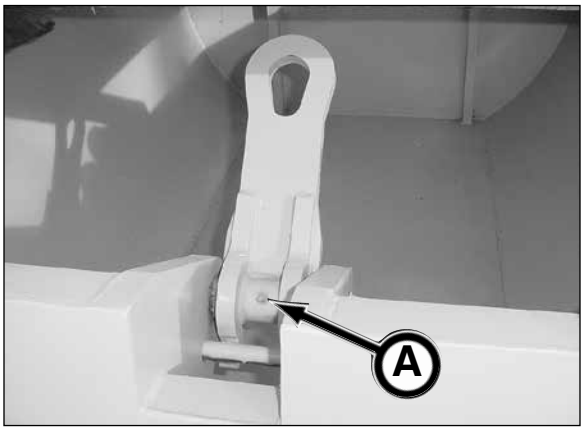


21. INSPECT HAUL UNIT FRAME RAILS

Inspect frame rails (A) for cracks.

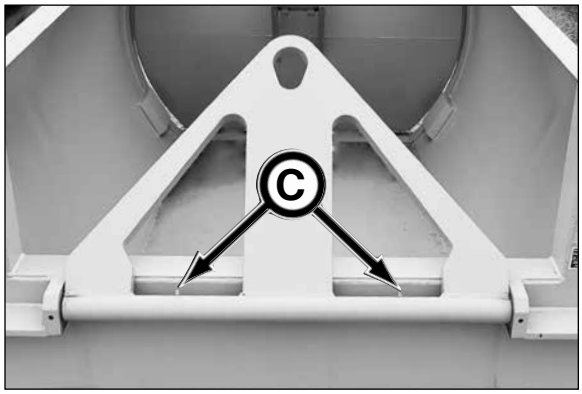
Contact your Akkerman Aftermarket Support representative if cracks are present.





22. LUBRICATE DIRT BUCKET LIFTING EYE & LIFTING EYE BAR HINGE

Lubricate lifting eyes (A) with Mobilgrease® XHP222 or equivalent until grease is forced out.

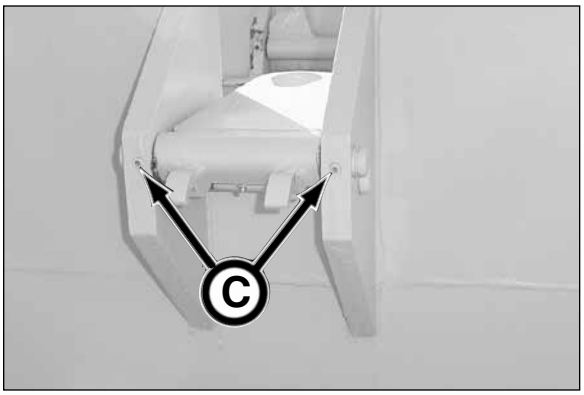


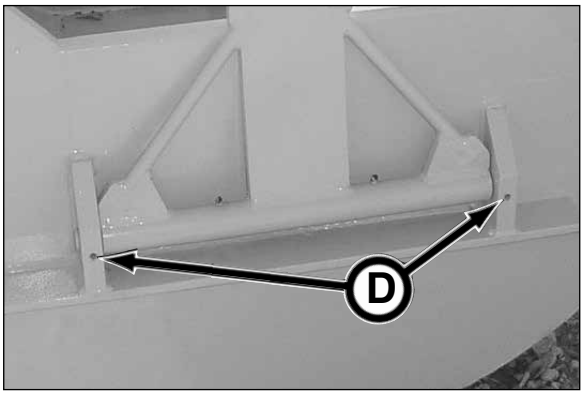
Lubricate lifting eye bar hinge (B) with Mobilgrease® XHP222 or equivalent until grease is forced out.

23. CHECK DIRT BUCKET LIFTING EYE & LIFT BAR HINGE PIN SET SCREWS

Tighten set screws (C) on lifting eye and set screws (D) on lift bar hinge pin if loose.

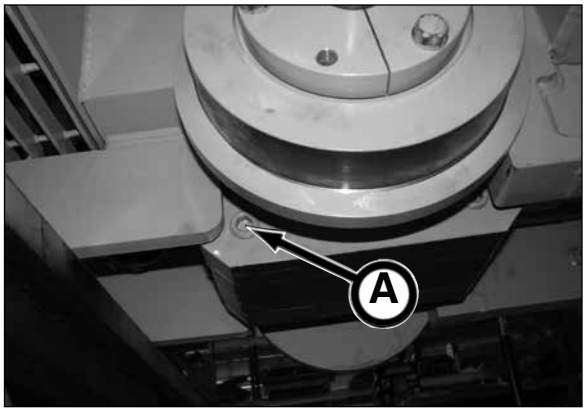
If set screws are damaged or will not hold, replace with new.





MONTHLY OR EVERY 250 HOURS OF OPERATION

24. DRAIN & FILL GEAR BOX



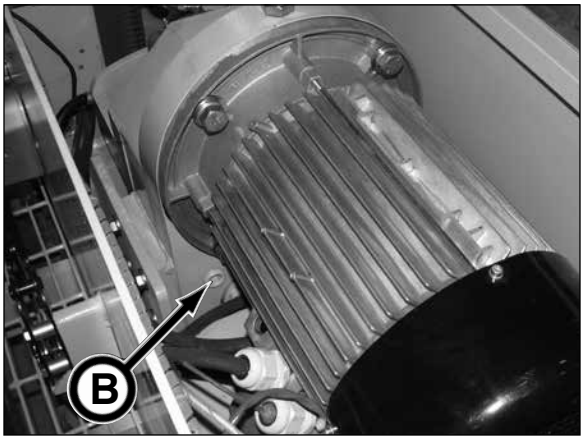
1. With haul unit on level ground, clean area around fill and drain plugs.

2. Remove drain plug (A) and empty fluid into a proper sized catch pan. Dispose of fluid properly.

3. Inspect drain plug and drained fluid for metal particles. If particles are present, contact your Akkerman Aftermarket Support representative for gear box maintenance procedures.

4. Clean drain plug.

5. Replace drain plug. If fluid leakage was present before draining gear box, or if leakage exists after filling gear box, replace with new drain plug.



6. Remove check/fill plug (B) and add Mobil SHC 626 Synthetic Bearing and Gear Oil or equivalent. Gear box capacity is 5 quarts (4.7 L).

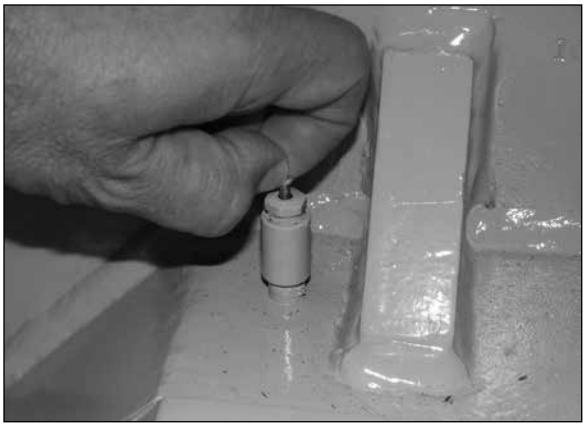
NOTICE The Mobil SHC 626 Synthetic Bearing and Gear oil is a synthetic oil specifically designed for this application. If you change to a different oil, use a reputable oil supplier to meet or exceed the Mobil SHC 626 oil specifications. Do not mix oil manufacturers or grades.

The fluid should be level with check/fill plug hole.

7. Place a small amount of pipe sealant on plug threads.

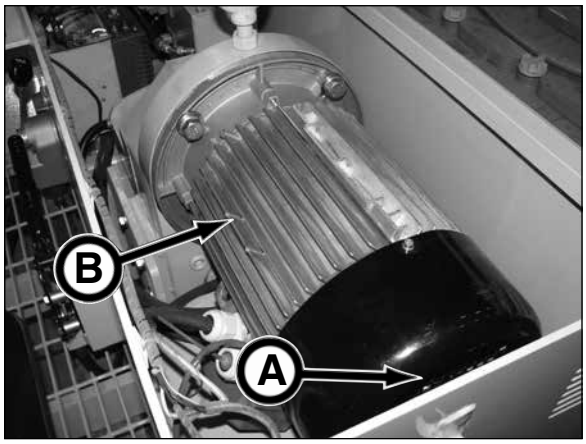
8. Replace check and fill plugs.

25. INSPECT GEAR BOX PRESSURE RELIEF



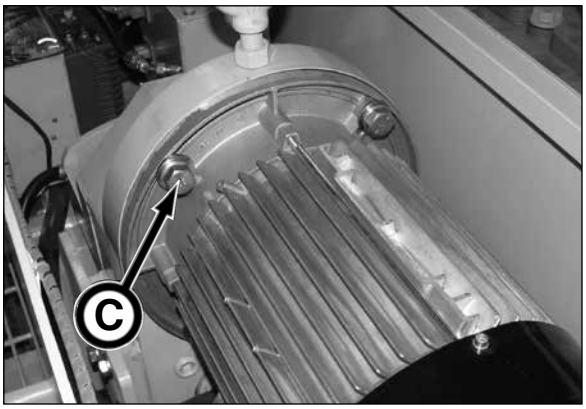
Inspect pressure relief fitting on the gear box to make sure the relief plug can open. If relief vent plug is stuck, or does not pop back into fitting, replace with new.

A malfunctioning pressure relief fitting could result in gear box seal failure.



26. INSPECT & CLEAN MOTOR VENT & VANES

Inspect and clean the motor vents (A) and vanes (B).



27. CHECK ELECTRIC MOTOR MOUNTINGS

Check four 1/2” motor mounting bolts (C) for tightness. Tighten to 90 ft-lb. (120 N·m) torque.

If bolts are damaged or do not hold torque, replace with new bolts, lock washers and flat washers.

28. PERFORM BATTERY MAINTENANCE

⚠WARNING Batteries produce explosive gases. Wear eye protection and protective clothing during battery service. Keep sparks, flames, and cigarettes away from batteries. Charge batteries only in a well ventilated area.

If acid enters eye, IMMEDIATELY flush eye with running cold water for at least 15 minutes and get medical attention.

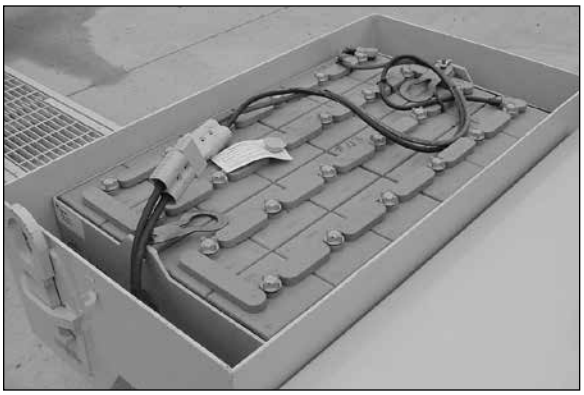
If battery acid contacts skin or clothing, wash immediately with soap and water.

If battery acid is inhaled, move to fresh air immediately. If breathing is difficult, administer oxygen.

If battery acid is ingested, give large quantities of water. DO NOT induce vomiting. Get medical attention immediately.

NOTICE For more information on battery maintenance, contact the battery manufacturer.

1. Clean cable connections with a wire brush. Coat the terminals with petroleum jelly to prevent corrosion. Never paint the terminal posts.



2. Check electrolyte level. Fill each cell with clean, distilled water to the bottom of the filler neck.

3. Check terminals and connections. Clean or replace if damaged. Maintenance on the battery must be performed only by a qualified battery technician.

4. Check cables for worn or frayed insulation. Replace cable or bolts if worn or corroded. Battery cable maintenance must be performed only by a qualified battery technician.

5. Inspect the batteries for dirt or corrosion. Clean corrosion with baking soda (1/4 pound of baking soda added to a quart of water).

6. Inspect battery pack frame for cracks or damage. If damaged, repair or replace.

7. If necessary, charge the batteries. See Recharging the Battery Pack in the Operation section of this manual.

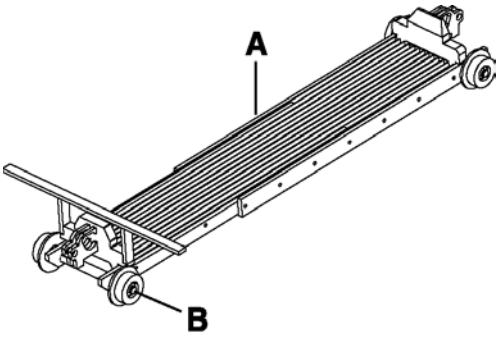
29. INSPECT DIRT BUCKET DOOR HARDWARE

Inspect door pivot hardware for damage. If damaged, repair or replace. Do not use until damaged hardware is repaired or replaced.

30. CHECK HAUL CART

Check the haul cart frame (A) for cracks or damage. If damaged, repair or replace.

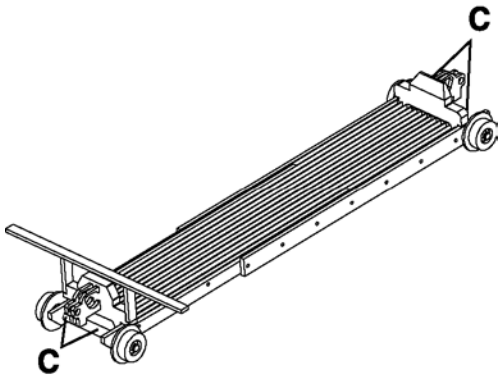
Check the wheel bearings (B) and hardware for damage. If damaged replace with new.



31. LUBRICATE HAUL CART WHEEL BEARINGS

Lubricate the bearings (C) (four places) with Mobilgrease® XHP222 or equivalent until grease is forced out.

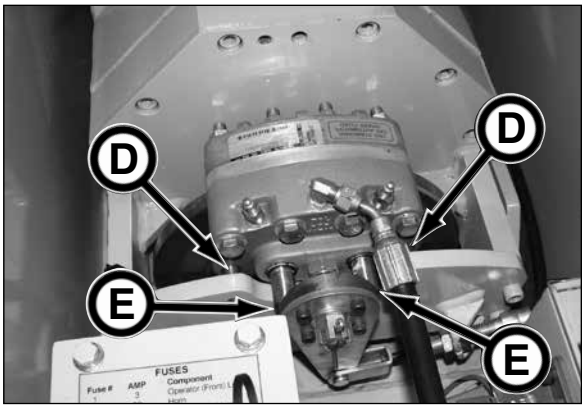
Lubricate more often in wet or muddy conditions.



32. LUBRICATE BRAKE CALIPER PINS

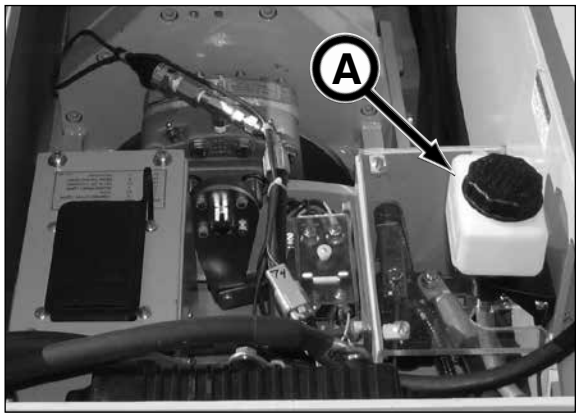
⚠WARNING DO NOT ALLOW ANY LUBRICANT TO CONTACT DISC BRAKE. DOING SO MAY CAUSE SERIOUS INJURY OR DEATH.

Apply a **light** coat of anti-sieze lubricant on the two brake caliper pins (D) and the ends of the two parking brake pins (E). DO NOT ALLOW ANY LUBRICANT TO CONTACT DISC BRAKE!



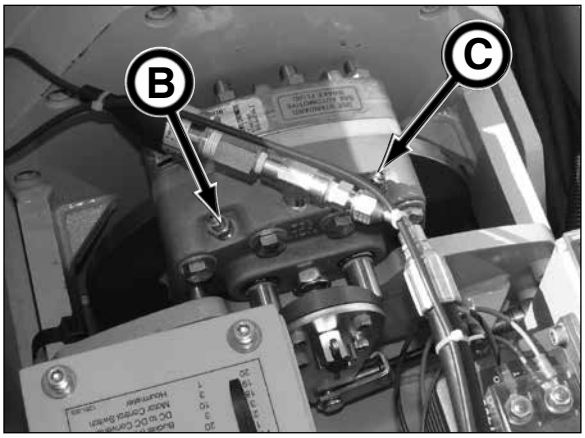
ANNUALLY OR EVERY 2000 HOURS OF OPERATION

33. DRAIN & FILL MASTER CYLINDER RESERVOIR



1. Remove drive box cover to gain access to the master cylinder reservoir (A).
2. Drain reservoir.
3. Fill reservoir with new, clean DOT 3 brake fluid to the MAX marking on the reservoir.
4. Bleed the brake system as instructed in steps 5 through 14.
5. Make sure the master cylinder reservoir is filled with DOT 3 brake fluid.

NOTICE The master cylinder reservoir may require refilling during the bleeding procedure.



6. Attach one end of a transparent hose to a bleed screw (B) on one of the calipers. Route the other end of hose into the master cylinder reservoir.
7. Pump brake pedal until there is a resistance.
8. Apply pressure on brake pedal and loosen bleed screw with hose attached.
9. When brake pedal is fully depressed, tighten bleed screw.
10. Release brake pedal.
11. Repeat steps 7 through 10 until transparent hose is free of air bubbles.
12. Remove transparent hose.
13. Recheck master cylinder reservoir fluid level. Use only DOT 3 fluid.
14. Attach transparent hose to other bleed screw (C) and repeat steps 7 through 13.

NOTES

Storage

PREPARING FOR STORAGE

1. Repair worn or damaged parts.

2. Wash all equipment thoroughly.

3. Grease haul unit and dirt bucket thoroughly. Grease threads on bolts used for adjustments.

4. Drain gear box. Add Mobil SHC 626 or equivalent until oil runs out of check/fill hole.

5. Remove battery pack and store in a cool, dry, well ventilated, place. Clean corrosion from cables and battery case. Charge battery packs.

6. Repaint equipment where necessary.

7. If possible, store machine under cover and out of the weather in a ventilated area.

REMOVING FROM STORAGE

1. Clean equipment thoroughly.

2. Check to make sure all decals including safety decals are clean and readable.

3. Check condition of wires and cables. Repair or replace as necessary.

4. Check gear box fluid level. Add oil as needed. See Gear Box Lubricant in Lubricants section.

5. Check for leaks. Repair or replace as necessary.

6. Charge battery packs. See Recharging the Battery Pack in the Operation section.

7. Review this Operator's Manual.

NOTES

Troubleshooting

Problem	Cause	Solution
Haul Unit does not move.	Hand brake applied.	Release brake.
	Main Power Lockout Switch is off.	Turn switch on.
	Drive Motor Control Switch is off.	Turn Drive Motor Control Switch on.
	Drive Motor Mode Selector switch to Inching Control.	Flip switch to Direction/Speed Control.
	Loose battery connections.	Secure battery harness to contactor harness.
	Loose wires.	Repair or replace.
	Dead battery.	Recharge battery or replace with spare battery pack.
	Motor control or motor overheating.	Cool down motor control or electric motor.
	Main fuse blown.	Replace fuse.
	Defective power switch.	Replace switch.
	If Haul Unit still does not move, contact your Akkerman Aftermarket Support Representative.	
Battery will not charge.	Blown charger fuse.	Replace fuse.
	Dead battery.	Check/replace battery.
	Battery charger malfunction.	Check/replace charger.
Brake does not apply.	Low brake fluid.	Add brake fluid.
	Worn or broken linkage.	Replace linkage.
	Defective master cylinder.	Replace master cylinder.
	Defective caliper.	Replace caliper.
	Defective brake pads.	Replace brake pads.
Reduction of performance.	Overheating of motor control or electric motor.	Cool down motor control or electric motor.
	Parking brake engaged, dragging or damaged.	Disengage parking brake or repair brake.
	Battery low/over voltage.	Check/replace battery.

