Switched Reluctance (SR) Drive System Safety

Section 06-03-01

Komatsu has made every effort to make this manual as accurate as possible based on the information available at the time of publication and printing. Continuous improvement and advancement of product design may cause changes to machines, which may not have been included in this publication. Komatsu reserves the right to make changes and improvements at any time. To ensure the most current information, please contact your service center.

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Safety

This publication contains special instructions that pertain to safety, operation, maintenance, and repair of the machine. Listed below are the signal words and symbols that precede these instructions and their meanings:

⚠ DANGER

- **The danger label indicates a hazardous situation which, if not avoided, will result in death or serious injury.**

⚠ WARNING

- **The warning label indicates a hazardous situation which, if not avoided, could result in death or serious injury.**

⚠ CAUTION

- **The caution label, used with the safety alert symbol indicates a hazardous situation which, if not avoided, could result in minor or moderate injury (includes the safety alert symbol ⚠).**

CAUTION

- **The caution label (without safety alert symbol) is used to address practices not related to personal injury – only equipment damage.**

NOTICE

The NOTICE graphic is to indicate areas of importance to the reader that are not related to personal injury or machine damage.

Safety, Warnings and Cautions

It is important that all personnel read and understand all CAUTIONS and WARNINGS before operating or working on or near the machine.

⚠ WARNING

ELECTRICAL SHOCK

- **Risk of shock or injury by contact in the electrical cabinet, axles, or at the braking grids is possible. Converter Bus voltage of up to 750VDC can be present in the electrical cabinet and axle areas, and up to 375VDC at the braking grids when the engine is running or the LINCS software indicates voltage on the bus, or the red bus LED's in the electrical cabinet are illuminated. Do not enter or touch any components in the electrical cabinet, do not remove the axle covers or enter the axle area, and do not open the door over the braking grids or touch anything on the grids if the engine is running or the LINCS software indicates voltage on the bus, or the red bus LED's in the electrical cabinet are illuminated. Perform the Bus Discharge Verification Procedure before entering the**

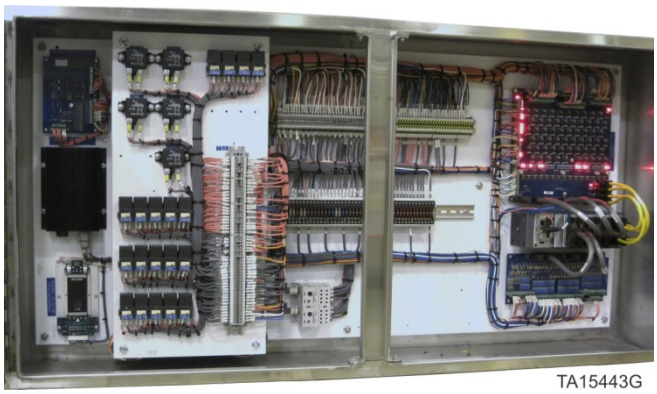
electrical cabinet, axle housing, or the braking grid enclosure. Failure to do so may result in shock or other injury.

- **Risk of fatal shock or injury by contact in the electrical cabinet is possible if the engine is running, the LINCS software indicates voltage on the bus, or the red bus LED's in the electrical cabinet are illuminated. All SR equipment has the ability to produce voltage at low throttle. Even with the engine off, there may be a residual of 12-15VDC on the bus. Do not enter the electrical cabinet or touch any components in the electrical cabinet without performing the Bus Discharge Verification Procedure. Failure to do so may result in fatal electrical shock or other injury.**
- **Risk of shock or equipment damage by use of an improperly rated meter is possible. Use a CAT III 1000V rated volt meter to take voltage readings. Shock or other injury may result from using improperly rated test equipment.**
- **Risk of shock or injury by contact of the braking grids is possible. Do not open the door over the braking grids or touch anything on the grids when the engine is running or the converter panel bus LED's are glowing red in the electrical cabinet. Do not touch or enter these areas unless the engine has been shut down and the bus discharge procedure has been followed. Failure to do so may result in shock or other injury.**

Switched Reluctance (SR) Drive System Safety

NOTICE

Instructions and data contained herein are applicable to the machines with switched reluctance motors and drive system.



