Service & Maintenance Manual

E18MML, E18MCL, E18MSP

PVC 2402

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October 30, 2024 - Rev A

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October 30, 2024	A	Original Issue

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SECTION CONTENTS

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SECTION 1
SAFETY

1.1 GENERAL

This Service Manual provides general directions for service and repair procedures. Following the procedures in this manual will help assure safety and equipment reliability.

This section contains general safety precautions that must be observed during maintenance of this machine. It is of utmost importance that maintenance personnel pay strict attention to these warnings and precautions to avoid possible injury to themselves or others, or damage to the equipment. A maintenance program must be followed to ensure the machine is safe to operate.

Read, understand and follow the information in this manual, and obey all locally approved safety practices, procedures, rules, codes, regulations and laws.

⚠ WARNING

Modification or alteration of this machine shall be made only with written permission from the manufacturer.

These instructions cannot cover all details or variations in the equipment, procedures, or processes described, nor provide directions for meeting every possible contingency during operation, maintenance, or testing. Supplementary information may be available from JLG Industries, Inc. or your local authorized servicing entity.

⚠ WARNING

Since the machine manufacturer has no direct control over the field inspection and maintenance, safety in this area is the responsibility of the owner/user.

1.1.1 Disclaimer

Due to continuous product improvements, JLG Industries, Inc. reserves the right to make specific changes without prior notification. Contact JLG Industries, Inc. for updated information.

Refer to www.JLG.com for Warranty, Product Registration, and other machine-related documentation.

1.1.2 Operation & Safety Manual

The machine must not be operated until the Operation & Safety manual has been read and understood, training has been accomplished, and operation of the machine has been completed under the supervision of an experienced and qualified operator.

1.2 SAFETY INFORMATION

The specific precautions to be observed during maintenance are inserted at the appropriate point in the manual. These precautions are generally those that apply when servicing electric, hydraulic, and larger machine component parts.

To avoid possible death or injury, carefully read, understand and comply with all safety messages on the machine and in the Service Manual.

1.2.1 Safety Alert System and Signal Words

⚠ DANGER

DANGER indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.

⚠ WARNING

WARNING indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

⚠ CAUTION

CAUTION indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury.

1.3 SAFETY HAZARDS

⚠ WARNING

Failure to comply with safety precautions listed in this section could result in machine damage, personnel injury or death, and is a safety violation.

1.3.1 Personal Hazards

- Wear eye protection at all times during maintenance procedures.
- Wear all personal protective equipment necessary to perform the job safely.
- Remove all rings, watches, and jewelry when performing any maintenance.
- Do not wear unrestrained long hair or loose fitting clothing which could become caught on or entangled in equipment.
- Do not smoke while servicing the machine.
- Never refuel during electrical storms.

1.3.2 Equipment Hazards

- Unless required by the service activity, if the machine is supporting a load it should be removed prior to any maintenance being conducted.
- Never work under an elevated boom or scissor stack until it has been safely restrained by blocking or an overhead sling, or the safety prop has been engaged.
- Be conscious of equipment weight. Do not move heavy parts without the aid of a mechanical device. Do not allow heavy objects to rest in an unstable position. When raising or supporting a portion of the equipment, make sure an adequate lifting capacity device is provided.

1.3.3 General Hazards

- Make sure the fuel cap is closed and secure during maintenance.
- Only use approved, nonflammable cleaning solvents.
- Keep oil, grease, water, etc. from all work areas, standing surfaces, and hand holds.
- Keep all support equipment and attachments stowed in the proper location.

- Avoid pressure-washing electrical/electronic components. In the event pressure-washing the machine is needed, make sure the machine is powered off before pressure-washing. If pressure-washing areas containing electrical/electronic components, it is recommended a maximum pressure of 750 psi (52 bar) at a minimum distance of 12 in. (30.5 cm) away from these components. If electrical/electronic components are sprayed, spraying must not be direct and spray for brief time periods to avoid heavy saturation.
- Check and obey all federal, state, and/or local regulations regarding waste storage, disposal, and recycling of components such as batteries, electronic components, fluids, tires, and hoses.

1.3.4 Operational Hazards

- Before making adjustments, lubricating, or performing any other maintenance, shut off all power controls. Never work on a machine when the engine, cooling, or hydraulic systems are hot. Allow systems to cool before proceeding.
- Use only replacement parts or components which are approved by JLG. To be considered approved, the replacement parts or components must be identical or equivalent to the original parts or components. Never alter, remove, or substitute any items such as counterweights, tires, batteries, or other items that may reduce or affect the overall weight or stability of the machine.
- On certain hybrid/electric machines, the electrical system operates at high, potentially dangerous voltages. Do not attempt repairs unless specific training has been completed.
- The fuel and hydraulic systems operate at extremely high, potentially dangerous pressures. Do not attempt repairs unless specific training has been completed.
- Never check for leaks using any part of your body.
- Relieve all pressure before disconnecting any component, part, line or hose.
- Never remove the radiator cap while the cooling system is hot.
- Do not service the fuel or hydraulic systems near an open flame, sparks, or smoking materials.
- Disconnect batteries prior to replacing of electrical components and prior to servicing fuel or hydraulic systems.
- Do not charge a frozen lead acid/AGM battery. Allow the battery to thaw before jump-starting or connecting a battery charger.
- Do not jump start lithium-ion batteries.
- Do not tamper with, open, or attempt to service lithium-ion batteries. They contain no serviceable parts.

1.4 SAFETY DECALS

Check that all safety decals are present and legible on the machine. Refer to the Operation & Safety Manual supplied with machine for information.

1.5 MACHINE VERIFICATION

Verify the machine operates properly after all maintenance or services have been performed.

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SECTION 2
GENERAL MACHINE INFORMATION AND SPECIFICATIONS

2.1 SPECIFICATIONS

2.1.1 Machine Specifications

SPECIFICATION	E18MML	E18MCL	E18MSP
Gross Machine Weight (Platform Empty)	1870 lbs (848 kg)	1900 lbs (862 kg)	1870 lbs (848 kg)
Machine Height (Platform Stowed)	78 in. (198 cm)		
Tilt Indicator Setting	1.5°		
Maximum Travel Grade (Gradeability) (Platform STOWED ONLY)	30%		
Maximum Travel Grade (Side Slope) (Platform STOWED ONLY)	5°		
Max. Allowable Operating Slope (Elevated) Front to Back Side to Side	 3.0° 1.5°		
Maximum Drive Speeds (Operator Variable)	0.5 - 2.5 mph (0.8 - 4.0 kph)		
Machine Base - Overall (Width x Length)	30 in.- W x 53 in.- L (76 cm - W x 134 cm - L)		
Ground Clearance PHP Retracted: PHP Deployed: Break Over Angle:	 2.5 in. (64 mm) 0.7 in. (19 mm) 12.5°		
Maximum Wind Speed	0 mph (0 m/s)	28 mph (12.5 m/s)	0 mph (0 m/s)
Maximum Horizontal Manual Side Force (Platform fully extended with Maximum load)	45 pound-force (200 Newton)		
Maximum Hydraulic System Pressure (Recommended initial setting)	3000 PSI (211 Bars)		
Hydraulic System Capacity	2.4 gallon (9.1 L)		
Maximum Ground Bearing Pressure	123.3 psi (8.6 kg/cm^2)	207.5 psi (14.5 kg/cm^2)	207.5 psi (14.5 kg/cm^2)

2.1.2 Battery Specifications

Table 1. Lead Acid Battery

SPECIFICATION	E18MML, E18MCL, E18MSP	
System Voltage	24 Volts DC	
Battery Type	GC -110 - WNL	EVGC6A - A (AGM)
Voltage (DC)	6 Volts DC - 4 Battery System	
Amp Hour (AH) Rating	225 Amp Hr. @ 20 Hr. Rate - 6V - 4 Battery System	213 Amp Hr. @ 20 Hr. Rate - 6V - 4 Battery System

Table 2. Lithium Ion Battery

Description	Value
System Voltage	24V
Amp Hour (AH) Rating	90 AH
Nominal Capacity	2.3 kWh
Nominal Module Voltage	25.6V
Maximum Module Voltage	29.2V
Minimum Module Voltage	20.0V
Continuous Discharge Current Limit	150A
Maximum Discharge Current	200A for 30 seconds/250A for 15 seconds
Maximum Charging Voltage	28V
Continuous Charging Current Limit	90A
Maximum Charging Current	100A for 30 seconds
Minimum Ambient Storage Temperature	-4°F (-20°C)
Cell Format	Prismatic
Cell Chemistry	LFP
Cell Arrangement	8 Series, 1 Parallel
Nominal Cell Voltage	3.2V
Maximum Cell Voltage	3.65V
Minimum Cell Voltage	2.5V
Maximum Cell Temperature for Charging	140°F (60°C)
Maximum Cell Temperature for Discharging	176°F (80°C)
Minimum Cell Temperature for Charging	33.8°F (1°C)
Minimum Cell Temperature for Discharging	-0.4°F (-18°C)
Cell Balancing	Resistive
Communication Interfaces (Vehicle CANbus/Battery CANbus)	250 kBaud
Firmware Version	BQ8050 A05, ATSAM A08
Functional Life Rating at room temperature	4000 Cycles at 100% DOD
Self Discharge Rate	1.5 % SOC per Month
Heater Power	4 X 40 WATT
Outer Housing Material	Polycarbonate
Weight	45.2 lb (20.5 kg)
IP Rating	IP 67
Allowable Mounting Locations	Any side down, except terminal side

2.1.3 Battery Charger

Description	Delta-Q 650 W (CAN)	Delta-Q 1200 W (CAN)	Green Power (CAN)
Input			
AC Input Voltage	85–270 VAC		100–240 VAC
Nominal AC Input Voltage	100/240 VAC		120/230 VAC
Input Frequency	50/60 Hz		
Max. AC Input Current	7.5A	14.5A	8.5A
Ingress Protection	IP66	IP66 NEMA4	IP66
Operating Temperature	-40°F (-40°C) to 149°F (+65°C)		
Output			
Nominal DC Output Voltage	24V		
Max. DC Output Voltage	36V		34V
Max. DC Output Current	27.1A	50A	30A
Max. Interlock Current	1.5A (resistive) @ 24V	10A @ 24V	5A
Protection			
Output Reverse Polarity	Electronic Protection - Auto Reset	Not Available	Electronic Protection-Auto Reset
Output Short Circuit	Current Limited		Electronic Protection-Auto Reset
AC Overload	Current Limited		
DC Overload	Current Limited		

2.1.4 Cylinder Specifications

Table 3. Cylinder Specifications

DESCRIPTION	BORE DIA.	STROKE	ROD DIA.
Lift Cylinder	1.57 in. (40 mm)	48.68 - 48.80 in. (1236.5 - 1239.5 mm)	1.38 in. (35 mm)
Steer Cylinder	2.36 in. (60 mm)	6.24 - 6.36 in. (158.5 - 161.5 mm)	1.38 in. (35 mm)

2.1.5 Platform Data

SPECIFICATION		E18MML	E18MCL	E18MSP
Occupants: (Persons allowed in Platform)		1	1	1
Maximum Work Load (Capacity)	Standard and Ceiling Platform:	450 lbs (204 kg)	450 lbs (204 kg)	450 lbs (204 kg)
	Extension Platform, Maintenance Tray Platform and Maintenance Aluminum Tray Platform:	400 lbs (181 kg)	400 lbs (181 kg)	400 lbs (181 kg)
Platform Height- Indoor	Indoor:	17 ft. 10 in. (5.43 m)	17 ft. 10 in. (5.43 m)	17 ft. 10 in. (5.43 m)
	Outdoor:	-	13 ft. (3.9 m)	-

SPECIFICATION		E18MML	E18MCL	E18MSP
	Stowed:	18.6 in. (0.47 m)	18.6 in. (0.47 m)	18.6 in. (0.47 m)
Platform Cycle Performance Lift Up:	With Rated Load:	25 - 29 seconds	25-29 seconds	25 - 29 seconds
	Without Load:	18-22 seconds	18-22 seconds	18-22 seconds
Platform Cycle Performance Lift Down:	With Rated Load:	21 - 25 seconds	21 - 25 seconds	21 - 25 seconds
	Without Load:	21 - 25 seconds	21 - 25 seconds	21 - 25 seconds

2.1.6 Machine Wheel Loads and PSI - Per Wheel

Platform Type (Loaded to Max. Capacity)	E18MML, E18MCL, E18MSP			
	Average Maximum			
	Wheel Load Per Wheel (lb)		(PSI) Per Wheel	
	Rear	Front	Rear	Front
29.5 x 51 S	Not Available at Publication	Not Available at Publication	Not Available at Publication	Not Available at Publication
22 x 26 CT	Not Available at Publication	Not Available at Publication	Not Available at Publication	Not Available at Publication
29.5 x 26 DB	Not Available at Publication	Not Available at Publication	Not Available at Publication	Not Available at Publication
w/Folding Tray	Not Available at Publication	Not Available at Publication	Not Available at Publication	Not Available at Publication

Note: Platform Types: DB - with Drop Bar Gate, S - with Saloon Gate, CT - with Ceiling Tile

2.1.7 Machine Component Weights

SPECIFICATION		E18MML, E18MCL, E18MSP
Platform Weight (Quick-Change Platforms)	Extension, Saloon Front Entry Platform:	161 lbs (73.1 kg)
	Extension, Drop Bar Front Entry Platform:	148.2 lbs (67.3 kg)
	Ceiling Tile Platform:	59.9 lbs (27.2 kg)
	Maintenance with Tray, Saloon Side Entry Platform:	95.7 lbs (43.5 kg)
	Maintenance with Tray, Drop Bar Side Entry Platform:	82.8 lbs (37.6 kg)
	Standard, Drop Bar Front Entry Platform:	67.8 lbs (30.8 kg)
	Aluminum Tray, Saloon Side Entry Platform:	95.7 lbs (43.5 kg)
Battery: (per battery)	GC -110 - WNL	63 lbs (28.6 kg) - 6 Volt - 4 Battery System
	EVGC6A - A (AGM)	66 lbs (30 kg) - 6 Volt - 4 Battery System

2.1.8 Specifications For Various Components

The following table contains specifications for E18MML, E18MCL and E18MSP machine components.

Table 4. Ohm Ratings for Various Components

COMPONENT	NOMINAL RESISTANCE @ TEMPERATURE	RESISTANCE RANGE POSSIBLE
Pump Motor	0.2 ohm - 0.4 ohm @ 77 °F	0.12 ohm - 0.49 ohm

Table 5. Amperage Draw for Various Components

COMPONENT	AMPERAGE
Ground Control Module	**E18MML, E18MCL and E18MSP** - 95 Amps @ room temperature with rated load

2.1.9 Torque Requirements

When maintenance becomes necessary or a fastener has loosened, refer to the applicable *Section — Torque Charts, page 357* in this section of the manual, to determine proper torque values for different size fasteners.

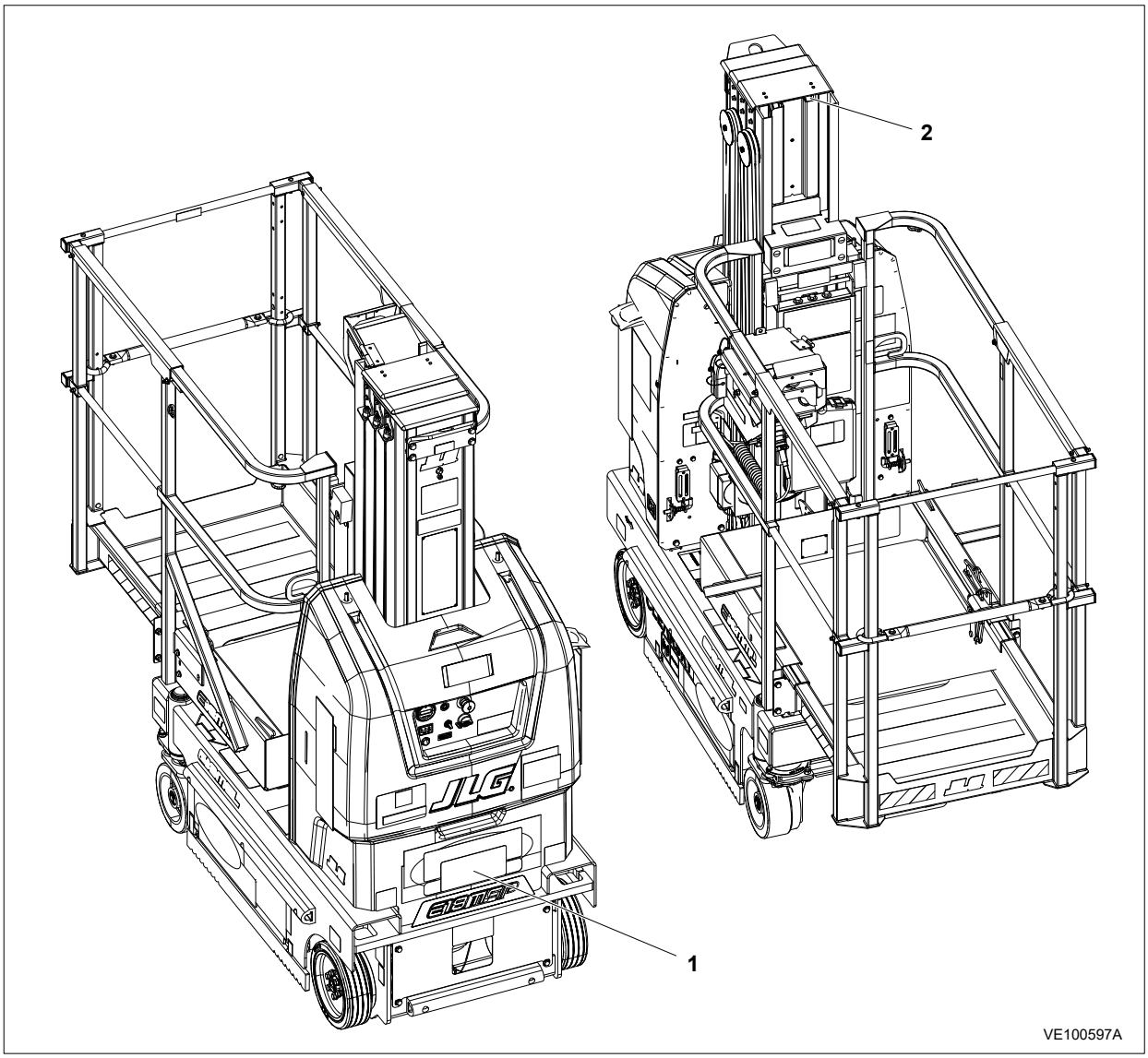


Figure 1. Torque Requirements

1. Hydraulic Oil	2. Mast Chains

2.2 SERIAL NUMBER LOCATION

For machine identification, a serial number plate is affixed to the machine. The plate is located on the back of the mast, just above the mast support bracket.

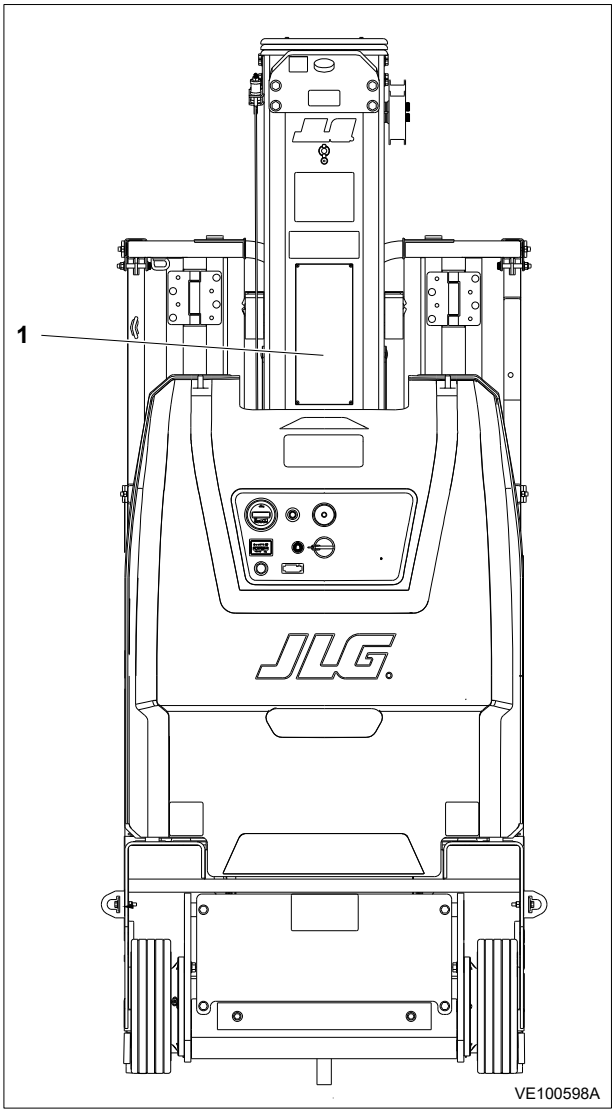


Figure 2. Serial Number Location

1. Serial Number Plate

2.3 FLUIDS AND LUBRICATION

2.3.1 Hydraulic System

The primary enemy of a hydraulic system is contamination. Contaminants enter the system by various means, e. g., using inadequate hydraulic oil, allowing moisture, grease, filings, sealing components, sand, etc., to enter when performing maintenance, or by permitting the pump to cavitate due to insufficient system warm-up or leaks in the pump supply.

The design and manufacturing tolerances of the component working parts are very close, therefore, even the smallest amount of dirt or foreign matter entering a system can cause wear or damage to the components and generally results in faulty operation. Every precaution must be taken to keep hydraulic oil clean, including reserve oil in storage.

Cloudy oils indicate a high moisture content which permits organic growth, resulting in oxidation or corrosion. If this condition occurs, the system must be drained, flushed, and refilled with clean oil.

It is not advisable to mix oils of different brands or types, as they may not contain the same required additives or be of comparable viscosities. Good grade mineral oils, with viscosities suited to the ambient temperatures in which the machine is operating, are recommended for use.

Note: Metal particles may appear in the oil of new machines due to the wear-in of meshing components.

2.3.2 Hydraulic Oil

Hydraulic System Operating Temperature Range	S.A.E. Viscosity Grade
+0° to + 180°F (-18° to +83°C)	10W
+0° to + 210° F (-18° to +99°C)	10W-20, 10W-30
+50° to + 210°F (+10° to +99°C)	20W-20

Note: Hydraulic oils require anti-wear qualities at least API Service Classification GL-3, and sufficient chemical stability for mobile hydraulic system service.

Note: Machines may be equipped with Standard UTTO biodegradable and non-toxic hydraulic oil. This is a fully synthetic hydraulic oil that possesses the same anti-wear and rust protection characteristics as mineral oils, but will not adversely affect the ground water or the environment when spilled or leaked in small amounts.

Note: Aside from JLG recommendations, it is not advisable to mix oils of different brands or types, as they may not contain the same required additives or be of comparable viscosities. If use of hydraulic oil other than Standard UTTO is desired refer contact JLG Industries for proper recommendations.

2.3.3 Changing Hydraulic Oil

Use of any of the recommended hydraulic oils eliminates the need for changing the oil on a regular basis. If it is necessary to change the oil, use only those oils meeting or exceeding the specifications appearing in this manual. If unable to obtain the same type of oil supplied with the machine, consult local supplier for assistance in selecting the proper equivalent. Avoid mixing petroleum and synthetic base oils. JLG Industries recommends changing the hydraulic oil annually.

Use every precaution to keep the hydraulic oil clean. If the oil must be poured from the original container into another, be sure to clean all possible contaminants from the service container.

While the unit is shut down, a good preventive maintenance measure is to make a thorough inspection of all hydraulic components, lines, fittings, etc., as well as a functional check of each system, before placing the machine back in service.

2.3.4 Lubrication Specifications

KEY	SPECIFICATIONS
MPG -	Multipurpose Grease having a minimum dripping point of 350° F. Excel- lent water resistance and adhesive qualities, and being of extreme pres- sure type. (Timken OK 40 pounds minimum.)
EPGL -	Extreme Pressure Gear Lube (oil) meeting API service classification GL-5 or MIL-Spec MIL-L-2105.
HO -	Hydraulic Oil. ISO-Vg grade 32, 46.
CL -	Chain Lube. Use a Mobil 375 NC.

2.3.5 Fluids

Table 6. Standard UTTO Hydraulic Fluid Specs

Inspection Data	Recommended SHELL SPIRAX S4 TXM	Optional MOBILFLUID 424
ISO Viscosity Grade	68	68
Specific Gravity	0.882	0.880
Pour Point	-43.6°F (-42°C)	-45.4°F (-43°C)
Flash Point	428°F (220°C)	442.4°F (228°C)
Base Oil Type	HV	HV
Viscosity		
Brookfield, at -20°C	-	4300 cP
Brookfield, at -5°C	-	-
Viscosity at 40° C	66.93 cSt	60.21 cSt
Viscosity at 100° C	10.53 cSt	9.26 cSt
Viscosity Index	146	134

Table 7. Biodegradable Synthetic Hydraulic Fluid (VG 32) Specs

Inspection Data	Recommended SHELL NATURELLE HF-E32	Optional MOBIL EAL ENVIROSYN H32
ISO Viscosity Grade	32	32
Specific Gravity	0.918	0.869
Pour Point	-38.2°F (-39°C)	-38.2°F (-39°C)
Flash Point	474.8°F (246°C)	514.4°F (268°C)
Base Oil Type	POLYOL ESTER	FATTY ACID ESTER
	HEES	-
	HFDU	-
Auto Ignition Temperature	>608°F(>320°C)	-
Biodegradability (%28 Days)	79%	>60%
Viscosity		

Table 7. Biodegradable Synthetic Hydraulic Fluid (VG 32) Specs (continued)

Inspection Data	Recommended SHELL NATURELLE HF-E32	Optional MOBIL EAL ENVIROSYN H32
Brookfield at -30°C	-	-
Brookfield at -20°C	-	-
Brookfield at -5°C	-	-
Viscosity at 40° C	30.78 cSt	33.59 cSt
Viscosity at 100° C	6.85 cSt	6.41 cSt
Viscosity Index	192	146

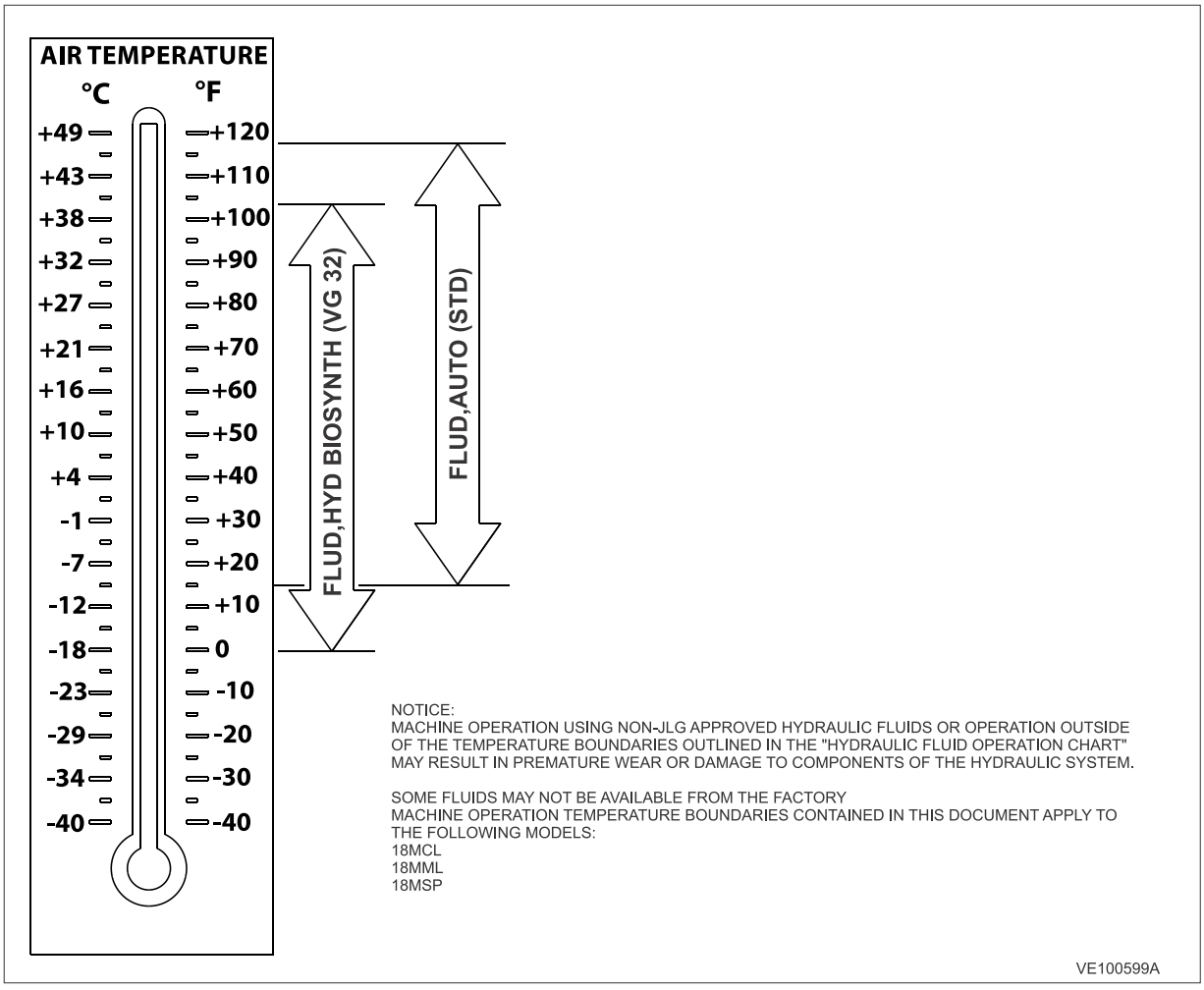


Figure 3. Hydraulic Oil Operating Temperature Specifications

2.4 MACHINE CHARACTERISTICS

2.4.1 Primary Regulatory Standards

The machine has been designed to conform to the listed regulatory standards. Option availability and market preferences may vary by market.

2.4.2 Languages of Markings

Machines are marked with the language appropriate to the market of sale. Those listed with dual languages such as (ENG, FRE) are marked with decals with both languages on the same machine. Some markets, including CE/UKCA and AUS, receive pictorial decals only and are not language-specific.

2.4.3 Outdoor Rating

The MCL machine has been designed to be used outdoors according to primary regulatory standards. Machines equipped with Indoor/Outdoor Mode will have de-rated performance (platform height) when outdoor mode is selected.

2.4.4 Tilt System

The Tilt System uses a CAN-based dual axis tilt sensor mounted on the chassis. The sensor measures the chassis angle with respect to gravity by providing tilt angles in both the X and Y directions. The X value indicates inclination from Left to Right; the Y value indicates inclination Front to Back. The sensor provides the X and Y tilt angles in degrees to the control system for interlocks and machine functions that are restricted when tilted.

When the machine is determined to be tilted beyond the specified limit, the tilt LED on the platform control station is illuminated and drive and lift are disabled. The allowable tilt angle for this machine is constant.

2.4.5 Platform Height Monitoring System

The Platform Height Monitoring System used in this machine utilizes three predetermined zones. Transport position or stowed, Zone one or Outdoor Zone and Zone two or Indoor Zone. Transport position is indicated by a proximity sensor at the bottom of the mast and pothole switch closed. Zone one is active when not in stowed or not in Zone two. This would be when Zone two switch is indicated and pothole switch and proximity sensor is open. This Zone is also known as the Outdoor Height zone and is limited to 13 feet by the limit switch on the side of the mast. Zone two is when the machine is beyond 13 feet or Indoor mode. This Zone will be when the limit switch on the side of the mast is open and the machine is in Indoor mode. Otherwise, Zone two will not be allowed.

2.4.6 Platform Joystick Trigger

The platform control station uses a joystick trigger switch which acts as an enable for platform functions. The trigger must be pressed and held, with the joystick in the neutral (centered) position, before the following functions can be activated: Lift, Drive, and Steer. If the trigger is released for more than one second, the operation of the function will stop. If the trigger is pressed and held for more than five seconds while the joystick position is centered, the trigger will time out and act as if it were released. At this point if a function is initiated, the trigger must be released for at least 80 mS before re-engaging the trigger and initiating the function.

When the trigger is released during the operation of a function, the function will ramp down at the normal deceleration rate for up to one second. If the trigger is re-engaged during this one second function deceleration, the trigger will be closed and the function will resume normal operation. If the operator does not re-engage the trigger within one second, the control system will perform an emergency stop for all functions.

2.4.7 Platform Footswitch

The platform footswitch is not an option for this machine. The gate switch option uses a common cable with the machine that is tagged with a foot switch connection, but this plug is not used on this machine. This machine does not support the footswitch inputs or outputs.

2.4.8 Battery Charger System

The machine is equipped with a battery charger that can be plugged into a standard 110 VAC or 220 VAC 50/60 Hz outlet to charge the batteries. The battery charger has a drive interlock that is monitored by the control system to prevent drive when the system is charging. Lift up and down functions are available by default. The control system has the option of disabling lift up and down during charge through the JLG Analyzer menu. The machine has a single plug which also powers the AC box at the platform. When plugged in, the machine will always be considered in charge mode.

2.4.9 Platform Load Sensing System (LSS)

The Load Sensing System (LSS) is designed to monitor the load of persons and equipment in the platform. The systems consists of a set of springs and limit switch. Prior to the weight in the platform(s) exceeding 120% of the rated load as indicated on the capacity decal, the springs will compress and engage the limit switch. This system is manually adjusted and calibrated with a defined weight and gaps per the instructions in Section – Calibration Procedures. Since this machine is designed for quick change platforms, there is one calibration procedure that accounts for any platform used on the machine. No setup or calibration changes are needed when changing platforms.

The LSS calibration consists of 3 steps. Setting of spring pre-load, followed by stops, and then adjusting of limit switch position.

1. **Weighted Calibration**
   Without the platform installed, the springs must be preloaded to the defined 2.125 in. (54 mm) height. The platform is then installed, and 520 lbs (236 kg) must be added to the platform in the closed position. Any platform can be used for this procedure. The positive stops are set with 0.05 – 0.12 in. (1.5 - 3.0 mm) gap prior to adjusting the limit switch plunger. The final step is to adjust the plunger into the limit switch until the LSS system is triggered. The jam nuts should be tightened to lock the plunger in this triggered position. The load should be removed and LSS system will disengage. The load can be reapplied and LSS system should be triggered as confirmation of initial setup.

2.4.10 Universal Telematics

Battery power, ground, ground mode, and platform mode are the signals provided to telematics connector on each machine. The telematics connector allows a variety of modules to be installed, some of which are installed by customers, to provide real-time status and location data to a remote server allowing machine data to be monitored via an internet connection.

2.4.11 Battery Charge Indication

The current battery charge state is visible in three machine locations depending on the machine’s configuration:

1. Platform Control Box (STD).
2. Battery Charger(STD), (when plugged into AC).
3. MDI (STD).

2.4.12 Control System

The control system is made up of the following modules, sensors, and components:

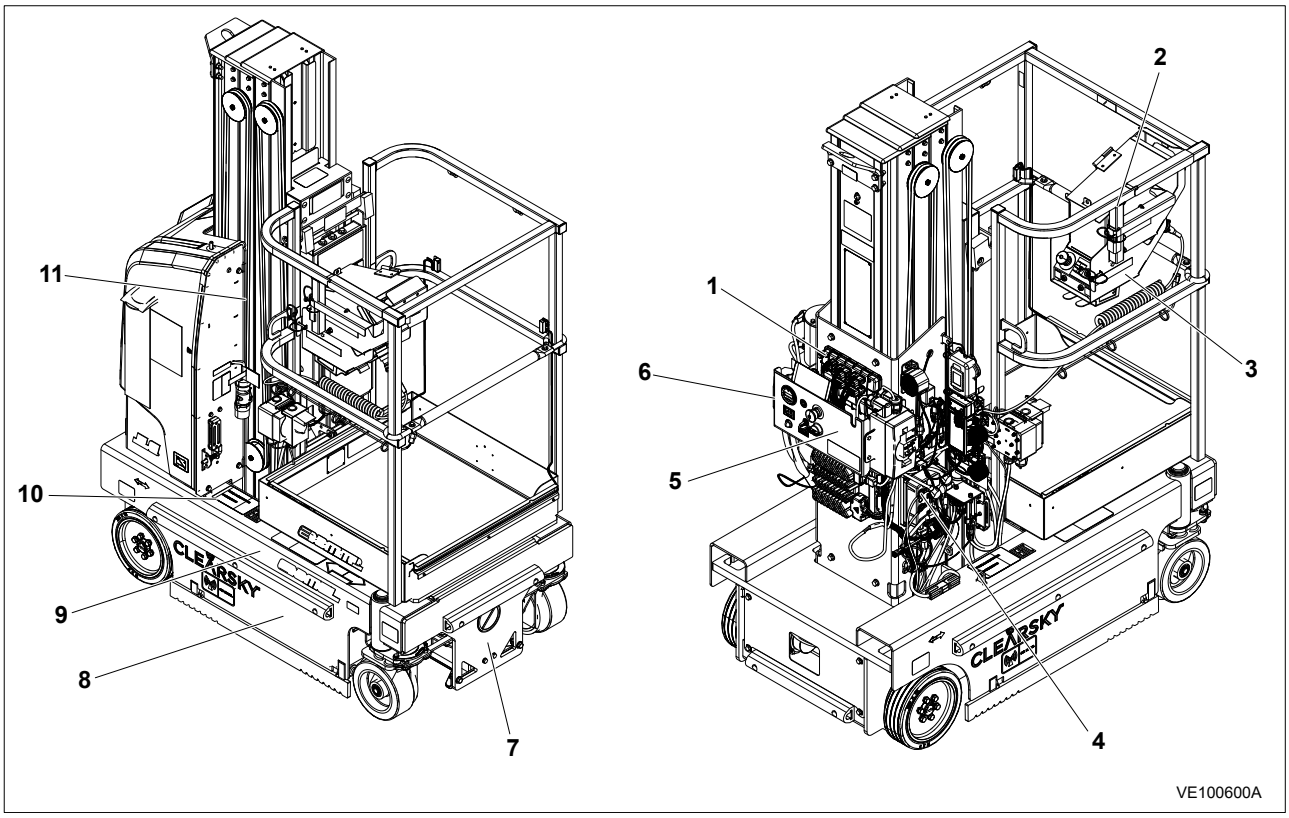


Figure 4. Control System

1. **Ground Module (GM)**
   The GM is the central control device for the machine. It communicates with the PM, PLTM, Tilt Sensor, and MDI via CANbus messages. The GM retains machine configuration and data logging information.

2. **Platform Module (PLTM)**
   The PLTM serves as a remote I/O for the operator to use while located in the platform of the machine. The PLTM reads the user input and sends this data to the GM via system CANbus. The GM then activates the appropriate functions. The PLTM sends diagnostic messages to the GM during machine operation.

3. **Platform Control Station**
   The machine will be in Platform Mode when the operator turns the key switch located at the Ground Control Station to Platform Mode. While in Platform Mode, all machine functions are available to the operator. The operator interfaces with the control system using the Platform Joystick, Drive/Lift switch, Indoor/Outdoor push button, E-stop, and Horn button.

4. **Pump and Drive Motor Control Module (Power module)**
   The PM controls hydraulic pump function speed and drive motor speed. The PM also sends diagnostic messages back to the GM via system CANbus.

5. **Ground Control Station**
   The machine will be in Ground Mode when the operator turns the key switch located at the Ground Control Station to Ground Mode. While in Ground Mode, the Platform Box can be removed and will not cause any DTC's. The only functions available in Ground Mode are Lift Up and Lift Down.

6. **Multifunctional Display Indicator**
   The Multifunctional Display Indicator (MDI) is located at the ground control panel and shows the current battery charge levels and any active machine DTC's (Diagnostic troubleshoot codes).

7. **Steering Angle Sensor (MCL only)**
   The MCL is equipped with a rotary angle sensor that indicates the position of the front steering wheels. This information is used to proportion the drive motors to support tighter turning radius and less tire scrubbing. It will also reduce the overall machine speed in tight turning situations.

8. **Tilt Sensor**
   The CAN-based dual axis tilt sensor provides both temperature and tilt angles in the X and Y directions to the GM.

9. **Pothole Protection Switch (PHP)**
   A positive acting switch with two digital input signals (1 normally open (NO) and 1 normally closed (NC)) is used to monitor the states of the pothole protection system.

10. **Elevation Switch 1**
    In order to ensure the machine is in travel or stowed position, a magnetic proximity sensor is located at the bottom of the mast to indicate the mast is in the fully closed or lowered position. This sensor along with the PHP switch will allow full travel speed when stowed.

11. **Elevation Switch 2**
    The machine is equipped with a positive acting switch with two digital input signals (Switch 2 normally open (NO) and Switch 3 normally closed (NC)) that will indicate when the machine has reached the outdoor height limit. The control system will react accordingly based on Indoor or Outdoor selection on the Platform control station to limit or allow further elevation.

2.4.13 Beacon

When the beacon is installed, it is energized anytime the machine is in Ground Mode or Platform Mode to alert others in the immediate area. In most applications, the beacon serves as a visual signal to bystanders that the machine is in operation. The beacon is also part of the machine lowering visual warning indication. This is accomplished by a unique blink rate vs normal.

2.4.14 Lithium-Ion Batteries (If Equipped)

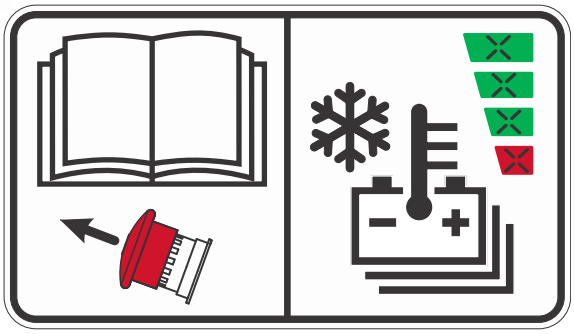
The vertical lift is powered by either a single 24V lithium-ion battery or two 24V lithium-ion batteries. The Battery Management System (BMS) is internal to the battery and monitors and maintains the health of the battery. It monitors internal cell voltages, temperatures, and calculates the battery State of Charge (SOC). 100% SOC is a fully charged battery. The BMS controls when the battery can be charged, discharged, and commands the required voltages and currents to the charger during charging.

⚠ WARNING

Do not use an additional battery heater or heater blanket in cold weather conditions.

Only use the JLG-installed 24 V charger, which has been rated specifically for this machine and battery type, to charge the batteries. Do not substitute this charger for a different one. Doing so will void the machine warranty.

If any damage to the batteries is discovered during machine inspection, discontinue use immediately. Do not use the machine until the issue has been inspected and corrected by a qualified mechanic.



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Machine operation may be limited if the lithium-ion battery is too cold.

Temperature	Functions	Behavior
Normal Battery Temperature (32°F/0°C)	Full machine operation	—
Chilled Battery Temperature (-10°F/-23°C)	Machine lift and drive functions operate at creep speed	Battery heater will activate. The system fault indicator will flash and an active DTC will appear for the battery heater. Once battery reaches normal temperature, full machine operation is restored.
Very Cold Battery Temperature (-22°F/-30°C)	Machine will not lift or drive	Battery heater will activate. The system fault indicator will flash, an active DTC will appear for the battery heater, and the battery charge indicators on the platform control box will flash simultaneously. Once the battery achieves an internal temperature permitting machine operation at creep speed, the platform and ground alarms will sound three times, and the battery charge indicators will show the current state of charge.

Note: For machines equipped with lithium-ion batteries, if the machine is being used, stored, or sitting overnight in a cold environment, plug in the machine to keep the batteries full and warm. If it is not plugged in, the batteries may be cold and will need to warm up before the machine can fully function. The battery heater is operational when the machine is powered on (both emergency stop switches pulled out and the keyswitch positioned to either ground or platform) or when the machine is charging.

If the machine is equipped with lithium-ion batteries, battery charging is a function of the battery cell temperature. Refer to the table below for details.

Table 8. Battery Heater Ranges (Lithium-Ion Only)

Cell Temperature Range			
Temperature Range Limits		Lithium-Ion with Heater	
Temp °C	Temp °F	Charge	Discharge
> 0	> 32	Yes	Yes
> -18	> 0	Yes *	Yes *
> -35	> -31	Yes *	No

* The battery heater turns on while charging at a cell temperature below 41°F (5°C) and shuts off at 59°F (15°C).

Note: The battery heater will raise the temperature of the battery at a rate of approximately 2°F (1°C) per minute.

Note: In order for the battery heater to operate, the battery state-of-charge must be 5% or greater if the machine is not actively charging. If the machine is actively charging, the battery heater is able to operate at any time.

2.4.15 FLA or AGM Batteries (If Equipped)

The batteries are the main power source of the vertical lift. Four 6V batteries are connected in series to make a 24V system. There are multiple battery options available: FLA (flooded lead acid) and AGM (absorbed glass mat) are offered with the machine.

2.4.16 Ground Control Key Switch

The ground control key switch is used for selecting the active control of the machine between the platform or ground control stations and as another shut off switch for machine power. The key switch is removable in the OFF position.

2.4.17 JLG Mobile Control System

When equipped with the optional JLG Mobile Control Module (Bluetooth), an operator will be able to remotely operate Drive and Steer functions from a compatible smartphone or tablet. This will allow an operator to control the vehicle without standing beside or on the platform of the vehicle. This functionality is helpful when environmental conditions limit the operator's ability to control the vehicle from the typical platform controls. To use this feature, the operator must have the JLG Mobile Control App installed on a device that can scan a machine's unique Mobile Control QR code affixed to multiple locations on the vehicle chassis. The vehicle must be in transport position, ground control mode, and powered on in order to activate mobile control functionality.

2.4.18 Drive System

The drive system consists of two PMDC drive motors. The drive motors are located at the rear of the machine. Drive speed is controlled by the drive motor control module and is proportional to the joystick input. The maximum speed of the drive system is achieved in the transport position. Drive speed is reduced in the above transport position.

While initiating steer command during drive operation, the drive speed is altered to improve drive and steer performance.

2.4.19 Brake System

The static brake system consists of two spring applied electrically released brakes which is integrated with drive motor. When actuate the joystick drive function, brakes will be released automatically. When release the joystick drive function, brakes will be active automatically. This brake will be used as static and dynamic brake.

2.4.20 Gate Alarm (Accessory on Material Tray Platform)

When equipped, there is a set of independent proximity sensors installed into the platform hinges and connected thru the platform control box to identify when the platform gate(s) are open or closed. Depending on the setting selected in the analyzer, the machine response will be different. This is selectable in order to meet different job site requirements.

ELEV CUTOUT ALL: Sounds the alarm and disables Lift Up and Drive whenever the gate is open out of transport.

ELEV CUT +ALARM: Sounds the alarm and disables Lift Up and Drive out of transport and sounds alarm stowed while commanding motion while the gate is opened. Traps in transport.

ELEV CUT+MOTION: Sounds the alarm and disables Lift Up and Drive out of transport when motion is commanded and the gate is open.

CUTOUT ALL: Sounds the alarm and disables vehicle operation when the gate is open.

CUT ALL+MOTION: Sounds the alarm and disables motion when the gate switch is open and motion is commanded.

2.4.21 Lift System

The lift system consists of a sequenced set of masts that extend (lift up) via a hydraulic cylinder connected to a series of chains and pulleys to achieve the machine's rated platform height. The cylinder is actuated hydraulically with the stroke being limited by contact between the piston and head of cylinder in the fully extend position. Each mast section moves at the same rate in the up and down direction. All of the parts are contained within the extruded mast sections.

Lift down is achieved by gravity and engaged by opening the lift down valve located on the lift cylinder. The lift up speed (proportional)is controlled by the pump whereas the lift down speed (proportional) is controlled by the lift down valve and also has a manual override (proportional). The masts maintain their sequence by a set of sequence cables on the outside of the mast assembly.

2.4.22 Steer System

The steer system consists of a double end rod, double acting cylinder, spindles, and tie rod links arranged in a 5-bar linkage located at the front of the machine (FWS). The Ackerman principle is applied to the steering geometry and designed to minimize tire scrub at zero turn radius

2.4.23 Pothole Protection System

The pothole protection system is designed to reduce ground clearance when the machine is in the above transport (elevated) position. The system consists of a mechanical linkage (rack and pinion) that allows the right and left pothole bars to rotate between the two positions of the system, raised and lowered.

Transport(stowed)Position:

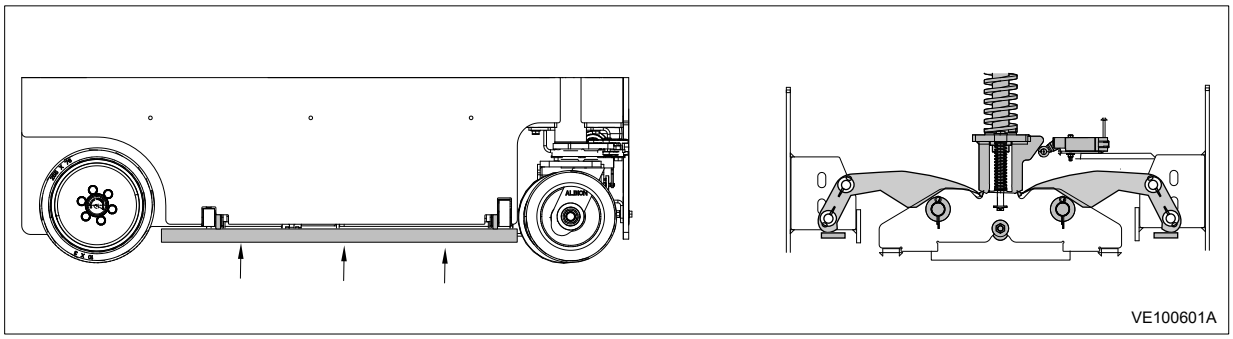

Figure 5. Platform Fully Lowered – Pothole Bars Fully Raised

In the machine's stowed position, the pothole bars are approximately parallel to the ground to increase the ground clearance of the machine as shown in the image above.

Above Transport (elevated) Position:

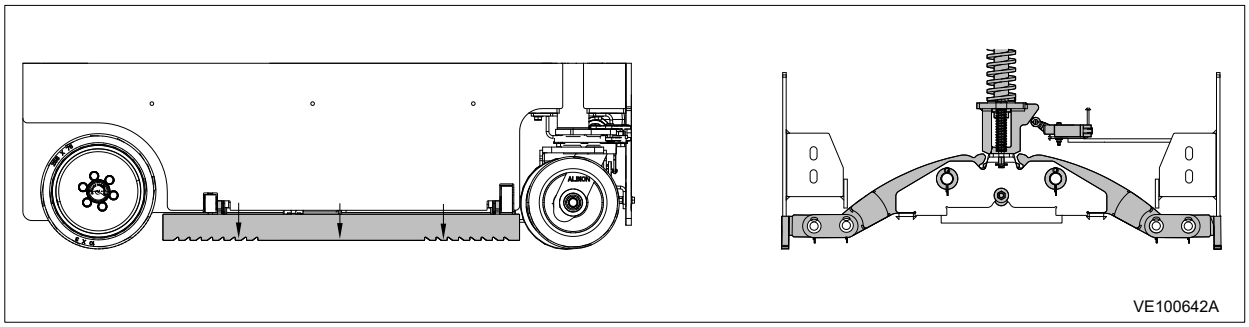

Figure 6. Platform Elevated – Pothole Bars Fully Lowered

The pothole bars' lowered position is achieved as the mast begins to depart from the machine's stowed position and before the mast reaches its elevated position. During this process, the pothole bars, which have a mechanical interaction with the mast, begin to rotate down towards the ground via their mechanical linkage as the mast elevates. The rotation of the bars is aided by a spring that is compressed in the machine's stowed position. The spring begins to release its energy as the mast rises into the machine's elevated position. When the pothole bars reach full rotation (fully lowered position), the linkage "cams over" into a self-locking position

The GM monitors the PHP system using a positive opening limit switch (dual channel). The limit switch can be adjusted for proper functionality (see service manual). The limit switch contacts the rack of the PHP linkage to monitor the raised and lowered position of the pothole bars. The drive function shall cutout if one or both of the pothole bars are not in the fully lowered position.

An added feature of the system is an over-travel spring that protects the system from being damaged if the pothole bars are obstructed in the lowered position and the mast is lifted down to the machines transport (stowed)position

2.4.24 Manual Descent System

The manual descent system allows the lift cylinder to be lowered without machine power. A hand operated push button will operate a valve on the lift cylinder and cause a flow-controlled (orifice) path to tank.

2.4.25 Wheels/Tires

The wheel/tire consists of a steel wheel with a molded solid non-marking tire. The wheels are connected to the machine by a pattern of bolts on the rear drive motors. The front wheels are either caster assemblies or wheels mounted to spindles via snap ring.

2.4.26 Platform Rail System

The system provides fall protection for the operator during operation of the machine. The rail system consists of vertical and horizontal rails and the configuration and gate style is dependent on platform purchased.

2.4.27 Tow System

The Tow system can be used to tow the machine. Brakes must be released by pushing the brake Release button located on the ground control panel for at least 3 seconds. The brake needs to be reset manually by pressing the button on the ground control panel once towing is complete. The machine requires power to disengage the brakes.

2.4.28 Pothole Protection Alarm

When this option is enabled, the pothole alarm will sound and drive will be prevented during the following conditions:

- While the machine is in the transport position and one or both of the pothole bars are obstructed to reach their fully raised position.
- While the machine is in the above transport position and one or both of the pothole bars are obstructed to reach their fully lowered position.

2.4.29 Low Temperature Cutout

This system is designed to inform the operator when the machine is operating in low ambient temperatures. By default, the system is triggered when ambient temperatures are less than -18°C, and can be adjust via the analyzer.

2.4.30 Indoor/Outdoor Mode

The Indoor/Outdoor push button, located at the platform control station, allows the operator to pick between Indoor or Outdoor Mode. The Indoor LED and Outdoor LED will alert the operator to the active mode.

When enabled, Indoor Mode shall allow the mast to lift rated capacity to full height and Outdoor Mode allows the mast to lift rated capacity to restricted height.

INDOOR USE is use of a vertical lift in areas shielded from wind so that there is no wind. OUTDOOR USE is use of a vertical lift in an environment that can be exposed to wind. Prior to selecting Indoor Mode, ensure that the machine is used in an area that is shielded from wind.

In CE/UKCA machines the platform must be in stowed position, to switch from one mode to another. If the mode switch is pressed while the machine is elevated, the indicator flashes but the machine state does not change.

2.4.31 Slope Descent System

The GM controls drive speed when descending slopes (Forward or Reverse) while in the transport positions. This is achieved by lowering the drive command percentage sent to the GM when the Y tilt (fore-aft) value exceeds 5°. The percentage of drive speed reduction increases as the slope increases.

2.4.32 Driving Above Elevated Position

The control system will determine the maximum allowed drive speed based on the status of the mast proximity (elevation) sensor and the PHP system's limit switch. Refer the table below for machine response.

Proximity Sensor	PHP Limit Switch	Response
Closed (Platform stowed)	Retracted	High Drive Speed
Open (Platform elevated)	Deployed	Reduced (elevated) Drive Speed
Closed (Platform stowed)	Deployed	Reduced (elevated) Drive Speed
Open (Platform elevated)	Retracted	Drive Prevented

2.5 CLEARSKY SMART FLEET™ (IF EQUIPPED)

2.5.1 General

ClearSky Smart Fleet™ integrates on-machine hardware (CS550) and app or web-based software to provide data, tools and analytics to aid in asset and fleet management. Personnel with the appropriate permissions can access these features using the ClearSky Smart Fleet web portal or the ClearSky Smart Fleet mobile app. Features include telematics data reporting (such as fuel level and battery charge), remote troubleshooting tools (including diagnostic trouble codes or system alerts), and access control (if available) restrictions.

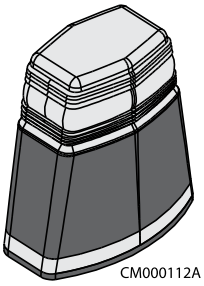

Figure 7. CS550 (LED Motion / Amber Beacon)

2.5.2 ClearSky Smart Fleet™ — Access Control

This machine may be equipped with ClearSky Smart Fleet™ Access Control. Using the ClearSky Smart Fleet mobile app or web portal (remotely or locally), the machine can be placed into restricted states that limit machine functionality for all operators. Only authorized personnel can make changes from within the web portal or app.

⚠ WARNING

Before placing the machine into a restricted state make sure the machine can be safely locked out or function speeds reduced. This includes verifying that it is the correct machine, the machine is not in use, and there are no personnel in the work platform. JLG Industries, Inc. assumes no responsibility or liability for any and all incidents involving personal injury, property damage, or equipment damage that may occur from the improper utilization of JLG products.

Restricted states may include:

1. Speed Restricted — Machine drive speed is restricted to low speed and lift speed is reduced.
2. Speed and Function Restricted — Machine drive speed is restricted to low speed and the platform is restricted to a fully-lowered position. In this state, once the platform is fully lowered, it is not permitted to leave that defined position.
3. Locked Out — Machine has been locked out and will not operate (including engine start, if applicable).

NOTICE

The Access Control function has the capability to place the machine into a restricted state remotely. Account for Access Control functionality, including restricted states, in a safe use plan.

Note: Restricted functionality may occur if the CS550 (ClearSky® LED Motion / Amber Beacon) is damaged or removed. A protective cage is available through JLG.

Machines equipped with ClearSky Smart Fleet Access Control are also equipped with the ClearSky CS550.

SECTION 3
MAINTENANCE AND INSPECTION SCHEDULES

3.1 MACHINE PREPARATION, INSPECTION, AND MAINTENANCE

3.1.1 General

This section provides the necessary information needed by those personnel that are responsible to place the machine in operation readiness and maintain its safe operating condition. For maximum service life and safe operation, ensure that all the necessary inspections and maintenance have been completed before placing the machine into service With proper care, maintenance, and inspections performed per JLG's recommendations, and with any and all discrepancies corrected, this product will be fit for continued use.

3.1.2 Preparation, Inspection, and Maintenance

It is important to establish and conform to a comprehensive inspection and preventive maintenance program. The following table outlines the periodic machine inspections and maintenance recommended by JLG Industries, Inc. Consult your national, regional, or local regulations for further requirements for mobile elevating work platform. The frequency of inspections and maintenance must be increased as environment, severity and frequency of usage requires.

3.1.3 Pre-Start Inspection

It is the User’s or Operator’s primary responsibility to perform a Pre-Start Inspection of the machine prior to use daily or at each change of operator. Reference the Operation and Safety Manual for completion procedures for the Pre-Start Inspection. The Operation and Safety Manual must be read in its entirety and understood prior to performing the Pre-Start Inspection.

3.1.4 Pre-Delivery Inspection and Frequent Inspection

The Pre-Delivery Inspection and Frequent Inspection shall be performed by a qualified JLG equipment mechanic. JLG Industries, Inc. recognizes a qualified JLG equipment mechanic as a person who, by possession of a recognized degree, certificate, extensive knowledge, training, or experience, has successfully demonstrated the ability and proficiency to service, repair, and maintain the subject JLG product model.

The Pre-Delivery Inspection and Frequent Inspection procedures are performed in the same manner, but at different times. The Pre-Delivery Inspection shall be performed prior to each sale, lease, or rental delivery. The Frequent Inspection shall be accomplished for each machine in service for 3 months; out of service for a period of more than 3 months; or when purchased used. The frequency of this inspection must be increased as environment, severity and frequency of usage requires.

Reference the JLG Pre-Delivery and Frequent Inspection Form and the Inspection and Preventative Maintenance Schedule for items requiring inspection during the performance of these inspections. Reference the appropriate areas of this manual for servicing and maintenance procedures.

3.1.5 Annual Machine Inspection

The Annual Machine Inspection must be performed by a Factory- Trained Service Technician on an annual basis, no later than thirteen (13) months from the date of the prior Annual Machine Inspection. JLG Industries, Inc. recognizes a qualified JLG equipment mechanic as a person who has successfully completed the JLG Service Training School for the subject JLG product model. Reference the machine Service and Maintenance Manual and appropriate JLG inspection form for performance of this inspection.

Reference the JLG Annual Machine Inspection Form and the Inspection and Preventative Maintenance Schedule for items requiring inspection during the performance of this inspection. Reference the appropriate areas of this manual for servicing and maintenance procedures.

For the purpose of receiving safety-related bulletins, it is important that JLG Industries, Inc. has updated ownership information for each machine. When performing each Annual Machine Inspection, notify JLG Industries, Inc. of the current machine ownership.

3.1.6 Preventative Maintenance

In conjunction with the specified inspections, maintenance shall be performed by a qualified JLG equipment mechanic. JLG Industries, Inc. recognizes a qualified JLG equipment mechanic as a person who, by possession of a recognized degree, certificate, extensive knowledge, training, or experience, has successfully demonstrated the ability and proficiency to service, repair, and maintain the subject JLG product model.

Refer to Section — Preventive Maintenance & Inspection Schedule, and appropriate areas of this manual for servicing and maintenance procedures. The frequency of service and maintenance must be increased as environment, severity and frequency of usage requires.

Table 9. Inspection and Maintenance

Type	Frequency	Primary Responsibility	Service Qualification	Reference
Pre-Start Inspection	Prior to use each day; or At each Operator change.	User or Operator	User or Operator	Operator and Safety Manual
Pre-Delivery Inspection	Prior to each sale, lease, or rental delivery.	Owner, Dealer, or User	Qualified JLG Mechanic	Service and Maintenance Manual and applicable JLG inspection form.
Frequent Inspection	In service for 3 months; or Out of service for a period of more than 3 months; or Purchased used.	Owner, Dealer, or User	Qualified JLG Mechanic	Service and Maintenance Manual and applicable JLG inspection form.
Annual Machine Inspection	Annually, no later than 13 months from the date of the prior inspection.	Owner, Dealer, or User	Factory- Trained Service Technician	Service and Maintenance Manual and applicable JLG inspection form.
Preventative Maintenance	At intervals as specified in the Service and Maintenance Manual.	Owner, Dealer, or User	Qualified JLG Mechanic	Service and Maintenance Manual

3.2 SERVICING AND MAINTENANCE GUIDELINES

3.2.1 General

The following information is provided to assist you in the use and application of servicing and maintenance procedures contained in this chapter.

3.2.2 Safety and Workmanship

Your safety, and that of others, is the first consideration when engaging in the maintenance of equipment. Always be conscious of component weight. Never attempt to move heavy parts without the aid of a mechanical device. Do not allow heavy objects to rest in an unstable position. When raising a portion of the equipment, ensure that adequate support is provided.

⚠ WARNING

Never work under an elevated platform until platform has been safely restrained from any movement by blocking or an overhead sling.

3.2.3 Cleanliness

The most important single item in preserving the long service life of a machine is to keep dirt and foreign materials out of the vital components. Precautions have been taken to safeguard against this. Shields, covers, seals, and filters are provided to keep the wheel bearings, mast sections and oil supply clean; however, these items must be maintained on a scheduled basis in order to function properly

At any time when oil lines are disconnected, clear adjacent areas as well as the openings and fittings themselves. As soon as a line or component is disconnected, cap or cover all openings to prevent entry of foreign matter.

Clean and inspect all parts during servicing or maintenance, and assure that all passages and openings are unobstructed. Cover all parts to keep them clean. Be sure all parts are clean before they are installed. New parts should remain in their containers until they are ready to be used.

3.2.4 Components Removal and Installation

Use adjustable lifting devices, whenever possible, if mechanical assistance is required. All slings *(chains, cables, etc.)* should be parallel to each other and as near perpendicular as possible to top of part being lifted.

Should it be necessary to remove a component on an angle, keep in mind that the capacity of an eyebolt or similar bracket lessens, as the angle between the supporting structure and the component becomes less than 90 degrees.

If a part resists removal, check to see whether all nuts, bolts, cables, brackets, wiring, etc., have been removed and that no adjacent parts are interfering.

3.2.5 Component Disassembly and Reassembly

When disassembling or reassembling a component, complete the procedural steps in sequence. Do not partially disassemble or assemble one part, then start on another. Always recheck your work to assure that nothing has been overlooked. Do not make any adjustments, other than those recommended, without obtaining proper approval.

3.2.6 Pressure-Fit Parts

When assembling pressure-fit parts, use an “anti-seize” or molybdenum disulfide base compound to lubricate the mating surface.

3.2.7 Bearings

When a bearing is removed, cover it to keep out dirt and abrasives. Clean bearings in nonflammable cleaning solvent and allow to drip dry. Compressed air can be used but do not spin the bearing.

Discard bearings if the races and balls *(or rollers)* are pitted, scored, or burned.

If bearing is found to be serviceable, apply a light coat of oil and wrap it in clean *(waxed)* paper. Do not unwrap reusable or new bearings until they are ready to install.

Lubricate new or used serviceable bearings before installation. When pressing a bearing into a retainer or bore, apply pressure to the outer race. If the bearing is to be installed on a shaft, apply pressure to the inner race.

3.2.8 Gaskets

Check that holes in gaskets align with openings in the mating parts. If it becomes necessary to hand-fabricate a gasket, use gasket material or stock of equivalent material and thickness. Be sure to cut holes in the right location, as blank gaskets can cause serious system damage.

3.2.9 Bolt Usage and Torque Application

Use bolts of proper length. A bolt which is too long will bottom before the head is tight against its related part. If a bolt is too short, there will not be enough thread area to engage and hold the part properly. When replacing bolts, use only those having the same specifications of the original, or one which is equivalent.

Unless specific torque requirements are given within the text, standard torque values should be used on heat-treated bolts, studs, and steel nuts, in accordance with recommended shop practices or Torque Chart in *Section — Torque Charts, page 357*.

3.2.10 Hydraulic Lines and Electrical Wiring

Clearly mark or tag hydraulic lines and electrical wiring, as well as their receptacles, when disconnecting or removing them from the unit. This will assure that they are correctly reinstalled.

3.2.11 Hydraulic System

Keep the system clean. If evidence of metal or rubber particles is found in the hydraulic system, drain and flush the entire system.

Disassemble and reassemble parts on clean work surface. Clean all metal parts with non-flammable cleaning solvent. Lubricate components, as required, to aid assembly.

3.2.12 Lubrication and Servicing

Components and assemblies requiring lubrication and servicing are shown in the below table. Service applicable components with the amount, type, and grade of lubricant recommended in this manual, at the specified intervals. When recommended lubricants are not available, consult your local supplier for an equivalent that meets or exceeds the specifications listed.

Table 10. Lubrication Intervals for Various Components

ITEM	COMPONENT	NO/TYPE [a] LUBE POINTS	LUBE/ METHOD	INTERVAL [b]				COMMENTS
				3 MONTHS	6 MONTHS	1 YEAR	2 YEARS	
1	Hydraulic Reservoir	Fill to Line on Reservoir 5 Qt. Reservoir	HO - Check Hyd. Oil Level HO - Change Hyd. Oil				√	Check fluid level every day. [c] Change hydraulic oil every 2 years.
2	Mast Chains	2 - Per Section	Chain Lube - Brush or Spray		√			Inspect and lubricate
Key to Lubricants:		**MPG** - Multipurpose Grease **HO** - Hydraulic Oil - ISO-Vg grade 32, 46. **CL** - Chain Lube. Use a Mobil 375 NC.						

Note:
(a) Be certain to lubricate like items on each side of the machine.
(b) Recommended lubricating intervals are based on normal use. If machine is subjected to severe operating conditions, such as a high number of cycles, location, corrosive/ dirty environment, etc., user must adjust lubricating requirements accordingly.
(c) Prior to checking hydraulic oil level, operate machine through one complete cycle of lift function (full up and down). Failure to do so will result in incorrect oil level reading on the hydraulic reservoir.

3.2.13 Batteries

Clean batteries, using a non-metallic brush and a solution of baking soda and water. Rinse with clean water. After cleaning, thoroughly dry batteries and coat terminals with an anti-corrosion compound.

3.2.14 Mast Chain Inspection Procedure

Inspect mast chains for the following conditions:

Wear: Always inspect that segment of chain that operates over a sheave. As the chain flexes over the sheaves, joints and plate edges very gradually wear. Chain “stretch” can be measured using a manufacturers wear scale or steel tape. When chains have elongated 3% they must be removed and replaced. Refer to table below for proper chain specifications and allowable stretch tolerances. Peening and wear of chain plate edges are caused by sliding over a chain worn contact face of a sheave, or unusually heavy loads. All of the above require replacement of the chain and correction of the cause. Chain side wear, noticeable when pin heads and outside plates show a definite wear pattern, is caused by misalignment of the sheave/chain anchors and must be corrected promptly. Do not repair chains; if a section of chain is damaged, replace the entire chain set.

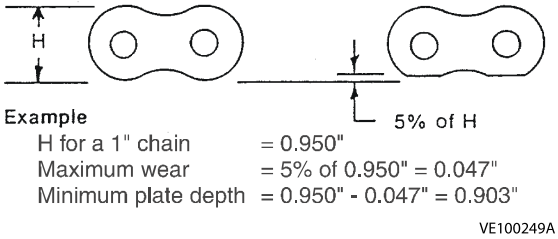

Figure 8. Chain Plate Wear

Table 11. Chain Stretch Tolerance

Chain Size	Pin to Pin Measurement	Allowable Stretch
.50 in. pitch	12 in or 24 pitches	.24 in /12 in. span
.625 in pitch	15 in or 24 pitches	.30 in /15 in. span

Rust and Corrosion: Rust and corrosion will cause a major reduction in the load carrying capacity of the chain, because these are primary reasons for side plate cracking. The initial lubrication at the factory is applied in a hot dip tank to assure full penetration into the joint. Do not steam clean or degrease chains. At time of chain installation, factory lube must be supplemented by a maintenance program to provide a film of oil on the chains at all times. If chains are corroded, they must be inspected, especially the outside plates, for cracks in-line with the pins. If cracks are found, replace the chain; if no cracks are discovered, lubricate the chains by dipping in heated oil, and reinstall on the machine. Keep chains lubricated.

Fatigue Cracks: Fatigue is a phenomenon that affects most metals, and is the most common cause of chain plate failures. Fatigue cracks are found through the link holes, perpendicular (90 degrees) from the pin in-line position. Inspect chains carefully after long time use and heavy loading for this type of crack. If any cracks are discovered, replace all chains, as seemingly sound plates are on the verge of cracking. Fatigue and ultimate strength failures on JLG Lifts are incurred as a result of severe abuse as design specs are well within the rated lifting capacity of these chains.

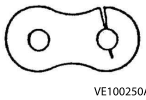

Figure 9. Chain Plate Crack

Tight Joints: All joints in the leaf chain should flex freely. On leaf chain, tight joints are usually caused by rust/corrosion, or the inside plates “walking” off the bushing. Limber up rusty/ corroded chains *(after inspecting care fully)* with a heavy application of oil *(preferably a hot oil dip)*. Tap inside “walking” plates inward; if “walking” persists, replace the chain. This type of problem is accelerated by poor lubrication maintenance practice, and most tight joint chains have been operated with little or no lubrication. Tight joints on leaf chain are generally caused by:

1. Bent pins or plates.
2. Rusty joints.
3. Peened plate edges.

Oil rusty chains, and replace chains with bent or peened chain components. Keep chains lubricated.

VE100251A

Figure 10. Tight Joints

Protruding or Turned Pins: Chains operating with inadequate lube generate tremendous friction between the pin and plates (pin and bushing on leaf chain). In extreme cases, this frictional torque can actually turn the pins in the outside press-fit plates. Inspect for turned pins, which can be easily spotted as the “V” flats on the pin heads are no longer in line. Replace all chains showing evidence of turned or protruding pins. Keep chains lubricated.

Stress Corrosion Cracking: The outside link plates, which are heavily press-fitted to the pins, are particularly susceptible to stress corrosion cracking. Like fatigue cracks, these initiate at the point of highest stress (aperture) but tend to extend in an arc-like path, often parallel to the rolling grain of the material.

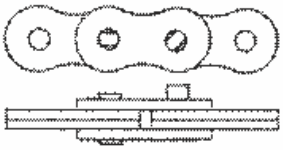

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Figure 11. Abnormal Protrusion or Turned Pins

Also, more then one crack can often appear on a link plate. In addition to rusting, this condition can be caused by exposure to an acidic or caustic medium or atmosphere. Stress corrosion is an environmentally assisted failure. Two conditions must be present; corrosive agent and static stress.

VE100253A

Figure 12. Arc-like Cracked Plates (Stress Corrosion)

In the chain, static stress is present at the aperture due to the press fit pin. No cycle motion is required and the plates can crack during idle periods. The reactions of many chemical agents (such as battery acid fumes) with hardened metals liberate hydrogen which attacks and weakens the metal grain structure.

Chain Anchors and Sheaves: An inspection of the chain must include a close examination of chain anchors and sheaves. Check chain anchors for wear breakage and misalignment. Anchors with worn or broken fingers should be replaced. They should also be adjusted to eliminate twisting the chain for an even load distribution.

Inspect the sheaves, sheave bearings, sheave grooves and pins for extreme wear, replace as necessary. A worn sheave can mean several problems, as follows:

1. Chains too tight.
2. Sheave bearings/pin bad.
3. Bent/misaligned chains.

3.2.15 Lift Cylinder Component Inspection

Cylinder Rod

There should be no scratches or pits deep enough to catch the fingernail. Pits that go to the base metal are unacceptable. Scratches that catch the fingernail but are not to the base metal, less than 0.5 inch long and primarily in the circumferential direction are acceptable provided they cannot cut the rod seal. Chrome should be present over the entire surface of the rod and the lack thereof is unacceptable. In the event that an unacceptable condition occurs, the rod should be repaired or replaced.