DRIVE MOTOR CONTROLLER LED STATUS DISPLAY SN F21700F-28 & BEFORE

NOTICE The instruction refers to the Drive Motor Controller with the pair of LED status lights, model 1236SE.

The Drive Motor Controller (A) detects a wide variety of operating modes, faults or error conditions and is displayed on the two LED status lights (B).

The two LEDs have four different display modes indicating the type of information status (refer to LED Status Display Modes chart).

The pair of LED status lights built into the controller (one red, one yellow) produce flash codes displaying all the currently set faults in a repeating cycle. Each code consists of two digits. The red flashes once to indicate that the first digit of the code will follow; the yellow LED then flashes the appropriate number of times for the first digit. The red LED flashes twice to indicate that the second digit of the code will follow; the yellow LED flashes the appropriate number of times for the second digit.

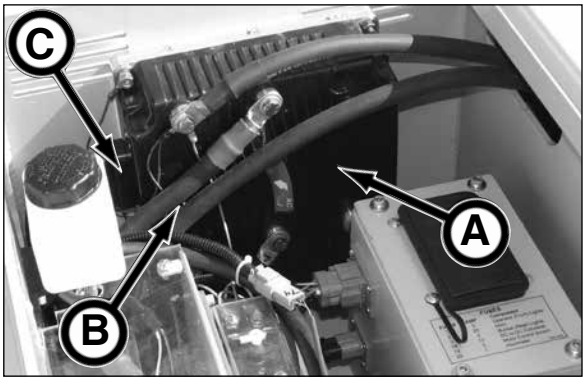
For example, Code 23 Battery Undervoltage:
The controller's two LEDs will display this repeating pattern:

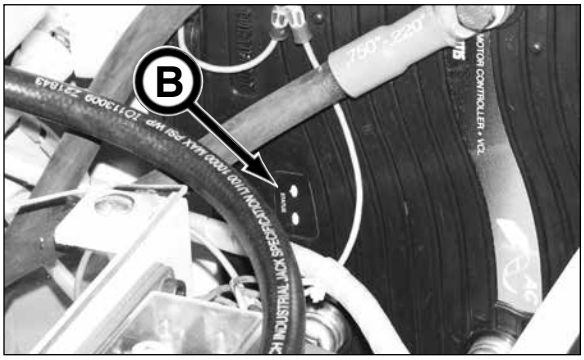
RED	YELLOW	RED	YELLOW
*	* *	* *	* * *
(first digit)	(2)	(second digit)	(3)

Whenever a fault is encountered and no wiring or haul unit issue can be found, shut off the Drive Motor Control Switch and the Main Power Lockout Switch. Then turn the Main Power Lockout Switch and Drive Motor Control Switch back on to see if the fault clears. If the fault does not clear, shut off Drive Motor Control Switch and Main Power Lockout Switch, then remove the 35 pin connector (C). Check the connector for corrosion or damage, clean connector if necessary and reinstall. If the fault still does not clear, contact your Akkerman Aftermarket Support representative to identify the fault code and assist in troubleshooting your controller.

Refer to the Fault Codes for Drive Motor Controller Model 1236SE on the next eight pages.

A handheld diagnostic tool with a gray or blue band (D) is available (Akkerman part no. P0304-324A) as a user-friendly method to troubleshoot the fault codes, particularly if there are multiple faults. The diagnostic tool is connected to the 4 pin molex plug behind the dash panel of the haul unit. Though most of the faults are cleared by cycling the main power off and on, a few faults can only be cleared with the use of the diagnostic tool.





Close Up of LED Status Lights

LED Status Display Modes

Display	Status
Neither LED Illuminated	Controller is not powered or haul unit battery is dead.
Yellow LED Flashing	Normal Operation
Red LED on Solid	General software failure. Turn off Drive Motor Control Switch & Main Power Lockout Switch, and then turn both switches on. If failure is still present, contact Akkerman Aftermarket Support representative.
Red LED and Yellow LED Flashing Alternately	Controller has detected a fault. 2-digit code flashed by yellow LED identifies the specific fault; one or two flashes by red LED indicate whether first or second code digit will follow by yellow LED.

FAULT CODES FOR DRIVE MOTOR CONTROLLER SN F21700F-28 & BEFORE

NOTICE The controller fault codes are subject to change. For latest fault codes refer to:
https://faultcodes.curtisinstruments.com/list.php?mc=1236SE&action=Submit

Code	Fault	Cause
12	Controller Overcurrent . Action: Shutdown Motor; Shutdown Main Contactor; Shutdown EMBrake; Shutdown Throttle; Full Brake.	1. External short of phase U,V, or W motor connections. 2. Motor parameters are mis-tuned. 3. Controller defective. 4. Speed encoder noise problems.
13	Current Sensor . Action: Shutdown Motor; Shutdown Main Contactor; Shutdown EMBrake; Shutdown Throttle; Full Brake.	1. Leakage to vehicle frame from phase U, V, or W (short in motor stator). 2. Controller defective.
14	Precharge Faulted . Action: Shutdown Motor; Shutdown Main Contactor; Shutdown EMBrake; Shutdown Throttle; Full/Brake.	1. See Monitor menu -> Battery: Capacitor Voltage. 2. External load on capacitor bank (B+ connection terminal) that prevents the capacitor bank from charging.
15	Controller Severe Undertemp . Action: Shutdown Motor; Shutdown Main Contactor; Shutdown EMBrake; Shutdown Throttle; Full Brake.	1. See Monitor menu -> Controller: Temperature. 2. Controller is operating in an extreme environment.
16	Controller Severe Overtemp . Action: Shutdown Motor; Shutdown Main Contactor; Shutdown EMBrake; Shutdown Throttle; Full Brake.	1. See Monitor menu -> Controller: Temperature. 2. Controller is operating in an extreme environment. 3. Excessive load on vehicle. 4. Improper mounting of Controller.
17	Severe B+ Undervoltage . Action: No drive torque.	1. Battery parameters are misadjusted. 2. Non-Controller system drain on battery. 3. Battery resistance too high. 4. Battery disconnected while driving. 5. See Monitor menu -> Battery: Capacitor Voltage. 6. Blown B+ fuse or main Contactor did not close.
17	Severe KSI Undervoltage . Action: No action.	1. See Monitor menu -> Battery: Key switch Voltage. 2. Non-Controller system drain on battery/ KSI circuit wiring. 3. KSI disconnected while driving. 4. Blown KSI fuse.
18	Severe B+ Over Voltage . Action: Shutdown Motor; Shutdown Main Contactor; Shutdown EMBrake; Shutdown Throttle; Full Brake.	1. See Monitor menu -> Battery: Capacitor Voltage. 2. Battery parameters are misadjusted. 3. Battery resistance too high for given regen current. 4. Battery disconnected while regen braking.

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22	Controller Overtemp Cutback . Action: Reduced drive and brake torque.	1. See Monitor menu -> Controller: Temperature. 2. Controller is performance-limited at this temperature. 3. Controller is operating in an extreme environment. 4. Excessive load on vehicle. 5. Improper mounting of Controller.
23	B+ Undervoltage Cutback . Action: Reduced drive torque.	1. Normal operation. Fault indicates the batteries need recharging. Controller is performance limited at this voltage. 2. Battery parameters are misadjusted. 3. Non-Controller system drain on battery. 4. Battery resistance too high. 5. Battery disconnected while driving. 6. See Monitor menu -> Battery: Capacitor Voltage. 7. Blown B+ fuse or main Contactor did not close.
24	B+ Overvoltage Cutback . Action: Reduced brake torque. Note: This is declared only when the Controller is running in regen.	1. Normal operation. Fault shows that regen braking currents elevated the battery voltage during regen braking. Controller is performance limited at this voltage. 2. Battery parameters are misadjusted. 3. Battery resistance too high for given regen current. 4. Battery disconnected while regen braking. 5. See Monitor menu -> Battery: Capacitor Voltage.
25	+5V Supply . Action None, unless a action is programmed in VCL.	1. External load impedance on the +5V supply (pin 26) is too low. 2. See Monitor menu -> outputs: 5 Volts and Ext Supply Current.
26	Digital Out 6 Open/Short . Action: Digital Output 6 driver will not turn on.	1. External load impedance on Digital Output 6 driver (pin 9) is too low.
27	Digital Out 7 Open/Short . Action: Digital Output 7 driver will not turn on.	1. External load impedance on Digital Output 7 driver (pin 20) is too low.
28	Motor Temp Hot Cutback . Action: Reduced drive torque.	1. Motor temperature is at or above the programmed Temperature Hot setting, and the current is being cut back. 2. Motor Temperature Contactor Menu parameters are mis-tuned. 3. See Monitor menu -> Motor: Temperature and -> Inputs: Analog 2. 4. If the application doesn't use a motor thermistor, Temp Compensation and Temp Cutback should be programmed Off.

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29	Motor Temp Sensor . Action: MaxSpeed reduced (LOS, Limited Operating Strategy), and motor temperature cutback disabled.	1. Motor thermistor is not connected properly. 2. If the application doesn't use a motor thermistor, Motor Temp Sensor Enable should be programmed Off. 3. See Monitor menu -> Motor: Temperature and -> Inputs: Analog 2.
31	Coil1 Driver Open/Short . Action:ShutdownDriver1.	1. Open or short on driver load. 2. Dirty connector pins. 3. Bad crimps or Faulty wiring.
31	Main Open/Short . Action: Shutdown Motor; Shutdown Main Contactor; Shutdown EMBrake; Shutdown Throttle; Full Brake.	1. Open or short on driver load. 2. Dirty connector pins. 3. Bad crimps or Faulty wiring.
32	Coil2 Driver Open/Short . Action:ShutdownDriver2.	1. Open or short on driver load. 2. Dirty connector pins. 3. Bad crimps or Faulty wiring.
32	EMBrake Open/Short . Action: Shutdown EMBrake; Shutdown Throttle; Full Brake.	1. Open or short on driver load. 2. Dirty connector pins. 3. Bad crimps or Faulty wiring.
33	Coil3 Driver Open/Short . Action:ShutdownDriver3.	1. Open or short on driver load. 2. Dirty connector pins. 3. Bad crimps or Faulty wiring.
34	Coil4 Driver Open/Short . Action:ShutdownDriver4.	1. Open or short on driver load. 2. Dirty connector pins. 3. Bad crimps or Faulty wiring.
35	Proportional Driver Open/Short . Action: ShutdownProportional Driver.	1. Open or short on driver load. 2. Dirty connector pins. 3. Bad crimps or Faulty wiring.
36	Encoder . Action: Shutdown EMBrake; Motor disabled.	1. Motor encoder failure. 2. Bad crimps or Faulty wiring. 3. See Monitor menu -> Motor: Motor RPM.
36	Sin/Cos Sensor . Action: Shutdown EMBrake; Motor disabled.	1. Sin/Cos sensor failure. 2. Bad crimps or Faulty wiring. 3. See Monitor menu -> Motor: Motor RPM.
37	Motor Open . Action: Shutdown Motor; Shutdown Main Contactor; Shutdown EMBrake; Shutdown Throttle; Ful/Brake.	1. Motor phase is open. 2. Bad crimps or Faulty wiring.

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38	Main Contactor Welded . Action: Shutdown Motor; Shutdown Main Contactor; Shutdown EMBrake; Shutdown Throttle; Full Brake.	1. Main Contactor tips are welded closed. 2. Motor phase U or V is disconnected or open. 3. An alternate voltage path (such as an external Precharge resistor) is providing a current to the capacitor bank (B+ connection terminal).
39	Main Contactor Did Not Close . Action: Shutdown Motor; Shutdown Main Contactor; Shutdown EMBrake; Shutdown Throttle; Full Brake.	1. Main Contactor did not close. 2. Main Contactor tips are oxidized, burned, or not making good Contactor.*. 3. External load on capacitor bank (B+ connection terminal) that prevents capacitor bank from charging. 4. Blown B+ fuse.
41	Throttle Wiper High . Action: Shutdown Throttle.	1. See Monitor menu -> Inputs: Throttle Pot. 2. Throttle pot wiper voltage too high.
42	Throttle Wiper Low . Action: Shutdown Throttle.	1. See Monitor menu -> Inputs: Throttle Pot. 2. Throttle pot wiper voltage too low.
43	Pot2 Wiper High . Action: Full/Brake.	1. See Monitor menu -> Inputs: Pot2 Raw. 2. Pot2 wiper voltage too high.
44	Pot2 Wiper Low . Action: Full/Brake.	1. See Monitor menu -> Inputs: Pot2 Raw. 2. Pot2 wiper voltage too low.
45	Pot Low Overcurrent . Action: Shutdown Throttle; Full Brake.	1. See Monitor menu -> Outputs: Pot Low. 2. Combined pot resistance connected to pot low is too low.
46	EEPROM . Action: Shutdown Motor; Shutdown Main Contactor; Shutdown EMBrake; Shutdown Throttle; Shutdown Interlock; ShutdownDriver1; ShutdownDriver2; ShutdownDriver3; ShutdownDriver4; ShutdownProportional Driver; Full Brake.	1. Failure to write to EEPROM memory. This can be caused by EEPROM memory writes initiated by VCL, by the CAN bus, by adjusting parameters with the programmer, or by loading new software into the Controller.
47	High Pedal Disable/Sequencing . Action: Shutdown Throttle.	1. KSI, interlock, direction, and throttle inputs applied in incorrect sequence. 2. Faulty wiring, crimps , or switches at KSI, interlock, direction, or throttle inputs. 3. See Monitor menu -> Inputs.
47	EMER Rev High Pedal Disable . Action: Shutdown Throttle; Shutdown EMBrake	. 4. Emergency Reverse operation has concluded, but the throttle, forward and reverse inputs, and interlock have not been returned to neutral.

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49	Parameter Change . Action: Shutdown Motor; Shutdown Main Contactor; Shutdown EMBrake; Shutdown Throttle; Full Brake.	1. This is a safety Fault caused by a change in certain parameter settings so that the vehicle will not operate until KSI is cycled. For example, if a user changes the Throttle Type this Fault will appear and require cycling KSI before the vehicle can operate.
51	OEM Faults(See OEM documentation.)	1. These Faults can be defined by the Vehicle Manufacturer and are implemented in the application-specific VCL code. See Vehicle Manufacturer documentation.
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61	OEM Faults(See OEM documentation.)	1. These Faults can be defined by the Vehicle Manufacturer and are implemented in the application-specific VCL code. See Vehicle Manufacturer documentation.
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67	OEM Faults(See OEM documentation.)	1. These Faults can be defined by the Vehicle Manufacturer and are implemented in the application-specific VCL code. See Vehicle Manufacturer documentation.
68	VCL Run Time Error . Action: Shutdown Motor; Shutdown Main Contactor; Shutdown EMBrake; Shutdown Throttle; ; ShutdownDriver1; ShutdownDriver2; ShutdownDriver3; ShutdownDriver4; ShutdownProportional Driver; Full Brake.	1. VCL code encountered a runtime VCL error. 2. See Monitor menu -> Controller: VCL Error Module and VCL Error. This error can then be compared to the runtime VCL module ID and error code definitions found in the specific OS system information file.
69	External Supply Out of Range . Action: None, unless a action is programmed in VCL.	1. External load on the 5V and 12V supplies draws either too much or too little current. 2. Fault Checking Menu parameters Ext Supply Max and Ext Supply Min are mis- tuned. 3. See Monitor menu -> Outputs: Ext Supply Current.
71	OS General . Action: Shutdown Motor; Shutdown Main Contactor; Shutdown EMBrake; Shutdown Throttle; ; ShutdownDriver1; ShutdownDriver2; ShutdownDriver3; ShutdownDriver4; ShutdownProportional Driver; Full Brake.	1. Internal Controller Fault.

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72	Proportional DriverO Timeout . Action: Shutdown Throttle; CAN NMT State set to Pre-operational.	1. Time between CAN PDO CAN message transmission rates received exceeded the PDO Timeout Period.
73	Stall Detected . Action: Shutdown EMBrake; Motor disabled; Controller Mode changed to LOS (Limited Operating Strategy).	1. Stalled motor. 2. Motor encoder failure. 3. Bad crimps or Faulty wiring. 4. Problems with power supply for the motor encoder. 5. See Monitor menu -> Motor: Motor RPM.
74	On Other Tractiontion Controller	1. Dual Drive Fault: see Dual Drive manual.
75	Dual Severe	1. Dual Drive Fault: see Dual Drive manual.
77	Supervisor . Action: Shutdown Motor; Shutdown Main Contactor; Shutdown EMBrake; Shutdown Throttle; Shutdown Interlock; ShutdownDriver1; ShutdownDriver2; ShutdownDriver3; ShutdownDriver4; ShutdownProportional Driver; Full/Brake.	1. The Supervisor has detected a mismatch in redundant readings. 2. Internal damage to Supervisor microprocessor. 3. Switch inputs allowed to be within upper and lower thresholds for over 100 milliseconds. (for recurring errors, check the switches for moisture).
78	Supervisor Incompatible . Action: Shutdown Motor; Shutdown Main Contactor; Shutdown EMBrake; Shutdown Throttle; ; ShutdownDriver1; ShutdownDriver2; ShutdownDriver3; ShutdownDriver4; ShutdownProportional Driver; Full/Brake.	1. The main OS is not compatible with the Supervisor OS.
82	Bad Calibrations . Action: Shutdown Motor; Shutdown Main Contactor; Shutdown EMBrake; Shutdown Throttle; Full Brake.	1. Internal Controller Fault
83	Driver Supply . Action: Shutdown Motor; Shutdown Main Contactor; Shutdown EMBrake; Shutdown Throttle; Full Brake.	1. Internal Controller Fault in the voltage supply for the driver circuits.
87	Motor Characterization . Action: Shutdown Motor; Shutdown Main Contactor; Shutdown EMBrake; Shutdown Throttle; Full Brake.	1. Motor characterization failed during characterization process. See Monitor menu -> Controller: Motor Characterization Error for cause = sequencing error. Normally caused by turning off Motor Characterization Test Enable before running the test. 1 = encoder signal seen but step size not auto-detected; set up Encoder Steps manually". 2 = motor temp sensor Fault. 3 = motor temp hot cutback Fault. 4 = Controller overtemp cutback Fault"". 5 = Controller undertemp cutback Fault. 6 = Under Voltage Cutback Fault. 7 = severe Over Voltage Fault"". 8 = encoder signal not seen, or one or both channels missing. 9 = motor parameters out of

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		characterization range. 20 = Sin/Cos sensor not found. 21 = phasing not detected"". 22 = Sin/Cos sensor characterization failure. 23 = started characterization procedure while motor rotating."
88	Encoder Pulse Count . Action: Shutdown Motor; Shutdown Main Contactor; Shutdown EMBrake; Shutdown Throttle; ; ShutdownDriver1; ShutdownDriver2; ShutdownDriver3; ShutdownDriver4; ShutdownProportional Driver; Full Brake.	1. Encoder Steps parameter does not match the actual motor encoder.
89	Motor Type . Action: Shutdown Motor; Shutdown Main Contactor; Shutdown EMBrake; Shutdown Throttle; Ful/Brake.	. 2. The Motor_Type parameter value is out of range.
91	VCL/OS Mismatch . Action: Shutdown Motor; Shutdown Main Contactor; Shutdown EMBrake; Shutdown Throttle; ; ShutdownDriver1; ShutdownDriver2; ShutdownDriver3; ShutdownDriver4; ShutdownProportional Driver; Full Brake.	1. The VCL software in the Controller does not match the OS software in the Controller.
92	EM Brake Faulted to Set . Action: Shutdown EMBrake; Shutdown Throttle. Position Hold is engaged when Interlock= On.	1. Vehicle movement sensed after the EM Brake has been commanded to set. 2. EM Brake will not hold the motor from rotating.
93	Encoder LOS (Limited Operating Strategy) . Action: Enter LOS Controller mode.	1. Limited Operating Strategy (LOS) Contactor mode has been activated, as a result of either an Encoder Fault (Code 36) or a Stall Detected Fault (Code 73). 2. Motor encoder failure. 3. Bad crimps or Faulty wiring. 4. Vehicle is stalled.
94	EMER Rev Timeout . Action: Shutdown EMBrake; Shutdown Throttle.	1. Emergency Reverse was activated and concluded because the EMR Timeout timer has expired. 2. The emergency reverse input is stuck On.
98	Illegal Model Number . Action: Shutdown Motor; Shutdown Main Contactor; Shutdown EMBrake; Shutdown Throttle; Full Brake.	1. Model_Number variable Contains illegal value. 2. Software and hardware do not match. 3. Controller defective.
99	Parameter Mismatch . Action: Shutdown Motor; Shutdown Main Contactor; Shutdown EMBrake; Shutdown Throttle; Full Brake.	1. Dual drive enabled on only one Controller. 2. Incorrect Position feedback type chosen for motor technology in use. 3. Dual drive is enabled in torque mode.