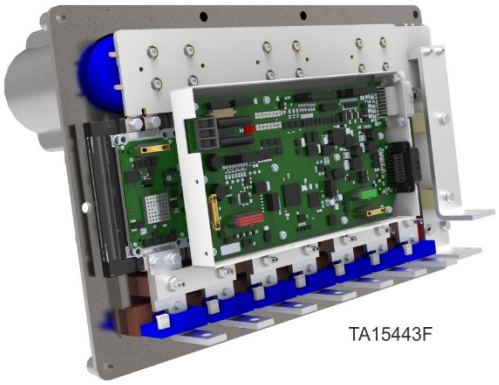


Figure 1. SR drive electrical components

CAUTION

The diagnostic and repair procedures contained in this publication may require the removal and installation of cards or assemblies. Removal or installation of any card or assembly with the key switch ON may result in an arc or a short to the components resulting in damage ruining the electronics. Place the key switch in the OFF position and wait for the VCU (Vehicle Control Unit) to power down before attempting repair or replacement of any card or component. This caution must be adhered to without exception to avoid component damage.

⚠ WARNING

Risk of shock or injury by contact in the electrical cabinet, axles, or at the braking grids is possible. Converter Bus voltage of up to 750VDC can be present in the electrical cabinet and axle areas, and up to 375VDC at the braking grids when the engine is running or the LINCS software indicates voltage on the bus, or the red bus LED's in the electrical cabinet are illuminated. Do not enter or touch any components in the electrical cabinet, do not remove the axle covers or enter the axle area, and do not open the door over the braking grids or touch anything on the grids if the engine is running or the LINCS software indicates voltage on the bus, or the red bus LED's in the electrical cabinet are illuminated. Perform the Bus Discharge Verification Procedure before entering the electrical cabinet, axle housing, or the braking grid enclosure. Failure to do so may result in shock or other injury.

NOTICE

The converter panel has several circuits with red LED's that will either be constantly illuminated, flashing, or off. The bus voltage LED's are distinct by the high intensity.

NOTICE

Under normal operating conditions the bus will almost instantly discharge once the machine has been shut down. However, under some fault conditions, the bus discharge circuit may become damaged. Under these conditions, bus discharge may require a longer period of time.

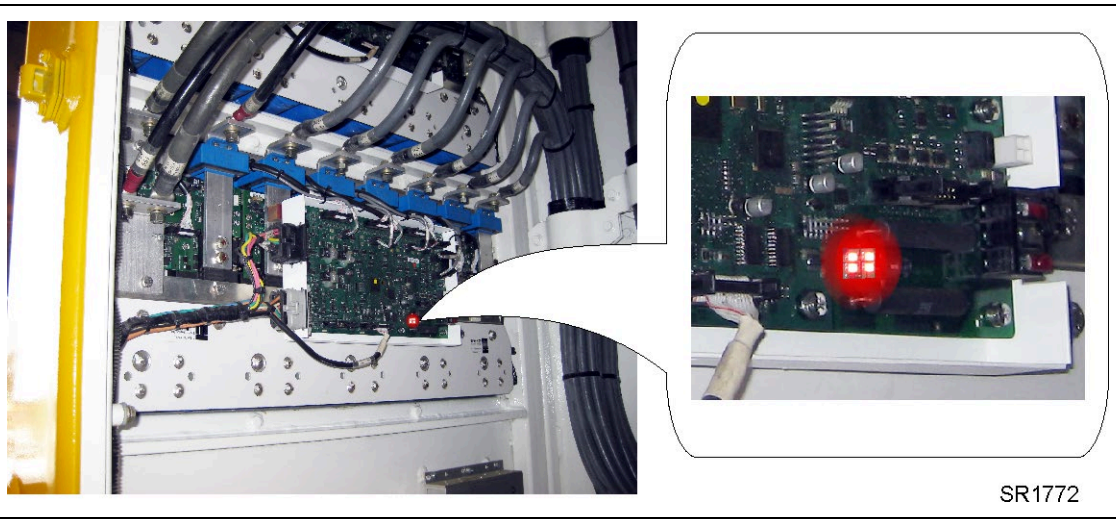


Figure 2. Converter bus LED lights

Bus Discharge Verification Procedure

Safety Preparations

Converter Bus Voltage

⚠ WARNING

Risk of fatal shock or injury by contact in the electrical cabinet is possible if the engine is running, the LINCS software indicates voltage on the bus, or the red bus LED's in the electrical cabinet are illuminated. All SR equipment has the ability to produce voltage at low throttle. Even with the engine off, there may be a residual of 12-15VDC on the bus. Do not enter the electrical cabinet or touch any components in the electrical cabinet without performing the Bus Discharge Verification Procedure. Failure to do so may result in fatal electrical shock or other injury.