Cylinder Head

Visually inspect the inside bore for scratches or polishing. Deep scratches are unacceptable. Polishing indicates uneven loading and when this occurs, the bore should be checked for out-of-roundness. If out-of-roundness exceed 0.007 in., this is unacceptable. Check the condition of the dynamic seals (wiper, rod seals) looking particularly for metallic particles embedded in the seal surface. It is normal to cut the static seal on the retaining ring groove upon disassembly. Remove the rod seal, static O-ring and backup and rod wiper. Damage to the seal grooves, particularly on the sealing surfaces, is unacceptable. In the event that an unacceptable condition occurs, the head should be replaced.

Piston

Visually inspect the outside surface for scratches or polishing. Deep scratches are unacceptable. Polishing indicates uneven loading and when this occurs, the diameter should be checked for out-of-roundness. If out-of-roundness exceeds 0.007 in., this is unacceptable. Check the condition of the dynamic seals and bearings looking particularly for metallic particles embedded in the bearing and in the piston seal surface. Remove the seals and bearings. Damage to the seal grooves, particularly on the sealing surfaces, is unacceptable. In the event that an unacceptable condition occurs, the piston should be replaced.

Tube Assembly

Visually inspect the inside bore for scratches and pits. There should be no scratches or pits deep enough to catch the fingernail. Scratches that catch the fingernail but are less than 0.5 inch long and primarily in the circumferential direction are acceptable provided they cannot cut the piston seal. The roughness of the bore should be between 10 and 20 µ inches RMS. Significant variation (greater than 8 µ inches difference) are unacceptable. In the event that an unacceptable condition occurs, the tube assembly should be repaired or replaced.

3.3 PREVENTIVE MAINTENANCE AND INSPECTION SCHEDULE

The preventive maintenance and inspection checks are listed and defined in the following table. This table is divided into two basic parts, the “AREA” to be inspected and the “INTERVAL” at which the inspection is to take place. Under the “AREA” portion of the table, the various systems along with the components that make up that system are listed. The “INTERVAL” portion of the table is divided into two columns representing the various inspection time periods. The numbers listed within the interval column represent the applicable inspection code for which that component is to be checked.

The checks and services listed in this schedule are not intended to replace any local or regional regulations that may pertain to this type of equipment nor should the lists be considered as all inclusive. Variances in interval times may occur due to climate and/or conditions and depending on the location and use of the machine.

Table 12. MML/MCL/MSP - Preventive Maintenance & Inspection Schedule

AREA ON MACHINE	INTERVAL	
	PRE-DELIVERY [b] OR FREQUENT [c] INSPECTION	ANNUAL [d] (YEARLY) INSPECTION
MAST ASSEMBLY		
Mast Sections	2, 5	2, 5
Chain Systems	3, 14	3,14, 25
Sequence Cable Systems	3	1, 2, 3
Covers or Shields	1	1
Sheave Systems	1, 2	1, 2
Bearings	1,2	1, 2
Slide Pads	1,2	1, 2
PLATFORM ASSEMBLY		
Platform	1	1
Guard Rails	1, 2, 4	1, 2, 4
Gate	1, 5	1, 5
Floor	1, 2	1, 2

Table 12. MML/MCL/MSP - Preventive Maintenance & Inspection Schedule (continued)

AREA ON MACHINE	INTERVAL	
	PRE-DELIVERY [b] OR FREQUENT [c] INSPECTION	ANNUAL [d] (YEARLY) INSPECTION
Extension Deck Assembly	1, 5	1, 5
CHASSIS ASSEMBLY		
Wheel Rim Nuts	1[50]	1[50]
Tires	1	1, 2
Steer and Drive Components	1	1, 2, 7
Side-Compartment Door Installation	1, 5, 7	1, 5, 7
Drive Motor	1	1, 11, 7
Platform Ladder	1, 7	1, 7
Drive Brakes	1	1, 7
Drive Hubs	1	1, 11, 7
Sliding Wear Pads**	1, 2, 7, 13	1, 2, 7, 13
Front Wheel Spindle Nuts/Bolts	1[50]	1[50]
FUNCTIONS/CONTROLS		
Platform Controls	5, 6, 7	5, 6, 7
Ground Controls	5, 6	5, 6, 14
Function Control Locks, Guards, or Detents	5	5
Function Enable System	5	5
Emergency Stop Switches (Ground & Plaform)	5	5
Function Limit or Cutout Switch Systems	5	5
Drive Brakes	5	5
Manual Descent or Auxiliary Power	5	5
Load Sensing System	5,21,22	5,21,22
POWER SYSTEM		
Batteries	9, 11, 23	9, 11, 23
Battery Charger	5	5
HYDRAULIC/ELECTRIC SYSTEM		
Hydraulic Pump	1, 2, 9	1, 2, 5, 9
Hydraulic Cylinder	1,2,7,9,12,13,14	1,2,9,11,12,13,14
Cylinder Attachment Pins and Pin Retainers	1, 2	1, 2
Hydraulic Hoses, Lines, and Fittings	1, 9	1, 9
Hydraulic Reservoir, Cap, and Breather	5, 7	5, 7
Hydraulic Filter	7,9	7,9

Table 12. MML/MCL/MSP - Preventive Maintenance & Inspection Schedule (continued)

Hydraulic Fluid ***	11	11
Electrical Connections	20	20
Instruments, Gauges, Switches, Lights, Horn	5,23	5,23
GENERAL		
Operator and Safety Manual in Storage Box	21	21
ANSI Manual of Responsibilities and AEM Safety Manual in Storage Box (ANSI Only)	21	21
Capacity Decals Installed, Secure, Legible	21	21
All Decals/Placards Installed, Secure, Legible	21	21
“Walk-Around” Inspection Performed	21	21
Annual Machine Inspection Due	21	21
No Unauthorized Modifications or Additions	21	21
All Relevant Safety Publications Incorporated	21	21, 22
General Structural Condition and Welds	2, 4	2, 4
All Fasteners, Pins, Shields, and Covers	1,2	1, 2
Grease and Lubricate to Specifications	22	22
Function Test of All Systems	22	22
Paint and Appearance	7	7
Notify JLG of Change in Machine Ownership	22	22

Table 12. MML/MCL/MSP - Preventive Maintenance & Inspection Schedule (continued)

Footnotes:
[a] Prior to use each day; or at each Operator change.
[b] Prior to each sale, lease, or delivery.
[c] In service for 3 months; or Out of service for 3 months or more; or Purchased used.
[d] Annually, no later than 13 months from the date of the prior annual inspection.
[50] Indicates a 50 hour interval required to perform task after initial use of machine. This only occurs once in machine life.
** Refer to Operation and Safety Manual for machine specific instructions.
*** Drain and refill with fresh hydraulic fluid every two years.

Inspection and Maintenance Codes:
1 - Check for proper and secure installation.
2 - Visual inspection for damage, cracks, distortion, or excessive wear.
3 - Check for proper adjustment.
4 - Check for cracked or broken welds.
5 - Operates properly.
6 - Returns to neutral or "off" position when released.
7 - Clean and free of debris.
8 - Interlocks function properly.
9 - Check for signs of leakage.
10 - Decals installed and legible.
11 - Check for proper fluid level.
12 - Check for chafing and proper routing.
13 - Check for proper tolerances.
14 - Properly lubricated.
15 - Torqued to proper specification.
16 - No gouges, excessive wear, or cords showing.
17 - Properly inflated and seated around rim.
18 - Proper and authorized components.
19 - Fully charged.
20 - No loose connections, corrosion, or abrasions.
21 - Verify.
22 - Perform.
23 - Sealed properly.
24 - Overrides Platform controls.
25 - Inspected per Service and Maintenance Manual.

3.4 TIRES AND WHEELS

3.4.1 Tire Wear and Damage

Inspect tires periodically for wear or damage. Tires with worn edges or distorted profiles require replacement. Tires with significant damage in the tread area or side wall, require immediate evaluation before replacing the machine into service.

3.4.2 Wheel and Tire Replacement

Replacement wheels must have the same diameter and profile as the original. Replacement tires must be the same size and rating as the tire being replaced.

3.5 BATTERY SYSTEM MAINTENANCE/TROUBLESHOOTING

3.5.1 Battery Management System (BMS)

The battery is integrated with the Battery Management System which monitors and maintains the health of the battery. It monitors internal cell voltages, temperatures, and calculates the battery State of Charge (SOC); i.e., 100% SOC is a fully charged battery. The BMS controls when the battery can be charged, discharged, and commands the required voltages and currents to the charger during charging. The BMS will control the heaters during charging if the battery cell temperature is below 41°F and will initiate charging when the battery cell temperature is above 41°F.

3.5.2 State of Charge (SOC)

Inventus Battery has a power button that allows you to check the SOC (5 bars - 20% increments). SOC can also be seen using the DaVinciGO mobile Application. Connect to machine, go to measure tab >> Battery and Charger >> SOC.

The SOC is a calculated value determine by the BMS Module to estimate the current charge state of the machine.

The battery state of charge (SOC) calculation needs periodic calibration for an accurate measurement. To calibrate the SOC measurement, ensure that you perform a complete charge to 100%. It is advised to charge machine to full 100%, perhaps once per week during frequent usage.

The battery controller calibration helps determine the life of the battery. To calibrate battery controller, it is advised to periodically (approximately every 6 months) to complete a charge cycle from 20% to 100%.

3.5.3 Battery Status Indicator (LED)

The chart below describes meaning for the Battery Status Indicator lights blink pattern.

Fault ID	LED Status	Description of Fault	Fix
F0		**Over-temperature (cells)**	Wait for temperature to drop into acceptable operating range.
F1		**Over-temperature (BMS)**	Wait for temperature to drop into acceptable operating range.
F2		**Under-temperature (charge)**	Wait for temperature to drop into acceptable operating range.
F3		**Over-current (recoverable)**	If charging, power cycle charger; replace charger if problem persists. If discharging, battery will resume operation after discharge has been stopped.
F4		**Over-current (permanent fault)**	Disconnect and replace battery.
F5		**Short-circuit**	Check all connection point to battery system.
F6		**Cell under-voltage during discharge only**	Recharge battery.
F7		**Cell over-voltage during charge only (primary)**	Discharge battery down to 20% SOC and then recharge battery.
F8		**Cell over-voltage during charge only (secondary)**	Disconnect and replace battery.
F9		**Safety under-voltage**	Recharge battery.

Fault ID	LED Status	Description of Fault	Fix
F10		**Cell pre-charge fault**	Power cycle charger and replace charger if problem persists.
F11		**Charge fault**	Power cycle charger and replace charger if problem persists.
F12		**Under-temperature (discharge)**	Wait for temperature to rise into acceptable operational range.
F13		**Miscellaneous fault**	Power cycle battery. Replace battery if problem persists.
F14		**Pre-discharge**	Enable the battery without load and check if fault goes away. If fault is not present, reconnect to system. If fault persists, disconnect and replace battery.
F15		**Permanent fault**	Disconnect and replace battery.

SECTION 4
TESTING, CALIBRATIONS AND SPECIAL PROCEDURES

4.1 SPECIAL TOOLS

4.1.1 Multimeter Basics

A wide variety of multi-meters or Volt Ohm Meters (VOM) can be used for troubleshooting your equipment. A digital meter with reasonable accuracy (within 7%) is recommended for the measurements in these procedures. This section shows diagrams of a common, digital VOM configured for several different circuit measurements. Instructions for your VOM may vary. Please consult the meter operator's manual for more information.

Grounding

"Grounding the meter" means to take the black lead (which is connected to the COM (common) or negative port) and touch it to a good path to the negative side of the voltage source.

Back-Probing

To "back-probe" means to take the measurement by accessing a connector's contact on the same side as the wires, the back of the connector. Readings can be done while maintaining circuit continuity this way. If the connector is the sealed type, great care must be taken to avoid damaging the seal around the wire. It is best to use probes or probe tips specifically designed for this technique, especially on sealed connectors. Whenever possible insert probes into the side of the connector such that the test also checks both terminals of the connection. It is possible to inspect a connection within a closed connector by back-probing both sides of a connector terminal and measuring resistance. Do this after giving each wire a gentle pull to ensure the wires are still attached to the contact and contacts are seated in the connector.

Min/Max

Use of the "Min/Max" recording feature of some meters can help when taking measurements of intermittent conditions while alone. For example, you can read the voltage applied to a solenoid when it is only operational while a switch, far from the solenoid and meter, is held down.

Polarity

Finding a negative voltage or current reading when expecting a positive reading frequently means the leads are reversed. Check what reading is expected, the location of the signal and that the leads are connected to the device under test correctly. Also check that the lead on the "COM" port goes to the ground or negative side of the signal and the lead on the other port goes to the positive side of the signal.

Scale

M = Mega = 1,000,000 * (Displayed Number)

k = kilo = 1,000 * (Displayed Number)

m = milli = (Displayed Number) / 1,000

μ = micro = (Displayed Number) / 1,000,000

Example: 1.2 kΩ = 1200 Ω

Example: 50 mA = 0.05 A

Voltage Measurement

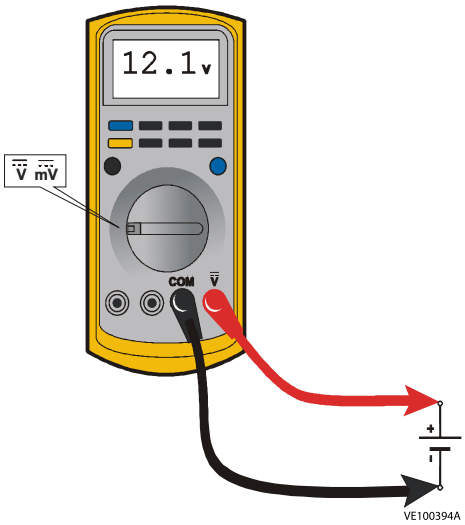


Figure 13. Voltage Measurement (DC)

- If meter is not auto ranging, set it to the correct range (See multimeter's operation manual)
- Use firm contact with meter leads

Resistance Measurement

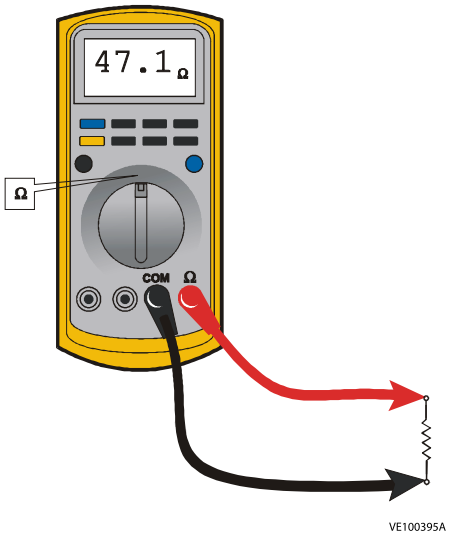


Figure 14. Resistance Measurement

- First test meter and leads by touching leads together. Resistance should read a short circuit (very low resistance).
- Circuit power must be turned OFF before testing resistance.
- Disconnect component from circuit before testing.
- If meter is not auto ranging, set it to the correct range (See multimeter's operation manual).
- Use firm contact with meter leads.

Continuity Measurement

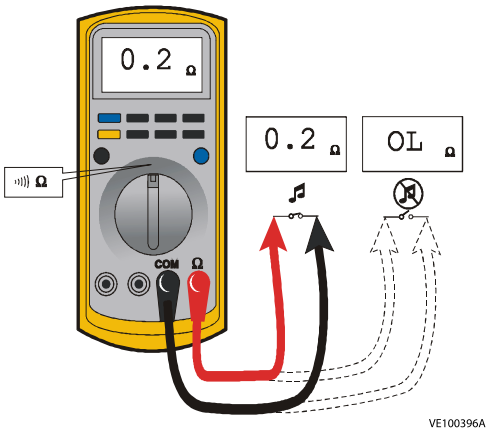


Figure 15. Continuity Measurement

- Some meters require a separate button press to enable audible continuity testing.
- Circuit power must be turned OFF before testing continuity.
- Disconnect component from circuit before testing.
- Use firm contact with meter leads.
- First test meter and leads by touching leads together. Meter should produce an audible alarm, indicating continuity.

Current Measurement

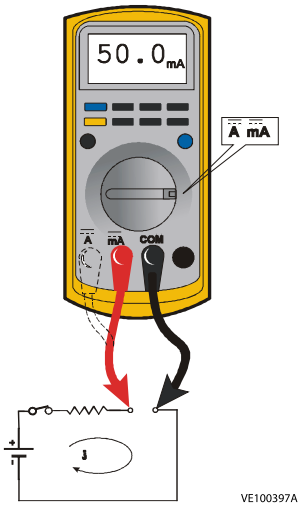


Figure 16. Current Measurment

- Set up the meter for the expected current range.
- Be sure to connect the meter leads to the correct jacks for the current range you have selected.
- If meter is not auto ranging, set it to the correct range (See multimeter's operation manual).
- Use firm contact with meter leads.

Continuity Measurement Over Long Distances

When trying to determine continuity of a harness or wire, longer than the reach of standard instrument leads, is possible to perform the check without excessively long leads. Using the other wires in the harness one can determine the condition of a particular wire in the harness.

Requirements:

- Harness with at least three separate wires including the wire under test.
- These wires must be able to be isolated from other wires, etc.
- Jumper or method to connect contacts on one side of harness.
- Meter that can measure resistance or continuity.

Procedure

Test multimeter leads resistance. Subtract this value from the measured resistance of the wires to get a more accurate measurement.

Consult the circuit schematic to determine which wires to use in addition to wire under test, here called wire #1 and wire #2, and how to isolate these wires. These wires should appear in the same connectors as the wire under test or are within reach of the jumper.

1. Disconnect all connections associated with the wire under test and the two additional wires. If harness is not completely isolated disconnect battery terminals also, as a precaution.
2. Measure continuity between all three wires, the wire under test, wire #1 and wire #2. These should be open. If not, repair the shorted wires or replace the harness.
3. On one side, jumper from contact of wire #1 and wire #2.
4. Measure continuity between wire #1 and wire #2. If there is continuity, both wires are good and can be used for this test. If there is not continuity, either wire could be bad. Check connections and measurement setup. Redo measurement. If still no continuity, repair wires or consult schematic for other wires to use for test.
5. Jumper from wire under test to wire #1.
6. Measure continuity. If there is continuity, the wire under test is good. Resistance of a wire increases as the length increases and as the diameter decreases.

One can find the continuity of two wires, here #1 and #2, at once by following steps 1 through 4. If there is a problem the third wire is used to troubleshoot the other wires. To find the problem, start at step 1 and use the entire procedure.

4.1.2 Threadlocking Compound

JLG PN	Loctite®	ND Industries	Description
0100011	242™	Vibra-TITE™ 121	Medium Strength (Blue)
1001095650	243™	Vibra-TITE™ 122	Medium Strength (Blue)
0100019	271™	Vibra-TITE™140	High Strength (Red)
0100071	262™	Vibra-TITE™ 131	Medium- High Strength (Red)

Note: Loctite® 243™ can be substituted in place of Loctite® 242™. Vibra-TITE™ 122 can be substituted in place of Vibra-TITE™ 121.

4.1.3 Tools Catalog

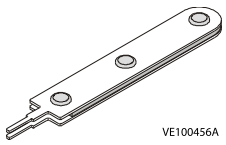
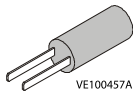
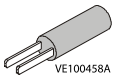
For additional special tools required, refer to the Tools Catalog.

The Tools Catalog can be found on JLG Online Express www.onlineexpress.jlg.com; JLG Catalog Part Number 401002.

4.1.4 Special Pin Extractor Tools For Electrical Connectors

The following table contains pin extractor tools for MML/MCL/MSP machine electrical connector components.

Table 13. Special Pin Extractor Tools for Electrical Connectors

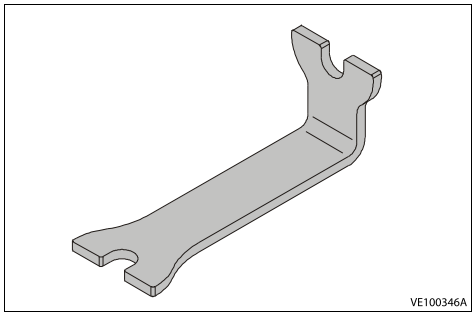
COMPONENT	DESCRIPTION	JLG PART NUMBER	ILLUSTRATION
Ground Control Station	For removal of electrical connector pins from the Ground Control Station connectors.	7016618	 VE100456A
Drive Motor	For removal of electrical connector pins from the Drive Motor main power connectors.	7002841	 VE100457A
Drive Motor Brake	For removal of electrical connector pins from the Drive Motor Brake power connectors.	7002842	 VE100458A

4.1.5 Hydraulic Line - Disconnect - Special Tool

The extend and return hydraulic line couplings and hose fittings on this machine require special tool JLG PN-7027247 to remove and install them.

⚠ CAUTION

Fully lower the mast to relieve pressure in the system before removing any hydraulic lines. Carefully loosen required fittings, wear safety protection equipment when working with hydraulic systems.



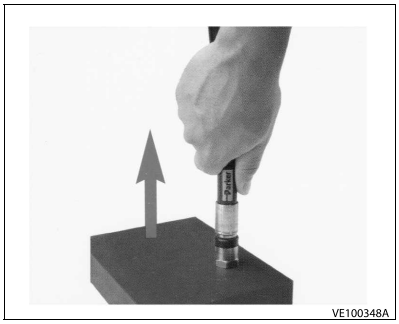
Push Type Hydraulic Line Removal - Special Tool JLG PN - 7027247

Instructions for tool use on both in-line and angled hose fittings are shown below:

Tool Use - In-Line Style Fittings

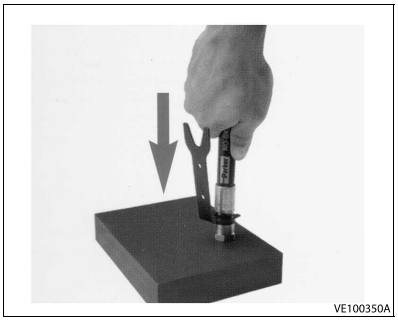
Step 1. Prior to disconnection, ensure that system is not under pressure.

Step 2. Pull on hose assembly to create a gap between the dust boot and hose fitting shoulder.

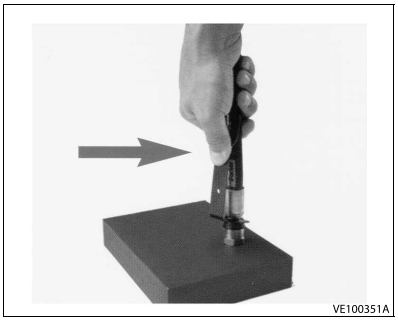


Step 3. Insert the disconnect tool in the gap created between the dust boot and hose fitting shoulder.

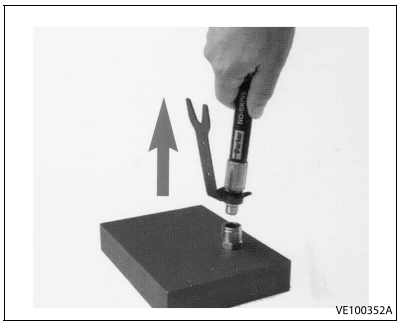
Step 4. Gently push hose assembly into coupling body (see directional arrow).

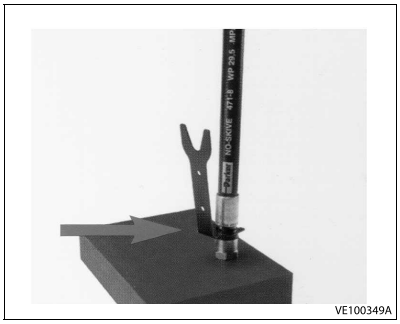


Step 5. Maintaining slight pressure on the hose assembly, actuate the tool (see arrow).



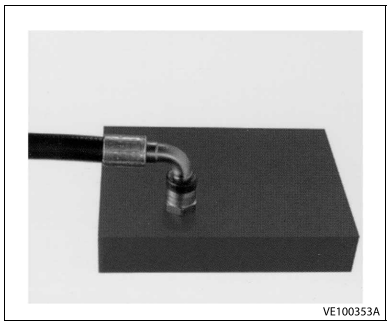
Step 6. Release the tool and pull on hose assembly to complete disconnection.



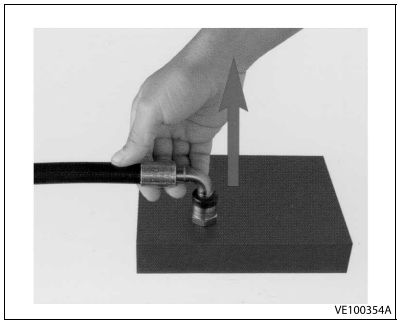


Tool Use - Angled Style Fittings

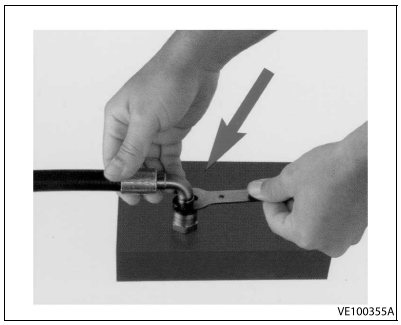
Step 1. Prior to disconnection, ensure that system is not under pressure.



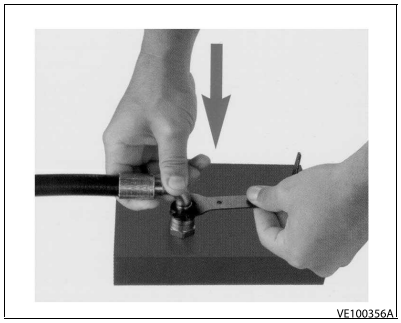
Step 2. Pull on hose assembly to create a gap between the dust boot and hose fitting shoulder.



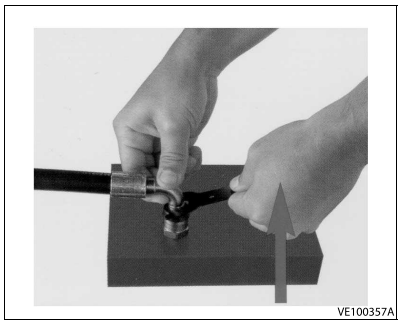
Step 3. Insert the disconnect tool in the gap created between the dust boot and hose fitting shoulder.



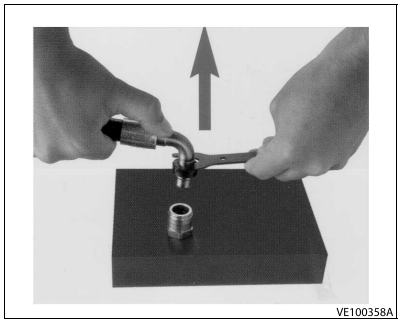
Step 4. Gently push hose assembly into coupling body (see directional arrow).



Step 5. While maintaining slight pressure on the hose assembly, actuate the tool (see arrow).



Step 6. Pull on hose assembly to complete disconnection.



4.2 TESTING PROCEDURES

4.2.1 LSS Testing and Evaluation

The following procedure should be executed to test LSS. The test confirms the LSS does not trigger when the platform carries 100% rated, load, and the LSS continuously triggers when the platform carries 120% rated load.

1. Turn the machine ON in Ground Mode.
2. Connect the JLG Analyzer to the diagnostic port in the wire harness. Go to Level 1 Access (Service Access) by entering password 33271 at the prompt.
3. Note the current setting of MACHINE SETUP 'LOAD' and then adjust it to CUTOUT ALL. This will allow LSS interlocks to work from Ground Mode.
4. Place weight corresponding to 100% of the machine's rated load in the center of the platform. Refer to the table below.

Table 14. Platform 100% Test Weight

MARKET	TEST WEIGHT	PLATFORM TYPE
ANSI USA, ANSI Export, CE, UKCA, AUS, CSA	400 lb (182 kg)	Extension with Saloon, Extension with Drop Bar, Maintenance Tray with Saloon, Maintenance Tray with Drop Bar and Aluminum Tray with Saloon
	450 lb (204 kg)	Standard Front Drop Bar, Ceiling Tile

5. Lift up to maximum elevation using the ground controls. LSS should not prevent motion and the Ground Overload Indicator should not illuminate.
6. Using the ground controls, lift down the platform until it is nearly stowed and not contacting the frame (about 3 - 6 in. from top of the frame. LSS should not prevent motion and the Ground Overload Indicator should not illuminate.
7. Place weight corresponding to 120% of the machine's rated load in the center of the platform. Refer to the table below.

Table 15. Platform 120% Test Weight

MARKET	TEST WEIGHT	PLATFORM TYPE
ANSI USA, ANSI Export, CE, UKCA, AUS, CSA	480 lb (218 kg)	Extension with Saloon, Extension with Drop Bar, Maintenance Tray with Saloon, Maintenance Tray with Drop Bar and Aluminum Tray with Saloon
	540 lb (245 kg)	Standard Front Drop Bar, Ceiling Tile

8. Lift up using the ground controls. LSS should prevent motion before reaching one (1) meter of platform travel, the Ground Overload Indicator should flash, and the alarm should sound.
9. If test is not successful, the LSS should be re-tested.
10. Readjust MACHINE SETUP 'LOAD' to the original setting.

4.2.2 Battery Condition Testing

Note: Batteries in storage should be kept at 6V or higher.

Before testing for battery condition, the open circuit voltage should be taken from each battery. If the voltage of the batteries differs by 0.3 volts or more, the lower voltage battery should be replaced.

Battery Testing Can Be Performed In Two Ways:

1. The batteries can be tested using a battery tester capable of testing 12V 100Ah AGM VRLA *(Valve Regulated Lead Acid)* batteries, using the instructions of the battery tester manufacturer.
2. If an appropriate battery tester is unavailable, the batteries can be tested by fully charging them with the charger that is installed on the machine. Then check the battery voltage of each battery - 4 hours - after charging is complete. Batteries less than 6V should be replaced.

Note: If a faulty charger is suspected, the batteries can be charged using a charger that supplies 2.45 volts/cell. Charging should be terminated when the charge current drops below 1 amp.

4.2.3 Electrical Switch Testing

Basic Check

The following check determines if the switch is functioning properly, not the circuit in which the switch is placed. A switch is functioning properly when there is continuity between the correct terminals or contacts only when selected.

1. De-energize the circuit.
2. Isolate the switch from the rest of the circuit if possible. If not possible, keep in mind it may affect readings.
3. Access the terminals to the switch.
4. If the switch has two terminals:
   a. Measure resistance across the terminals.
   b. Change the switch position.
   c. Measure resistance again with the leads in the same positions. If the meter was reading short, it should read an open. If the meter was reading open it should read short.
5. If the switch has more than two terminals, consult the schematic or switch diagram to determine what terminals will be connected. The test is similar to testing a switch with two terminals.
   a. Place one meter lead on the common contact and the other on a different contact in the same circuit.
   b. Cycle through all positions of the switch. The meter should read short only when the switch connects the two terminals and open otherwise.
   c. If the switch has more than one common contact repeat the process for that circuit.

Limit Switches

Limit switches are used to control movement or indicate position. Mechanical limit switches are just like manually operated switches except that the moving object operates the switch. These switches can be tested the same way as a standard switch by manually operating the sensing arm.

Another type of limit switch used by JLG is the inductive proximity switch, also referred to as a “prox switch”. Inductive proximity switches are actuated only by ferrous metal (metal that contains Iron, such as steel) near the switch. They do not require contact, and must be energized to actuate. These types of switches can be used to detect boom or platform position, for example. These switches have a sensing face where the switch can detect ferrous metal close to it. To find the sensing face, take note how the switch is mounted and how the mechanisms meet the switch. Test this type of switch as follows:

1. Remove prox switch from its mount.
2. Reconnect harness if it was disconnected for step 1, and turn on machine.
3. Hold switch away from metal and observe switch state in the control system diagnostics using the Analyzer. See vehicle or control system documentation on how to do this.
4. Place sensing face of switch on the object to be sensed by the switch. If that is not available, use a piece of ferrous metal physically similar to it. The switch state in the control system diagnostics should change.
5. When reinstalling or replacing switch be sure to follow mounting instructions and properly set the gap between the switch and object sensed.

Automatic Switches

If the switch is actuated automatically, by temperature or pressure for example, find a way to manually actuate the switch to test it. Do this either by applying heat or pressure, for example, to the switch. These switches may need to be energized to actuate.

1. Connect instrumentation to monitor and/or control the parameter the switch is measuring.
2. Observe switch state in control system with the Analyzer. See vehicle or control system documentation on how to do this.
3. Operate system such that the switch actuates. This could be going over a certain pressure or temperature, for example. The state indicated in the control system should change.

Switch Wiring - Low Side, High Side

When controlling a load, a switch can be wired between the positive side of the power source and the load. This switch is called a “high side” switch. The switch supplies the power to the load. When a switch is wired between the negative side of the power source and the load, it is a “low side” switch. The switch provides the ground to the load.

A low side switch will allow voltage to be present on the load. No power is applied because the switch is stopping current flow. This voltage can be seen if the measurement is taken with one test lead on the load and the other on the battery negative side or grounded to the vehicle. What is actually being measured is the voltage drop across the switch. This could mislead a technician into thinking the load is receiving power but not operating. To produce an accurate picture of power or voltage applied to the load, measure voltage across the load’s power terminals. Also, the technician can measure the voltage at both power terminals with respect to battery ground. The difference between those two measurements is the voltage applied to the load.

4.2.4 Verify Elevation

Purpose

The feature is designed to detect issues with all the elevation sensors and Pothole Sensors. Run this test in the event of an elevation or Pothole sensor DTCs to verify which systems are functioning incorrectly. To perform this test, turn the machine on in ground mode and perform Lift Up to max elevation, Lift down to stowed. If no issues are present, the analyzer will report a PASS. If issues are detected, the analyzer will report FAIL. The operator must then press ENTER after the FAIL screen to see the individual report for each failed sensor.

Table 16. Analyzer Screen

MENU	SUBMENU	COMMENTS
SYSTEM TEST:		
VERIFY ELEVATION		
	VERIFY ELEV:	
	YES:ENTER;NO:ESC	
	VERIFY ELEV:	Technician presses ENTER to acknowledge the stowed position.
	PLATFORM STOWED?	
	VERIFY ELEV:	Technician presses ENTER to acknowledge the platform is unloaded.
	PLATFORM EMPTY?	
	VERIFY ELEV:	Lift the machine to Maximum Elevation (the mast must lift high enough to cease contact the Outdoor Max Height mast switch: Elevation Sensor Switch 2 and 3).
	LIFT TO MAX ELEV	Pressing ESC will immediately exit to the VERIFY ELEV: COMPLETE screen
	VERIFY ELEV:	The technician commands Lift Down to the stowed position.
	LOWER TO STOWED	The test will progress to the PASS or FAIL screen.
	VERIFY ELEV:	This screen will display if no issues were found in the Lift Up and Lift Down sequence. Pressing ENTER or ESC will exit to the VERIFY ELEV: COMPLETE screen.
	PASS	
	VERIFY ELEV:	This screen will display if an error was found or the operator released the Lift Down switch early. Press ENTER to see each of the following failures detected during the test.
	FAIL	
	ELEV SWITCH 1:	This screen will only be visible if any of the following conditions were identified:
	STUCK OPEN/STUCK CLOSED/ INTERNAL ERROR/ OUT OF SEQUENCE	
		Stable Failures:

Table 16. Analyzer Screen (continued)

MENU	SUBMENU	COMMENTS
		· STUCK OPEN
		· STUCK CLOSED
		Intermittent Failures:
		· INTERNAL ERROR
		· REVERSED ORDER
		· OUT OF SEQUENCE
		(For Intermittent Failures, the switch being described changed in the incorrect order through the test. This could be water damage, harness damage, or physical switch damage causing an intermittent short or open circuit).
		Pressing ENTER will progress the analyzer to the next faulty sensor status or to the “COMPLETE” screen.
CALIBRATIONS: STEER ANGLE		
	CAL STEER ANGLE:YES:ENTER;NO:ESC	The technician chooses to calibrate by pressing ENTER, leave by pressing ESC.
	CAL STEER ANGLE:STR LEFT TO MAX	The technician steers the wheels to the maximum position left and presses ENTER. The technician chooses to leave by pressing ESC.
	CAL STEER ANGLE: CAL FAIL	The technician steers the wheels to the maximum position left and presses ENTER but the voltage is less than 2.5V or greater than 4.5V. This screen shall appear immediately after attempting to calibrate STR LEFT TO MAX.
	CAL STEER ANGLE:STR RIGHT TO MAX	The technician steers the wheels to the maximum position right and presses ENTER. The technician chooses to leave by pressing ESC.
	CAL STEER ANGLE:CAL FAIL	The technician steers the wheels to the maximum position right and presses ENTER but the voltage is less than 0.5V or greater than 2.5V. This screen shall appear immediately after attempting to calibrate STR RIGHT TO MAX.
	CAL STEER ANGLE:COMPLETE!	The Steer Sensor has completed Calibration. Otherwise, the CAL FAIL message shall be displayed (Restore Default Values in the Steer Angle Senor section).

4.3 CALIBRATION PROCEDURE

4.3.1 Load Sensing System (LSS)

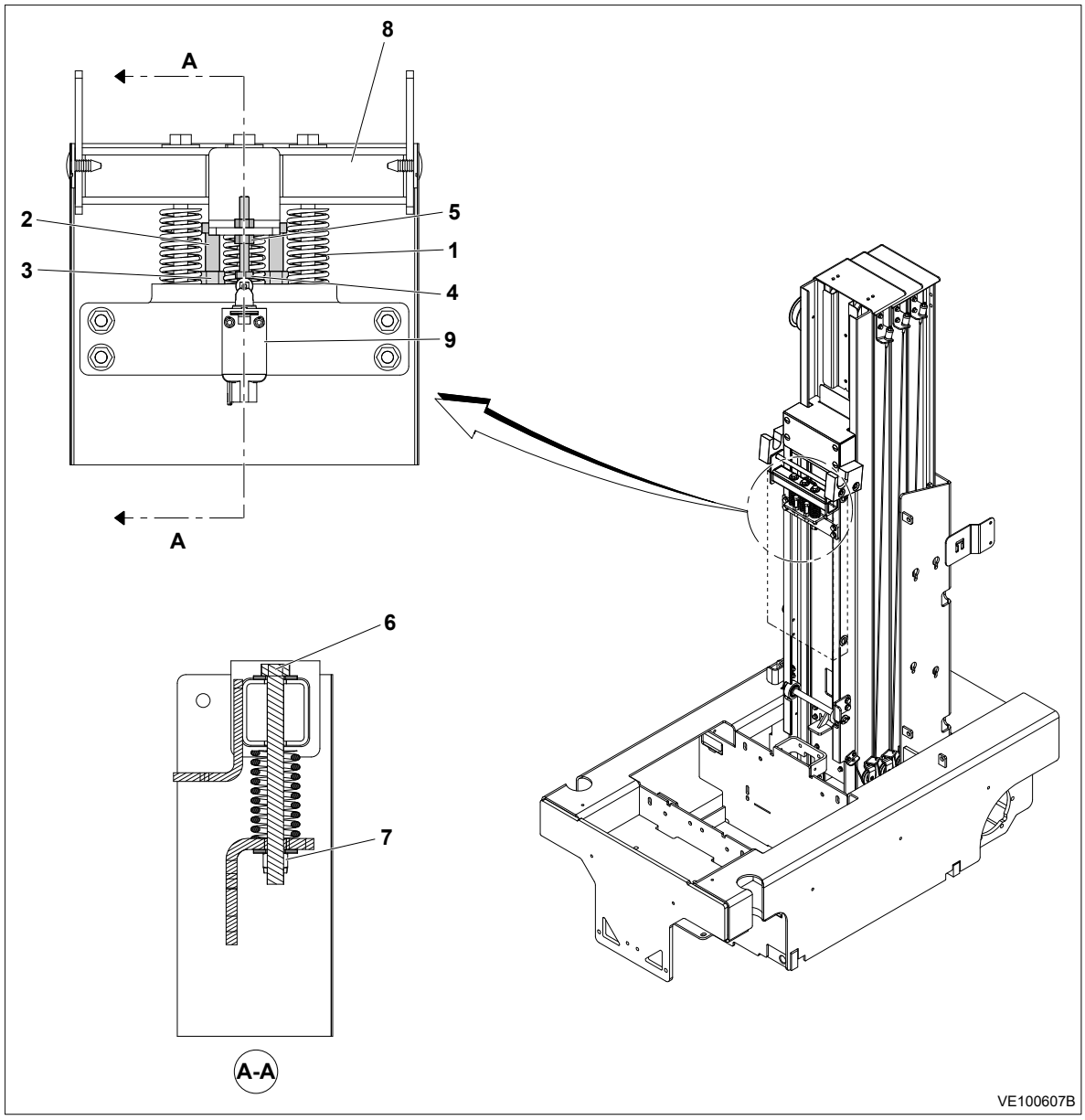


Figure 17. Load Sensing System

1. Coil Spring	4. Bolt	7. Lock Nut
2. Bolt	5. Nut	8. LSS Support Bracket
3. Nut	6. Bolt	9. Limit Switch

Setting Spring Pre-Load

1. Make sure that platform is not contacting bumpers.
2. Adjust the height of coil springs (**1**) to 2.125 in. (54 mm) by tightening bolt (**6**) and nut (**7**) (using center bolt and nut).

3. Tighten remaining (outside) bolts (**6**) and nuts (**7**), until nuts (**7**) are flush with end of bolts (**6**).

Note: Make sure that outside bolts (**6**) are loose and springs are centered on bolts (**6**).

Setting Positive Stops

1. Adjust bolt (**4**) to remove contact with limit switch (**9**) and then load the platform with calibration weight (120%).

Note: Load platform with extension retracted or material tray stowed.

2. Make sure that platform does not contact bumpers. Raise the platform by 3 in. (76 mm) if platform contacts bumpers.
3. Adjust bolt (**2**) with 0.0625 – 0.125 in. (1.5 to 3.0 mm) air gap between bolt head and angle on LSS support bracket (**8**).

⚠ IMPORTANT

Do not add extra weight to platform when calibrating.

4. Lock bolt (**2**) with nut (**3**) after adjustment.

Adjusting Switch

1. Load platform with calibration weight (120%). Make sure that LSS system is not binding or uneven.

Note: Load platform with extension retracted or material tray stowed.

2. Align center of limit switch (**9**) with plunger.
3. Adjust bolt (**4**) down until switch contact opens.

⚠ IMPORTANT

Do not add extra weight to platform when calibrating.

4. Tighten the bolt (**4**) with nut (**5**) after adjustment.

4.4 SPECIAL PROCEDURES

4.4.1 Emergency Procedure

Operator Unable to Control Machine

If the platform operator is pinned, trapped or unable to operate or control the machine:

1. Other personnel should operate the machine from ground controls only as required.
2. Only qualified personnel in the platform may use the platform controls. DO NOT CONTINUE OPERATION IF CONTROLS DO NOT FUNCTION PROPERLY.
3. Rescue equipment can be used to remove the platform occupant. Cranes and forklifts can be used to stabilize motion of the machine.

Platform Caught Overhead

If the platform becomes jammed or snagged in overhead structures or equipment, do the following:

1. Shut off the machine.
2. Rescue all people in the platform before freeing the machine. Personnel must be out of the platform before operating any controls on the machine

3. Use cranes, forklifts or other equipment to stabilize motion of the machine to prevent a tip over as required.
4. From the ground controls, carefully free the platform from the object.
5. Once clear, restart the machine and return the platform to a safe position.
6. Inspect the machine for damage. If the machine is damaged or does not operate properly, turn off the machine immediately. Report the problem to the proper maintenance personnel. Do not operate the machine until it is declared safe for operation.

Incident Notification

JLG Industries, Inc. must be notified immediately of any incident involving a JLG product. Even if no injury or property damage is evident, JLG must be contacted by telephone and provided with all necessary details.

- USA: 877-JLG-SAFE (554-7233)
- EUROPE: (32) 0 89 84 82 20
- AUSTRALIA: (61) 2 65 811111
- E-mail: productsafety@jlg.com

Failure to notify the manufacturer of an incident involving a JLG Industries product within 48 hours of such an occurrence may void any warranty consideration on that particular machine.

NOTICE

Following any incident, thoroughly inspect the machine. Do not elevate the platform until it is certain that all damage has been repaired and that all controls are operating correctly. Test all functions first from the ground control station then from the platform control console.

Platform Manual Descent

The platform manual descent valve is used in the event of total power failure to retract and lower the platform using gravity. The manual descent valve is located on the rear of the machine inside an access hole just below the hood. Look for the instruction decal located just above the access hole.

The procedure is as follows:

1. Locate the manual descent valve (**1**) on the rear of the machine just below the hood.

⚠ WARNING

Keep hands and arms out of the path of the mast and platform while lowering.

2. Press and hold the RED button on the manual descent valve, release the button when the platform is lowered to desired level.

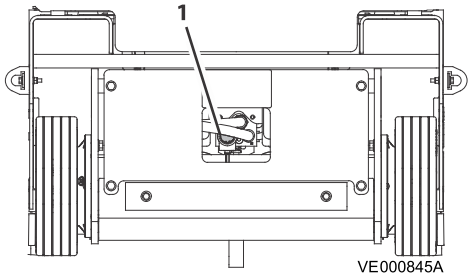


Figure 18. Location of Manual Descent Valve (Rear of Machine)

4.4.2 Base Assembly Components

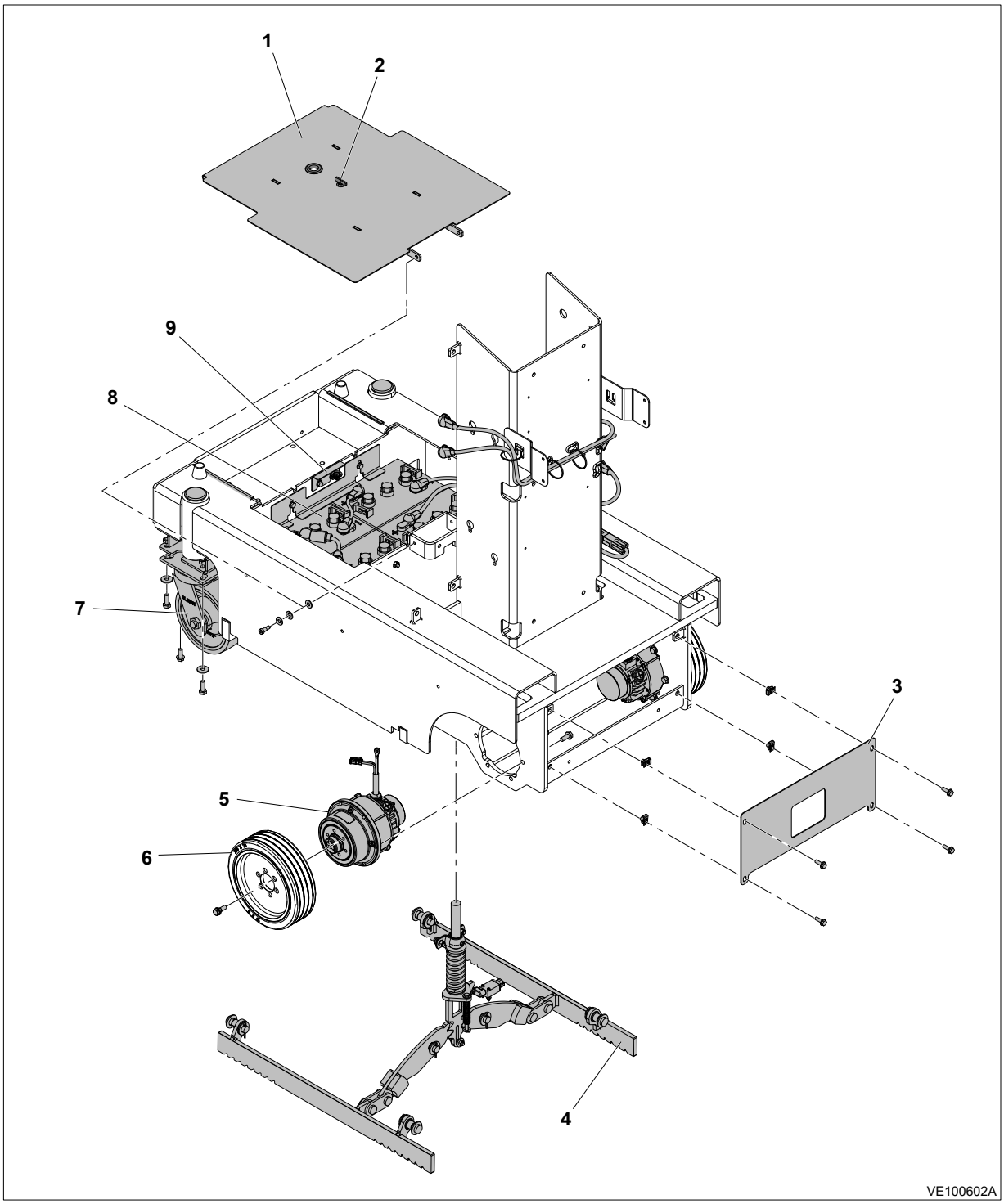


Figure 19. Base Components

1. Battery Cover Panel	5. Drive Motor Assembly	9. Latch Support Bracket
2. Battery Cover Latch	6. Rear Wheel Assembly.	10. Rear Tie Down Lug

3. Rear Cover Panel	7. Front Caster Wheel Assembly.	11. Right Drive Motor Assembly.
4. Pot Hole Protection System	8. Battery	

4.4.3 Joystick Controller

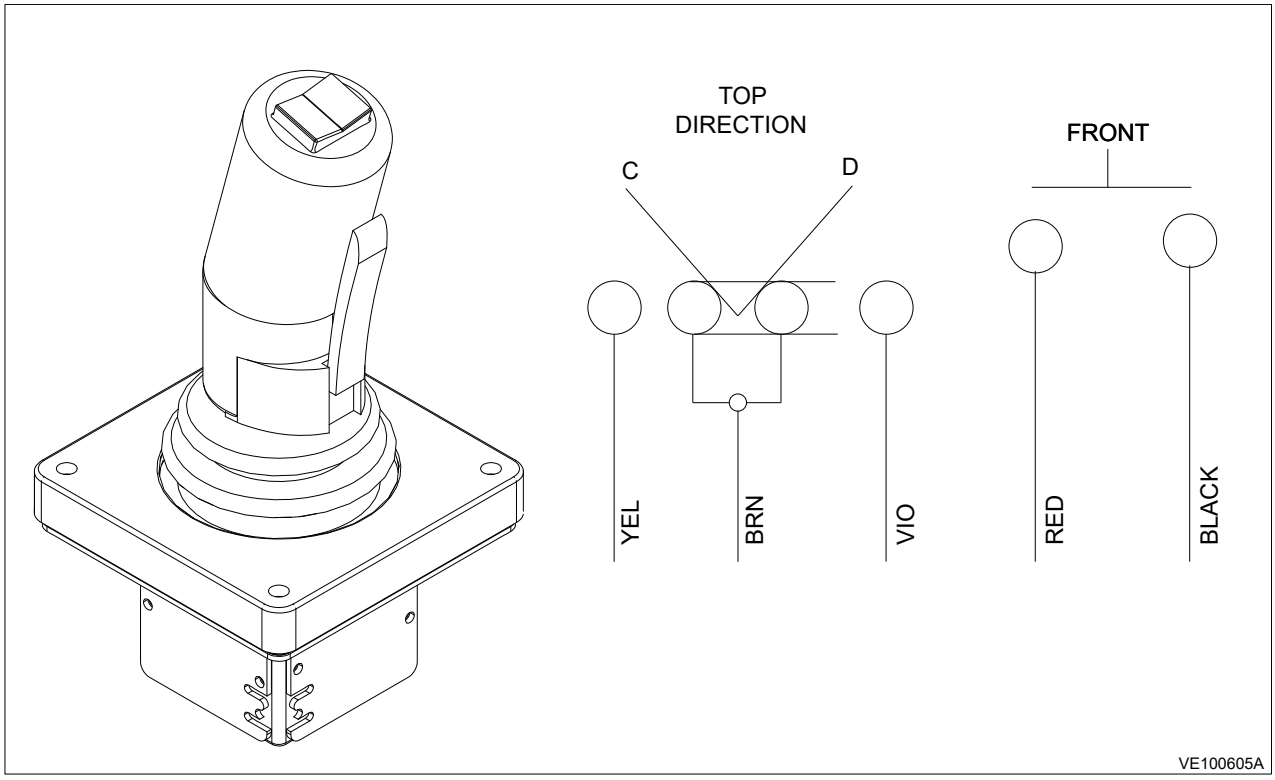


Figure 20. Joystick Controller

Table 17. Pin Function

P/N	Color	Function
1	ORN	POWER
2	GRN	GND
3	BLU	A/B OUT
4	GRY	C/D OUT
5	RED	TRIGGER
6	BLK	TRIGGER
7	VIO	ROCKER ‘D’
8	BRN	ROCKER ‘COM’
9	YEL	ROCKER ‘C’
10	—	N/C

4.4.4 Mast Chains And Sequencing Cables Adjustment

Mast Chain/Cable Adjustment

The intention of this procedure is to assure equal load distribution between the individual chains of a mast section chain sets. Also to step each front mast section up approximately 7/16 in. (12 mm) from the section behind it to allow clearance for the individual mast section covers.

Adjust using the following procedure;

1. With mast retracted, step into the platform and bounce your weight up and down a few times to be certain platform is at the bottom of travel. Be certain all chain/cable sets are seated in their sheaves properly at the top of each mast section.
2. Then with no load in the platform check the side profile of the top of the mast for the amount of adjustment necessary to obtain the 7/16 in. (12 mm) step for mast sections-3 and up.

Note: Mast section-1 is fixed to the base and mast section-2 is attached to the lift cylinder, these sections require no adjustment.

3. Adjust one mast section at a time starting from the back (section-3, section-4, etc.) of the mast and work forward. (i.e. if three is OK, then jump to four, etc.)
4. To adjust, elevate the platform until the chain/cable anchor adjust nuts are accessible at the front and bottom of each mast section.

⚠ WARNING

Never work under an elevated platform until platform has been safely restrained from any movement by blocking or an overhead sling.

5. Start with the mast section which needs adjustment and loosen the bottom *(jam)* nut on each chain/cable.
6. Tighten (to raise mast section), or loosen (to lower mast section) the adjusting nut against the anchor plate on each chain/cable. Adjust the nut the amount required to raise or lower the top of the mast section to match the side profile, when the mast is retracted.

Note: It is more important that the (threaded ends) studs protruding on the adjustments are equal side to side on a mast section, than it is that the tension in the chains is equal. The chain equalizers will always assure equal tension, but if the adjustment isn't equal as described, the chains may tend to pull to one side or the other.
The threaded end of the chain/cable may need to be restrained while tightening the adjust nut to keep the chain/cable from twisting.

7. Retract the mast all the way and check if the top of the mast sections appear.
8. Repeat steps (1) through (7) for remaining mast sections.
9. Once mast section adjustment is completed, apply Medium Strength Threadlocking Compound to the threads under the *(jam)* nuts that were loosened. Then re-tighten the loosened *(jam)* nuts until tight against the top *(adjust)* nut. Chain/cable should have slight tension but should not be taut.
10. (MSP Only) After all mast adjustments are complete, if necessary adjust the bumpers on the underside of the stock-picker platform so the platform rests slightly above the base frame when it is lowered and empty.

Sequencing Cable Adjustment

1. Retract mast completely, and check each sequencing cable on outside of masts for excessive slack. Adjust only to remove slack from cable.
2. Tighten nylock-nut just enough to remove excessive slack from sequencing cable. The springs should not be compressed more than 25% after adjusting.
3. Run mast through several cycles to verify cable/chain adjustments and ensure no interference exists between chain anchor brackets and mast.

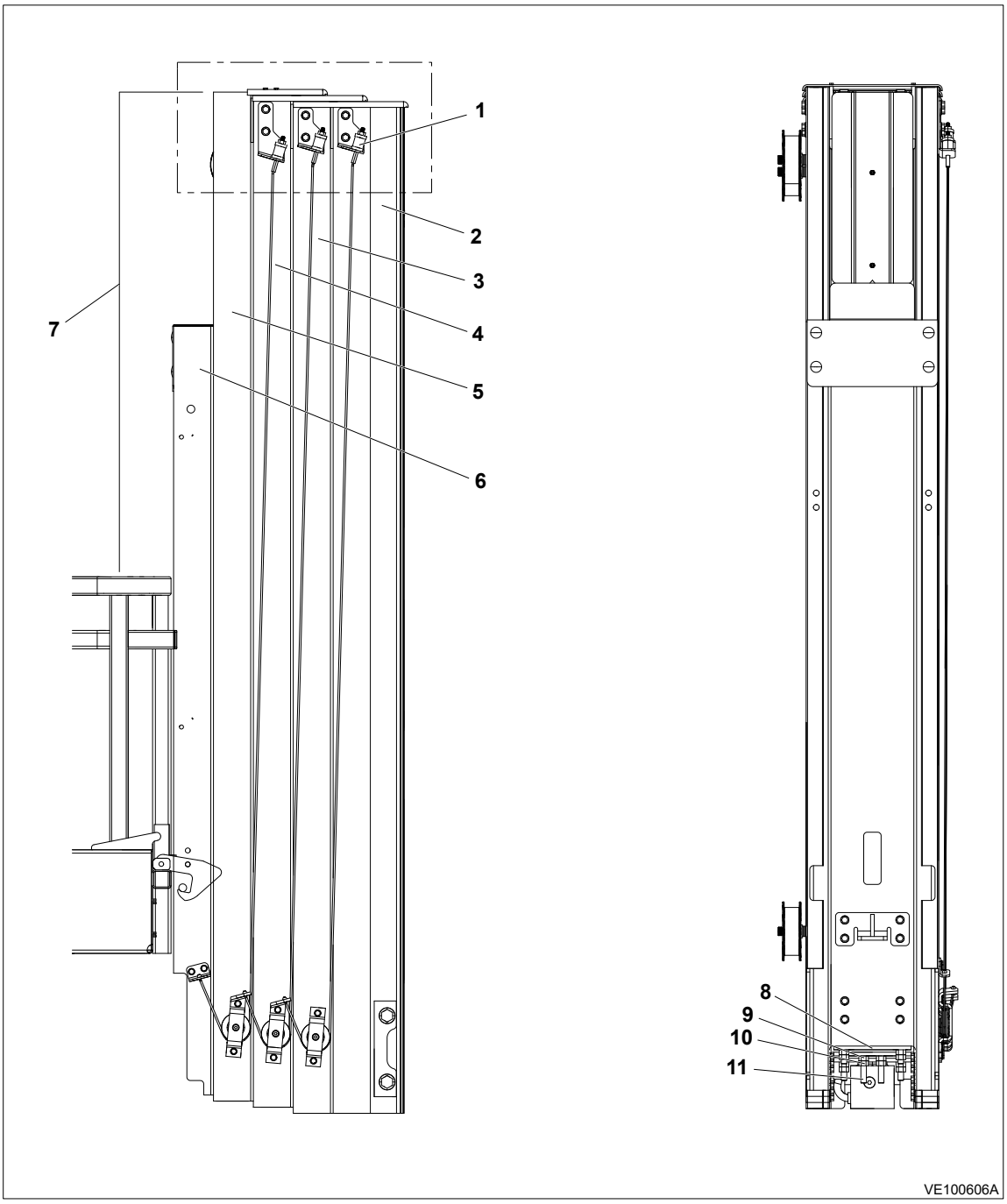


Figure 21. MML/MCL/MSP - Mast Chain and Sequence Cable Adjustment Components

1. Sequence Cable Adjust Nut	5. Mast Section - 4	9. Chain Adjust Nut
2. Mast Section - 1	6. Mast Section - 5	10. Chain Lock Nut
3. Mast Section - 2	7. Check Mast Stowed Height	11. Threaded Chain End
4. Mast Section - 3	8. Chain Anchor Plate	

4.4.5 Sequence Cable Replacement Kit

A sequence cable replacement kit is available from the JLG Parts Department to service broken or worn sequence cables. This kit consists of a replacement sequence cable with the threaded (top) end attached same as the top end of the factory cable. Also included is a clamp (drum/socket type) to secure the bottom end of the cable. Use the following procedure to install the replacement cable and clamp kit.

Remove Old Cable

1. Remove the locking nut from the threaded end of the cable at the top of the mast and then remove the spring cap, spring, and spacer washers if installed.
2. Slide the threaded top end out of the upper anchor bracket, then at the bottom end pull the cable out though the sheave pulley/anchor bracket until it is completely clear of the machine.

Replacement Cable Installation

1. Be certain the mast is completely retracted and at the bottom of travel. Check the mast “Side Profile” at the top of the mast and adjust mast sections to proper height if necessary.
2. To determine where the clamp will be installed at the bottom of the replacement cable, temporarily assemble the new replacement cable to the top cable anchor bracket on the mast using the washers, spring, spring cap and lock nut previously disassembled. Thread the lock nut on until approximately 1/8 in. (3 mm) of threads are exposed.
3. At the bottom of the mast, thread the loose end of the replacement cable through the proper sheave pulley and through the hole in the sheave pulley/anchor bracket on the mast section ahead of the sheave pulley.
4. Grasp the cable and pull on the cable until the spring at the top of the cable is slightly compressed. Use a black marker to mark the cable on the top side of the sheave pulley/anchor bracket. This will determine where the clamp (drum/socket) sleeve will be positioned on the cable.

NOTICE

Do not cut the cable at the marked point on the cable this is only used as a reference for positioning the cable sleeve which will rest against the anchor bracket once installed.

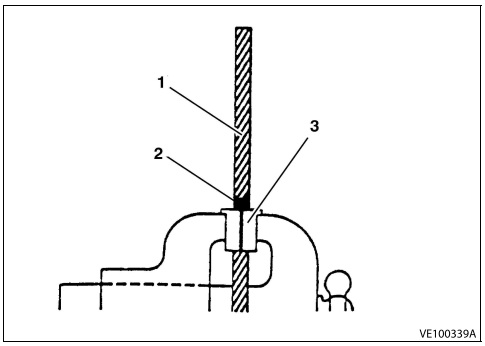
Clamp Installation (Drum/Socket Type)

NOTICE

The manufacturer of the drum/socket clamp recommends the use of their cable clamp assembly kit (JLG PN - 7023275) to assemble the clamp to the wire rope. The kit consists of vise jaws to hold the wire rope in a vise properly without damaging any rope strands and a plug driver to drive the plug into the center of the wire rope and is also used to form the strands of the rope during assembly.

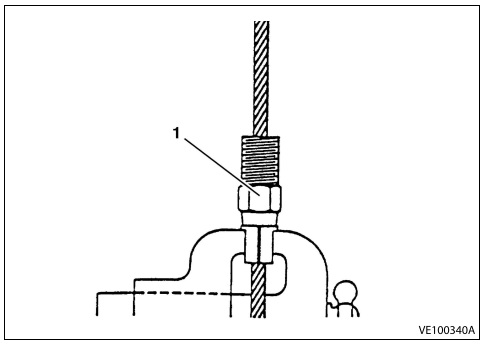
Note: The tools in the clamp assembly kit may be fabricated if necessary. The vise clamp consists of vise jaws with a hole drilled 1/32 in. smaller than the diameter of the wire rope you are working with (i.e. 1/8 in. rope - 3/32 in. hole.) The plug driver is a metal tube with a hole in the bottom to allow the strands of the wire rope to be shaped after the plug has been tapped into the center of the wire rope.

1. Using the recommended vise jaws, clamp the wire rope into a vise with the bottom edge of the black mark made on the wire rope resting just above the vise jaws.



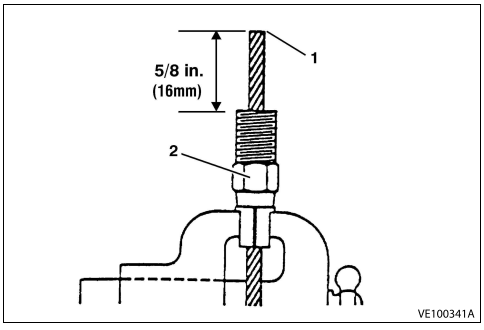
1. Cable	2. Mark on Cable	3. Recommended Vise Jaws

2. Twist the sleeve from the clamp kit onto the rope until it is flat against the vise jaws at the mark made on the wire rope.



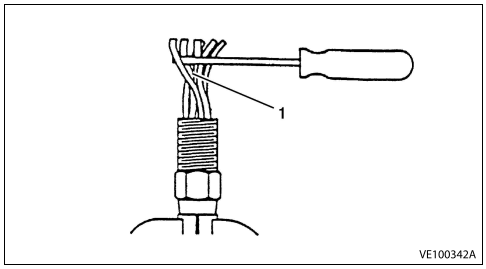
1. Sleeve Installed on Cable

3. Use a suitable tool and cut the cable as shown in the illustration following. For 1/8 in. cable the recommended length is 5/8 in. past the end of the sleeve.



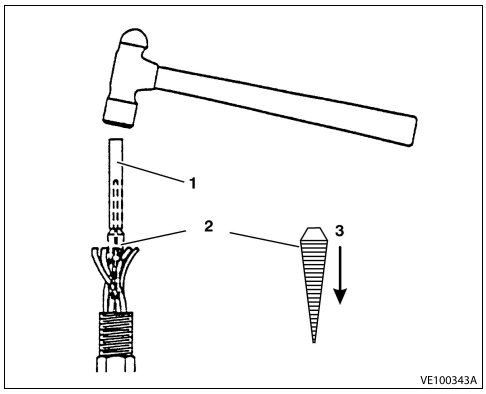
1. Cut To This Length	2. Sleeve

4. Unlay the cable strands by gently forcing a screwdriver between the outer strands to unlay the cable. When done properly the outer strands will form a symmetrical basket. Do not straighten out the spiral lay of the strands, unlay any wires that make up the strand, or allow the strands to cross each other inside the sleeve.



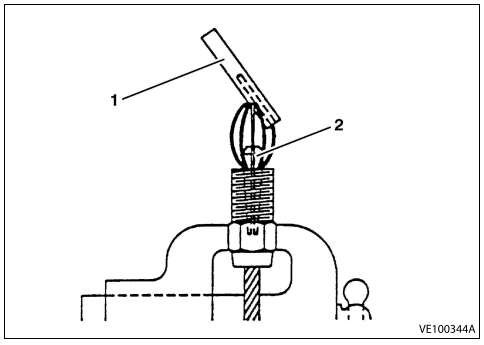
1. Cable Strands Unlayed

5. Install the plug supplied with the kit by placing the plug in the center of the strands starting with the small tapered end of the plug. Use a metal tube (plug driver) and hammer to drive the plug into the sleeve while assuring that the strands are spaced somewhat equally around the plug. Drive the plug until it is firmly seated and no more than 1/3 of the plug is visible from above the sleeve.



1. Plug Driver	2. Plug	3. Insert Plug in this Position

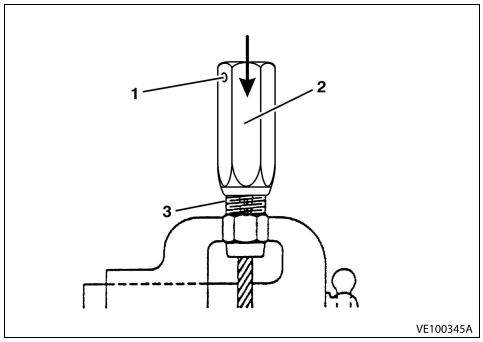
6. Reclamp the assembly in the vise on the flats of the sleeve. Using the plug driver, a metal tube or pliers, bend the outer strands toward the center strands enough that the socket can be slipped over all the strands.



1. Use Plug Driver, Metal Tube or Pliers	2. Shape Strands Around Plug

Note: When assembling stainless steel parts all threads must be coated with a dry lubricant or an anti-seize lubricant to prevent seizing.

7. Coat the threads of the socket and sleeve with lubricant and install the socket by twisting it over the strands of the cable and engage the threads of the sleeve with the socket. Tighten until four threads or fewer are visible. If more than four threads are visible, proof load the cable and retighten the socket fitting. (There is no specific requirement for torque.)



1. Inspection Hole	2. Install Socket and Tighten	3. Four Threads or Less Showing

8. Inspect for proper assembly prior to loading the cable. Strands visible through the inspection hole are your assurance of a proper assembly.

Note: The end of the rope may not be visible in the inspection hole after loading.

9. Install cable on machine and adjust per instructions shown previously in Section — Mast Chains And Sequencing Cables Adjustment.

4.4.6 Traction System

Theory of Operation

The traction, or drive system, moves the vehicle along the ground by electric motors. The Armatures (rotating windings) of the PM (Permanent Magnet) drive motors are wired to the Power Module's U, V and W terminals. The U terminal connects to black wire of right motor, the V terminal connects to Red wire of Left Motor, the W terminal connects to Red wire of Right Motor and Black wire of left motor together.

To provide variable speed control, the Armature MOSFET transistors switch On and Off at high frequencies (PWM/pulse width modulation; 16kHz). The Duty Cycle (On & Off time) is varied to control the voltage applied to the Armatures. When the MOSFET's spend 50% of the period On and 50% Off, approximately ½ of the available power will be applied to the Armatures (50% Duty Cycle). Similarly, the MOSFET are On continuously (100% Duty Cycle) to apply all available Battery power to the Armatures (as in Driving at Full Speed).

Instead of electro-magnets (called Field Windings), the permanent magnet drive motors use permanent magnets located in the stator (non-rotating) portion of the motor. The magnetism from permanent magnets cannot be adjusted by the Power Module, but permanent magnet drive motors have very good power density and torque which can provide strong electro-motive force when climbing a grade at low speeds. The noise and RPM capability are also good performance.

Common Traction System Difficulties

1. Ground Module Interlocks
   There are a variety of interlocks that prevent Drive due to system events (Elevated but Pot- Hole Mechanism Failed to Deploy, etc.). Before investigating Traction System issues, examine the JLG Analyzer's HELP Menu while attempting to Drive from Platform Mode.

2. Power Module Diagnostic Issues
   For simple visual diagnosis of system faults and to monitor system status, a red LED is provided on the body of the controller. The Power Module executes a self-test during every power-up to ensure proper functionality. If a Diagnostic Issue is detected, the Power Module will not energize the Line Contactor. Instead, it will flash the Red LED, a different number of times, in a repeated pattern, when there is a fault. The number of flashes indicates the type of fault. Please connect JLG Analyzer to diagnostic.

3. Open-Circuit Motor Armature
   This issue will not allow the vehicle to drive, investigate for issues like improper crimps, loose terminals, corrosion and resistance between Armature cables (heavy red and black conductors).

4. Short-Circuit Motor Armature
   This issue will not allow the vehicle to drive. To find the source of the difficulty. Investigate for crushed and burned cables. Note if the drive motor smells burned.

5. Short-Circuit Brake Release
   This issue will not allow the vehicle to drive. This situation can be investigated by using JLG analyzer. It will display "POWER MODULE BREAK WIRING ISSUE".

6. Open-Circuit Brake Release
   This issue happened on Right drive motor brake will not allow the vehicle to drive. This situation can be investigated by using JLG Analyzer. It will display "POWER MODULE BRAKE WIRING ISSUE".
   This issue happened on Left drive motor brake will allow the vehicle to drive. Continued attempts to drive the vehicle may result motor overheating and armature damage. The Ground Module and ZAPI Power Module cannot detect this fault during power-up or self-test. This situation can be detected by elevating the vehicle's front wheels and engaging drive (platform stowed). The motor will not rotate.

4.4.7 Factory Reset

The CALIBRATIONS to FACTORY RESET shall be used to reset all sections of EEPROM excluding logged operating hours from On-Board Data Logging.

MENU	SUBMENU	COMMENTS
CALIBRATIONS: FACTORY RESET?	ERASE MACHINE CALIBRATIONS?	The technician is notified of items to be erased and continues by pressing ENTER, or leave by pressing ESC.
	CLEAR CALS YES:ERASE;NO:ESC	The technician chooses to erase the vehicle calibrations by pressing enter again or escaping the sequence.

4.4.8 Preventative Maintenance - Brush Wear - Dust Removal Procedure

Due to a possible build-up of dust from brush wear inside the pump motor cover around the brushes and armature under heavy usage. It is recommended to perform this dust cleaning task on an annual basis.

Follow the procedure for motor cover removal. Once the motor cover is removed, blow any accumulated brush dust from inside the cover and around the brushes, and armature commutator. Check brushes for wear, replace if necessary. Once complete, reassemble for operation, do not overtighten the motor cover bolts into the aluminum valve body.

4.4.9 Lithium-Ion Battery Troubleshooting Notes

1. If F5 fault is active on a machine with a lithium-ion battery and an inverter, disconnect the inverter. If the issue is resolved, check Logic Module J5 Pin 17 for wire damage. This is the inverter ON signal.

2. If there is no voltage on the battery terminals when machine E-Stops are pulled out, check the battery wake-up signal. To do this, unplug the battery M12 connector (X503) and short pins 3 and 4 together. Now check for voltage across the terminals with a multi-meter. When this connection is broken, the lights on the battery count down from 5 to 0. If this test was successful, troubleshoot the wire loop in the battery harness. In ground mode, this circuit path goes from battery to E-Stop to key switch and then back to battery

4.5 WHEEL DRIVE ASSEMBLY - SERVICING

The component parts of the left and right drive motor assemblies are identical. The left drive motor is run in the reverse direction of the right motor.

4.5.1 Roll And Leak Testing

Drive-Hub units should always be roll and leak tested before disassembly and after assembly to make sure that the unit's gears, bearings and seals are working properly. The following information briefly outlines what to look for when performing these tests.

Note: The brake must be released before performing the roll test. This can be accomplished by supplying 24 Volts D.C. to the gray 2-pin brake connector.