NOTES

DRIVE MOTOR CONTROLLER LED STATUS DISPLAY SN F21700F-29 & AFTER

NOTICE These instructions refer to the Drive Motor Controller with the single LED status light, model ACF6A.

The Drive Motor Controller (A) detects a wide variety of operating modes, faults or error conditions and is displayed on the LED status indicator (B).

The LED status indicator displays the type of flash code, fault name, possible causes, conditions and actions when the fault is active (refer to LED fault code chart on the next pages).

The LED status indicator is built into the controller. The LED status indicator flashes a series of red then yellow flashes in a consistent repeating cycle. The number of red flashes indicate the first digit(s) of the flash code; and the number of yellow flashes indicate the second digit(s) of the flash code.

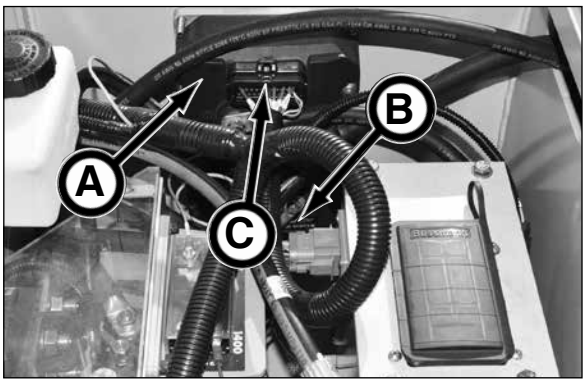
For example, Code 2-3 Undervoltage Cutback: The controller's LED will display this repeating pattern:

RED	YELLOW
* *	* * *
(2) (first digit)	(3) (second digit)

Whenever a fault is encountered and no wiring or haul unit issue can be found, shut off the Drive Motor Control Switch and the Main Power Lockout Switch. Then turn the Main Power Lockout Switch and Drive Motor Control Switch back on to see if the fault clears. If the fault does not clear, shut off Drive Motor Control Switch and Main Power Lockout Switch, then remove the 35 pin connector (C). Check the connector for corrosion or damage, clean connector if necessary and reinstall.
If the fault still does not clear, contact your Akkerman Aftermarket Support representative to identify the fault code and assist in troubleshooting your controller.

Refer to the Fault Codes for Drive Motor Controller Model ACF6A on the next 34 pages.

A handheld diagnostic tool with a blue band (D) is available (Akkerman part no. P0304-324A) as a user-friendly method to troubleshoot the fault codes, particularly if there are multiple faults. The diagnostic tool is connected to the DB9 plug behind the dash panel of the haul unit. Though most of the faults are cleared by cycling the main power off and on, a few faults can only be cleared with the use of the diagnostic tool.



LED Status Display Modes

Display	Status
No LED Illumination	Controller is not powered or haul unit battery is dead.
Yellow LED Flashing	Normal Operation
Yellow LED on Solid	Controller is in flash program mode.
Red and Yellow LED Flashing Pattern	Controller has detected a fault. The number of red flashes followed by the number of yellow flashes indicates the flash code.
Red LED on Solid	Internal hardware failure. Turn off Drive Motor Control Switch & Main Power Lockout Switch, and then turn both switches on. If failure is still present, contact Akkerman Aftermarket Support representative.

A handheld diagnostic tool P0304-324A with a blue band is compatible with the Drive Motor Controller SN F21700F 29 & after.

FAULT CODES FOR DRIVE MOTOR CONTROLLER SN F21700F-29 & AFTER

FLASH CODE	FAULT NAME (Curtis Integrated Toolkit™)	POSSIBLE CAUSES	SET/CLEAR CONDITIONS	FAULT ACTIONS
1-2 0x12	**Controller Overcurrent** *Controller_Overcurrent* 0x2510 Fault Type(s): 1 = Controller Overcurrent Phase U 2 = Controller Overcurrent Phase W 3 = Controller Overcurrent Phase V 4 = Irms > 120% Current Limit 5 = PMAC motor speed exceeds controller's ability to safely regulate voltage. 6 = PMAC motor speed causes back emf to exceed controller voltage rating and controller cannot enable the bridge because KSI voltage is below brownout. 7 = Reserved. 8 = PMAC motor speed causes back emf to exceed controller voltage rating and controller cannot enable the bridge because no weakening is available for the selected motor type.	1. External short of phase U, V, or W motor connections. 2. Speed encoder noise problems. 3. Motor parameters are mistuned. 4. Controller defective.	*Set:* Phase current exceeded the current measurement limit. *Clear: Reset Controller.*	ShutdownVehicle: *ShutdownMotor* *ShutdownMainContactor* *ShutdownEMBrake* *ShutdownThrottle* *FullBrake* *ShutdownPump* *ShutdownCoilSupply* Dual Drive Same, both motors
1-3 0x13	**Current Sensor** *Current_Sensor* 0x2832 Fault Type(s): 1 = Controller current reading failed to stabilize at startup. 2 = Controller current reading failed to stabilize after startup. 3 = Controller current reading outside calibrated limits while acquiring offset.	1. Leakage to vehicle frame from phase U, V, or W (short in motor stator). 2. Controller defective.	*Set:* Controller current sensors have invalid offset reading. *Clear: Reset Controller.*	ShutdownVehicle (except pump): *ShutdownMotor* *ShutdownMainContactor* *ShutdownEMBrake* *ShutdownThrottle* *FullBrake* *ShutdownCoilSupply* Dual Drive Same, both motors

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FLASH CODE	FAULT NAME (Curtis Integrated Toolkit™)	POSSIBLE CAUSES	SET/CLEAR CONDITIONS	FAULT ACTIONS
1-4 0x14	**Precharge Failed** *Precharge_Failed* 0x2223 Fault Type(s): 1 = Abort 2 = Energy Limit Exceeded 3 = Time Limit Exceeded	1. An external load on the capacitor bank (B+ connection terminal) that prevents the capacitor bank from charging. 2. See Programmer » System Monitor menu » Controller » Capacitor Voltage.	*Set:* The precharge failed to charge the capacitor bank. *Clear:* Cycle Interlock or *Reset Controller.*	ShutdownVehicle: *ShutdownMotor* *ShutdownMainContactor* *ShutdownEMBrake* *ShutdownThrottle* *FullBrake* *ShutdownPump* *ShutdownCoilSupply* Dual Drive Same, both motors
1-5 0x15	**Controller Severe Undertemp** *Controller_Severe_Undertemp* 0x2141 Fault Type(s): 1	1. Controller is operating in an extreme environment. 2. See Programmer » System Monitor menu » Controller » Controller Temperature.	*Set:* Heatsink temperature below –40°C (–40°F). *Clear:* Bring the heatsink temperature above –40°C (–40°F) and then *Reset Controller.*	Fault Action: None, unless a fault action is programmed in VCL. Dual Drive Same, both motors
1-6 0x16	**Controller Severe Overtemp** *Controller_Severe_Overtemp* 0x2142 Fault Type(s): 1	1. Controller is operating in an extreme environment. 2. Excessive load on vehicle. 3. Improper mounting of controller. 4. See Programmer » System Monitor menu » Controller » Controller Temperature.	*Set:* Heatsink temperature above +95°C. *Clear:* Bring heatsink temperature below +95°C, and then *Reset Controller*.	ShutdownVehicle: *ShutdownMotor* *ShutdownMainContactor* *ShutdownEMBrake* *ShutdownThrottle* *FullBrake* *ShutdownPump* *ShutdownCoilSupply* Dual Drive Same, both motors
1-7 0x17	**Severe B+ Undervoltage** *Severe_B_Plus_Undervoltage* 0x2120 Fault Type(s): 1 = Undervoltage cutback (0x343B = 0%) or capacitor voltage below safe limits for 64 ms. 2 = Commanded voltage could not be achieved due to low capacitor voltage, see also phase PWM mismatch.	1. Non-controller system drain on battery. 2. Battery resistance too high. 3. Battery disconnected while driving. 4. Blown B+ fuse or main contactor did not close. 5. Battery parameters are misadjusted. 6. See Programmer » Monitor menu » Controller » Capacitor Voltage. 7. See the Voltage Limits in Chapter 3.	*Set:* When Main is closed and the FET Bridge is enabled, either the undervoltage drive current cut back = 0% for 64 ms or the Brownout Voltage is reached. *Clear:* Undervoltage drive current cut back > 0% for 100 ms and capacitor voltage > brownout voltage, or if phase PWM mismatch also present, cycle keyswitch.	No drive torque. Fault Action: *ShutdownPump* *ShutdownMotor* Dual Drive This Motor: *TrimDisable* *ShutdownPump* *ShutdownMotor* Other Motor: *TrimDisable*

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FLASH CODE	FAULT NAME (Curtis Integrated Toolkit™)	POSSIBLE CAUSES	SET/CLEAR CONDITIONS	FAULT ACTIONS
1-7 0x17	**Severe KSI Undervoltage** *Severe_KSI_Undervoltage* 0x2122 Fault Type(s): 1 = Brownout is disabled due to invalid product data configuration. 2 = Keyswitch_Voltage below brownout threshold at bootup. 3 = Keyswitch_Voltage below low brownout threshold for 5 ms. 4 = Keyswitch_Voltage below high brownout threshold for 64 ms.	1. Non-controller system drain on battery/keyswitch circuit wiring. 2. Resistance in low-power (KSI) circuit is too high. 3. KSI disconnected while driving. 4. Blown fuse. 5. See Programmer » System Monitor menu » Battery » Keyswitch Voltage. 6. See the Voltage Limits in Chapter 3.	*Set:* The KSI voltage dropped into the Brownout Voltage regions. *Clear:* Bring KSI voltage above Brownout Voltage.	ShutdownAll: *ShutdownMotor* *ShutdownMainContactor* *ShutdownEMBrake* *ShutdownThrottle* *ShutdownInterlock* *ShutdownDriver1* *ShutdownDriver2* *ShutdownDriver3* *ShutdownDriver4* *ShutdownDriver5* *ShutdownDriver6* *ShutdownDriver7* *ShutdownPD* *FullBrake* *ShutdownPump* *ShutdownCoilSupply* *ShutdownVehicle* *RequestTractionStop* *ShutdownLower* *ShutdownLift* *TrimDisable (Dual Drive)* *SevereDual (Dual Drive)* *LOSDual (Dual Drive)* Dual Drive Same, both motors
1-8 0x18	**Severe B+ Overvoltage** *Severe_B_Plus_Overvoltage* 0x2130 Fault Type(s): 1	1. Battery parameters are misadjusted. 2. Battery resistance too high for given regen current. 3. Battery disconnected while regen braking. 4. See Programmer » System Monitor menu » Controller » Capacitor Voltage. 5. See the Voltage Limits in Chapter 3.	*Set:* Capacitor bank voltage exceeded the Severe Overvoltage limit with the FET bridge enabled. *Clear:* Bring capacitor voltage below Severe Overvoltage limit, and then *Reset Controller*.	ShutdownVehicle: *ShutdownMotor* *ShutdownMainContactor* *ShutdownEMBrake* *ShutdownThrottle* *FullBrake* *ShutdownPump* *ShutdownCoilSupply* Dual Drive This Motor: *ShutdownMotor* *SevereDual* Other Motor: *SevereDual* *LOSDual* *TrimDisable*
1-8 0x18	**Severe KSI Overvoltage** *Severe_KSI_Overvoltage* 0x2132 Fault Type(s): 1	1. Battery-voltage applied to KSI (pin 1) exceeds the Severe Overvoltage limit. 2. See Programmer » Monitor menu » Battery » Keyswitch Voltage. 3. See the Voltage Limits in Chapter 3.	*Set:* KSI voltage exceeded the Severe Overvoltage limit. *Clear:* Bring KSI voltage below the Severe Overvoltage limit, and then *Reset Controller.*	ShutdownVehicle: *ShutdownMotor* *ShutdownMainContactor* *ShutdownEMBrake* *ShutdownThrottle* *FullBrake* *ShutdownPump* *ShutdownCoilSupply* Dual Drive This Motor: *ShutdownMotor* *SevereDual* Other Motor: *SevereDual* *LOSDual* *TrimDisable*

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FLASH CODE	FAULT NAME (Curtis Integrated Toolkit™)	POSSIBLE CAUSES	SET/CLEAR CONDITIONS	FAULT ACTIONS
1-9 0x19	**Speed Limit Supervision** *Speed_Limit_Supervision* 0x2133 Fault Type(s): 1	1. Motor speed detected that exceeds the limit set by the Max Speed Supervision parameter. 2. Misadjusted Max Speed Supervision parameters. 3. See: Programmer » Application Setup » Max Speed Supervision menu.	*Set:* Motor rpm has exceeded the Max Speed Limit setting for the Max Speed Time Limit setting's duration. *Clear: Reset Controller.*	*ShutdownInterlock* *ShutdownEMBrake* Dual Drive Same, both motors
1-10 0x1A	**Motor Not Stopped** *Motor_Not_Stopped* 0x2134 Fault Type(s): 1 = The motor moved more revolutions than the parameter, *Motor_Not_Stopped_Position_Error* setting. 2 = The motor moved faster than the parameter, *Motor_Not_Stopped_Speed_Error* (RPM) for 160 ms. 3 = The three-phase drive has applied an electrical frequency greater than the *Motor_Not_Stopped_Max_Frequency* parameter, and applied an RMS current greater than the *Motor_Not_Stopped_Max_Current* parameter for 64 ms.	1. Misadjusted Motor Not Stopped parameters. 2. See: Programmer » Application Setup » Motor Not Stopped menu. 3. Internal Controller fault or conflict allowing the motor to rotate when in the stopped state.	*Set:* Motor Not Stopped is a safety function implemented in the Primary microprocessor on a category 2 architecture per ISO 13849. The purpose of this function is to detect hazardous movement when the AC motor is stopped and expected to stay stopped (i.e., no throttle command). There are three main checks done when the motor is in the stopped state, each of which can be independently enabled and each of which has a unique fault type. *Clear: Reset Controller.*	ShutdownVehicle: *ShutdownMotor* *ShutdownMainContactor* *ShutdownEMBrake* *ShutdownThrottle* *FullBrake* *ShutdownPump* *ShutdownCoilSupply* Dual Drive Same, both motors
1-11 0x1B	**Critical OS General** *Critical_OS_General* 0x2109 Fault Type(s): (1-100) Internal Fault, kindly contact your Curtis representative immediately. (101-200) Ill-formed or corrupted application package was loaded into controller. (>200) Internal Fault, kindly contact your Curtis representative immediately.	(1–100) Internal Fault. (101–200) CIT version is too old to fully support the FOS version. (>200) Internal Fault.	*Set:* Program execution within the controller encountered a serious problem and could not recover (from it). *Clear:* (1–100) Internal Fault. (101–200) Update CIT version, re-package the project, and re-flash the application package. (>200) Internal Fault.	ShutdownAll: *ShutdownMotor* *ShutdownMainContactor* *ShutdownEMBrake* *ShutdownThrottle* *ShutdownInterlock* *ShutdownDriver1* *ShutdownDriver2* *ShutdownDriver3* *ShutdownDriver4* *ShutdownDriver5* *ShutdownDriver6* *ShutdownDriver7* *ShutdownPD* *FullBrake* *ShutdownPump* *ShutdownCoilSupply* *ShutdownVehicle* *RequestTractionStop* *ShutdownLower* *ShutdownLift* *TrimDisable (Dual Drive)* *SevereDual (Dual Drive)* *LOSDual (Dual Drive)* Dual Drive Same, both motors

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FLASH CODE	FAULT NAME (Curtis Integrated Toolkit™)	POSSIBLE CAUSES	SET/CLEAR CONDITIONS	FAULT ACTIONS
1-12 0x1C	**OS General 2** *OS_General_2* 0x210A Fault Type(s): (<100) Internal Fault. Contact Curtis support. (>100) An ill-formed or corrupted application package was loaded into controller.	1. (<100) Internal Fault. 2. (>100) CIT version is too old to fully support the FOS version.	*Set:* Program execution within the controller encountered a serious problem and could not recover. *Clear:* (<100) Internal Fault. (>100) Update CIT version, re-package the project, and re-flash the application package.	NO ACTION (controller is not operable) Dual Drive Same, both motors
1-13 0x1D	**Reset Rejected** *Reset_Rejected* 0x2110 Fault Type(s): 1	This occurs if a controller is commanded to reset while controlling a PMAC motor that is not stationary. Examples of resets include sending an NMT reset or calling *reset_controller()* in VCL. Note, the controller will NOT reset when the controller later does enter a safe state unless the NMT is resent or *reset_controller()* is called again. If legacy brownout is set to Off, the user may see this fault if the controller is turned off and on again at an unsafe time, but in this instance the controller will reset as soon as it is safe to do so. Consult Curtis Support for further assistance using non legacy brownout.	*Set:* A reset was called at a time unsafe for the controller. *Clear:* Cycle KSI.	*ShutdownInterlock* *ShutdownThrottle* Dual Drive Same, both motors
1-14 0x1E	**Motor Short** *Motor_Short* 0x210E Fault Type(s): 1	Check Motor Type and Parameters. See the PMAC considerations. Indicates whether the fault is presently active or not.	*Set:* Indicates the motor was shorted to avoid dangerous voltage levels. *Clear: Reset controller.*	NO ACTION (controller is not operable) Dual Drive Same, both motors
2-2 0x22	**Controller Overtemp Cutback** *Controler_Overtemp_Cutback* 0x2140 Fault Type(s): 1 = Controller heatsink high temperature (affecting AC phases) 2 = Controller heatsink high temperature (affecting pump phase) 3 = Capacitor bank high temperature 4 = AC phase FET high temperature 5 = Pump phase FET high temperature 6 = Low Frequency single phase high temperature.	1. Controller is operating in an extreme environment. 2. Excessive load on vehicle. 3. Improper mounting of controller which is preventing controller cooling. 4. Controller is performance-limited at this temperature. 5. See Programmer » System Monitor menu » Controller: Controller Temperature. Capacitor Bank Temperature. » Cutbacks menu.	*Set:* The controller's temperature exceeded temperature cutback threshold. *Clear:* Bring controller temperature below overtemperature threshold.	Reduced drive torque. Reduced regen-braking torque. Fault Action: None, unless a fault action is programmed in VCL. Dual Drive This Motor: *TrimDisable* Other Motor: *TrimDisable*