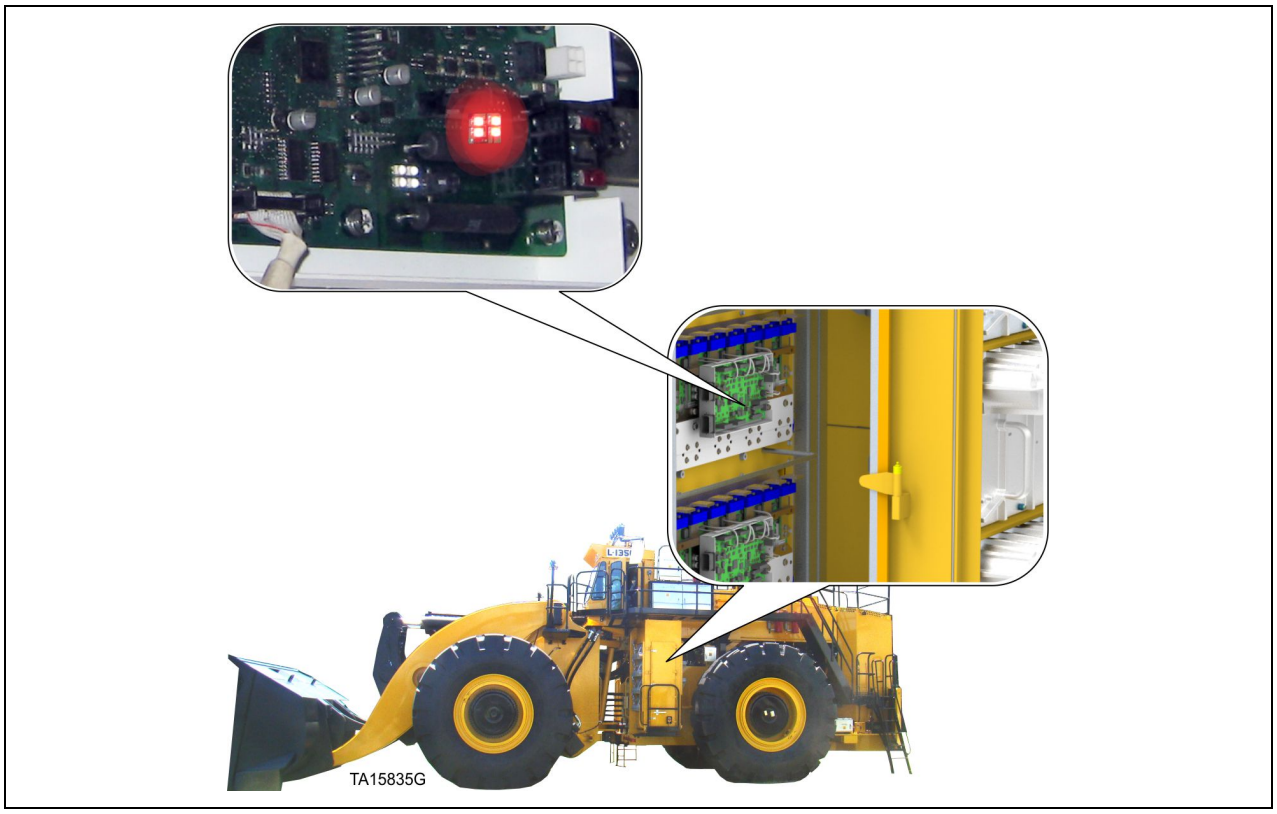


Figure 3. Converter assembly bus LED's

There are three different methods that are combined to verify when it is safe to enter the electrical cabinet.

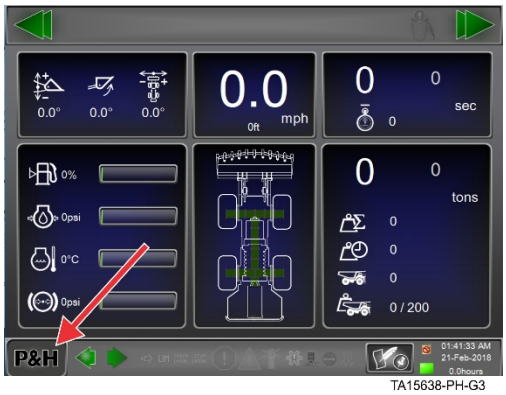
1. LINCS II display in cab
2. visual indication in electrical cabinet
3. physical measurement

All of these steps are required in order to assure that the system is properly discharged.