The Roll Test

The purpose of the roll test is to determine if the unit's gears are rotating freely and properly. You should be able to rotate the wheel or hub of the gearbox by hand. If you feel more drag in the gears only at certain points, then the gears are not rolling freely and should be examined for improper installation or defects. Some gear packages roll with more difficulty than others. Do not be concerned if the gears in your unit seem to roll hard as long as they roll with consistency.

The Leak Test

The purpose of a leak test is to make sure the unit is air tight. You can tell if your unit has a leak if the pressure gauge reading on your leak checking fitting starts to fall after the unit has been pressurized and allowed to equalize. Leaks will most likely occur at the pipe plugs, the main seal or wherever O-rings are located.

⚠ WARNING

DO NOT use hand to check for leaks. Use a piece of cardboard or paper to search for leaks. Always wear gloves.

The exact location of a leak can usually be detected by brushing a soap and water solution around the main seal and where the O-rings or gaskets meet on the exterior of the unit, then checking for air bubbles. If a leak is detected in a seal, O-ring or gasket, the part must be replaced, and the unit rechecked. Leak test at 10 psi for 20 minutes.

Note: Due the small air volume inside this Drive-Hub, it will pressurize to 10 psi very quickly. If the pressure becomes excessive in the unit the seals will be destroyed.

4.5.2 Oil Type & Capacity

This drive hub unit is shipped with ISO 68 viscosity oil (hydraulic fluid). It is designed to utilize the same oil throughout its service life. However, should it need to be serviced the oil will need to be drained and replaced.

In the event of servicing, fill the unit with ISO grade 68 oil or oil of a similar viscosity *(80W gear oil or 20W engine oil)*.

The gearbox will need to be filled with 10 oz. of oil.

Oil Filling Instructions

10 oz. of gearbox oil will fill the gearbox cavity approximately half full. To check the oil level, rotate the wheel so that the cover plugs are at 12 o-clock and 3 o-clock. Allow the oil to settle. Slowly loosen the 3 o-clock plug. If oil begins to come out then the oil level is sufficient. If no oil is noticed at the 3 o-clock plug location, then remove both plugs. Slowly add oil at the 12 o-clock plug location until oil begins to seep out of the 3-clock plug location. Reinstall and tighten plugs to 6-8 ft. lbs.

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SECTION 5
SYSTEM SOFTWARE

5.1 CONTROL MODULE

5.1.1 Ground Control Module

The Ground Control Module is located under the center cover at the rear of the machine and is mounted on the mast support column. All electrical components on the machine operate directly or indirectly through the Ground Control Module. The module is currently programmed at the factory with the machines operating profile. If replacing a Ground Control Module the new module may require some programming to enable any optional equipment. Refer to Section – Ground Control Station - Programming.

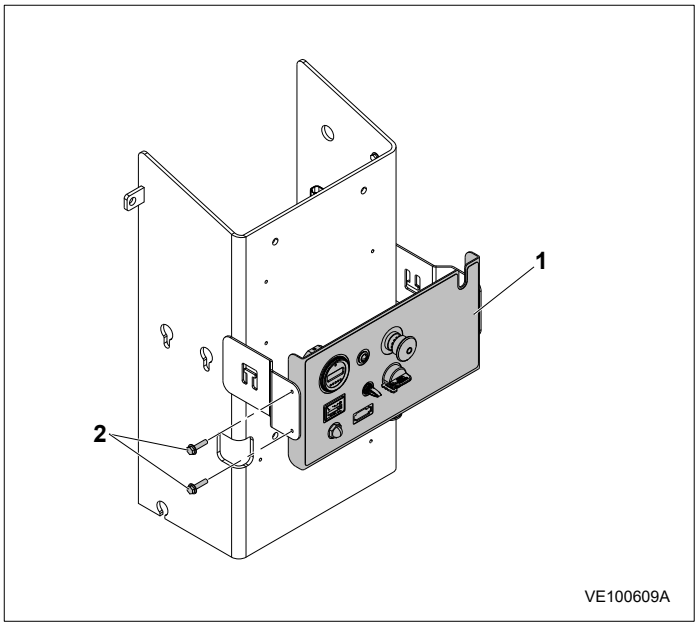
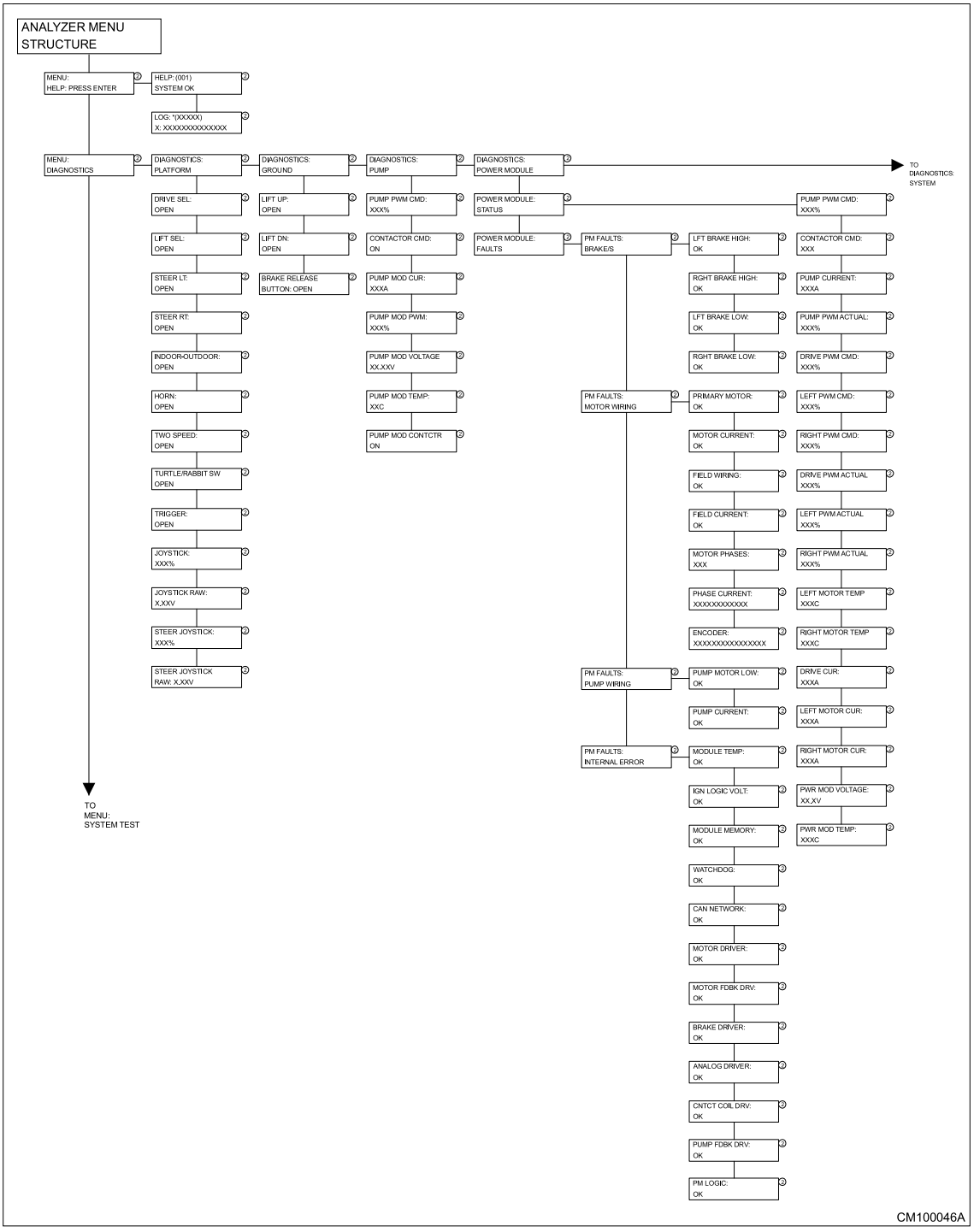


Figure 22. Ground Control Module Installation

1. Ground Control Module	2. Attach Screws/Washers

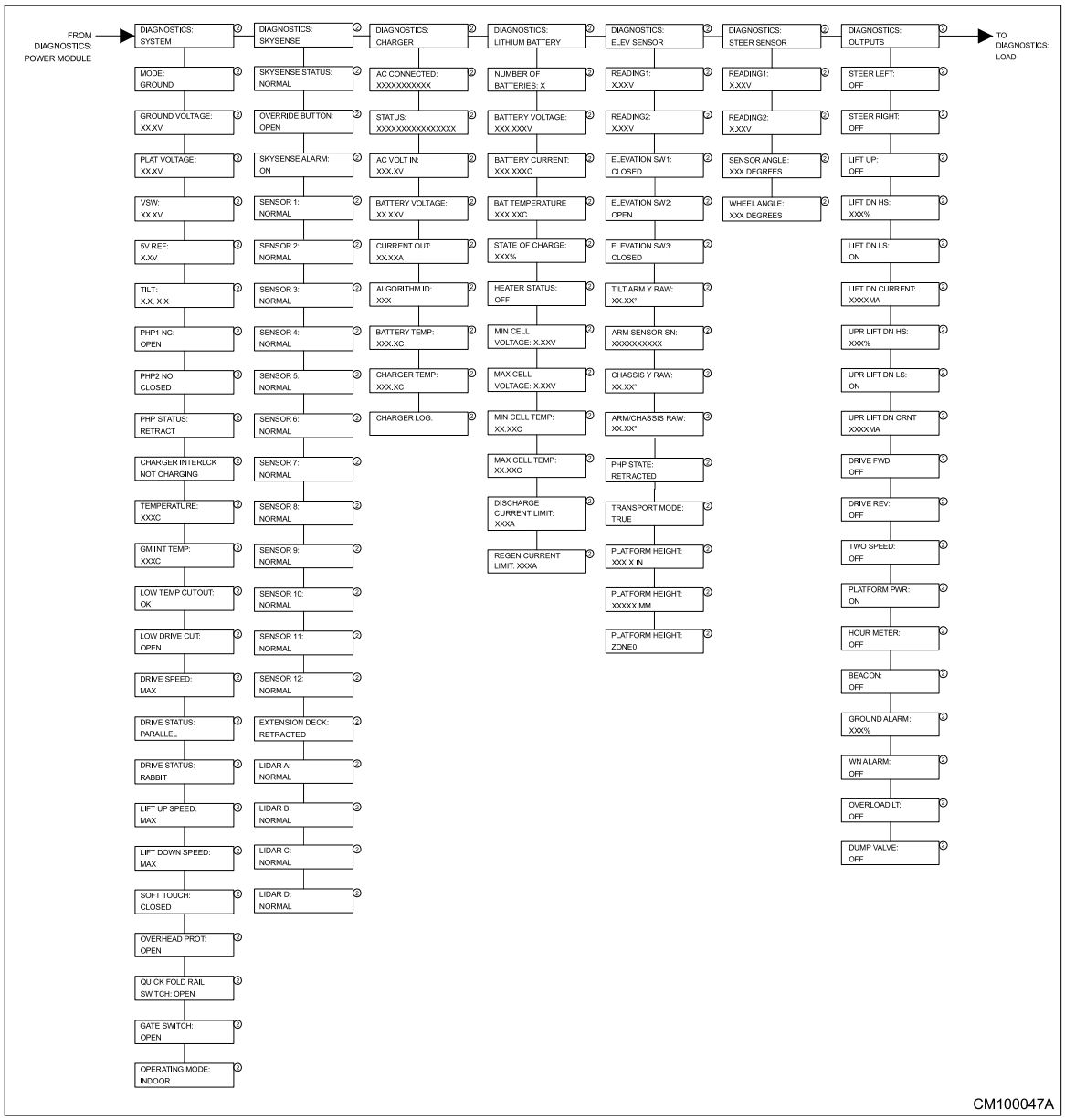
5.1.2 Machine Software



Note: 1. The layout shown includes all possible analyzer screens. Please note that some screens may not be available depending upon machine configuration and software versions.

2. Select Market as CE for UKCA specification machine on Analyzer.

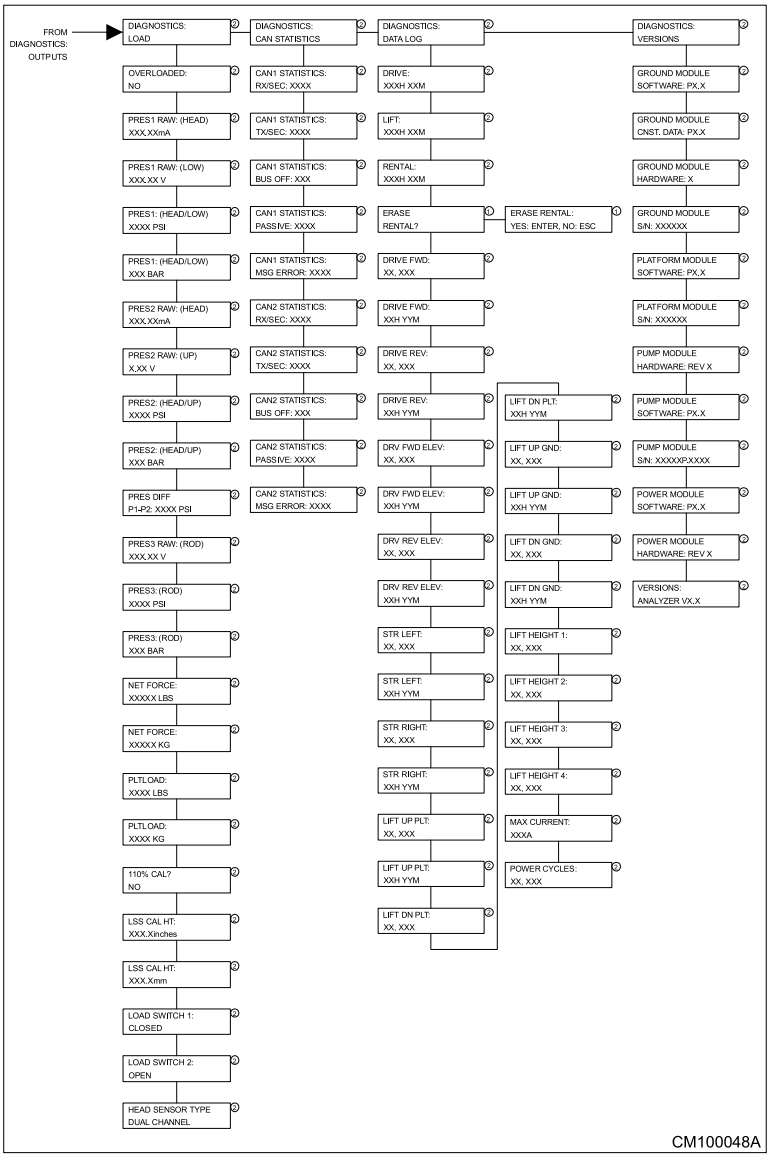
Figure 23. Machine Software (P1.19.4) - Sheet 1 of 5



Note: 1. The layout shown includes all possible analyzer screens. Please note that some screens may not be available depending upon machine configuration and software versions.

2. Select Market as CE for UKCA specification machine on Analyzer.

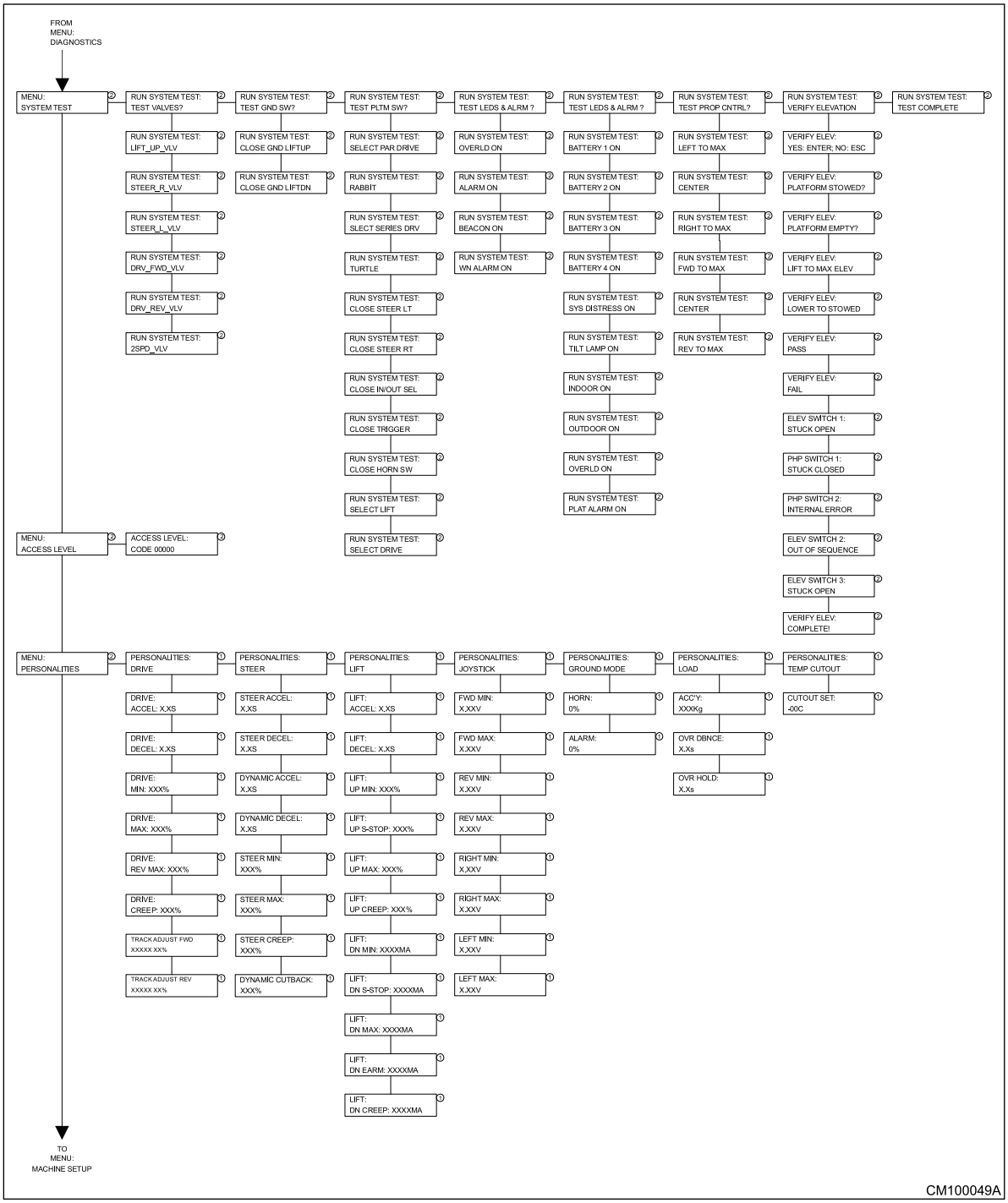
Figure 24. Machine Software (P1.19.4) - Sheet 2 of 5



Note: 1. The layout shown includes all possible analyzer screens. Please note that some screens may not be available depending upon machine configuration and software versions.

2. Select Market as CE for UKCA specification machine on Analyzer.

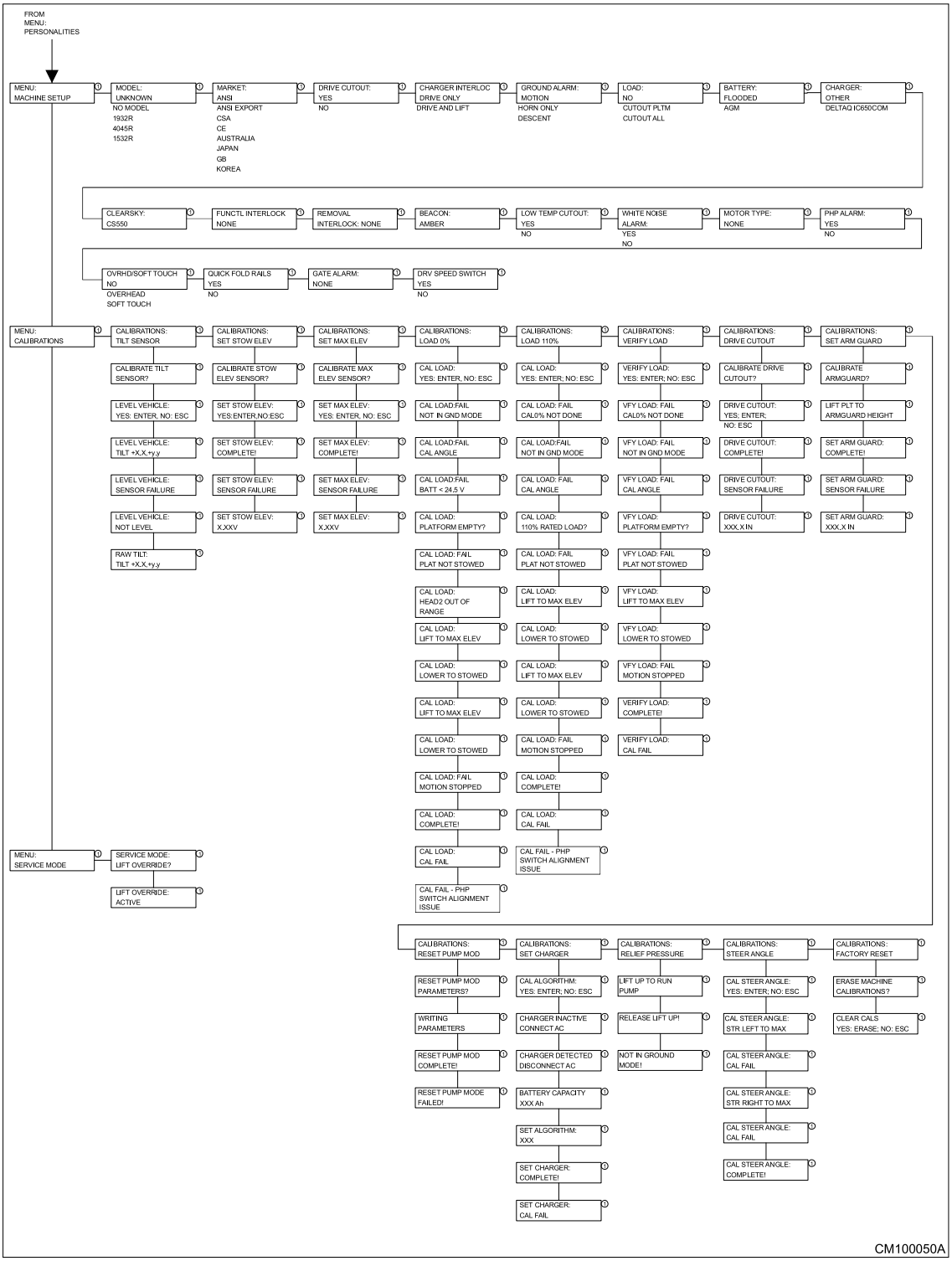
Figure 25. Machine Software (P1.19.4) - Sheet 3 of 5



Note: 1. The layout shown includes all possible analyzer screens. Please note that some screens may not be available depending upon machine configuration and software versions.

2. Select Market as CE for UKCA specification machine on Analyzer.

Figure 26. Machine Software (P1.19.4) - Sheet 4 of 5



Note: 1. The layout shown includes all possible analyzer screens. Please note that some screens may not be available depending upon machine configuration and software versions.

2. Select Market as CE for UKCA specification machine on Analyzer.

Figure 27. Machine Software (P1.19.4) - Sheet 5 of 5

5.2 GROUND CONTROL STATION - PROGRAMMING

5.2.1 General

The MML/MCL/MSP machine Ground Control Module allows onboard programming of various component and control function personality settings.

Programming may be required under circumstances such as:

- Optional equipment has been added to the machine in the field and a function must be enabled before operation.
- Customizing the machine to fit a specific application, such as changing the LCD display language,

There are three (3) password protected programming levels, from highest to lowest, the levels are:

- **Level-1**: JLG Engineering Settings
- **Level-2**: Service and Maintenance Settings - **Level-2 Password: 33271**
- **Level-3**: Operator Settings - **No code required.**

NOTICE

The LEVEL 1 JLG engineering settings are not displayed in the programmable settings under password LEVEL-2. LEVEL-1 settings must not be modified unless directed by JLG engineering department personnel.

Level-1: JLG Engineering Settings include voltage, amperage, and ohm output settings that are within the operating parameters of various machine components. This Level can adjust all programmable settings.

Level-2: Service and Maintenance Settings allow modification to machine personality settings such as lift speeds, drive speeds, as well as various switch polarity settings, also enable various optional equipment if installed. This level can also adjust Level-3 settings.

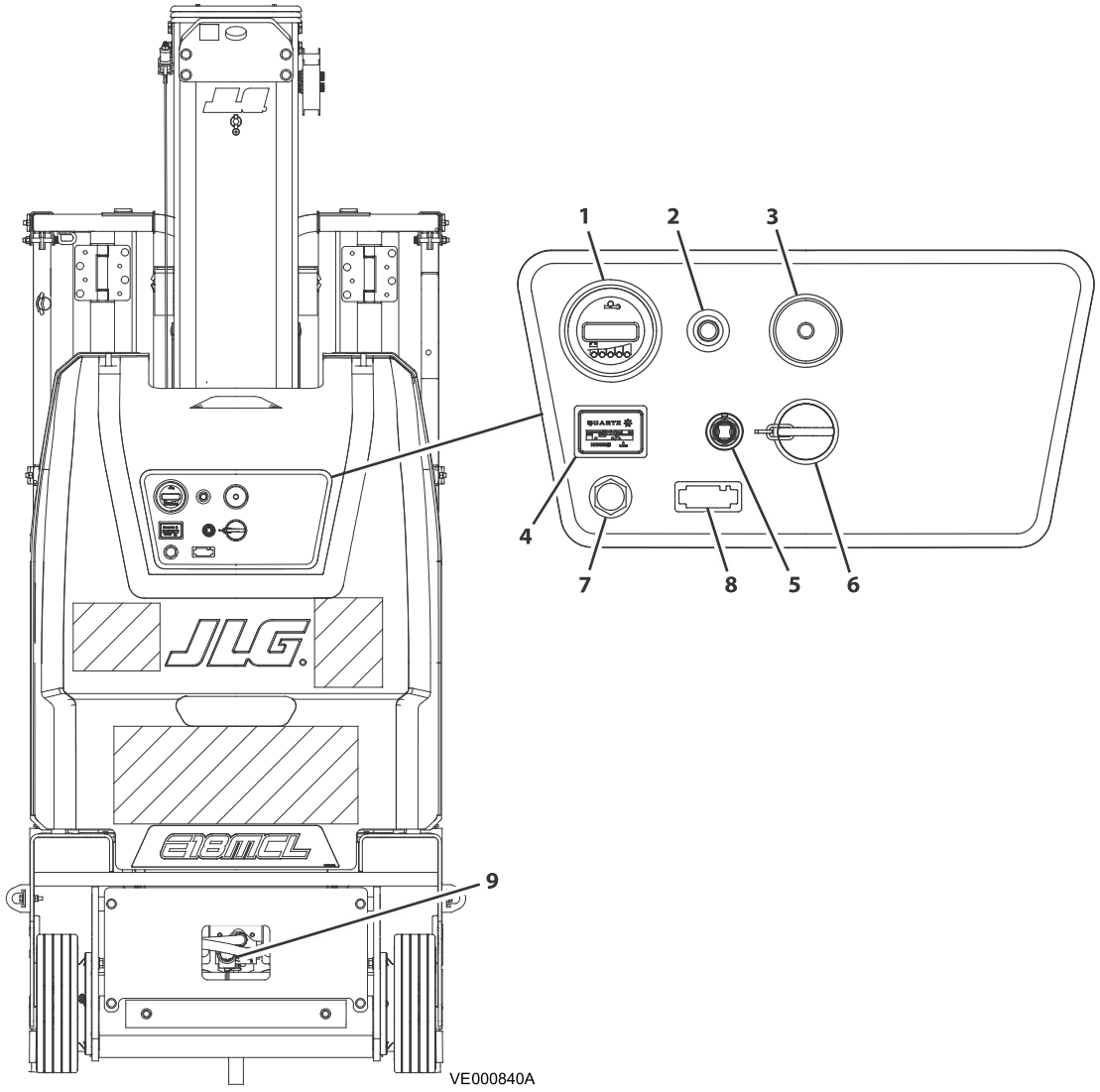


Figure 28. Ground Control Station

1. MDI Indicator	4. Hour Meter Gauge	7. Brake Release Button
2. Overload Indicator (LSS)	5. Platform Up/Platform Down Toggle Switch	8. Analyzer Port
3. Emergency Stop/Shut Down Button	6. Main Power Selector Switch	9. Manual Descent Control Valve

5.2.2 Ground Control Station Functions

MDI Indicator

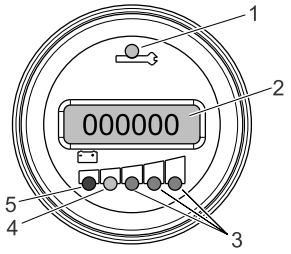


Figure 29. MDI Indicator

1. System Fault LED Indicator (RED LED)	3. 100% Battery Charge Indicator (GREEN AREA)	5. Battery Re-Charge Indicator (RED AREA)
2. DTC Code Display	4. Battery Charge LOW Indicator (YELLOW AREA)	

The Multifunction Digital Indicator (MDI) displays a Battery Discharge Indicator (BDI), a system distress LED, and Diagnostic Trouble Codes (DTC) when a functional problem occurs with the machine.

When a problem occurs and a DTC Code displays:

- An LED wrench icon (1) LED illuminates.
- A three to five digit DTC code will display on the DTC LCD display (2) below the wrench icon.

Note: When more than one DTC exists, each DTC will be displayed on the LCD for three seconds before changing to the next DTC. Once the last active DTC is displayed, the display will recycle indefinitely until the DTCs are corrected. For DTCs and descriptions, refer to Diagnostic Trouble Codes.

Also located on the MDI are Battery Discharge Indicators (BDI) (3, 4, 5). The BDIs (3, 4, 5) will blink while charging and the machine in powered On.

The level of charge (voltage) remaining in the batteries is determined by the LEDs.

- All LEDs On = 76%-100%
- Red, Yellow, and 2 Green LEDs On = 51%-75%
- Red, Yellow, and 1 Green LED On = 26%-50%
- Red and Yellow LEDs On = 11%-25%
- Red LED On = 0%-10%

BDIs display under normal operating conditions. When a DTC exists other than 00x DTCs, the BDI LEDs are not be displayed. Additionally, when the platform is elevated and the machine is driving in creep mode, the turtle icon is displayed.

Overload Indicator (LSS)

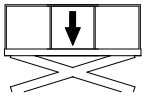


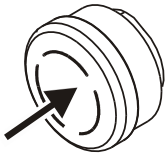
Figure 30. Overload Indicator Symbol

The Overload Indicator indicates when the platform has been overloaded. An audible alarm will also signal when the platform is overloaded.

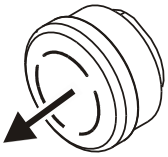
Note: If the Overload Indicator is illuminated, further elevation will be prevented. Reduce the weight in the platform to not exceed the rated workload indicated on the capacity decal, then the controls will work again.

Emergency Stop/Shut Down Button

POWER OFF
PUSH IN - To Engage Emergency Stop



POWER ON
PULL OUT - To Reset Emergency Stop



Hour Meter Gauge

The machine is equipped with an hour meter to indicate the number of hours the machine has been operated.

Platform Up/Platform Down Toggle Switch

PLATFORM UP

PUSH UPWARD - TO ELEVATE Platform

RELEASE - TO STOP Elevating

PLATFORM DOWN

PUSH DOWNWARD - TO LOWER Platform

RELEASE - TO STOP Platform Descent

Main Power Selector Switch

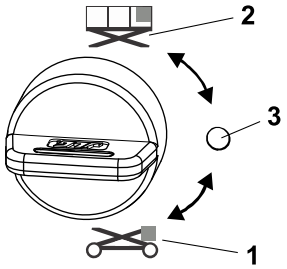


Figure 31. Main Power Selector Switch

1. Ground Control Mode	2. Platform Control Mode	3. OFF

Set the Main Power Selector Switch to Ground Control Mode for Ground Control Operation or Platform Control Mode for Platform Operation.

Brake Release Button

Figure 32. Brake Release Button

⚠ CAUTION

Do not manually disengage the brakes unless machine is setting on a level surface or machine is fully restrained.

The Brake Release only works while in Ground Control Mode and machine is in transport position.

PUSH and HOLD for 1 second - TO DISENGAGE Brakes

Note: The alarms will sound and a Brake Release DTC will activate.

PUSH and RELEASE - TO ENGAGE Brakes

Note: The brakes only DISENGAGE (electrically) when the joystick control is moved off center during driving or are manually DISENGAGED (electrically) using the Brake Release Button.

Note: If the machine's batteries are completely depleted of electrical charge the brakes cannot be released manually.

5.3 MACHINE CONFIGURATION PROGRAMMING INFORMATION

Note:
1. When configuring a machine, the Machine Configuration must be completed before any Personality settings can be changed. Changing the Personality settings first and then changing the Model and Market of the Machine Configuration will cause the Personality settings to return to default values.
2. Solid shaded entries are not available for the selected Market.
3. Select Market as CE for UKCA specification machine on Analyzer.

Table 18. Machine Configuration Programming Information

Configuration Setting	Description	Market Default				
		ANSI USA	ANSI EXPORT	CSA	CE	AUS
MODEL	E18MCL E18MML/E18MSP					
MARKET	ANSI USA ANSI EXPORT CSA CE AUS					
DRIVE CUTOUT	NO – Vehicle is not configured with Drive cutout when elevated YES – Vehicle is configured with Drive cutout when elevated	NO	NO	NO	NO	NO
CHARGER INTER LOCK	DRIVE ONLY – Drive motion Prevented while vehicle is Charging. DRV & LIFT UP – Drive and Lift Up motions are prevented while Vehicle is charging. Required for CE	DRIVE ONLY	DRIVE ONLY	DRIVE ONLY	DRIVE ONLY	DRIVE ONLY
GROUND ALARM	MOTION – Ground Alarm sounds during Lift Up, Lift Down, Drive Forward, or Drive Reverse. HORN ONLY – Ground Alarm only sounds when user presses Platform Horn button. DESCENT – Ground Alarm sounds during Lift Down.	MOTION	MOTION	MOTION	MOTION	MOTION
LOAD	NO – Load Sensing System (LSS) is not fitted to the vehicle CUTOUT PLTM – Load Sensing System (LSS) is fitted, and Platform Controls are prevented, other than lower in the event of an Overload. Ground Controls remain functional. CUTOUT ALL – Load Sensing System (LSS) is fitted. Platform and Ground Controls are prevented in the event of an Overload other than lower.	CUTOUT PLTM	CUTOUT PLTM	CUTOUT PLTM	CUTOUT ALL	CUTOUT ALL
CHARGER	OTHER – Regular Charger DELTAQ IC650COM – Smart Charger used for the Battery Management System as part of Mobile Control	OTHER	OTHER	OTHER	OTHER	OTHER
BEACON	YES – Optional beacon is present NO – Optional beacon not present	NO	NO	NO	YES	YES
LOW TEMP CUTOUT	YES – Low temp cutout is active NO – Low temp cutout is not active	NO	NO	NO	NO	NO
WHT.NOISE ALARM	NO – Vehicle does not have the white noise alarm YES – Vehicle has the white noise alarm	NO	NO	NO	NO	NO
PHP ALARM	NO – Vehicle is not configured with PHP Alarm when Pothole bar is blocked YES – Vehicle is configured with PHP Alarm when Pothole bar is blocked	NO	NO	NO	NO	NO
GATE SWITCH	ELEV CUTOUT ALL: Sounds the alarm and disables Lift Up and Drive whenever the gate is open out of transport ELEV CUT+ALARM: Sounds the alarm and disables Lift Up and Drive out of transport and sounds alarm stowed while commanding motion while the gate is opened. Traps in transport. ELEV CUT+MOTION: Sounds the alarm and disables Lift Up and Drive out of transport when motion is commanded, and the gate is open CUTOUT ALL: Sounds the alarm and disables vehicle operation when the gate is open CUTOUT ALL: Sounds the alarm and disables vehicle operation when the gate is open	NONE	NONE	NONE	NONE	NONE

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5.4 MACHINE MODEL ADJUSTMENT

Note: Personality settings can be adjusted within the adjustment range for optimum machine performance.

Table 19. Machine Model Adjustment (Personality Settings)

Adjustment	Adjustment range		Model	
			E18MCL	E18MML/E18MSP
DRIVE				
ACCEL	0.1 - 5.0 Sec		1.5	1
DECEL	0.1 - 2.0 Sec		0.8	0.8
MIN	1 - 25 %		1	15
MAX	26 - 100 %		100	100
REV MAX	26 - 100 %		NA	75
CREEP	0 - 50 %		22	22
TRACK ADJUST FWD	Left 25 % - Right 25 %		NA	0
TRACK ADJUST REV	Left 25 % - Right 25 %		NA	0
STEER				
ACCEL	0.1 - 5.0 Sec		0.1	0.3
DECEL	0.1 - 1.0 Sec		0.1	0.1
DYNAMIC ACCEL	0.1 - 5.0 Sec		0.1	0.2
DYNAMIC DECEL	0.1 - 1.0 Sec		0.1	0.1
MIN	1 - 25 %		25	9
MAX	26 - 100%		60	26
CREEP	15 - 100%		NA	15
LIFT				
ACCEL	0.1 - 5.0 Sec		0.7	0.7
DECEL	0.1 - 1.0 Sec		0.4	0.4
UP MIN	1 - 45 %		20	20
UP MAX	31 - 100 %		75	75
UP CREEP	1 - 100 %		50	50
DN MIN	250 – 1200 mA		550	550
DN MAX	350 - 1600 mA		700	700
DN CREEP	250 - 1300 mA		600	600
JOYSTICK				
FWD MIN	1.95 - 2.45 V	2.59 - 3.09 V	2.20	2.84
FWD MAX	0.94 - 1.44 V	3.53 - 4.55 V	1.19	4.40
REV MIN	2.59 - 3.09 V	1.95 - 2.45 V	2.84	2.20
REV MAX	3.53 - 4.03 V	0.45 - 1.44 V	3.78	0.60
RIGHT MIN	2.59 - 3.09 V		NA	2.84
RIGHT MAX	3.53 - 4.55 V		NA	4.00
LEFT MIN	1.95 - 2.45 V		NA	2.20
LEFT MAX	0.45 - 1.44 V		NA	1.00
GROUND				

Table 19. Machine Model Adjustment (Personality Settings) (continued)

Adjustment	Adjustment range	Model	
		E18MCL	E18MML/E18MSP
HORN	1 – 100 %	94	94
ALARM	1 – 100 %	25	25
LOAD			
OVERLOAD DEBOUNCE	0.0 - 5.0 Sec	0.1	0.1
OVERLOAD HOLD	0.0 - 5.0 Sec	5.0	5.0
ACC'Y	0 - 500 lbs	0	0
TEMP CUTOUT			
CUTOUT SET	-30 - 0 °C	-18	-18
OFFSET	0 - 15 °C	5	5

1001278587-C

5.5 CLEARSKY CS550 CONFIGURATION AND TROUBLESHOOTING

5.5.1 ClearSky Smart Fleet™ CS550 Configuration

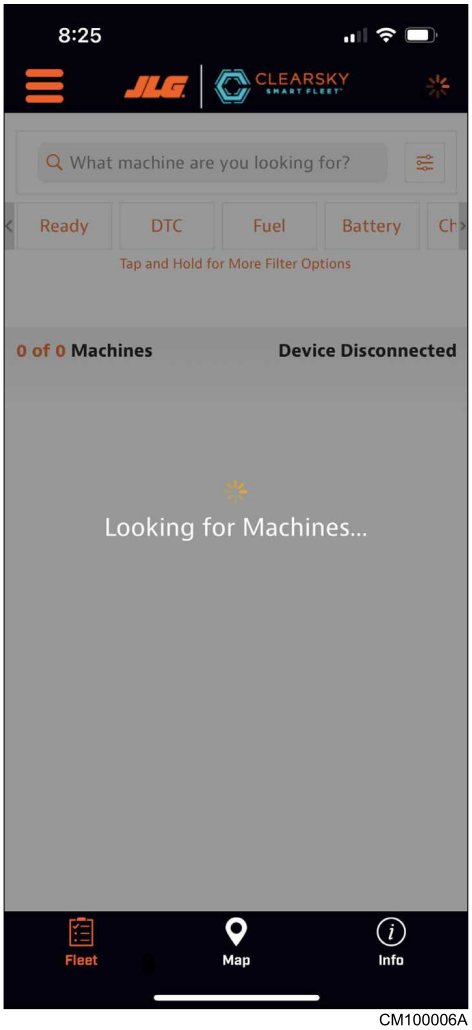
Configuration requires Bluetooth enabled mobile device with ClearSky Smart Fleet application, internet connectivity and a JLG Online Express account.

Machine Association

1. Open ClearSky Smart Fleet™ application and log in using JLG Online Express account credentials.

2. Wait for “Looking for Machines” process to complete.

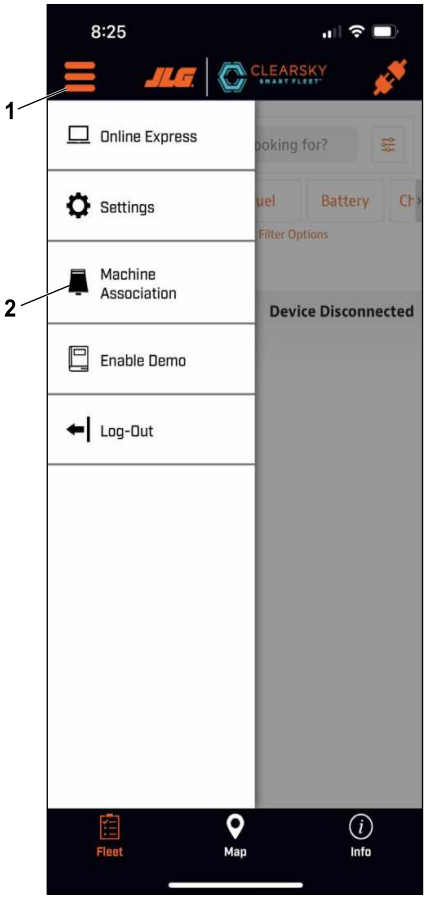
Note: If “Bluetooth Error” pop-up box appears, Refer to *Section - Troubleshooting, page 98*.



CM100006A

3. Turn the machine power ON. The CS550 should repeatedly flash white at a slow rate.
4. Select Menu (**1**) in the upper left corner.

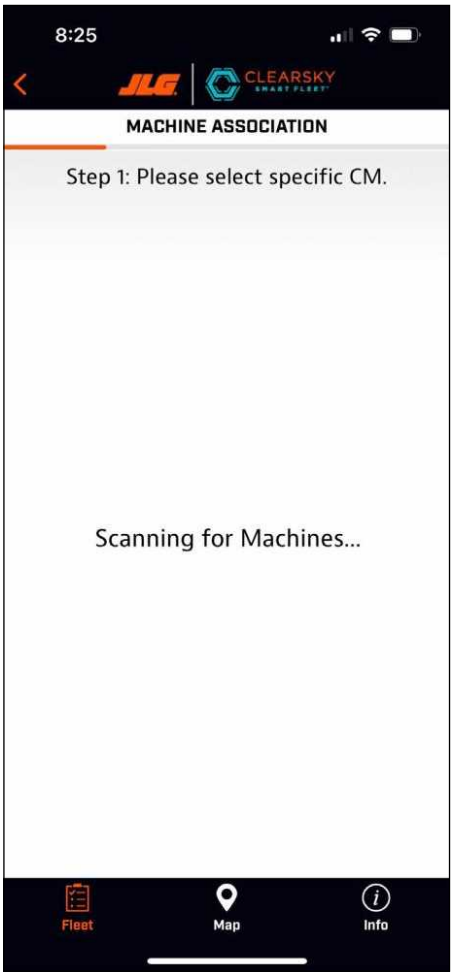
5. Select ”Machine Association" (**2**).



CM100007A

6. Wait while the application searches for the CS550.

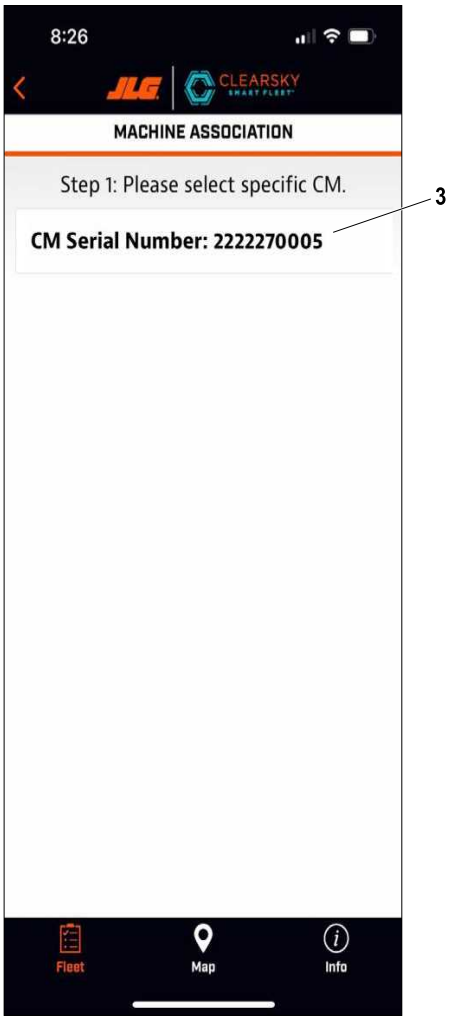
Note: If application cannot find the CS550, make sure the machine power is ON and that a multi-color flash occurs when ignition changes from OFF to ON.



CM100008A

7. Select Serial number (**3**) that needs to be configured.

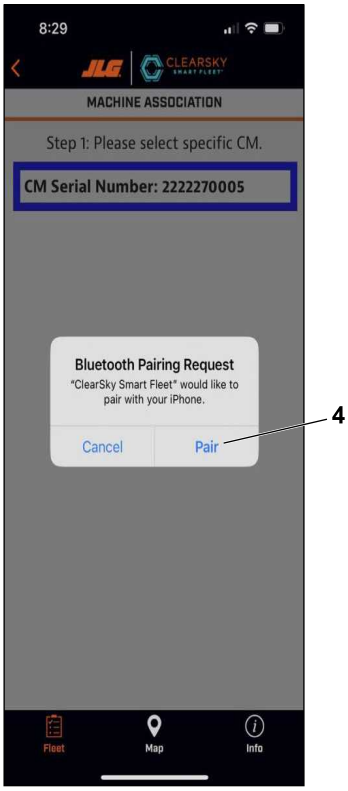
Note: If multiple Serial numbers (**3**) listed, those will be listed from near to far distance from the user.



CM100009A

8. Wait for application to connect to CS550.

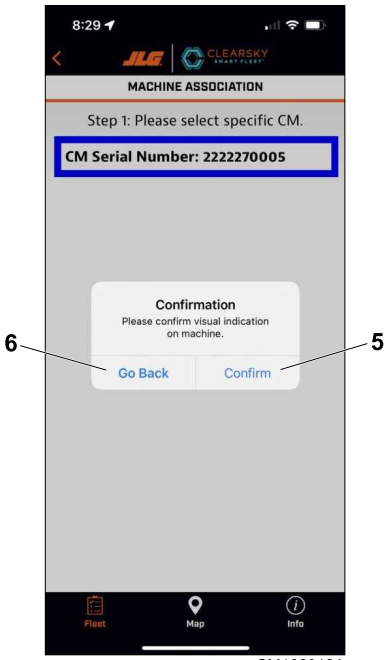
9. When “Bluetooth Pairing Request” pop-up box appears, select Pair (**4**).



CM100010A

10. When “Confirmation” pop-up box appears, the CS550 module will flash blue for five seconds.
    a. If intended machine CS550 flashes blue, select ”Confirm" (**5**).
    b. If intended machine CS550 does not flash blue, select ”Go Back" (**6**) and make sure correct CS550 serial number is selected.

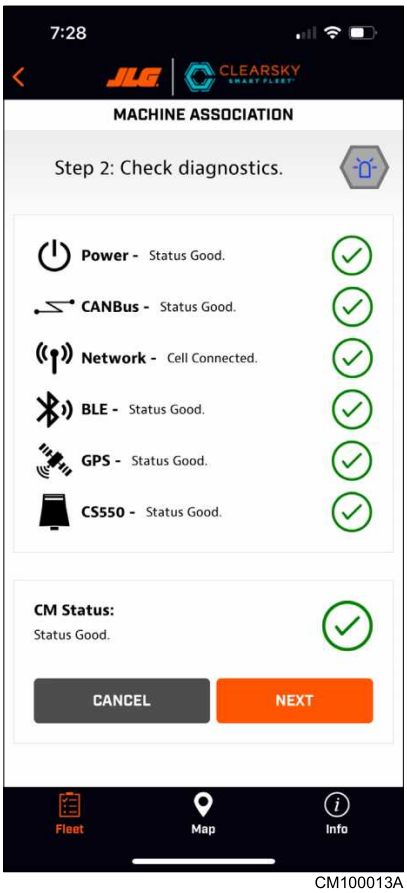
CM100011A



CM100012A

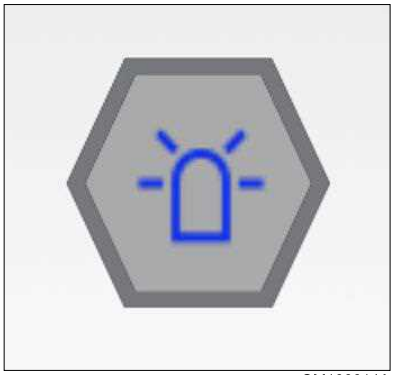
11. Wait for the CS550 diagnostics check to run.

12. If any step of the check fails, Refer to *Section - Troubleshooting, page 98*.



CM100013A

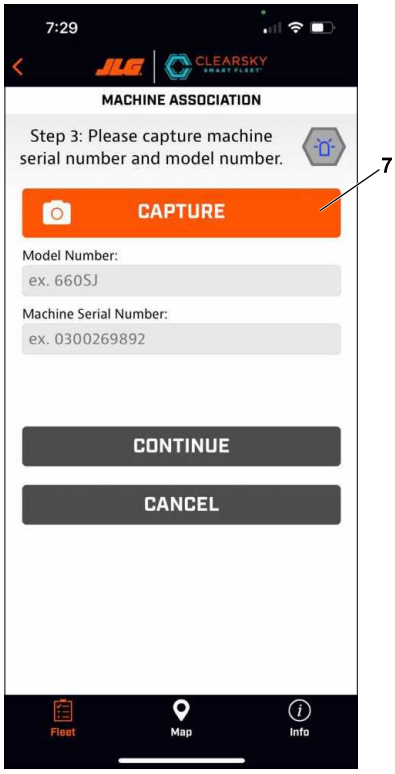
Note: At any point during configuration process, the button shown below can be used to force the CS550 to flash blue. This may be useful to find machine if configuration process is interrupted.



CM100014A

13. Select “NEXT” and then locate the serial number plate on the machine.

14. Select ”Capture" (**7**).



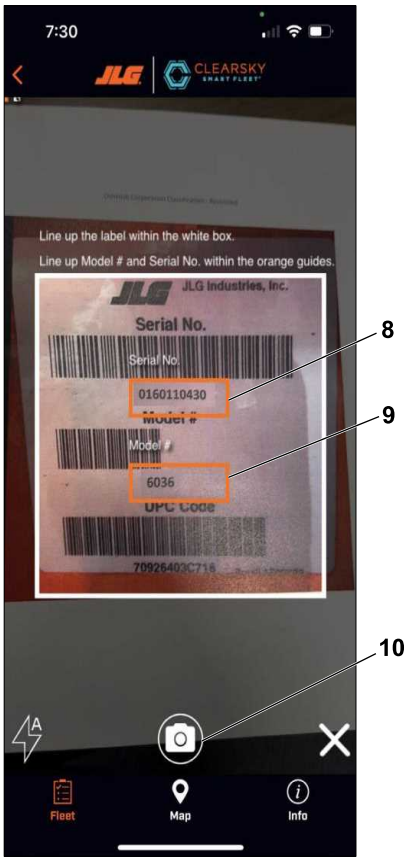
CM100015A

15. Select serial number plate style that matches the one on the machine.

CM100016A

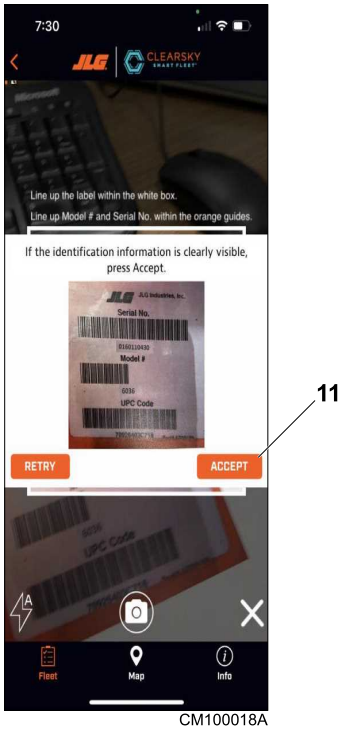
16. Make sure the model number (**8**) and serial number (**9**) are inside the orange boxes.

17. Select ”Camera" (**10**) icon to take picture.



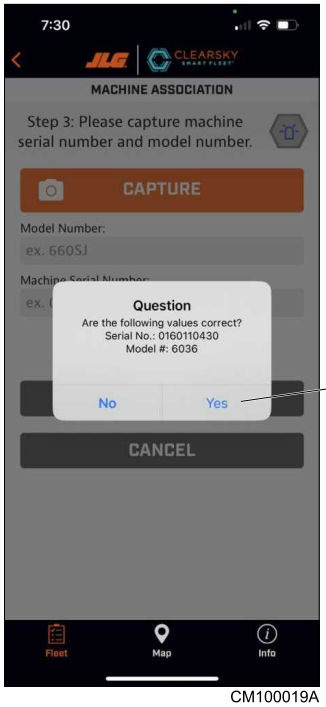
CM100017A

18. Make sure the picture is clearly visible, select ”Accept" (**11**).



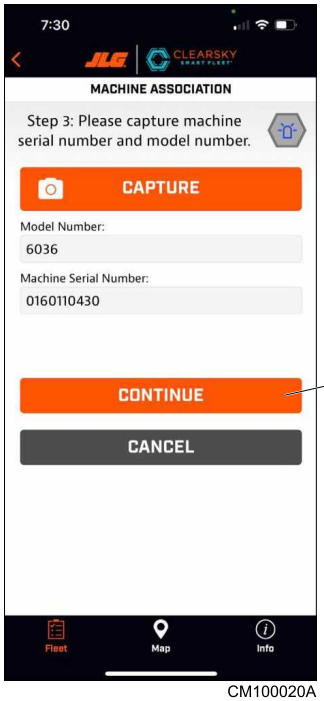
CM100018A

19. Confirm serial number and model number matches serial number plate.
20. If correct, select "Yes" (**12**).



CM100019A

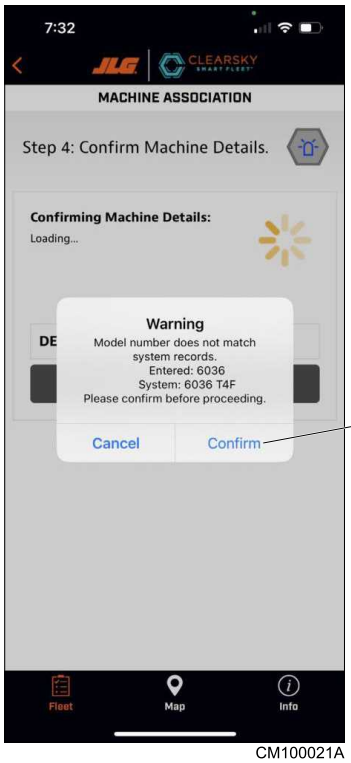
21. Select "Continue" (**13**).



CM100020A

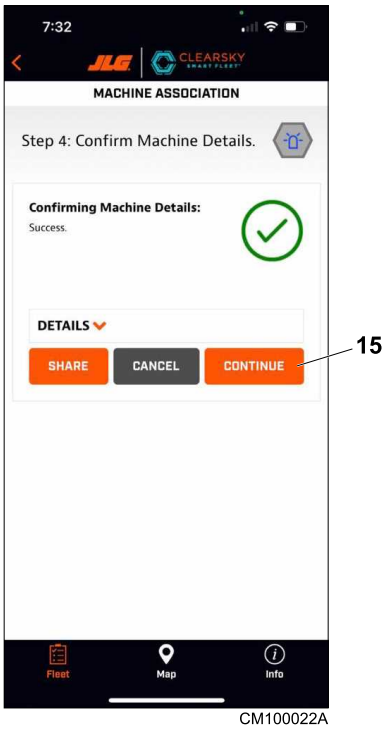
22. Wait for the application to confirm the machine details.

23. If “Warning” pop-up box appears, verify the entered detail is similar to the machine detail. If similar, select ”Confirm" (**14**).



CM100021A

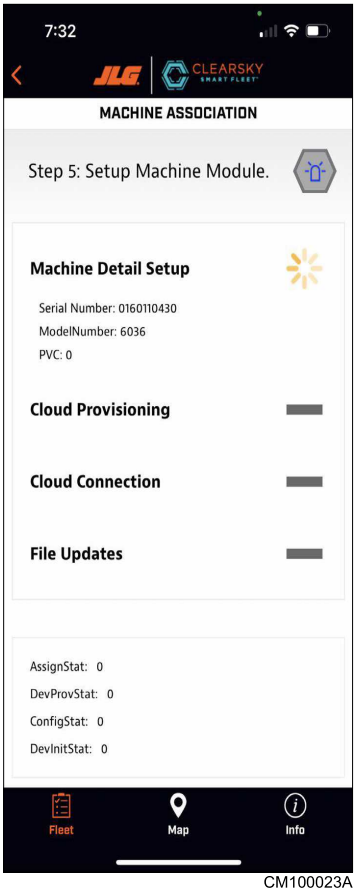
24. If successful, select ”Continue" (**15**).



CM100022A

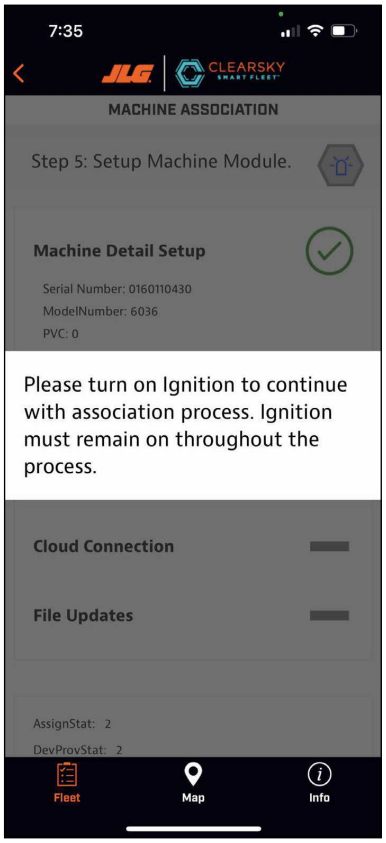
25. Wait for machine module setup to complete. This may take a maximum of 15 minutes.

Note: The device may be closed at this time while other work is completed.



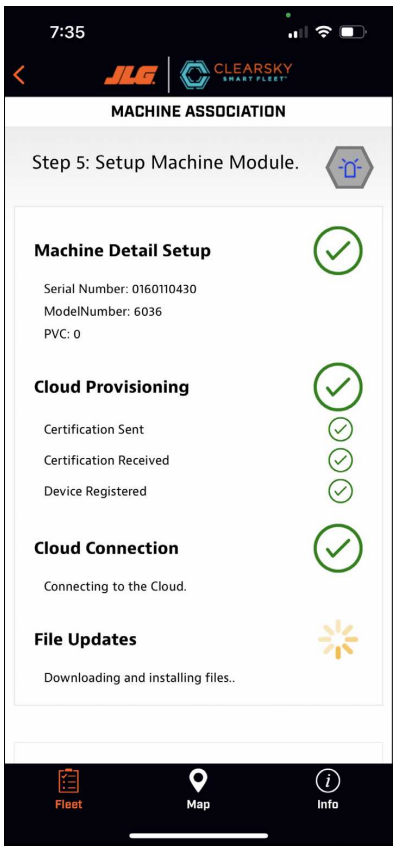
CM100023A

Note: Make sure during configuration, the machine power is ON. If OFF, switch machine power ON.



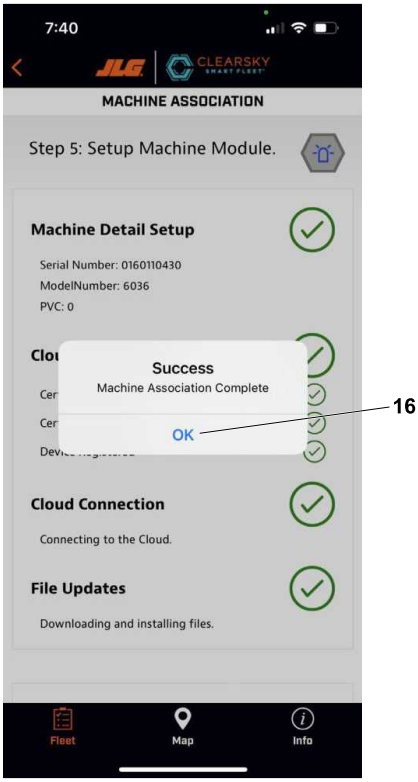
CM100005A

Note: If any step fails during machine module setup, Refer to *Section - Troubleshooting, page 98*.


7:35
MACHINE ASSOCIATION
Step 5: Setup Machine Module.
Machine Detail Setup
Serial Number: 0160110430
ModelNumber: 6036
PVC: 0
Cloud Provisioning
Certification Sent
Certification Received
Device Registered
Cloud Connection
Connecting to the Cloud.
File Updates
Downloading and installing files..
Fleet
Map
Info

CM100024A

26. When “Success” pop-up box appears, machine association is complete. Select “OK” (**16**).



CM100025A

27. After machine association is completed, the CS550 should stop slow flashing white and begin fast flashing amber if machine ignition is ON.

Note: The setting in analyzer's Machine Setup must be ON or AMBER for beacon.

28. Make sure CS550 flashes and horn or alarm sounds. If CS550 doesn’t flash and/or horn or alarm doesn’t annunciate, refer to ***Beacon Test*** in *Section – Troubleshooting, page 98*.

29. Application can be closed.

30. Turn machine power OFF.

5.5.2 Troubleshooting

If Bluetooth error appears:

1. Click on “OK” (**1**) button.

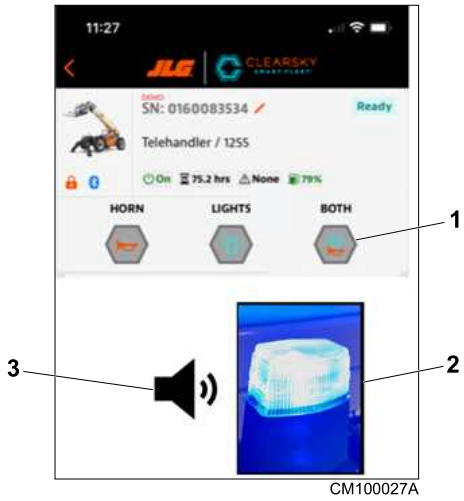
CM100026A

2. Slide finger down from the upper right of the screen.

3. Make sure Bluetooth is ON on mobile device.

Beacon Test:

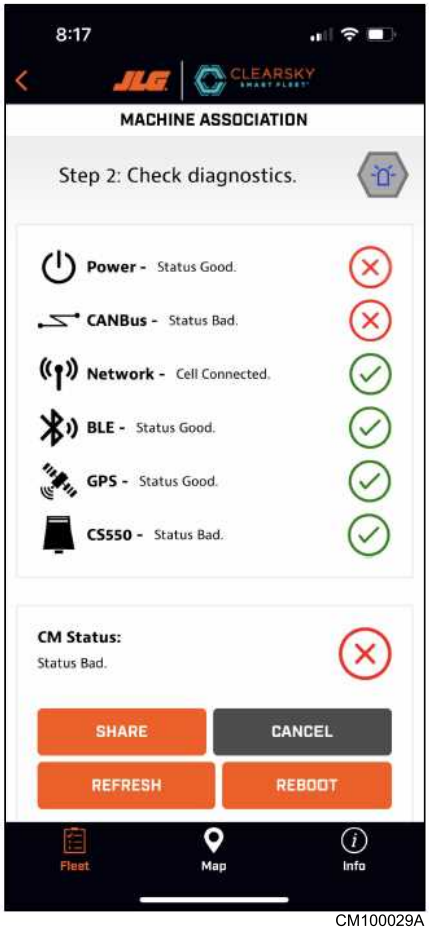
1. Turn machine power ON.
2. Select associated machine.
3. Select “Both” (**1**).
4. Make sure CS550 flashes (**2**) and horn or alarm sounds (**3**).
5. Turn machine power OFF.
6. Repeat test with machine power OFF.



CM100027A

If either power or CANBus indicate “Status Bad”:

1. Check connections on the machine.
   a. Beacon to Harness.
   b. Harness to CANBus.



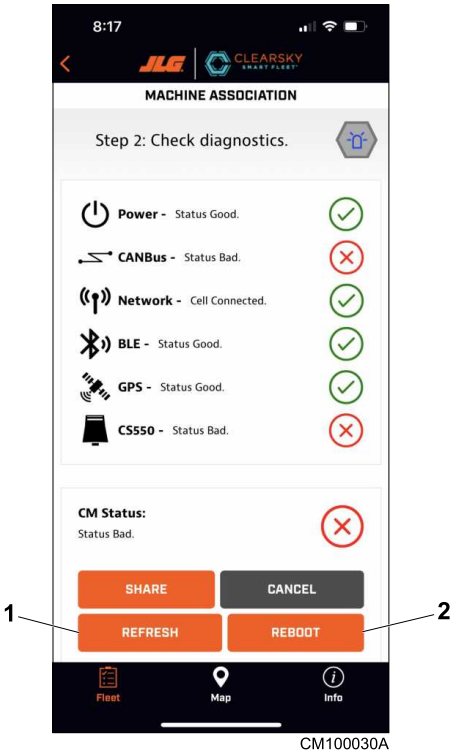
CM100029A

2. Confirm machine has latest software version.
3. Confirm analyzer setting for Clearsky = CS550. If machine DTC66111 is active, there is a bad CAN connection to CS550 or wiring is connected to incorrect CAN bus.
4. Replace CS550. Refer to the *Section - ClearSky® LED Motion / Amber Beacon (CS550), page 248* for removal and installation procedure.

If Network, BLE, GPS, or CS550 indicate “Status Bad”:

1. Select ”Refresh" (**1**).

2. If “Status Bad” still appears, select ”Reboot" (**2**) button. This will restart machine association procedure.

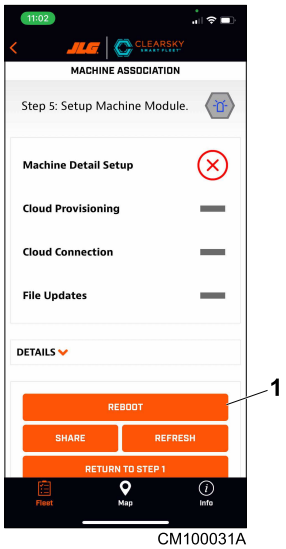


CM100030A

3. If “Status Bad” still appears, replace CS550. Refer to the *Section - ClearSky® LED Motion / Amber Beacon (CS550), page 248*.

If “Machine Detail Setup” fails:

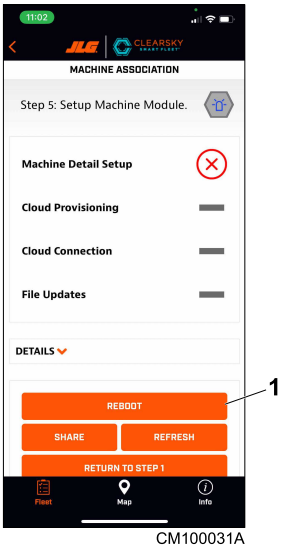
1. Select “Reboot" (**1**). This will restart machine association procedure.



CM100031A

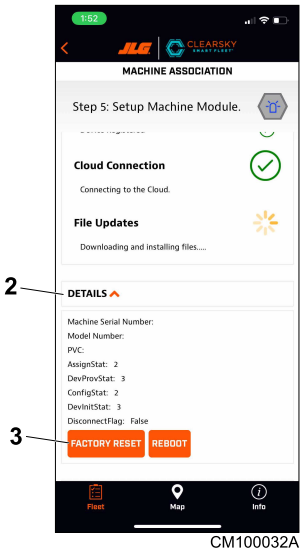
If “Cloud Provisioning”, “Cloud Connection”, or “File Updates” fails:

1. Select “Reboot” (**1**). This will restart machine association procedure.



CM100031A

2. If error still appears, expand the Details (**2**) section and select Factory Reset (**3**). This will restart machine association procedure.



CM100032A

Machine Disassociation:

If module is being transferred to another machine follow below machine disassociation procedure:

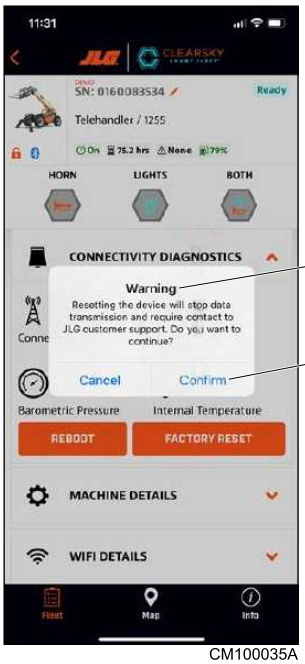
1. Select machine to be disassociated from Fleet or Map screen.

CM100033A

2. Select “Factory Reset” (**1**).

CM100034A

3. When “Warning” (**2**) pop-up box appears, select “confirm” (**3**).



CM100035A

4. Wait for the CS550 to begin slowly flashing white. This indicates, process is completed.
5. Remove CS550 from machine. Refer to the *Section - ClearSky® LED Motion / Amber Beacon (CS550), page 248*.
6. Contact JLG customer support with CS550 serial number and machine serial number that it was removed from. (JLG will update equipment records to allow CS550 to be used on another machine).

SECTION 6
FAULT CODES

6.1 INTRODUCTION

6.1.1 General

This section contains troubleshooting information to be used for locating and correcting most operating problems. If a problem should develop which is not presented in this section or which is not corrected by listed corrective actions, technically qualified guidance should be obtained before proceeding with any maintenance.

NOTICE

It is a good practice to avoid pressure-washing electrical/electronic components. Should pressure washing be utilized to wash areas containing electrical/electronic components, JLG Industries, Inc. Recommends a maximum pressure of 750 psi (52 bar) at a minimum distance of 12 in. (30.5 cm) away from these components. If electrical/electronic components are sprayed, spraying must not be direct and be for brief time periods to avoid heavy saturation.

6.1.2 Troubleshooting Information

Troubleshooting procedures applicable to this machine are listed and defined starting with Troubleshooting Tables Index in this section of the manual.

Each malfunction within an individual group or system is followed by a listing of probable causes which will enable determination of the applicable remedial action. The probable causes and the remedial action should, where possible, be checked in the order listed in the troubleshooting tables.

It should be noted that there is no substitute for a thorough knowledge of the equipment and related systems.

It should be recognized that the majority of the problems arising in the machine will be centered in the hydraulic and electrical systems. For this reason, every effort has been made to ensure that all likely problems in these areas are given the fullest possible treatment. In the remaining machine groups, only those problems which are symptomatic of greater problems which have more than one probable cause and remedy are included. This means that problems for which the probable cause and remedy may be immediately obvious are not listed in this section.

The first rule for troubleshooting any circuit that is hydraulically operated and electrically controlled is to determine if the circuit is lacking hydraulic oil and electrical control power. This can be ascertained by overriding the bypass valve *(mechanically or electrically)* so that oil is available to the function valve, then overriding the function valve mechanically. If the function performs satisfactorily, the problem exists with the control circuit.