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FLASH CODE	FAULT NAME (Curtis Integrated Toolkit™)	POSSIBLE CAUSES	SET/CLEAR CONDITIONS	FAULT ACTIONS
2-3 0x23	**Undervoltage Cutback** *Undervoltage_Cutback* 0x2121 Fault Type(s): 1	1. Batteries need recharging. Controller is performance limited at this voltage. 2. Battery parameters are misadjusted. 3. Non-controller system-drain on battery. 4. Battery resistance too high. 5. Battery disconnected while driving. 6. Blown B+ fuse or main contactor did not close. 7. See Programmer » System Monitor menu » Controller » *Cutbacks* » *Undervoltage Cutback*. 8. See Programmer » System Monitor menu » Controller » Capacitor Voltage.	*Set:* Capacitor bank voltage dropped below the *Undervoltage Cutback* limit with the FET bridge enabled. *Clear:* Bring the capacitor voltage above the controller's *Undervoltage Cutback* limit.	Reduced drive torque. Reduced regen braking torque. <u>Fault Action:</u> None, unless a fault action is programmed in VCL. <u>Dual Drive</u> This Motor: *TrimDisable* Other Motor: *TrimDisable*
2-4 0x24	**Overvoltage Cutback** *Overvoltage_Cutback* 0x2131 Fault Type(s): 1	1. Normal operation. Fault shows that regen braking currents elevated the battery voltage during regen braking. Controller is performance limited at this voltage. 2. Battery parameters are misadjusted. 3. Battery resistance too high for given regen current. 4. Battery disconnected while regen braking. 5. See Programmer » System Monitor menu » Controller » *Cutbacks* » *Overvoltage Cutback*. 6. See Programmer » System Monitor menu » Controller » Capacitor Voltage.	*Set:* The controller's capacitor bank voltage exceeded the *Overvoltage Cutback* limit with the FET bridge enabled. *Clear:* Bring controller's capacitor voltage below the *Overvoltage Cutback* limit.	Reduced brake torque. Note: This fault is declared only when the controller is running in regen. <u>Fault Action:</u> None, unless a fault action is programmed in VCL. <u>Dual Drive</u> This Motor: *TrimDisable* Other Motor: *TrimDisable*
2-5 0x25	**Ext 5V Supply Failure** *Ext_5V_Supply_Failure* 0x2531 Fault Type(s): 1 = The 5V supply is outside 5V ± 10%. 2 = The current is outside the limits defined by: - Ext_5V_Supply_Min. - Ext_5V_Supply_Max.	1. External load impedance on the +5V supply is too low (i.e., a short circuit). 2. See the *System Monitor » Outputs* menu: *External_5V_Supply,* *Ext_5V_Current.* .	*Set:* Triggered by the Fault Type indicated. *Clear: Reset Controller*, or Reset using the VCL variable *Ext_5V_Output_Enable.*	Disables the 5V Supply. <u>Fault Action:</u> None, unless a fault action is programmed in VCL. <u>Dual Drive</u> Same, both motors

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FLASH CODE	FAULT NAME (Curtis Integrated Toolkit™)	POSSIBLE CAUSES	SET/CLEAR CONDITIONS	FAULT ACTIONS
2-6 0x26	**Ext 12V Supply Failure** *Ext_12V_Supply_Failure* 0x2532 Fault Type(s): 1 = The 12V supply is outside 12V ± 15%. 2 = The current is outside the limits defined by: - Ext_12V_Supply_Min. - Ext_12V_Supply_Max.	1. External load impedance on the +12V supply is too low (i.e., a short circuit). 2. See Programmer » System Monitor menu » Outputs: *External_12V_Supply,* *Ext_12V_Current.*	*Set:* Triggered by the Fault Type indicated. *Clear: Reset Controller.* Or Reset using the VCL variable *Ext_12V_Output_Enable*.	Disables the 12V Supply. <u>Fault Action:</u> None, unless a fault action is programmed in VCL. <u>Dual Drive</u> Same, both motors
2-8 0x28	**Motor Temp Hot Cutback** *Motor_Temp_Hot_Cutback* 0x2151 Fault Type(s): 1	1. Motor temperature is at or above the programmed Temperature Hot setting—resulting in a reduction of controller drive current. 2. The motor temperature and sensor control parameters are misadjusted. 3. See Programmer » AC Motor Setup » Temperature Sensor.	*Set:* Motor temperature is at or above the Temperature Hot parameter setting. *Clear:* Bring the motor temperature within range.	Reduced Drive Torque. If MotorBrakingThermal CutBack_Enable = On, then Regen Braking Torque is reduced. <u>Fault Action:</u> None, unless a fault action is programmed in VCL. <u>Dual Drive</u> This Motor: *TrimDisable* Other Motor: *TrimDisable*
2-9 0x29	**Motor Temp Sensor** *Motor_Temp_Sensor* 0x2150 Fault Type(s): 1	1. Motor thermistor is not connected properly. 2. Sensor polarity (between Motor-temp pin and ground) is incorrect. See wiring diagrams. 3. The motor temperature and sensor parameters are misadjusted. 4. See Programmer » System Monitor menu » AC Motor » Temperature.	*Set:* Motor thermistor input is at the voltage rail. *Clear:* Bring the motor thermistor input voltage within range.	Motor temperature cutback disabled. <u>Fault Action:</u> None, unless a fault action is programmed in VCL. <u>Dual Drive</u> This Motor: *LOSDual* Other Motor: *LOSDual*

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FLASH CODE	FAULT NAME (Curtis Integrated Toolkit™)	POSSIBLE CAUSES	SET/CLEAR CONDITIONS	FAULT ACTIONS
3-1 0x31	**MAIN DRIVER** *Main_Driver_Fault* 0x2222 Fault Type(s): 1 = Driver current exceeded hardware limits. 2 = Driver current exceeded configured overcurrent limits. 3 = Driver commanded PWM active, using diagnostic pulses. Voltage measured high, should be low. Typically caused by driver failure, or driver pin short to high. 4 = Driver commanded PWM active, using diagnostic pulses. Voltage measured low, should be high. Either open circuit, or driver pin short to ground. 5 = Driver commanded PWM is 0, and voltage measured low (should be high). Either open circuit, or driver pin short to ground. 6 = Driver current DC offset out of range. 7 = Driver undercurrent — Monitored current is below undercurrent threshold. 8 = Driver following — Driver in current control is not within error bounds. Fault types 1-2 are always checked. Fault types 3-5 are only checked if driver checks are enabled.	1. Open or short on driver load. 2. Dirty connector pins at controller or contactor coil. 3. Bad connector crimps or faulty wiring. 4. Driver overcurrent, as set by the Driver x Overcurrent parameter. 5. See Programmer » Controller Setup » Outputs » Driver x » Driver x Overcurrent.	*Set:* Main Contactor driver is either open or shorted. This fault can be set only when Main Enable = On. *Clear:* Restore/repair any external wiring or device-coil to their correct state, Correct the open or short, then *Reset Controller*.	ShutdownVehicle: *ShutdownMotor* *ShutdownMainContactor* *ShutdownEMBrake* *ShutdownThrottle* *FullBrake* *ShutdownPump* *ShutdownCoilSupply* Dual Drive Same, both motors

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FLASH CODE	FAULT NAME (Curtis Integrated Toolkit™)	POSSIBLE CAUSES	SET/CLEAR CONDITIONS	FAULT ACTIONS
3-2 0x32	**EM Brake Driver Fault** *EM_Brake_Driver_fault* 0x2320 Fault Type(s): 1 = Driver current exceeded hardware limits. 2 = Driver current exceeded configured overcurrent limits. 3 = Driver commanded PWM active, using diagnostic pulses. Voltage measured high, should be low. Typically caused by driver failure, or driver pin short to high. 4 = Driver commanded PWM active, using diagnostic pulses. Voltage measured low, should be high. Either open circuit, or driver pin short to ground. 5 = Driver commanded PWM is 0, and voltage measured low (should be high). Either open circuit, or driver pin short to ground. 7 = Driver undercurrent — Monitored current is below undercurrent threshold. 8 = Driver following — Driver in current control is not within error bounds. Fault types 1-2 are always checked. Fault types 3-5 are only checked if driver checks are enabled.	1. Open or short on driver load. 2. Dirty connector pins at controller or contactor coil. 3. Bad connector crimps or faulty wiring. 4. Driver overcurrent, as set by the Driver x Overcurrent parameter. 5. See Programmer » Controller Setup » Outputs » Driver x » Driver x Overcurrent.	*Set:* Electromagnetic brake driver (pin 4) is either open or shorted. This fault can be set only when EM Brake Type >0. *Clear:* Restore/repair any external wiring or device-coil to their correct state, then *Reset Controller.*	*ShutdownEMBrake* *ShutdownThrottle* *FullBrake* Dual Drive Same, both motors

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FLASH CODE	FAULT NAME (Curtis Integrated Toolkit™)	POSSIBLE CAUSES	SET/CLEAR CONDITIONS	FAULT ACTIONS
3-3 0x33	**Pump Driver Fault** *Pump_Driver_fault* 0x2420 Fault Type(s): 1 = Driver current exceeded hardware limits. 2 = Driver current exceeded configured overcurrent limits. 3 = Driver commanded PWM active, using diagnostic pulses. Voltage measured high, should be low. Typically caused by driver failure, or driver pin short to high. 4 = Driver commanded PWM active, using diagnostic pulses. Voltage measured low, should be high. Either open circuit, or driver pin short to ground. 5 = Driver commanded PWM is 0, and voltage measured low (should be high). Either open circuit, or driver pin short to ground. 6 = Driver current DC offset out of range. 7 = Driver undercurrent — Monitored current is below undercurrent threshold. 8 = Driver following — Driver in current control is not within error bounds. Fault types 1-2 are always checked. Fault types 3-5 are only checked if driver checks are enabled.	1. Open or short on driver load. 2. Dirty connector pins at controller or contactor coil. 3. Bad connector crimps or faulty wiring. 4. Driver overcurrent, as set by the Driver x Overcurrent parameter. 5. See Programmer » *Controller Setup » Outputs » Driver x » Driver x Overcurrent*.	*Set:* The assigned pump-contactor driver is either open or shorted, or exceeded its overcurrent setting. Note: This fault is typically associated with non-pump controllers operating a DC pump contactor via a Driver, yet can apply to controllers with the pump (e.g., the F2-T/F2-C) if also so configured. *Clear:* Correct the open or short, and then *Reset Controller*.	*Shutdownpump* Dual Drive Same, both motors

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FLASH CODE	FAULT NAME (Curtis Integrated Toolkit™)	POSSIBLE CAUSES	SET/CLEAR CONDITIONS	FAULT ACTIONS
3-4 0x34	**Load-Hold Driver Fault** *Load_Hold_Driver_Fault* 0x2430 Fault Type(s): 1 = Driver current exceeded hardware limits. 2 = Driver current exceeded configured overcurrent limits. 3 = Driver commanded PWM active, using diagnostic pulses. Voltage measured high, should be low. Typically caused by driver failure, or driver pin short to high. 4 = Driver commanded PWM active, using diagnostic pulses. Voltage measured low, should be high. Either open circuit, or driver pin short to ground. 5 = Driver commanded PWM is 0, and voltage measured low (should be high). Either open circuit, or driver pin short to ground. 6 = Driver current DC offset out of range. 7 = Driver undercurrent — Monitored current is below undercurrent threshold. 8 = Driver following — Driver in current control is not within error bounds. Fault types 1-2 are always checked. Fault types 3-5 are only checked if driver checks are enabled.	1. Open or short on driver load. 2. Dirty connector pins at controller or contactor coil. 3. Bad connector crimps or faulty wiring. 4. Driver overcurrent, as set by the Driver x Overcurrent parameter. 5. See Programmer » *Controller Setup » Outputs » Driver x » Driver x Overcurrent.*	*Set:* The assigned load-hold driver is either open or shorted, or exceeded its overcurrent setting. *Clear:* Correct the open or short, and then *Reset Controller.*	NO ACTION Dual Drive Same, both motors

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FLASH CODE	FAULT NAME (Curtis Integrated Toolkit™)	POSSIBLE CAUSES	SET/CLEAR CONDITIONS	FAULT ACTIONS
3-5 0x35	**Lower Driver Fault** *Lower_Driver_Fault* 0x2440 Fault Type(s): 1 = Driver current exceeded hardware limits. 2 = Driver current exceeded configured overcurrent limits. 3 = Driver commanded PWM active, using diagnostic pulses. Voltage measured high, should be low. Typically caused by driver failure, or driver pin short to high. 4 = Driver commanded PWM active, using diagnostic pulses. Voltage measured low, should be high. Either open circuit, or driver pin short to ground. 5 = Driver commanded PWM is 0, and voltage measured low (should be high). Either open circuit, or driver pin short to ground. 6 = Driver current DC offset out of range. 7 = Driver undercurrent — Monitored current is below undercurrent threshold. 8 = Driver following — Driver in current control is not within error bounds. Fault types 1-2 are always checked. Fault types 3-5 are only checked if driver checks are enabled.	1. Open or short on driver load. 2. Dirty connector pins at controller or contactor coil. 3. Bad connector crimps or faulty wiring. 4. Driver overcurrent, as set by the Driver x Overcurrent parameter. 5. See Programmer » Controller Setup » Outputs » Driver x » Driver x Overcurrent. Note: See Driver 1* Fault * *Driver 1 is the PD Driver, therefore the Lower Driver fault cascades to the Driver 1 fault (see flash code 10-1).*	*Set:* The assigned lower driver is either open or shorted, or exceeded its overcurrent setting. *Clear:* Correct the open or short, and then *Reset Controller.*	*ShutdownLower* Dual Drive Same, both motors
3-6 0x36	**IM MOTOR FEEDBACK** *IM_Motor_Feedback* 0x2230 Fault Type(s): 1. Controller saw a fast transition to zero speed. 2. Encoder supply failed. 3. Sine or Cosine input differs from expected. 4. Controller saw sensor failure at speed. 5. Unrealistic motor acceleration seen. 6. Resolver loss of signal. 7. Resolver degradation of signal. 8. Resolver loss of tracking.	1. Motor encoder failure. 2. Bad crimps or faulty wiring. 3. See Programmer » System Monitor menu » AC Motor: Motor RPM. 4. See Programmer » AC Motor Setup » Quadrature Encoder » Encoder Fault Setup. 5. See Programmer » System Monitor menu » Hardware Inputs: Analog 3 and 4.	*Set:* Motor position/speed sensor fault. *Clear: Either Reset Controller, or if parameter LOS Upon Encoder Fault = On and Interlock has been cycled, then the Encoder Fault is cleared and Encoder LOS fault (flash code 9-3) is set, allowing limited motor control.*	*ShutdownEMBrake* *ShutdownMotor* Dual Drive This Motor: *SevereDual* *ShutdownMotor* Other Motor: *SevereDual* *LOSDual* *TrimDisable*

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FLASH CODE	FAULT NAME (Curtis Integrated Toolkit™)	POSSIBLE CAUSES	SET/CLEAR CONDITIONS	FAULT ACTIONS
3-6 0x36	**PM Motor Feedback** *PM_Motor_Feedback* 0x2232 Fault Type(s): 1. Controller saw a fast transition to zero speed. 2. Encoder supply failed. 3. Sine or Cosine input differs from expected. 4. Controller saw sensor failure at speed. 5. Unrealistic motor acceleration seen. 6. Resolver loss of signal. 7. Resolver degradation of signal. 8. Resolver loss of tracking. 9. PMAC motor stalled.	1. Motor encoder failure. 2. Bad crimps or faulty wiring. 3. EMC induced signal corruption by poor wire routing and/or shielding. 4. See Programmer » System Monitor menu » Hardware Inputs: Analog 3 and 4.	*Set:* Motor position/speed Sin/Cos sensor fault. *Clear: Reset Controller.*	ShutdownVehicle: *ShutdownMotor* *ShutdownMainContactor* *ShutdownEMBrake* *ShutdownThrottle* *FullBrake* *ShutdownPump* *ShutdownCoilSupply* Dual Drive Same, both motors
3-7 0x37	**Motor Open** *Motor_Open* 0x2240 Fault Type(s): 1. Current mismatch while running. 2. Reserved. 3. Weld check failed to achieve commanded current. 4. Voltage mismatch during startup.	1. Motor phase is open. 2. Bad crimps or faulty wiring.	*Set:* Motor phase U, V, or W detected open. *Clear: Reset Controller.*	ShutdownVehicle: *ShutdownMotor* *ShutdownMainContactor* *ShutdownEMBrake* *ShutdownThrottle* *FullBrake* *ShutdownPump* *ShutdownCoilSupply* Dual Drive This Motor: *ShutdownMotor* *SevereDual* Other Motor: *SevereDual* *LOSDual* *TrimDisable*
3-8 0x38	**Main Contactor Welded** *Main_Contactor_Welded* 0x2220 Fault Type(s): 1	1. Main contactor tips are welded closed. 2. Motor phase U or V is disconnected or open. 3. An alternate voltage path (such as an external circuit to B+) is providing a current to the capacitor bank (B+ connection terminal).	*Set:* Just prior to the main contactor closing, the capacitor bank voltage (B+ connection terminal) was loaded (via the motor) for a short time and the voltage did not discharge, indicating a direct-contact to the battery (i.e., Main tips are welded closed). *Clear: Reset Controller.*	ShutdownVehicle: *ShutdownMotor* *ShutdownMainContactor* *ShutdownEMBrake* *ShutdownThrottle* *FullBrake* *ShutdownPump* *ShutdownCoilSupply* Dual Drive Same, both motors