In Cab Verification Using LINCS II Display

1. Make sure that the LINCS II system is booted (key switch ON) with the engine NOT running and the park brake SET.

2. As shown in the following figure, on the touch panel in the dash, press the Main Menu button in the lower left corner, then select Data Logging then Logging/Monitoring.



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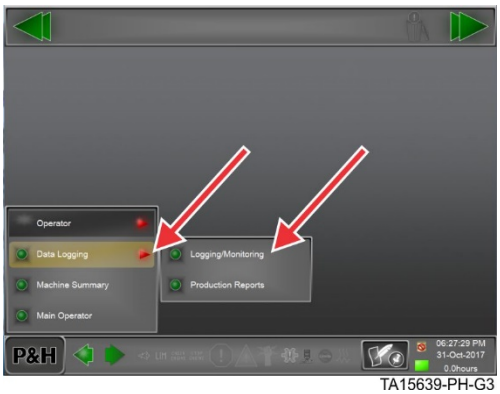
Main Menu Button



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Data Logging & Logging/Monitoring

Figure 4. LINCS logging/monitoring menu access

3. Select the Trash Can icon and then select the Check Mark to clear any selection on the right hand side of the screen (if applicable).

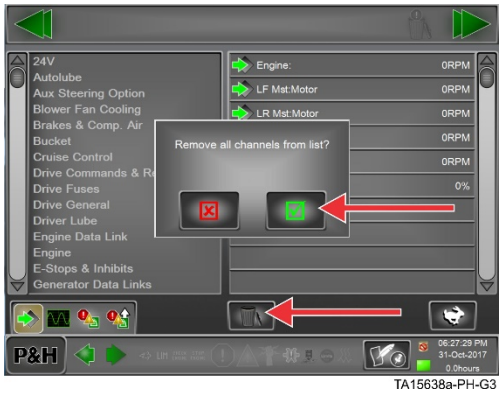

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Figure 5. Remove channels

4. Scroll down the left hand list until Drive Fuses is displayed.

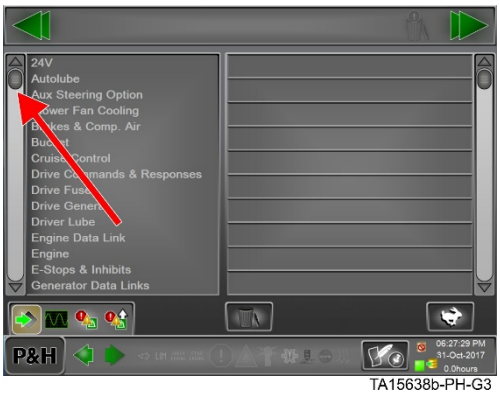


Figure 6. Left hand scroll

5. Drag the Drive Fuses category to the right hand side of the screen, all of the bus voltage channels should now be visible.

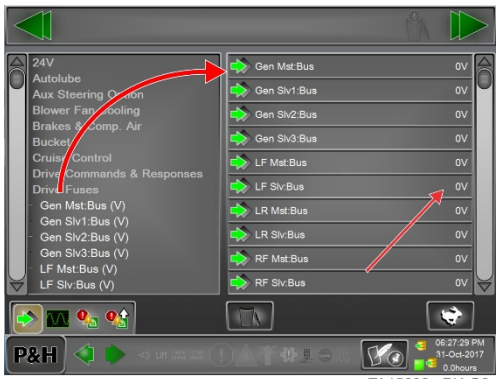


Figure 7. Bus voltage indication

6. Verify bus voltage is less than 24VDC.

NOTICE

Should any voltage (greater than 24VDC) be present on any of the DC busses, allow the system to discharge for a period of no less than 10 minutes. Re-test the bus voltages prior to continuing.