6.2 DTC CHECK TABLES

Table 20. Ground Module Faults

Help Message	DTC	Alarm	Flash Code	Action	Trigger	Latch Condition
EVERYTHING OK	001	None	None	• No Motion restrictions	Platform Mode and no Faults are active.	Not Latched
GROUND MODE OK	002	None	None	• No Motion restrictions	Ground Mode and no Faults are active.	Not Latched
ALARM SOUNDING – TILTED & ABOVE ELEVATION	003	PF: Continuous	None	• No Motion restrictions	Platform is elevated and chassis is not level	Not Latched
DRIVING AT CUTBACK – ABOVE ELEVATION	004	None	None	• Drive = CREEP	Platform is elevated and the machine is in the drive mode of operation	Not Latched

Table 20. Ground Module Faults (continued)

Help Message	DTC	Alarm	Flash Code	Action	Trigger	Latch Condition
DRIVE & LIFT UP PREVENTED TILTED & ELEVATED	005	PF: Continuous	None	• Drive = PREVENTED • Lift Up = PREVENTED	Driving and lift up are not possible since the platform is elevated and the chassis is not level.	Not Latched
LIFT UP PREVENTED - MAX HEIGHT REACHED	0052	None	None	• Lift Up = PREVENTED	The vehicle has reached the maximum height allowed by the Indoor/Outdoor selection and further lift up motion is not possible.	Not Latched
FUNCTIONS LOCKED OUT – SYSTEM POWERED DOWN	008	None	None	• Enter Safe Mode • Lift Down = PREVENTED	A period of time elapsed without activity and the Control System entered a low-power state to preserve battery charge and disarm controls. Cycle the Ground EMS in Ground Mode or the Platform EMS in Platform Mode to re-enable the vehicle. • 45 minutes without Drive Forward, Drive Reverse, Lift Up, Lift Down, Steer Left, or Steer Right in Platform Mode. • 10 minutes without Lift Up or Lift Down in Ground Mode. • Timer resets if user changes Platform Mode/Ground Mode	Latched
DRIVE PREVENTED – ELEVATED ABOVE DRIVE CUT-OUT HEIGHT	009	None	None	• Drive = PREVENTED	The Drive Cutout functionality is enabled, and the Platform is out of Transport. (Refer to Drive Cutout Functionality)	Not Latched
POWER CYCLE	211	None	2_1	• No Motion restrictions	This Help Message is issued at each power-up. This serves to indicate which messages have been recorded in the failure log since the last power-up event.	Not Latched
KEYSWITCH FAULTY	212	None	2_1	• Force to Ground Mode	Both the Ground Select and Platform Select signals are energized, which means there is an issue with the keyswitch or one of the lines are shorted to battery. • V4-20 PF_SEL and V1-5 GRND_SEL are energized simultaneously.	Not Latched
FUNCTION PROBLEM – HORN PERMANENTLY SELECTED	221	None	2_2	• Horn Prevented	Horn Switch in the Platform Control Box was closed during power-up. Release or repair the switch to clear the message. • In Platform Mode and Horn is Energized during Startup. Retained until Horn is momentarily De-energized.	Not Latched
TRIGGER CLOSED TOO LONG WHILE IN NEUTRAL	2210	None	2_2	• Drive = PREVENTED • Lift Up = PREVENTED • Lift Down = PREVENTED	Trigger Switch in the Platform Control Box was closed for more than five seconds while the Joystick (accelerator) was in the neutral position (centered). Release switch or repair the switch / wiring to clear the difficulty. • In Platform Mode, the TRIGGER input was Energized for 5,000mS AND JoystickCommand is 0% and Stable (within +/- 0.05V change). Retained until the TRIGGER input is momentarily De-energized.	Not Latched
FUNCTION PROBLEM – INDOOR / OUTDOOR PERMANENTLY SELECTED	222	None	2_2	• Previously selected Indoor / Outdoor Mode maintained	Indoor / Outdoor Switch in the Platform Control Box was closed during power-up. Release or repair the switch to clear the message. • In Platform Mode, the IN/OUT switch is energized during Platform Mode Startup. Retained until IN/OUT is momentarily De-energized. Only applicable if {MACHINE SETUP-> MARKET supports both Indoor and Outdoor operating modes	Not Latched
FUNCTION PROBLEM – DRIVE & LIFT ACTIVE TOGETHER	223	None	2_2	• Function Selected = LIFT • Drive = PREVENTED • Lift Up = PREVENTED • Lift Down = MAX	The Drive - Lift Selector Switch indicates that both functions are selected simultaneously. Repair the wiring or switch to clear the message.	Not Latched
FUNCTION PROBLEM – DRIVE & LIFT BOTH OPEN	2232	None	2_2	• MoveState = LIFT • Drive = PREVENTED • Lift Up = PREVENTED • Lift Down = MAX	In Platform Mode, the Drive - Lift Selector Switch indicates that neither function is selected. Repair the wiring or switch to clear the message. • In Platform Mode, the DRIVE_SEL and LIFT_SEL are open circuit at the same time. Retained until either is momentarily energized.	Not Latched

Table 20. Ground Module Faults (continued)

Help Message	DTC	Alarm	Flash Code	Action	Trigger	Latch Condition
FUNCTION PROBLEM – STEER LEFT PERMANENTLY SELECTED	224	None	2_2	• Drive = PREVENTED	Steer Left Switch in the Platform Control Box was closed during power-up. Release or repair the switch to clear the message.	Not Latched
FUNCTION PROBLEM – STEER RIGHT PERMANENTLY SELECTED	225	None	2_2	• Drive = PREVENTED	Steer Right Switch in the Platform Control Box was closed during power-up. Release or repair the switch to clear the message.	Not Latched
ACCELERATOR FAULTY – WIPER OUT OF RANGE	226	None	2_2	• Drive = PREVENTED • Lift Up = PREVENTED • Lift Down = PREVENTED	The joystick (accelerator) wiper signal input is outside the acceptable voltage range. The wiper wire may be off, shorted to +B, or shorted to –B (ground)to cause this difficulty. • In Platform Mode, the joystick voltage is > 4.60V OR < 0.40V. Retained until the EMS is cycled.	Latched
STEER SWITCHES FAULTY	227	None	2_2	• Drive = PREVENTED	Both the Steer Left and Steer Right Inputs are closed as the same time. A short in the Steer Switch wiring or a failed Steer Switch can cause this difficulty.	Latched
FUNCTION LOCKED OUT – ACCELERATOR NOT CENTERED	228	None	2_2	If the forward/backward voltage is not in within a range representing "centered" • Drive = PREVENTED • Lift Up = PREVENTED • Lift Down = PREVENTED If the left/right joystick voltage (MML/MSP only) is not with a range representing "centered" • Drive = PREVENTED	•For the MCL, MML, and MSP, Selected function (Drive or Lift) is not allowed because the joystick (PLTM_J1-18_JOY_SIG) was not centered at power-up. Return joystick to center momentarily. •For the MML and MSP, Selected function (Drive or Lift) is not allowed because the joystick (PLTM_J1-18_JOY_SIG) OR SteerJoystick (PLTM_J1-19_JOY_SIG) was not centered at power-up. Return joystick to center momentarily.	Not Latched
FUNCTION PROBLEM – TRIGGER PERMANENTLY CLOSED	229	None	2_2	• Drive = PREVENTED • Lift Up = PREVENTED • Lift Down = PREVENTED	Trigger Switch in the Platform Control Box was closed at power-up. Release switch or repair the switch / wiring to clear the difficulty.	Not Latched
STEER JOYSTICK FAULTY - WIPER OUT OF RANGE	22104	None	2_2	• Drive = PREVENTED	The MML or MSP steer joystick wiper signal input is outside the acceptable voltage range. The wiper wire may be off, shorted to +B, or shorted to –B (ground)to cause this difficulty. • In Platform Mode, The Joystick steer axis is > 4.60V OR < 0.40V. Retained until the EMS is cycled.	Latched
FUNCTION PROBLEM – LIFT PERMANENTLY SELECTED	231	None	2_3	In Ground Mode • Lift Up = PREVENTED • Lift Down = PREVENTED	Lift Switch (Up or Down) in the Ground Control Box was closed during power-up. Release or repair the switch to clear the message.	Not Latched
GROUND LIFT UP/DOWN ACTIVE TOGETHER	232	None	2_3	In Ground Mode • Lift Up = PREVENTED • Lift Down = PREVENTED	In Ground Mode, the control system has detected the Lift Up and Down are active simultaneously. Check the Lift Switch and associated wiring in the Ground Control Box.	Latched
FUNCTION PROBLEM – BRAKE RELEASE PERMANENTLY SELECTED	233	None	2_3	In Ground Mode • Brake Release Option is not allowed to disengage brakes	In Ground Mode, the Manual Brake Release Digital Input is energized at power-up. Retained until the brake release signal is momentarily de-energized.	Not Latched
LIFT UP SWITCH - INVALID SIGNAL	23200		2_3	• Lift Up = PREVENTED	Ground Module detects an internal error on the Lift Up switch Digital Input	Latched

Table 20. Ground Module Faults (continued)

Help Message	DTC	Alarm	Flash Code	Action	Trigger	Latch Condition
LIFT DOWN SWITCH - INVALID SIGNAL	23201		2_3	• Lift Up = PREVENTED • Lift Down = PREVENTED	Ground Module detects an internal error on the Lift Down switch Digital Input	Latched
POT HOLE PREVENTION SWITCH 1 - INVALID SIGNAL	23202		2_3	• Pot Hole Sensor = DISAGREEMENT	Ground Module detects an internal error on the Pothole Switch 1 Digital Input	Latched
POT HOLE PREVENTION SWITCH 2 - INVALID SIGNAL	23203		2_3	• Pot Hole Sensor = DISAGREEMENT	Ground Module detects an internal error on the Pothole Switch 2 Digital Input	Latched
ELEVATION SENSORS - INVALID SIGNAL	23205		2_3	• Lift Up = PREVENTED • Platform Height assumed to be Zone2 (Indoor Max Height) • Drive = CREEP	• Elevation Sensor 1 reports Closed while Elevation Sensor 2 AND Elevation Sensor 3 both report max height • Elevation Sensor 1 changes state (Open to Close OR Closed to Open) within 4500mS of Elevation Sensor 2 OR Elevation Sensor 3 while the operator successfully commands Lift Up OR Lift Down • Elevation Sensor 1 continues to report Closed after commanding Lift Up for 2500mS above 30% LiftDemand • Elevation Sensor 1 reports Open while commanding Lift Down for 750mS after the Pothole Bars retract	Latched
ELEVATION SENSORS - DISAGREEMENT	23245		2_3	• Lift Up = PREVENTED • If the Pot Hole Sensor Reports RETRACTED AND Elevation Sensor 1 Reports CLOSED, Platform Height assumed to be Zone0 (Transport). Drive = MAX • If the Pot Hole Sensor Reports EXTENDED OR DISAGREEMENT OR Elevation Sensor 1 Reports OPEN, Platform Height assumed to be Zone2 (Indoor Max Elevation)	• Elevation Sensor 2 and Elevation Sensor 3 signals report the same output (both closed or both open) for a duration of 500mS while Lift Up OR Lift Down is successfully commanded by the operator	Latched
AMBIENT TEMPERATURE SENSOR – OUT OF RANGE LOW	241	PF: Continuous	2_4	• Drive and Lift Restrictions	The temperature as communicated by the temperature/tilt sensor is less than -40 degrees Celsius. •While in transport, Drive is prevented, Lift Down is limited to Creep speeds, and Lift Up is prevented. The platform alarm shall continuously sound. •While out of transport, Lift Down speeds will be limited to creep and Lift Up will be prevented (Drive will operate normally), the platform alarm shall continuously sound.	Not Latched
AMBIENT TEMPERATURE SENSOR – OUT OF RANGE HIGH	242	PF: Continuous	2_4	• Drive and Lift Restrictions	The temperature as communicated by the temperature/tilt sensor is less than -40 degrees Celsius. •While in transport, Drive is prevented, Lift Down is limited to Creep speeds, and Lift Up is prevented. The platform alarm shall continuously sound. •While out of transport, Lift Down speeds will be limited to creep and Lift Up will be prevented (Drive will operate normally), the platform alarm shall continuously sound.	Not Latched
FUNCTIONS LOCKED OUT - CONSTANT DATA VERSION IMPROPER	2520	None	2_5	• Drive = PREVENTED • Lift Up = PREVENTED • Lift Down = PREVENTED	The Ground Module's Application and ConstantData Versions do not match which could lead to improper operation therefore machine shall not be allowed to function. Update/reinstall the latest Vehicle software from Online Express	Latched
DRIVE PREVENTED – CHARGER CONNECTED	253	None	2_5	• Drive = PREVENTED	Driving is not possible since the vehicle is charging.	Not Latched

Table 20. Ground Module Faults (continued)

Help Message	DTC	Alarm	Flash Code	Action	Trigger	Latch Condition
DRIVE & LIFT UP PREVENTED – CHARGER CONNECTED	254	None	2_5	• Drive = PREVENTED • Lift Up = PREVENTED	Driving and Lifting are not possible since the vehicle is charging and it is configured in Machine Setup to prevent all motion while charging.	Not Latched
PLATFORM OVERLOADED	255	PF: 5000ms ON/ 2000ms OFF GND: 5000ms ON/ 2000ms OFF	2_5	• Drive = PREVENTED if out of transport • Lift Up = PREVENTED if in Platform Mode OR (Ground Mode AND MACHINE SETUP -> LOAD = CUTOUT ALL)	Triggers when the LSS is overloaded or unhealthy While the Load Sensing System is enabled, the Platform Load measured by the Load Sensing System is excessive. Lift Up is Prevented, as well as drive above transport height. • This fault shall be suppressed if technician navigates to the CALIBRATIONS menu of the ANALYZER.	Not Latched
DRIVE PREVENTED – POTHOLE NOT ENGAGED	256	If {MACHINE SETUP->PHP ALARM = YES} PF: 500ms On/ 500ms Off GND: 500ms On/ 500ms Off	2_5	• Drive = PREVENTED • Force to Zone 1 if the mast is not extended • Force to Zone 2 if the mast is extended above Outdoor Max Height or the Outdoor Height Switch has a disagreement	• This triggers when drive is selected from platform, the Pothole Bars are Retracted/Unhealthy and the machine is out of transport {ElevSen1 = OPEN} • Platform and Ground alarm will sound if MACHINE SETUP -> PHP ALARM is set to YES	Not Latched
TEMPERATURE CUTOUT ACTIVE - AMBIENT TEMPERATURE TOO LOW	2568	If TransportMode = TRUE PF: Continuous If TransportMode = FALSE PF: OFF	2_5	• Drive and Lift Restrictions	The temperature reported by the temperature/tilt sensor is less than or equal to {PERSONALITIES->TEMP CUTOUT->CUTOUT SET} (See Low Temperature Cutout Functionality) Only applicable if {MACHINE SETUP->LOW TEMP CUTOUT=YES} This DTC shall not be displayed in Ground Mode, and no restrictions shall be implemented.	Not Latched
DRIVE & LIFT PREVENTED – BRAKES ELECTRICALLY RELEASED FOR TOWING	258	Motion Alarm	2_5	• Drive = PREVENTED • Lift Up = PREVENTED • Lift Down = PREVENTED	• Brake Release button was pressed and held for 1000mS while in Ground Mode • The charger is not connected to an outlet • Press the brake release button again or cycle the EMC to clear this DTC and reapply the brakes	Not Latched
MODEL CHANGED – HYDRAULICS SUSPENDED – CYCLE EMS	259	None	2_5	• Drive = PREVENTED • Lift Up = PREVENTED • Lift Down = PREVENTED	The user changed the Model Selection using the JLG Analyzer. All functions are prevented until the EMS is cycled.	Latched
POTHOLE SENSOR – DISAGREEMENT	25115	PF: Continuous if forced to Zone 0	2_5	• Assume Zone 0 (Transport Mode) if Outdoor Switch State shows the mast is still below Outdoor Mode max height AND the Transport Switch reports the mast is fully stowed. Lift Up State = PREVENTED. Drive = Creep. • Assume Zone 1 if Outdoor Switch State shows the mast is still below	Both Pothole Switches {GM_V5-12 and GM_V5-2} both report CLOSED or both report OPEN for more than 500mS	Latched

Table 20. Ground Module Faults (continued)

Help Message	DTC	Alarm	Flash Code	Action	Trigger	Latch Condition
				Outdoor Mode max height AND the Transport Switch report the mast is not fully stowed. Lift Up State = MAX. Drive = PREVENTED. • Assume Zone 2 if Outdoor Switch State is extended above max outdoor height or the Outdoor Max Height Switch is in disagreement. Lift Up State = MAX. Drive = Prevented		
VALVE ENABLE DRIVER PERMANENTLY ON	324	None	3_2	• Drive = PREVENTED • Lift Up = PREVENTED	The VSW signal is shorted to Battery during startup prior to enabling the VSW switch. VSW > 14V when VSW switch is in the off state.	Latched
STEER RIGHT VALVE – OPEN CIRCUIT	3310	None	3_3	• Disable Output • Drive = PREVENTED	Open Circuit detected on the Steer Right Valve (MCL only)	Latched
GROUND ALARM– SHORT TO BATTERY	3311	None	3_3	• Disable Output	Only applicable iwhile MACHINE SETUP->WHITE NOISE ALARM=YES Short to Battery was detected on White Noise Alarm Digital Output	Latched
HORN - SHORT TO BATTERY	33208	None	3_3	• Disable Output	Short to Battery was detected on Ground Alarm Output	Latched
HORN SHORT TO GROUND	33209	None	3_3	• Disable Output	Short to Ground was detected on Ground Alarm Output	Latched
STEER LEFT VALVE – SHORT TO GROUND	33298	None	3_3	• Disable Output • Drive = PREVENTED	Short to Ground was detected on the Steer Left Valve (MCL only)	Latched
LINE CONTACTOR COIL – SHORT TO BATTERY	33299	None	3_3	• Enter Safe Mode	The Ground Module has been powered up due to a wiring fault • Ground Module is powered but both V4-20 PF_SEL and V1-5 GRND_SEL are read as de-energized.	Latched
LIFT UP VALVE – SHORT TO BATTERY	333	None	3_3	• Disable Output • Lift Up = PREVENTED • Drive = PREVENTED	Short to Battery was detected on the Lift Up Valve (18MCL only)	Latched
STEER RIGHT VALVE – SHORT TO GROUND	33305	None	3_3	• Disable Output • Drive = PREVENTED	Short to Ground was detected on the Steer Right Valve (MCL only)	Latched
BEACON LIGHT – SHORT TO GROUND	33384	None	3_3	• Disable output • No motion restrictions	Short to Ground was detected on BEACON AND {MACHINE SETUP-> BEACON= YES}.	Latched
LIFT UP VALVE – OPEN CIRCUIT	334	None	3_3	• Disable Output • Lift Up = PREVENTED	Open Circuit detected on the Lift Up Valve (MCL only)	Latched
LIFT UP VALVE – SHORT TO GROUND	33406	None	3_3	• Disable Output • Lift Up = PREVENTED	Short to Ground was detected on the Lift Up Valve (MCL only)	Latched
LIFT DOWN VALVE – SHORT TO GROUND	33407	None	3_3	• Disable Highside Output • Open Lowside Output • Lift Down = PREVENTED • Lift Up = PREVENTED	Short to Ground was detected on the Lift Down Valve	Latched

Table 20. Ground Module Faults (continued)

Help Message	DTC	Alarm	Flash Code	Action	Trigger	Latch Condition
LIFT DOWN VALVE – SHORT TO BATTERY	335	None	3_3	• Disable Highside Output • Open Low-side Output • Lift Down = PREVENTED • Lift Up = PREVENTED	Short to Battery was detected on the Lift Down Valve	Latched
BEACON LIGHT – SHORT TO BATTERY	33562	None	3_3	• Disable output • No motion restrictions	Short to Battery was detected on BEACON AND {MACHINE SETUP-> BEACON=YES}.	Latched
LIFT DOWN VALVE – OPEN CIRCUIT	336	None	3_3	• Disable Highside Output • Open Low-side Output • Lift Down = PREVENTED • Lift Up = PREVENTED	Open Circuit detected on the Lift Down Valve	Latched
PLATFORM POWER – SHORT TO BATTERY	33674	None	3_3	• Force to Ground Mode • Disable output	Short to Battery was detected on the PLATFORM_PWR digital output.	Latched
PLATFORM POWER – SHORT TO GROUND	33676	None	3_3	• Platform Mode Prevented • Disable output	Short to Ground was detected on the PLATFORM_PWR digital output.	Latched
STEER LEFT VALVE – SHORT TO BATTERY	337	None	3_3	• Disable Output • Drive = PREVENTED • Lift Up = PREVENTED	Short to Battery was detected on the Steer Left Valve (MCL only)	Latched
GROUND ALARM– SHORT TO GROUND	3371	None	3_3	• Disable output	Short to Ground was detected on the White Noise Alarm Output Only applicable if {MACHINE SETUP->WHITE NOISE ALARM=YES}	Latched
HOUR METER– SHORT TO GROUND	3379	None	3_3	• Disable output	Short to Ground was detected on the Ground Station Hour Meter	Latched
LIFT DOWN VALVE - CURRENT FEEDBACK READING TOO LOW	33739	None	3_3	• Normal operation	Current Reading Too Low was detected on the Lift Down Valve. There might be an Open Circuit forming or a short to ground on the chassis/Arm harness	Latched
STEER LEFT VALVE – OPEN CIRCUIT	338	None	3_3	• Disable Output • Drive = PREVENTED	Open Circuit detected on the Steer Left Valve (MCL only)	Latched
HOUR METER– SHORT TO BATTERY	3381	None	3_3	• Disable output	Short to Battery was detected on the Hour Meter	Latched
STEER RIGHT VALVE – SHORT TO BATTERY	339	None	3_3	• Disable Output • Drive = PREVENTED • Lift Up = PREVENTED	Short to Battery was detected on the Steer Right Valve (MCL only)	Latched
MASTER MODULE TEMPERATURE – OUT OF RANGE	426	None	4_2	• Normal operation	The Ground Module's internal temperature sensor is out of range. (< 40C or > 150C)	Not Latched
BATTERY VOLTAGE TOO LOW – SYSTEM SHUTDOWN	441	None	4_4	• Enter Safe Mode • Lift Down = MAX	Battery Voltage(VBAT) momentarily dropped below 14.5V when using flooded lead-acid batteries, or 16.0V when using AGM batteries. With a low battery charge, this can occur during heavy current demand due to Drive, Steer, or Lift Up. Recharge batteries or check for damaged batteries, sulfated batteries, or poor power connections.	Latched
BATTERY VOLTAGE TOO HIGH – SYSTEM SHUTDOWN	442	None	4_4	• Enter Safe Mode • Lift Down = MAX	The Ground Module measured excessively high battery voltage (VBAT) (>32.0V) and de-energized the Main Line Contactor and Battery Relay to protect system devices and was	Latched

Table 20. Ground Module Faults (continued)

Help Message	DTC	Alarm	Flash Code	Action	Trigger	Latch Condition
					unable to bring voltage down to normal operating range. This may be due to improper battery charging or incorrect voltage batteries being used. If this fault occurs while charging, disconnect the charger immediately	
LOGIC SUPPLY VOLTAGE OUT OF RANGE HIGH	4421	None	4_4	• Enter Safe Mode • Lift Down = MAX	The Ground Module's VSW voltage was measured to be more than 32V. This may be caused by loose battery terminal, severely discharge batteries, a damaged battery, or an improper wire harness connection.	Latched
LOGIC SUPPLY VOLTAGE OUT OF RANGE LOW	446	None	4_4	• Drive = PREVENTED • Lift Up = PREVENTED	The Ground Module's VSW voltage was measured to be out of range <13V by the Ground Module. This may be caused by loose battery terminal, severely discharged batteries, a damaged battery, or an improper wire harness connection.	Latched
VOLTAGE REFERENCE OUT OF RANGE	447	None	4_4	• Drive = PREVENTED • Lift Up = PREVENTED • Platform Height is assumed to be Max Elevation for the purposes of other interlocks • LSS Overload = TRUE	The Ground Modules 5V supply voltage was measured to be out of range (<4.5V or >5.5V). This may be caused by loose battery terminal, severely discharged batteries, a damaged battery, or an improper wire harness connection.	Latched
BATTERY VOLTAGE TOO HIGH – UNPLUG CHARGER	4476	None	4_4	• Enter Safe Mode • Lift Down = MAX	The Ground Module momentarily measured excessively high battery voltage (VBAT) (>32.0V) and entered Safe Mode to protect system devices. This may be due to improper battery charging or incorrect voltage batteries being used.	Latched
BATTERY VOLTAGE TOO HIGH – FORCING DISCHARGE	4477	None	4_4	• Disable VSW, Lift Down = PREVENTED Lift Up = PREVENTED Drive = PREVENTED suppress other system errors, then (MCL only) Energize the Steer Right Valve and the Steer Left Valve	The Ground Module momentarily measured excessively high battery voltage (VBAT) (>32.0V) and entered Safe Mode. This may be due to improper battery charging or incorrect voltage batteries being used. • The Ground Mddule measured battery voltage greater than 32.0V • System Devices powered by VSW will be disabled • GM shall energize the Steer Left Valve and Steer Right Valve in an effort to lower float charge down below 31V to get to normal operation state (MCL only) • If VBAT reading does not go below 31V after 10 seconds, GM shall denenergize the Steer Left and Steer Right Valve (MCL only) • If VBAT reading does go below 31V before 10 seconds, GM shall enable VSW and resume with normal startup procedure.	Not Latched
GROUND MODULE - OVERCURRENT	4478	None	4_4	• Enter Safe Mode • Lift Down = MAX	The current being measured through the Ground Module is too high. • The Ground Module measure more than 8 Amps through the VSW switch.	Latched
VOLTAGE REFERENCE OUT OF RANGE	448	None	4_4	• Lift Up = PREVENTED • Drive = PREVENTED	The Ground Modules internal voltage is out of range. Check for wiring damage and consider replacing the Ground Module	Latched
CANBUS FAILURE – PLATFORM MODULE	662	None	6_6	• All Platform functions Prevented. Normal operation is allowed from Ground Mode	In Platform Mode, the control system failed to receive messages from the Platform Module. Check wiring at the Platform Box. Check wiring along the mast leading up to Platform.	Latched
CANBUS FAILURE – TILT/ TEMP SENSOR	6649	None	6_6	• Tilted = TRUE • Low Temperature Cutout = TRUE if {MACHINE SETUP->TEMP CUTOUT = YES}	The control system failed to receive messages from the tilt sensor. Check for wiring damage to the chassis harness or tilt sensor	Latched

Table 20. Ground Module Faults (continued)

Help Message	DTC	Alarm	Flash Code	Action	Trigger	Latch Condition
FUNCTIONS CUTOUT - GATE OPEN DETECTED	673	Based on Gate Alarm Selection • None • PF Continuous • GM Continuous	6_7	Functions Restricted based on Gate Alarm Selection	The Gate Switch reports open circuit while MACHINE SET-UP ==> GATE SWITCH: ≠ NONE.	Not Latched
	66111 682, 683, 684, 685, 686	Refer to ***Section — Clearsky Smart Fleet DTC Fault Codes, page 119*** for details				
TILT SENSOR NOT CALIBRATED	811	None	8_1	• Tilted = TRUE (+20.0' X, +20.0' Y); Drive Speed Forward will be restricted Drive and Lift Up are prevented out of Transport	The Chassis Tilt Sensor has never been calibrated so the control system assumes that the vehicle is tilted. Drive speed is reduced since a valid tilt reading is not available. Calibrate the Tilt Sensor using the calibration procedure to clear the message.	Not Latched
LSS SENSOR DISAGREEMENT	8218	None	8_2	• LSS Overload = TRUE	The LSS Switch Input J3-8_LoadSwitch1 and J2-2_LoadSwitch2 both report CLOSED or both report OPEN for more than 500mS	Latched
STEER SENSOR - OUT OF RANGE HIGH	8664	None	8_6	• Drive = Force to Turtle speed while in Zone0 (Transport) • Use the output of any steer sensor that has not reported a voltage out of range to determine motor speed	The Steer Angle Sensor Outputs (V3-2 OR V3-12) are reporting more than 4.50V for 250mS (MCL only)	Latched
STEER SENSOR - OUT OF RANGE LOW	8665	None	8_6	• Drive = Force to Turtle speed while in Zone0 (Transport) • Use the output of any steer sensor that has not reported a voltage out of range to determine motor speed	The Steer Angle Sensor Outputs (V3-2 OR V3-12) are reporting less than 0.50V for 250mS (MCL only)	Latched
STEER SENSOR - DECOUPLED	8666	None	8_6	• Drive = Force to Turtle speed while in Zone0 (Transport)	The Steer Angle Sensor Outputs (V3-2 OR V3-12) are reporting less than 0.50V (MCL only)	Latched
STEER SENSOR - NOT RESPONDING	8667	None	8_6	• Drive = Force to Turtle speed while in Zone0 (Transport)	The E18MCL Steer angle sensor does not report a change of more than 4 degrees in 1000mS while successfully commanding steer	Latched
STEER SENSOR - NOT CALIBRATED	8669	None	8_6	• Normal operation • Factory default Calibration Values shall be used	The Steer Angle Sensor has not been calibrated or the calibration has been erased by FACTORY RESET (MCL only)	Not Latched
STEER SENSOR – INTERNAL ERROR	86178	None	8_6	• Drive = Force to PARALLEL speed	The control system has detected a disagreement between the E18MCL Steer Angle Sensor Output 1 and Steer Angle Sensor Output 2. Replace Sensor. • Only Valid if (J3-2 and	Latched

Table 20. Ground Module Faults (continued)

Help Message	DTC	Alarm	Flash Code	Action	Trigger	Latch Condition
				while in Zone0 (Transport)	J3-12) disagree by more than +/- .25V of their inverse signals	
FUNCTIONS LOCKED OUT – PLATFORM MODULE SOFTWARE VERSION IMPROPER	9910	None	9_9	If in Platform Mode • Drive = PREVENTED • Lift Up = PREVENTED • Lift Down = PREVENTED	The control system will not function in Platform Mode because the Platform Module Software Version is not compatible with the rest of the system. Re-program or replace with a Version P1.xx module.	Latched
FUNCTIONS LOCKED OUT – MACHINE NOT CONFIGURED	9924	None	9_9	• Drive = PREVENTED • Lift Up = PREVENTED • Lift Down = PREVENTED	The Ground Module has not been configured for the first time. Use the JLG Analyzer to adjust all Machine Setup and Personality settings and re-cycle power to clear the fault code.	Latched
MACHINE CONFIGURATION OUT OF RANGE – CHECK ALL SETTINGS	9949	Continuosly	9_9	• Drive = PREVENTED • Lift Up = PREVENTED • Lift Down = PREVENTED	Ground Module detects a memory issue. Try toggling model, perform a Factory Reset in CALIBRATIONS, or Update/Reinstall the latest software from Online Express	Latched
EEPROM FAILURE – CHECK ALL SETTINGS	998	None	9_9	• Enter Safe Mode • Lift Down = PREVENTED	The control system detected an EEPROM failure. Personalities and Machine Setup settings may be reset to default values. Check / correct all settings and re-cycle power to clear difficulty. Also try toggling model, perform a Factory Reset in CALIBRATIONS, or Update/Reinstall the latest software from Online Express	Latched

Table 21. Smart Charger IC650COM Faults

Help Message	DTC	Alarm	Flash Code	Action	Trigger	Latch Condition
BATTERY CHARGER - FAULT (SPN:FMI)	44136	NONE	4_4	• Normal operation	The GM evaluates the Battery Charger is communicating any one of the following SPN:FMI's. The GM shall display the DTC followed by the specific (SPN:FMI) in parentheses. Any (SPN:FMI) not present in the list below shall be ignored. The Service Manual shall contain Troubleshooting/Customer Actions for each of these Faults DeltaQ Fault Code (SPN:FMI) - Description E013 (4993:5) – Battery Does Not Take Current E014 (524032:31) – Number of Cells Invalid E015 (524032:31) – End of Charge Voltage Not in Algo E016 (524033:31) – Upgrade Failed E017 (524034:31) – USB Error E018 (524033:31) – Storage Error E019 (524033:31) – Incomaptible Software Error E024 (524032:31) – Charger Failed to Init E026 (524033:31) – USB Script Error E027 (524034:6) – USB Overcurrent E028 (524032:31) – Incomaptible Algorithm Error E029 (524035:31) – CAN Bus Comm Error E030 (524042:31) – BMS Module Comm Error E031 (524036:31) – Reference Out of Range Error E032 (524035:9) – Comm Heartbeat Lost Error E034 (524032:31) – Battery Capacity Config Not Set E035 (524032:31) – Target Voltage Config Too Low E037 (524033:31) – CAN Download Failed E038 (8014:31) – Fan Error E039 (524037:31) – Button Stuck Down E040 (8014:18) – Fan Supply Voltage Low E041 (524032:31) – Software Internal Error E042 (524032:31) – CAN Configuration Error E047 (4992:3) – Platform over Voltage E048 (524038:31) – Parallel Charge Multiple Master E049 (524038:31) – Parallel Charge Out of Resource E050 (524038:31) – Parallel Charge Issue E051 (524038:31) – Parallel Charge Issue E052 (524041: 31) – Parallel Charge Issue E053 (524041: 31) – Parallel Charge Issue	Not Latched

Table 21. Smart Charger IC650COM Faults (continued)

Help Message	DTC	Alarm	Flash Code	Action	Trigger	Latch Condition
					E054 (524040:31) – Parallel Charge Issue E055 (524040:5) – Parallel Charge Issue E056 (524041:31) – Parallel Charge Issue	
BATTERY CHARGER - HIGH BATTERY VOLTAGE ERROR	44137	NONE	4_4	• Normal operation	The GM detects SPN:FMI 4992:16 which is DeltaQ Code E001	Not Latched
BATTERY CHARGER - BATTERY VOLTAGE TOO LOW FOR CHARGE	44138	NONE	4_4	• Normal operation	The GM detects SPN:FMI 4992:18 which is DeltaQ Code E002	Not Latched
BATTERY CHARGER - CHARGE TIMEOUT OCCURRED	44139	NONE	4_4	• Normal operation	The GM detects SPN:FMI 520194:16 which is DeltaQ Code E003	Not Latched
BATTERY CHARGER - AMP HOUR LIMIT EXCEEDED	44141	NONE	4_4	• Normal operation	The GM detects SPN:FMI 520196:16 which is DeltaQ Code E007	Not Latched
BATTERY CHARGER - BATTERY TEMPERATURE SENSOR OUT OF RANGE	44142	NONE	4_4	• Normal operation	The GM detects SPN:FMI 520192:31 which is DeltaQ Code E008	Not Latched
BATTERY CHARGER - BATTERY VOLTAGE POLARITY REVERSED	44143	NONE	4_4	• Normal operation	The GM detects SPN:FMI 4992:4 which is DeltaQ Code E012	Not Latched
BATTERY CHARGER - ALGORITHM NOT SET	44144	NONE	4_4	• Normal operation	The GM detects SPN:FMI 520236:31 which is DeltaQ Code E020 OR the GM does not have record of SET CHARGER CAL being completed (result of new GM or FACTORY RESET)	Not Latched
BATTERY CHARGER - AC SUPPLY VOLTAGE TOO HIGH	44147	NONE	4_4	• Normal operation	The GM detects SPN:FMI 520193:3 which is DeltaQ Code E023	Not Latched
BATTERY CHARGER - AC SUPPLY VOLTAGE TOO LOW	44148	NONE	4_4	• Normal operation	The GM detects SPN:FMI 520193:4 which is DeltaQ Code E025	Not Latched
BATTERY CHARGER - BATTERY TEMPERATURE SENSOR NOT INSTALLED	44149	NONE	4_4	• Normal operation	The GM detects SPN:FMI 520192:5 which is DeltaQ Code E036	Not Latched
BATTERY CHARGER - BATTERY DISCONNECTED	44150	NONE	4_4	• Normal operation	The GM detects SPN:FMI 4992:5 which is DeltaQ Code E045	Not Latched
BATTERY CHARGER - FAILURE	99365	NONE	9_9	• Normal operation	F001 (524160:31) – Output Stage Fault F002 (524160:31) – Input Stage Fault F003 (524160:31) – Input Stage Fault F004 (524160:31) – Current Calibration Error F005 (524160:31) – Output Relay Fault F006 (524160:31) – Output Current Fault F007 (524160:31) – Hardware Fault F008 (524160:31) - Currently not used	Not Latched

Table 22. Power Module Faults

Help Message	DTC	Alarm	Flash Code	Action	Trigger	Latch Condition
MAIN CONTACTOR COIL - SHORT TO BATTERY	3116	None	3_1	• DriveState = PREVENTED • LiftUpState = PREVENTED	The Power Module detects that the Main Contactor Coil is Short to Battery	Latched
MAIN CONTACTOR COIL - OPEN CIRCUIT	3117	None	3_1	• DriveState = PREVENTED • LiftUpState = PREVENTED	The Power Module detects that the Main Contactor Coil is Open Circuit	Latched
MAIN CONTACTOR COIL - SHORT TO GROUND	3118	None	3_1	• DriveState = PREVENTED • LiftUpState = PREVENTED	The Power Module detects that the Main Contactor Coil is Short to Ground	Latched
MAIN CONTACTOR – SHORT TO BATTERY	3111	None	3_1	• DriveState = PREVENTED • LiftUpState = PREVENTED	The Power Module detects that the Main Contactor Contact is Short to Battery	Latched
MAIN CONTACTOR - OPEN CIRCUIT	3113	None	3_1	• DriveState = PREVENTED • LiftUpState = PREVENTED	The Power Module detects that the Main Contactor Contact is Open Circuit	Latched
POWER MODULE BRAKE WIRING - ISSUE	33815	None	3_3	• DriveState = PREVENTED • LiftUpState = PREVENTED	The Power Module detects that the one of the brakes has an Open Circuit, Short to Ground, or Short to Battery	Latched
POWER MODULE TOO HOT – PLEASE WAIT	421	None	4_2	• DriveState = PREVENTED • LiftUpState = PREVENTED	The Power Module internal temperature is too high. Let the machien cool down to clear the DTC	Latched
POWER MODULE VOLTAGE – OUT OF RANGE	44161	None	4_4	• DriveState = PREVENTED • LiftUpState = PREVENTED	The Power Module detects that the Ground Module V5-5 ignition voltage is out of range low or high (<14V or >32V)	Not Latched
POWER MODULE LOGIC VOLTAGE - INCORRECT AT POWER ON	44156	None	4_4	• DriveState = PREVENTED • LiftUpState = PREVENTED	The Ground Module V5-5 ignition voltage was out of range low or out of range high (<14V or >32V)	Not Latched
CANBUS FAILURE – POWER MODULE	661	None	6_6	• DriveState = PREVENTED • LiftUpState = PREVENTED	The Ground Module failed to receive messages from the Power Module longer than 250mS. This may occur if re-programming was interrupted. Alternately, this may be an internal fault associated with the Power Module but is most likely caused by harness damage to the CAN 1 network near the power module	Latched
POWER MODULE FAILURE - INTERNAL ERROR	996	None	9_9	• DriveState = PREVENTED • LiftUpState = PREVENTED	The Power Module has detected an internal hardware error. Check for wiring damage around the controller or physical damage to the controller. Try updating Ground Module and Power Module software to the latest version found on Online Express and cycling power before considering the replacement of the Power Module	Not Latched
POWER MODULE FAILURE - INTERNAL ERROR	9950	None	9_9	• DriveState = PREVENTED • LiftUpState = PREVENTED	The Power Module has detected an internal software error. Try updating Ground Module and Power Module software to the latest version found on Online Express and cycling power. Inspect the chassis harness for damage (look at Ground Module V5-5, the EMS Circuitry voltage, and ground lines) before considering a replacement of the Power Module	Latched

Table 22. Power Module Faults (continued)

Help Message	DTC	Alarm	Flash Code	Action	Trigger	Latch Condition
POWER MODULE MOTOR WIRING - ISSUE	7775	None	7_7	• DriveState = PREVENTED • LiftUpState = PREVENTED	The Power Module has detected a wiring issue on one of the drive motors (Open Circuit, Short to Ground, or Short to Battery). Look for harness damage, loose motor terminals, or visible motor damage. Using the analyzer, go to DIAGNOSTICS->POWER MODULE->FAULTS->MOTOR WIRING to see the exact failure mode being reported by the Power Module	Latched
POWER MODULE PUMP WIRING - ISSUE	33819	None	3_3	• DriveState = PREVENTED • LiftUpState = PREVENTED	The Power Module has detected a wiring issue on the Pump Motor (Open Circuit, Short to Ground, or Short to Battery). Look for harness damage, loose motor terminals, or visible motor damage. Using the analyzer, go to DIAGNOSTICS->POWER MODULE->FAULTS->PUMP WIRING to see the exact failure mode being reported by the Power Module	Latched
POWER MODULE – CAPACITOR BANK FAULT	7780	None	7_7	• DriveState = PREVENTED • LiftUpState = PREVENTED	The Power Module detects an internal error. Inspect the harness (contactor B+, Ground, Ground Module V5-5 Ignition Voltage, Motor Terminals, and Contactor Coil) before considering replacing the Power Module	Not Latched
POWER MODULE MOTOR CURRENT - OUT OF RANGE	33823	None	3_3	• DriveState = PREVENTED • LiftUpState = PREVENTED	The Power Module has detected irregular current through one of the drive motors (Current Out of Range Low or Current Out of Range High). Look for harness damage, loose motor terminals, or visible motor damage. Using the analyzer, go to DIAGNOSTICS->POWER MODULE->FAULTS->MOTOR CURRENT to see the exact failure mode being reported by the Power Module	Latched
POWER MODULE PUMP CURRENT - OUT OF RANGE	33824	None	3_3	• DriveState = PREVENTED • LiftUpState = PREVENTED	The Power Module has detected irregular current through the pump motor (Current Out of Range Low or Current Out of Range High). Look for harness damage, loose motor terminals, or visible motor damage. Using the analyzer, go to DIAGNOSTICS->POWER MODULE->FAULTS->PUMP CURRENT to see the exact failure mode being reported by the Power Module	Latched

Table 23. Diagnostic Trouble Codes (Delta Q Battery Charger)

DTC	Fault	Solution
E-0-0-1 E-0-2-1	Battery high voltage	Check the battery voltage and cable connections. Check battery size and condition. This error will automatically clear once the condition has been corrected.
E-0-0-2 E-0-2-2	Battery low voltage	Check the battery voltage and cable connections. Check battery size and condition. This error will automatically clear once the condition has been corrected.
E-0-0-3	Charge time out caused by battery pack not reaching required voltage within safe time limit.	Possible causes: Charger output reduced due to high temperatures, poor batter y health, very deeply discharged battery and /or poorly connected battery. Possible solutions: Operate at lower ambient temperature. Replace battery pack. Check DC connections. This error will automatically clear once the charger is reset by cycling DC.
E-0-0-4	Battery could not meet minimum voltage	Check for shorted or damaged cells. Replace battery pack. Check DC connections. This error will automatically clear once the charger is reset by cycling DC.
E-0-0-7	Battery amp hour limit exceeded	Possible causes include poor battery health, ve y deeply discharged battery, poorly connected batter y, and / or high parasitic loads on battery while charging. Possible solutions: Replace battery pack. Check DC connections. Disconnect parasitic loads. This error will automatically clear once the charger is reset by cycling DC.
E-0-0-8	Battery temperature is out of range	Possible battery temperature sensor error. Check temperature sensor and connections. Reset charger. This error will automatically clear once the condition has been corrected.

Table 23. Diagnostic Trouble Codes (Delta Q Battery Charger) (continued)

DTC	Fault	Solution
E-0-1-2	Reverse polarity error	Battery is connected to the charger incorrectly. Check the battery connections. This error will automatically clear once the condition has been corrected.
E-0-1-6 E-0-1-8 E-0-2-6	USB operation failed (Software)	Software upgrade failure or script operation failure. Ensure the USB flash drive is properly formatted and retry inserting the USB flash drive into the charger.
E-0-1-7	USB operation failed (Hardware)	Remove and reinsert the USB drive. If condition persists, cycle AC and retry by reinserting the USB drive.
E-0-2-3	High AC voltage error (>270 VAC)	Connect charger to an AC source that provides stable AC between 85 - 270 VAC / 45 - 65 Hz. This error will automatically clear once the condition has been corrected.
E-0-2-4	Charger failed to initialize	The charger has failed to turn on properly. Disconnect AC input and battery for 30 seconds before retrying.
E-0-2-5	Low AC voltage oscillation error	AC source is unstable. Could be caused by undersized generator and /or severely undersized input cables. Connect charger to an AC source that provides stable AC between 85 - 270 VAC / 45-65 Hz. This error will automatically clear once the condition has been corrected.
F-0-0-1, F-0-0-2, F-0-0-3, F-0-0-4, F-0-0-6		Internal charger fault. Remove AC and batter y for minimum 30 seconds and retry charger. If itfails again, please contact the manufacturer of your vehicle or machine.

Table 24. Fault Codes (Green Power)

Flash Code	Cause	Solution
1	Connection Issue	1) Check battery connection is correct. 2) Check charger connection is correct. 3) Check each battery is good.
2	Abnormal AC Power Input (Voltage)	1) Check AC input cord is connected between charger and AC outlet. 2) Make sure AC plug is tightly secured into AC outlet.
3	Charger High Temperature Protection	1) Charger shuts down and goes into protection mode due to charger/ environmental temperature is too high for charger to function properly. Please place the charger into an area with ambient air flow or to a cooler place. 2) Disconnect the charger and wait for 15-20 mins before reconnecting for charging.
4	Battery High Temperature Protection	1) Charger will reduce or even stop charging when the battery temperature exceeds 50° C. This is to avoid battery overheating. 2) Disconnect the charger and wait for 15-20 mins before reconnecting for charging.
5	Output Current is too high	Return to factor y for repair.
6	Battery Voltage is too high(>30.5V)	Check and assure that the correct output batter y voltage is connected.
7	Battery Voltage is too low(<18V)	Check and assure that the correct output batter y voltage is connected.

Table 25. Battery Charger Calibration

Menu	Submenus	Comments
Calibrations: Set Charger		The technician chooses to calibrate by pressing ENTER, leave by pressing ESC
	CAL Algorithm: YES: ENTER; NO: ESC	The technician chooses to calibrate by pressing ENTER or leave by pressing ESC.

Table 25. Battery Charger Calibration (continued)

Menu	Submenus	Comments
	Charger Inactive Connect AC	The charger is not detected on the CAN bus. This prompts the user to power the charger to wake up the CAN board on the charger. The analyzer will move to the CHARGER DETECTED screen automatically once the CAN board wakes up.
	Charger Detected Disconnect AC	The Charger is reporting that it is connected to a wall outlet. The Algorithm can only be changed when the charger is disconnected from an AC source. This prompts the user to disconnect AC before switching to the BATTERY CAPACITY screen.
	Battery Capacity XXX Ah	The Battery Capacity uses the same interface to adjust numbers as the Access Level Screen. This should speed up the calibration process for the end user. The range is limited by vehicle model. Pressing ESC will take you to the SET CHARGER: CAL FAIL screen.
	Set Algorithm: XXX	All available algorithms listed in the GM that meet the Chemistry and a Capacity range of the selected vehicle can be cycled through by pressing Up Arrow or Down Arrow on the analyzer. Pressing ENTER will attempt to set the displayed algorithm in the charger. Pressing ESC will take you to the SET CHARGER: CAL FAIL screen.
	Set Charger: Complete!	The parameters were correctly written from the SET ALGORITHM screen. Press ESC to return to the CALIBRATIONS menu.
	Set Charger: CAL Fail	An error occurred and the parameters were not written correctly, or Algorithm is not present in the charger. Press ESC to return to the CALIBRATIONS menu.

6.2.1 ClearSky Smart Fleet DTC Fault Codes

Table 26. Diagnostic Trouble Codes (DTC) - Telematics and Communication

DTC	Help Message	Flash Code	Action	Trigger	Latch Condition
682	FUNCTIONS IN CREEP - CONNECTIVITY INTERLOCK	6_8	• DriveState = CREEP (or ELEVATED) • LiftUpState = CREEP • LiftDownState = CREEP	DTC 66111 is active OR a FUNCTIONAL INTERLOCK is received and REMOVAL INTERLOCK is set to CREEP	Latched
683	FUNCTIONS IN CREEP AND RESTRICTED TO TRANSPORT - CONNECTIVITY INTERLOCK	6_8	While TransportState = FALSE • DriveState = PREVENTED • LiftUpState = PREVENTED • LiftDownState = CREEP While TransportState = TRUE • DriveState = CREEP (or ELEVATED) • LiftUpState = PREVENTED • LiftDownState = CREEP	DTC 66111 is active OR a FUNCTIONAL INTERLOCK is received and REMOVAL INTERLOCK is set to CREEP + TSPRT LK	Latched
684	FUNCTIONS LOCKED OUT - CONNECTIVITY INTERLOCK	6_8	• DriveState = PREVENTED • LiftUpState = PREVENTED • LiftDownState = CREEP	DTC 66111 is active OR a FUNCTIONAL INTERLOCK is received and REMOVAL INTERLOCK is set to MACHINE LOCKOUT	Latched
685	ALL FUNCTIONS LOCKED OUT - CONNECTIVITY INTERLOCK	6_8	• DriveState = PREVENTED • LiftUpState = PREVENTED • LiftDownState = PREVENTED	DTC 66111 is active OR a FUNCTIONAL INTERLOCK is received and REMOVAL INTERLOCK is set to MACHINE LOCKOUT	Latched

Table 26. Diagnostic Trouble Codes (DTC) - Telematics and Communication (continued)

DTC	Help Message	Flash Code	Action	Trigger	Latch Condition
			AND Engine Shutdown Command Sent to ECU (Only for Engine Driven Machines)		
686*	ENGINE START PREVENTED - CONNECTIVITY INTERLOCK	6_8	Engine Start Prevented	DTC 66111 is active OR a FUNCTIONAL INTERLOCK is received and REMOVAL INTERLOCK is set to MACHINE LOCKOUT	Not Latched
66111	CANBUS FAILURE - CONNECTIVITY MODULE	6_6	GM to Ignore Processes that require CAN Communication / Requests / Acknowledgements with CM	After Startup complete, CM messages are received then subsequently lost for > 1000ms OR No CM messages 3000ms after startup has completed and Machine Setup CLEARSKY is set to CS550	Not Latched

Note: Creep restricts drive motors to a low maximum speed.

Note: * This DTC is applicable only for Engine Driven Machines.

6.3 MAIN POWER CIRCUIT TROUBLESHOOTING

6.3.1 Machine Will Not Power Up

Machine Will Not Power Up

Check For These Obvious Conditions First:

- Battery voltage is 24 volts. (Sufficient Charge in Batteries to Operate Machine)
- Positive (+) and negative (–) battery cable connections clean and tight at both the Batteries and the Ground Control Module lugs.
- Main Power Selector Switch (key) positioned to either Platform or Ground Control Mode.
- Emergency stop buttons on both the Ground Control Module and the Platform Control Console in the RESET position (out).

Table 27. Machine Will Not Power UP

STEP	ACTION	SPEC	YES	NO
1.	Check for 24V DC at the positive (+) and negative (–) main power cable connections on the Ground Control Module.	24 V DC	Go to Step 2	Replace the 175 Amp Inline Fuse on the Positive power cable
2.	Check continuity of the Emergency Stop wires running to the Plat- form Control Console, pins-10 and 1 on the P4 connector at the Ground Control Module.	—	Replace the Ground Control Module	Go to Step 3
3.	Remove the 9-pin Platform Control Console connector at the Plat- form Junction Box and check continuity between pins-1 and 2 to the Emergency Stop Switch in the Platform Control Console cable.	—	Go to Step 4	Replace the Platform Control Console
4.	Check continuity of the wires running from the P4 connector on Ground Control Module to the Platform Junction Box;P4 connector, Pin-1 to Junction Box Pin-2 and P4 connector, Pin-10 to Junction Box Pin-1	—	Replace Platform Control Console	Repair or Replace Wiring

6.4 MAST TROUBLESHOOTING

6.4.1 Platform Will Not Lower Manually

Platform Will Not Lower Manually

Check For These Obvious Conditions First:

- Is there an obstruction in the mast assembly?
- Is there a restricted hydraulic line (smashed)?
- Are the mast slide pads shimmed properly (not too tight), per Mast Assembly procedure in Service Manual?

Table 28. Platform Will Not Lower Manually

STEP	ACTION	SPEC	YES	NO
1.	Check to see of the platform will lower from the Ground Control Station in Ground Control Mode.	—	Repair or Replace the Manual Descent Control Valve	Go to Step 2
2.	Check to see if the lift down valve is opening completely.	—	Go to Step 3	Replace the Lift Down Valve
3.	Check the flow valve in the lift cylinder for a restriction.	—	Clean or Replace Flow Valve	Consult Factory

6.4.2 Platform Lift Up And Down - Jerky

Platform Lift Up And Down - Jerky

Overview Of Procedure

The following procedure suggests areas on the machine which might attribute to erratic movement of the platform during lift up and down.

Check For These Obvious Conditions First:

- If mast is not running smooth or has tight and rough spots, refer to the Mast Section Rebuild.
- Hydraulic oil level in reservoir tank at full level.
- Hydraulic oil is not milky (presence of water), or foamy (full of air).

Table 29. Platform Lift Up and Down Jerky

STEP	ACTION	SPEC	YES	NO
CONTROLS (ELECTRICAL)				
1.	Is platform control console, platform enable, up or down pad defective or worn out?	—	Replace pad	Go to Step 2
2.	Loose connections, ground and power.	—	Repair connection	Go to Step 3
3.	Valve solenoid keeps opening and closing.	—	Repair Connection or Replace Valve	Go to Step 4
4.	Problem internal to the Ground Control Module.	—	Replace Module	Go to Step 5
HYDRAULIC				
5.	Is the hydraulic valve working properly.	—	Go to Step 6	Replace Valve
6.	Pump drive cavatating.	—	Replace Pump	Go to Step 7
7.	Lift cylinder	—	Rebuild or Replace Cylinder	—

6.4.3 Mast Noisy When Lifting And Lowering

Mast Noisy When Lifting And Lowering

Overview Of Procedure

This procedure examines components of the mast itself and as well as it's lifting components for dirt, debris, proper lubrication and operation.

Table 30. Mast Noisy when Lifting and Lowering

STEP	ACTION	SPEC	YES	NO
1.	Do slide pads and slide pad channels need to be cleaned of dust, dirt, or other debris?	—	Clean Pads and Channels	Go to Step 2
2.	Do mast chains need to be lubricated per JLG specification in the Service Manual?	—	Lubricate as Required	Go to Step 3
3.	Are the chain/cable sheave wheels dry and need lubrication? Note: Plastic wheels will howl on the sheave pin when they are dry. Sheave wheels may seize to the sheave pin and the pin may turn in the pin retainer blocks.	—	Lubricate or Replace Sheave Pins and Wheels	Go to Step 4
4.	Are the sequence cables (located on the side of mast) chattering when the springs are compressed? Note: This noise is normal at the sequence cable sheave wheels when the mast is completely lowered. However if the sequence cable chattering is happening no matter what position the mast is in, it could be a result of the mast being shimmed to tight or dirt and debris in the slide pad channels causing the mast to be tight.	—	Clean Slide Pads/ Channels or Reshim Mast per Service Manual	Go to Step 5
5.	Is the bore of the lift cylinder dry?	—	Replace Packing or Lift Cylinder	Go to Step 6
6.	Are the bearings in the lift pump motor and pump drive worn?	—	Repair or Replace Pump	Go to Step 7
7.	Are the hydraulic lines vibrating together?	—	Adjust the Position of the Lines	Go to Step 8
8.	Check if the pump motor is loose to it's mounting plate.	—	Tighten pump mounting fasteners	Go to Step 9
9.	Hydraulic oil could be cavatating inside the pump.	—	Repair or Replace Pump	—

6.4.4 Platform (Mast) Will Not Stay Elevated

Platform (Mast) Will Not Stay Elevated

Overview Of Procedure

The following procedure requests that the lift down, dump, and pump internal valves be checked to see if any are stuck open, it also examines the lift down and dump valve circuits. Also suggests that the lift cylinder packing could be leaking internally.

Check For These Obvious Conditions First:

- Manual descent valve is closed tight.

Table 31. Platform (Mast) Will Not Stay Elevated

STEP	ACTION	SPEC	YES	NO
1.	Is the lift down valve stuck open?	—	Repair or Clean Valve	Go to Step 2
2.	Lift down valves could be open due to incorrect electrical signal.	—	Check Pump Valve Electrical Circuit	Go to Step 3
3.	Oil could be passing around the lift cylinder bore packing.	—	Replace or Rebuild the Lift Cylinder	—

6.4.5 Platform (Mast) Descends Too Slowly

Platform (Mast) Descends Too Slowly

Overview Of Procedure

The following procedure examines the mast some hydraulic components for obstructions and defects.

Table 32. Platform (Mast) Descends Too Slowly

STEP	ACTION	SPEC	YES	NO
1.	Check mast slide pads shimmed to tight.	—	Reshim Mast	Go to Step 2
2.	Is there an obstruction in the mast?	—	Remove Obstruction	Go to Step 3
3.	The lift cylinder packing could be too tight in the bore of the cylinder barrel.	—	Rebuild or Replace Cylinder	Go to Step 4
4.	Check if the lift down valve is opening completely.	—	Clean or Replace Valve	Go to Step 5
5.	Is there a restricted hydraulic line (smashed)?	—	Replace Hydraulic Line	Go to Step 6
6.	Check the flow valve in the cylinder valve block for a restriction, i.e. dirt.	—	Clean or Replace Flow Valve	—

6.5 HYDRAULIC LEAK TROUBLESHOOTING

6.5.1 Miscellaneous Hydraulic Leak Troubleshooting

Miscellaneous Hydraulic Leak Troubleshooting

Overview Of Procedure

This series of steps gives remedies for various areas of the machine where leaks could occur.

Table 33. Hydraulic Leak Troubleshooting

STEP	ACTION	SPEC	YES	NO
1.	Oil leaking around the lift cylinder rod.	—	Replace the Seal at the end of the Piston and Cylinder Barrel	—
2.	Oil leaking around the cylinder extend or return line fittings.	—	Tighten or Replace Fittings	—
3.	Oil leaking around the hydraulic lines.	—	Tighten or Replace Hydraulic Lines	—
4.	Oil leaking around the lift down valve.	—	Tighten Cartridge in Pump Case	—
5.	Oil leaking around the (Red) manual descent valve.	—	Replace Lift Down Valve	—
Note: Do not overtighten the nut on the solenoid in step 5.				

6.6 BASE FRAME COMPONENTS TROUBLESHOOTING

6.6.1 Caster Wheels Not Operating Freely

Caster Wheels Not Operating Freely

Check For These Obvious Conditions First:

- Is machine operating on a smooth, level surface?

Table 34. Caster Wheels Not Operating Freely

STEP	ACTION	SPEC	YES	NO
1.	Is the caster rotating freely?	—	Go to Step 2	Lubricate or Replace Caster Housing
2.	Is the wheel spinning freely?	—	Go to Step 3	Lubricate or Replace Wheel
3.	Is debris stuck in the rubber wheel?	—	Remove Debris or Replace Wheel	—

6.6.2 Pot Hole Protection (PHP) Bars will not Lower

Pot Hole Protection (PHP) Bars will not Lower

Check For These Obvious Conditions First:

- Obstruction under pot hole bar on either side of machine.
- Obstruction around the actuator assembly at the base of the mast.

Table 35. Pot Hole Protection (PHP) Bars will not Lower

STEP	ACTION	SPEC	YES	NO
1.	Check the actuator assembly and cables for adjustment or damage.	—	Adjust or Replace	Consult Factory

6.7 DRIVE SYSTEM TROUBLESHOOTING

6.7.1 Will Not Climb Grade

Will Not Climb Grade

Overview Of Procedure

The following procedure checks the drive motor and attached components for component failure, misadjustment due to wear.

Check For These Obvious Conditions First:

- Batteries are Fully Charged (6 Volts)
- Speed Control is Set to Maximum
- Is Grade within the Maximum Allowable Specification of 30% Grade
- Is Platform Load within the Maximum Rated Capacity

Table 36. Will Not Climb Grade

STEP	ACTION	SPEC	YES	NO
1.	Does machine drive straight on a level surface?	—	Go to Step 2	Refer to Section — Machine Will Not Drive Straight
2.	Do the left and right drive motor brakes release properly and allow the drive wheels to rotate freely?	—	Go to Step 3	Dragging? Repair, Replace or Adjust Brakes
3.	Check the amperage output of the on the drive motor leads. They should not exceed 100 amps while pulling a grade.	—	Controller will Shut Drive Down and will flash a 7 LED Code	Go to Step 5
4.	Check the condition of the drive motor brushes.	—	OK, go to Step 6	Worn down, replace brushes or drive motor
5.	If all above is OK, Drive motors are working properly. Consult Factory.	—	—	—

6.7.2 Machine Drives in Opposite Direction

Machine Drives in Opposite Direction

Table 37. Machine Drive in Opposite Direction

STEP	ACTION	SPEC	YES	NO
1.	At the Traction Control Module, check if the left drive motor power lead is plugged into the M1 socket.	—	Go to Step 2	Switch the Left and Right Drive Motor Power Leads at the Traction Module
2.	Remove the right drive motor power lead at the traction control module (M2) and check if the WHITE wire is connected to the positive (+) terminal and the BLACK wire is connected to the negative (–) terminal. Refer to ***Figure - Electrical Schematic – Sheet 4 of 5***.	—	Go to Step 3	Rewire as Necessary
3.	Remove the left drive motor power lead at the traction control module (M1) and check if the BLACK wire is connected to the positive (+) terminal and the WHITE wire is connected to the negative (–) terminal. The left motor power lead is reversed from the right motor lead due to the reverser harness. Refer to ***Figure - Electrical Schematic – Sheet 4 of 5***.	—	Consult Factory	Rewire as Necessary

6.7.3 Machine will Not Drive Straight

Machine Won't Drive Straight

Overview Of Procedure

The following procedure examines the drive motor assembly weldments attaching the drive motors to the base frame. Also internal components of the drive motors, gear box and a check of the components between the gear box and the drive wheels.

Check For These Obvious Conditions First:

- Battery voltage 24 volts. (Fully charge batteries)
- Nothing is lodged between one of the wheels and the base frame.
- A caster wheel on the front of the machine is seized up, creating resistance.

Table 38. Machine will Not Drive Straight

STEP	ACTION	SPEC	YES	NO
1.	Check for the following on the drive assembly, drive attachment weldments; is bent, has broken welds, or loose hardware.	—	Repair/Replace/ Tighten weldment	Go to Step 2
2.	Check for the following on the drive assembly, drive motor mounting plates; are bent, are square with drive weldments, or is hardware loose?	—	Repair/Replace/ Tighten weldment	Go to Step 3
3.	Check for the following on the drive assembly, drive motor hard- ware; is hardware loose.	—	Repair/Replace/ Tighten component	Go to Step 4
4.	Check the left and right drive motor brakes for loose hardware & not releasing properly.	—	Tighten or Adjust per procedure in this Service Manual	Go to Step 5
5.	Is the electrical signal and amperage draw to the drive motors equal? Check with machine on level surface.	Refer to ***Table – Amperage Draw for Various Components***.	Recheck Steps 1 thru 5	Go to Step 6
6.	Check the drive motor brushes, do they need replaced?	—	Replace per procedure in this Service Manual	Go to Step 7
7.	Is joystick control defective? If possible, swap out with another platform control.	—	Repair/Replace Platform control	Go to Step 8
8.	Is the Traction Control Module defective or connections not tight? If possible, swap out with another Traction Control Module.	—	Tighten Connections or Replace Traction Control Module	Go to Step 9
9.	Inside the drive motor gear box check if; the drive shaft is excessively loose & condition of drive shaft bearings. Are any gears broken or gear teeth excessively worn.	—	Repair/Replace gear box components per procedure in this Service Manual	

6.7.4 Noise From Drive Assembly

Noise From Drive Assembly

Overview Of Procedure

The following procedure examines the drive motor assembly weldments attaching the drive motors to the base frame. Also internal components of the drive motors, gear box and a check of the components between the gear box and the drive wheels.

Check For These Obvious Conditions First:

- Battery voltage 24 volts. (Fully charge batteries)
- Nothing is lodged between one of the wheels and the base frame.
- A caster wheel on the front of the machine is seized up, creating resistance.

Table 39. Noise from Drive Assembly

STEP	ACTION	SPEC	YES	NO
1.	Check for the following on the drive assembly, drive attachment weldment; is bent, has broken welds, or loose hardware.	—	Repair/Replace/ Tighten weldment	Go to Step 2
2.	Check for the following on the drive assembly, drive motor mounting plates; are bent, are square with drive weldments, or is hardware loose?	—	Repair/Replace/ Tighten weldment	Go to Step 3
3.	Check for the following on the drive assembly, drive motor hard- ware; is hardware loose.	—	Repair/Replace/ Tighten Component	Go to Step 4
4.	Check the left and right drive motor brakes for loose hardware & not releasing properly.	—	Tighten or Adjust per procedure in this Service Manual	Go to Step 5

Table 39. Noise from Drive Assembly (continued)

STEP	ACTION	SPEC	YES	NO
5.	Is the electrical signal and amperage draw to the drive motors equal? Check with machine on level surface.	Refer to ***Table – Amperage Draw for Various Components***	Recheck Steps 1 thru 5	Go to Step 6
6.	Check the drive motor brushes, do they need replaced?	—	Replace per procedure in this Service Manual	Go to Step 7
7.	Inside the drive motor gear box check if; the drive shaft is excessively loose & condition of drive shaft bearings. Are any gears broken or gear teeth excessively worn.	—	Repair/Replace gear box components per procedure in this Service Manual	

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SECTION 7
HYDRAULICS

7.1 GENERAL INFORMATION AND SAFETY

This section covers the hydraulic circuits and includes listings for all hydraulic function pressures, as well as where and how to check those pressures.

Electrical and hydraulic functions are often related. Verify that electrical components of the circuit are functioning properly whenever troubleshooting the hydraulic circuit.

Always check the following before beginning to troubleshoot a circuit that is not functioning correctly.

1. Check hydraulic oil level in reservoir. Level should be in middle of sight glass with all cylinders retracted.

⚠ WARNING

DO NOT use hand to check for leaks. Use a piece of cardboard or paper to search for leaks. Always wear gloves.

2. Check hoses, tubes, fittings and other hydraulic components for leaks, bends, kinks, interference, etc.
3. Check for air in the hydraulic system. Erratic machine performance and/or spongy cylinder operation are signs of air in the hydraulic system. If air in the hydraulic system is suspected, you will hear air leakage when hydraulic fittings are loosened and see air bubbles in the hydraulic fluid.

4. Loose fittings, faulty O-rings or seals, trapped oil, leaks, system opened for service, etc., can cause air in the system. Determine what is causing air to enter the system and correct it. Bleed air from the system.

⚠ WARNING

DO NOT service the machine without following all safety precautions as outlined in *Section – Safety, page 9* of this manual.

Petroleum-based hydraulic fluids are used in this machine. The temperature of hydraulic fluid increases during the operation of various hydraulic functions. A heated petroleum-based hydraulic fluid presents a fire hazard, especially when an ignition source is present. Hydraulic fluid has a flash point that ranges from 300°F - 600°F (150°C- 318°C) and an auto-ignition temperature of 500°F - 750°F (262°C - 402°C).

Accordingly, periodically inspect all hydraulic system components, hoses, tubes, lines, fittings, etc. Carefully examine any deterioration and determine whether any further use of the component would constitute a hazard. If in doubt, replace the component.

Operate the hydraulic controls after the engine has stopped to relieve trapped pressure.

Whenever you disconnect a hydraulic line, coupler, fitting or other component, slowly and cautiously loosen the part involved. A hissing sound or slow seepage of hydraulic fluid may occur in most cases. After the hissing sound has ceased, continue removing the part. Any escaping oil should be directed into an appropriate container. Cap or otherwise block off the part to prevent further fluid seepage.

Hydraulic system maintenance will, at times, require that the engine be operated. Always follow safety precautions.

A major cause of hydraulic component failure is contamination. Keeping the hydraulic fluid as clean as possible will help avoid downtime and repairs. Dirty or contaminated hydraulic oil can damage internal components and void the manufacturer's warranty. When servicing the system, cap or plug hydraulic fittings, hoses and tube assemblies. Plug all cylinder ports, valves and the hydraulic reservoir, and openings until installation occurs. Protect threads from contamination and damage.

Manufacturer's recommended hydraulic oil cleanliness levels are based on the three digit ISO code for 6 micron/14 micron particle sizes found in one ml of fluid (reference ISO 4406: 199(E). The acceptable level is 17/14 or below; anything higher requires system cleaning and filter replacement.

Note: The human eye can only distinguish particles down to 40 microns.

Refer to Section — Preventive Maintenance and Inspection Schedule for the appropriate maintenance intervals based on hours of operation, but if your equipment is exposed to extremely dirty or hostile conditions service may be required more frequently. Always use OEM filters to assure the necessary filtration requirements are met.

Note: Replace the reservoir breathers to prevent dust contamination into the reservoir.

Some hydraulic functions are actuated by interfacing with electrical system components (switches, solenoids and sensors). When the hydraulic system is not functioning properly, check the electrical aspect of the malfunctioning circuit also.

7.2 THEORY OF OPERATION

7.2.1 Cylinders

Cylinders are of the double acting type. The Lift and Steer systems incorporate double acting cylinders. A double acting cylinder is one that requires oil flow to operate the cylinder rod in both directions. Directing oil (by actuating the corresponding control valve to the piston side of the cylinder) forces the piston to travel toward the rod end of the barrel, extending the cylinder rod (piston attached to rod). When the oil flow is stopped, movement of the rod will stop. By directing oil to the rod side of the cylinder, the piston will be forced in the opposite direction and the cylinder rod will retract.

Note: The lift cylinder is a single acting cylinder which takes hydraulic pressure to extend and gravity to retract.

A holding valve is used in the hydraulic lift circuit to prevent motion unintended by the operator in the event of a hydraulic line failure.

7.2.2 Valves

Solenoid Control Valves (Bang-Bang)

Control valves used are four-way, three-position solenoid valves of the sliding spool design. When a circuit is activated and the control valve solenoid energizes, the spool is shifted and the corresponding work port opens to permit oil flow to the component in the selected circuit, with the opposite work port opening to reservoir. Once the circuit is deactivated (control returned to neutral), the valve spool returns to neutral (center) and oil flow is then directed through the valve body and returns to reservoir. A typical control valve consists of the valve body, sliding spool, and two solenoid assemblies. The spool is machine fitted in the bore of the valve body. Lands on the spool divide the bore into various chambers, which, when the spool is shifted, align with corresponding ports in the valve body open to common flow. At the same time other ports would be blocked to flow. The spool is spring-loaded to center position, therefore when the control is released, the spool automatically returns to neutral, prohibiting any flow through the circuit.

Relief Valves

Main relief valves are installed at various points within the hydraulic system to protect associated systems and components against excessive pressure. Excessive pressure can be developed when a cylinder reaches its limit of travel and the flow of pressurized fluid continues from the system control. The relief valve provides an alternate path for the continuing flow from the pump, thus preventing rupture of the cylinder, hydraulic line or fitting. Complete failure of the system pump is also avoided by relieving circuit pressure. The relief valve is installed in the circuit between the pump outlet (pressure line) and the cylinder of the circuit, generally as an integral part of the system valve bank. Relief pressures are set slightly higher than the load requirement, with the valve diverting excess pump delivery back to the reservoir when operating pressure of the component is reached.

Crossover Relief Valves

Crossover relief valves are used in circuits where the actuator requires an operating pressure lower than that supplied to the system. When the circuit is activated and the required pressure at the actuator is developed, the crossover relief diverts excess pump flow to the reservoir. Individual, integral relief's are provided for each side of the circuit.

Proportional Valve

Flow is proportional to the amount of voltage supplied to the valve coil. Voltage is gained by the machine controller and determined by the position of the joystick.

Flow Control Valve

The flow control valve is located on the top of the holding valve on the lift cylinder. The holding valve is a normally closed solenoid valve, and holds the platform in place when raised. When activated, the valve opens to permit lift down. The holding valve is connected to the manual descent valve, which is connected to a cable which, when pulled, manually opens the lift down port of the valve and allows the platform to be lowered in the event hydraulic and/or electric power is lost.

7.2.3 Pump/Motor

The Power Module is essentially a "low-side" switch for the pump motor. The positive terminal of the pump is tied to Battery Positive after the Line Contactor. The negative terminal of the pump connects to the P Terminal of the Power Module, which switches current through MOSFET transistors to the Battery Negative.

For variable speed pump operation, the MOSFET transistors switch On and Off at high frequencies. The Duty Cycle is varied to control the voltage applied to the pump motor. When the MOSFET's spend 50% of the period On and 50% Off, approximately ½ of the available Battery Voltage will be applied to the pump motor. Similarly, the MOSFET are On continuously (100% Duty Cycle) to apply all available Battery Voltage to the pump motor (as in Lift Up at full speed).

When the Control System is energized, the voltage at the P Terminal will be approximately +24V (referenced to -B) when the pump is static. The P Terminal will be approximately at +1V (referenced to -B) when the pump is running at full speed (Lift Up from Ground Mode).

Pump Motor Electrical Evaluation

Several basic electrical tests can be performed on the Pump Motor. Failure of one of these evaluations is significant and may indicate that the device is physically damaged.

Make all measurements with a voltmeter set to resistance scale (Ohms). Disconnect main power at the batteries and all pump motor cables during this analysis.

- **Resistance < 5Ω between Motor Terminals.**
  The internal windings are very low impedance and should appear to be a short-circuit for an ordinary voltmeter (other tests can determine if the windings are truly shorted). High resistance can signal worn brushes, a faulty commutator, or open windings.

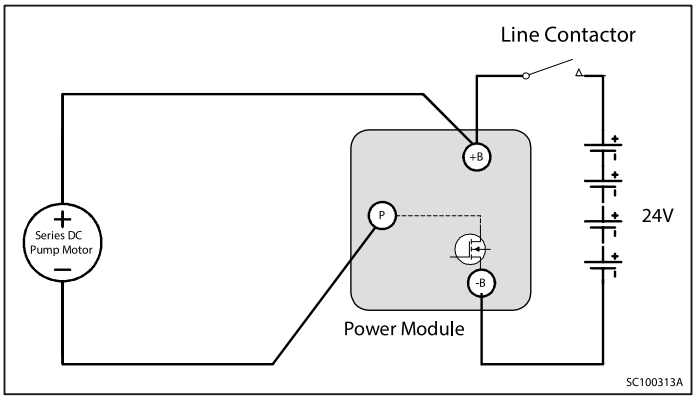
- **Resistance > 1MΩ between Motor Terminals and Motor Housing.**
  The internal windings should be electrically isolated from the motor housing. Low resistance may be an indication of a broken motor terminal, damaged brush, faulty commutator, or burned winding.

Troubleshooting

The following difficulties can be examined using the JLG Analyzer, a voltmeter, and simple hand tools. Unless otherwise noted, the Control System shall be energized in Ground Mode during testing. For a convenient Ground Reference, place the black meter lead on the negative post of the left battery in the left-side batter compartment. The vehicle should be placed on a smooth, firm, and level surface for all analysis.