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FLASH CODE	FAULT NAME (Curtis Integrated Toolkit™)	POSSIBLE CAUSES	SET/CLEAR CONDITIONS	FAULT ACTIONS
3-9 0x39	**Main Contactor Did Not Close** *Main_Contactor_Did_Not_Close* 0x2221 Fault Type(s): 1 = Main did not close when commanded. 2 = Main disconnected during operation. 3 = Battery disconnected with main enable off.	Type 1: 1. Main contactor did not close. 2. Main contactor tips are oxidized, burned, or not making good contact. 3. An external load on the capacitor bank (B+ connection terminal) is preventing the capacitor bank from charging. 4. Blown B+ fuse. 5. Main Contactor parameters mistuned; • Main Pull-in Voltage, • Main Holding Voltage. Type 2: 1. Main contactor opened during operation (while commanded closed). 2. Driver wiring to contactor's coil (e.g., pin wiring) removed during operation. 3. Contactor/coil defective. Type 3: Main Enable is false, expect B+ supply controlled externally. Interlock applied, ready to enable the power stage. B+ capacitor voltage is below 95% of the KSI voltage.	*Set:* With the main contactor commanded closed, the capacitor bank voltage (B+ connection terminal) did not charge to B+. *Clear: Reset Controller.*	ShutdownVehicle: *ShutdownMotor* *ShutdownMainContactor* *ShutdownEMBrake* *ShutdownThrottle* *FullBrake* *ShutdownPump* *ShutdownCoilSupply* Dual Drive Same, both motors
3-10 0x3A	**Motor Setup Needed** *Motor_Setup_Needed* 0x2103 Fault Type(s): Bit 1 = Current regulator needs to be configured. Bit 2 = Slip gain test needs to be run. Bit 3 = Base speed test needs to be run. Bit 4 = Automated test needs to be run. --------- Hex# = bit 1– 4 Binary 0000 => bits 4 3 2 1	Motor setup incomplete. Run the appropriate motor commissioning sequences. **Note:** The Fault Type number in CIT is in hex (h), which is correct. See/Used bits as described.	*Set:* Motor setup is required. Please refer to fault type. *Clear:* Motor commissioning completed successfully.	Fault Action: None. Yet, the motor will not operate until the motor configuration and/or commissioning tests are complete.
3-11 0x3B	**Misalignment Error** *Misalignment_Error* 0x2102 Fault Type(s): 1	1. This fault is only for PMAC, indicating the position sensor (e.g., Sin/Cos) is not in alignment. 2. Possible motor setup and/or commissioning errors. 3. If the sensor is continuously becoming misaligned, the likely cause is motor damage. Consult with the motor manufacturer.	*Set:* The motor offset has shifted so controller is producing torque in an uncommanded direction. *Clear:* Reset the controller. If the fault persists, try rerunning the PMAC (field) commissioning (Chapter 6, PMAC Commissioning Procedure).	ShutdownVehicle: *ShutdownMotor* *ShutdownMainContactor* *ShutdownEMBrake* *ShutdownThrottle* *FullBrake* *ShutdownPump* Dual Drive Same, both motors

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FLASH CODE	FAULT NAME (Curtis Integrated Toolkit™)	POSSIBLE CAUSES	SET/CLEAR CONDITIONS	FAULT ACTIONS
4-2 0x42	**Throttle Input** *Throttle_Input* 0x2210 Fault Type(s): 4* 1. Outside the Low or High parameter. 2. Throttle voltage exceeded the *Analog Low* parameter. 3. *Analog High* parameters for the analog input defined for the throttle input. 4. Input 1 fault diagnostics may be either out of range if it is configured as a voltage input or may include potentiometer faults if configured as a 2/3-wire pot. * based upon the associated Analog Input faults.	1. Throttle voltage exceeded the Analog Low or Analog High parameters for the analog input defined for the throttle input. 2. See Programmer » Controller Setup » Inputs » Analog 1 Type. 3. See Programmer » Controller Setup » Inputs » Configure.	*Set:* This fault is triggered by the respective fault diagnostic associated with the throttle input source. For example, if *Throttle_Source* is set to Input 1, then any faults detected by the Input 1 fault diagnostics are reported in this fault code. *Clear:* Bring throttle input voltage within the Min and Max thresholds, then Reset the Controller.	*ShutdownThrottle* Dual Drive This Motor: *ShutdownThrottle* Other Motor: No Action
4-4 0x44	**Brake Input** *Brake_Input* 0x2310 Fault Type(s): 1*	*Triggered by the respective fault diagnostic associated with the brake input source (assigned Analog X input).	*Set:* See Throttle Input. Note: An Input 1 fault diagnostics may be out of range if it is configured as a voltage input or may include potentiometer faults if configured as a 2/3-wire pot. *Clear:* Bring Brake Input voltage within the Min and Max thresholds. *Reset Controller*.	*FullBrake* Dual Drive Same, both motors. Any additional fault action that is programmed in VCL (see Analog X).
4-6 0x46	**NV Memory Failure** *NV_Memory_Failure* 0x2830 Fault Type(s): 1 = Invalid checksum. 2 = NV write failed. 3 = NV read failed. 4 = NV write did not complete during power down.	1. Failure to read or write to non-volatile (NV) memory. 2. Internal controller fault.	*Set:* Controller operating system tried to read or write to EEPROM memory and failed. *Clear:* Download the correct software and matching parameter default settings into the controller and *Reset Controller.*	ShutdownAll: *ShutdownMotor* *ShutdownMainContactor* *ShutdownEMBrake* *ShutdownThrottle* *ShutdownInterlock* *ShutdownDriver1* *ShutdownDriver2* *ShutdownDriver3* *ShutdownDriver4* *ShutdownDriver5* *ShutdownDriver6* *ShutdownDriver7* *ShutdownPD* *FullBrake* *ShutdownPump* *ShutdownCoilSupply* *ShutdownVehicle* *RequestTractionStop* *ShutdownLower* *ShutdownLift* *TrimDisable (Dual Drive)* *SevereDual (Dual Drive)* *LOSDual (Dual Drive)* Dual Drive Same, both motors

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FLASH CODE	FAULT NAME (Curtis Integrated Toolkit™)	POSSIBLE CAUSES	SET/CLEAR CONDITIONS	FAULT ACTIONS
4-7 0x47	**HPD Sequencing** *Hpd_Sequencing* 0x2211 Fault Type(s): Type 1 through 9 — HPD depends on HPD_SRO_Type Type 10 — Interlock Anti-Tiedown	1. Incorrect sequence in application of Keyswitch, Interlock, Direction, or Throttle. 2. Faulty wiring, crimps, or switches at KSI, Interlock, Direction, or Throttle. 3. Moisture in above-noted digital input switches causing invalid (real) On/Off state. 4. Verify input switch status. See Programmer » System Monitor menu » Hardware Inputs » Switch Status. 5. Verify Throttle. See Programmer » System Monitor menu » Hardware Inputs » Throttle Command.	*Set:* HPD (High Pedal Disable) or SRO (Static Return to Off) sequencing fault caused by incorrect sequence of KSI, interlock, direction, and throttle inputs. *Clear:* Reapply inputs in correct sequence.	*ShutdownThrottle* Dual Drive Same, both motors
4-7 0x47	**EMER Rev HPD** *Emer_Rev_Hpd* 0x2331 Fault Type(s): 1	Emergency Reverse operation has concluded, but the throttle, forward and reverse, and interlock inputs have not been returned to neutral.	*Set:* At the conclusion of Emergency Reverse, the fault was set because various inputs were not returned to neutral. *Clear:* If EMR_Interlock = On, clear the interlock, throttle, and direction inputs. If EMR_Interlock = Off, clear the throttle and direction inputs.	*ShutdownThrottle* *ShutdownEMBrake* Dual Drive Same, both motors
4-7 0x47	**Hydraulic HPD SRO Lower** *Hydraulic_HPD_SRO_Lower* 0x2124 Fault Type(s): 1	Review the hydraulic parameters and application setup and usage.	*Set:* This fault is trigged if the Lower throttle is non-zero when Hydraulic Interlock transitions to ON. *Clear:* Return both hydraulic throttle inputs to zero.	*ShutdownLower* Dual Drive This Motor: *ShutdownLower* Other Motor: None
4-7 0x47	**Hydraulic HPD SRO Lift** *Hydraulic_HPD_SRO_Lift* 0x2125 Fault Type(s): 1	Review the hydraulic parameters and application setup and usage.	*Set:* This fault is trigged if the Lift throttle is non-zero when Hydraulic Interlock transitions to ON. *Clear:* Return both hydraulic throttle inputs to zero.	*ShutdownLift* Dual Drive This Motor: *ShutdownLift* Other Motor: None
4-7 0x47	**LHS Throttle Conflict** *LHS_Throttle_Conflict* 0x2126 Fault Type(s): 1	Review the hydraulic parameters and application setup and usage.	*Set:* The hydraulic lift and lower inputs were both non-zero simultaneously. *Clear:* Return both hydraulic throttle inputs to zero. If lower throttle is returned to zero prior to lift throttle, the lower throttle may be used to control the Hydraulic Lowering Proportional Valve while LHS Throttle Conflict is still active.	*ShutdownLift* Dual Drive This Motor: *ShutdownLift* Other Motor: None

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FLASH CODE	FAULT NAME (Curtis Integrated Toolkit™)	POSSIBLE CAUSES	SET/CLEAR CONDITIONS	FAULT ACTIONS
4-9 0x49	**Parameter Change** *Parameter_Change* 0x2813 Fault Type(s): Reports the CAN Object ID of parameter.	While the Interlock was On, a safety-based parameter was changed. Parameters with this property are marked with a [PCF] (Parameter Change Fault) in the Parameter menu listings.	*Set:* Adjustment of a parameter setting that requires cycling of KSI. *Clear: Reset Controller.*	ShutdownVehicle: *ShutdownMotor* *ShutdownMainContactor* *ShutdownEMBrake* *ShutdownThrottle* *FullBrake* *ShutdownPump* *ShutdownCoilSupply* Dual Drive Same, both motors
4-10 0x4A	**EMR Switch** *EMR_Switch_Fault* 0x2817 Fault Type(s): 3 1. The Emergency Reverse Switch NO input does not agree with the Emergency Reverse Switch NC input. They are opposites: NO and NC. 2. EMR Switch input(s) are active within EMR_Anti_Tiedown_Time (ms) of Key-Switch Input. 3. EMR Switch input(s) are active while Interlock Switch input(s) is not active.	1. Either or both Emergency Reverse input switches are inoperative, resulting in an invalid state. NO / NC / State On / Off / valid Off / On / valid On / On / invalid Off / Off / invalid 2. Ingress of dirt or moisture in switch(es).	*Set:* Indicates a fault originating from the EMR switch inputs. *Clear:* Correct the two switch states. Deactivate Interlock and EMR Switch. *Reset Controller.*	*ShutdownInterlock* *ShutdownEMBrake* Dual Drive Same, both motors

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Table 7-3 Fault Code Troubleshooting Chart, cont'd

FLASH CODE	FAULT NAME (Curtis Integrated Toolkit™)	POSSIBLE CAUSES	SET/CLEAR CONDITIONS	FAULT ACTIONS
6-8 0x68	**VCL Run Time Error** *VCL_Run_Time_Error* 0x2820 Fault Type(s): 1	1. Runtime errors are defined using the VCL Error Module and VCL Error. See the System Information file: • Curtis Integrated Toolkit™ » VCL Studio » Help » System Information. 2. Using driver control commands in VCL can lead to VCL runtime errors if the VCL command and the driver assignment do not match.	*Set:* VCL Run Time Error detected. *Clear:* Edit the VCL application software to fix this error condition; flash the new compiled software and matching parameter settings; *Reset Controller.*	ShutdownAll: *ShutdownMotor* *ShutdownMainContactor* *ShutdownEMBrake* *ShutdownThrottle* *ShutdownInterlock* *ShutdownDriver1* *ShutdownDriver2* *ShutdownDriver3* *ShutdownDriver4* *ShutdownDriver5* *ShutdownDriver6* *ShutdownDriver7* *ShutdownPD* *FullBrake* *ShutdownPump* *ShutdownCoilSupply* *ShutdownVehicle* *RequestTractionStop* *ShutdownLower* *ShutdownLift* *TrimDisable (Dual Drive)* *SevereDual (Dual Drive)* *LOSDual (Dual Drive)* Dual Drive Same, both motors
6-8 0x68	**ECC_RUN_TIME_ERROR** *ECC_Run_Time_Error* 0x2871 Fault Type(s): 0 = Hard Fault. 1 = Memory Violation. 2 = Bus Fault. 3 = Usage Fault. 4 = Stack Fault. 5 = CPU Usage Fault. 100 = Heap Fault. 101 = Unhandled Exception. 10000 (and above) ccapi exception exit. All other codes are app-specific application exit codes.	Programming Error	*Set:* An embedded C application has encountered a runtime error. *Clear:* Edit the ECC application software to fix this error condition; flash the new compiled software and matching parameter settings; *Reset Controller.*	ShutdownAll: *ShutdownMotor* *ShutdownMainContactor* *ShutdownEMBrake* *ShutdownThrottle* *ShutdownInterlock* *ShutdownDriver1* *ShutdownDriver2* *ShutdownDriver3* *ShutdownDriver4* *ShutdownDriver5* *ShutdownDriver6* *ShutdownDriver7* *ShutdownPD* *FullBrake* *ShutdownPump* *ShutdownCoilSupply* *ShutdownVehicle* *ShutdownLower* *ShutdownLift* Dual Drive Same, both motors

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FLASH CODE	FAULT NAME (Curtis Integrated Toolkit™)	POSSIBLE CAUSES	SET/CLEAR CONDITIONS	FAULT ACTIONS
7-1 0x71	**OS General** *OS_General* 0x2831 Fault Type(s): 1	Physical damage from external sources/events.	*Set:* Internal controller fault detected. *Clear: Reset Controller.*	ShutdownAll: *ShutdownMotor* *ShutdownMainContactor* *ShutdownEMBrake* *ShutdownThrottle* *ShutdownInterlock* *ShutdownDriver1* *ShutdownDriver2* *ShutdownDriver3* *ShutdownDriver4* *ShutdownDriver5* *ShutdownDriver6* *ShutdownDriver7* *ShutdownPD* *FullBrake* *ShutdownPump* *ShutdownCoilSupply* *ShutdownVehicle* *RequestTractionStop* *ShutdownLower* *ShutdownLift* *TrimDisable (Dual Drive)* *SevereDual (Dual Drive)* *LOSDual (Dual Drive)* Dual Drive Same, both motors
7-2 0x72	**PDO Timeout** *PDO_Timeout* 0x2541 Fault Type(s): 1	1. The time between CAN PDO messages received exceeded the PDO Timeout Period as defined by the Event Timer parameter. 2. Adjust PDO Settings. See Programmer » Application Setup » CAN Interface » PDO Setups.	*Set:* Time between CAN PDO messages received exceeded the PDO Timeout Period. *Clear:* Receive CAN NMT message, or *Reset Controller.*	*ShutdownInterlock* Dual Drive Same, both motors

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FLASH CODE	FAULT NAME (Curtis Integrated Toolkit™)	POSSIBLE CAUSES	SET/CLEAR CONDITIONS	FAULT ACTIONS
7-3 0x73	**Stall Detected** *Stall_Detected* 0x2231 Fault Type(s): 1 Set Conditions – Motor speed is less than *Enc_Fault_Stall_Speed* for *Enc_Fault_Stall_Time* and *Brake_Command* is zero and *Throttle_Command* is active. – For Speed and Torque Modes, current is greater than 90 percent of available. – For Direct Torque Mode, torque request is greater than 90 percent.	1. Stalled motor. 2. Motor encoder failure. 3. Bad crimps or faulty wiring. 4. Problems with power supply for the motor encoder. 5. See Programmer »System Monitor menu » AC Motor » Motor RPM.	*Set:* No motor encoder movement detected. *Clear:* Either *Reset Controller,* or if parameter LOS Upon Encoder Fault = On and Interlock has been cycled, then the Stall Detected fault is cleared and the Encoder LOS fault (flash code 9-3) is set, allowing limited motor control.	*ShutdownEMBrake* *ShutdownMotor* Control Mode changed to LOS (Limited Operating Strategy). Dual Drive This Motor: *SevereDual* *ShutdownMotor* Other Motor: *SevereDual* *LOSDual* *TrimDisable*
7-7 0x77	**Supervision** *Supervision* 0x2840 Fault Type(s): 1-4 = Primary Init Error 10 = Primary Task Queue Check 12 = Primary ALU Check 13 = Primary Message Watchdog 100-103 = Supervisor Init Error 104-108 = Supervisor Write Error 109 = Supervisor Task Queue Check 110 = Supervisor ALU Check 111 = Supervisor Message Watchdog 113-118 = Supervisor Firmware Update Failure 119 = Supervisor CRC Check	Internal controller fault.	*Set:* Internal controller failure. *Clear: Reset Controller.*	ShutdownAll: *ShutdownMotor* *ShutdownMainContactor* *ShutdownEMBrake* *ShutdownThrottle* *ShutdownInterlock* *ShutdownDriver1* *ShutdownDriver2* *ShutdownDriver3* *ShutdownDriver4* *ShutdownDriver5* *ShutdownDriver6* *ShutdownDriver7* *ShutdownPD* *FullBrake* *ShutdownPump* *ShutdownCoilSupply* *ShutdownVehicle* *RequestTractionStop* *ShutdownLower* *ShutdownLift* *TrimDisable (Dual Drive)* *SevereDual (Dual Drive)* *LOSDual (Dual Drive)* Dual Drive Same, both motors

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FLASH CODE	FAULT NAME (Curtis Integrated Toolkit™)	POSSIBLE CAUSES	SET/CLEAR CONDITIONS	FAULT ACTIONS
7-9 0x79	**Supervision Input Check** *Supervision_Input_Check* 0x2841 Fault Type(s): 1	Internal controller fault.	*Set:* Damaged Controller. *Clear: Reset Controller.*	ShutdownAll: *ShutdownMotor* *ShutdownMainContactor* *ShutdownEMBrake* *ShutdownThrottle* *ShutdownInterlock* *ShutdownDriver1* *ShutdownDriver2* *ShutdownDriver3* *ShutdownDriver4* *ShutdownDriver5* *ShutdownDriver6* *ShutdownDriver7* *ShutdownPD* *FullBrake* *ShutdownPump* *ShutdownCoilSupply* *ShutdownVehicle* *RequestTractionStop* *ShutdownLower* *ShutdownLift* *TrimDisable (Dual Drive)* *SevereDual (Dual Drive)* *LOSDual (Dual Drive)* Dual Drive Same, both motors
8-2 0x82	**PDO Mapping Error** *PDO_Mapping_Error* 0x2542 Fault Type(s): 1	1. The PDO Map has too many data bytes assigned or has objects mapped that are not compatible. 2. Adjust PDO Settings. See Programmer » Application Setup » CAN Interface » PDO Setups.	*Set:* Incorrect PDO map detected. *Clear: Reset Controller.*	PDO message disabled. Fault Action: None, unless a fault action is programmed in VCL. Dual Drive Same, both motors
8-3 0x83	**Internal Hardware** *Internal_Hardware* 0x2835 Fault Type(s): Curtis hardware code.	Internal controller fault detected.	*Set:* Internal controller fault detected. *Clear: Reset Controller.*	ShutdownVehicle: *ShutdownMotor* *ShutdownMainContactor* *ShutdownEMBrake* *ShutdownThrottle* *FullBrake* *ShutdownPump* *ShutdownCoilSupply* Dual Drive Same, both motors
8-4 0x84	**Motor Braking Impaired** *Motor_Braking_Impaired* 0x211A Fault Type(s): 1	Motor braking was impaired beyond a safe threshold. 1. Battery overcharged. 2. Excessive motor or controller heating. 3. Misadjusted parameters.	*Set:* OverallCutback (0x32D9) fell below *Motor_Braking_Impaired_Threshold* for *Motor_Braking_Impaired_Time* during regen (braking). *Clear:* Reset interlock.	ShutdownInterlock: Dual Drive This Motor: *ShutdownMotor* *SevereDual* Other Motor: *TrimDisable* *SevereDual* *LOSDual*

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<table>
<tr><th>FLASH CODE</th><th>FAULT NAME (Curtis Integrated Toolkit™)</th><th>POSSIBLE CAUSES</th><th>SET/CLEAR CONDITIONS</th><th>FAULT ACTIONS</th></tr>
<tr><td rowspan="3">8-7
0x87</td><td rowspan="2">Motor Characterization Error
Motor_Characterization
0x2850</td><td>Motor characterization failed during characterization process. The fault type indicates the cause.</td><td>Set: Motor characterization failed during the motor characterization process.
Clear: Reset Controller.</td><td rowspan="2">ShutdownVehicle:

ShutdownMotor
ShutdownMainContactor
ShutdownEMBrake
ShutdownThrottle
FullBrake
ShutdownPump
ShutdownCoilSupply

Dual Drive
Same, both motors</td></tr>
<tr><td colspan="2">Type 84:
During commissioning, if the Type 84 fault occurs, check that the Sin/Cos signal voltages at their maximums and minimums have differences less than 78 mV. (i.e., that |Sinmax Δ Cosmax| < 78 mV and the |Sinmin Δ Cosmin| < 78 mV). If the differences are greater than 78 mV (e.g., 100 mV), it will trigger the Type 84 fault and abort the motor characterization routine.