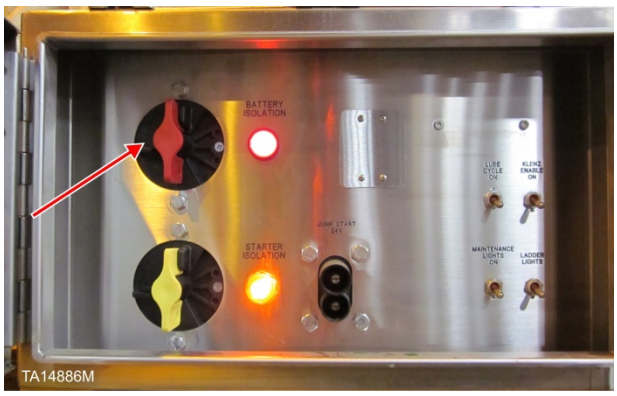
7. Turn the key switch to the OFF position and proceed to the next step in the verification process.

Verification by Visual Indication

Following the verification by LINCS II software, the next step is to verify the existence of bus voltage by the array of four LED indicators located on the main SR control board on each converter assembly.

To conduct this test, ensure that:

- The 24V DC power is isolated at the battery disconnect (turned off and locked out) per site requirements.



Isolate the battery and lockout the machine

Figure 8. Isolation and control switch assembly

- The SR electrical converter cabinet door should now be opened.
- DO NOT enter the cabinet at this time.

View the LED arrays on each of the converter assemblies and verify the LED's are not illuminated. The LED's will be illuminated when a potential of greater than approximately 35VDC is present on the DC bus connections on the converter assemblies. The light intensity varies with voltage and a greater intensity indicates a higher bus voltage.

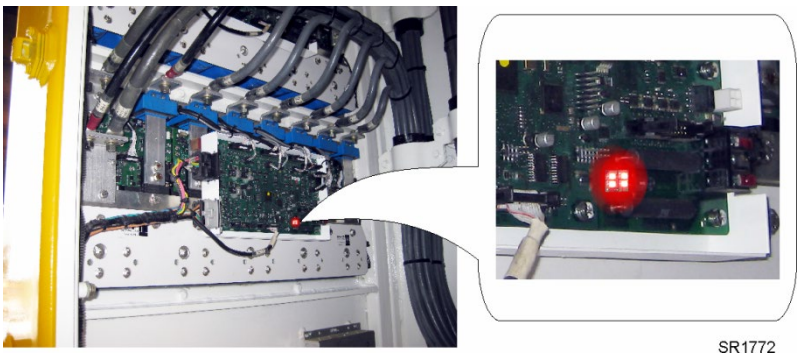


Figure 9. Bus voltage LED array on SR control board

Once verified that the LED's are NOT illuminated, proceed with Verification by Physical Measurement of the main bus bars.

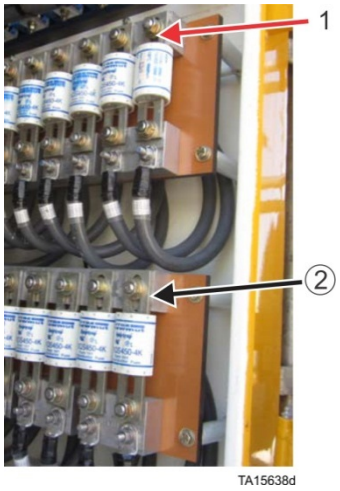
Verification by Physical Measurement Main Bus Bars

Once the visual indicators have been verified, the bus voltage should be physically measured. The bus voltage should be fully discharged based on the previous checks.

a. Measure between the positive and negative bus bars using a voltmeter rated for 1000V. The potential voltage on a bus that has not discharged could be over 700VDC. A properly discharged bus should be less than 24VDC as verified by the completion of LINCS system verification.

⚠ WARNING

Risk of shock or equipment damage by use of an improperly rated meter is possible. Use a CAT III 1000V rated volt meter to take voltage readings. Shock or other injury may result from using improperly rated test equipment.



1) Positive bus bar, **2)** Negative bus bar

Figure 10. Main bus bars

Converter Assembly Bus Connections

The final point of verification is the bus connections to each individual converter assembly. The bus voltage can be measured at the two bus tabs located adjacent to the electrical converter cabinet door.