1. Open-Circuit between +B Terminal and Pump Motor Positive Terminal
   This issue will allow the vehicle to Lift Down, but Drive, Steer, and Lift Up will be lost and the Pump Motor will not Operate. Under DIAGNOSTICS - PUMP, the JLG Analyzer will show PUMP PWM 100% and PUMP CUR 0.0A when Lift Up is operated from Ground Mode.
   As shown in the diagram, the voltage measured between the Pump Motor Positive Terminal and Ground Reference should be 24V. If it is not, examine the cable between the terminal and the Power Module compartment. Inspect crimps for corrosion and ensure that bolted connections are tight. Ensure that the cable is not crushed where it passes between the frame side sheets and the cylinder assembly.

2. Open-Circuit between Pump Motor Negative Terminal and P Terminal
   This issue will allow the vehicle to Lift Down, but Drive, Steer, and Lift Up will be lost and the Pump Motor will not Operate. Under DIAGNOSTICS - PUMP, the JLG Analyzer will show PUMP PWM 100% and PUMP CUR 0.0A when Lift Up is operated from Ground Mode.
   After ensuring there is not an Open-Circuit between the +B Terminal and Pump Motor Positive Terminal, check that the voltage measured between the Pump Motor Negative Terminal and Ground Reference is 24V. If not, examine the issues within Open-Circuit Pump Motor. This voltage should ramp to approximately 0V when Lift Up is operated from Ground Mode. If not, examine the cable between the terminal and the Power Module compartment (P Terminal). Inspect crimps for corrosion and ensure that bolted connections are tight. Ensure that the cable is not crushed where it passes between the frame side sheets and the cylinder assembly.



3. Open-Circuit Pump Motor
   This issue will allow the vehicle to Lift Down, but Drive, Steer, and Lift Up will be lost and the Pump Motor will not Operate. Under DIAGNOSTICS - PUMP, the JLG Analyzer will show PUMP PWM 100% and PUMP CUR 0.0A when Lift Up is operated from Ground Mode.
   Disconnect main power at the batteries to completely de-energize the Control System. Next, detach the cable from Pump Motor Positive Terminal. Using a voltmeter set for resistance measurement (Ohms), ensure that the resistance between the Pump Motor Positive and Negative Terminals is less than 2 Ohms. If not, examine the pump motor for worn brushes or broken terminals. After examination, re-connect the Pump Motor Positive Terminal and main power at the batteries.

4. Short-Circuit between Pump Motor Positive and Negative Terminals
   This issue will allow the vehicle to Lift Down, but Drive, Steer, and Lift Up will be lost and the Pump Motor will not Operate. Under DIAGNOSTICS - PUMP, the JLG Analyzer will show an erratic reading for PUMP PWM% and PUMP CUR will hover around 150A when Lift Up is operated from Ground Mode.
   Disconnect main power at the batteries to completely de-energize the Control System. Next, detach both Pump Motor Terminals and insulate them independently. Re-connect main power at the batteries and re-try Lift Up. If the same symptoms persist (erratic PUMP PWM%, PUMP CUR around 150A), examine the cabling between the Pump Motor and Power Module compartment for a short-circuit (most likely near area where cylinder retracts between frame side sheets or near pothole mechanism, if equipped). If the symptoms change, suspect a short-circuited (or mechanically frozen) pump motor.
   A clamp-on ammeter (set for 200A DC) can be placed on either Pump Motor Cable for verification. During Lift Up, the ammeter will read approximately 150A.

7.2.4 Hydraulic Circuit Checks

The first reference for improper function of a hydraulic system, where the cause is not immediately apparent, should be the Hydraulic Diagram Circuit. The best place to begin the problem analysis is at the power source (pump). Once it is determined that the pump is serviceable, then a systematic check of the circuit components, would follow.

Note: For aid in troubleshooting, refer to Figure – Hydraulic Schematic – Sheet 2 of 2.

7.3 PRESSURE SETTING PROCEDURES

7.3.1 Main/Lift Relief

1. Connect a pressure gauge (rated to 5000 PSI (345 Bar) or higher) to the MP port by installing fitting part.

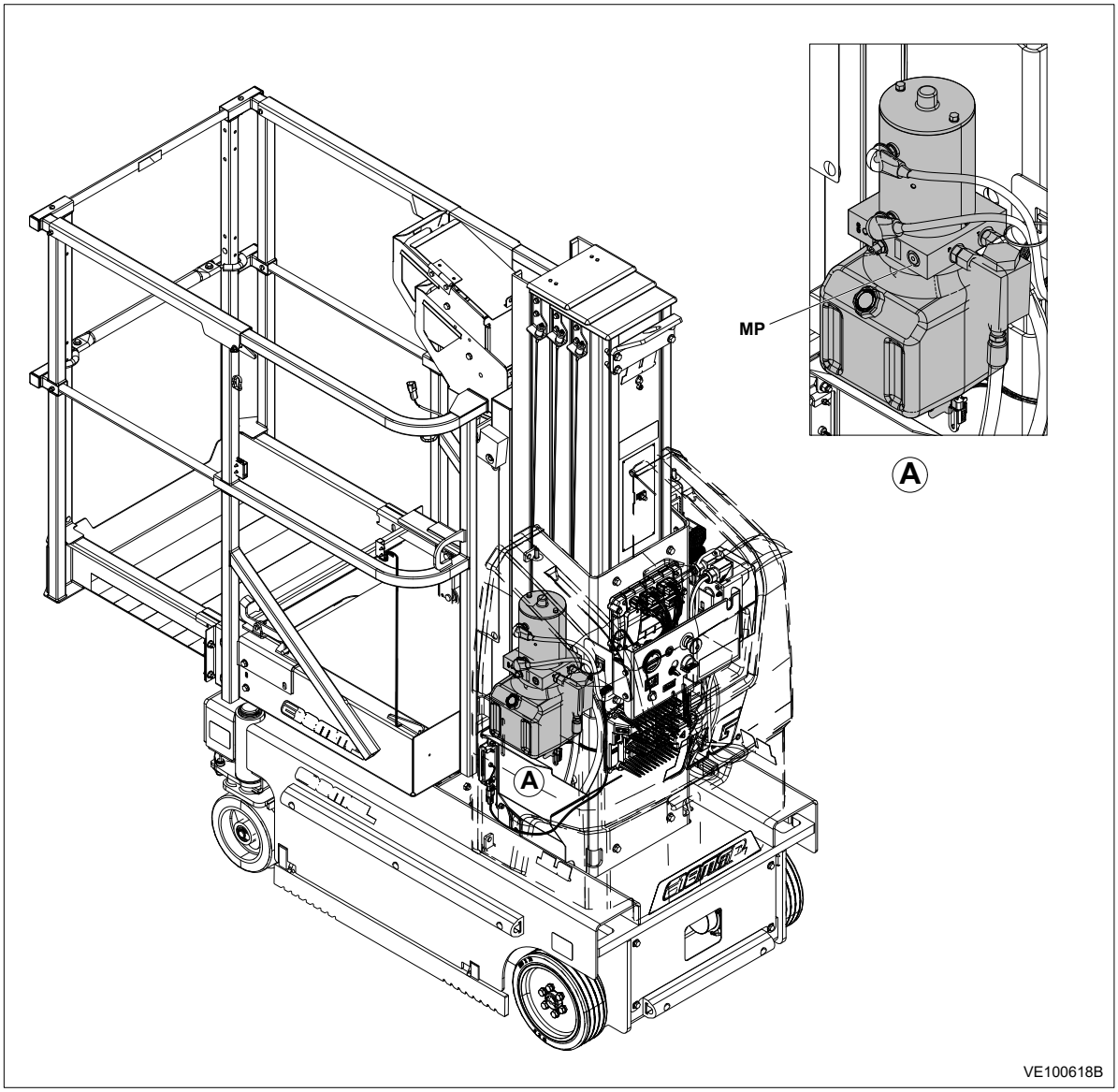


Figure 33. Gauge Port Location

2. With the machine running and platform in the fully elevated position command “lift up”.
3. While continuing to command “lift up” note the pressure on the gauge.
4. If the pressure gauge reads between 50 PSI – 3000 PSI (3.5 Bar – 209 Bar), adjustment is required.
5. Loosen the jam nut (**1**) on the relief valve and turn the adjustment screw (**2**) clockwise to increase pressure or counterclockwise to decrease pressure.

6. Once the gauge reads a pressure of 2950 PSI – 3050 PSI (203 Bar – 210 Bar) tighten down the jam nut (**1**).

Note: Make sure the adjustment screw (**2**) does not rotate.

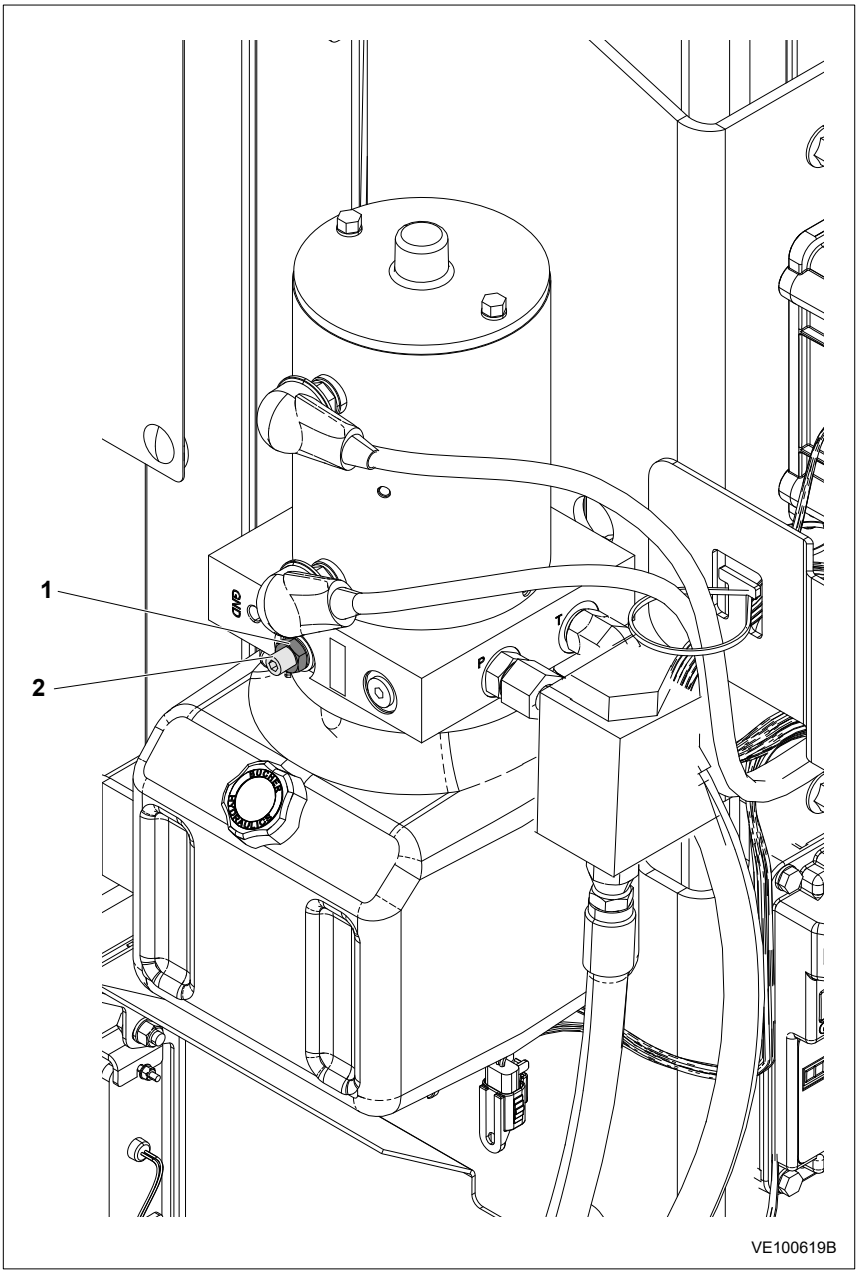


Figure 34. Main Relief Valve Location

1. Jam Nut	2. Adjustment Screw

7.3.2 Steer Reliefs - 18MCL only

1. Connect a pressure gauge (rated to 3000 PSI (206.8 Bar) or higher) to the P port by installing diagnostic fitting part. All check and settings to be performed at default 25% personality.
2. Do Instrumentation/Setup process so that the gauge connected at P Port is reading the steer right relief setting.

3. Loosen the jam nut (**1**) on the steer right relief valve and turn the adjustment screw (**2**) clockwise to increase pressure or counterclockwise to decrease pressure as shown below. Pressure should be set at default steer personality 25%.

4. Once the gauge reads a pressure of 1070 PSI – 1170 PSI (73.8 Bar – 80.7 Bar) tighten down the jam nut (**1**). This will result in a steer pressure of 1015 PSI (70 Bar) at the cylinder.

Note: Make sure the adjustment screw (**2**) does not rotate.

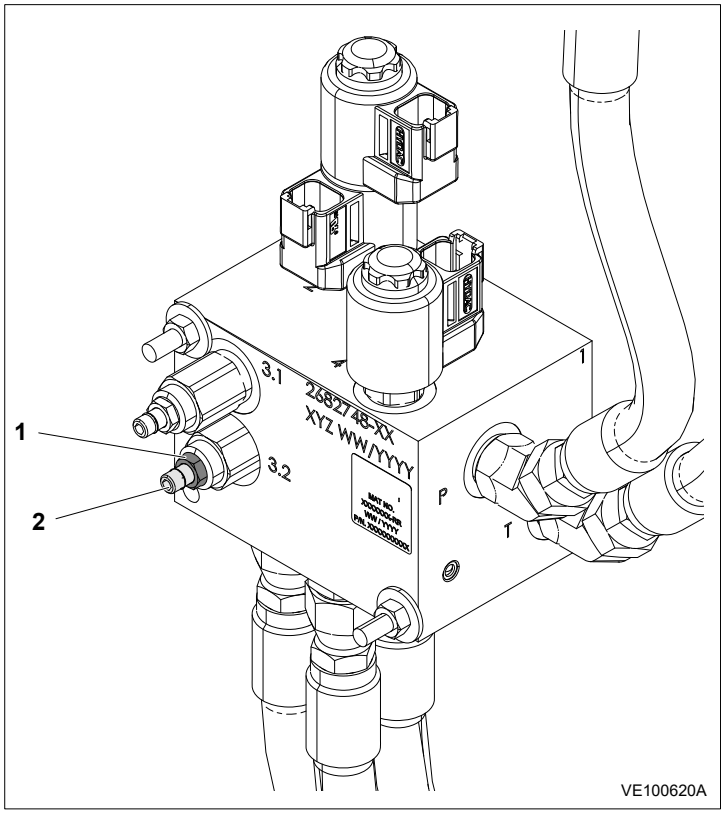


Figure 35. Steer Right Relief Valve

1. Jam Nut	2. Adjustment Screw

5. Do Instrumentation/Setup process so that the gauge connected at P Port is reading the steer right relief setting.

6. Loosen the jam nut (**1**) on the steer Left relief valve and turn the adjustment screw (**2**) clockwise to increase pressure or counterclockwise to decrease pressure as shown below. Pressure should be set at default steer personality 25%.

7. Once the gauge reads a pressure of 1070 PSI – 1170 PSI (73.8 Bar – 80.7 Bar) tighten down the jam nut (**1**). This will result in a steer pressure of 1015 PSI (70 Bar) at the cylinder.

Note: Make sure the adjustment screw (**2**) does not rotate.

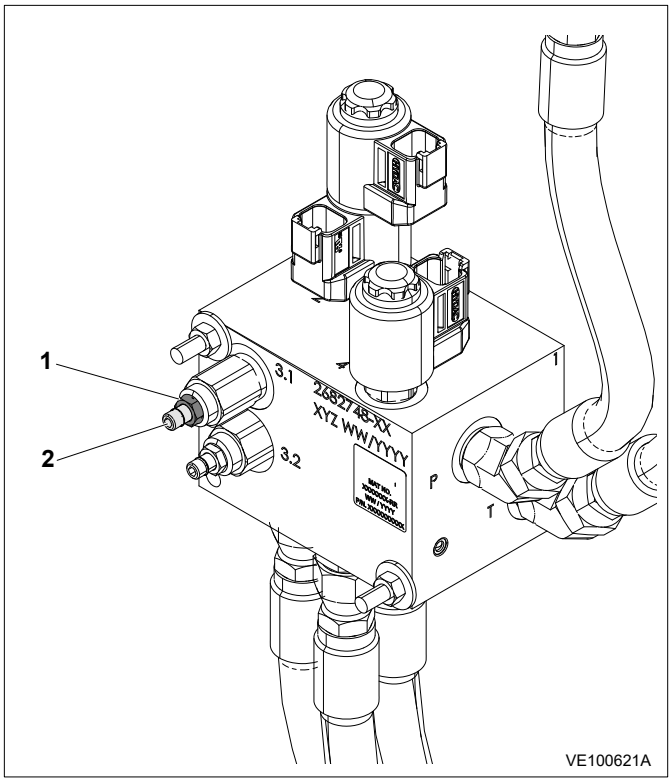


Figure 36. Steer Left Relief Valve

1. Jam Nut	2. Adjustment Screw

7.4 TORQUE VALUES

7.4.1 Manifold Valve Torque Specifications

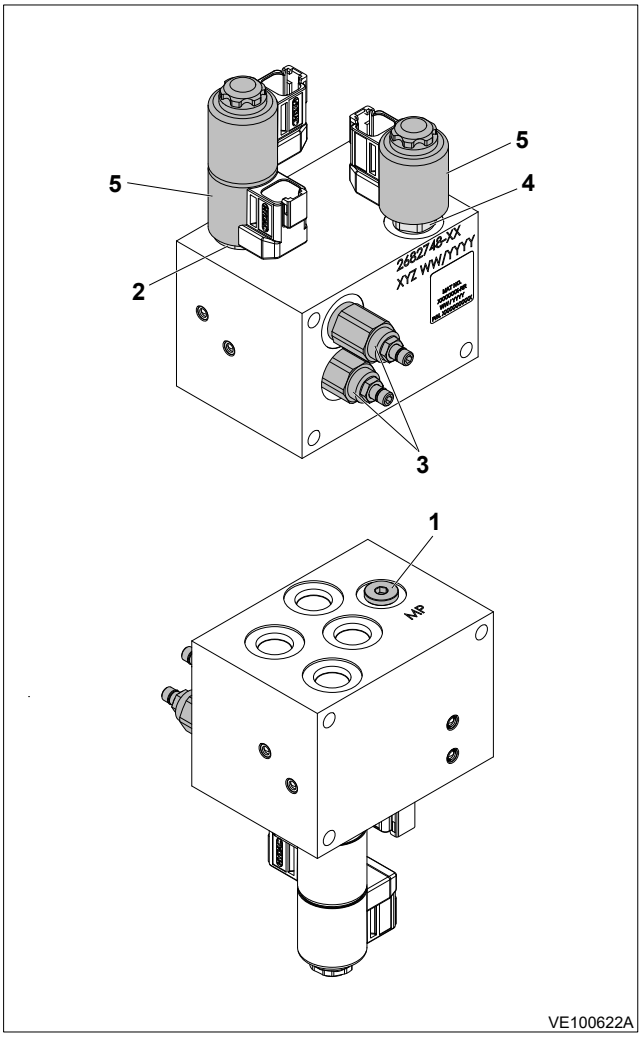


Figure 37. Manifold Valves – Torque Values

Sr No.	Ft. Lbs.	Nm
1	10 – 11	14 – 15
2,3,4	12 – 15	16 – 20
5	1 – 2	1.4 – 2.7

SECTION 8
ELECTRICALS

8.1 GENERAL ELECTRICAL INFORMATION

8.1.1 Applying Silicone Dielectric Compound to Amp Connectors

Silicone Dielectric Compound must be used on the AMP connections for the following reasons:

- To prevent oxidation at the mechanical joint between male and female pins.
- To prevent electrical malfunction caused by low level conductivity between pins when wet.

Use the following procedure to apply Silicone Dielectric Compound to the electrical connectors.

1. To prevent oxidation and low level conductivity, silicone dielectric grease must be packed completely around male and female pins on the inside of the connector after the mating of the housing to the header. This is easily achieved by using a syringe to fill the header with silicone dielectric compound, to a point just above the top of the male pins inside the header. When assembling the housing to the header, it is possible that the housing will become air locked, thus preventing the housing latch from engaging.
2. Pierce one of the unused wire seals to allow the trapped air inside the housing to escape.
3. Install a hole plug into this and/or any unused wire seal that has silicone dielectric compound escaping from it.

8.1.2 Dielectric Grease Application

Dielectric grease helps to prevent corrosion of electrical contacts and improper conductivity between contacts from moisture intrusion. Non-waterproof connectors benefit from the application of dielectric grease.

8.1.3 Installation

The following is general guidance for the installation of dielectric grease in a connector system.

- Use dielectric grease in a tube for larger connection points or apply with a syringe for small connectors.
- Apply dielectric grease to plug/male connector housing which typically contains sockets contact/female terminals.
- Leave a layer of dielectric grease on the mating face of the connector, completely covering each connector terminal hole. Refer the pictures shown below.
- Assemble the connector system immediately to prevent moisture ingress or dust contamination.

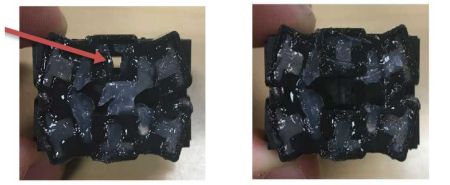
The following connector systems are specifically addressed because of their widespread use at JLG. However, this guidance may be applied to similar devices.

8.1.4 AMP Mate-N-Lok

This connector system is widely used inside enclosures for general-purpose interconnect. Follow the general guidance for installation.

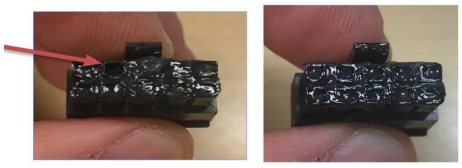
8.1.5 AMP Faston

This connector system is typically used on operator switches at JLG. Follow the general guidance for installation



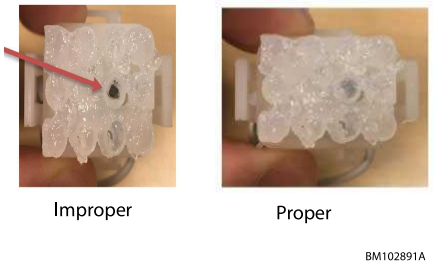
8.1.6 AMP Micro-Fit

This connector system is typically used on control modules at JLG. Follow the general guidance for installation.



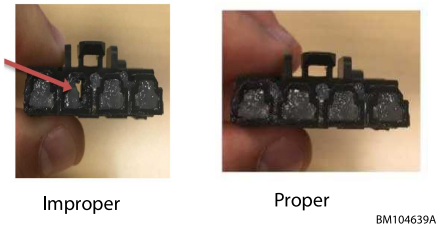
8.1.7 AMP Mini Fit Jr

This connector system is typically used on control modules at JLG. Follow the general guidance for installation.



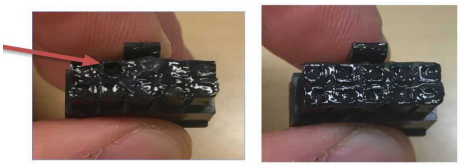
8.1.8 Mini Fit Sr

This connector system is typically used on control modules at JLG. Follow the general guidance for installation.



8.1.9 DIN Connectors

This connector is typically used on hydraulic valves. Follow the installation instructions



Improper Proper

BM102893A

8.1.10 Exceptions

Some waterproof connector applications do benefit from dielectric grease, and some non waterproof connectors do not benefit from dielectric grease.

In the exceptions below, we have found dielectric grease is not needed for some applications, and in some cases can interfere with the intended connection. Dielectric grease shall be used as an exception in other applications.

Enclosures

Application of dielectric grease is not required in properly sealed enclosures. To meet criteria, the enclosure must be rated to at least IP56 (dust protected; protected from powerful jets of water).

Carling Switch Connectors

Carling switches may experience high impedance, or discontinuity, due to silicone dielectric grease ingress when switching inductive loads. Therefore, dielectric grease shall not be applied to Carling switch mating connectors unless specifically noted.

Scissor Platform Cable at the Platform Control

Some waterproof connectors are exposed to the elements when disconnected by the customer benefit from having protection using dielectric grease.

SC100153A

8.1.11 Electrical Circuit Checks

The drive system on the MVL and MSP machines requires a microprocessor controlled electrical circuit to operate smoothly and accurately. All platform control console functions are relayed to various machine components *(i. e. platform up/down, drive functions, etc.)* through the Ground Control Module microprocessor box *(mounted at the rear of the machine)*. The Ground Control Module is pre-programmed with factory pre-set personality settings for each machine function.

To help diagnose any problems with components plugged into the Ground Control Module, the module is designed with an internal fault code and text messaging system displayed on an LCD screen at the module. The platform control console also will display LED Flash Codes using the LED strip at the top of the console. When operating normally the LED panel on the platform control console indicates the battery voltage status using ten (10) LEDs *(red/yellow/green)*. If a malfunction to the machine's electrical components occurs, the platform console LED's will flash a number of LEDs to help indicate the problem to the Operator in the platform. The Fault Codes and LED Flash Codes are outlined in the following sub-sections of this chapter.

Note: For aid in troubleshooting electrical problem, refer to Section – Electrical Schematic for an ELECTRICAL DIAGRAM of the various circuits.

8.2 ELECTRICAL CONNECTORS

8.2.1 Deutsch Connectors

DT/DTP Series Assembly

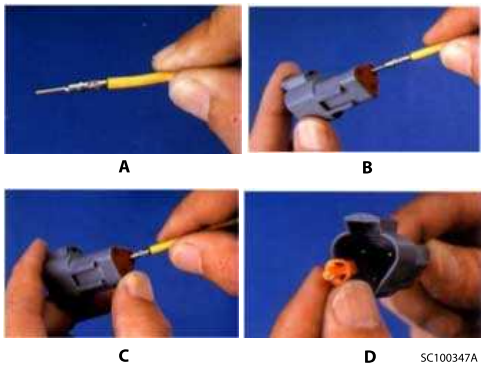


Figure 38. DT/DTP Contact Installation

1. Grasp crimped contact about 25 mm behind the contact barrel.
2. Hold connector with rear grommet facing you.
3. Push contact straight into connector grommet until a click is felt. A slight tug will confirm that it is properly locked in place.
4. Once all contacts are in place, insert wedgelock with arrow pointing toward exterior locking mechanism. The wedgelock will snap into place. Rectangular wedges are not oriented. They may go in either way.

Note: The receptacle is shown - use the same procedure for plug.

DT/DTP Series Disassembly

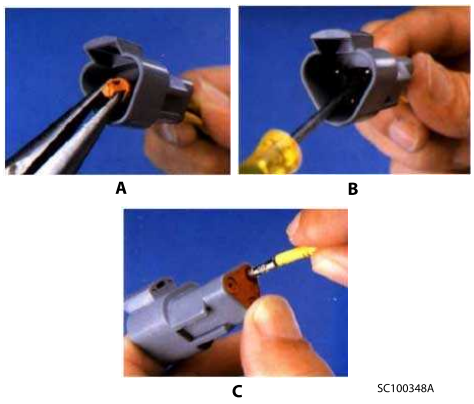


Figure 39. DT/DTP Contact Removal

1. Remove wedgelock using needle nose pliers or a hook shaped wire to pull wedge straight out.
2. To remove the contacts, gently pull wire backwards, while at the same time releasing the locking finger by moving it away from the contact with a screwdriver.
3. Hold the rear seal in place, as removing the contact may displace the seal.

HD30/HDP20 Series Assembly

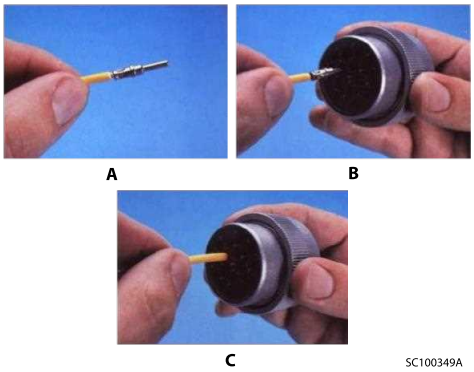


Figure 40. HD/HDP Contact Installation

1. Grasp contact about 25 mm behind the contact crimp barrel.
2. Hold connector with rear grommet facing you.
3. Push contact straight into connector grommet until a positive stop is felt. A slight tug will confirm that it is properly locked in place.

CONTACT INSERTION

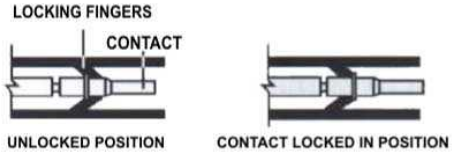


Figure 41. HD/HDP Locking Contacts Into Position

Note: For unused wire cavities, insert sealing plugs for full environmental sealing.

HD30/HDP20 Series Disassembly

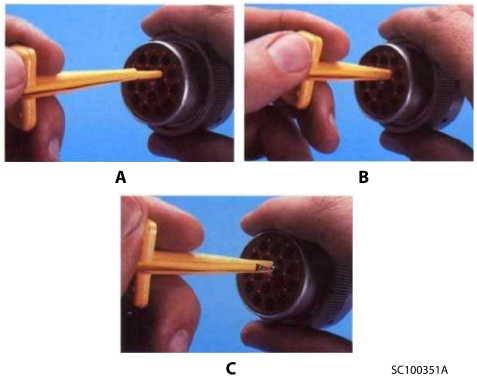


Figure 42. HD/HDP Contact Removal

1. With rear insert toward you, snap appropriate size extractor tool over the wire of contact to be removed.
2. Slide tool along into the insert cavity until it engages contact and resistance is felt.
3. Pull contact-wire assembly out of connector.

CONTACT REMOVAL

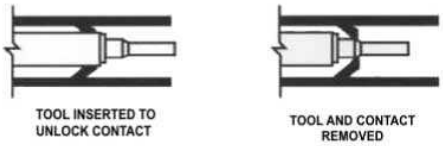


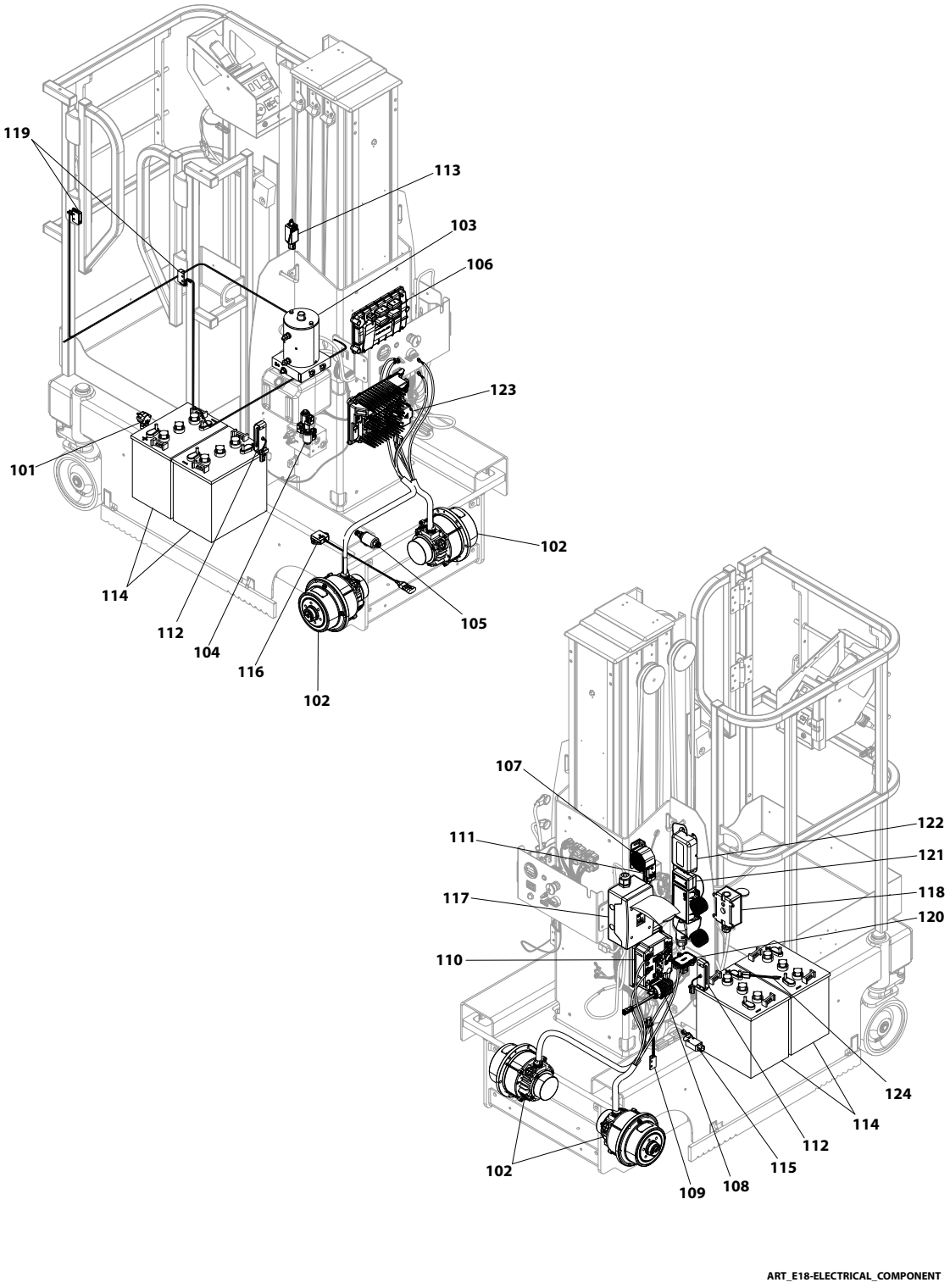
Figure 43. HD/HDP Unlocking Contacts

Note: Do Not twist or insert tool at an angle.

8.3 ELECTRICAL COMPONENT TERMINOLOGY

To understand the safety, operation, and service information presented in this section, it is necessary that the operator/mechanic be familiar with the name and location of the electrical components of the machine. These illustrations are provided to give visual aid.

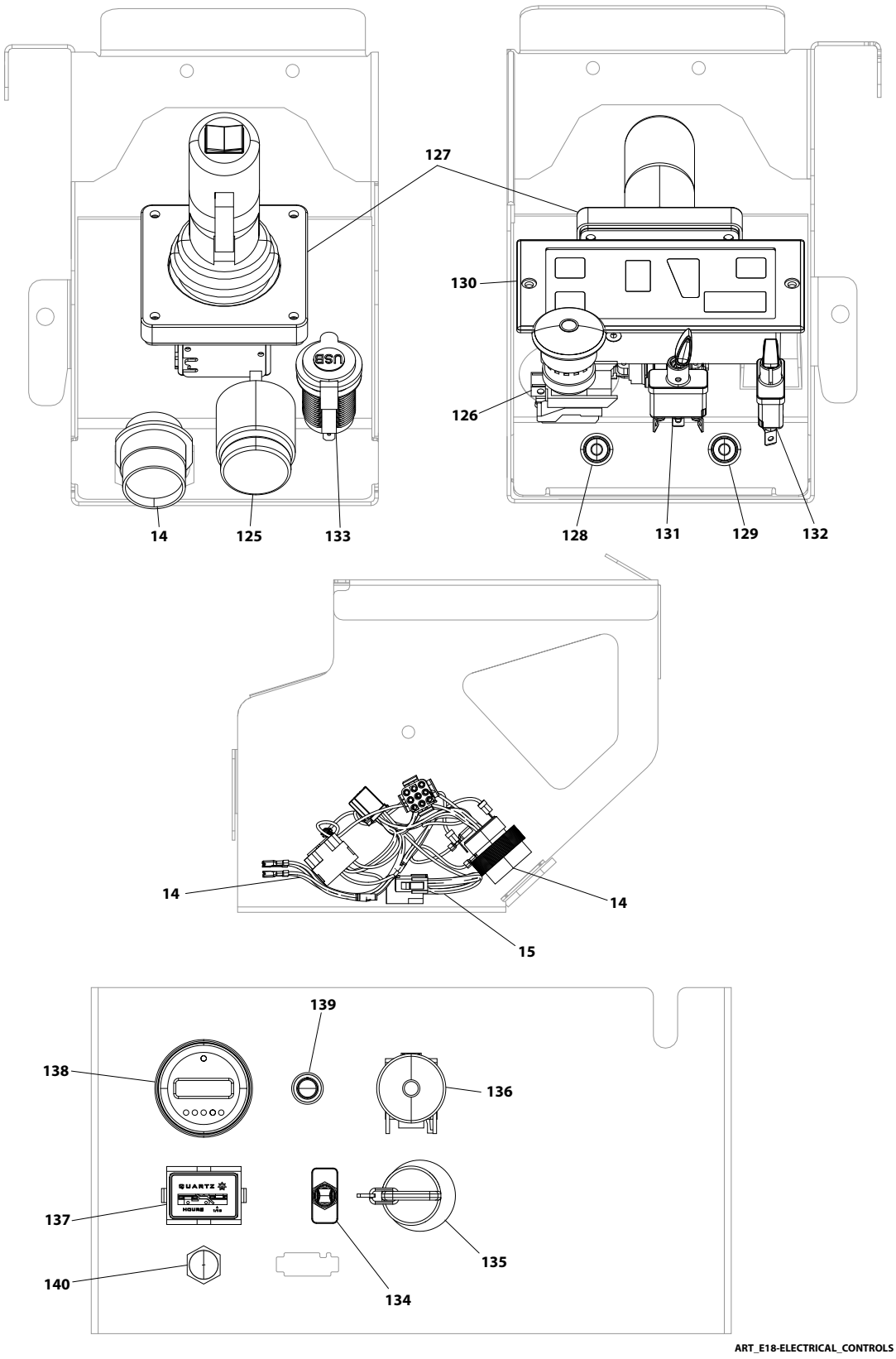
8.3.1 Component Location



ART_E18-ELECTRICAL_COMPONENT

Component	
Number	**Description**
101	Steer Angle Sensor
102	Drive Motor/Brake Assembly
103	Drive Pump/Motor
104	Main Control Valve Solenoids
105	Manual Descent Valve Solenoids
106	Ground Control Module
107	Alarm
108	Relay
109	Mast Proximity Sensor
110	Drive Module
111	Mast Limit Switch
112	Beacon
113	LSS Limit Switch
114	Battery
115	Pothole Protection Limit Switch
116	Tilt Sensor
117	AC Breaker Box
118	AC Receptacle
119	Gate Alarm Sensor
120	Mobile Control Module
121	Clearsky Telematics CANBUS Moduler
122	Clearsky Telematics Antennae
123	Charger
124	Temperature Sensor

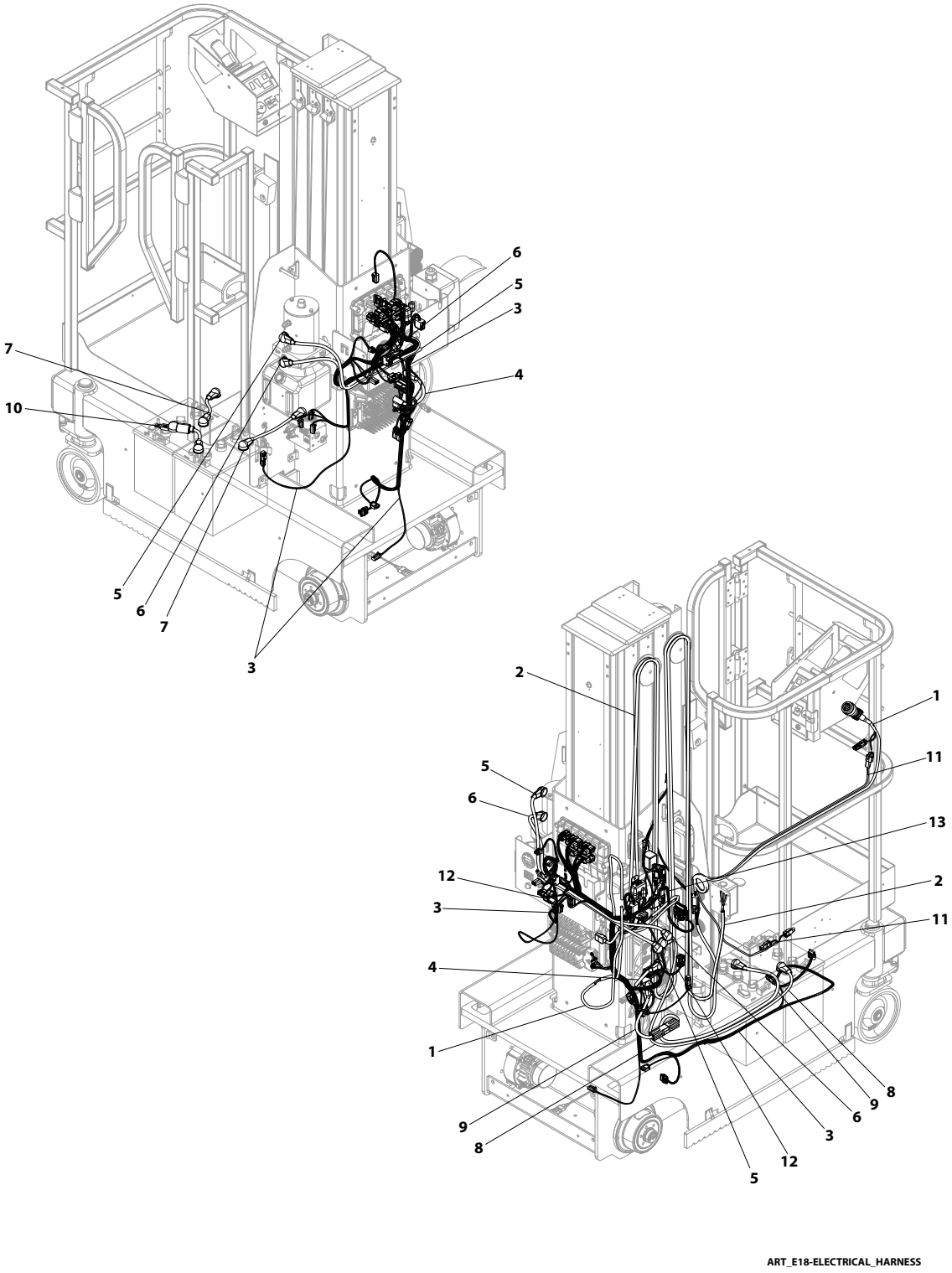
8.3.2 Controls



Harness	
Number	**Description**
14	Platform Control Box Harness
15	Joystick Jumper Harness

Component	
Number	**Description**
125	Alarm
126	Emergency Stop Switch
127	Joystick
128	Horn Switch
129	Indoor/Outdoor Switch
130	Platform Display
131	Lift/Drive Select Switch
132	Speed Select Switch
133	USB Port
134	Platform Lift/Lower Switch
135	Key Switch
136	Emergency Stop Switch
137	Gauge Hourmeter
138	Ground Display
139	Load Sense Overload Indicator Light
140	AC Receptacle

8.4 HARNESS LAYOUTS



ART_E18-ELECTRICAL_HARNESS

Harness	
Number	**Description**
1	Platform Control Box Harness
2	AC Ground to Platform Cable
3	Chassis Harness
4	Drive Module to Relay Cable
5	Drive Module to Pump Cable +
6	Drive Module to Pump Cable -
7	Battery Jumper Cable
8	Drive Module to Battery Cable -
9	Battery Disconnect to Relay Cable
10	Battery Jumper with Fuse Cable
11	Gate Alarm Harness
12	Mobile Control Harness
13	Clearsky Harness

8.5 BOARD LAYOUTS

8.5.1 Logic Control Module

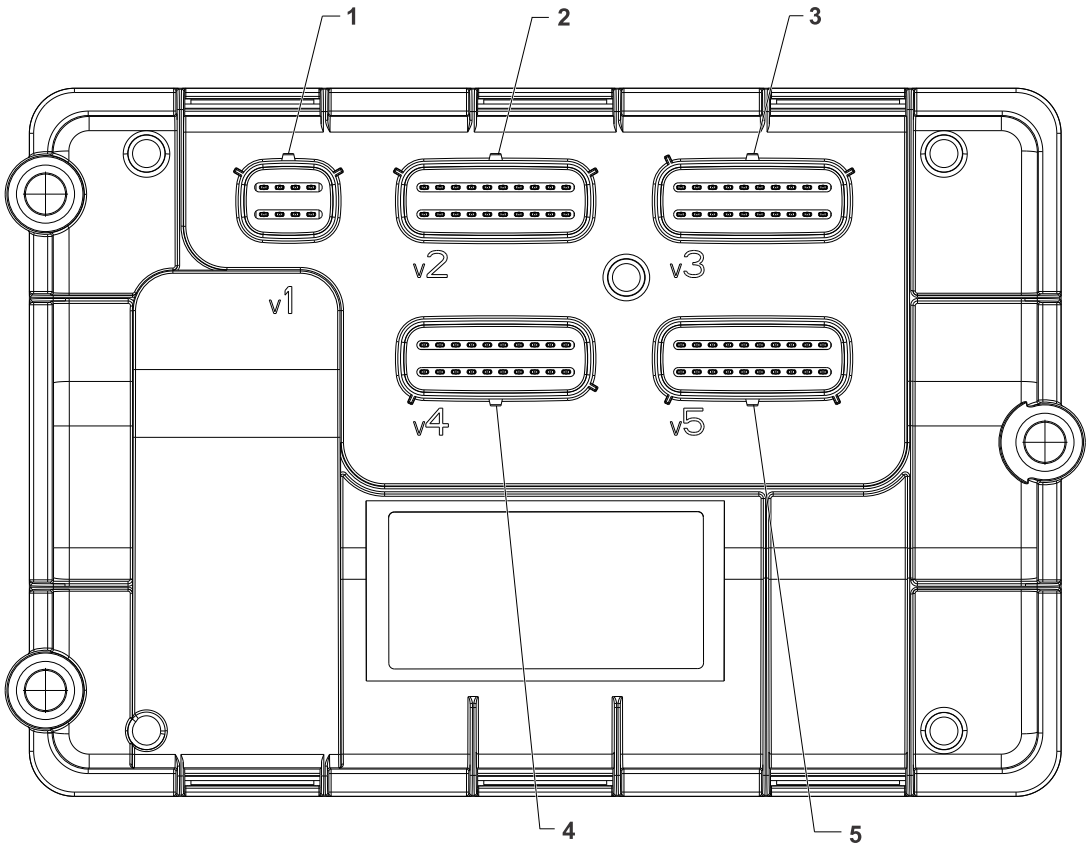


Figure 44. Logic Control Module

1. V1 – Black 8 Pin	4. V4 – Black 20 Pin
2. V2 – Black 20 Pin	5. V5 – Black 20 Pin
3. V3 – Black 20 Pin	

Connector	Pin	Tagname	Abstract	Type		Function
V1 (BLACK)	1	GND	MASTER GROUND	POWER	INPUT	MASTER GROUND
	2	CAN2L	CAN 2 LOW	SERIAL	I/O	CAN 2 LOW
	3	CAN2H	CAN 2 HIGH	SERIAL	I/O	CAN 2 HIGH
	4	CAN1L	CAN 1 LOW	SERIAL	I/O	CAN 1 LOW
	5	DIT2	DIGITAL INPUT TYPE 2	DIGITAL	INPUT	GROUND SELECT SIGNAL
	6	TX	RS-232 TRANSMIT	SERIAL	OUTPUT	ANALYZER TRANSMIT
	7	RX	RS-232 RECEIVE	SERIAL	INPUT	ANALYZER RECEIVE
	8	CAN1H	CAN 1 HIGH	SERIAL	I/O	CAN 1 HIGH

Connector	Pin	Tagname	Abstract	Type		Function
V2 (BLACK)	1	DIT3	DIGITAL INPUT TYPE 3	DIGITAL	INPUT	CONFIG PIN 1
	2	DIT3	DIGITAL INPUT TYPE 3	DIGITAL	INPUT	BRAKE RELEASE SWITCH SIGNAL
	3	DIT3	DIGITAL INPUT TYPE 3	DIGITAL	INPUT	AUXILLARY MODE (CHARGE)
	4	GND	GROUND	POWER	OUTPUT	TILT SENSOR GROUND
	5	VSW	SWITCHING VOLTAGE	POWER	OUTPUT	TILT SENSOR POWER
	6	DOT1	DIGITAL OUTPUT TYPE 1	DIGITAL	OUTPUT	SPARE
	7	VSW	SWITCHING VOLTAGE	POWER	OUTPUT	BRAKE RELEASE SWITCH POWER
	8	VSW	SWITCHING VOLTAGE	POWER	OUTPUT	INVERTER SWITCH POWER
	9	DOT2	DIGITAL OUTPUT TYPE 2	DIGITAL	OUTPUT	SPARE
	10	DOT2	DIGITAL OUTPUT TYPE 2	DIGITAL	OUTPUT	HOUR METER SIGNAL
	11	GND	GROUND	POWER	OUTPUT	MDI GROUND
	12	VON	VOLTAGE ON	POWER	OUTPUT	MDI POWER
	13	VON	VOLTAGE ON	POWER	OUTPUT	MAINLINE CON-TACTOR COIL+
	14	GND	GROUND	POWER	OUTPUT	GROUND ALARM GROUND
	15	VSW	SWITCHING VOLTAGE	POWER	OUTPUT	GROUND ALARM POWER
	16	DOT1	DIGITAL OUTPUT TYPE 1	DIGITAL	OUTPUT	GROUND ALARM CONTROL SIGNAL
	17	LSCS	LOW SIDE CUR-RENT SENSE	DIGITAL	OUTPUT	SPARE
	18	VSW	SWITCHING VOLTAGE	POWER	OUTPUT	CONFIG PIN 1 IGN

Connector	Pin	Tagname	Abstract	Type		Function
	19	VSW	SWITCHING VOLTAGE	POWER	OUTPUT	SPARE
	20	GND	GROUND	POWER	OUTPUT	HOUR METER GROUND

Connector	Pin	Tagname	Abstract	Type		Function
V3 (BLACK)	1	GND	GROUND	POWER	OUTPUT	ROTARY SENSOR 1 GROUND
	2	AIT1	ANALOG INPUT TYPE 1	ANALOG	INPUT	ROTARY SENSOR 1 ANALOG SIGNAL
	3	5VREF	+5V ANALOG REFERENCE	POWER	OUTPUT	ROTARY SENSOR 1 5V POWER
	4	5VREF	+5V ANALOG REFERENCE	POWER	OUTPUT	SPARE
	5	AIT1	ANALOG INPUT TYPE 1	ANALOG	INPUT	SPARE
	6	GND	GROUND	POWER	OUTPUT	SPARE
	7	DIT3	DIGITAL INPUT TYPE 3	DIGITAL	INPUT	SPARE
	8	DIT3	DIGITAL INPUT TYPE 3	DIGITAL	INPUT	BATTERY CHARGER INTERLOCK SIGNAL
	9	DOT4	DIGITAL OUTPUT TYPE 4	DIGITAL	OUTPUT	SPARE
	10	GND	GROUND	POWER	OUTPUT	SPARE
	11	GND	GROUND	POWER	OUTPUT	ROTARY SENSOR 2 GROUND
	12	AIT1	ANALOG INPUT TYPE 1	ANALOG	INPUT	ROTARY SENSOR 2 ANALOG SIGNAL
	13	5VREF	+5V ANALOG REFERENCE	POWER	OUTPUT	ROTARY SENSOR 2 5V POWER
	14	5VREF	+5V ANALOG REFERENCE	POWER	OUTPUT	SPARE
	15	AIT1	ANALOG INPUT TYPE 1	ANALOG	INPUT	SPARE
	16	GND	GROUND	POWER	OUTPUT	SPARE
	17	DIT3	DIGITAL INPUT TYPE 3	DIGITAL	INPUT	SPARE
	18	VSW	SWITCHING VOLTAGE	POWER	OUTPUT	SPARE
	19	DOT3	DIGITAL OUTPUT TYPE 3	DIGITAL	OUTPUT	BEACON CONTROL SIGNAL
	20	GND	GROUND	POWER	OUTPUT	BEACON GROUND

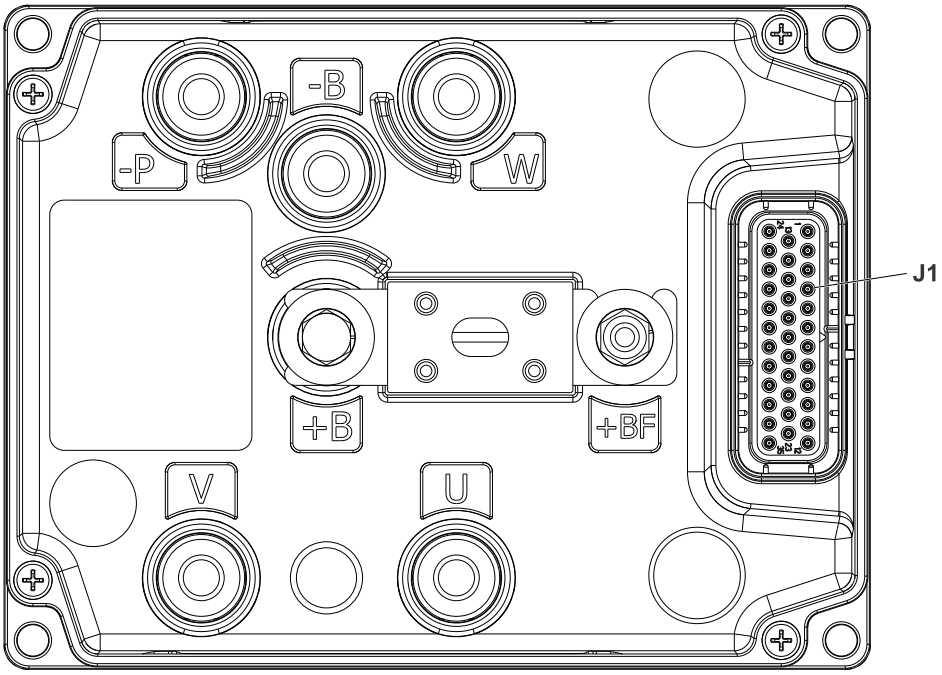
Connector	Pin	Tagname	Abstract	Type		Function
V4 (BLACK)	1	GND	GROUND	POWER	OUTPUT	LIFT UP VLV GROUND

Connector	Pin	Tagname	Abstract	Type		Function
	2	DOT2	DIGITAL OUTPUT TYPE 2	DIGITAL	OUTPUT	LIFT UP VLV CONTROL SIGNAL
	3	DOT1	DIGITAL OUTPUT TYPE 1	DIGITAL	OUTPUT	LIFT DN VLV HS CONTROL SIGNAL
	4	DOT1	DIGITAL OUTPUT TYPE 1	DIGITAL	OUTPUT	SPARE
	5	GND	GROUND	POWER	OUTPUT	TOW VALVE GROUND
	6	GND	GROUND	POWER	OUTPUT	PRESSURE TRANS GROUND
	7	AIT1	ANALOG INPUT TYPE 1	ANALOG	INPUT	PRESSURE TRANS ANALOG SIGNAL 1
	8	VBAT	VBAT	POWER	INPUT	BATTERY CONNECTION
	9	DIT3	DIGITAL INPUT TYPE 3	DIGITAL	INPUT	LIFT UP SWITCH SIGNAL
	10	DIT3	DIGITAL INPUT TYPE 3	DIGITAL	INPUT	LIFT DOWN SWITCH SIGNAL
	11	GND	GROUND	POWER	OUTPUT	AMBIENT ALARM GROUND
	12	DOT2	DIGITAL OUTPUT TYPE 2	DIGITAL	OUTPUT	AMBIENT ALARM CONTROL SIGNAL
	13	LSCS	LOW SIDE CURRENT SENSE	DIGITAL	OUTPUT	LIFT DN VLV LS CONTROL SIGNAL
	14	DOT4	DIGITAL OUTPUT TYPE 4	DIGITAL	OUTPUT	OVERLOAD LIGHT CONTROL SIGNAL
	15	VSW	SWITCHING VOLTAGE	POWER	OUTPUT	OVERLOAD LIGHT POWER
	16	VSW	SWITCHING VOLTAGE	POWER	OUTPUT	PRESSURE TRANS POWER
	17	AIT1	ANALOG INPUT TYPE 1	ANALOG	INPUT	PRESSURE TRANS ANALOG SIGNAL 2
	18	5VREF	+5V ANALOG REFERENCE	POWER	OUTPUT	SPARE
	19	5VREF	+5V ANALOG REFERENCE	POWER	OUTPUT	SPARE
	20	DIT2	DIGITAL INPUT TYPE 2	DIGITAL	INPUT	PLATFORM SELECT SIGNAL

Connector	Pin	Tagname	Abstract	Type		Function
V5 (BLACK)	1	GND	GROUND	POWER	OUTPUT	ANALYZER GROUND
	2	DIT3	DIGITAL INPUT TYPE 3	DIGITAL	INPUT	POTHOLE SWITCH 2 SIGNAL
	3	VSW	SWITCHING VOLTAGE	POWER	OUTPUT	POTHOLE SWITCH 2 POWER
	4	VSW	SWITCHING VOLTAGE	POWER	OUTPUT	TELEMATICS POWER

Connector	Pin	Tagname	Abstract	Type		Function
	5	DOT2	DIGITAL OUTPUT TYPE 2	DIGITAL	OUTPUT	TOW VALVE SIGNAL
	6	DOT2	DIGITAL OUTPUT TYPE 2	DIGITAL	OUTPUT	PLATFORM POWER SIGNAL
	7	DOT2	DIGITAL OUTPUT TYPE 2	DIGITAL	OUTPUT	DRIVE REVERSE VLV CONTROL SIGNAL
	8	GND	GROUND	POWER	OUTPUT	DRIVE REVERSE VLV GROUND
	9	GND	GROUND	POWER	OUTPUT	STEER LEFT VLV GROUND
	10	DOT2	DIGITAL OUTPUT TYPE 2	DIGITAL	OUTPUT	STEER LEFT VLV CONTROL SIGNAL
	11	VON	VOLTAGE ON	POWER	OUTPUT	ANALYZER POWER
	12	DIT3	DIGITAL INPUT TYPE 3	DIGITAL	INPUT	POTHOLE SWITCH 1 SIGNAL
	13	VSW	SWITCHING VOLTAGE	POWER	OUTPUT	POTHOLE SWITCH 1 POWER
	14	VSW	SWITCHING VOLTAGE	POWER	OUTPUT	POWER MODULE POWER
	15	VSW	SWITCHING VOLTAGE	POWER	OUTPUT	SPARE
	16	GND	GROUND	POWER	OUTPUT	PLATFORM GROUND
	17	DOT2	DIGITAL OUTPUT TYPE 2	DIGITAL	OUTPUT	DRIVE FORWARD VLV CONTROL SIGNAL
	18	GND	GROUND	POWER	OUTPUT	DRIVE FORWARD VLV GROUND
	19	GND	GROUND	POWER	OUTPUT	STEER RIGHT VLV GROUND
	20	DOT2	DIGITAL OUTPUT TYPE 2	DIGITAL	OUTPUT	STEER RIGHT VLV CONTROL SIGNAL

8.5.2 Drive Control Module



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Connector	Pin	Function	Type	
JI AMSEAL 35 (Black)	1	UNUSED	DIGITAL	INPUT
	2	ELECTRONIC RIGHT BRAKE	DIGITAL	OUTPUT
	3	ELECTRONIC BRAKE SUPPLY (POS)	VBAT	INPUT
	4	ELECTRONIC RIGHT BRAKE DRIVER (NEG)	PWM	OUTPUT
	5	UNUSED	GND	OUTPUT
	6	UNUSED	DIGITAL	INPUT
	7	UNUSED	DIGITAL	INPUT
	8	UNUSED	DIGITAL	OUTPUT
	9	ELECTRONIC LEFT BRAKE DRIVER (NEG)	PWM	OUTPUT
	10	KEY SWITCH (IGNITION)	DIGITAL	INPUT
	11	UNUSED	DIGITAL	OUTPUT
	12	MAIN CONTACTOR LOW SIDE DRIVER	PWM	OUTPUT
	13	UNUSED	DIGITAL	INPUT
	14	UNUSED	DIGITAL	INPUT

Connector	Pin	Function	Type	
	15	UNUSED	ANALOG	INPUT
	16	UNUSED	DIGITAL	INPUT
	17	UNUSED	DIGITAL	INPUT
	18	UNUSED	DIGITAL	INPUT
	19	UNUSED	DIGITAL	INPUT
	20	UNUSED	DIGITAL	INPUT
	21	CHARGER INTERLOCK	DIGITAL	INPUT
	22	UNUSED	ANALOG	INPUT
	23	UNUSED	PWM	OUTPUT
	24	UNUSED	PWM	OUTPUT
	25	UNUSED	VOLTAGE	OUTPUT
	26	UNUSED	DIGITAL	OUTPUT
	27	CAN LOW	COMM	I/O
	28	CAN HIGH	COMM	I/O
	29	UNUSED	DIGITAL	INPUT
	30	UNUSED	ANALOG	INPUT
	31	UNUSED	DIGITAL	INPUT
	32	ELEVATION SWITCH 2	DIGITAL	INPUT
	33	BRAKE RELEASE SWITCH	DIGITAL	OUTPUT
	34	UNUSED	DIGITAL	OUTPUT
	35	UNUSED	DIGITAL	INPUT

Connector	Pin	Function	Type	
-B	1	MODULE GROUND	GROUND	INPUT

Connector	Pin	Function	Type	
+BF	1	MODULE FUSE POWER	VBAT	INPUT

Connector	Pin	Function	Type	
+B	1	MODULE POWER	VBAT	INPUT

Connector	Pin	Function	Type	
-P	1	PUMP	PWM	OUTPUT

Connector	Pin	Function	Type	
U	1	RIGHT TRACTION MOTOR POS	DC	OUTPUT

Connector	Pin	Function	Type	
V	1	LEFT TRACTION MOTOR POS	DC	OUTPUT

Connector	Pin	Function	Type	
W	1	RIGHT/LEFT TRACTION MOTOR NEG	PWM	OUTPUT

8.6 AMP CONNECTOR

8.6.1 Assembly

Check to be sure the wedge lock is in the open, or as shipped position. Proceed as follows:

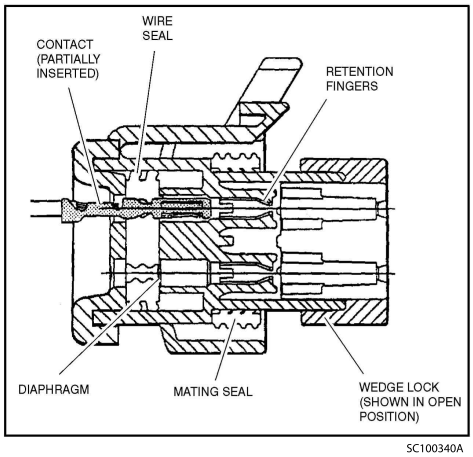

Figure 45. Connector Assembly Figure 1

1. To insert a contact, push it straight into the appropriate circuit cavity as far as it will go.

2. Pull back on the contact wire with a force of 1 or 2 lbs. to be sure the retention fingers are holding the contact.

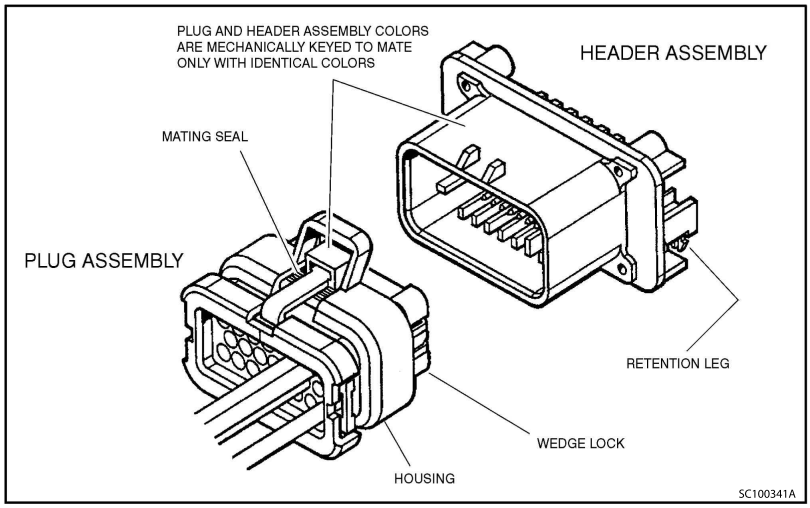

Figure 46. AMP Connector

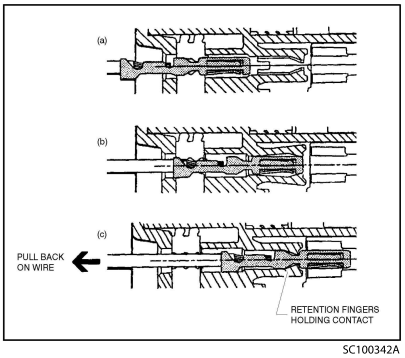

Figure 47. Connector Assembly Figure 2

3. After all required contacts have been inserted, the wedge lock must be closed to its locked position. Release the locking latches by squeezing them inward.

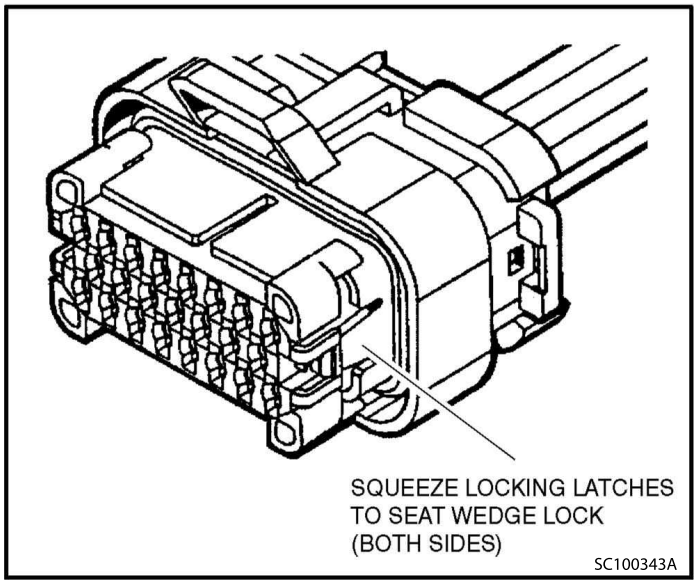

Figure 48. Connector Assembly Figure 3

4. Slide the wedge lock into the housing until it is flush with the housing.

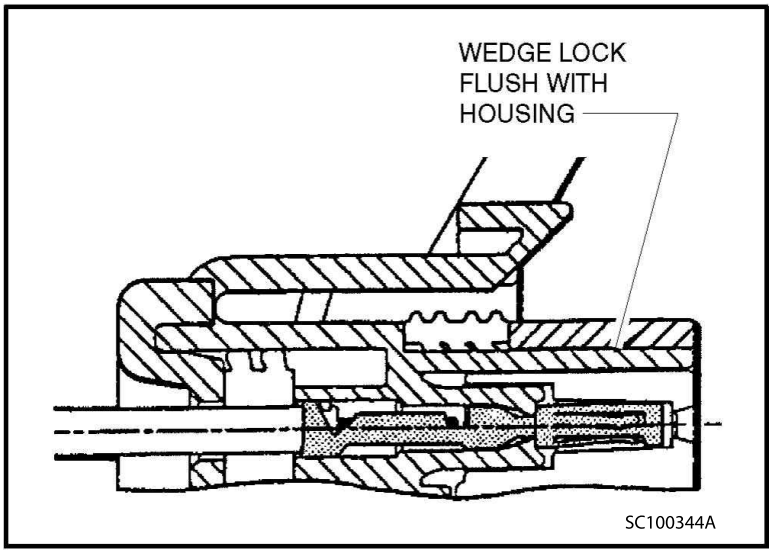

Figure 49. Connector Assembly Figure 4

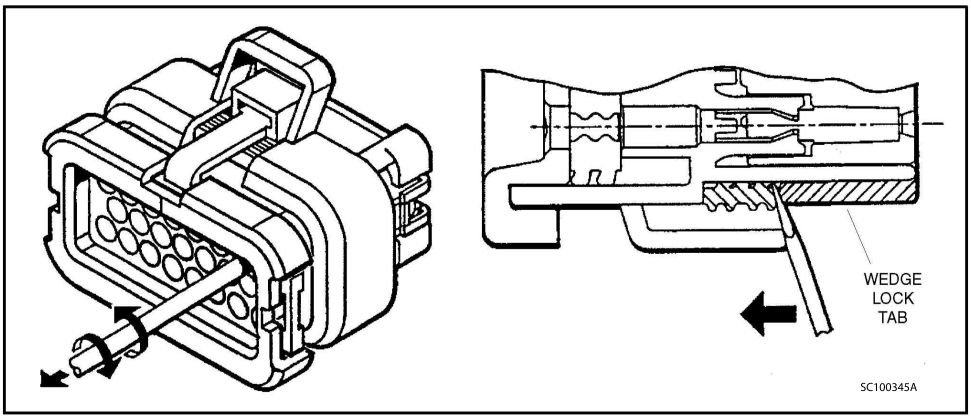

Figure 50. Connector Disassembly

8.6.2 Disassembly

1. Insert a 4.8 mm (3/16 in.) wide screwdriver blade between the mating seal and one of the red wedge lock tabs.
2. Pry open the wedge lock to the open position.
3. While rotating the wire back and forth over a half turn (1/4 turn in each direction), gently pull the wire until the contact is removed.

Note: The wedge lock should never be removed from the housing for insertion or removal of the contacts.

8.6.3 Wedge Lock

The wedge lock has slotted openings in the forward, or mating end. These slots accommodate circuit testing in the field, by using a flat probe such as a pocket knife. DO NOT use a sharp point such as an ice pick.

8.6.4 Service - Voltage Reading

⚠ CAUTION

Do not pierce wire insulation to take voltage readings.

It has been common practice in electrical troubleshooting to probe wires by piercing the insulation with a sharp point. This practice should be discouraged when dealing with the AMPSEAL plug assembly, or any other sealed connector system. The resulting pinholes in the insulation will allow moisture to invade the system by traveling along the wire strands. This nullifies the effectiveness of the connector seals and could result in system failure.

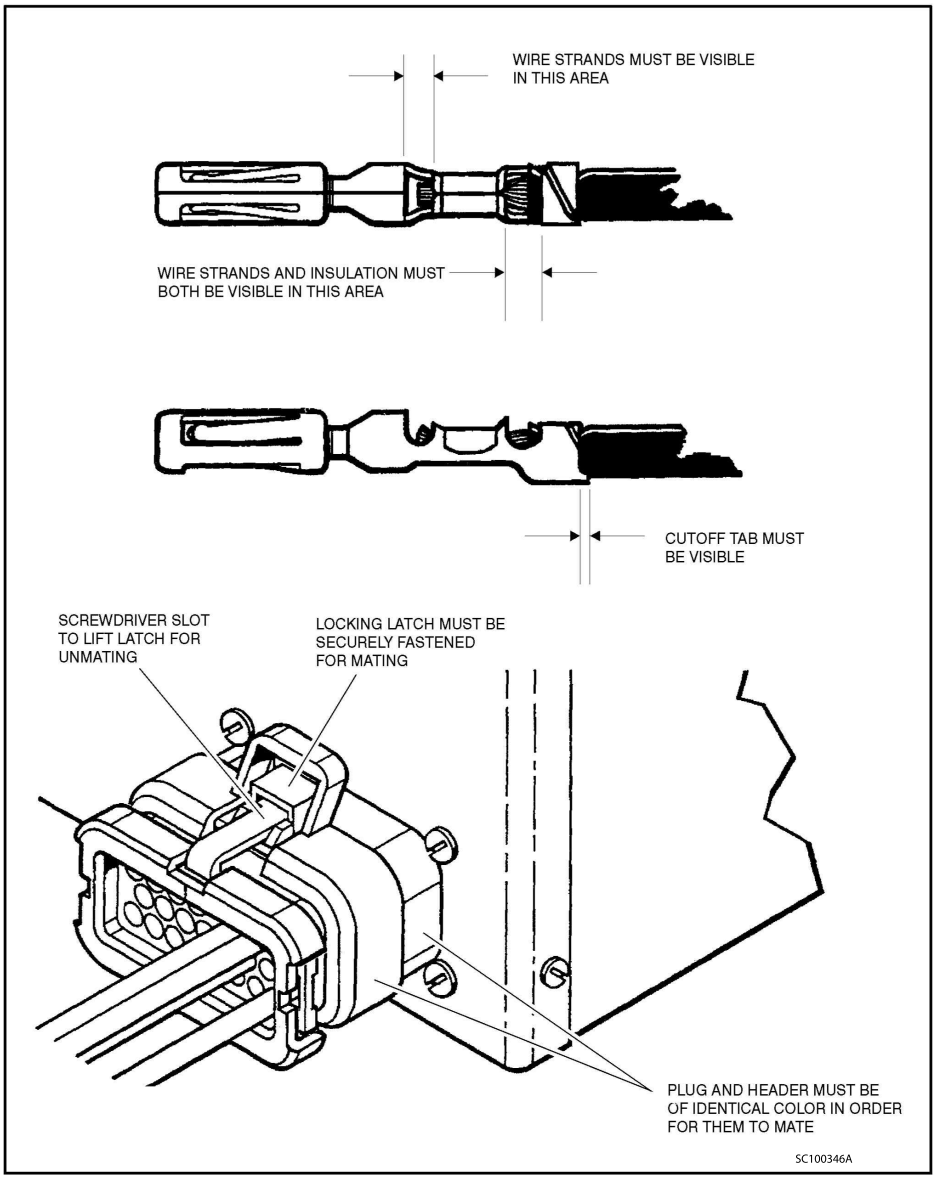

Figure 51. Connector Installation

8.7 SWITCHES

8.7.1 Basic check

The following check determines if the switch is functioning properly, not the circuit in which the switch is placed. A switch is functioning properly when there is continuity between the correct terminals or contacts only when selected.