Types are also listed in Chapter 6, Table 6-2.</td></tr>
<tr><td colspan="4">Fault Type(s):
71 Failure to determine encoder pulses. Must be set manually.
72 Temp sensor fault.
73 Motor hot.
74 Controller temperature cutback.
76 Undervoltage cutback.
77 Overvoltage cutback.
78 Encoder not reading properly.
79 Current Regulator Tuning out of range.
80 Current Regulator Tuning out of range.
81 Encoder signal seen but step size not auto-detected, it must be set manually.
82 Aborted commissioning.
83 Sensor signal too noisy for characterization.
84 Motor not rotating, Sin/Cos sensor voltages out of spec, or Multiturn Sensor setting incorrect.
85 Sensor signal too noisy for characterization.
86 Sin/Cos sensor missing or sensor voltage out of range.
87 PMAC Motor Type must be set before commissioning.
88 PMAC motor fell to zero speed, check your system for excessive friction or loading, retry with a higher test speed, or consult Curtis.
91 PMAC motor not rotating or motor type incorrect.
92 PMAC motor not accelerating. Low acceleration.
93 Started motor characterization while motor was spinning.
94-98 PMAC lag compensation out of range.
99 PMAC motor not accelerating. Low acceleration.
102 PMAC motor temp sensor.
103 PMAC motor temp hot cutback.
104 PMAC controller temp cutback.
106 PMAC undervoltage cutback.
107 PMAC overvoltage cutback.
108 Commissioning stopped by user.
500 The Hall patterns do not match the pattern table during refining process.
501 Hall patterns and angles are not consistent during rebuilding of sectors in reverse direction.
502 The rebuilt angle in reverse direction does not align to the calibrated angle.
503 Hall patterns and angles are not consistent during rebuilding of sectors in forward direction.
504 The rebuilt angle in forward direction does not align to the calibrated angle.
504 The controller does not get enough Hall switch pulses.
505 The Hall switch patterns are not consistent.
506 Invalid patterns are detected.</td></tr>
</table>

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FLASH CODE	FAULT NAME (Curtis Integrated Toolkit™)	POSSIBLE CAUSES	SET/CLEAR CONDITIONS	FAULT ACTIONS
8-8 0x88	**Encoder Pulse Error** *Encoder_Pulse_Error* 0x2234 Fault Type(s): 1	1. Encoder Steps parameter does not match the actual motor encoder. 2. Verify parameter settings: AC Motor Setup » Quadrature Encoder » Encoder Steps.	*Set:* Detected wrong setting of the Encoder Steps parameter. *Clear:* Ensure the Encoder Steps parameter matches the actual encoder. *Reset Controller.*	ShutdownVehicle: *ShutdownMotor* *ShutdownMainContactor* *ShutdownEMBrake* *ShutdownThrottle* *FullBrake* *ShutdownPump* *ShutdownCoilSupply* Dual Drive Same, both motors
8-9 0x89	**Parameter Out of Range** *Parameter_Out_Of_Range* 0x2811 Fault Type(s): Reports the CAN Object ID of parameter.	1. Parameter value detected outside of the limits. 2. Use CIT or the 1313 HHP to view the parameter's range and adjust the parameter's value.	*Set:* Parameter detected outside of limits. *Clear:* Bring parameter within its limits.	ShutdownVehicle: *ShutdownMotor* *ShutdownMainContactor* *ShutdownEMBrake* *ShutdownThrottle* *FullBrake* *ShutdownPump* *ShutdownCoilSupply* Dual Drive Same, both motors
9-1 0x91	**Bad Firmware** *Bad_Firmware* 0x2815 Fault Type(s): 1	The firmware in the controller is incorrect. 1. The CRC of the application or OS does not match. 2. The application was built with an incompatible OS version.	*Set:* The loaded software is not compatible with the controller hardware. *Clear:* Load the matching software. Verify that the controller model matches the cdev version for the project and the CIT VCL Studio application.	ShutdownAll: *ShutdownMotor* *ShutdownMainContactor* *ShutdownEMBrake* *ShutdownThrottle* *ShutdownInterlock* *ShutdownDriver1* *ShutdownDriver2* *ShutdownDriver3* *ShutdownDriver4* *ShutdownDriver5* *ShutdownDriver6* *ShutdownDriver7* *ShutdownPD* *FullBrake* *ShutdownPump* *ShutdownCoilSupply* *ShutdownVehicle* *RequestTractionStop* *ShutdownLower* *ShutdownLift* *TrimDisable (Dual Drive)* *SevereDual (Dual Drive)* *LOSDual (Dual Drive)* Dual Drive Same, both motors

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FLASH CODE	FAULT NAME (Curtis Integrated Toolkit™)	POSSIBLE CAUSES	SET/CLEAR CONDITIONS	FAULT ACTIONS
9-2 0x92	**EM Brake Failed To Set** *EM_Brake_Failed_to_Set* 0x2321 Fault Type(s): 1 = Vehicle movement sensed after the EM Brake has been commanded to set. 2 = Vehicle movement more than EM_Brake_Test_ Threshold sensed during EM Brake Test. 3 = Vehicle not reaching 90% of the requested torque target, forward direction. 4 = Vehicle not reaching 90% of the requested torque target, reverse direction.	1. Vehicle movement sensed after the EM Brake has been commanded to set. 2. EM Brake will not hold the motor from rotating.	*Set:* After the EM Brake was commanded to set and time has elapsed to allow the brake to fully engage, vehicle movement has been sensed. *Clear:* Cycle KSI	Position Hold is engaged when Interlock = On. Fault Action: None, unless a fault action is programmed in VCL. Dual Drive Same, both motors
9-3 0x93	**Encoder LOS** *Encoder_LOS* 0x2233 Fault Type(s): 1	1. Limited Operating Strategy (LOS) control mode has been activated as a result of either an Encoder Fault (flash code 3-6) or a Stall Detected fault (flash code 7-3). 2. Motor encoder failure. 3. Bad crimps or faulty wiring. 4. Vehicle has stalled.	*Set:* Either the Encoder Fault (flash code 3-6) or Stall Detected (flash code 7-3) was detected. If the parameter LOS Upon Encoder Fault = On and the Interlock has been cycled, then the Encoder LOS (flash code 9-3) control mode is activated, allowing limited motor control (limp home mode). *Clear:* Cycle KSI or, if LOS Mode was activated by the Stall Detected fault, clear by ensuring the encoder senses the proper operation, Motor RPM = 0, and Throttle Command = 0.	LOS Mode Fault Action: None, unless a fault action is programmed in VCL. Dual Drive Same, both motors
9-4 0x94	**Emer Rev Timeout** *Emer_Rev_Timeout* 0x2330 Fault Type(s): 1	1. Emergency Reverse was activated and concluded because the EMR Timeout timer expired. 2. The emergency reverse input is stuck On.	*Set:* Emergency Reverse was activated and ran until the EMR Timeout timer expired. *Clear:* Turn the emergency reverse input (switch) to Off.	*ShutdownThrottle* *ShutdownEMBrake* Dual Drive Same, both motors
9-6 0x96	**Pump BDI** *Pump_BDI* 0x2450 Fault Type(s): 1	1. The BDI is below the *Lift_BDI_ Lockout* setting. 2. BDI parameters are mistuned.	*Set:* Pump deactivated when BDI Percentage below Lift lockout setting. *Clear:* Charge Battery; Cycle KSI.	No Fault Action. Yet, the pump is deactivated. Dual Drive Same, both motors

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FLASH CODE	FAULT NAME (Curtis Integrated Toolkit™)	POSSIBLE CAUSES	SET/CLEAR CONDITIONS	FAULT ACTIONS
9-9 0x99	**Parameter Mismatch** *Parameter_Mismatch* 0x2812	1. A parameter with the [PCF] label was changed. 2. Incorrect position feedback type chosen for motor technology in use. 3. Dual drive is enabled in torque mode. 4. Dual drive enabled on only one controller. **Note:** There are two conditions that can set that Parameter_Mismatch type 4. 1. When in the Torque mode simplified, direct torque mode, servo mode or generator mode then the EM Brake type must be = 0. 2. If have an EM Brake type other that 0 with a PMAC motor and EM_ Brake Set Upon Fault is set to 0.	*Set:* Two or more parameter settings conflict and cannot both be honored. *Clear:* Adjust parameters to appropriate values and then *Reset Controller*. Cycle KSI.	ShutdownVehicle: *ShutdownMotor* *ShutdownMainContactor* *ShutdownEMBrake* *ShutdownThrottle* *FullBrake* *ShutdownPump* *ShutdownCoilSupply* Dual Drive Same, both motors

Fault Type(s):

0) Dual Drive is set up incorrectly. Speed Mode or Speed Mode Express must be used, EM Brake Type must be 2, *Dual_Drive_Mode_Type* must be 1. Dual DC Motor Technology does not support AC dual drive.
4) EM Brake type must be 0 for selected control mode and motor technology.
5) Interlock Brake Control Mode is invalid.
6) PMAC Short Circuit Current if *PMAC_Short_Circuit_Current* set above *Base_Current_Limit* in a non-test mode.
7) In a differential steer system, fault actions are misconfigured.
8) Dual motor type must be Differential.
9) PMAC EMF Restriction — In a PMAC application configured for restricted mode operation, the back EMF per speed value is not configured.
10) PMAC Release — A restricted and test mode for PMAC is being used in released software.
11) Torque preload is configured to be saved across key-cycles, but EM Brake preload torque is not set.
12) Invalid Torque Estimate — Configured torque estimation type is incompatible with the selected “Direct Torque” control mode.
13) Command Map Stop — [STEERING] *CommandMapLeftStop* or *CommandMapRightStop* equals zero.
14) [STEERING] Improper sequence of the redundant Command Analog map points.
15) Analog Feedback Maps — [STEERING] Primary or Secondary Analog Feedback maps do not have continuous slope.
16) Sawtooth Command — [STEERING] For Sin/Cos or Sawtooth Command device selection, the primary and secondary types do not match.
17) Sawtooth Feedback — [STEERING] For Sin/Cos or Sawtooth Feedback device selection, the primary and secondary types do not match.
18) Feedback Type — [STEERING] Autocenter is declared as Never and the feedback device type is a relative position device type.
19) Interlock braking supervision must be enabled in PMAC if interlock braking is on.
20) The selected motor type has not been fully characterized and should only be used for development.
21) *R_sys* did not commission properly, contact CCA support.
22) Product Data Code not found in database.
23) Incompatible Motor Technology and Control Mode.
24) Invalid Feedback Type for selected Motor Technology.
25) External supply max current set above hardware limit.
26) Metric off in servo mode.
27) EM brake enabled in servo mode.
28) Travel control supervision not supported in selected control mode.
29) HPD enabled in servo mode.
30) Dual drive enabled in servo mode.

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FLASH CODE	FAULT NAME (Curtis Integrated Toolkit™)	POSSIBLE CAUSES	SET/CLEAR CONDITIONS	FAULT ACTIONS
9-9 0x99	31) Emergency reverse enabled in servo mode. 32) Selected control mode is incompatible with controller model. 33) Selected Feedback Type is incompatible with controller model. 34) Emergency Reverse not supported for Motor Technology. 35) Selected encoder power source is not enabled. 36) Interlock Braking selected in torque mode. 37) There are duplicated patterns in Switch Hall Pattern table. 38) External supply type is not supported. 39) Supervisor or Primary input has not been assigned to the appropriate input. 100) Parameter Integrity.			
9-10 0x9A	**Interlock Braking Supervision** *Interlock_Braking_Supervision* 0x2332 Fault Type(s): 1 = MotorSpeed did not ramp down fast enough to meet configuration (set by *Interlock_Brake_Supervision_Ramp_Delay* and *Interlock_Brake_Superivsion_Ramp_Rate*). 2 = Vehicle brought to stop, but then EM brake (if configured) failed to set. 3 = Vehicle brought to stop, but then traversed a distance beyond that set by *Interlock_Brake_Supervision_Position_Settling_Limit*.	1. For 1, ramp rate/time set too conservatively (needs to be set for worst case braking (full load) to prevent false trip). 2. The vehicle could have a full battery due to which regen is limited and cannot decelerate fast enough. 3. For 2, check EM Brake for failures/wear.	*Set:* The interlock brake supervision function, when enabled, monitors the vehicle speed during interlock braking to ensure the vehicle is decelerating and stops within the stopping distance. *Clear: Reset Controller.*	*ShutdownMotor* *ShutdownEMBrake* *ShutdownMainContactor* Dual Drive Same, both motors
9-11 0x9B	**EMR Supervision** *Emr_Supervision* 0x2333 Fault Type(s): 1	1. During an EMR event, the motor speed exceeded the limit set by the Emergency Reverse Supervision parameters. 2. See Programmer » Application Setup » Emergency Reverse » Emergency Reverse Supervision.	*Set:* During an EMR event, the motor speed exceeded the limit set by the Emergency Reverse Supervision parameters. *Clear: Reset Controller.*	*ShutdownMotor* *ShutdownEMBrake* *ShutdownMainContactor* Dual Drive Same, both motors

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FLASH CODE	FAULT NAME (Curtis Integrated Toolkit™)	POSSIBLE CAUSES	SET/CLEAR CONDITIONS	FAULT ACTIONS
10-1 0xA1	**Driver 1 Fault** *Driver_1_Fault* 0x2160 Fault Type(s): 1 = Driver current exceeded hardware limits. 2 = Driver current exceeded configured overcurrent limits. 3 = Driver commanded PWM active, using diagnostic pulses. Voltage measured high, should be low. Typically caused by driver failure, or driver pin short to high. 4 = Driver commanded PWM active, using diagnostic pulses. Voltage measured low, should be high. Either open circuit, or driver pin short to ground. 5 = Driver commanded PWM is 0, and voltage measured low (should be high). Either open circuit, or driver pin short to ground. 6 = Driver current DC offset out of range. 7 = Driver undercurrent - Monitored current is below undercurrent threshold. 8 = Driver following - Driver in current control is not within error bounds. Fault types 1-2 are always checked. Fault types 3-5 are only checked if driver checks are enabled.	1. Open or short on driver load. 2. Dirty connector pins at controller or contactor coil. 3. Bad connector crimps or faulty wiring. 4. Driver overcurrent, as set by the Driver 1 Overcurrent parameter. 5. See Programmer » Controller Setup » Outputs » Driver 1 » Driver 1 Overcurrent.	*Set:* Driver 1 is either open or shorted, or Driver 1 exceeded its overcurrent setting. *Clear:* Correct the open or short, and then *Reset Controller.*	Use the variable *System_Action* (0x4E00) to determine the fault_ action(s). See Fault Actions section and Table 7-2. Dual Drive Same, both motors
10-*X* 0xA*X*	**Driver *X* Fault** *Driver_X_Fault* 0x2161 Fault Type(s): See Driver 1 *X* = 2-7 2 = 0x2161 3 = 0x2162 4 = 0x2163 5 = 0x2164 6 = 0x2165 7 = 0x2166	See Driver 1	See Driver 1	See Driver 1
10-8 0xA8	**Driver Assignment** *Driver_Assignment* 0x2632 Fault Type(s): 5 {X} = Driver number that caused the fault.	1. A Driver Output is used for two or more functions. 2. See Programmer » Controller Setup » IO Assignments » Coil Drivers: Main Contactor Driver, EM Brake Driver, Hydraulic Contactor Driver.	*Set:* Driver assignment conflict (i.e., duplicate items assigned to the same driver). *Clear:* Resolve the conflicted driver assignment, then *Reset Controller.*	Fault Action: None, unless a fault action is programmed in VCL. Dual Drive Same, both motors

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FLASH CODE	FAULT NAME (Curtis Integrated Toolkit™)	POSSIBLE CAUSES	SET/CLEAR CONDITIONS	FAULT ACTIONS
10-9 0xA9	**Coil Supply** *Coil_Supply_Fault* 0x2169 Fault Type(s): 1 = Short to B- or hardware fault. 2 = One or more drivers that have the drivers checks configured as "Safety Designated" did not shut down when commanded to do so. 3 = Coil Supply startup enable check failed. 4 = Coil Supply startup disable check failed.	1. Short on driver loads. 2. Shorted to B+/KSI/external voltage source at startup or runtime. 3. A driver load may be wired to an external source, not coil supply, being supplied during startup checks. 4. Dirty connector pins at controller or device. 5. Bad connector crimps or faulty wiring. 6. Controller is defective. **Note:** 1. When using a driver as a switch input (i.e., a switch to KSI/B+), if the Driver input has the switch applied (KSI/B+) at startup/power-on, it will trigger a Type 4 fault. 2. If the driver (as a switch) is connected to an external B+ voltage (within the model's voltage range), such a condition at startup/power-on, it will trigger a Type 4 fault. Either method allows power to feed through the driver pin and the flyback diode back to the coil supply, causing the coil supply startup check to fail. It will also defeat the safety aspect of turning off the Coil Supply in a safety related fault condition.	*Set:* Short detected after the startup check has passed. A low side driver short is detected and the respective fault action fails to cut off driver current. Coil supply startup test fails. *Clear: Reset Controller.*	ShutdownAll: *ShutdownMotor* *ShutdownMainContactor* *ShutdownEMBrake* *ShutdownThrottle* *ShutdownInterlock* *ShutdownDriver1* *ShutdownDriver2* *ShutdownDriver3* *ShutdownDriver4* *ShutdownDriver5* *ShutdownDriver6* *ShutdownDriver7* *ShutdownPD* *FullBrake* *ShutdownPump* *ShutdownCoilSupply* *ShutdownVehicle* *RequestTractionStop* *ShutdownLower* *ShutdownLift* *TrimDisable (Dual Drive)* *SevereDual (Dual Drive)* *LOSDual (Dual Drive)* Dual Drive Same, both motors
11-1 0xB1	**ANALOG 1 OUT OF RANGE** *Analog_1_Out_Of_Range* 0x2620 Analog_X_Out_of_Range Fault Type(s): 1 = Above High limit. 2 = Below Low limit.	1. Analog 1 input voltage is above the parameter setting of Analog 1 High. 2. Analog 1 input voltage is below the parameter setting of Analog 1 Low. 3. See Programmer » Controller Setup » Inputs » Analog 1. 4. See Programmer » Controller Setup » Inputs » Configure » Analog 1 Low / Analog 1 High.	*Set:* (1) Input voltage (on pin) is above the parameter's set-point threshold. (2) Input voltage (on pin) is below the parameter's set-point threshold. *Clear:* Return the voltage to within the allowed range, then *Reset Controller.*	Fault Action: None, unless a fault action is programmed in VCL. Dual Drive Same, both motors
11-2 0xB2	**ANALOG 2 OUT OF RANGE** *Analog_2_Out_Of_Range* 0x2621	See Analog 1 Out of Range.	See Analog 1 Out of Range.	See Analog 1 Out of Range.
11-3 0xB3	**ANALOG 3 OUT OF RANGE** *Analog_3_Out_Of_Range* 0x2622	See Analog 1 Out of Range.	See Analog 1 Out of Range.	See Analog 1 Out of Range.
11-4 0xB4	**ANALOG 4 OUT OF RANGE** *Analog_4_Out_Of_Range* 0x2623	See Analog 1 Out of Range.	See Analog 1 Out of Range.	See Analog 1 Out of Range.
11-5 0xB5	**ANALOG 5 OUT OF RANGE** *Analog_5_Out_Of_Range* 0x2624	See Analog 1 Out of Range.	See Analog 1 Out of Range.	See Analog 1 Out of Range.
11-6 0xB6	**ANALOG 6 OUT OF RANGE** *Analog_6_Out_Of_Range* 0x2625	See Analog 1 Out of Range.	See Analog 1 Out of Range.	See Analog 1 Out of Range.