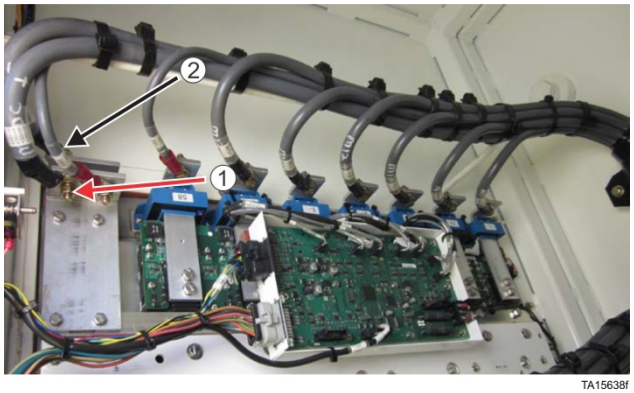
NOTICE

The converter assemblies on the rear of the cabinet are inverted in comparison to those mounted on the front. Similarly, the positive and negative bus connections will be inverted.

Connect a voltmeter across the two bus connection points. Bus voltage should be less than 24VDC following the completion of the previous checks. Once the check has been completed, the entire drive system has been verified as discharged.

1) Positive bus bar, **2)** Negative bus bar

Figure 11. Converter assembly bus connections (rear of cabinet)



1) Positive bus bar, **2)** Negative bus bar

Figure 12. Converter assembly bus connections (front of cabinet)

Once verified that bus voltage does not exist, entry into the electrical cabinet, axles, and grid area are permissible.

KESS Discharge Procedure

The KESS (Kinetic Energy Storage System) is composed of one or more ESD's (Energy Storage Device), converter panels, and fuses, controlled by the Vehicle Control Unit (VCU).

If the KESS is not discharged, the ESD can continue to rotate for two hours once the machine has been shut down.

Before performing any work procedures on the KESS system, verify the ESD is not rotating. Verification can be accomplished by using the LINCS II software to view the ESD RPM.

The purpose of the KESS discharge procedure is to dissipate potential energy so that the KESS system components may be serviced or repaired. If for any reason, the KESS cannot be discharged, service on the machine must be delayed for two hours, giving the ESD time to come to a complete stop.

⚠WARNING

Shock hazard exists on the components of the KESS system. Perform the KESS discharge procedure to remove stored energy from the KESS system and bring the ESD to a stop. Once the ESD has stopped, perform the Bus Discharge Verification Procedure. Failure to do so may result in electrical shock or other injury.

Safety Preparations

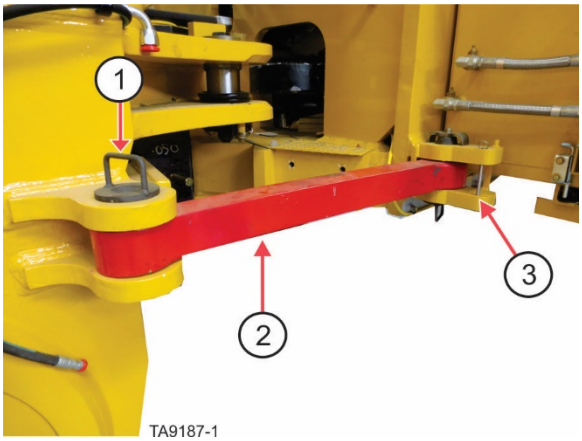
⚠WARNING

Crush hazards are possible if the machine is started or moved while work processes are being performed on the machine. Place bucket flat and level on the ground. Place frame lock in the locked position and lock out the machine's starting capability before performing any work process. Follow all applicable lockout procedures and local rules and regulations for performing work processes. Serious personal injury or death could occur if the machine is started or moves while any type of work process is being conducted on the machine.

a. Stop the wheel loader on flat level ground.
b. Move the frame lock to the locked position so that the frame cannot be steered.
c. Place wheel chocks in front and behind each wheel.

⚠WARNING

Crush hazard is possible if the frame lock is not locked to prevent machine articulation while personnel are in the machine articulation area. Do not enter this area unless you have verified that the operator has control over the steering and that you have good communication with the operator. Crush hazard is possible if personnel are in this area while the machine is articulated, which could result in serious injury or death.



1) Retaining pin for locked position, **2)** Frame lock – shown in locked position**, 3)** Retaining pin bracket for un-locked position

Shown in locked position

Figure 13. Frame Lock

d. Set bucket flat and level on the ground.

e. Set the parking brakes.