1. De-energize the circuit.
2. Isolate the switch from the rest of the circuit if possible. If not possible, keep in mind it may affect readings.
3. Access the terminals to the switch.
4. If the switch has two terminals:
   a. Measure resistance across the terminals.
   b. Change the switch position.
   c. Measure resistance again with the leads in the same positions. If the meter was reading short, it should read an open. If the meter was reading open it should read short.
5. If the switch has more than two terminals, consult the schematic or switch diagram to determine what terminals will be connected. The test is similar to testing a switch with two terminals.
   a. Place one meter lead on the common contact and the other on a different contact in the same circuit.
   b. Cycle through all positions of the switch. The meter should read short only when the switch connects the two terminals and open otherwise.
   c. If the switch has more than one common contact repeat the process for that circuit.

8.7.2 Limit Switches

Limit switches are used to control movement or indicate position. Mechanical limit switches are just like manually operated switches except that the moving object operates the switch. These switches can be tested the same way as a standard switch by manually operating the sensing arm.

Another type of limit switch used by JLG is the inductive proximity switch, also referred to as a "prox switch". Inductive proximity switches are actuated only by ferrous metal (metal that contains Iron, such as steel) near the switch. They do not require contact, and must be energized to actuate. These types of switches can be used to detect boom or platform position, for example. These switches have a sensing face where the switch can detect ferrous metal close to it. To find the sensing face, take note how the switch is mounted and how the mechanisms meet the switch. Test this type of switch as follows:

1. Remove prox switch from its mount.
2. Reconnect harness if it was disconnected for step a, and turn on machine.
3. Hold switch away from metal and observe switch state in the control system diagnostics using the Analyzer. See vehicle or control system documentation on how to do this.
4. Place sensing face of switch on the object to be sensed by the switch. If that is not available, use a piece of ferrous metal physically similar to it. The switch state in the control system diagnostics should change.
5. When reinstalling or replacing switch be sure to follow mounting instructions and properly set the gap between the switch and object sensed.

8.7.3 Automatic Switches

If the switch is actuated automatically, by temperature or pressure for example, find a way to manually actuate the switch to test it. Do this either by applying heat or pressure, for example, to the switch. These switches may need to be energized to actuate.

1. Connect instrumentation to monitor and/or control the parameter the switch is measuring.
2. Observe switch state in control system with the Analyzer. See vehicle or control system documentation on how to do this.
3. Operate system such that the switch actuates. This could be going over a certain pressure or temperature, for example. The state indicated in the control system should change.

8.7.4 Switch Wiring - Low Side, High Side

When controlling a load, a switch can be wired between the positive side of the power source and the load. This switch is called a "high side" switch. The switch supplies the power to the load. When a switch is wired between the negative side of the power source and the load, it is a "low side" switch. The switch provides the ground to the load.

A low side switch will allow voltage to be present on the load. No power is applied because the switch is stopping current flow. This voltage can be seen if the measurement is taken with one test lead on the load and the other on the battery negative side or grounded to the vehicle. What is actually being measured is the voltage drop across the switch. This could mislead a technician into thinking the load is receiving power but not operating. To produce an accurate picture of power or voltage applied to the load, measure voltage across the load’s power terminals. Also, the technician can measure the voltage at both power terminals with respect to battery ground. The difference between those two measurements is the voltage applied to the load.

8.8 WIRING HARNESS

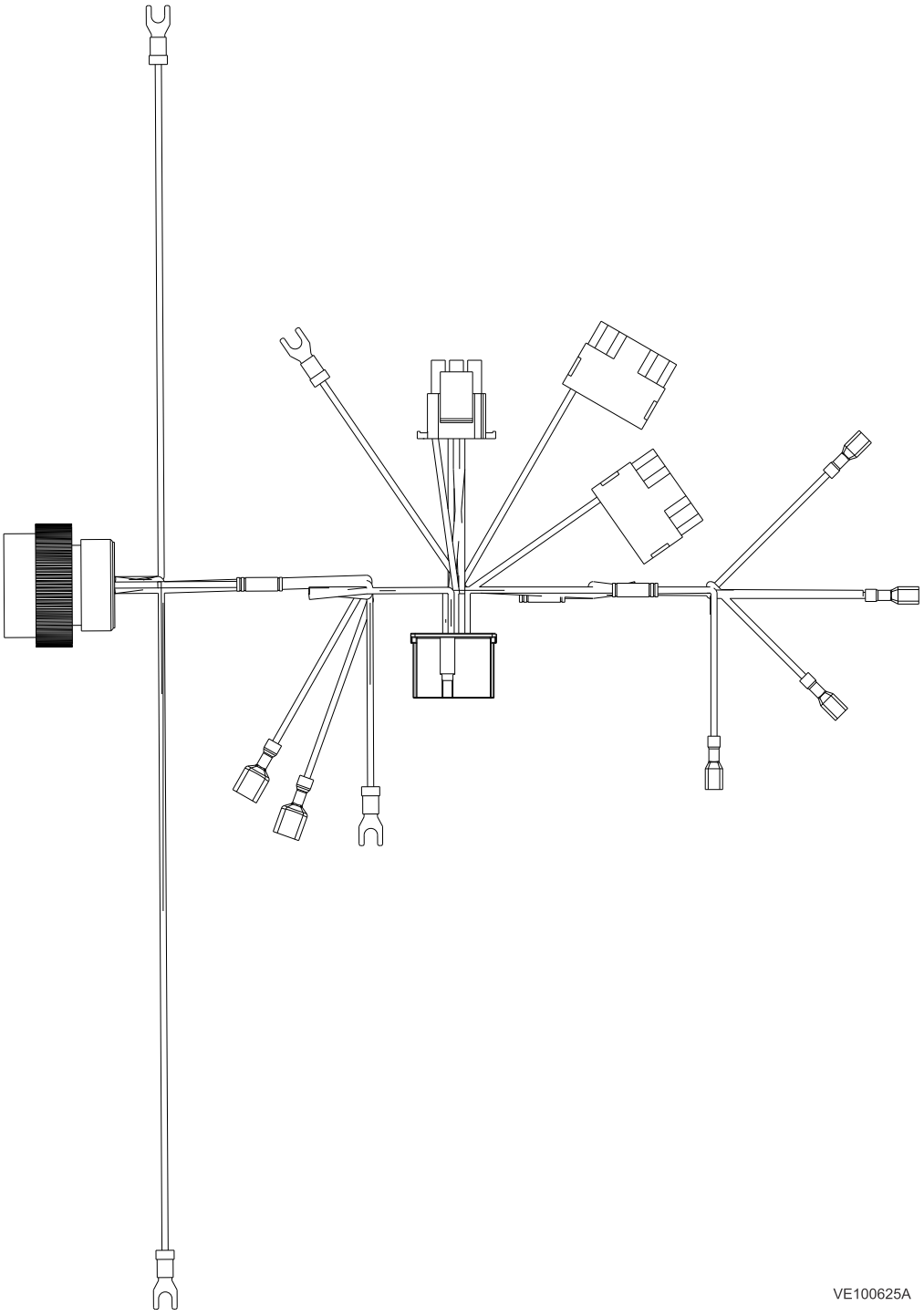

Figure 52. Platform Box Harness – Sheet 1 of 2

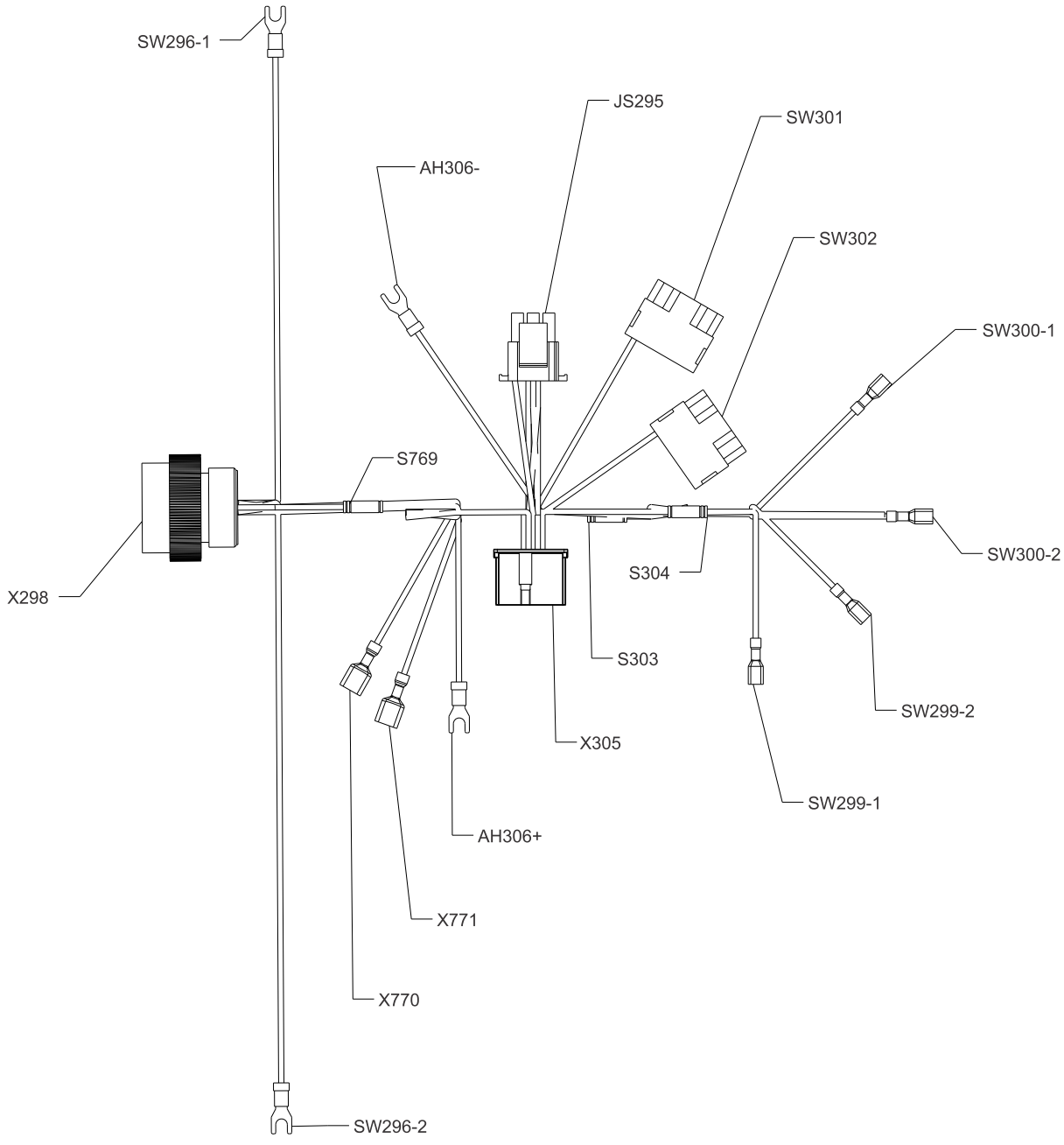

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Figure 53. Platform Box Harness – Sheet 2 of 2

JS295 - JOYSTICK					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	YEL	PWR 5V	20 AWG	GXL	JS295 (7)
2	WHT	43-1 TRIGGER	20 AWG	GXL	X298 (J)
3					
4	WHT	86 ST RIGHT SIG	20 AWG	GXL	X305 (15)
5	WHT	87 ST LEFT SIG	20 AWG	GXL	X305 (14)
6					
7	WHT	88 JOY 5V	20 AWG	GXL	X305 (16)
7	YEL	PWR 5V	20 AWG	GXL	JS295 (1)
8	WHT	89 JOY GND	20 AWG	GXL	X305 (17)
9	WHT	90 JOY SIG	20 AWG	GXL	X305 (18)

X305 - PLT MODULE					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	YEL	PWR	20 AWG	GXL	S303 (2)
2	BLK	1-42 PLT GND	20 AWG	GXL	S769 (1)
3	YEL	1-5 CAN HIGH	20 AWG	GXL	X298 (E)
4	GRN	1-5 CAN LOW	20 AWG	GXL	X298 (F)
5	WHT	81 SERIES DRIVE	20 AWG	GXL	SW301 (1)
6	WHT	84 IN/OUT SIG	20 AWG	GXL	SW300-1 (1)
7	WHT	85 HORN SIG	20 AWG	GXL	SW299-1 (1)
8	WHT	82 DRIVE SELECT	20 AWG	GXL	SW302 (3)
9	WHT	83 LIFT SELECT	20 AWG	GXL	SW302 (1)
10	WHT	98 DRV CUTOUT	20 AWG	GXL	X298 (N)
11					
12	WHT	80 PLT ALARM	20 AWG	GXL	AH306- (1)
13	WHT	43-2 TRIGGER	20 AWG	GXL	X298 (K)
14	WHT	87 ST LEFT SIG	20 AWG	GXL	JS295 (5)
15	WHT	86 ST RIGHT SIG	20 AWG	GXL	JS295 (4)
16	WHT	88 JOY 5V	20 AWG	GXL	JS295 (7)
17	WHT	89 JOY GND	20 AWG	GXL	JS295 (8)
18	WHT	90 JOY SIG	20 AWG	GXL	JS295 (9)
19					
20					

SW296-1 - E-STOP					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	RED	2-6 PLT MODE	20 AWG	GXL	X298 (C)

SW296-2 - E-STOP					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
2	RED	2-5-1 BATT PWR	20 AWG	GXL	X298 (B)

AH306+ - PLT ALARM					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	YEL	PWR	20 AWG	GXL	S303 (2)

AH306- - PLT ALARM					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	WHT	80 PLT ALARM	20 AWG	GXL	X305 (12)

SW299-1 - HORN SW					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	WHT	85 HORN SIG	20 AWG	GXL	X305 (7)

SW299-2 - HORN SW					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	YEL	PWR	20 AWG	GXL	S304 (2)

X770 - USB CHARGER NEG					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	BLK	1-43 PLT GND	20 AWG	GXL	S769 (2)

X298 - PLT CONN					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
A	BLK	1-41 PLT GND	20 AWG	GXL	S769 (2)
B	RED	2-5-1 BATT PWR	20 AWG	GXL	SW296-2 (2)
C	RED	2-6 PLT MODE	20 AWG	GXL	SW296-1 (1)
D	YEL	3-41 PLT PWR	20 AWG	GXL	S303 (2)
E	YEL	1-5 CAN HIGH	20 AWG	GXL	X305 (3)
F	GRN	1-5 CAN LOW	20 AWG	GXL	X305 (4)
G					
H					
J	WHT	43-1 TRIGGER	20 AWG	GXL	JS295 (2)
K	WHT	43-2 TRIGGER	20 AWG	GXL	X305 (13)
L					

X298 - PLT CONN					
CONN POS	WIRE COLOR	WIRE LABEL	GAUGE	JACKET	TO
M					
N	WHT	98 DRV CUTOUT	20 AWG	GXL	X305 (10)
P	YEL	PWR	20 AWG	GXL	S303 (2)

SW301 - PARALLEL/SERIES					
CONN POS	WIRE COLOR	WIRE LABEL	GAUGE	JACKET	TO
1	WHT	81 SERIES DRIVE	20 AWG	GXL	X305 (5)
2	YEL	PWR	20 AWG	GXL	S304 (1)
3					
4					
5					
6					

SW302 - DRIVE/LIFT					
CONN POS	WIRE COLOR	WIRE LABEL	GAUGE	JACKET	TO
1	WHT	83 LIFT SELECT	20 AWG	GXL	X305 (9)
2	YEL	PWR	20 AWG	GXL	S304 (1)
3	WHT	82 DRIVE SELECT	20 AWG	GXL	X305 (8)
4					
5					
6					

S303 - SPLICE					
CONN POS	WIRE COLOR	WIRE LABEL	GAUGE	JACKET	TO
1	YEL	PWR	20 AWG	GXL	S304 (1)
2	YEL	3-41 PLT PWR	20 AWG	GXL	X298 (D)
2	YEL	PWR	20 AWG	GXL	AH306+ (1)
2	YEL	PWR	20 AWG	GXL	X298 (P)
2	YEL	PWR	20 AWG	GXL	X305 (1)
2	YEL	PWR	20 AWG	GXL	X771 (1)

S304 - SPLICE					
CONN POS	WIRE COLOR	WIRE LABEL	GAUGE	JACKET	TO
1	YEL	PWR	20 AWG	GXL	S303 (1)
1	YEL	PWR	20 AWG	GXL	SW301 (2)
1	YEL	PWR	20 AWG	GXL	SW302 (2)

S304 - SPLICE					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
2	YEL	PWR	20 AWG	GXL	SW299-2 (1)
2	YEL	PWR	20 AWG	GXL	SW300-2 (1)

SW300-1 - INDOOR/OUTDOOR					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	WHT	84 IN/OUT SIG	20 AWG	GXL	X305 (6)

SW300-2 - INDOOR/OUTDOOR					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	YEL	PWR	20 AWG	GXL	S304 (2)

S769 - SPLICE					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	BLK	1-42 PLT GND	20 AWG	GXL	X305 (2)
2	BLK	1-41 PLT GND	20 AWG	GXL	X298 (A)
2	BLK	1-43 PLT GND	20 AWG	GXL	X770 (1)

X771 - USB CHARGER POS					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	YEL	PWR	20 AWG	GXL	S303 (2)

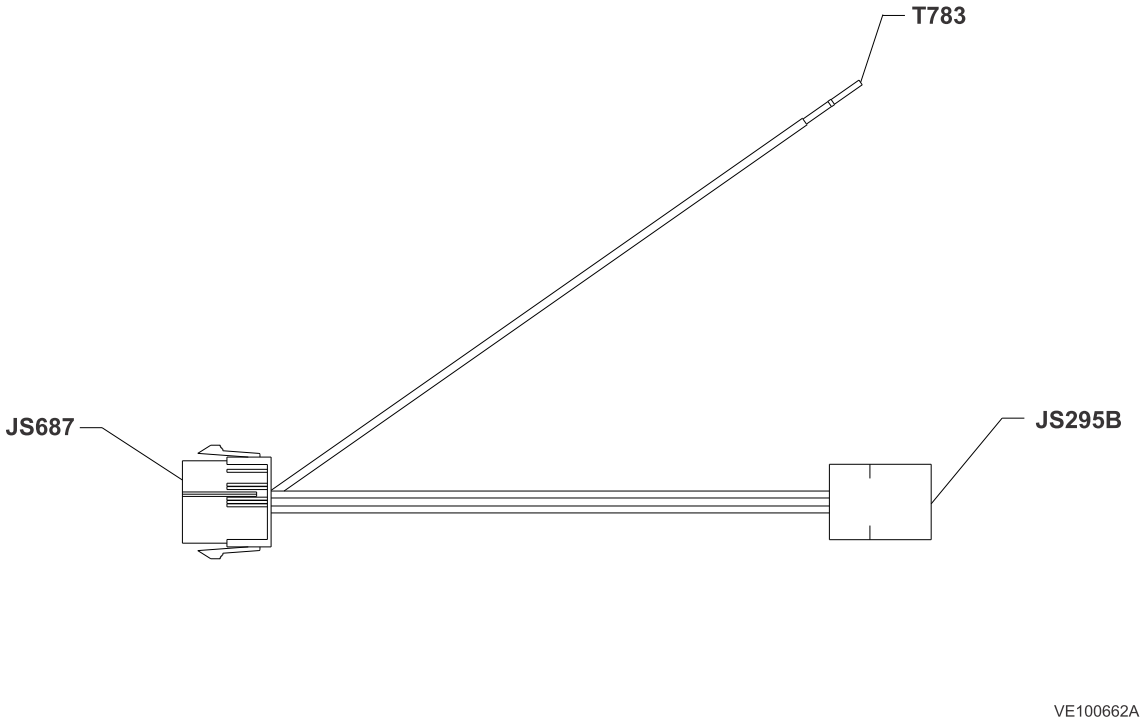

Figure 54. Joystick Jumper harness

JS687 - JOYSTICK					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	WHT	JOY 5V	20 AWG	GXL	JS295B (7)
2	WHT	JOY GND	20 AWG	GXL	JS295B (8)
3	WHT	JOY A/B SIGNAL	20 AWG	GXL	JS295B (9)
4	WHT	JOY C/D SIGNAL	20 AWG	GXL	T783 (1)
5	YEL	PWR 5V	20 AWG	GXL	JS295B (1)
6	WHT	43-1 TRIGGER	20 AWG	GXL	JS295B (2)
7					
8					
9					
10					

T783 - TO X305(19)					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	WHT	JOY C/D SIGNAL	20 AWG	TXL	JS687 (4)

JS295B - TO JS295					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	YEL	PWR 5V	20 AWG	GXL	JS687 (5)
2	WHT	43-1 TRIGGER	20 AWG	GXL	JS687 (6
3					
4					
5					
6					
7	WHT	JOY 5V	20 AWG	GXL	JS687 (1)
8	WHT	JOY GND	20 AWG	GXL	JS687 (2)
9	WHT	JOY A/B SIGNAL	20 AWG	GXL	JS687 (3)

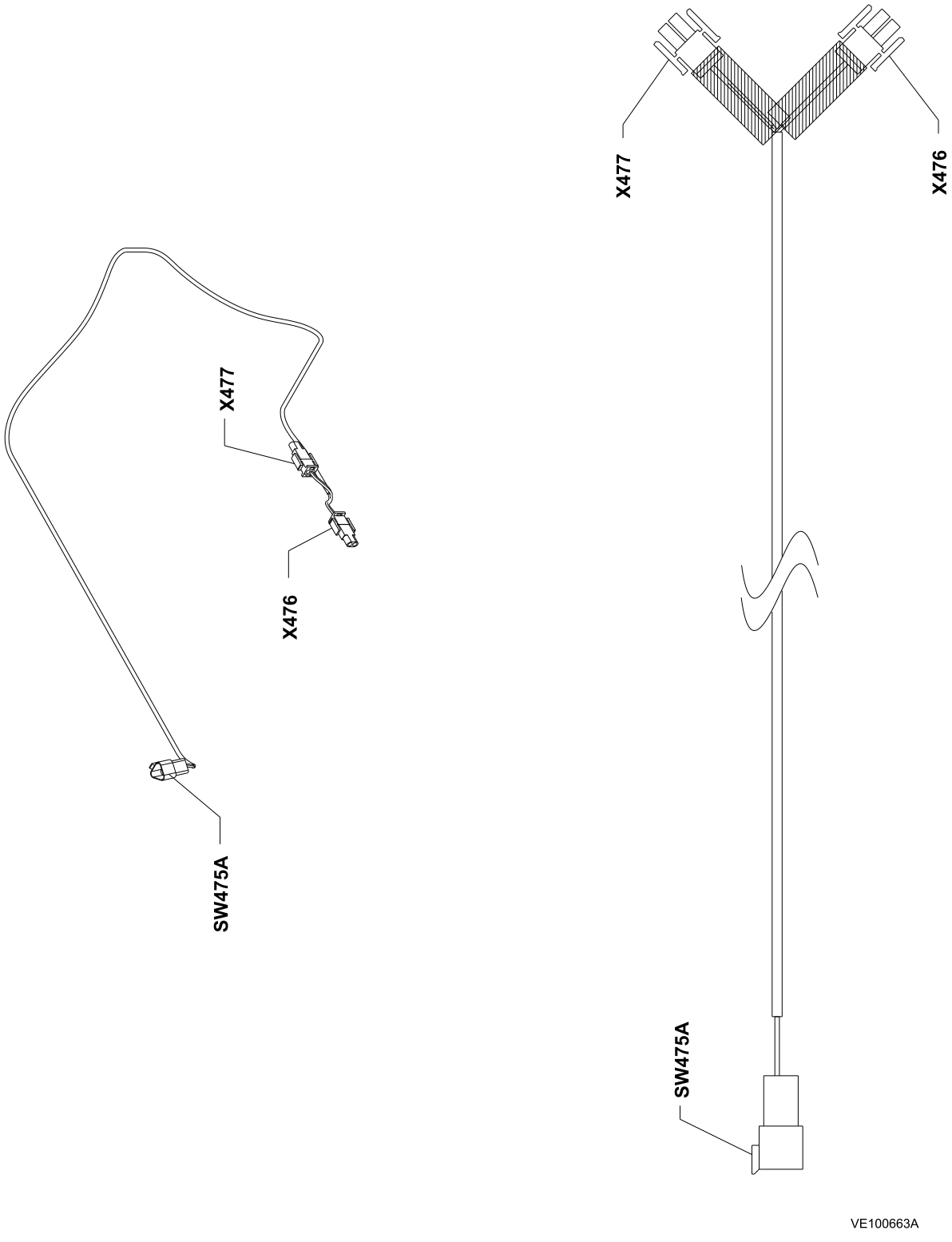

Figure 55. Gate Alarm Harness

X477 - TO RIGHT GATE ALARM					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	WHT	JUMPER	18 AWG	GXL	X476 (2)
2	BLK	GATE ALARM PWR	18 AWG	CABLE	SW475A (B)

SW475A - TO SW475 (PLAT CNTRL CABLE)					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
A	WHT	GATE ALARM SIG	18 AWG	CABLE	X476 (1)
B	BLK	GATE ALARM PWR	18 AWG	CABLE	X477 (2)
C					

X476 - TO LEFT GATE ALARM					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	WHT	GATE ALARM SIG	18 AWG	CABLE	SW475A (A)
2	WHT	JUMPER	18 AWG	GXL	X477 (1)

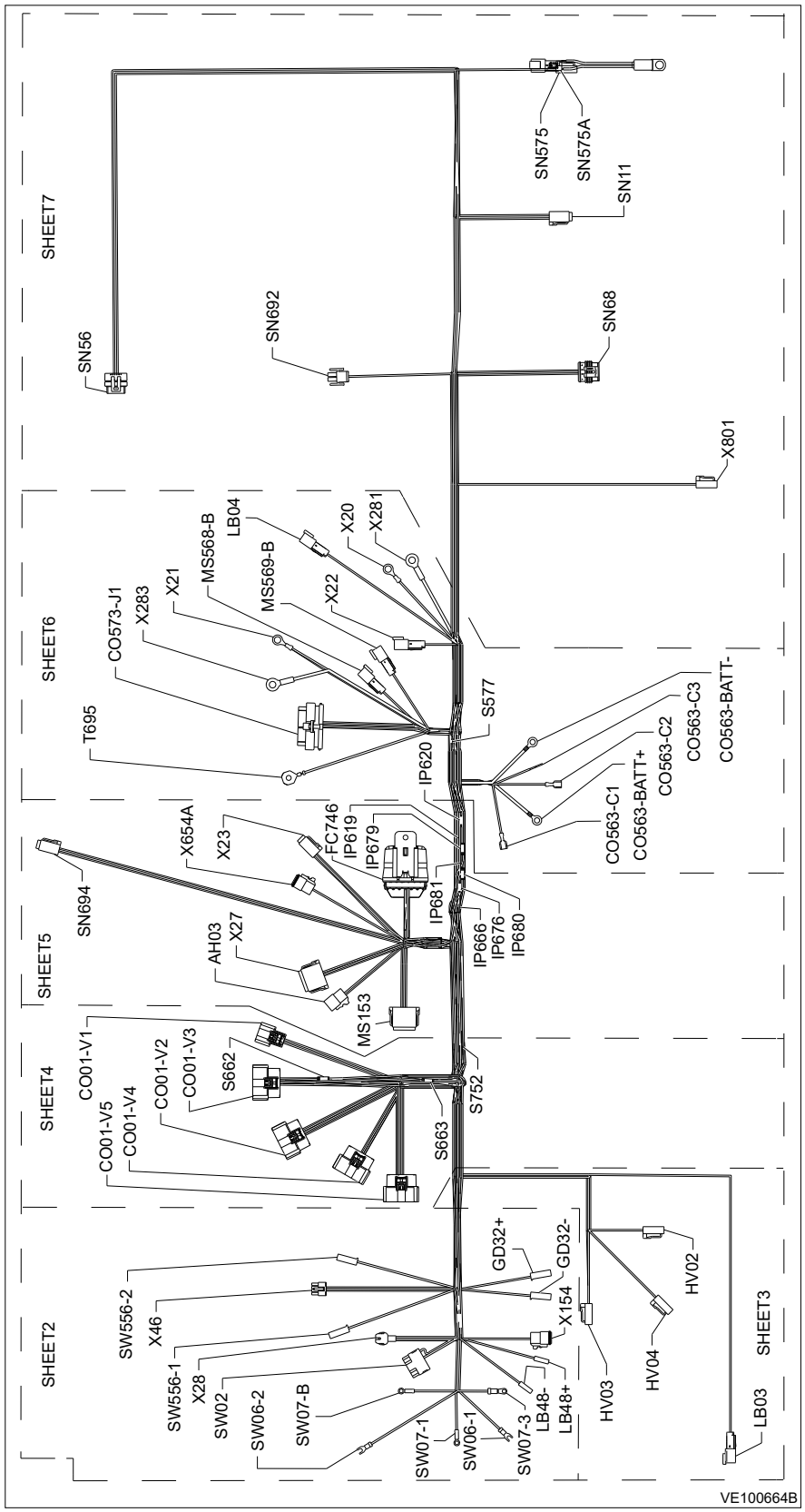

Figure 56. Chassis Harness – Sheet 1 of 8

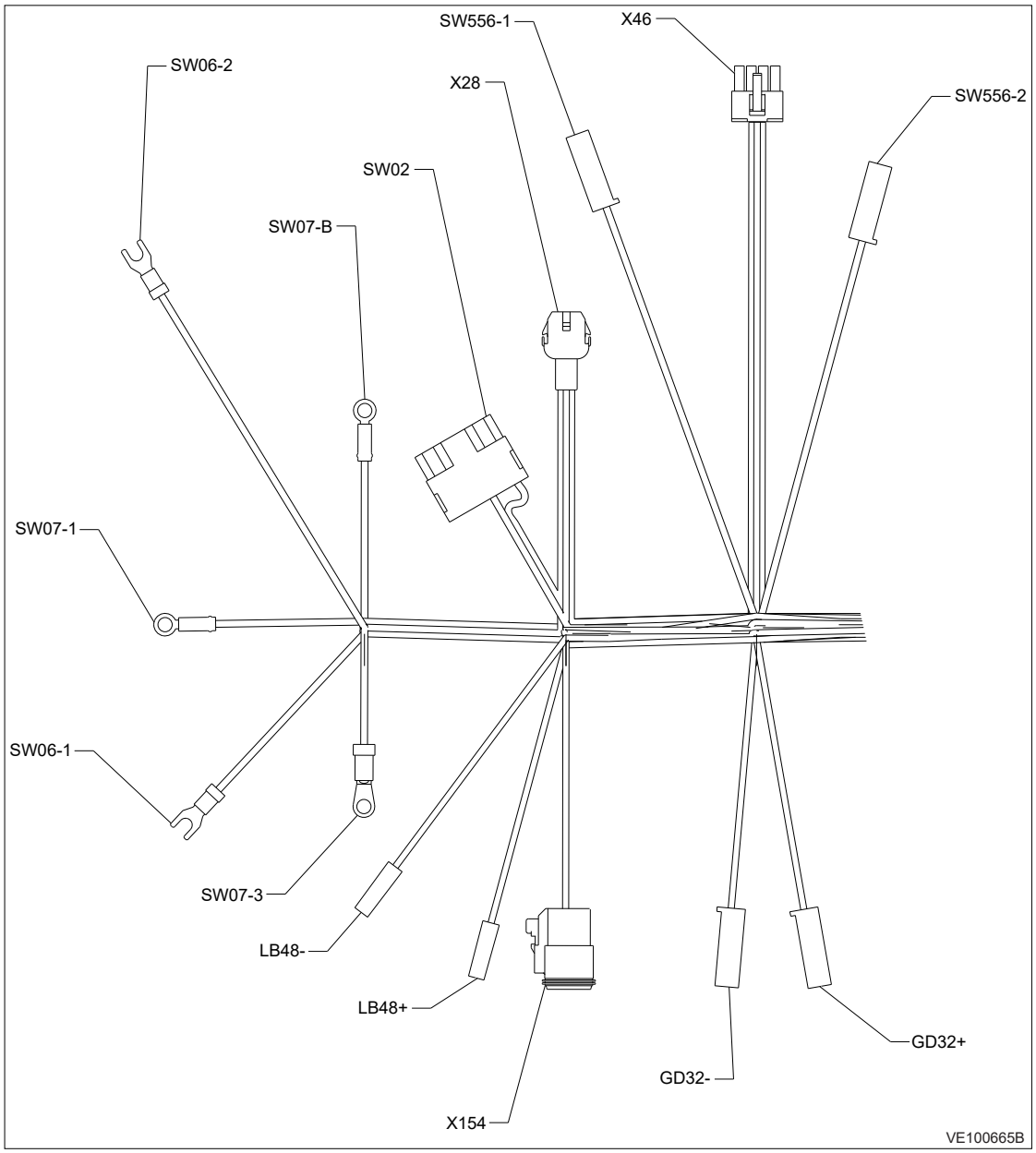

Figure 57. Chassis Harness – Sheet 2 of 8

SW07-1 - PLT MODE					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	YEL	2-5 PLT MODE	18 AWG	GXL	S752 (2)

SW06-1 - EMS PWR					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	YEL	2-12 PWR	18 AWG	GXL	FC746 (2)

SW06-2 - EMS GND					
CONN POS	WIRE COLOR	WIRE LABEL	GAUGE	JACKET	TO
2	YEL	2-1 GND EMS	18 AWG	GXL	CO01-V4 (8)
2	YEL	2-2 GND EMS	18 AWG	GXL	SW07-B (1)

SW07-B - KEYSWITCH					
CONN POS	WIRE COLOR	WIRE LABEL	GAUGE	JACKET	TO
1	YEL	2-2 GND EMS	18 AWG	GXL	SW06-2 (2)

SW07-3 - GROUND MODE					
CONN POS	WIRE COLOR	WIRE LABEL	GAUGE	JACKET	TO
1	YEL	2-3 GND MODE	18 AWG	GXL	CO01-V1 (5)
1	YEL	2-4 GND MODE	18 AWG	GXL	SW02 (2)

SW02 - LIFT SWITCH					
CONN POS	WIRE COLOR	WIRE LABEL	GAUGE	JACKET	TO
1	WHT	5 LIFT UP SW	18 AWG	GXL	CO01-V4 (9)
2	YEL	2-4 GND MODE	18 AWG	GXL	SW07-3 (1)
3	WHT	4 LIFT DN SW	18 AWG	GXL	CO01-V4 (10)
4					
5					
6					

SW556-1 - BRAKE RELEASE SW					
CONN POS	WIRE COLOR	WIRE LABEL	GAUGE	JACKET	TO
1	YEL	3-28 BRK REL IGN	18 AWG	GXL	CO01-V2 (7)

SW556-2 - BRAKE RELEASE SW					
CONN POS	WIRE COLOR	WIRE LABEL	GAUGE	JACKET	TO
1	WHT	104 BRK RELEASE	18 AWG	GXL	CO573-J1 (32)

X28 - ANALYZER					
CONN POS	WIRE COLOR	WIRE LABEL	GAUGE	JACKET	TO
1	YEL	3-21 ANL IGN	20 AWG	GXL	CO01-V5 (11)
2	WHT	23 RX	20 AWG	GXL	CO01-V1 (7)
3	WHT	24 TX	20 AWG	GXL	CO01-V1 (6)
4	BLK	1-22 ANL GND	20 AWG	GXL	CO01-V5 (1)

X154 - CANBUS DIAGNOSTIC					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
A	YEL	CAN1-6 HIGH	20 AWG	GXL	MS153 (9)
B	GRN	CAN1-6 LOW	20 AWG	GXL	MS153 (12)
C					

LB48- - OVRLD LIGHT SIG (SILVER					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	WHT	42 OVLD LIGHT SIG	20 AWG	GXL	CO01-V4 (14)

GD32+ - HOURMETER					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	WHT	40 HOURMETER	20 AWG	GXL	CO01-V2 (10)

X46 - MDI					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	YEL	CAN1-3 HIGH	20 AWG	GXL	MS153 (6)
2	GRN	CAN1-3 LOW	20 AWG	GXL	MS153 (3)
3					
4					
5	YEL	3-27 MDI IGN	20 AWG	GXL	CO01-V2 (12)
6					
7					
8	BLK	1-27 MDI GND	20 AWG	GXL	CO01-V2 (11)

LB48+ - OVRLD LIGHT IGN (GOLD)					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	YEL	2-42 OVLD LIGHT IGN	20 AWG	GXL	CO01-V4 (15)

GD32- - HOURMETER GND					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	BLK	1 - 40 HOURMETER GND	20 AWG	GXL	CO01-V2 (20)

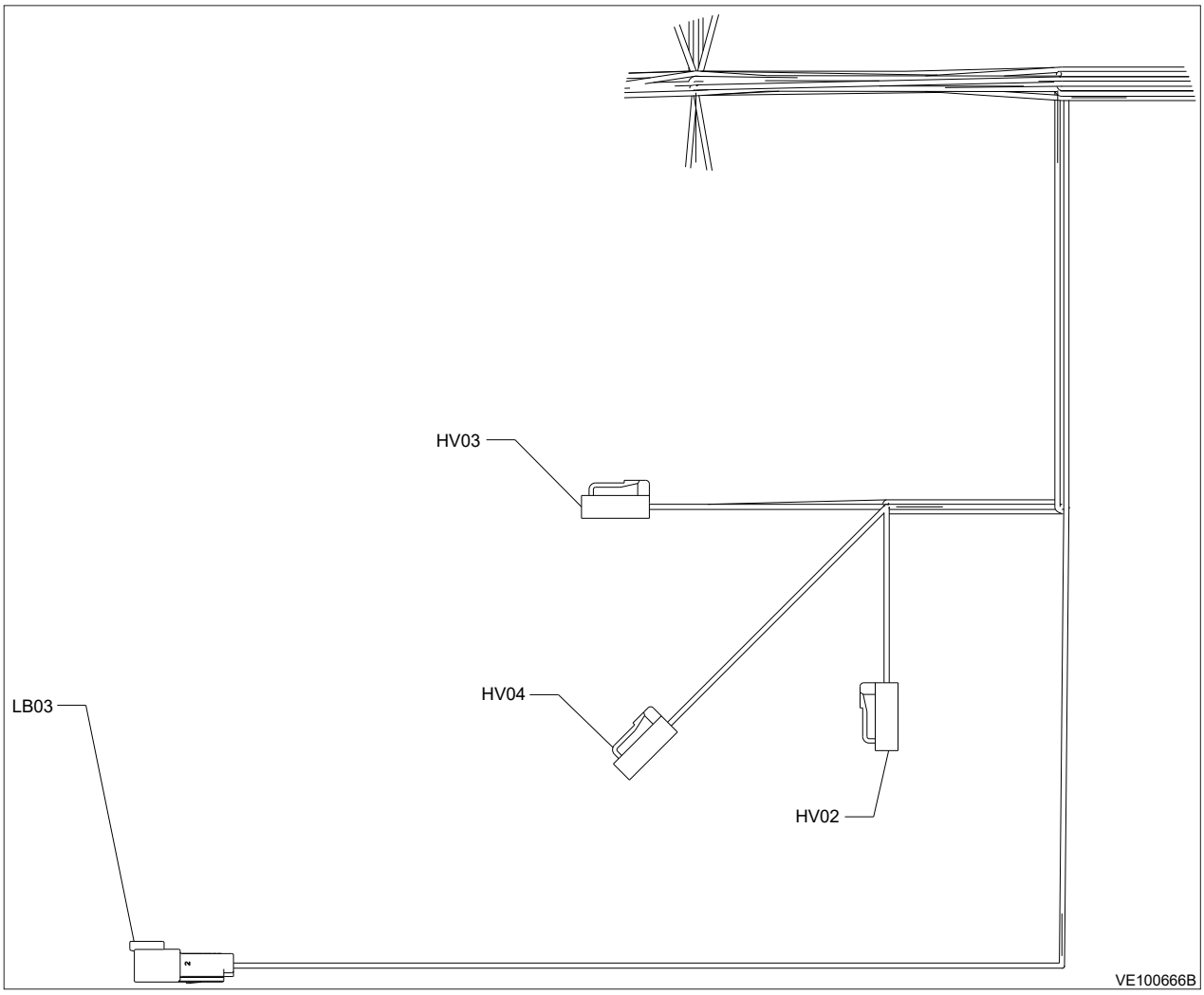

Figure 58. Chassis Harness – Sheet 3 of 8

HV03 - STEER LEFT VLV					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	WHT	34 ST LEFT VLV	20 AWG	GXL	CO01-V5 (10)
2	BLK	1-34 ST LEFT GND	20 AWG	GXL	CO01-V5 (9)

HV04 - STEER RIGHT VLV					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	WHT	35 ST RIGHT VLV	20 AWG	GXL	CO01-V5 (20)
2	BLK	1-35 ST RIGHT GND	20 AWG	GXL	CO01-V5 (19)

HV02 - LIFT UP VLV					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	WHT	33 LIFT UP VLV	20 AWG	GXL	CO01-V4 (2)
2	BLK	1-33 LIFT UP GND	20 AWG	GXL	CO01-V4 (1)

LB03 - BEACON					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	WHT	62-2 BEACON	20 AWG	GXL	S662 (1)
2	BLK	1-48 BEACON GND	20 AWG	GXL	S663 (1)

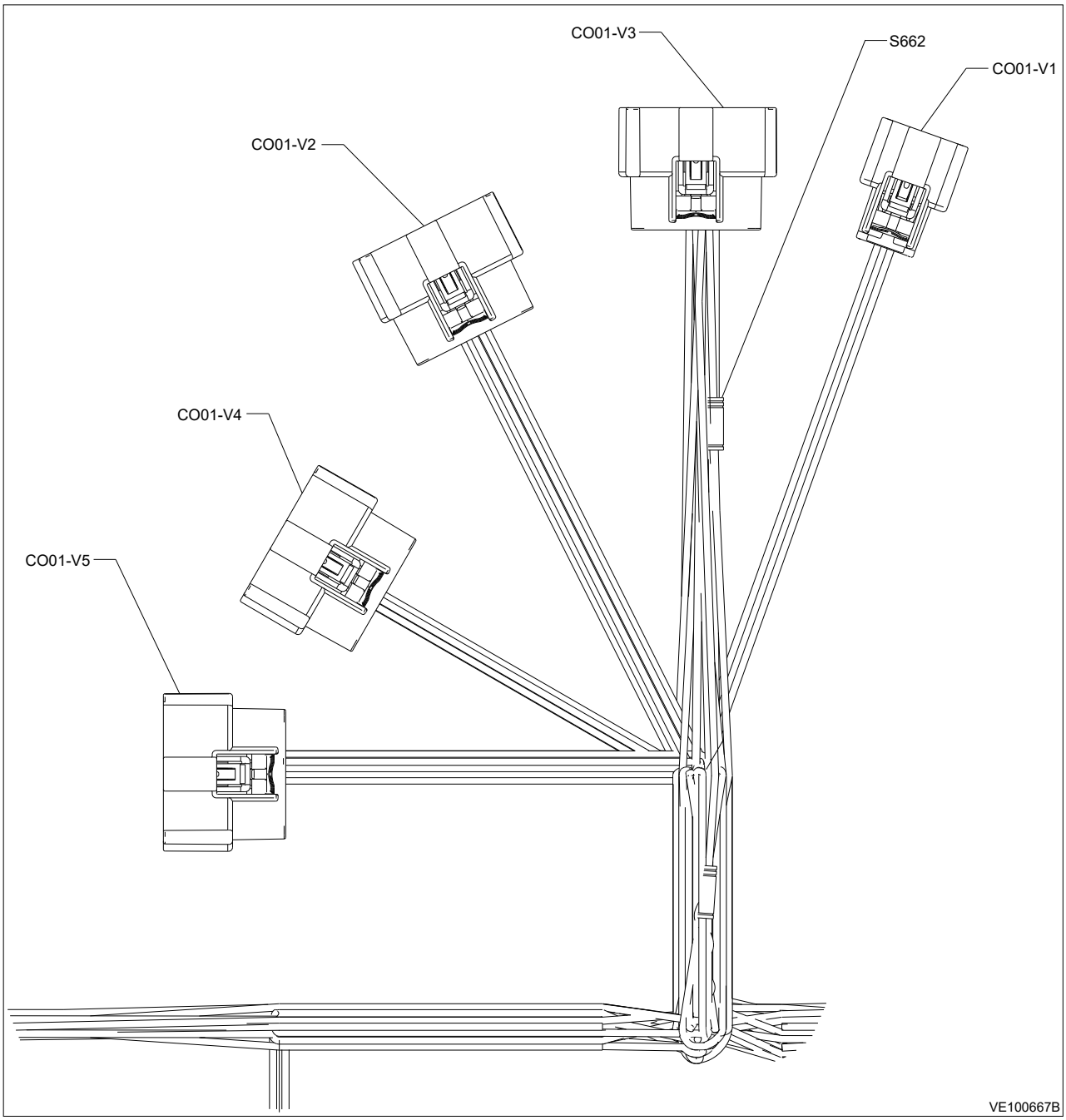

Figure 59. Chassis Harness – Sheet 4 of 8

CO01-V3 - LOGIC MODULE					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	WHT	72 GND ANGLE 1	18 AWG	GXL	SN56 (A)
2	WHT	68 ANGLE 1	18 AWG	GXL	SN56 (C)
3	WHT	70 5V ANGLE 1	18 AWG	GXL	SN56 (B)
4					
5					

CO01-V3 - LOGIC MODULE					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
6					
7	WHT	96 ELEVSEN3 SW	20 AWG	GXL	SN694 (4)
8	WHT	92 LSS SW1	20 AWG	GXL	X27 (8)
9					
10					
11	WHT	73 GND ANGLE 2	18 AWG	GXL	SN56 (E)
12	WHT	69 ANGLE 2	18 AWG	GXL	SN56 (D)
13	WHT	71 5V ANGLE 2	18 AWG	GXL	SN56 (F)
14					
15					
16					
17	WHT	79 ELEVSEN1 SW	20 AWG	GXL	SN692 (2)
18	YEL	ELEVSEN1 SW PWR	20 AWG	GXL	IP679 (2)
19	WHT	62 BEACON	20 AWG	GXL	S662 (2)
20	BLK	1-46 BEACON GND	20 AWG	GXL	S663 (2)

CO01-V3 - LOGIC MODULE					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1					
2	WHT	75 LSS SW2	20 AWG	GXL	X27 (7)
3					
4	BLK	1-3 TILT GND	20 AWG	GXL	SN68 (2)
5	YEL	3-3 TILT IGN	20 AWG	GXL	SN68 (1)
6					
7	YEL	3-28 BRK REL IGN	18 AWG	GXL	SW556-1 (1)
8	YEL	74-1 LSS SW2 PWR	20 AWG	GXL	IP666 (2)
9					
10	WHT	40 HOURMETER	20 AWG	GXL	GD32+ (1)
11	BLK	1-27 MDI GND	20 AWG	GXL	X46 (8)
12	YEL	3-27 MDI IGN	20 AWG	GXL	X46 (5)
13	WHT	6 P MAIN CON	20 AWG	GXL	X22 (1)
14	BLK	1-14 GND ALARM GND	20 AWG	GXL	AH03 (C)
15	YEL	3-14 GND ALARM IGN	20 AWG	GXL	AH03 (A)
16	WHT	14 GND ALARM	20 AWG	GXL	AH03 (B)
17					

CO01-V3 - LOGIC MODULE					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
18					
19	YEL	76 ELEVSEN2 SW PWR	20 AWG	GXL	IP680 (2)
20	BLK	1-40 HOURMETER GND	20 AWG	GXL	GD32- (1)

S663					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	BLK	1-47 BEACON GND	20 AWG	GXL	LB04 (2)
1	BLK	1-47 BEACON GND	20 AWG	GXL	LB03 (2)
2	BLK	1-47 BEACON GND	20 AWG	GXL	CO01-V3 (20)

S662					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	WHT	62-1 BEACON	20 AWG	GXL	LB04 (1)
1	WHT	62-2 BEACON	20 AWG	GXL	LB03 (1)
2	WHT	62 BEACON	20 AWG	GXL	CO01-V3 (19)

CO01-V4 - LOGIC MODULE					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	BLK	1-33 LIFT UP GND	20 AWG	GXL	HV02 (2)
2	WHT	33 LIFT UP VLV	20 AWG	GXL	HV02 (1)
3	WHT	20 P LIFT DN	20 AWG	GXL	X801 (1)
4					
5					
6					
7					
8	YEL	2-1 GND EMS	18 AWG	GXL	SW06-2 (2)
9	WHT	5 LIFT UP SW	18 AWG	GXL	SW02 (3)
10	WHT	4 LIFT DN SW	18 AWG	GXL	SW02 (1)
11					
12					
13	WHT	19 N LIFT DN	20 AWG	GXL	X801 (2)
14	WHT	42 OVLD LIGHT SIG	20 AWG	GXL	LB48- (1)
15	YEL	2-42 OVLD LIGHT IGN	20 AWG	GXL	LB48+ (1)
16					
17					
18					

CO01-V4 - LOGIC MODULE					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
19					
20	WHT	2-6 PLT MODE	20 AWG	GXL	X27 (2)

CO01-V5 - LOGIC MODULE					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	BLK	1-22 ANL GND	20 AWG	GXL	X28 (4)
2	WHT	2-35 PHP SW2	18 AWG	GXL	SN11 (4)
3	YEL	3-35 PHP SW2 PWR	18 AWG	GXL	IP619 (2)
4	YEL	3-5 TEL IGN	20 AWG	GXL	X23 (3)
5	YEL	3-10 PWR MOD IGN	20 AWG	GXL	CO573-J1 (10)
6	WHT	41 PLT PWR	20 AWG	GXL	X27 (3)
7					
8					
9	BLK	1-34 ST LEFT GND	20 AWG	GXL	HV03 (2)
10	WHT	34 ST LEFT VLV	20 AWG	GXL	HV03 (1)
11	YEL	3-21 ANL IGN	20 AWG	GXL	X28 (1)
12	WHT	2-34 PHP SW1	18 AWG	GXL	SN11 (3)
13	YEL	3-34 PHP SW1 PWR	18 AWG	GXL	IP620 (2)
14	YEL	95 ELEVSEN3 SW PWR	20 AWG	GXL	IP681 (2)
15	YEL	91-1 LSS SW1 PWR	18 AWG	GXL	IP676 (2)
16	BLK	1-41 PLT GND	20 AWG	GXL	X27 (4)
17					
18					
19	BLK	1-35 ST RIGHT GND	20 AWG	GXL	HV04 (2)
20	WHT	35 ST RIGHT VLV	20 AWG	GXL	HV04 (1)

CO01-V1 - LOGIC MODULE					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	BLK	1 GND	18 AWG	GXL	X21 (1)
2	GRN	CAN2-1 LOW	20 AWG	GXL	X654A (B)
3	YEL	CAN2-1 HIGH	20 AWG	GXL	X654A (A)
4	GRN	CAN1-1 LOW	20 AWG	GXL	MS153 (1)
5	YEL	2-3 GND MODE	18 AWG	GXL	SW07-3 (1)
6	WHT	24 TX	20 AWG	GXL	X28 (3)

CO01-V1 - LOGIC MODULE					
CONN POS	WIRE COLOR	WIRE LABEL	GAUGE	JACKET	TO
7	WHT	23 RX	20 AWG	GXL	X28 (2)
8	YEL	CAN1-1 HIGH	20 AWG	GXL	MS153 (4)

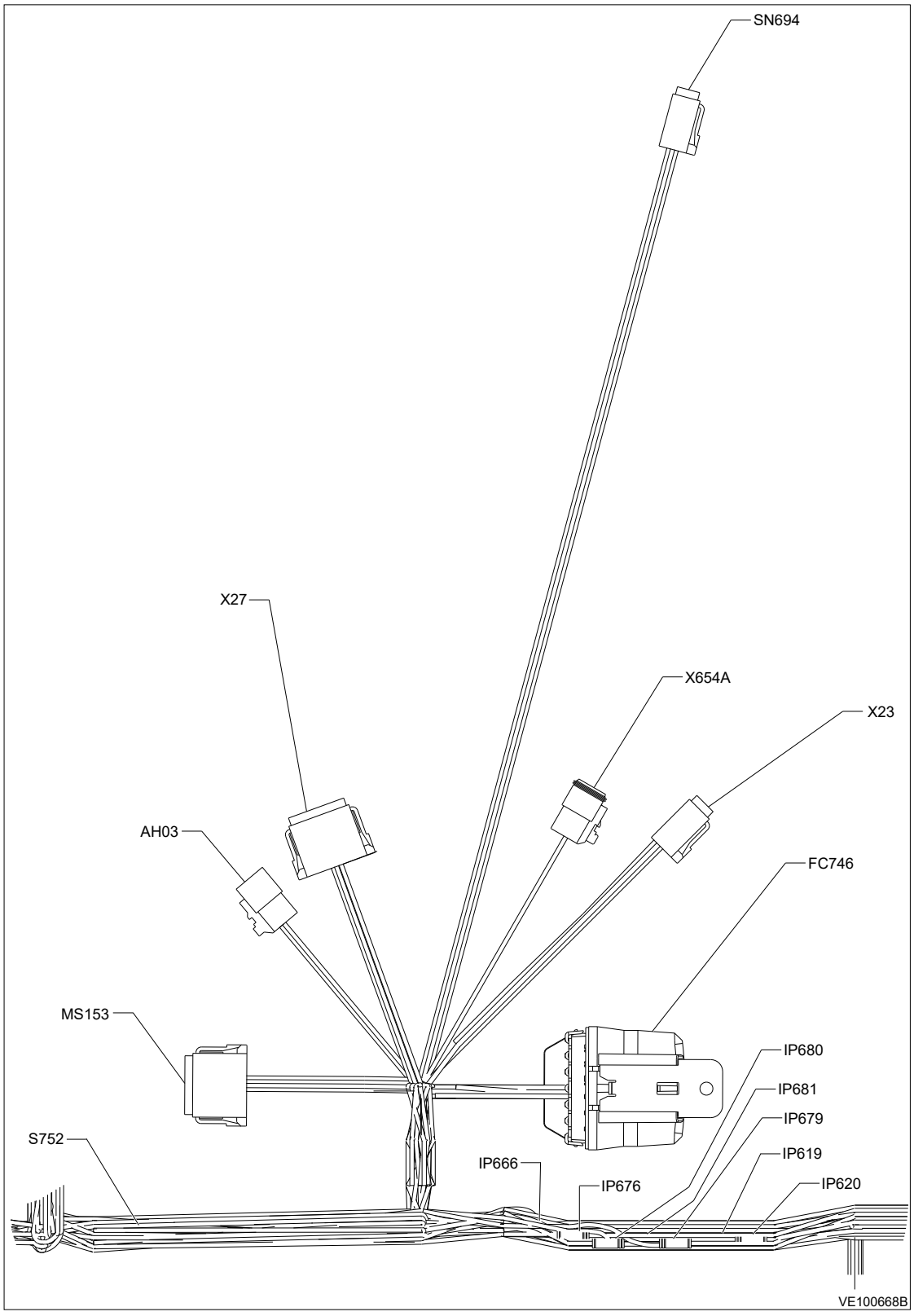

Figure 60. Chassis Harness – Sheet 5 of 8

IP666 - DIODE-6A					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	YEL	74 LSS SW2 PWR	20 AWG	GXL	X27 (10)
2	YEL	74-1 LSS SW2 PWR	20 AWG	GXL	CO01-V2 (8)

IP676 - DIODE-6A					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	YEL	91 LSS SW1 PWR	20 AWG	GXL	X27 (9)
2	YEL	91-1 LSS SW1 PWR	18 AWG	GXL	CO01-V5 (15)

IP679 - DIODE-6A					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	YEL	78-1 ELEVSEN1 SW PWR	20 AWG	GXL	SN692 (1)
2	YEL	78 ELEVSEN1 SW PWR	20 AWG	GXL	CO01-V3 (18)

X27 - PLATFORM					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	YEL	2-7 PLT MODE	18 AWG	GXL	FC746 (8)
2	WHT	2-6 PLT MODE	20 AWG	GXL	CO01-V4 (20)
3	WHT	41 PLT PWR	20 AWG	GXL	CO01-V5 (6)
4	BLK	1-41 PLT GND	20 AWG	GXL	CO01-V5 (16)
5	YEL	CAN1-5 HIGH	20 AWG	GXL	MS153 (8)
6	GRN	CAN1-5 LOW	20 AWG	GXL	MS153 (11)
7	WHT	75 LSS SW2	20 AWG	GXL	CO01-V2 (2)
8	WHT	92 LSS SW1	20 AWG	GXL	CO01-V3 (8)
9	YEL	91 LSS SW1 PWR	20 AWG	GXL	IP676 (1)
10	YEL	74 LSS SW2 PWR	20 AWG	GXL	IP666 (1)
11					
12					

AH03 - GROUND ALARM					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
A	YEL	3-14 GND ALARM IGN	20 AWG	GXL	CO01-V2 (15)
B	WHT	14 GND ALARM	20 AWG	GXL	CO01-V2 (16)
C	BLK	1-14 GND ALARM GND	20 AWG	GXL	CO01-V2 (14)

MS153 - CAN BUSS BAR					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	GRN	CAN1-1 LOW	20 AWG	GXL	CO01-V1 (4)
2	GRN	CAN1-2 LOW	20 AWG	GXL	SN68 (4)
3	GRN	CAN1-3 LOW	20 AWG	GXL	X46 (2)
4	YEL	CAN1-1 HIGH	20 AWG	GXL	CO01-V1 (8)
5	YEL	CAN1-2 HIGH	20 AWG	GXL	SN68 (3)
6	YEL	CAN1-3 HIGH	20 AWG	GXL	X46 (1)
7	YEL	CAN1-4 HIGH	20 AWG	GXL	CO573-J1 (28)
8	YEL	CAN1-5 HIGH	20 AWG	GXL	X27 (5)
9	YEL	CAN1-6 HIGH	20 AWG	GXL	X154 (A)
10	GRN	CAN1-4 LOW	20 AWG	GXL	CO573-J1 (27)
11	GRN	CAN1-5 LOW	20 AWG	GXL	X27 (6)
12	GRN	CAN1-6 LOW	20 AWG	GXL	X154 (B)

SN694 - ELEVATION SENSOR 2&3					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	YEL	95-1 ELEVSEN3 SW PWR	20 AWG	GXL	IP681 (1)
2	YEL	76-1 ELEVSEN2 SW PWR	20 AWG	GXL	IP680 (1)
3	WHT	77 ELEVSEN2 SW	20 AWG	GXL	CO573-J1 (31)
4	WHT	96 ELEVSEN3 SW	20 AWG	GXL	CO01-V3 (7)

IP680 - DIODE-6A					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	YEL	76-1 ELEVSEN2 SW PWR	20 AWG	GXL	SN694 (2)
2	YEL	76 ELEVSEN2 SW PWR	20 AWG	GXL	CO01-V2 (19)

X654A - CAN2 PLUG					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
A	YEL	CAN2-1 HIGH	20 AWG	GXL	CO01-V1 (3)
B	GRN	CAN2-1 LOW	20 AWG	GXL	CO01-V1 (2)
C					

X23 - TELEMATICS					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	RED	2-11 TEL PWR	18 AWG	GXL	FC746 (4)
2	BLK	1-1 TEL GND	18 AWG	GXL	X21 (1)

X23 - TELEMATICS					
CONN POS	WIRE COLOR	WIRE LABEL	GAUGE	JACKET	TO
3	YEL	3-5 TEL IGN	20 AWG	GXL	CO01-V5 (4)
4	YEL	2-8 PLT MODE	18 AWG	GXL	S752 (1)

FC746 - FUSE BOX					
CONN POS	WIRE COLOR	WIRE LABEL	GAUGE	JACKET	TO
1	YEL	2-9 PWR	18 AWG	GXL	X20 (1)
2	YEL	2-12 PWR	18 AWG	GXL	SW06-1 (1)
3	RED	2-10 PWR	18 AWG	GXL	X20 (1)
4	RED	2-11 TEL PWR	18 AWG	GXL	X23 (1)
5	RED	50 BRAKE	16 AWG	GXL	T695 (1)
6	RED	51 BRAKE	16 AWG	GXL	S577 (2)
9	YEL	2-13 PLATF MODE	18 AWG	GXL	S752 (1)
7	YEL	2-7 PLT MODE	18 AWG	GXL	X27 (1)
8					
9					
10					
11					
12					

S752					
CONN POS	WIRE COLOR	WIRE LABEL	GAUGE	JACKET	TO
1	YEL	2-8 PLT MODE	18 AWG	GXL	X23 (4)
1	YEL	2-13 PLATF MODE	18 AWG	GXL	FC746 (7)
2	YEL	2-5 PLT MODE	18 AWG	GXL	SW07-1 (1)

IP681 - DIODE-6A					
CONN POS	WIRE COLOR	WIRE LABEL	GAUGE	JACKET	TO
1	YEL	95-1 ELEVSEN3 SW PWR	20 AWG	GXL	SN694 (1)
2	YEL	95 ELEVSEN3 SW PWR	20 AWG	GXL	CO01-V5 (14)

IP619 - DIODE-6A					
CONN POS	WIRE COLOR	WIRE LABEL	GAUGE	JACKET	TO
1	YEL	3-35 PHP SW2 PWR	18 AWG	GXL	SN11 (1)
2	YEL	3-35 PHP SW2 PWR	18 AWG	GXL	FC746 (7)

IP620 - DIODE-6A					
CONN POS	WIRE COLOR	WIRE LABEL	GAUGE	JACKET	TO
1	YEL	3-34 PHP SW1 PWR	18 AWG	GXL	SN11 (2)
2	YEL	3-34 PHP SW1 PWR	18 AWG	GXL	CO01-V5 (13)

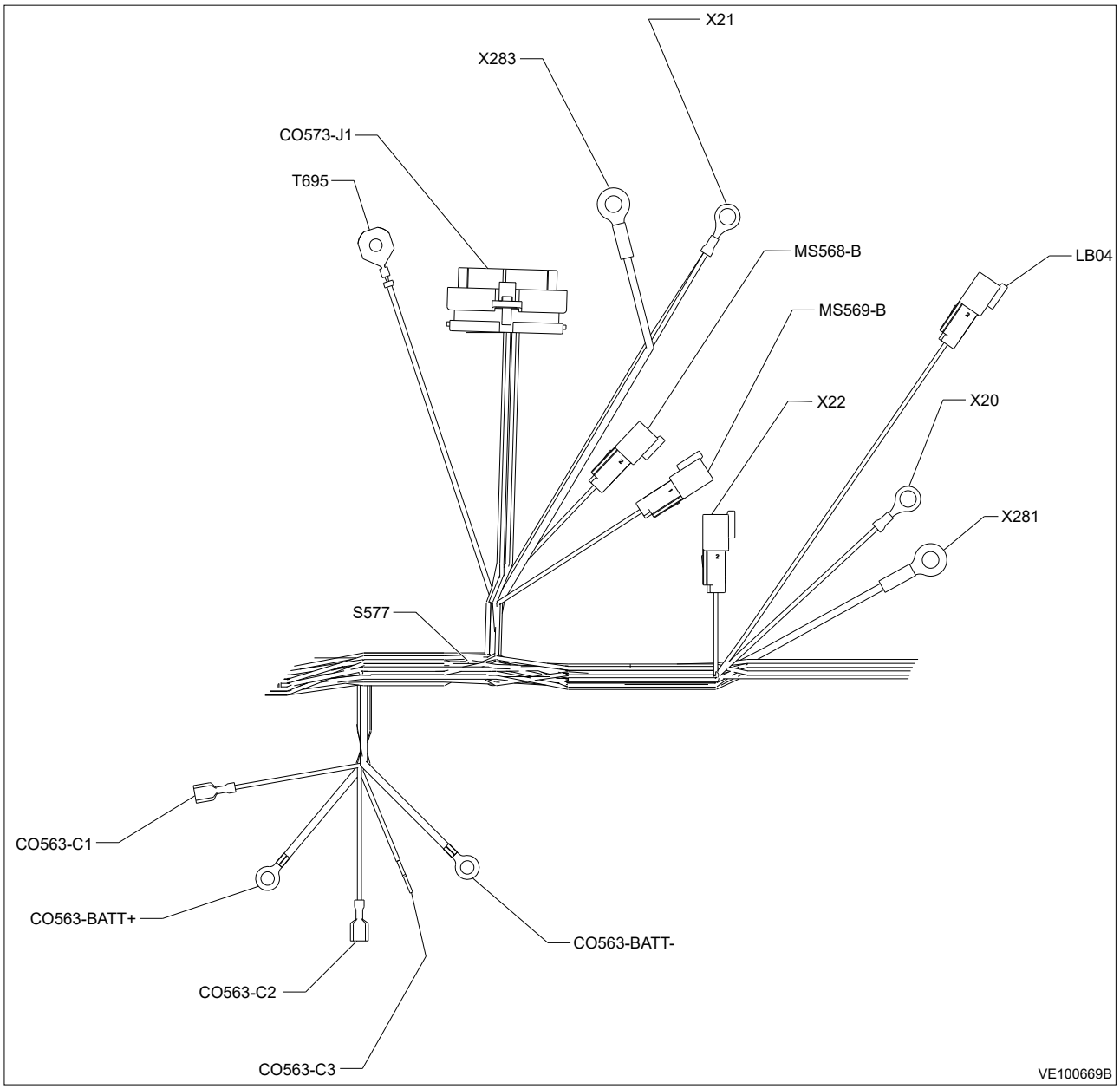

Figure 61. Chassis Harness – Sheet 6 of 8

T695 - TO BF+ DRIVE CONTROLLER					
CONN POS	WIRE COLOR	WIRE LABEL	GAUGE	JACKET	TO
1	RED	50 BRAKE	16 AWG	GXL	FC746 (5)

CO573-J1 - DRIVE CONTROLLER					
CONN POS	WIRE COLOR	WIRE LABEL	GAUGE	JACKET	TO
1					
2	WHT	56 P RBRAKE	20 AWG	GXL	MS568-B (1)
3	RED	52 BRAKE IN	16 AWG	GXL	S577 (1)
4	WHT	57 N RBRAKE	20 AWG	GXL	MS568-B (2)
5					
6					
7					
8					
9	WHT	55 N LBRAKE	20 AWG	GXL	MS569-B (2)
10	YEL	3-10 PWR MOD IGN	20 AWG	GXL	CO01-V5 (5)
11					
12	WHT	7 N MAIN CON	20 AWG	GXL	X22 (2)
13					
14					
15					
16					
17					
18					
19					
20	WHT	18 CHARGING STAT	20 AWG	GXL	CO563-C3 (1)
21					
22					
23					
24					
25					
26					
27	GRN	CAN1-4 LOW	20 AWG	GXL	MS153 (10)
28	YEL	CAN1-4 HIGH	20 AWG	GXL	MS153 (7)
29					
30					
31	WHT	77 ELEVSEN2 SW	20 AWG	GXL	SN694 (3)
32	WHT	104 BRK RELEASE	18 AWG	GXL	SW556-2 (1)
33					
34					
35					
NC					

CO563-C1 - BATT TEMP-					
CONN POS	WIRE COLOR	WIRE LABEL	GAUGE	JACKET	TO
1	WHT	93 BATT TEMP SENSE	20 AWG	GXL	SN575 (2)

CO563-BATT+ - BATT+					
CONN POS	WIRE COLOR	WIRE LABEL	GAUGE	JACKET	TO
1	WHT	BAT_POS CHARGER	12 AWG	GXL	X281 (1)

CO563-C2 - BATT TEMP+					
CONN POS	WIRE COLOR	WIRE LABEL	GAUGE	JACKET	TO
1	BLK	94 BATT TEMP SENSE	16 AWG	GXL	SN575 (1)

CO563-C3 - CHARGER INTERLOCK					
CONN POS	WIRE COLOR	WIRE LABEL	GAUGE	JACKET	TO
1	WHT	18 CHARGING STAT	20 AWG	GXL	CO573-J1 (20)

CO563-BATT- - BATT-					
CONN POS	WIRE COLOR	WIRE LABEL	GAUGE	JACKET	TO
1	BLK	B- CHARGER	12 AWG	GXL	B- CHARGER

MS568-B - RIGHT BRAKE					
CONN POS	WIRE COLOR	WIRE LABEL	GAUGE	JACKET	TO
1	WHT	56 P RBRAKE	20 AWG	GXL	CO573-J1 (2)
2	WHT	57 N RBRAKE	20 AWG	GXL	CO573-J1 (4)

MS569-B - LEFT BRAKE					
CONN POS	WIRE COLOR	WIRE LABEL	GAUGE	JACKET	TO
1	WHT	54 P LBRAKE	20 AWG	GXL	S577 (1)
2	WHT	55 N LBRAKE	20 AWG	GXL	CO573-J1 (9)

LB04 - BEACON					
CONN POS	WIRE COLOR	WIRE LABEL	GAUGE	JACKET	TO
1	WHT	62-1 BEACON	20 AWG	GXL	S662 (1)
2	BLK	1-47 BEACON GND	20 AWG	GXL	S663 (1)

X20 - CONTACTOR B+					
CONN POS	WIRE COLOR	WIRE LABEL	GAUGE	JACKET	TO
1	YEL	2-9 PWR	18 AWG	GXL	FC746 (1)
2	RED	2-10 PWR	18 AWG	GXL	FC746 (3)

X281 - CONTACTOR B+					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	WHT	BAT_POS CHARGER	12 AWG	GXL	CO563-BATT+ (1)

X21 - PMP CTRL B-					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	BLK	1 GND	18 AWG	GXL	CO01-V1 (1)
1	BLK	1-1 TEL GND	18 AWG	GXL	X23 (2)

X283 - DRIVE CONTROL B-					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	BLK	B- CHARGER	12 AWG	GXL	CO563-BATT- (1)

X22 - TO MAIN CONTACTOR					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	WHT	6 P MAIN CON	20 AWG	GXL	CO01-V2 (13)
2	WHT	7 N MAIN CON	20 AWG	GXL	CO573-J1 (12)

S577					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	RED	52 BRAKE IN	16 AWG	GXL	CO573-J1 (3)
1	WHT	54 P LBRAKE	20 AWG	GXL	MS569-B (1)
2	RED	51 BRAKE	16 AWG	GXL	FC746 (6)

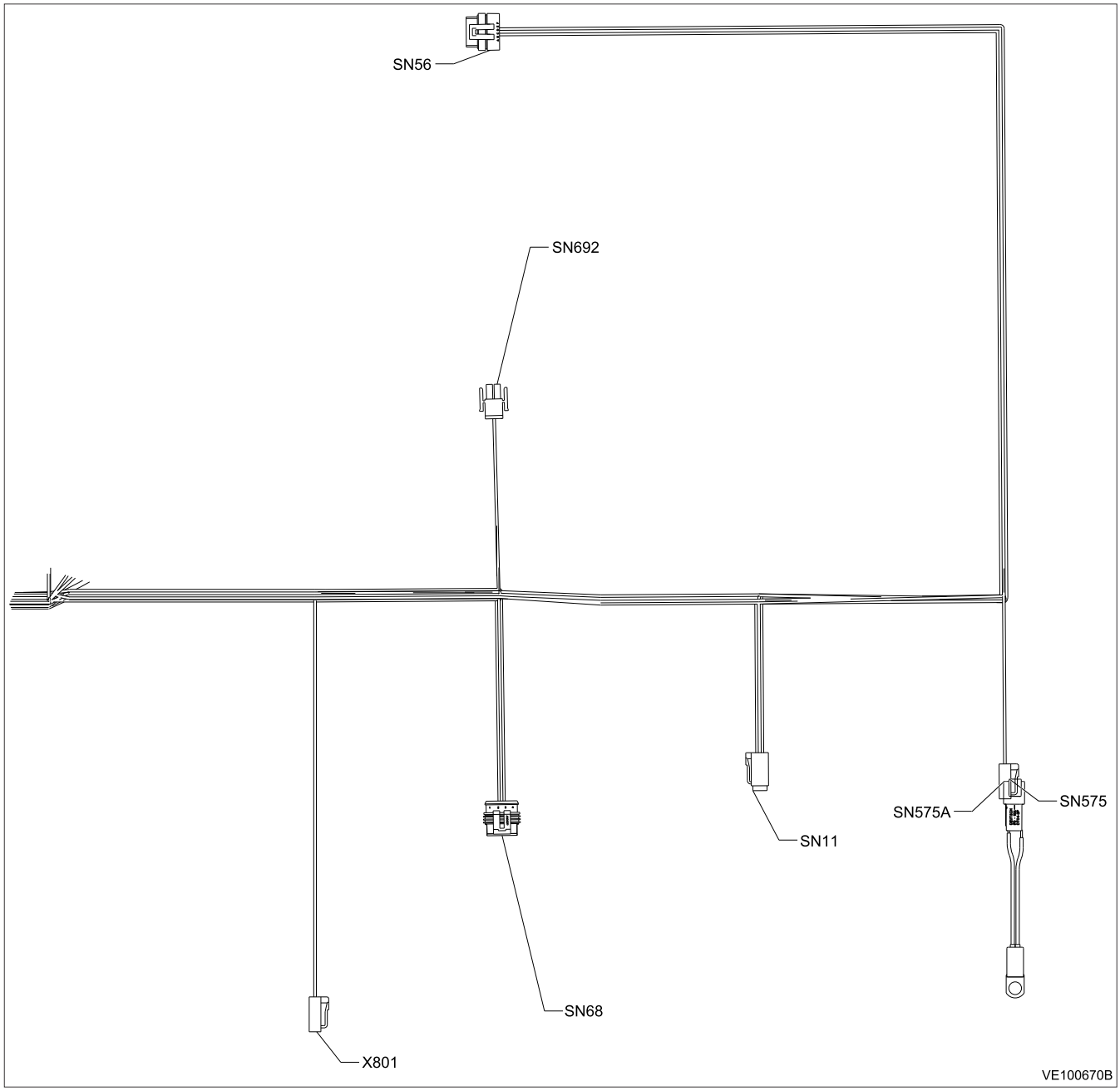

Figure 62. Chassis Harness – Sheet 7 of 8

X801 - LIFT DOWN					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	WHT	20 P LIFT DN	20 AWG	GXL	CO01-V4 (3)
2	WHT	19 N LIFT DN	20 AWG	GXL	CO01-V4 (13)

SN692 - ELEVATION SENSOR 1					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	YEL	78-1 ELEVSEN1 SW PWR	20 AWG	GXL	IP679 (1)
2	WHT	79 ELEVSEN1 SW	20 AWG	GXL	CO01-V3 (17)

SN11 - ACTIVE PHP					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	YEL	3-35 PHP SW2 PWR	18 AWG	GXL	IP619 (1)
2	YEL	3-34 PHP SW1 PWR	18 AWG	GXL	IP620 (1)
3	WHT	2-34 PHP SW1	18 AWG	GXL	CO01-V5 (12)
4	WHT	2-35 PHP SW2	18 AWG	GXL	CO01-V5 (2)

SN68 - TILT SENSOR					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	YEL	3-3 TILT IGN	20 AWG	GXL	CO01-V2 (5)
2	BLK	1-3 TILT GND	20 AWG	GXL	CO01-V2 (4)
3	YEL	CAN1-2 HIGH	20 AWG	GXL	MS153 (5)
4	GRN	CAN1-2 LOW	20 AWG	GXL	MS153 (2)

SN575 - TO TEMP SENSOR					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
1	BLK	94 BATT TEMP SENSE	20 AWG	GXL	CO563-C2 (1)
2	WHT	93 BATT TEMP SENSE	20 AWG	GXL	CO563-C1 (1)

SN56 - STEER ANGLE SENSOR					
CONN POS	**WIRE COLOR**	**WIRE LABEL**	**GAUGE**	**JACKET**	**TO**
A	WHT	72 GND ANGLE 1	18 AWG	GXL	CO01-V3 (1)
B	WHT	70 5V ANGLE 1	18 AWG	GXL	CO01-V3 (3)
C	WHT	68 ANGLE 1	18 AWG	GXL	CO01-V3 (2)
D	WHT	69 ANGLE 2	18 AWG	GXL	CO01-V3 (12)
E	WHT	73 GND ANGLE 2	18 AWG	GXL	CO01-V3 (11)
F	WHT	71 5V ANGLE 2	18 AWG	GXL	CO01-V3 (13)

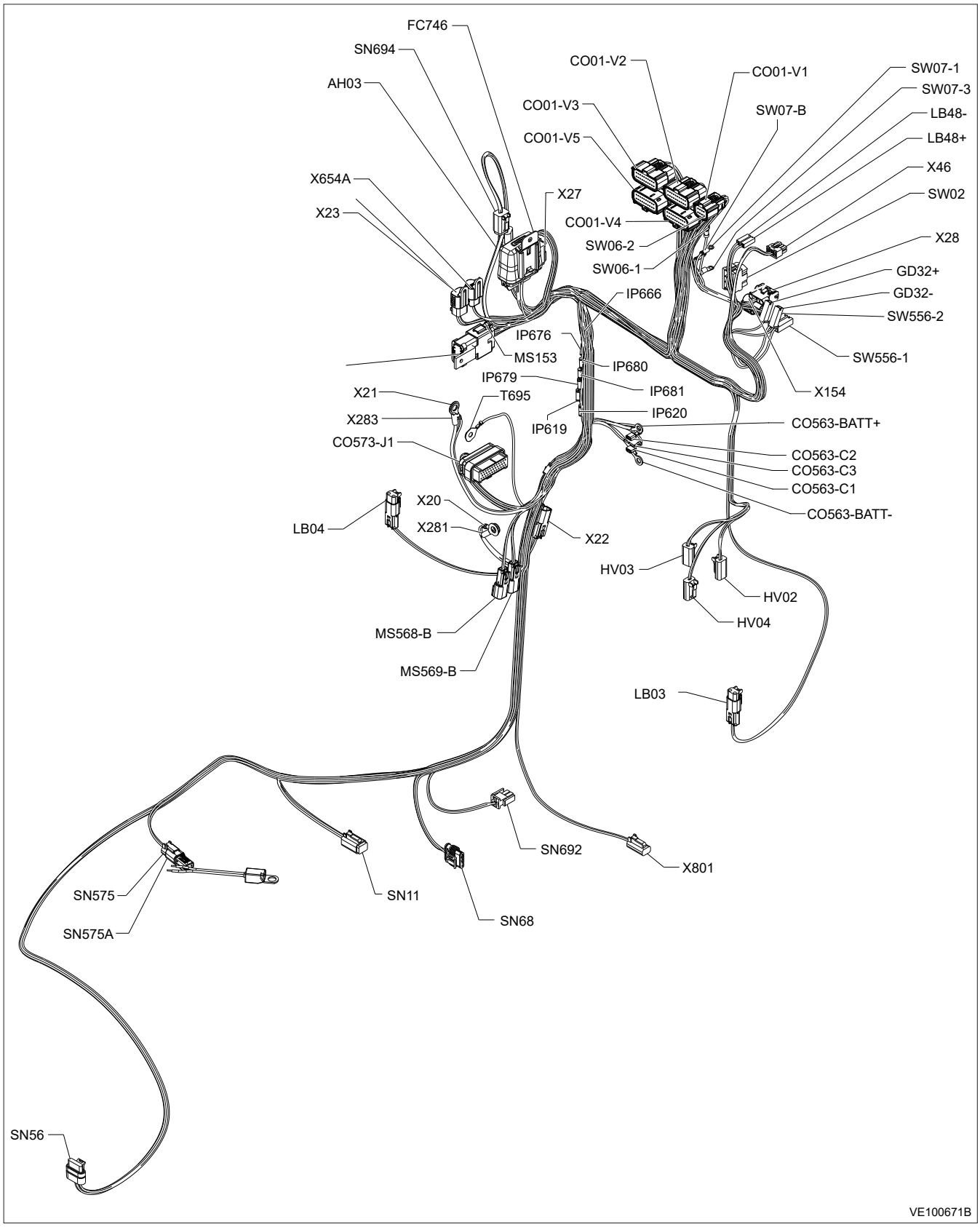

Figure 63. Chassis Harness – Sheet 8 of 8

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SECTION 9
REMOVAL AND INSTALLATION

9.1 POTHOLE PROTECTION SYSTEM

9.1.1 Pothole Protection System Components

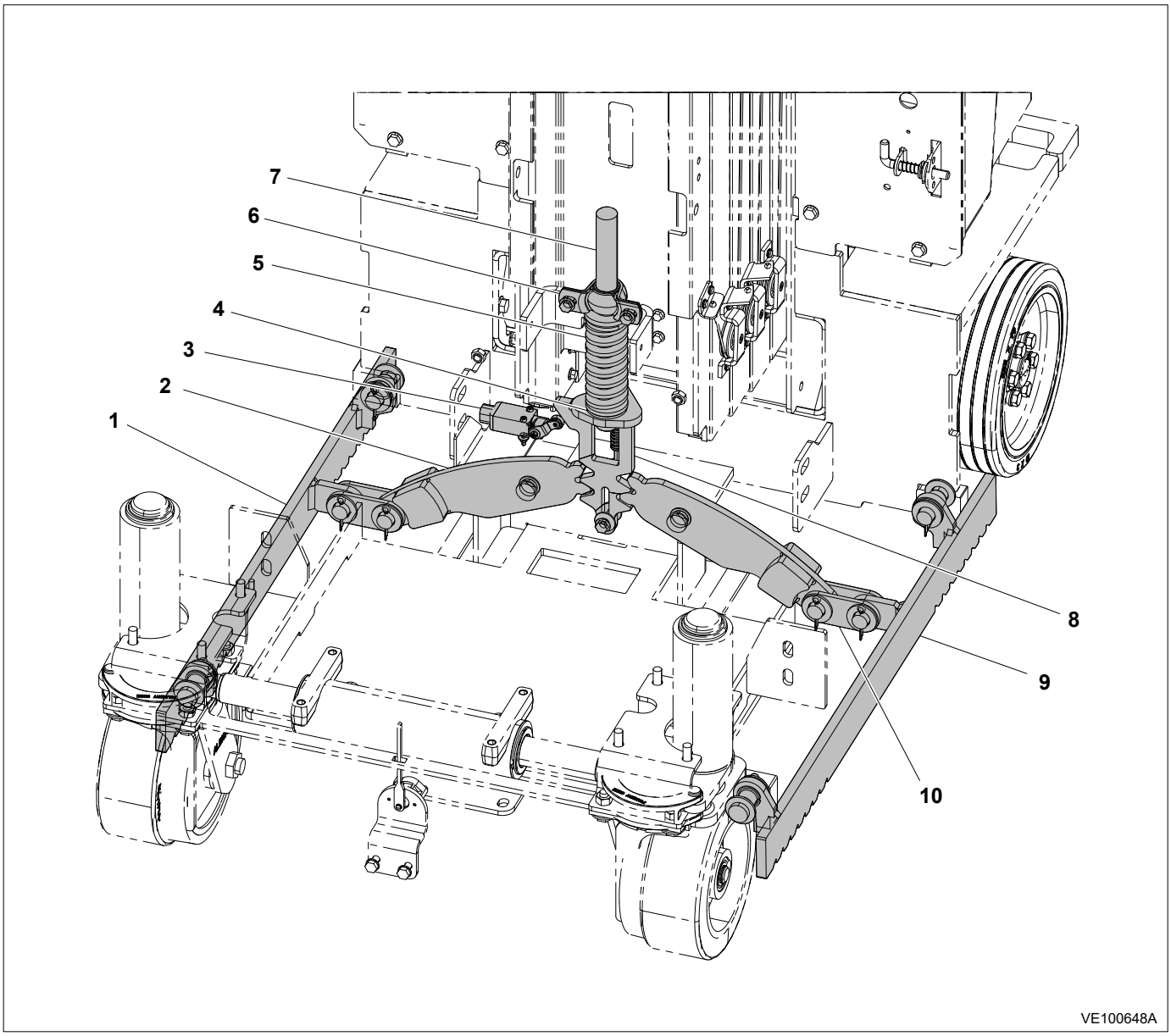


Figure 64. Pothole Protection Assembly

1. Pothole Bar (Right)	5. Actuator Spring	9. Pothole Bar (Left)
2. Crank Plate	6. Actuator Bearing Bracket	10. Link Plate
3. Roller Switch	7. Actuator Upper	
4. Bearing Flange	8. Actuator Lower	

⚠ WARNING

Never work under an elevated platform until it has been restrained from movement with safety props, blocking, or an overhead sling.