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FLASH CODE	FAULT NAME (Curtis Integrated Toolkit™)	POSSIBLE CAUSES	SET/CLEAR CONDITIONS	FAULT ACTIONS
11-7 0xB7	**ANALOG 7 OUT OF RANGE** *Analog_7_Out_Of_Range* 0x2626	See Analog 1 Out of Range.	See Analog 1 Out of Range.	See Analog 1 Out of Range.
11-8 0xB8	**ANALOG 8 OUT OF RANGE** *Analog_8_Out_Of_Range* 0x2627	See Analog 1 Out of Range.	See Analog 1 Out of Range.	See Analog 1 Out of Range.
11-9 0xB9	**ANALOG 9 OUT OF RANGE** *Analog_9_Out_Of_Range* 0x2628	See Analog 1 Out of Range.	See Analog 1 Out of Range.	See Analog 1 Out of Range.
11-11 0xBB	**ANALOG 14 OUT OF RANGE** *Analog_14_Out_Of_Range* 0x262A	See Analog 1 Out of Range.	See Analog 1 Out of Range.	See Analog 1 Out of Range.
11-13 0xBD	**Analog 18 Out of Range** *Analog_18_Out_Of_Range* 0x262B	See Analog 1 Out of Range.	See Analog 1 Out of Range.	See Analog 1 Out of Range.
11-14 0xBE	**Analog 19 Out of Range** *Analog_19_Out_Of_Range* 0x262C	See Analog 1 Out of Range.	See Analog 1 Out of Range.	See Analog 1 Out of Range.
11-12 0xBC	**Analog Assignment** *Analog_Assignment* 0x2631 Fault Type(s): 13 {X = 1-9, 14, 18-19, 31} X = Analog Input number that caused the fault.	1. An Analog input is used for two or more functions (for example, throttle and brake). 2. Analog Inputs are misconfigured for a potentiometer (pot). 3. See Programmer » Controller Setup » IO Assignments » Controls.	*Set:* An Analog input is used for two or more functions or is misconfigured for a potentiometer. *Clear:* Resolve assignment conflict, and then *Reset Controller.*	Fault Action: None, unless a fault action is programmed in VCL. Dual Drive Same, both motors
12-1 0xC1	**Branding Error** *Branding_Error* 0x2860 Fault Type(s): 1	1. Software and hardware branding mismatch. 2. For technical support on this fault, contact the Curtis distributor where you obtained your controller or the Curtis sales-support office in your region.	*Set:* Software/hardware incompatibility. *Clear:* As applicable: Load Branded software, or use Branded controller with the correct device profile and the correct Curtis Software Suite toolkit key.	ShutdownVehicle: *ShutdownMotor* *ShutdownMainContactor* *ShutdownEMBrake* *ShutdownThrottle* *FullBrake* *ShutdownPump* *ShutdownCoilSupply* Dual Drive Same, both motors
12-2 0xC2	**BMS Cutback** *BMS_Cutback* 0x2861 Fault Type(s): 1 = Battery Current Cutback. 2 = Low Cell Cutback. 3 = High Cell Cutback.	A cutback based on cell loading has occurred.	*Set:* See Fault Type. *Clear:* Resolve battery or battery cell issue.	Fault Action: None, unless a fault action is programmed in VCL. Dual Drive Same, both motors

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FLASH CODE	FAULT NAME (Curtis Integrated Toolkit™)	POSSIBLE CAUSES	SET/CLEAR CONDITIONS	FAULT ACTIONS
12-5 0xC5	**PWM Input 10 Out of Range** *PWM_Input_10_Out_Of_Range* 0x2629	1. This fault diagnostic execution cycles every 4 ms. The input is considered disconnected if no PWM signal occurs for 16 ms or the measurements are not updated every 16 ms. 2. Mistuned parameters. 3. Faulty wiring.	*Set:* The input frequency and/or duty cycle on Input 10 exceeds the configured limits set by PWM_Input_10 _x_ Duty_Cycle and PWM_Input_10_x_ Frequency, where x = {Low, High}. *Clear: Reset controller*.	Fault Action: None, unless a fault action is programmed in VCL. Dual Drive Same, both motors
	Fault Type(s): 1. The input is disconnected. 2. The measured input frequency is below the (*PWM_Input_10_Low_Frequency*) – (*PWM_Input_10_Frequency_Fault_Tolerance*). 3. The measured input frequency is above the (*PWM_Input_10_High_Frequency*) + (*PWM_Input_10_Frequency_Fault_Tolerance*). 4. The measured duty cycle is below set limits, (*PWM_Input_10_Low_Duty_Cycle*) – (*PWM_Input_10_Duty_Cycle_Fault_Tolerance*). 5. The measured duty cycle is above set limits, (*PWM_Input_10_High_Duty_Cycle*) + (*PWM_Input_10_Duty_Cycle_Fault_Tolerance*)			
12-7 0xC7	**Analog 31 Out of Range** *Analog_31_Out_Of_Range* 0x2106	See Analog 1 Out of Range.	See Analog 1 Out of Range.	See Analog 1 Out of Range. Dual Drive Same, both motors
12-8 0xC8	**Invalid CAN Port** *Invalid_CAN_Port* 0x2107 Fault Type(s): The condition is checked at startup, (i.e. during the dual drive initialization).	1. Mistuned Dual Drive CAN parameters. 2. Conflicting CAN Node IDs for Dual Drive.	*Set:* This fault is triggered when the Dual CAN Port (*DualMotorCanPort*) parameter is set to a CAN port that does not exist on a controller setup for Dual Drive. *Clear: Reset controller*.	NO ACTION Dual Drive Same, both motors
12-9 0xC9	**VCL Watchdog** *VCL_Watchdog* 0x2108	See the associated VCL Functions, • *Set_Watchdog_Timeout( ).* • *Set_Watchdog_Fault_Action( ).* • *Kick_Watchdog( ).* The fault actions can be defined by the User/OEM in the application-specific VCL software.	*Set:* The time interval of the VCL watchdog (*WD#*) exceeded the timeout value. *Clear: Kick_Watchdog( ).* Start and reset the specified watchdog timer.	NO ACTION Dual Drive Same, both motors
12-11 0xCB	**Primary State Error** *Primary_State_Error* 0x2113	If the fault persists, contact Curtis.	*Set:* These are internal issues either occurring during startup, parameter initialization, secondary micro update or other runtime issues. *Clear: Reset controller.*	NO_ACTION (controller is not operable) Dual Drive Same, both motors
	Fault Type(s): 0 = PRIMARY_DEVICE_STARTUP 1 = PRIMARY_WAIT_KSI_STABLE 2 = PRIMARY_DEVICE_STARTUP_VALID 3 = PRIMARY_INITIALIZE_PARAMETERS 4 = PRIMARY_WAIT_FOR_FIRST_SIGNALS 5 = PRIMARY_WAIT_FOR_SUPERVISOR 6 = PRIMARY_RESTORE_PARAMETER_FAIL 7 = PRIMARY_SUPERVISOR_FIRST_SIGNALS_ERROR 8 = PRIMARY_SUPERVISOR_STARTUP_ERROR 9 = PRIMARY_STARTUP_TIMER_FAILURE 10 = PRIMARY_WAIT_CAN_HANDSHAKING_DONE 11 = PRIMARY_RUNNING			

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FLASH CODE	FAULT NAME (Curtis Integrated Toolkit™)	POSSIBLE CAUSES	SET/CLEAR CONDITIONS	FAULT ACTIONS
12-12 0xCC	**PWM Input 29 Out of Range** *PWM_Input_29_Out_of_Range* 0x210D	1. This fault diagnostic execution cycles every 4 ms. The input is considered disconnected if no PWM signal occurs for 16 ms or the measurements are not updated every 16 ms. 2. Mistuned parameters. 3. Faulty wiring.	*Set:* The input frequency and/or duty cycle on Input 29 exceeds the configured limits set by *PWM_Input_29_x_Duty_Cycle* and *PWM_Input_29_x_Frequency, where x = {Low, High}.* *Clear: Reset Controller.*	Fault Action: None, unless a fault action is programmed in VCL. Dual Drive Same, both motors
	Fault Type(s): 1 = The input is disconnected. 2 = The measured input frequency is below the (*PWM_Input_29_Low_Frequency*) – (*PWM_Input_29_Frequency_Fault_Tolerance*). 3 = The measured input frequency is above the (*PWM_Input_29_High_Frequency*) + (*PWM_Input_29_Frequency_Fault_Tolerance*). 4 = The measured duty cycle is below set limits, (*PWM_Input_29_Low_Duty_Cycle*) – (*PWM_Input_29_Duty_Cycle_Fault_Tolerance*). 5 = The measured duty cycle is above set limits, (*PWM_Input_29_High_Duty_Cycle*) + (*PWM_Input_29_Duty_Cycle_Fault_Tolerance*).			
12-13 0xCD	**PWM Input 28 Out of Range** *PWM_Input_28_Out_of_Range* 0x210C	1. This fault diagnostic execution cycles every 4 ms. The input is considered disconnected if no PWM signal occurs for 16 ms or the measurements are not updated every 16 ms. 2. Mistuned parameters. 3. Faulty wiring.	*Set:* The input frequency and/or duty cycle on Input 28 exceeds the configured limits set by *PWM_Input_28_x_Duty_Cycle* and *PWM_Input_28_x_Frequency, where x = {Low, High}.* *Clear: Reset Controller.*	Fault Action: None, unless a fault action is programmed in VCL. Dual Drive Same, both motors
	Fault Type(s): 1 = The input is disconnected. 2 = The measured input frequency is below the (*PWM_Input_28_Low_Frequency*) – (*PWM_Input_28_Frequency_Fault_Tolerance*). 3 = The measured input frequency is above the (*PWM_Input_28_High_Frequency*) + (*PWM_Input_28_Frequency_Fault_Tolerance*). 4 = The measured duty cycle is below set limits, (*PWM_Input_28_Low_Duty_Cycle*) – (*PWM_Input_28_Duty_Cycle_Fault_Tolerance*). 5 = The measured duty cycle is above set limits, (*PWM_Input_28_High_Duty_Cycle*) + (*PWM_Input_28_Duty_Cycle_Fault_Tolerance*).			
13-1 0xD1	**Lift Input Fault** *Lift_Input* 0x2104 Fault Type(s): 1	The associated fault diagnostic with the assigned lift-input source triggers this fault. For example: If the *Lift_Input_Source* is an analog input, then any faults detected by the respective Input fault diagnostics are cascaded and reported within this fault code. Note: An analog input fault diagnostics may be out of range when set as a voltage input or may include potentiometer faults if configured as a 2/3-wire pot.	*Set:* Faults from the respective/assigned "Lift_Input_Source" are cascaded and reported. *Clear:* Resolve any input assignment conflict, or out of-range faults, then *Reset Controller.*	*ShutdownLift* Dual Drive Same, both motors

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FLASH CODE	FAULT NAME (Curtis Integrated Toolkit™)	POSSIBLE CAUSES	SET/CLEAR CONDITIONS	FAULT ACTIONS
13-2 0xD2	**Phase PWM Mismatch** *Phase_PWM_Mismatch* 0x2101 Fault Type(s): 0 = U phase. 1 = V phase. 2 = W phase.	Internal to Controller Motor Phase PWM.	*Set:* The difference between the commanded phase PWM duty cycle and the measured is greater than allowed. *Clear: Reset Controller.*	ShutdownVehicle: *ShutdownMotor* *ShutdownMainContactor* *ShutdownEMBrake* *ShutdownThrottle* *FullBrake* *ShutdownPump* *ShutdownCoilSupply* Dual Drive Same, both motors
13-3 0xD3	**Hardware Compatibility** *Hardware_Compatibility* 0x2870 Fault Type(s): 1	The OS (device profile, .cdev file) is incompatible with the controller. The loaded software (.cdev) is not compatible with the controller hardware.	*Set:* Incorrect OS (device profile). *Clear:* Load the matching OS (device profile).	ShutdownVehicle: *ShutdownMotor* *ShutdownMainContactor* *ShutdownEMBrake* *ShutdownThrottle* *FullBrake* *ShutdownPump* *ShutdownCoilSupply* Dual Drive Same, both motors
13-4 0xD4	**Lower Input Fault** *Lower_Input* 0x2105 Fault Type(s): 1	The associated fault diagnostic with the assigned lower-input source triggers this fault. For example: If the *Lower_Input_Source* is an analog input, then any faults detected by the respective Input fault diagnostics are cascaded and reported within this fault code. Note: An analog input fault diagnostics may be out of range when set as a voltage input or may include potentiometer faults if configured as a 2/3-wire pot.	*Set:* Faults from the respective/assigned "*Lower_Input_Source*" are cascaded and reported. *Clear:* Resolve any input assignment conflict, or out-of-range faults, *then Reset Controller.*	*ShutdownLower* Dual Drive Same, both motors

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FLASH CODE	FAULT NAME (Curtis Integrated Toolkit™)	POSSIBLE CAUSES	SET/CLEAR CONDITIONS	FAULT ACTIONS
13-6 0xD6	**Hazardous Movement** *Hazardous_Movement* 0x211C Fault Type(s): 1 = The motor speed is in the opposite direction of the speed request and the motor fails to accelerate in the correct direction for a programmed time. In the event of a change to neutral, this hazard will be detected if the motor fails to accelerate toward zero speed for a programmed time. 2 = The acceleration is in the opposite direction of the difference between the operator speed request and the motor speed. The speed in the commanded direction is greater than the commanded speed by more than a parameter (*Hazardous_Speed*) for a programmed time (*Hazardous_Throttle_Response_Time*).	(1) Mistuned *Hazardous_Direction_Response_Time* parameter. (2) Mistuned *Hazardous_Accel* parameter. (2) Mistuned *Hazardous_Speed_Error* parameter. (2) Mistuned *Hazardous_Throttle_Response_Time* parameter.	*Set:* This fault detects hazardous movement when the motor is requested to be moving. The first hazard is a motor that is not able to slow down if the throttle goes to zero or the direction switch is not in the direction of travel. The second hazard is a motor that accelerates the wrong way or goes too fast. Note: This fault only occurs when the Control Mode Select is in *Speed_Mode, Speed_Mode_Express*, or *Servo_Mode*. *Clear: Reset Controller.* Setting *Hazardous_Direction_Response_Time* = 0 will disable these checks.	*ShutdownInterlock* Dual Drive Same, both motors
13-8 0xD8	**Estop Mismatch** *Estop_Mismatch* 0x2892 Fault Type(s): 1 1 = Mismatch Detected.	Wiring Error (incorrect inputs). External Switch (moisture).	*Set:* A mismatch exists between the primary and supervisor micro ESTOP inputs. *Clear:* Mismatch resolved — wiring corrected. Then, Reset controller.	Fault Action: None, unless a fault action is programmed in VCL. Dual Drive Same, both motors
13-9 0xD9	**Estop SRO** *Estop_SRO* 0x2893 Fault Type(s): 1 1 = Fault Detected.	Interlock on when estop is deactivated.	*Set:* Interlock was on when ESTOP transitioned from active to inactive. *Clear:* Interlock Off. Then, Reset controller.	Fault Action: *ShutdownInterlock* *ShutdownPump* *ShutdownLift* *ShutdownLower* Dual Drive Same, both motors
13-10 0xDA	**Lift Limit** *Lift_Limit_Fault* 0x2127 Fault Type(s): 1	1. The associated fault diagnostic with the assigned lift-limit source triggers this fault. For example: If the *Lift_Limit_Source* (0x3C3E) is an analog input, then any faults detected by the respective Input fault diagnostics are cascaded and reported within this fault code. **Note:** An analog input fault diagnostics may be out of range when set as a voltage input or may include potentiometer faults if configured as a 2/3-wire pot.	*Set:* Faults from the respective/assigned "*Lift_Limit_Source*" are cascaded and reported. *Clear:* Resolve any input assignment conflict, or out of range faults, then Reset Controller.	*ShutdownLift* Dual Drive Same, both motors