KESS Discharge Procedure

Figure 14. Operators Screen – KESS at 60%

Discharging the KESS should be done before shutting the machine down by performing the following steps:

1. Ensure Park Brake is SET
2. Place machine at LO Throttle

3. LINCS II Screen
    a. Select Main Menu button
    b. Select Data Logging
    c. Select Logging/Monitoring
    d. Select Energy Storage Data Link
    e. Move ESD 1 Mst:Motor (RPM) and ESD 2 Mst:Motor (RPM) to right column by clicking and dragging

Figure 15. ESD Motor Channel Select

4. Press the Drive Enable Switch

Figure 16. Drive Enable Switch

5. The ESD Mst:Motor RPM will start to decline and will reach 0 RPM in approximately 35 seconds.

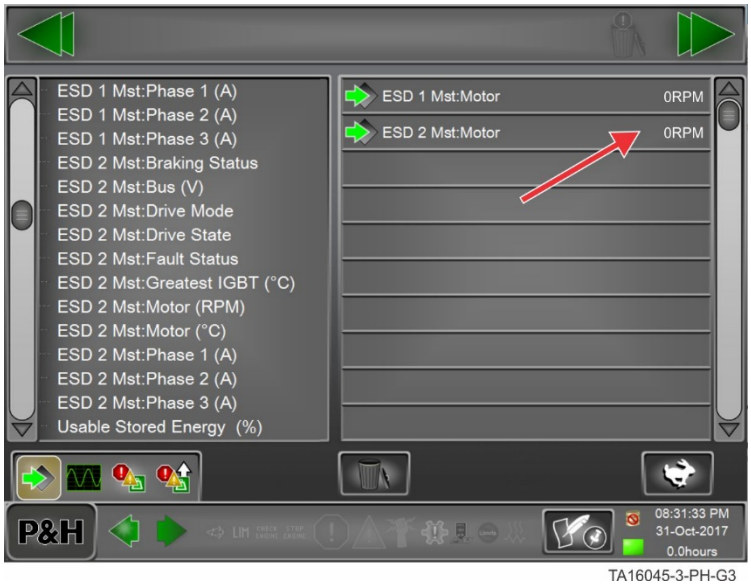


Figure 17. ESD Motor RPM

6. Shut down the machine as normal.

Braking Grids

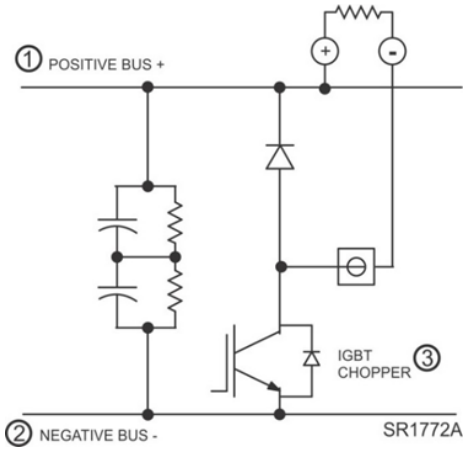
Braking grids are located at the rear of the machine to dissipate energy and provide electrical braking capability. These grids are connected to one side of the electrical bus. They have high voltage present at all times that bus voltage is present.

⚠ WARNING

Risk of shock or injury by contact of the braking grids is possible. Do not open the door over the braking grids or touch anything on the grids when the engine is running or the converter panel bus LED's are glowing red in the electrical cabinet. Do not touch or enter these areas unless the engine has been shut down and the bus discharge procedure has been followed. Failure to do so may result in shock or other injury.

NOTICE

Under some fault conditions, the bus discharge circuit may become damaged. Under these conditions, bus discharge may require a longer period of time.



1. Positive bus +
2. Negative bus –
3. IGBT Chopper

Figure 18. LINCS II grid connections

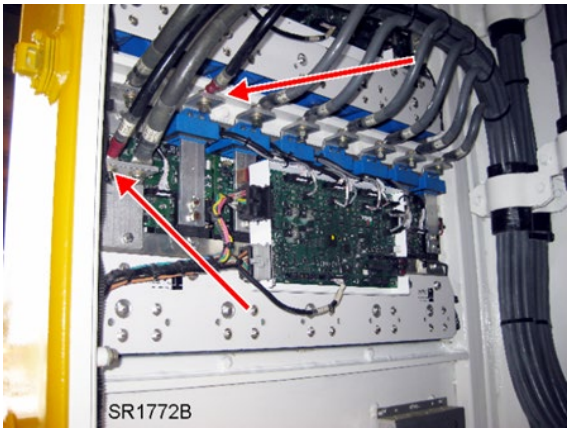


Figure 19. LINCS II braking grids – connections – warning labels

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