1. Install flange bearings into the frame holes with the flange side facing inside of frame against Pot- Hole bar hinge.
2. PHP Bearing Adjustment - If reassembling or replacing PHP components, PHP bars may not store at same height due to manufacturing tolerances of parts. Adjustment may be needed after assembly:
   a. Completely lower the platform and compress the actuator assembly to raise the PHP bars, check to see If only one PHP bar is raised against the frame.
   b. If Yes, elevate the platform to release the actuator assembly and deploy the PHP bars. The actuator bearing bracket (3) allows for some side to side adjustment, mark the current position of the actuator bearing bracket (**3**) on the frame.
   c. Loosen and move the actuator bearing bracket slightly towards the PHP bar that will not raise completely, and re-tighten bracket down.
   d. Compress the actuator assembly again to stow the PHP bars and check bar ground clearance. Repeat steps (a) through (c) above until both PHP bars achieve maximum ground clearance. Refer to Section – Machine Specification for Ground Clearance value.
3. Do not tighten limit switch mounting screws beyond 31 in. lbs. (3.5 Nm).
4. PHP Limit Switch Adjustment - When the platform is raised and PHP bars fully DOWN, adjust the switch until it lightly contacts the ramp on the lower actuator.

9.2 TIRES AND WHEELS

⚠ WARNING

DO NOT service the machine without following all safety precautions as outlined in *Section – Safety, page 9* of this manual.

9.2.1 Removal

1. Park the machine on a firm level surface. Make sure that the mast is fully lowered.
2. Push in the power/emergency stop switch (down) to off, turn the key switch to the (center) OFF position.
3. Remove key and tag machine out of service.
4. Place a suitable jack under the axle pad closest to the wheel being removed. Raise the machine and position a suitable support beneath the frame. Allow sufficient room to lower the machine onto a support and to remove the wheel and tire assembly.
5. Loosen but Do Not remove the lug nuts on the wheel and tire assembly that is to be removed.
6. Lower the machine on a support.
7. Remove bolts in alternating pattern. Refer to Figure – Wheel Lug Nut Tightening Sequence.
8. Remove the wheel and tire assembly from the machine.

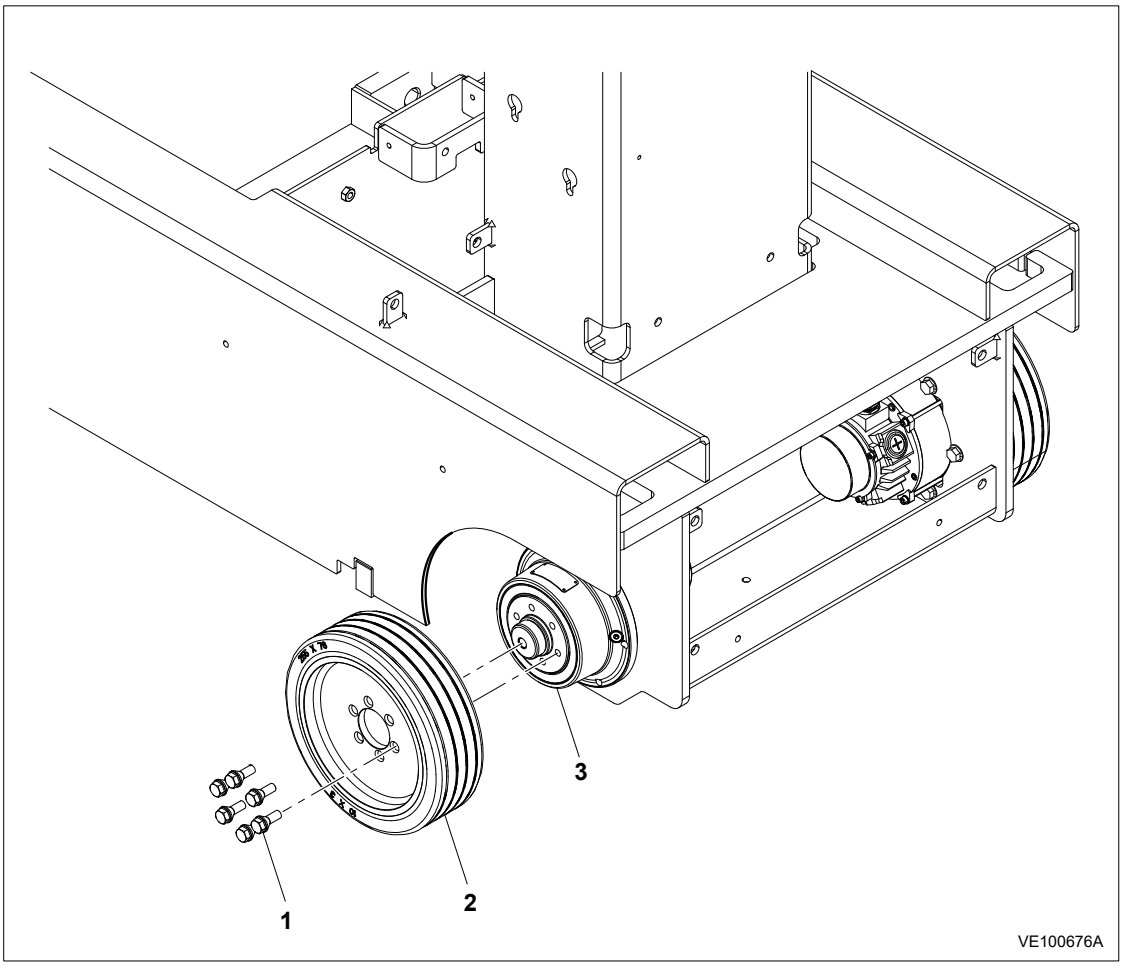


Figure 65. Wheel Removal/Installation

1. Wheel Bolts	2. Wheel and Tire Assembly	3. Drive Hub

9.2.2 Installation

It is extremely important to apply and maintain proper wheel mounting torque.

⚠ WARNING

Wheel bolts must be installed and maintained at the correct torque to prevent loose wheels and possible separation of wheel from the axle. Be sure to only use bolts matched to the cone angle of the wheel.

Tighten bolts to the correct torque to prevent wheels from becoming loose. Use a torque wrench to tighten the bolts. Over-tightening will break the bolts or permanently deform the mounting holes in the wheels. The proper procedure for attaching wheels is as follows:

1. Tighten all the bolts by hand to prevent cross threading. DO NOT use lubricant on the bolt threads.

2. Tighten bolts in the following sequence.

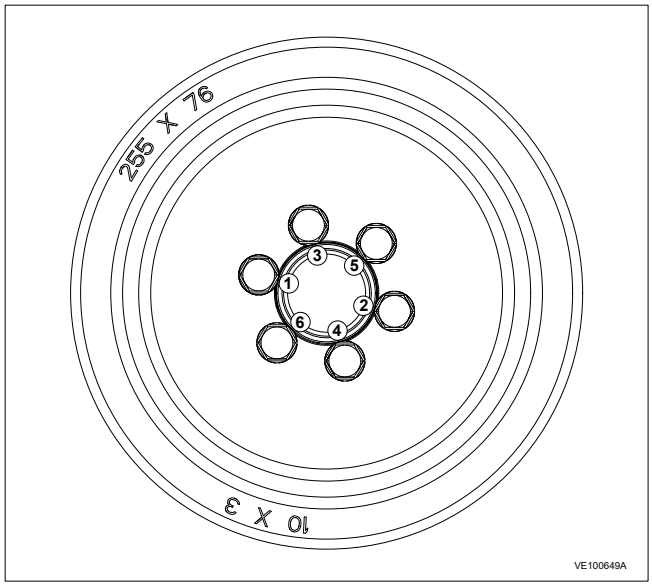


Figure 66. Wheel Lug Nut Tightening Sequence

3. Tighten the bolts in stages. Torque each bolt to 42.78 ft. lbs. (58 Nm).
4. Remove the machine out of service tag and re-insert the key.

9.3 STEERING – CASTER WHEEL AND HYDRAULIC STEERING

9.3.1 Caster Wheel

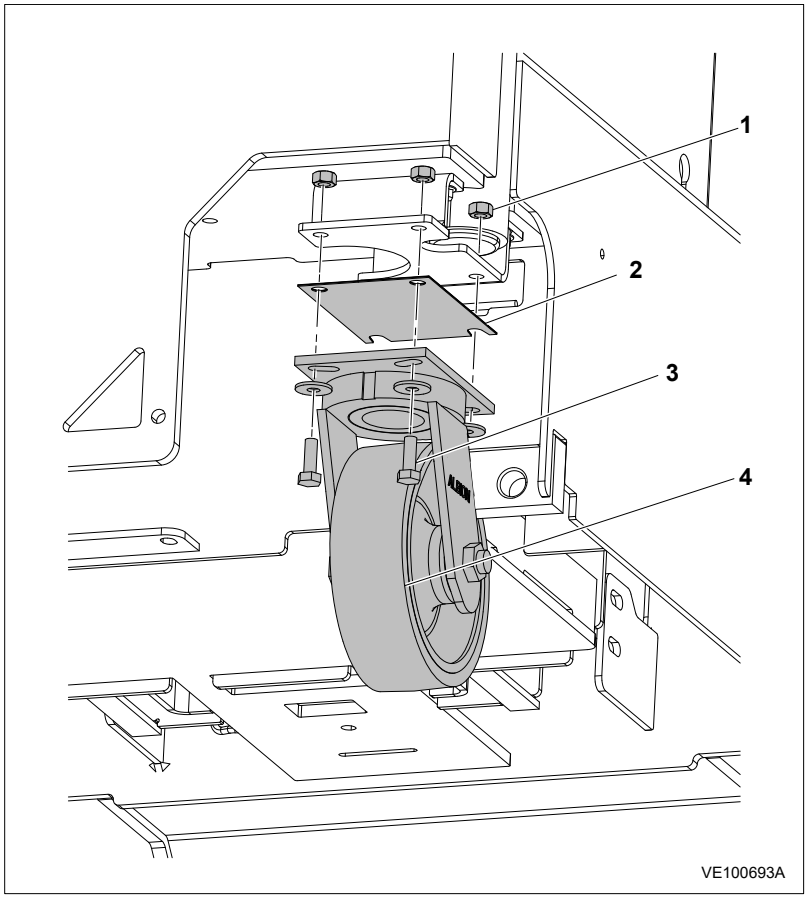


Figure 67. Caster Wheel

1. Nuts	3. Bolts
2. Caster Shim	4. Caster Wheel

Removal

1. Park the machine on a firm level surface. Make sure that the mast is fully lowered.
2. Push in the power/emergency stop switch (down) to off, turn the key switch to the (center) OFF position.
3. Remove key and tag machine out of service.
4. Place the lifting jack beneath the machine.
5. Lift the machine with the jack to proper height to access the caster wheel.
6. Remove nuts (**1**), bolts (**3**) and washers from caster shim (**2**) and secure caster wheel (**4**).

Installation

1. Place the lifting jack beneath the machine.
2. Place and align caster wheel (**4**) with the mounting holes.
3. Insert caster shim (**2**) if required to fix the height of the machine.

4. Secure caster wheel (**4**) with nuts (**1**), bolts (**3**) and washers.
5. Remove the machine out of service tag and re-insert the key.

9.3.2 Hydraulic Steering

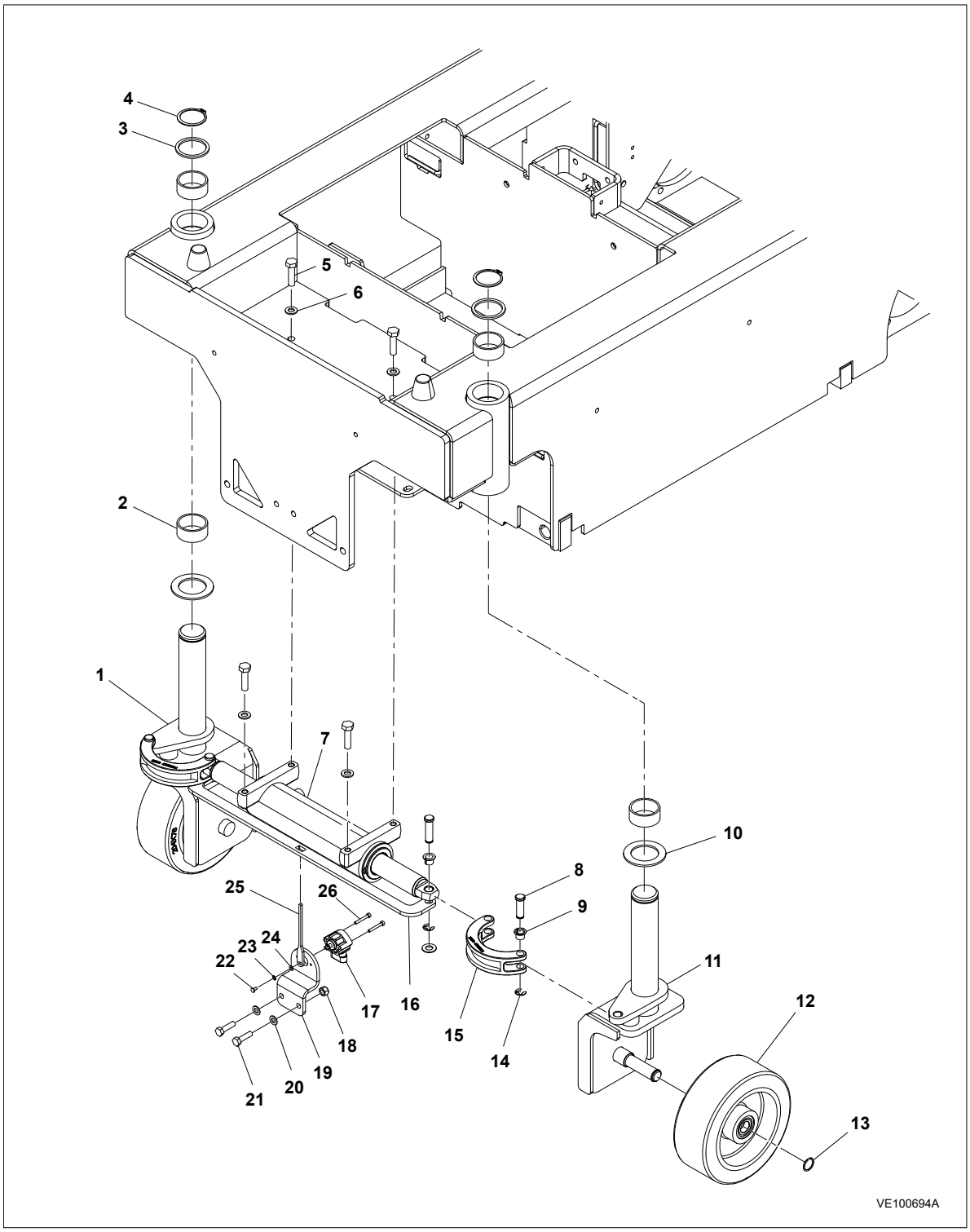


Figure 68. Hydraulic Steering

1. Spindle Right	10. Washer	19. Bracket
2. Bushing	11. Spindle Left	20. Washer
3. Washer	12. Wheel	21. Bolt
4. Ring	13. Retaining Ring	22. Screw
5. Bolt	14. Clip	23. Star Washer
6. Washer	15. Steer Lug	24. Washer
7. Steer Spindle Assembly	16. Steer Angle Bar	25. Steer Wisker Bar
8. Clevis Pin	17. Steer Angle Sensor	26. Bolt
9. Flange bearing	18. Nut	

9.4 BATTERIES - SERVICE PROCEDURES

9.4.1 Battery Cover Removal

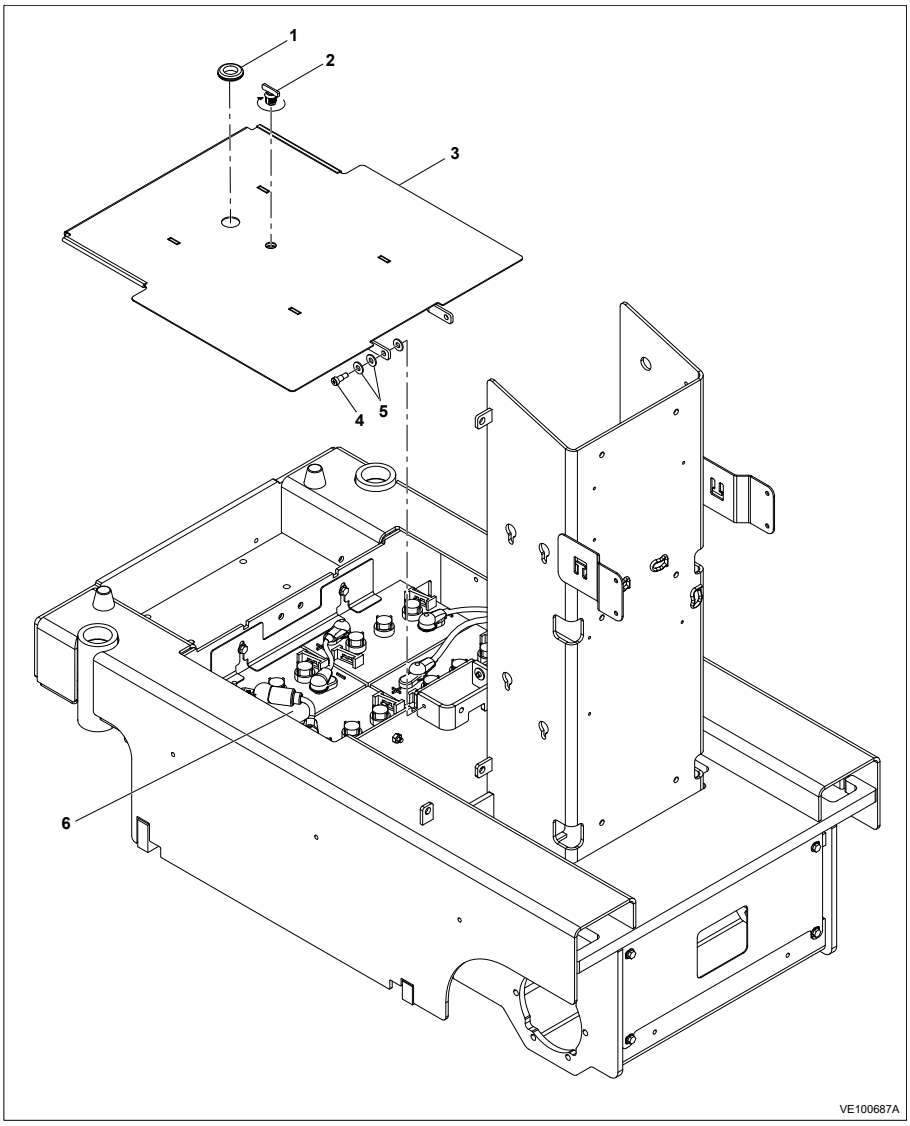


Figure 69. Battery Cover Removal

1. Grommet	3. Battery Cover	5. Washer
2. Latch	4. Screw	6. Battery

1. Park the machine on a firm level surface. Make sure that the mast is fully lowered.
2. Push in the power/emergency stop switch (down) to off, turn the key switch to the (center) OFF position.
3. Remove key and tag machine out of service.
4. Remove the platform to gain access to the battery cover. Refer Section – Platform Removal/Installation for detailed procedure.
5. Turn latch (**2**) to set free from the bracket.

6. Remove screw (**4**) and washer (**5**) from the frame.
7. Remove the battery cover (**3**) from the machine.

9.4.2 Battery Cover Installation

1. Place and align battery cover (**3**) on the machine.
2. Install screw (**4**) and washer (**5**) to the frame.
3. Turn latch (**2**) to fit it to the bracket.
4. Install the platform. Refer Section – Platform Removal/Installation for detailed procedure.
5. Remove the machine out of service tag and re-insert the key.

9.4.3 Battery Replacement

NOTICE

JLG machines equipped with Delta-Q battery chargers are designed for the best performance with OEM factory approved batteries.

Approved JLG replacement batteries are available through JLG's aftermarket parts distribution centers or JLG's aftermarket programs. For assistance with proper battery replacement, please contact your local JLG support office.

Batteries approved by JLG have been tested for compatibility with the algorithm programming of the Delta Q battery charger to optimize battery life and machine cycle times. The use of non approved batteries in your JLG equipment may result in performance issues or battery charger fault codes. JLG assumes no responsibility for service or performance issues arising from the use of non approved batteries.

Replacement battery (s) must be of equivalent voltage and amperage output as the OEM battery (s) in order for the machine to operate to as manufactured specifications. Battery replacement part weight must also be equivalent to OEM per battery, in order to maintain machine stability as manufactured. (Refer to Section - Electrical Specifications of this manual for battery specifications).

⚠ WARNING

Do not replace items critical to stability, such as batteries, with items of different weight or specification. Do not modify unit in any way to affect stability.

9.4.4 Battery Quick-Disconnect

The battery quick-disconnect allows all machine power to be easily disconnected at the batteries without removing battery cables from the battery posts. To disconnect power, locate the RED quick-disconnect connector on left of the mast compartment and pull halves apart.

9.4.5 Lead Acid Battery

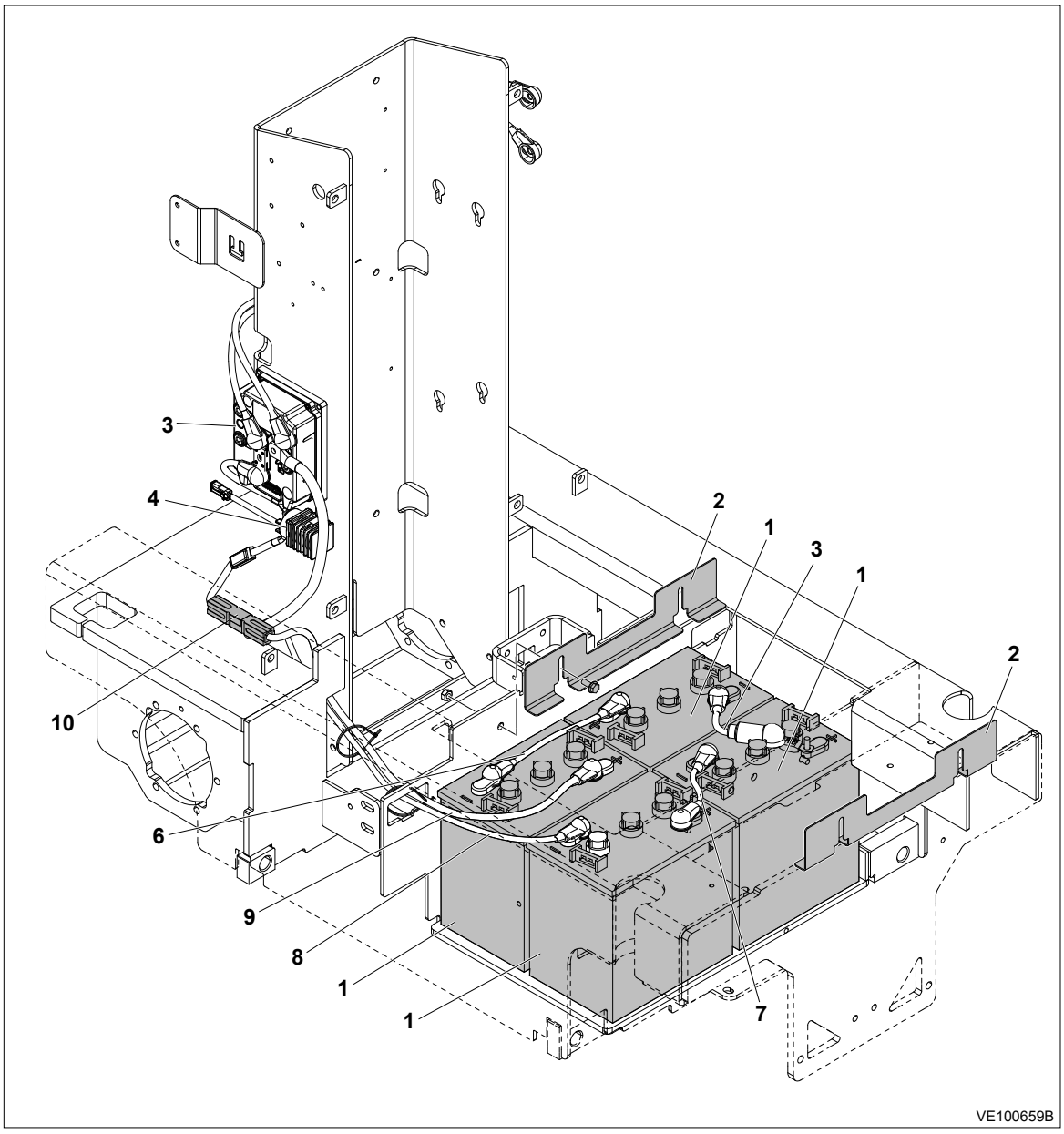


Figure 70. Lead Acid Battery Removal and Installation

1. Battery	5. Battery Jumper Cable with Fuse	9. Battery Disconnect Cable
2. Battery Support Bracket	6. Battery Cable	10. Battery Quick-Disconnect
3. Drive Module	7. Battery Cable	
4. Main Contactor Relay	8. Battery Cable	

Removal

⚠ WARNING

Make sure that positive (+) and negative (–) battery cables are properly disconnected before removal of the battery.

1. Park the machine on a firm level surface. Make sure that the mast is fully lowered.
2. Push in the power/emergency stop switch (down) to off, turn the key switch to the (center) OFF position.
3. Remove key and tag machine out of service.
4. Remove battery cover to access the batteries. Refer to Section — Battery Cover Removal for detailed procedure.
5. Disengage battery quick-disconnect (**10**) and disconnect battery power to the machine.
6. Label and remove battery disconnect cable (**9**) from batteries (**1**). This cable connects batteries (**1**) to main contactor relay (**5**) with battery quick-disconnect (**10**).
7. Label and remove battery cable (**8**) from batteries (**1**) and drive module (**4**).
8. Label and remove battery cables (**5** – **7**) that connect batteries (**1**) with each other.
9. Remove the hardware that attach battery support brackets (**2**) to the frame.
10. Remove battery support brackets (**2**) from the frame.
11. Carefully lift and remove batteries (**1**) from the frame and place them on a clean and dry surface.

Installation

Note: Torque the battery terminal hardware to 8 ft. lbs. (10.8 Nm). Apply battery terminal grease to the battery terminal connections.

1. Carefully lift and position batteries (**1**) into the frame.
2. Position battery support brackets (**2**) over batteries (**1**) inside the frame.
3. Install battery support brackets (**2**) on the frame with hardware.
4. Remove the labels and install battery cables (**5** – **7**) to connect batteries (**1**) with each other.
5. Remove the labels and connect battery cable (**8**) to drive module (**4**) and batteries (**1**).
6. Connect one end of battery disconnect cable (**9**) to main contactor relay (**4**). Make sure that battery quick-disconnect (**10**) is disengaged.
7. Connect other end of battery disconnect cable (**9**) to batteries (**1**).
8. Engage battery quick-disconnect (**10**) and connect battery power to the machine.
9. Install battery cover. Refer to Section — Battery Cover Installation for detailed procedure.
10. Remove the machine out of service tag and re-insert the key.

9.4.6 Lithium Ion Battery

Lithium Ion Battery (1-Battery System)

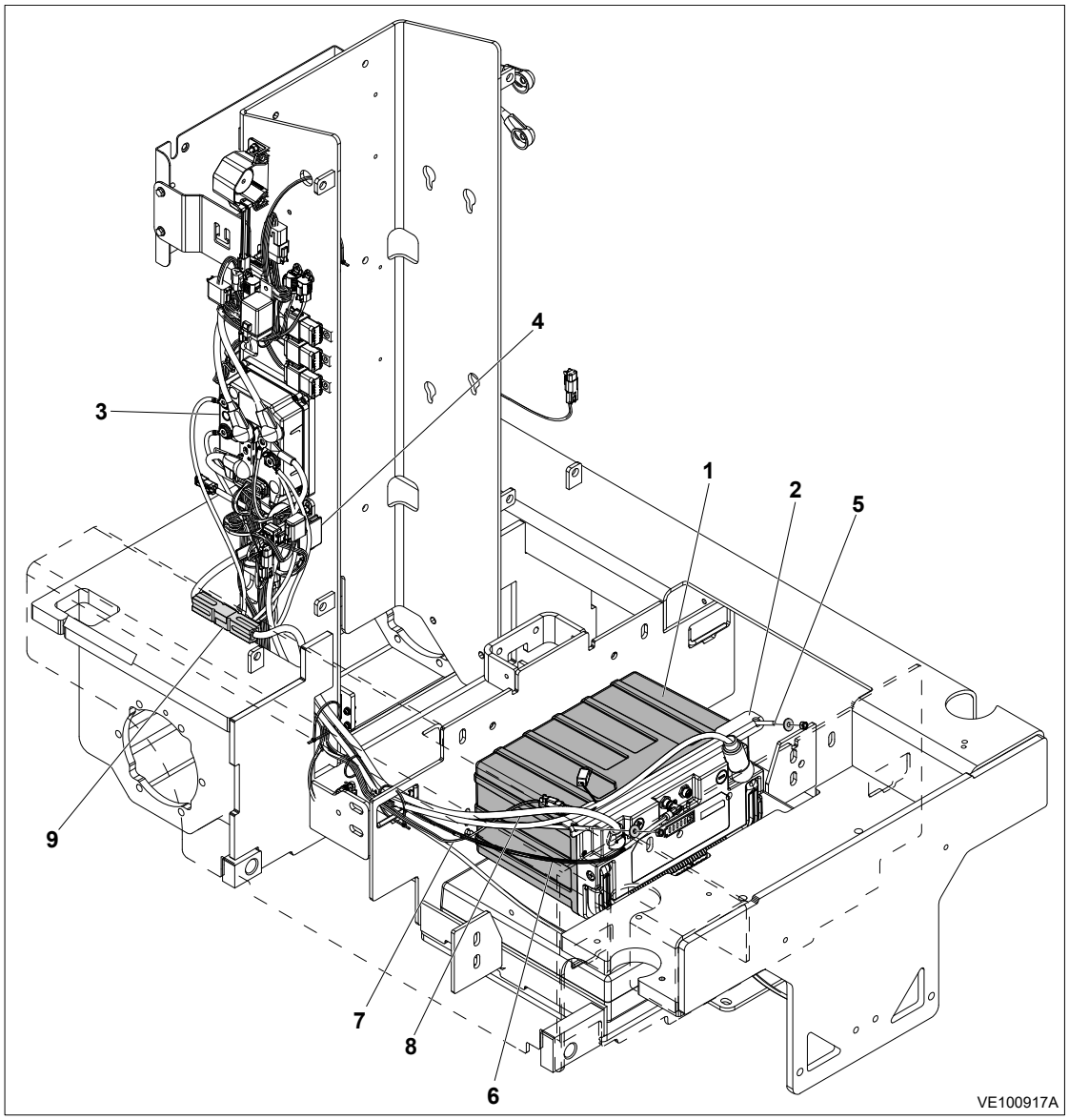


Figure 71. Lithium Ion Battery Removal and Installation (1-Battery System)

1. Battery	4. Main Contactor Relay	7. Battery Cable
2. Battery Support Bracket	5. Battery Hold Down Hook	8. Battery Disconnect Cable
3. Drive Module	6. Lithium Battery Harness	9. Battery Quick-Disconnect

Removal

⚠ WARNING

Make sure that positive (+) and negative (–) battery cables are properly disconnected before removal of the battery.

1. Park the machine on a firm level surface. Make sure that the mast is fully lowered.
2. Push in the power/emergency stop switch (down) to off, turn the key switch to the (center) OFF position.
3. Remove key and tag machine out of service.
4. Remove battery cover to access the battery. Refer to Section — Battery Cover Removal for detailed procedure.
5. Disengage battery quick-disconnect (**9**) and disconnect battery power to the machine.
6. Label and remove battery disconnect cable (**8**) from battery (**1**). This cable connects battery (**1**) to main contactor relay (**4**) with battery quick-disconnect (**9**).
7. Label and remove battery cable (**7**) from battery **(**1) and drive module (**3**).
8. Label and remove lithium battery harness (**6**) from battery (**1**).
9. Remove nuts and washers that attach battery support bracket (**2**) to battery hold down hooks (**5**).
10. Remove battery support bracket (**2**) and battery hold down hooks (**5**) from the frame.
11. Carefully lift and remove battery (**1**) from the frame and place it on a clean and dry surface.

Installation

Note: Torque the positive (+) battery terminal hardware to 177 – 204 in. lbs. (20 – 23 Nm) and negative (-) battery terminal hardware to 133 – 160 in. lbs. (15 – 18 Nm). Apply battery terminal grease to the battery terminal connections.

1. Carefully lift and position battery (**1**) into the frame.
2. Install battery hold down hooks (**5**) on sides of battery (1) on the mounting location in the frame.
3. Install battery support bracket (**2**) through battery hold down hooks (**5**) on the battery. Make sure that the battery support bracket is positioned correctly on the top edge of battery (**1**) as shown in Figure — Lithium Ion Battery Removal and Installation (1-Battery System).
4. Secure battery support bracket (**2**) to battery hold down hooks (**5**) with washers and nuts. Torque the nuts to 15 in. lbs. (1.69 Nm).
5. Remove labels and connect lithium battery harness (**6**) to battery (**1**).
6. Remove labels and connect battery cable (**7**) to drive module (**3**) and battery (**1**).
7. Connect one end of battery disconnect cable (**8**) to main contactor relay (**4**). Make sure that battery quick-disconnect (**9**) is disengaged.
8. Connect other end of battery disconnect cable (**8**) to battery (**1**).
9. Engage battery quick-disconnect (**9**) and connect battery power to the machine.
10. Install battery cover. Refer to Section — Battery Cover Installation for detailed procedure.
11. Remove the machine out of service tag and re-insert the key.

Lithium Ion Battery (2-Battery System)

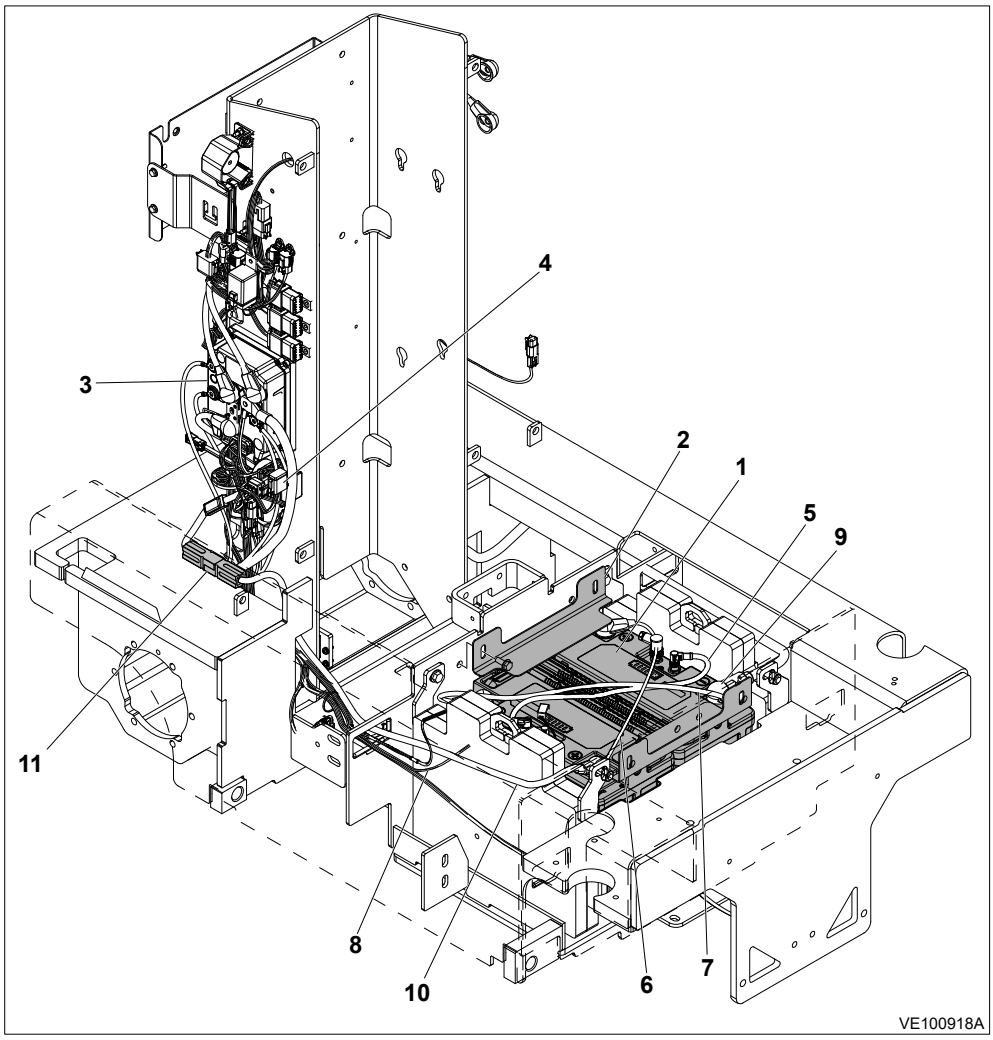


Figure 72. Lithium Ion Battery (2-Battery System)

1. Battery	5. Battery Cable	9. Battery Cable
2. Battery Support Bracket	6. Battery Cable	10. Battery Disconnect Cable
3. Drive Module	7. Battery Cable	11. Battery Quick-Disconnect
4. Main Contactor Relay	8. Lithium Battery Harness	

Removal

⚠ WARNING

Make sure that positive (+) and negative (–) battery cables are properly disconnected before removal of the battery.

1. Park the machine on a firm level surface. Make sure that the mast is fully lowered.
2. Push in the power/emergency stop switch (down) to off, turn the key switch to the (center) OFF position.
3. Remove key and tag machine out of service.

4. Remove battery cover to access the batteries. Refer to Section — Battery Cover Removal for detailed procedure.
5. Disengage battery quick-disconnect (**11**) and disconnect battery power from the machine.
6. Label and remove battery disconnect cable (**10**) from batteries (**1**). This cable connects batteries (**1**) to main contactor relay (**4**) with battery quick-disconnect (**11**).
7. Label and remove battery cable (**9**) from batteries (**1**) and drive module (**3**).
8. Label and remove lithium battery harness (**8**) from batteries. (**1**).
9. Label and remove battery cables (**5** – **7**) that connect batteries (**1**) with each other.
10. Remove the bolts that attach battery support brackets (**2**) to the frame and remove battery support brackets (**2**).
11. Carefully lift and remove batteries (**1**) from the frame and place them on a clean and dry surface.

Installation

Note: Torque the positive (+) battery terminal hardware to 177 – 204 in. lbs. (20 – 23 Nm) and negative (-) battery terminal hardware to 133 – 160 in. lbs. (15 – 18 Nm). Apply battery terminal grease to the battery terminal connections.

1. Carefully lift and position batteries (**1**) into the frame.
2. Position battery support brackets (**2**) over batteries (**1**) inside the frame.
3. Install battery support brackets (**2**) on the frame with bolts.
4. Remove the labels and install battery cables (**5** – **7**) to connect batteries (**1**) with each other.
5. Remove the labels and connect lithium battery harness (**8**) to batteries (**1**).
6. Remove the labels and connect battery cable (**9**) to drive module (**3**) and batteries (**1**).
7. Connect one end of battery disconnect cable (**10**) to main contactor relay (**4**). Make sure that battery quick-disconnect (**11**) is disengaged.
8. Connect other end of battery disconnect cable (**10**) to batteries (**1**).
9. Engage battery quick-disconnect (**11**) and connect battery power to the machine.
10. Install battery cover. Refer to Section — Battery Cover Installation for detailed procedure.
11. Remove the machine out of service tag and re-insert the key.

9.5 BATTERY CHARGER

9.5.1 Battery Charger (Delta-Q 650 W (CAN))

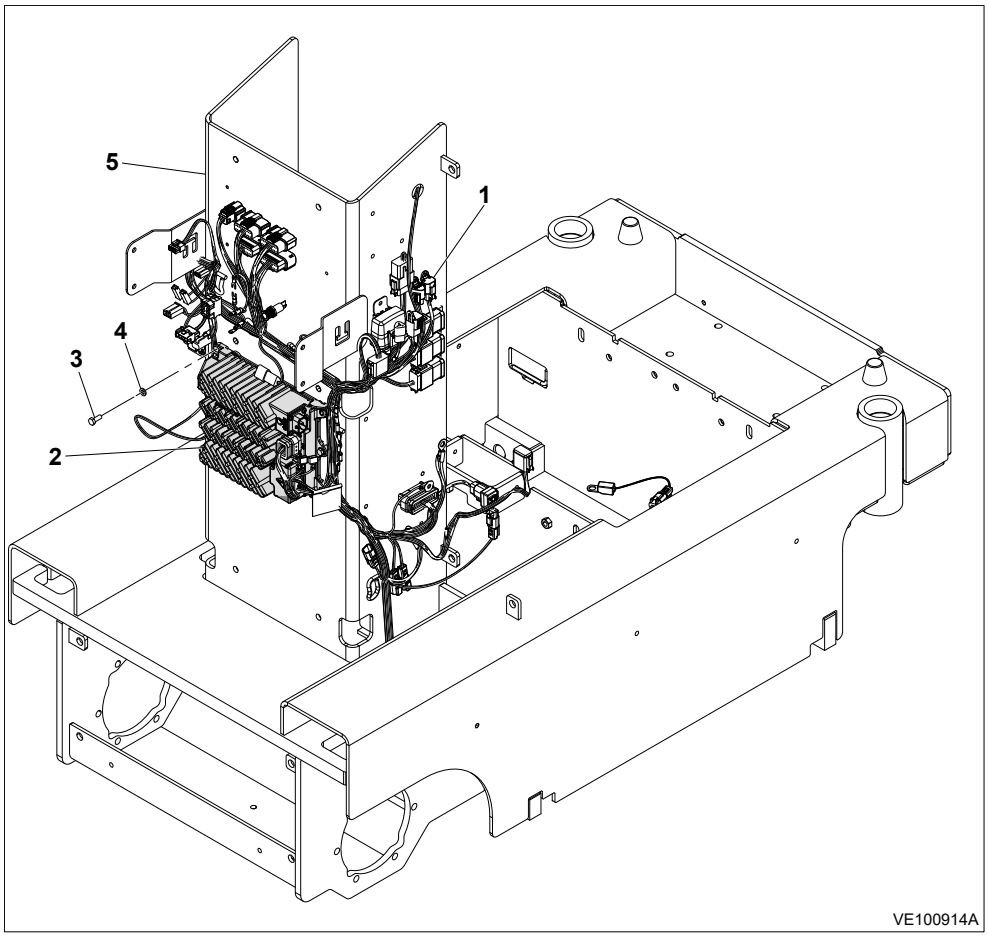


Figure 73. Battery Charger (Delta-Q 650 W (CAN)) – Removal/Installation

1. Chassis Harness	3. Bolt	5. Frame
2. Battery Charger	4. Washer	

⚠ CAUTION

Plug the battery charger AC supply cord into a properly installed and grounded outlet. Do not modify the plug or use ground adapters. Do not touch the portion of the output connector or battery terminal which is improperly insulated.

Do not operate the battery charger if the AC supply cord has received a sharp blow, or has been dropped, or is damaged in any way.

Always disconnect AC supply to the battery charger before connecting or disconnecting cables to the (positive/negative) terminals of the battery.

Do not disassemble the battery charger.

Note: The battery charger weighs approximately 5.3 lb (2.4 kg).

Removal

1. Park the machine on a firm level surface. Make sure that the mast is fully lowered.
2. Push in the power/emergency stop switch (down) to off, turn the key switch to the (center) OFF position.
3. Remove key and tag machine out of service.
4. Open the rear hood of the machine.
5. Disconnect battery power from the machine.
6. Disconnect AC supply cord from battery charger (**2**).
7. Tag and disconnect chassis harness (**1**) from battery charger (**2**).
8. Remove bolts (**3**) and washers (**4**) that attach battery charger (**2**) to frame (**5**).
9. Remove and place battery charger (**2**) on a clean, dry surface.

Installation

1. Position battery charger (**2**) on frame (**5**).

Note: Apply medium strength threadlocking compound to the bolts before installation.

2. Install bolts (**3**) and washers (**4**) to secure battery charger (**2**) to frame (**5**). Torque the bolts to 8.85 ft. lbs. (12 Nm).
3. Connect chassis harness (**1**) to battery charger (**2**) as tagged during removal. Torque the battery positive and battery negative connections to 40 in. lbs. (4.5 Nm).
4. Connect AC supply cord to battery charger (**2**).
5. Reconnect battery power to the machine.
6. Close the rear hood of the machine.
7. Remove the machine out of service tag and re-insert the key.
8. Verify proper operation of battery charger (**2**).

9.5.2 Battery Charger (Delta-Q 1200 W (CAN))

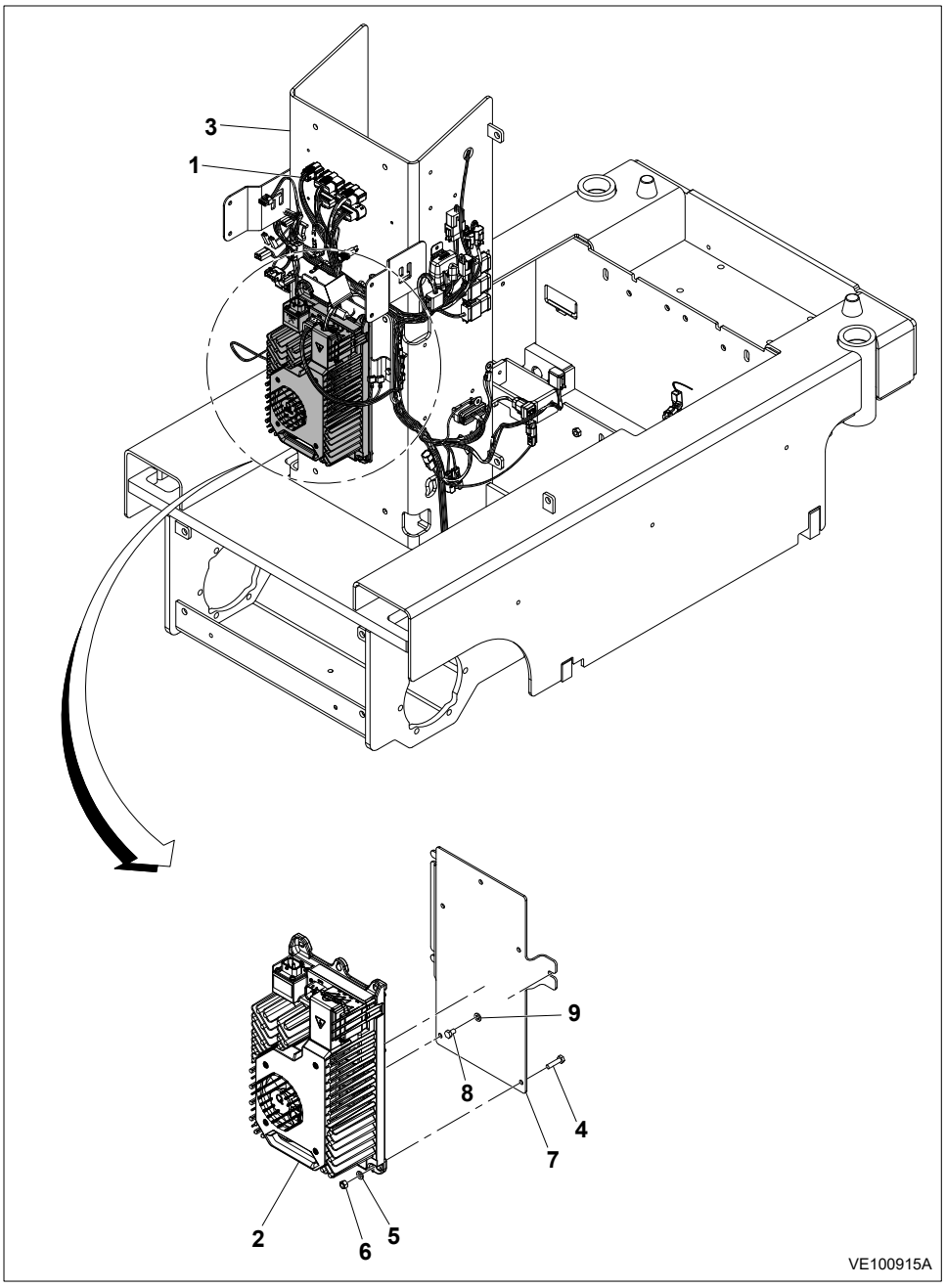


Figure 74. Battery Charger (Delta-Q 1200 W (CAN)) – Removal/Installation

1. Chassis Harness	4. Bolt	7. Mounting Plate
2. Battery Charger	5. Washer	8. Bolt
3. Frame	6. Nut	9. Washer

⚠ CAUTION

Plug the battery charger AC supply cord into a properly installed and grounded outlet. Do not modify the plug or use ground adapters. Do not touch the portion of the output connector or battery terminal which is improperly insulated.

Do not operate the battery charger if the AC supply cord has received a sharp blow, or has been dropped, or is damaged in any way.

Always disconnect AC supply to the battery charger before connecting or disconnecting cables to the (positive/negative) terminals of the battery.

Do not disassemble the battery charger.

Note: The battery charger weighs approximately 9 lb (4.1 kg).

Removal

1. Park the machine on a firm level surface. Make sure that the mast is fully lowered.
2. Push in the power/emergency stop switch (down) to off, turn the key switch to the (center) OFF position.
3. Remove key and tag machine out of service.
4. Open the rear hood of the machine.
5. Disconnect battery power from the machine.
6. Disconnect AC supply cord from battery charger (**2**).
7. Tag and disconnect chassis harness (**1**) from battery charger (**2**).
8. Remove bolts (**8**) and washers (**9**) and pull out battery charger (**2**) along with mounting plate (**7**) from frame (**3**).
9. Remove bolts (**4**), washers (**5**) and nuts (**6**) that attach battery charger (**2**) to mounting plate (**7**).
10. Remove battery charger (**2**) from mounting plate (**7**).
11. Place battery charger (**2**) on a clean, dry surface.

Installation

1. Position battery charger (**2**) onto mounting plate (**7**).
2. Install bolts (**4**), washers (**5**), and nuts (**6**) to secure battery charger (**2**) to mounting plate (**7**).
3. Align mounting plate (**7**) along with battery charger (**2**) on the mounting location of frame (**3**).

Note: Apply medium strength threadlocking compound to the bolts before installation.

4. Install bolts (**8**) and washers (**9**) to secure mounting plate (**7**) to frame (**3**). Torque the bolts to 8.85 ft. lbs. (12 Nm).
5. Connect chassis harness (**1**) to battery charger (**2**) as tagged during removal. Torque the battery positive and battery negative connections to 40 in. lbs. (4.5 Nm).
6. Connect AC supply cord to battery charger (**2**).
7. Reconnect battery power to the machine.
8. Close the rear hood of the machine.
9. Remove the machine out of service tag and re-insert the key.
10. Verify proper operation of battery charger (**2**).

9.5.3 Battery Charger (Green Power)

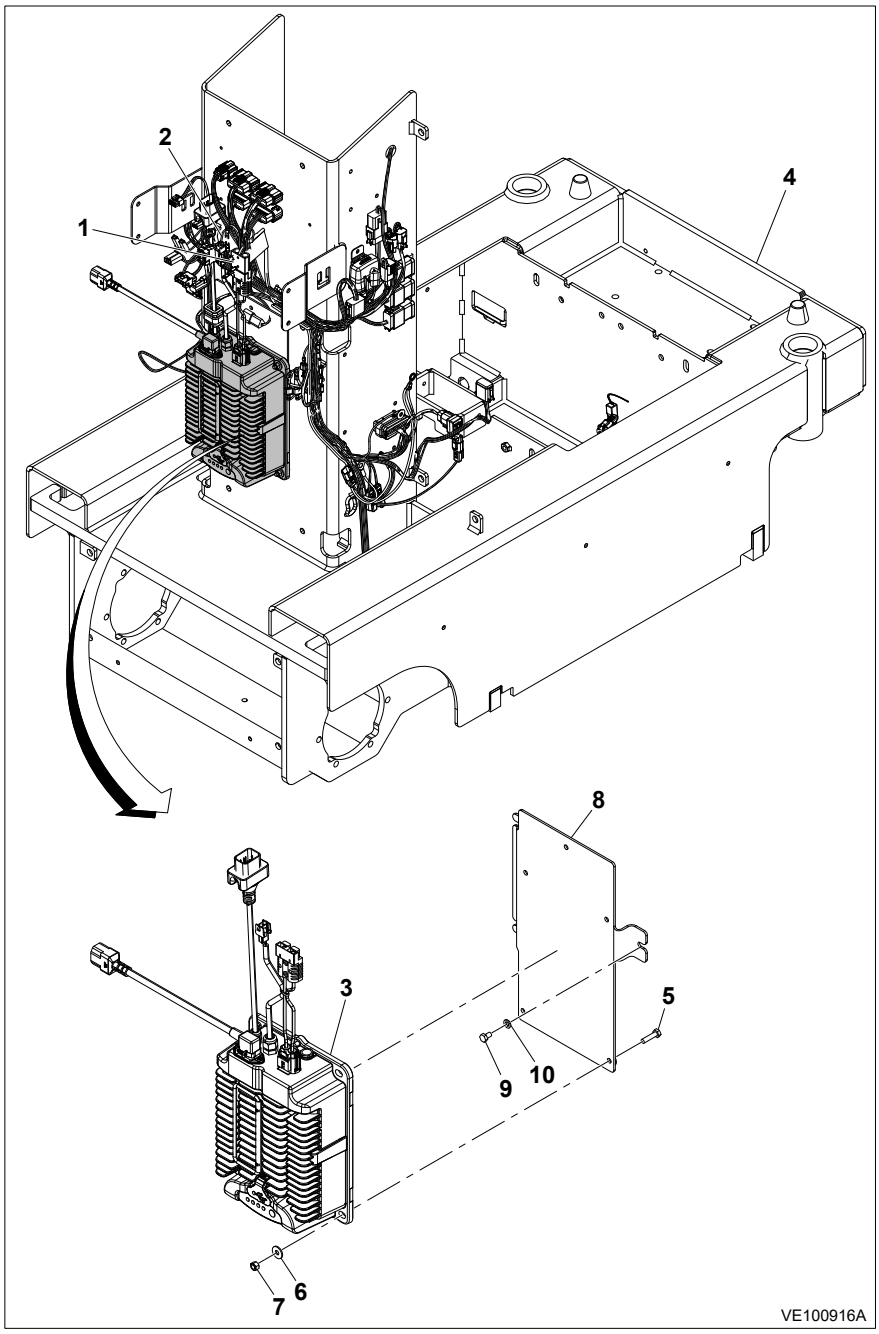


Figure 75. Battery Charger (Green Power) – Removal/Installation

1. Charger DC Connection Harness	5. Bolt	9. Bolt
2. Charger Jumper Harness	6. Washer	10. Washer

3. Battery Charger	7. Nut	
4. Frame	8. Mounting Plate	

⚠ CAUTION

Plug the battery charger AC supply cord into a properly installed and grounded outlet. Do not modify the plug or use ground adapters. Do not touch the portion of the output connector or battery terminal which is improperly insulated.

Do not operate the battery charger if the AC supply cord has received a sharp blow, or has been dropped, or is damaged in any way.

Always disconnect AC supply to the battery charger before connecting or disconnecting cables to the (positive/negative) terminals of the battery.

Do not disassemble the battery charger.

Note: The battery charger weighs approximately 7.7 lb (3.5 kg).

Removal

1. Park the machine on a firm level surface. Make sure that the mast is fully lowered.
2. Push in the power/emergency stop switch (down) to off, turn the key switch to the (center) OFF position.
3. Remove key and tag machine out of service.
4. Open the rear hood of the machine.
5. Disconnect battery power from the machine.
6. Disconnect AC supply cord from battery charger (**3**).
7. Tag and disconnect charger DC connection harness (**1**) from battery charger (**3**).
8. Tag and disconnect charger jumper harness (**2**) from battery charger (**3**).
9. Remove bolts (**9**) and washers (**10**) and pull out battery charger (**3**) along with mounting plate (**8**) from frame (**4**).
10. Remove bolts (**5**), washers (**6**) and nuts (**7**) that attach battery charger (**3**) to mounting plate (**8**).
11. Remove battery charger from mounting plate (**8**).
12. Place battery charger (**3**) on a clean, dry surface.

Installation

1. Position battery charger (**3**) onto mounting plate (**8**).
2. Install bolts (**5**), washers (**6**), and nuts (**7**) to secure battery charger (**3**) to mounting plate (**8**).
3. Align mounting plate (**8**) along with battery charger (**3**) on the mounting location of frame (**4**).

Note: Apply medium strength threadlocking compound to the bolts before installation.

4. Install bolts (**9**) and washers (**10**) to secure mounting plate (**8**) to frame (**4**). Torque the bolts to 8.85 ft. lbs. (12 Nm).
5. Connect charger jumper harness (**2**) to battery charger (**3**) as tagged during removal.
6. Connect charger DC connection harness (**1**) to battery charger (**3**) as tagged during removal.
7. Connect AC supply cord to battery charger (**3**).
8. Reconnect battery power to the machine.

9. Close the rear hood of the machine.
10. Remove the machine out of service tag and re-insert the key.
11. Verify proper operation of battery charger (**3**).

9.6 TILT SENSOR

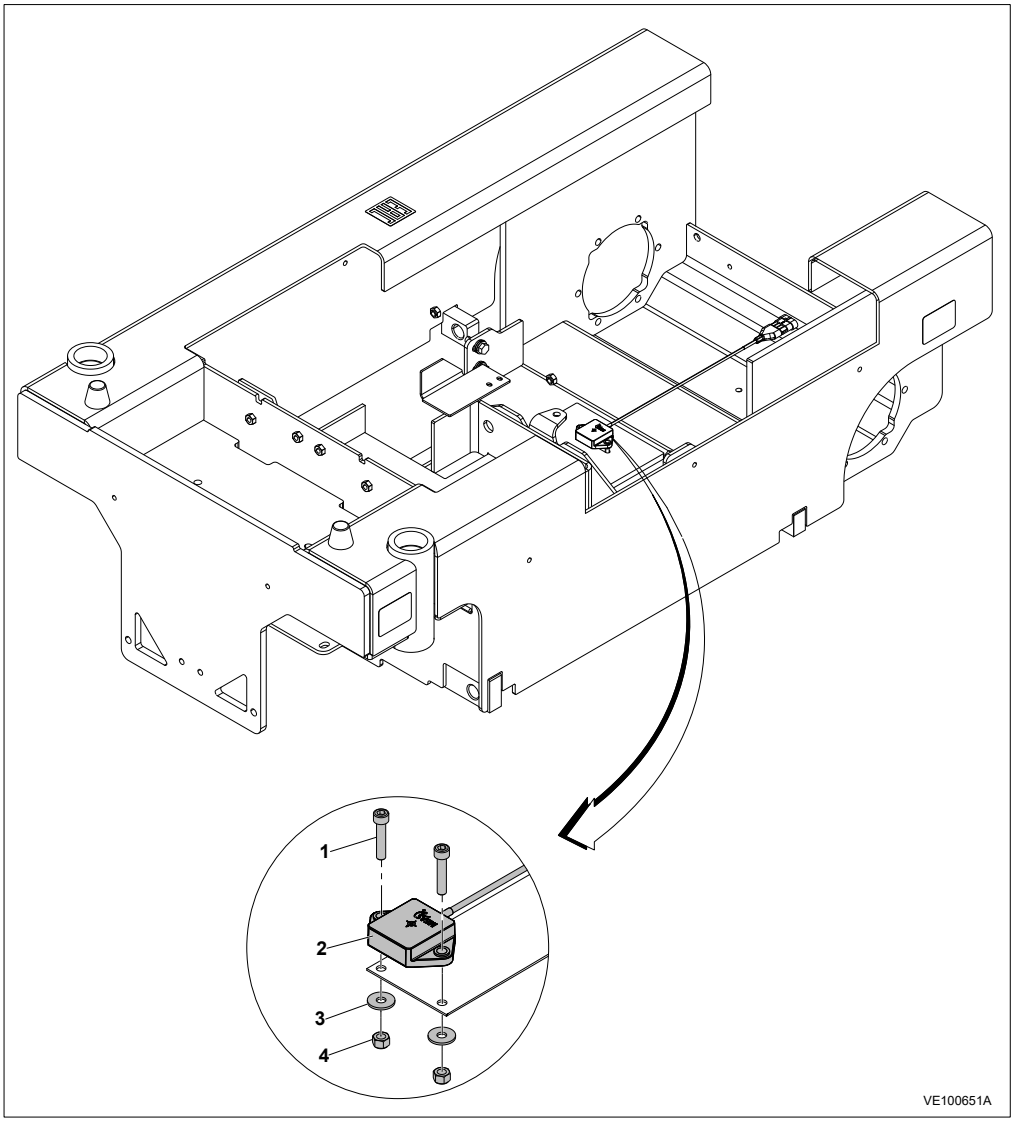


Figure 76. Tilt Sensor Location

1. Bolts	3. Washers
2. Tilt Sensor	4. Nuts

9.6.1 Removal

1. Park the machine on a firm level surface. Make sure that the mast is fully lowered.
2. Push in the power/emergency stop switch (down) to off, turn the key switch to the (center) OFF position.
3. Remove key and tag machine out of service.

4. Disconnect battery power from the machine.
5. Locate tilt sensor on the frame. Unplug the tilt sensor harness connector.
6. Remove mounting bolts (**1**), washers (**3**) and nuts (**4**) attaching tilt sensor to the base frame.

9.6.2 Installation

1. Before mounting tilt sensor on the base frame, make sure that the mating surfaces of the sensor and base are free from debris or burrs for a flush mount.
2. Secure tilt sensor onto base frame with mounting bolts (**1**), washers (**3**) and nuts (**4**).
3. Connect the wire harness connector to the tilt sensor.
4. Reconnect battery power to the machine.
5. Remove the machine out of service tag and re-insert the key.
6. Start the machine and complete tilt sensor calibration using analyzer. For detailed calibration procedure refer to Section — Tilt Sensor Calibration.

Table 40. Tilt Sensor Wiring Pin Assignment

Pin	Function	Wire Color	Description
1	Vcc	WHT	8 V to 30 V (32 V Max)
2	GND	YEL	Ground
3	CANH	GRN	CAN HIGH LINE
4	CANL	BRN	CAN LOW LINE

9.7 GROUND CONTROL

NOTICE

Do not attempt to disassemble the ground control module if the machine is still under warranty. Opening the ground control module while the machine is under warranty will void the warranty. If under warranty, request a replacement module from the factory.

NOTICE

Electrostatic discharge can damage components on the integrated circuit board. Place the ground control module on a non-conductive surface when opening.

NOTICE

Disconnect main power from the batteries before attempting to service the electrical system. Failure to do so could cause damage to the machine’s electrical components.