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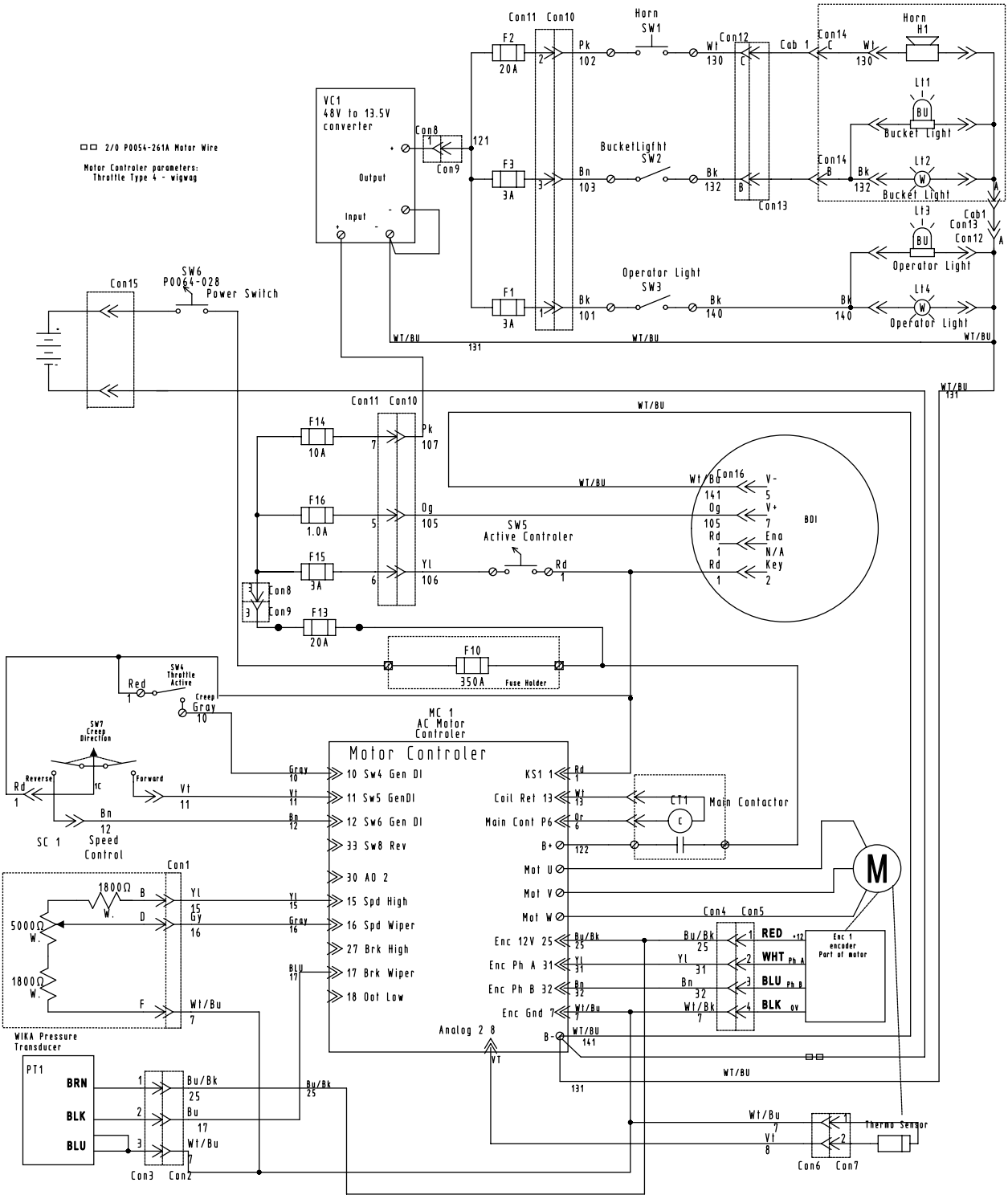
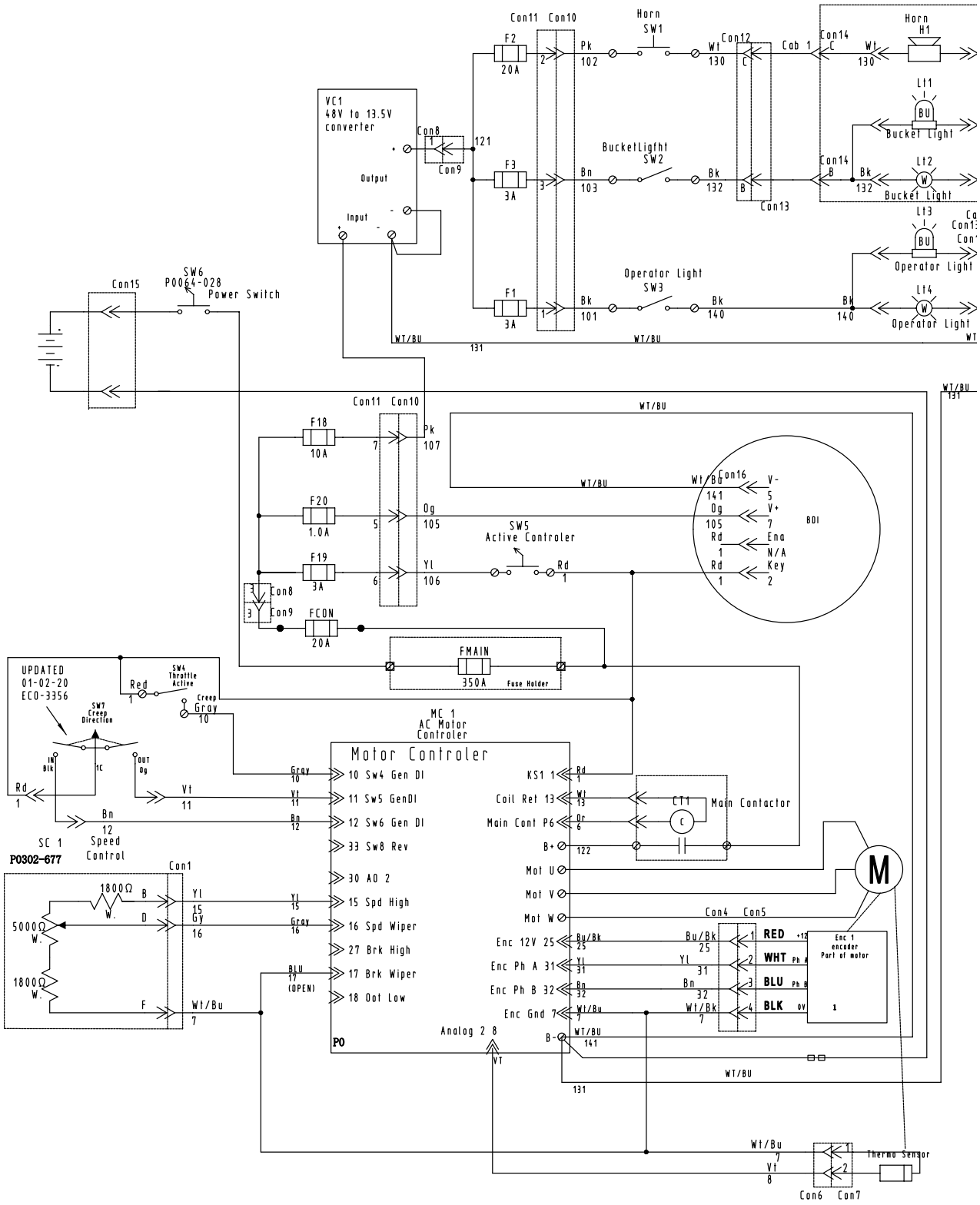
FLASH CODE	FAULT NAME (Curtis Integrated Toolkit™)	POSSIBLE CAUSES	SET/CLEAR CONDITIONS	FAULT ACTIONS
13-13 0xDD	**IMU Failure** *IMU_Failure* 0x2114 Fault Type(s): 1 = SPI Communication Failure. 2 = Curtis Factory Self Test Failure. 3 = Reserved. 4 = Gyro Cal out of range, maximum calibration offset exceeded.	Interlock on when estop is deactivated.	*Set:* Internally set as per fault type. *Clear: Cycle KSI.*	NO_ACTION <u>Dual Drive</u> Same, both motors
15-1 0xF1	**MEMORY PARITY** *MEMORY_PARITY* 0x212A Fault Type(s): 1. PSRAM Memory 2. DSRAM1 Memory 3. DSRAM2 Memory 4. USIC0 Memory 5. USIC1 Memory 6. USIC2 Memory 7. MultiCAN Memory 8. PMU Prefetch Memory 9. USB Memory 10. ETH TX Memory 11. ETH RX Memory 12. SDMMC0 Memory 13. SDMMC1 Memory	1. An electromagnetic transient may have caused a bit to change state. 2. Possible damage to the microcontroller may have caused a memory cell to not operate properly.	*Set:* Fault Type: Indicates in which memory or peripheral the fault occurred. *Clear: Reset Controller.*	<u>ShutdownVehicle:</u> *ShutdownMotor* *ShutdownMainContactor* *ShutdownEMBrake* *ShutdownThrottle* *FullBrake* *ShutdownPump* <u>Dual Drive</u> Same, both motors

NOTES

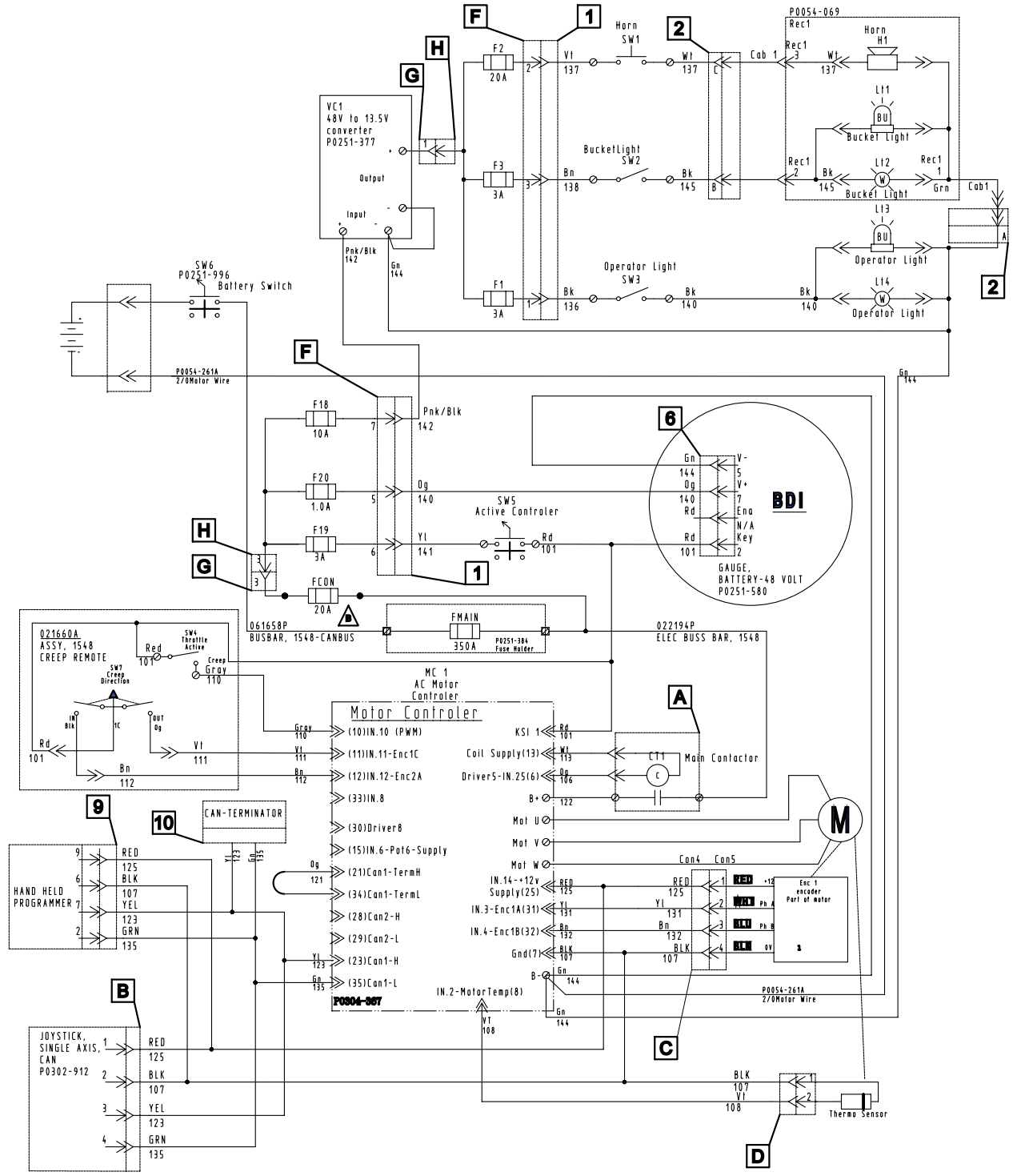
1548 HAUL UNIT ELECTRICAL SCHEMATIC - SN F21700F-11 & BEFORE



1548 HAUL UNIT ELECTRICAL SCHEMATIC - SN F21700F-12 THRU 28



1548 HAUL UNIT ELECTRICAL SCHEMATIC - SN F21700F-29 & AFTER



Specifications

1548 HAUL UNIT

Weight (w/ battery pack) ..... 4,800 lbs. (2,177 kg)
Height ..... 25.875 in. (657 mm)
Length
Standard ..... 142.625 in. (3,623 mm)
Extended ..... 172.625 in. (4,385 mm)

Width ..... 47.625 in. (1,210 mm)

Wheel Base ..... 129.25 in. (3,283 mm)

Drive Wheels ..... Two, 10-in. Diameter

Battery Pack
Weight ..... 1,800 lbs. (816.5 kg)
Voltage ..... 48 VDC

Electrical Horsepower ..... 15 HP (11.2 kW)

Propel ..... Forward, Reverse

Drive Type ..... Electric Driven

Brake
Service Brake .....Hydraulic, Caliper Disc
Parking Brake ..... Cable/Mechanical

Speed*
Feet per minute ..... 750 (228.6 m/min)
Miles per hour ..... 0-8.5 mph (0-13.7 Km/h)

Towing Capacity ..... 20,000 lbs. (9,072 kg)

Gear Box
Oil Capacity ..... 5 qt. (4.7 L)
Oil Type ..... Mobil SHC 626 Synthetic Bearing and Gear Oil

Gross Vehicle Weight ..... 25,000 lbs. (11,340 kg)

Maximum Operating Grade
Unloaded 5%
Loaded 2.5%

Pipe (tunnel) Size
Minimum ..... 60 in. (1524 mm) ID

Track
Track Gage** ..... 20 in. (508 mm)
Base ..... 22.75 in. (578 mm)
Height ..... 3 in. (76 mm)
Length ..... 8 ft. (2.4 m)
** A 24-in. gage track kit is available.

** Contact your Akkerman Aftermarket Support Representative for speed ratings at various haul capacities.*

DIRT BUCKETS

Model	**600**	**660**	**720**	**780**
Height				
in.	38.3	45	41.8	47.7
(mm)	(973)	(1,143)	(1,063)	(1,211)
Width (Dia.)				
in.	55	60.4	64	70
(mm)	(1,397)	(1,534)	(1,626)	(1,778)
Length				
standard				
in.	61	61	61	-
(mm)	(1,549)	(1,549)	(1,549)	-
extended				
in.	90	-	90	90
(mm)	(2,286)	-	(2,286)	(2,286)
Weight				
standard				
lbs.	1,280	1,500	1,570	-
(kg)	(581)	(680)	(712)	-
extended				
lbs.	1,470	-	1,820	2,100
(kg)	(667)	-	(825)	(952)
Capacity				
standard				
cu. yd.	2.3	2.9	2.9	-
(m^3)	(1.7)	(2.2)	(2.2)	-
extended				
cu. yd.	3.5	-	4.4	5.4
(m^3)	(2.6)	-	(3.3)	(4.1)

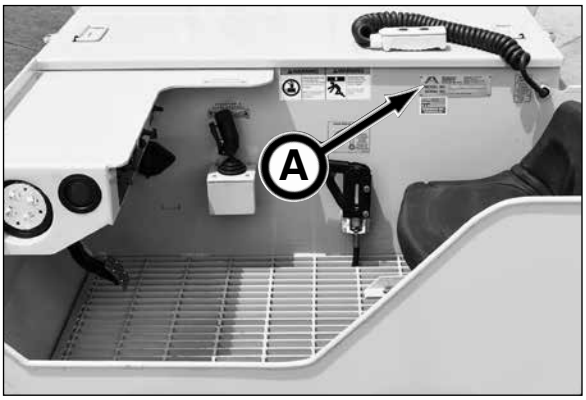
TORQUE CHART

Use these torque values as a guideline when tightening hardware unless otherwise specified in this manual.

Lubricated Coarse UNC Threads Grade 8 Fasteners			**Lubricated Fine UNF Threads Grade 8 Fasteners**		
Bolt Size	**Torque ft. lbs.**	**(N·m)**	**Bolt Size**	**Torque ft. lbs.**	**(N·m)**
1/4 - 20	10	(14)	1/4 - 28	11	(15)
5/16 - 18	20	(27)	5/16 - 24	22	(30)
3/8 - 16	35	(47)	3/8 - 24	39	(53)
7/16 - 14	56	(76)	7/16 - 20	62	(84)
1/2 - 13	85	(115)	1/2 - 20	96	(130)
9/16 - 12	123	(167)	9/16 - 18	137	(186)
5/8 - 11	170	(231)	5/8 - 18	192	(260)
3/4 - 10	301	(408)	3/4 - 16	336	(456)
7/8 - 9	450	(610)	7/8 - 14	500	(678)
1 - 8	680	(922)	1 - 12	740	(1003)
1-1/8 - 7	960	(1302)	1-1/8 - 12	1030	(1397)
1-1/4 - 7	1360	(1844)	1-1/4 - 12	1500	(2034)
1-1/2 - 6	2360	(3200)	1-1/2 - 12	2660	(3607)

Identification Numbers

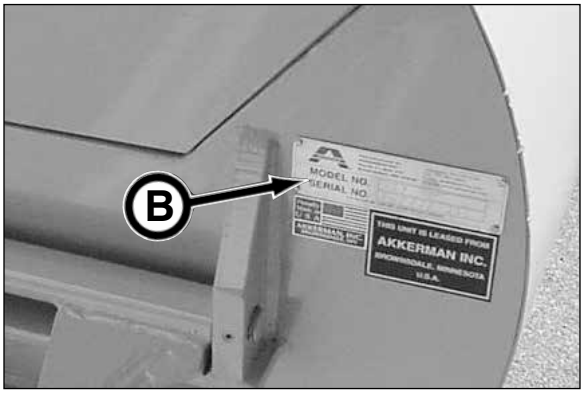
Model and serial numbers are required when ordering parts or requesting service information. Record your model and serial numbers below.



HAUL UNIT (A)

Model Number _____

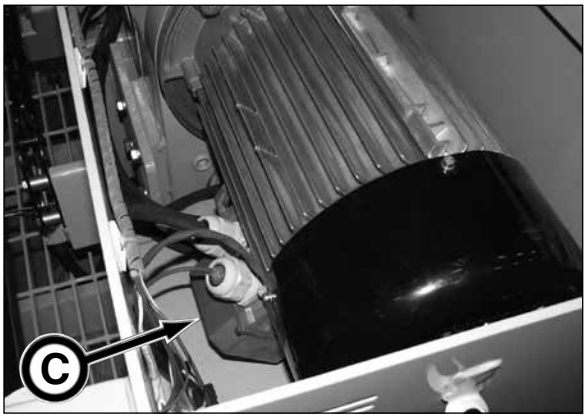
Serial Number _____



DIRT BUCKET (B)

Model Number _____

Serial Number _____



ELECTRIC MOTOR (C)

Model Number _____

Serial Number _____

DRIVE MOTOR CONTROLLER (D)

Model Number _____

Serial Number _____

NOTES

Safety Data Sheets

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

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

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

NOTES

Warranty

Akkerman, Inc. warrants that all equipment manufactured by it be free from defects due to workmanship or material when normally used and serviced for a period of 90 days from the date of shipment by Akkerman, Inc. Normal wear and tear to the equipment, including, but not limited to brakes and wheels are not covered by this warranty. Akkerman, Inc. does not warrant that the equipment meets the requirements of any particular safety code or rule governing equipment classification. If the Customer has questions about local safety codes, rules or ordinances, authorities local to the project should be consulted.

In order to be considered as a potential warranty claim, the components in question must be returned to Akkerman, Inc. (freight prepaid) for factory inspection and analysis, and determination of warranty applicability. No warranty is provided for electronics or electrical components of any kind. The validity of all warranty claims are subject to the discretion and determination of the Akkerman Aftermarket Support Department. All such determinations are final.

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