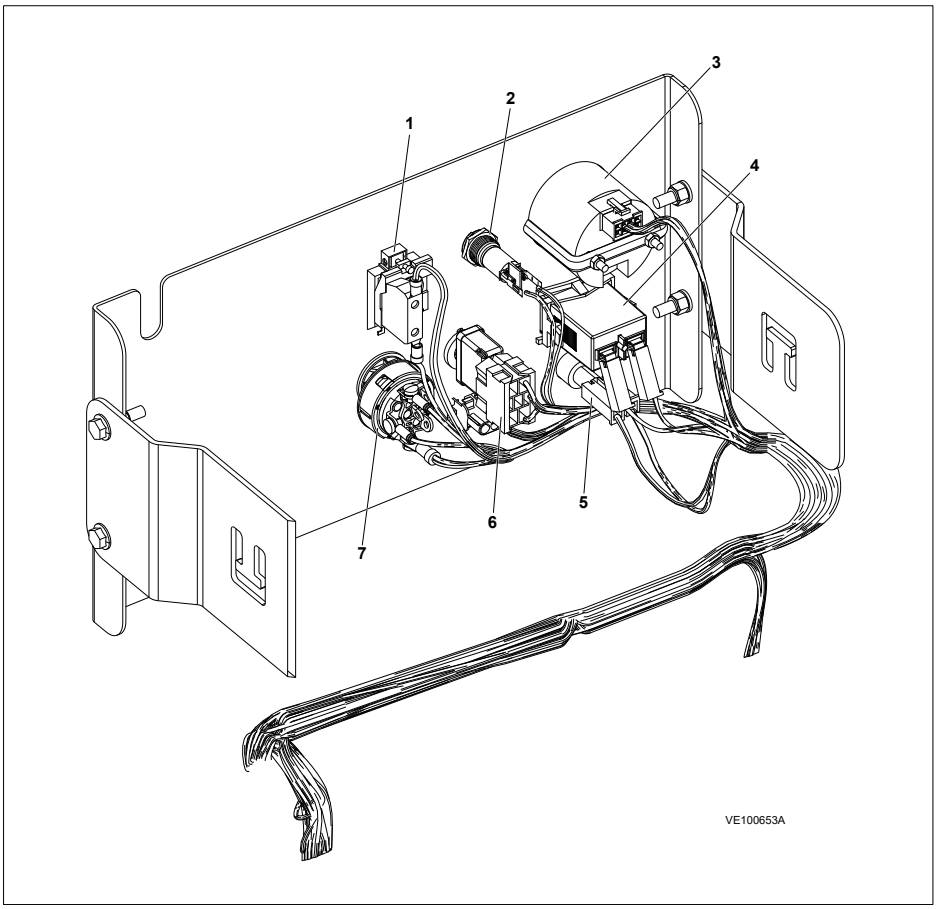


Figure 77. Ground Control Station - Rear of Panel

1. E-Stop Connector	4. Hour Meter Gauge	7. Key ON/OFF Switch
2. LED Indicator	5. Yellow Push Button Switch	
3. LCD Gauge	6. Toggle Switch	

9.7.1 Removal

1. Park the machine on a firm level surface. Make sure that the mast is fully lowered.
2. Push in the power/emergency stop switch (down) to off, turn the key switch to the (center) OFF position.
3. Remove key and tag machine out of service.
4. Remove the hood assembly to gain access to the mounting nuts on the control station bracket mounting bolts. Refer to Section – Hood Removal and Installation for hood assembly removal.
5. Disconnect battery power from the machine.
6. Remove bolts, washers and nuts attaching the ground control panel to the frame.
7. Rotate the ground control station and disconnect the desired connectors and remove components on the back of the panel as shown above.

9.7.2 Installation

1. Check that all components are installed in the control station panel and connected to the wiring harness on the back of the panel.
2. Position the control station on the machine and align the mounting holes on the panel with the mounting holes on the frame.

3. Tighten using mounting bolts, washers and nuts.
4. Reconnect battery power to the machine.
5. Remove the machine out of service tag and re-insert the key.
6. Start the machine and check machine operation.

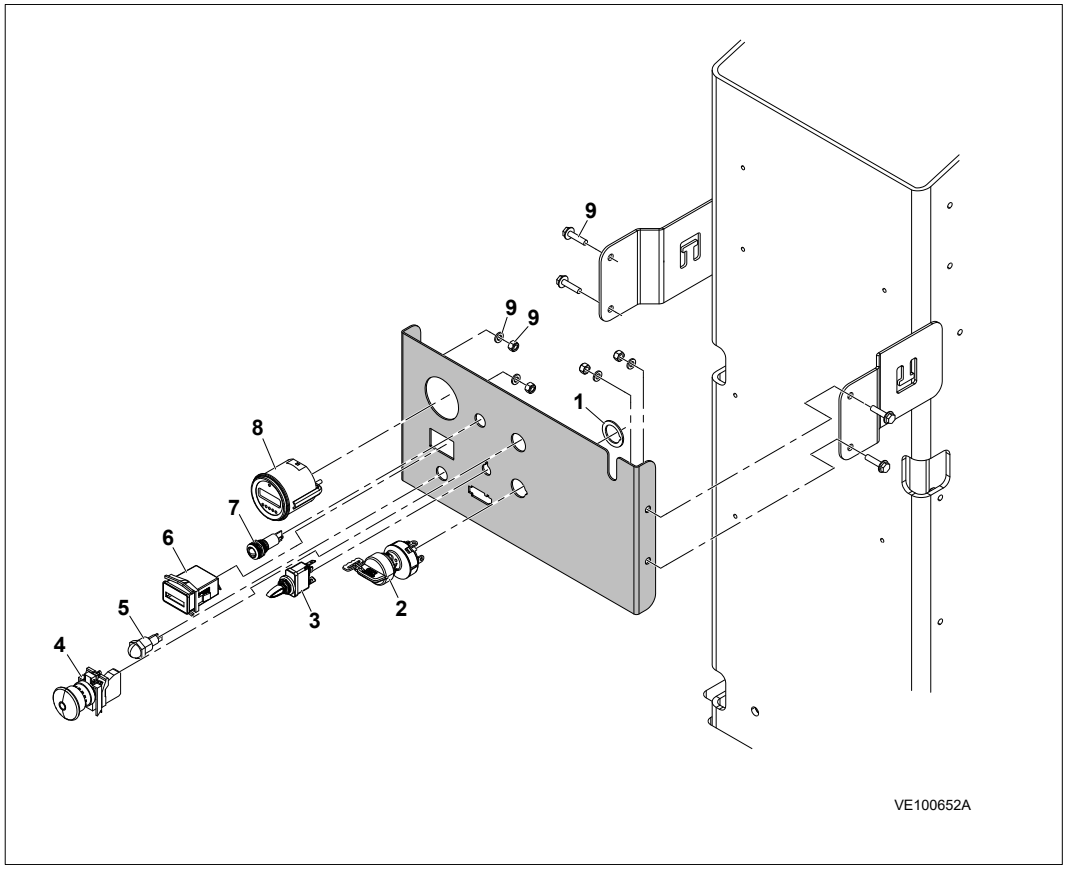


Figure 78. Ground Control Station Removal/Installation

1. Shim	4. E-Stop Switch	7. LED Indicator
2. Key ON/OFF Switch	5. Yellow Push Button Switch	8. LCD Guage
3. Toggle Switch	6. Hour Meter Guage	9. Bolt, Washer, Nut

9.7.3 Alarm Removal

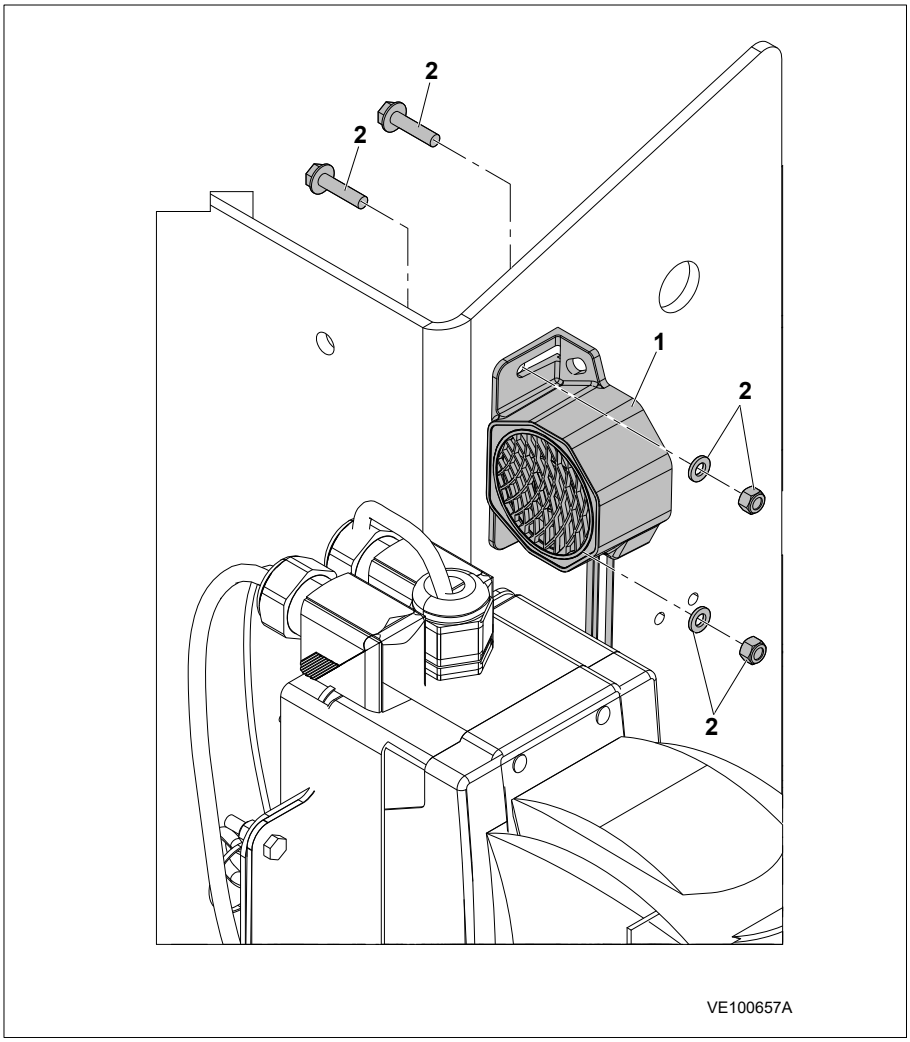


Figure 79. Alarm Removal

1. Alarm	2. Hardware (Bolt, Nut and Washer)

9.8 HOOD REMOVAL AND INSTALLATION

9.8.1 Removal

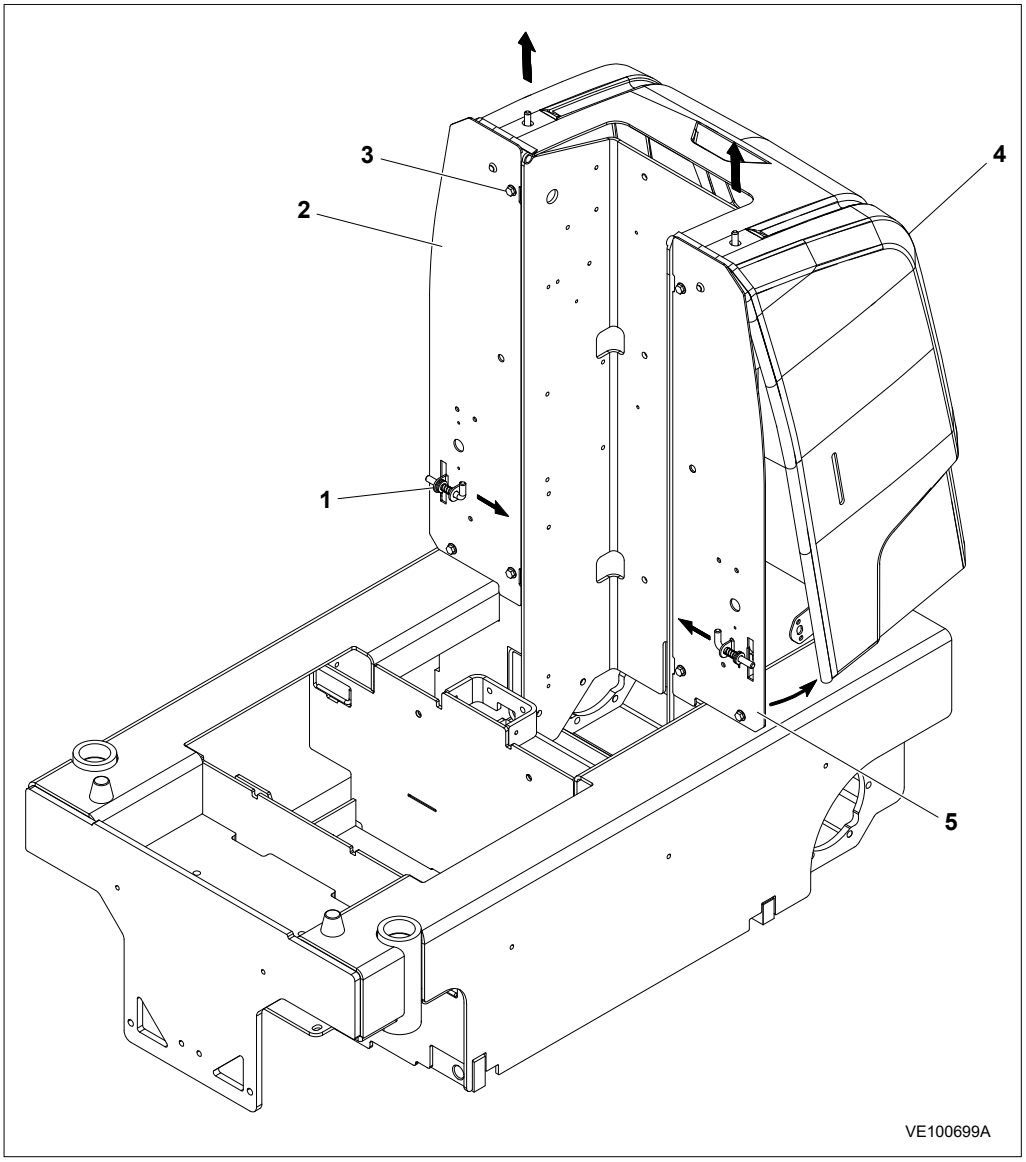


Figure 80. Hood Removal and Installation

1. Door Latch Pin	3. Bolt	5. Hood Support (Left)
2. Hood Support (Right)	4. Hood Assembly	

1. Park the machine on a firm level surface. Make sure that the mast is fully lowered.
2. Push in the power/emergency stop switch (down) to off, turn the key switch to the (center) OFF position.
3. Remove key and tag machine out of service.
4. Locate door latch pin (**1**) behind the mast assembly on the side of hood support left (**5**) and right (**2**).
5. Pull the pin inside to release the lock.

6. Tilt hood assembly (**4**) slightly outside to remove from the door latch pin.
7. Lift hood assembly (**4**) upwards to remove from the hood support.
8. Secure the hood assembly.

9.8.2 Installation

1. Place hood assembly (**4**) on hood supports (**2** & **5**).
2. Align the hood bracket into door latch pin (**1**) for locking.
3. Pull latch pin (**1**) and fix the hood assembly in place.
4. Release the pin.
5. Remove the machine out of service tag and re-insert the key.

9.9 DRIVE SYSTEM

9.9.1 Drive Cover Removal

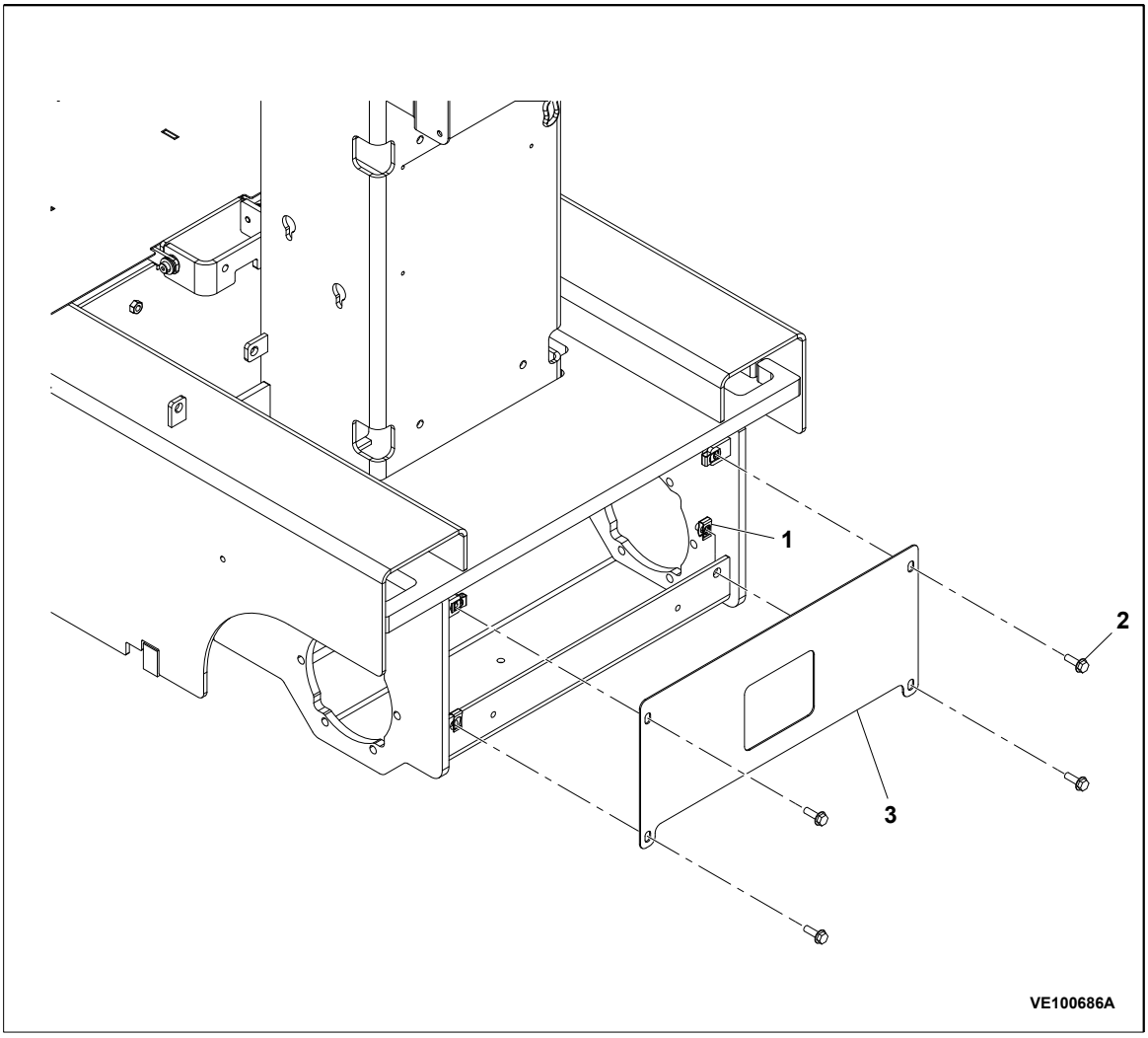


Figure 81. Drive Cover Removal

1. Nuts	2. Bolts	3. Rear Cover

1. Park the machine on a firm level surface. Make sure that the mast is fully lowered.
2. Push in the power/emergency stop switch (down) to off, turn the key switch to the (center) OFF position.
3. Remove key and tag machine out of service.
4. Locate the drive cover panel on back side of the machine.
5. Remove bolts (**2**) and nuts (**1**) and remove rear cover (**3**).

9.9.2 Installation

1. Install nuts (**1**) onto the frame.
2. Place rear cover (**3**) and align on the frame.
3. Install rear cover (**3**) with bolts (**2**).

4. Remove the machine out of service tag and re-insert the key.

9.9.3 Drive Motor Removal

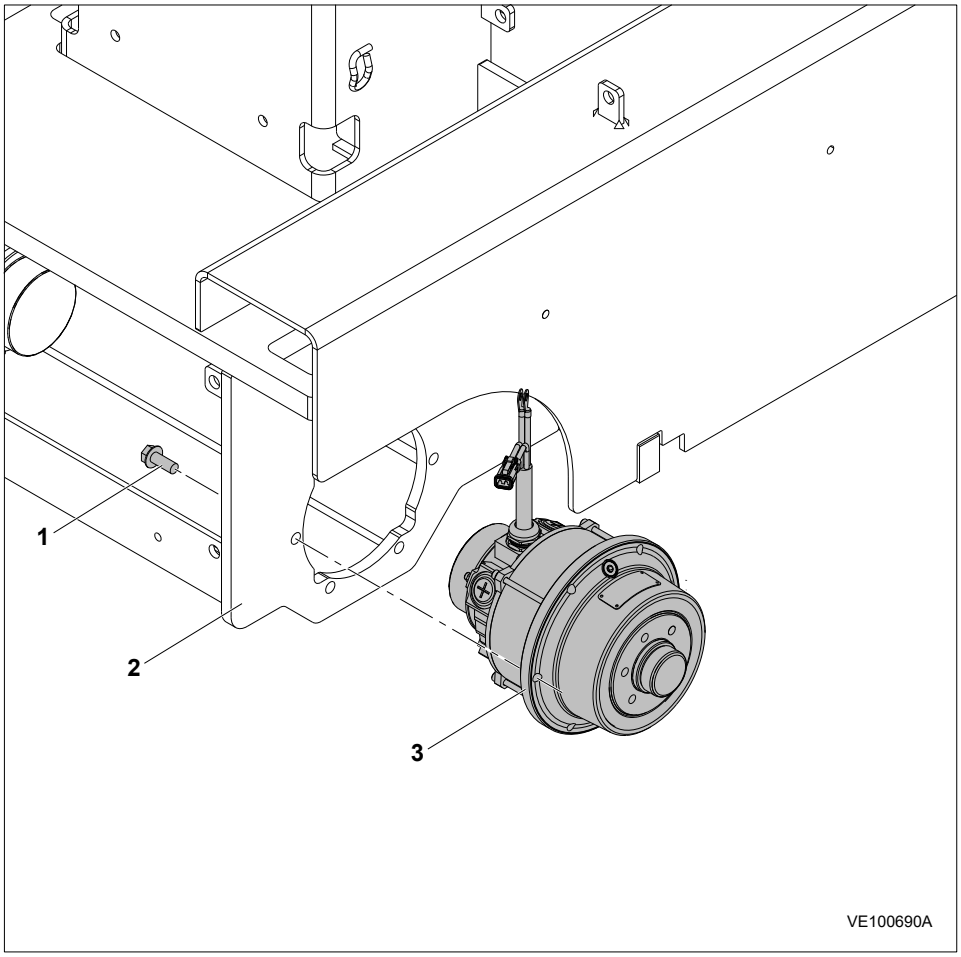


Figure 82. Drive Motor System – Removal

1. Bolt	2. Base Frame	3. Drive Motor Assembly

Note: Removal/Installation is same for left and right drive motor (**3**).

⚠ CAUTION

Never work under an elevated platform. Platform should be fully lowered on the base of the machine.

The electric wheel drive assemblies are mounted independent of each other on the base frame at the front of the machine.

The wheel drive assembly consists of an 24V DC electric motor driving a 45 – 44.80:1 ratio gear box. The assembly also includes a friction disk parking brake assembly. This brake assembly is mounted internally on the drive assembly between the drive motor and the gear box assembly.

1. Park the machine on a firm level surface. Make sure that the mast is fully lowered.
2. Push in the power/emergency stop switch (down) to off, turn the key switch to the (center) OFF position.
3. Remove key and tag machine out of service.

4. Turn off the battery power supply to the machine.
5. Apply the parking brake to stop machine movement.
6. Disconnect the positive battery terminal from the left side battery.
7. Raise the rear drive wheels of the machine off the ground, using a fork truck or floor jack. Place a block or safety stand under the machine.
8. Remove the drive wheel mounting lugs and remove the drive wheel(s). Refer to Section – Wheel.
9. Disconnect the power harness terminals and brake harness connector(s) from the drive motor (**3**).
10. Remove the six hex head bolts (**1**) attaching the drive assembly to the base frame (**2**).
11. Carefully slide the drive motor assembly (**3**) out of the base frame (**2**) for removal.

9.9.4 Drive Motor Installation

1. Use a fork truck or floor jack to lift the machine. Place a block or safety stand under the machine.
2. Use a suitable lifting device to support the drive motor (**3**).
3. Install the drive motor (**3**) onto base frame (**2**).

⚠ CAUTION

Do not damage the harness while installing the drive motor.

4. Make sure that the drive motor (**3**) is properly aligned with base frame (**2**).
5. Install six hex head bolts (**1**) to drive motor assembly (**3**) and base frame (**2**). Tighten the bolts to the specified torque.

Note: Apply Loctite 242 to bolts (**1**) before installation.

6. Connect the power harness terminals and brake harness connector(s) to the drive motor (**3**).
7. Secure extra length of harness under the frame with tie straps.
8. Install the drive wheel mounting lugs and the drive wheel(s). Refer to Section – Wheel.
9. Remove the machine from the block or safety stand and lower using fork truck or floor jack.
10. Connect the positive battery terminal to the left side battery.
11. Turn on the battery power supply to the machine.
12. Remove the machine out of service tag and re-insert the key.
13. Start the machine and check the drive motor for proper functioning.

9.10 DRIVE CONTROL MODULE

The drive control module is located on the right side of the machine on the mast support as shown below. Use the following instructions when removing and installing the drive control module.

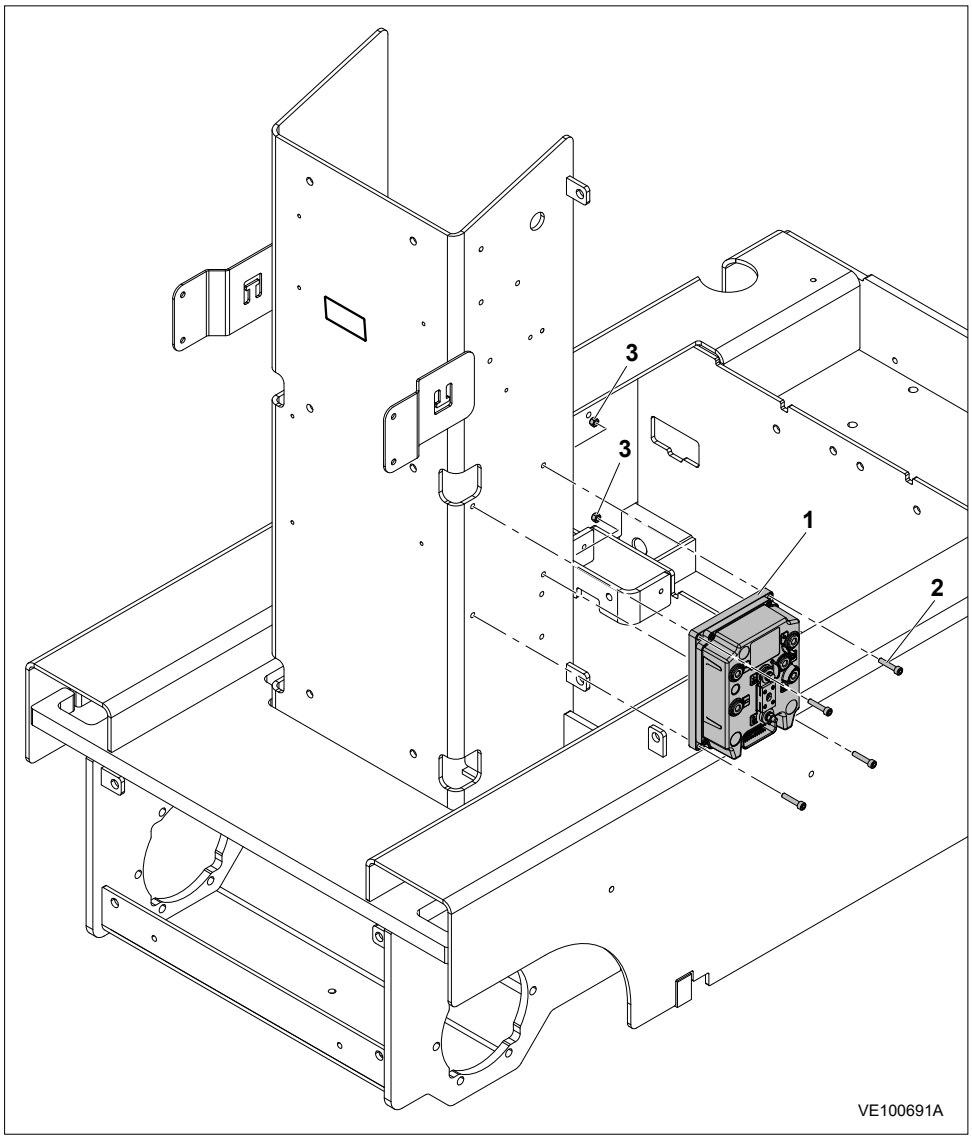


Figure 83. Drive Control Module - Removal

1. Drive Control Module	3. Nut
2. Bolt	

9.10.1 Removal

1. Park the machine on a firm level surface. Make sure that the mast is fully lowered.
2. Push in the power/emergency stop switch (down) to off, turn the key switch to the (center) OFF position.
3. Remove key and tag machine out of service.
4. Disconnect the batteries.

Note: Note the wire terminal locations when removing the Drive Control Module.

5. Disconnect all wires from the power module and remove module mounting bolts (**2**) and remove drive control module (**1**) from the machine.

9.10.2 Installation

1. Be sure that the terminals are oriented as shown.
2. After installing drive control module (**1**) to the machine, connect the wires back to the drive control module.
3. Install the mounting bolts (**2**).

NOTICE

Do not overtighten the terminal bolts, or the unit could be damaged.

4. Torque the mounting bolts to 5.6 Nm to 8.4 Nm.
5. After all connections to the power module are made, the battery can be reconnected.
6. Remove the machine out of service tag and re-insert the key.

9.11 LOGIC CONTROL MODULE

All machine electrical functions are controlled through the logic control module. The logic control module also monitors all the machine's electrical systems. If a system fault should happen with the logic module or one of the machine's electrical systems, the logic control module will generate a DTC code. Refer to Section – Diagnostic Trouble Codes for diagnostic information concerning any DTC code generated by the logic control module.

The logic control module is located on the back side of the mast column frame.

9.11.1 Module Access

1. Open the hood cover to access the logic control module.

9.11.2 Removal

1. Park the machine on a firm level surface. Make sure that the mast is fully lowered.
2. Push in the power/emergency stop switch (down) to off, turn the key switch to the (center) OFF position.
3. Remove key and tag machine out of service.
4. Disconnect machine power at the positive (+) battery cable or use quick disconnect.
5. Mark or note the harness connector positions before removing from the control module (**1**).
6. Disconnect the harness connectors from the front of the module (**1**).
7. Loosen and remove the bolt (**4**), washer (**3**), and sleeve (**2**) from the module (**1**).
8. Remove the module (**1**) from the machine and place aside on a clean and dry surface.

9.11.3 Installation

1. Support and align control module (**1**) to the mast frame.
2. Install control module (**1**) to mast frame and secure with bolt (**2**), washer (**3**) and sleeve (**2**).
3. Connect main harness connectors to front of the module (**1**).
4. Connect main power to positive (+) battery cable.
5. Remove the machine out of service tag and re-insert the key.

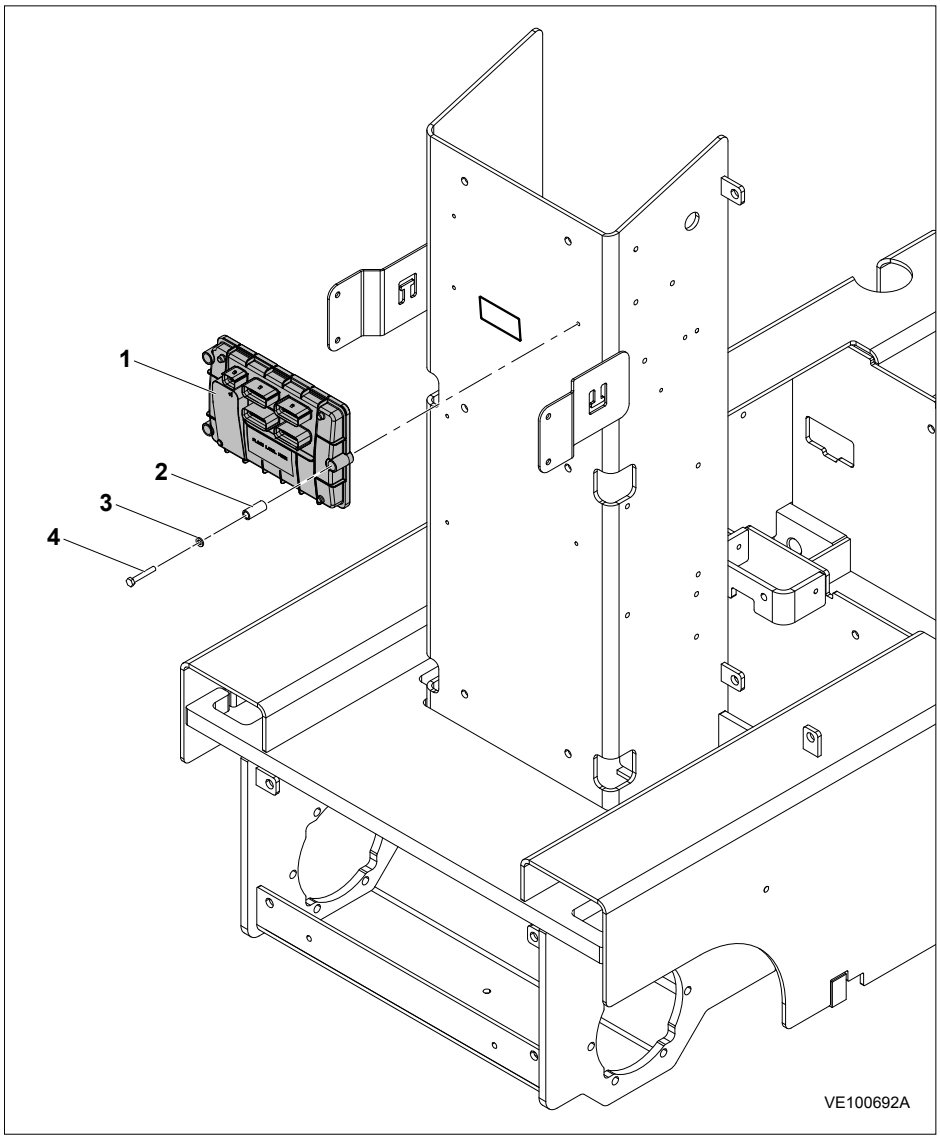


Figure 84. Logic Module Components

1. Logic Module Assembly	3. Washer
2. Sleeve	4. Bolt

9.12 PUMP MOTOR

9.12.1 Removal

⚠ WARNING

Make sure that the pressure is properly relieved from the hydraulic system before proceeding to remove the pump motor assembly.

NOTICE

Be certain that the mast is fully lowered before removing any hydraulic lines from the pump unit. Wear protective gear when working around pressurized hydraulic lines. Remove connections carefully and cap all lines.

1. Park the machine on a firm level surface. Make sure that the mast is fully lowered.
2. Push in the power/emergency stop switch (down) to off, turn the key switch to the (center) OFF position.
3. Remove key and tag machine out of service.
4. Disconnect the battery (+) cable or use quick disconnect.
5. Label and disconnect the positive (+) (**5**) and negative (-) (**6**) power cables from the electric motor.
6. Disconnect the inlet port (**4**) and outlet (**2**) ports of the filter (**3**) from pump motor assembly (**7**).

NOTICE

Cap all hydraulic hoses to prevent entrapment of dust and dirt into it.

7. Remove bolts (**1**) from hydraulic tank and pump motor assembly (**7**).
8. Finally remove hydraulic tank and pump motor assembly (**7**) and keep on a clean working surface.

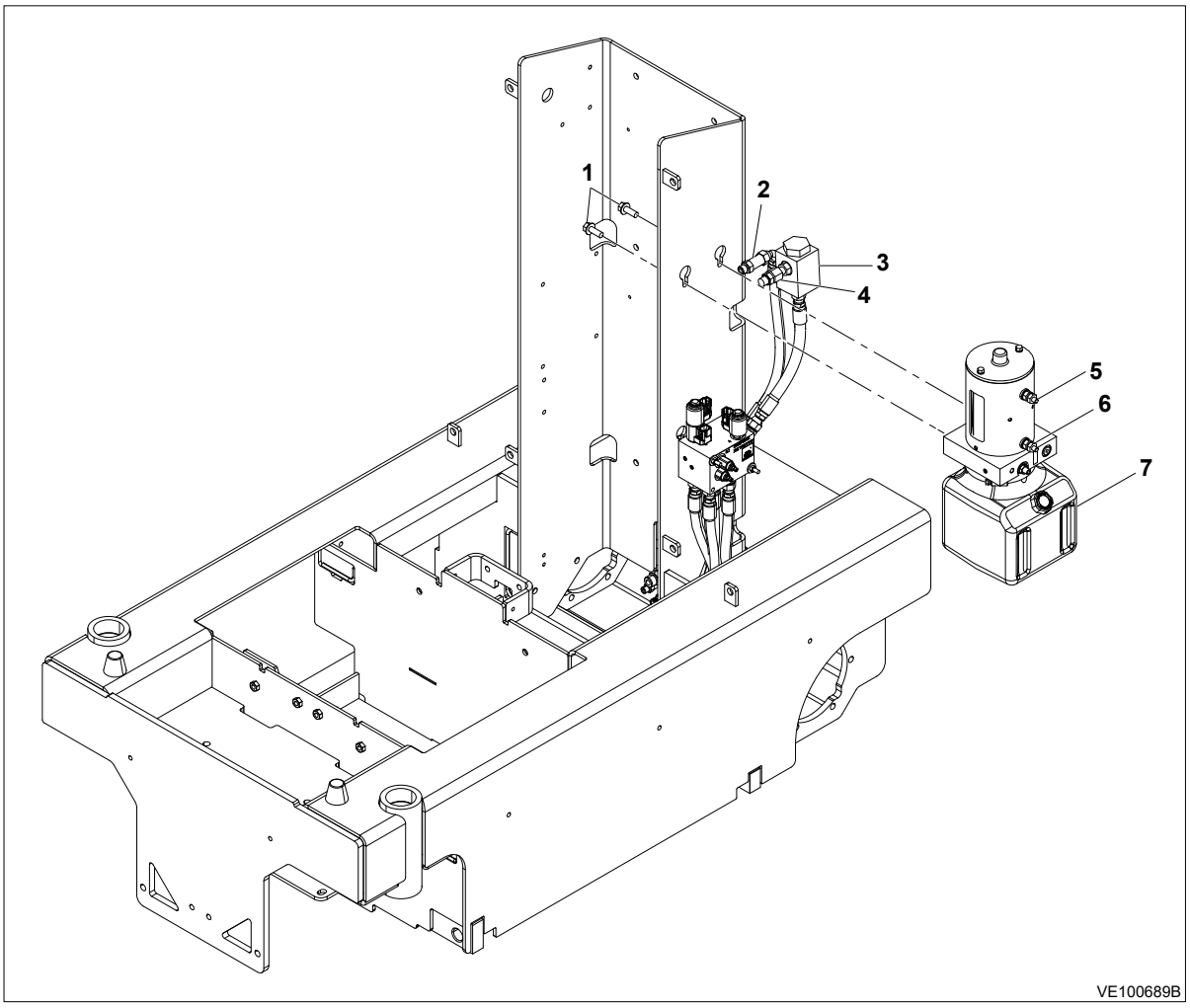


Figure 85. Pump Motor Removal

1. Bolt	5. Positive (+)
2. Outlet port	6. Negative (+)
3. Filter	7. Hydraulic Tank and Pump Motor Assembly
4. Inlet port	

9.12.2 Installation

Note:

1. Using suitable holding device carefully position the pump motor assembly and valve assembly on to the mast support frame.
2. Secure with mounting bolts (**1**).
3. Connect inlet (**4**) and outlet (**2**) ports of filter (**3**) to pump motor assembly (**7**).
4. Plug the harness connectors to the lift-up solenoid connections on the pump valve assembly.
5. Connect the power cable to the pump motor assembly.
6. Connect battery power to the machine.

7. Remove the machine out of service tag and re-insert the key.

9.13 PLATFORM CONTROL CONSOLE

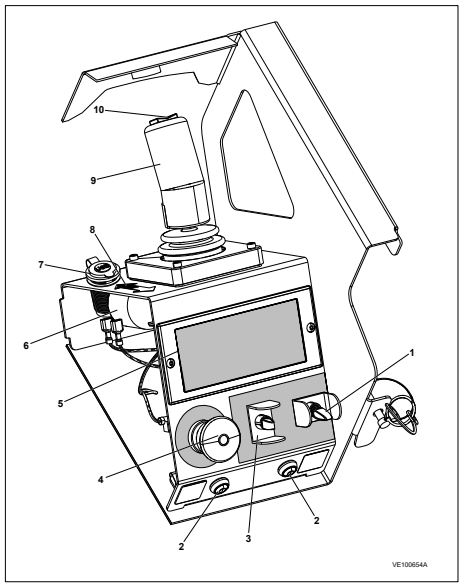


Figure 86. Platform Control Components

1. Toggle Switch	5. Platform Control Module	9. Controller Assembly
2. Push Button (Indoor/Outdoor and Horn)	6. Alarm	10. Steer Switch and Decal
3. Switch Guard	7. USB Connection	
4. Emergency Stop Switch	8. Arrow Decal	

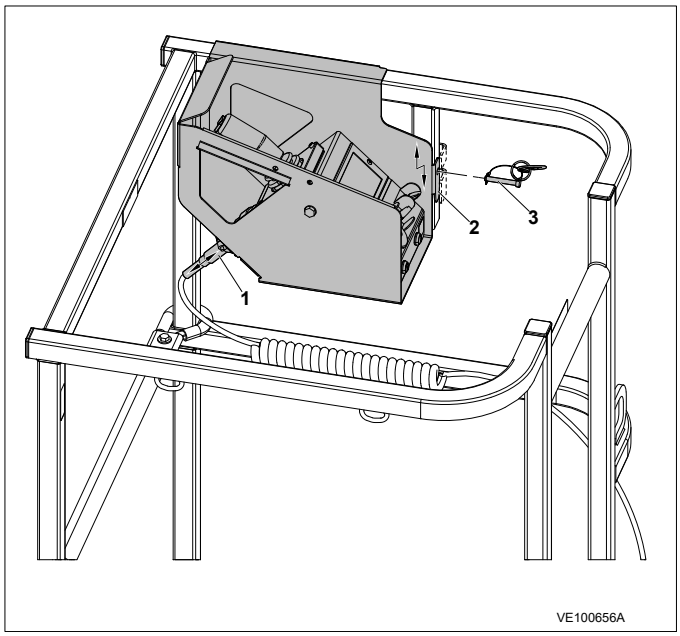


Figure 87. Platform Control Station

1. Harness Connector	2. Platform Control Station	3. Mounting Pin

9.13.1 Removal

1. Park the machine on a firm level surface. Make sure that the mast is fully lowered.
2. Push in the power/emergency stop switch (down) to off, turn the key switch to the (center) OFF position.
3. Remove key and tag machine out of service.
4. Disconnect the platform control station harness (**1**) from the round connector in front of the control station.
5. Support the platform control station and remove the mounting pin (**3**) securing the control station to the platform station mount. Lift up and swing the tab out of slot in mount to remove control station from the machine.

9.13.2 Installation

1. Install platform control station onto the platform station mount and secure with mounting pin (**3**).
2. Connect the platform station harness (**1**) to the front of the control station.
3. Remove the machine out of service tag and re-insert the key.

9.13.3 Joystick Assembly

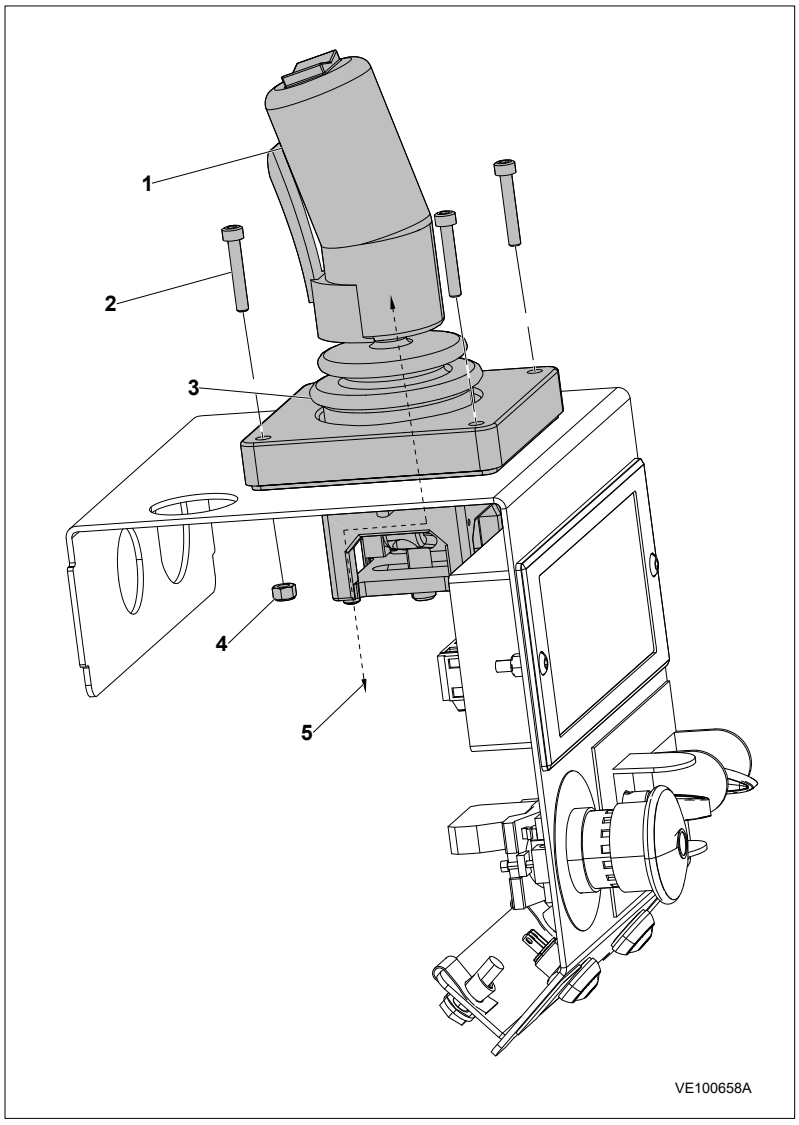


Figure 88. Joystick Assembly

1. Joystick Controller	3. Rubber Boot	5. Install/Remove through Access Hole
2. Screw	4. Nut	

9.14 MAST ASSEMBLY

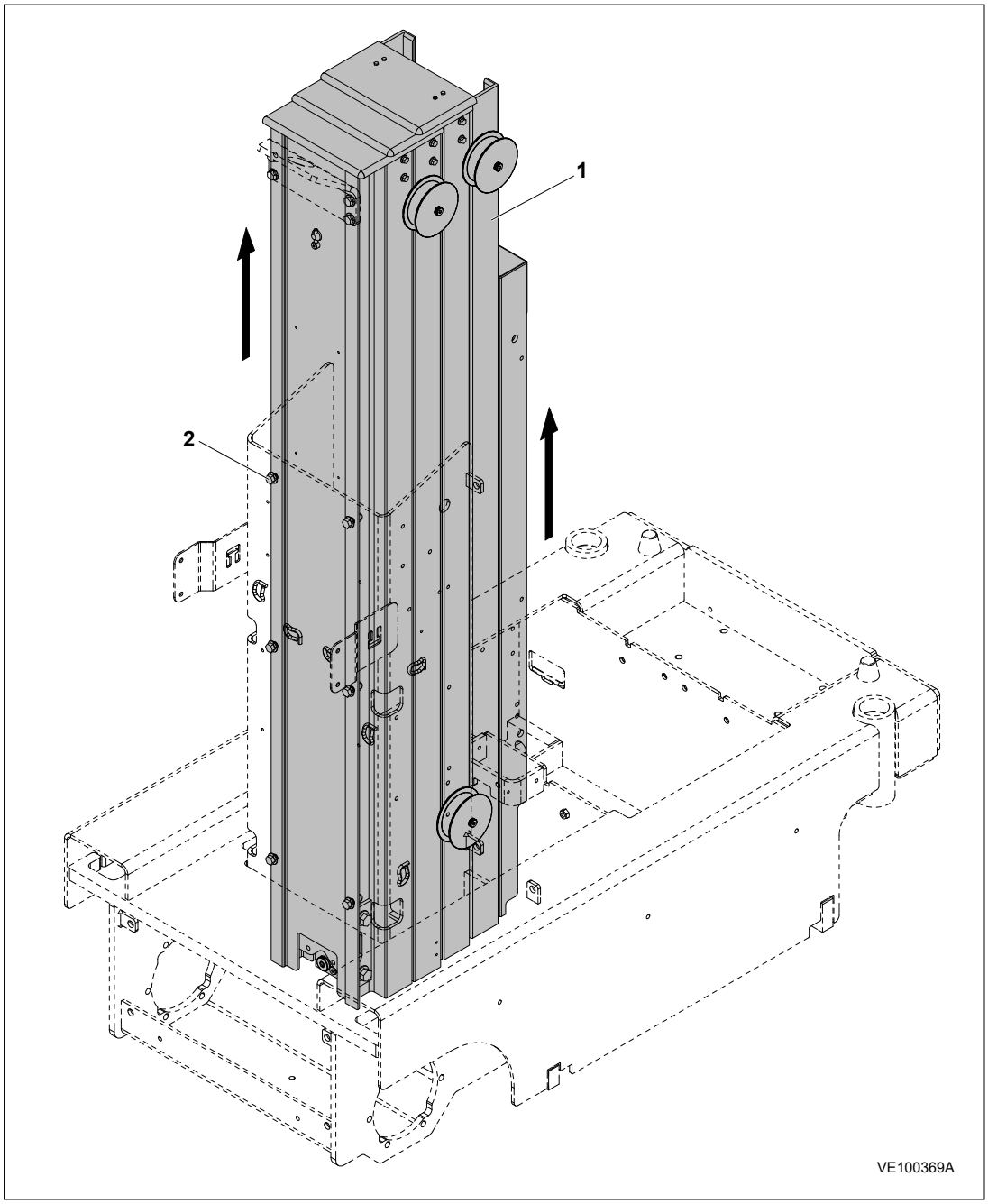


Figure 89. Mast Assembly Removal

1. Mast	2. Flange screw, Washer and Nut location

9.14.1 Removal

1. The following components must be removed from the machine before removing the mast assembly:
   - Hood
   - Disconnect the Platform Control Console from the Mast mounted junction box
   - Platform Assembly
2. Disconnect the positive battery cable from the battery.
3. Unplug the platform control cable connector at the ground control module.
4. Remove the clamp attaching the platform control cable from inside the mast mounting column.
5. Disconnect the spring and clamp attaching the AC receptacle cable inside the mast mounting column.
6. Under the machine, disconnect and cap the hydraulic extend and return lines from the hydraulic cylinder.
7. Using an overhead crane or suitable lifting device capable of supporting the weight of the mast assembly, attach a sling strap to the mast. *(If installed, use the optional crane lifting lug on the back of the mast.)*
8. Remove the flange screw (**2**) securing the mast (**1**)to the mounting column.
9. Lift the mast off the base frame and place on a suitable work surface.

9.14.2 Installation

To install the mast assembly reverse the Mast Assembly Removal instructions, however perform the following additional steps during re-assembly.

1. Install machine hood per instructions .
2. Once assembly is complete cycle the mast up and down several times, then check the oil level in the hydraulic reservoir.

Note: (a) Apply High Strength Threadlocking Compound to bolt threads on final assembly.

9.15 LIFT CYLINDER REMOVAL AND INSTALLATION

⚠ WARNING

Hydraulic cylinders are designed to hold hydraulic fluid under high pressure. Ensure all appropriate measures are taken to relieve residual pressure in the cylinder before disconnecting lines.

9.15.1 Removal

Removal of the hydraulic lift cylinder without removing the mast from the machine requires laying the machine on it's back (hood side) with the platform end on top.

1. Remove the following components from the machine before laying machine on it's back:
   - Hood.
   - Drive Cover Removal.
2. Seal the vented cap on the hydraulic fluid reservoir by removing the cap, covering the hole with a few layers of plastic wrap or equivalent. Then install and tighten the cap over the plastic wrap to prevent leakage of hydraulic oil from the reservoir while machine is in a layed back position.

3. Use a forklift truck or an overhead crane and carefully lay the machine on it's back, place a support under the mast end, keeping mast close to level as shown below.

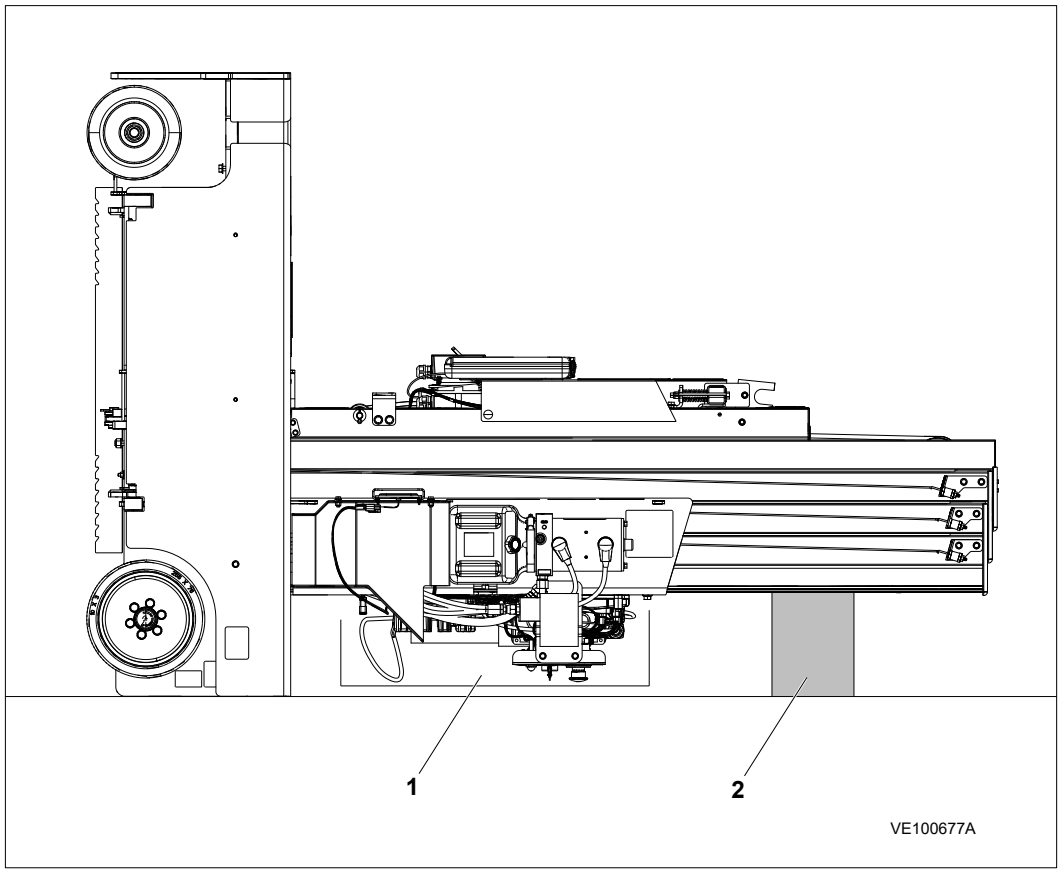


Figure 90. Machine Position for Cylinder Removal

1. Be Careful of Control Components in this Area	2. Support Mast Here - Keep Mast Approximately Level

4. At the base end, remove and cap the extend and return hydraulic lines.

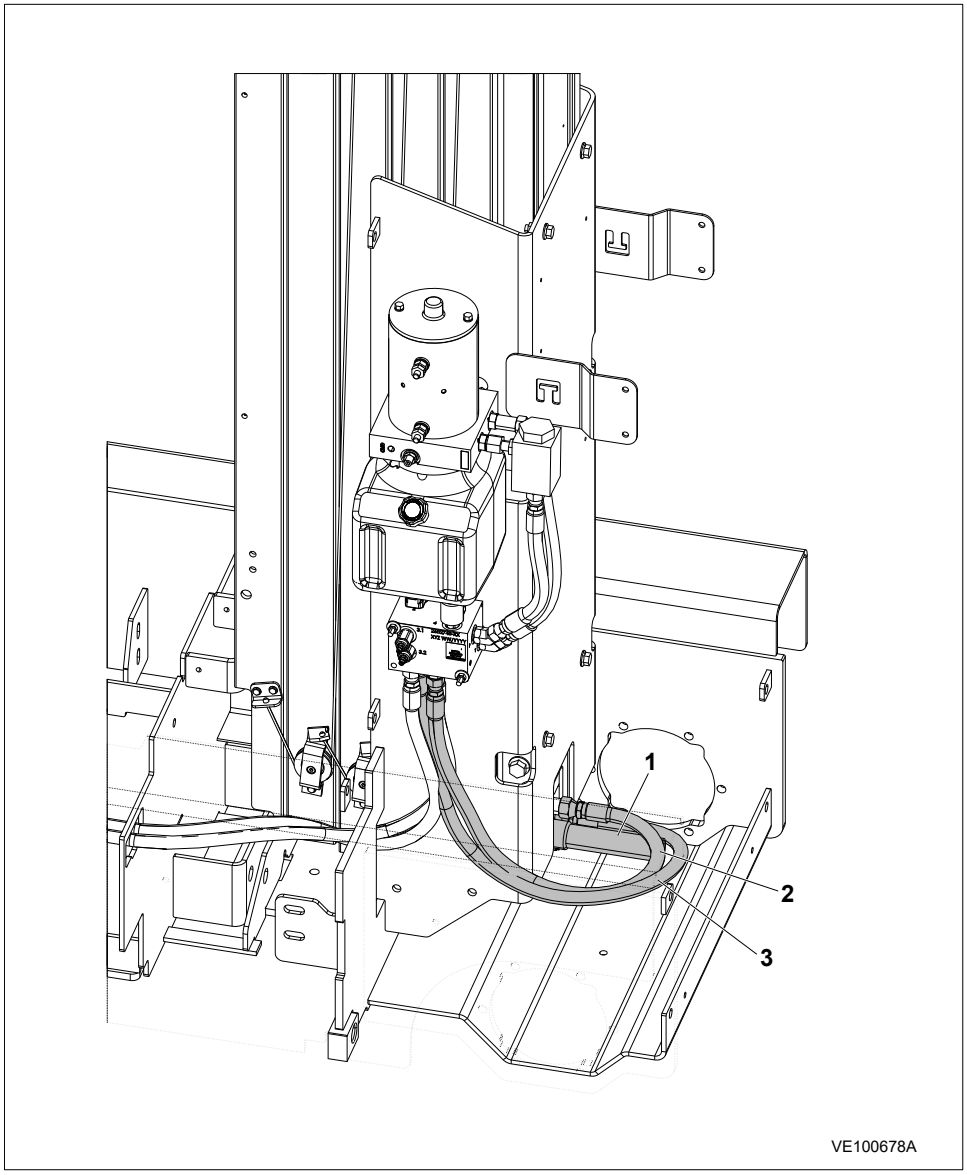


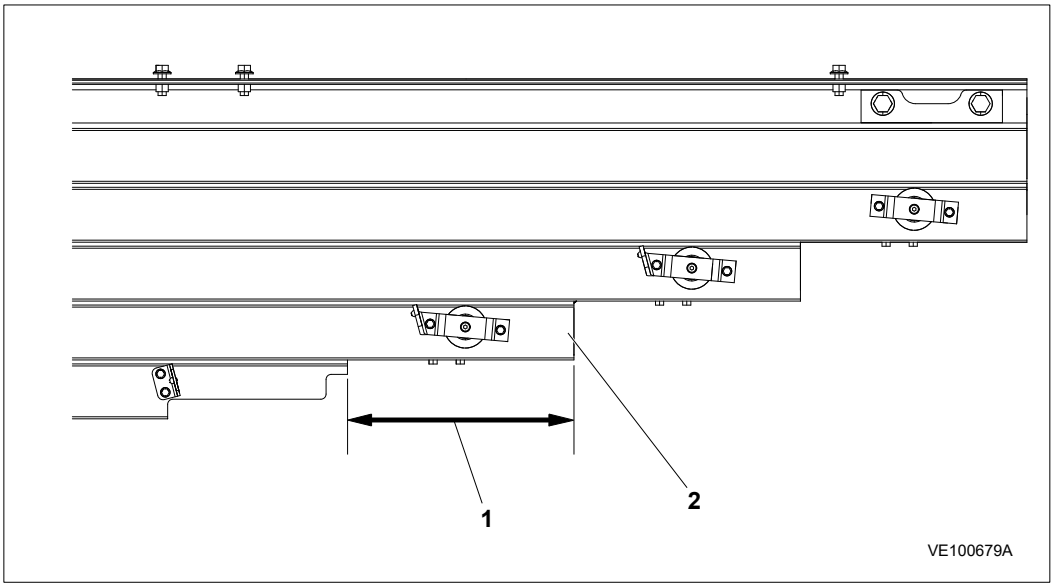
Figure 91. Hydraulic Extend and Return Lines

1. Manual Descent Valve	2. Cylinder Extend Line	3. Cylinder Return Line

5. Remove the mini covers from the tops of the mast sections.

6. Manually extend the mast assembly until the top of mast section-2 is extended approximately one (1) foot (31cm), to allow access to the sheave wheel-anchor block at the top of mast section-2 and the lift cylinder.

Figure 92. Extending Mast Sections



1. 1 ft. (31cm) Extended	2. Mast Section-2

7. Remove the adjust and lock nuts from the chain studs at the bottom of mast section-3.

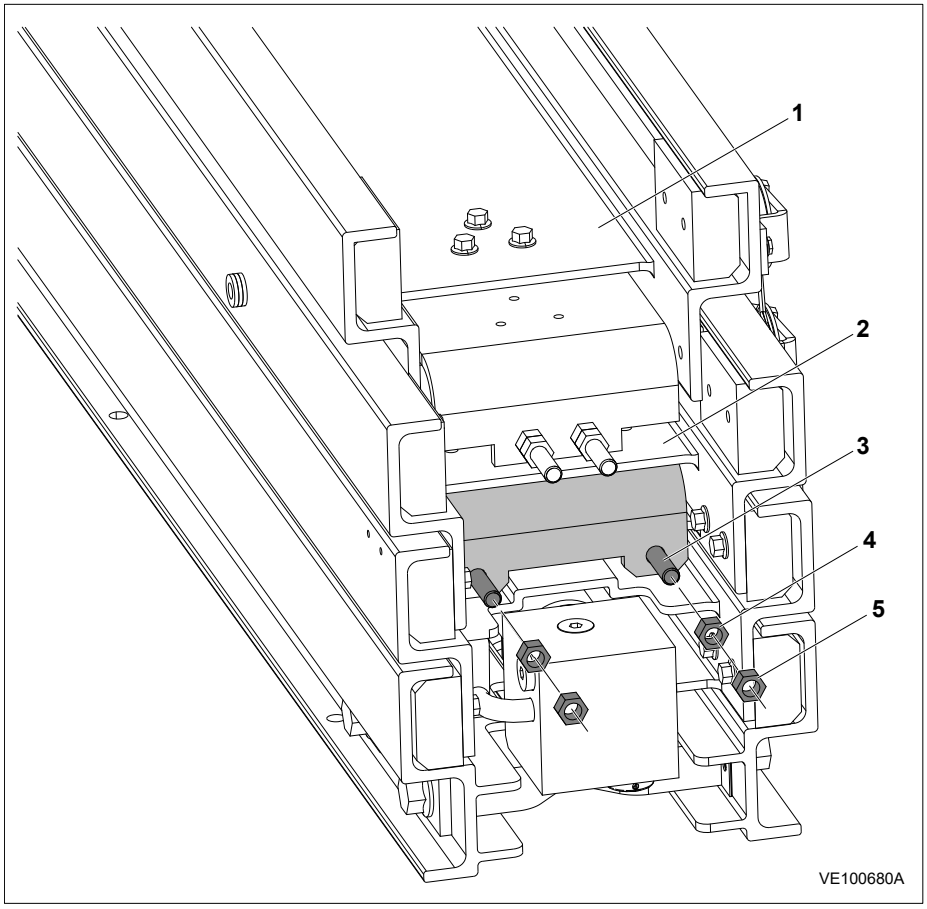


Figure 93. Chain Assembly - Bottom of Mast Section-3

1. Mast Section-4	3. Chain Assembly Stud	5. Lock Nut
2. Mast Section-3	4. Adjust Nut	

Note: (a) Remove nuts and push studs through anchor plate.

8. Push mast sections-3, 4 and 5 back towards the base assembly allowing the top of mast section-2 to be completely exposed.

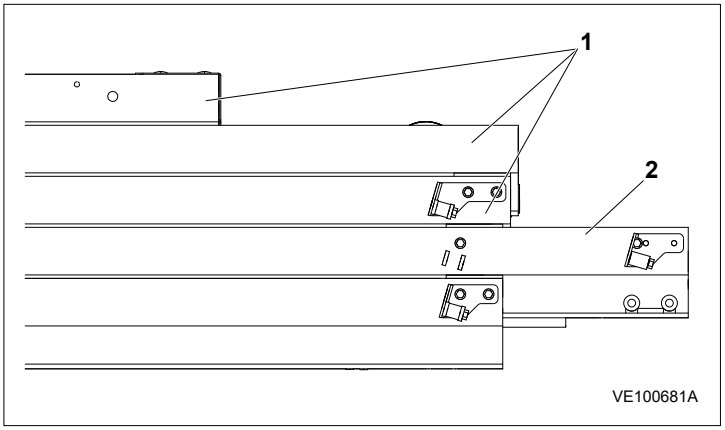


Figure 94. Exposing Top of Mast Section-2

1. Sections-3, 4 and 5 Pushed Back	2. Top of Mast Section-2 Exposed

9. Remove the cylinder/anchor block attach pin – snap ring from the back of the top of mast section-2.

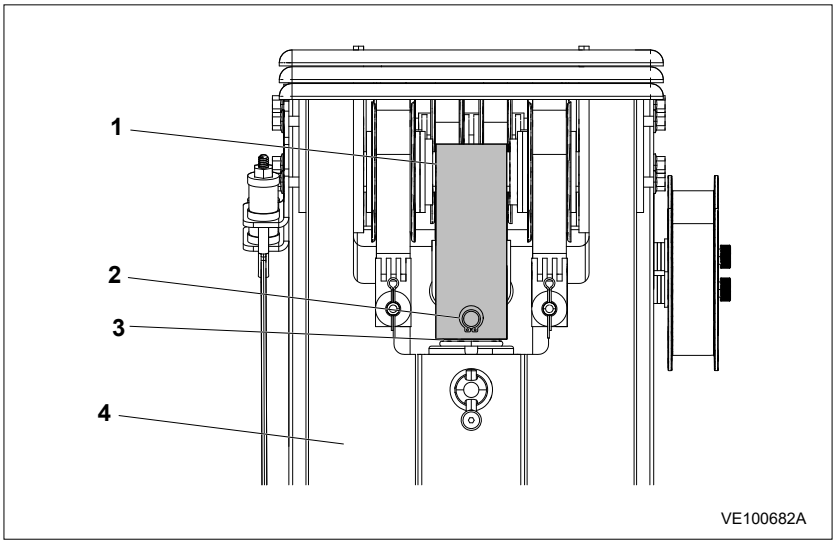


Figure 95. Snap Ring Installation

1. Cylinder/Chain Anchor Block	3. Cylinder Rod
2. Pin and Snap Ring	4. Back of Mast Section-2

10. Remove the cylinder rod pin from the cylinder/chain anchor block.

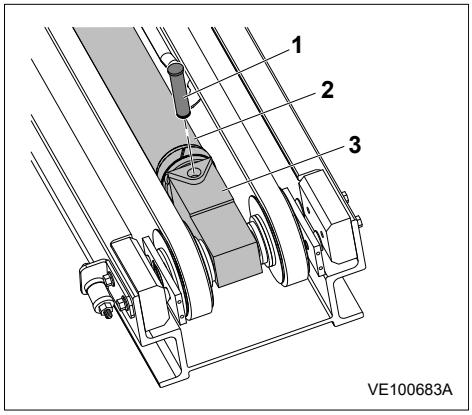


Figure 96. Cylinder Rod Pin Installation

1. Cylinder Rod Pin	2. Cylinder Rod	3. Cylinder/Chain Anchor Block

11. At the bottom of mast section-1, remove the cylinder mount bolts, and mounting plates.

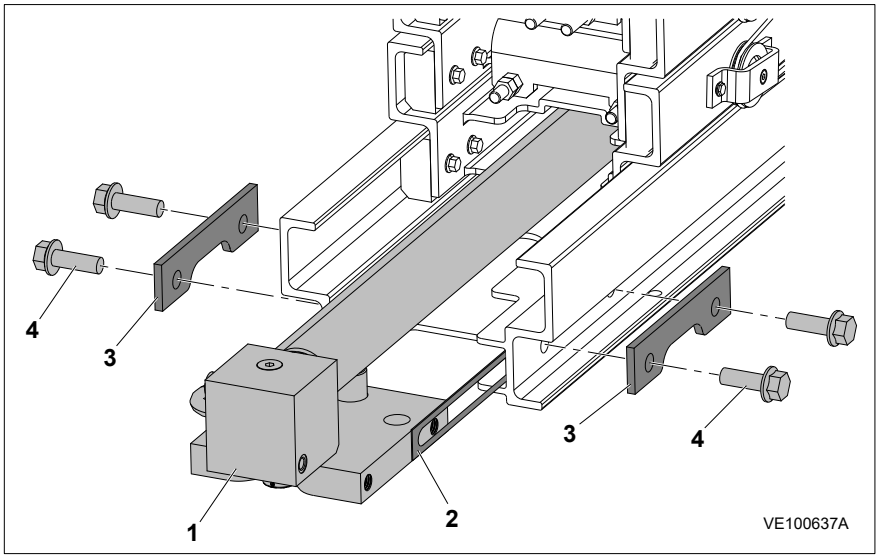


Figure 97. Lift Cylinder Mount Removal

1. Cylinder/Mount Assembly	3. Mounting Plates
2. Mount Shims (Mark Shims)	4. Mounting Bolts

Note: If mount shims are installed, mark the mast and the shim to which side the shims came out of for re-installation.

12. Slide the lift cylinder and mount assembly out of the bottom of mast section-1 and -2 and place on a suitable work surface.

9.15.2 Installation

To install the lift cylinder reverse the Lift Cylinder Removal instructions at the start of this section, however perform the following additional steps during re-assembly.

1. Apply Low Strength Threadlocking Compound (purple) and torque to 85 ft. lbs. (115 Nm) the cylinder mount shoulder screws securing the lift cylinder mount halves together at the bottom of the mast.
2. Check that the platform electrical control cables and the sequence cables are seated in their sheave wheel assemblies when extending mast sections for reassembly.

3. After assembly, readjust the chain at the bottom of mast section-3 and apply Medium Strength Threadlocking Compound to the lock nuts before final tightening.
4. Remove the plastic from under the hydraulic reservoir tank cap.

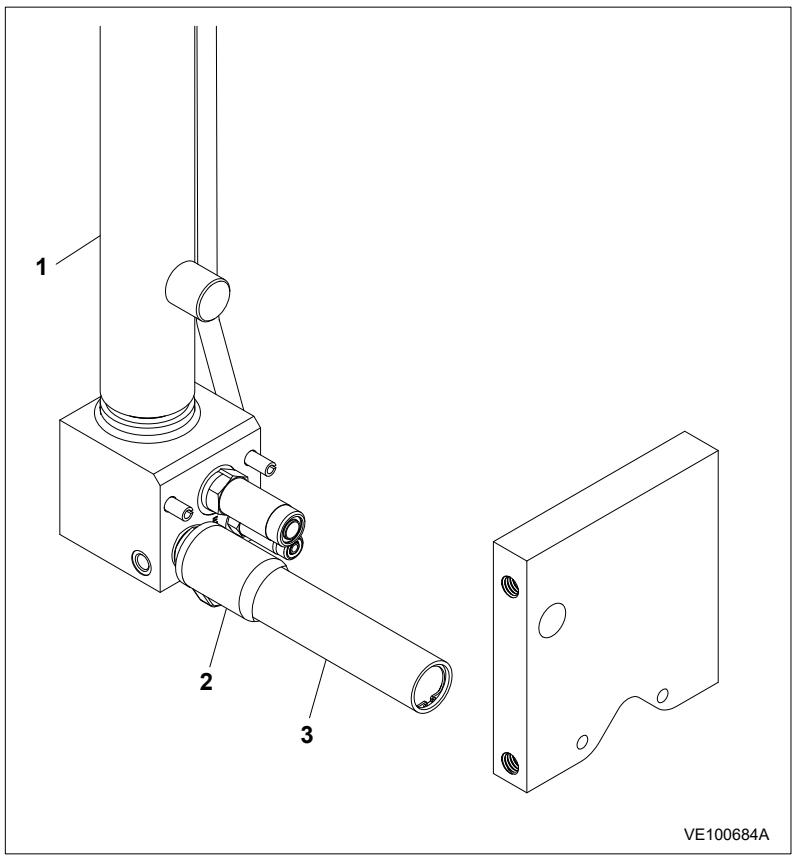


Figure 98. Lift Down Valve and Manual Release Installation

1. Lift Cylinder	3. Manual Release Assembly
2. Valve Solenoid	

Note: (a) Coat all O-rings with clean hydraulic fluid before assembling.
(b) Mount with electrical terminals pointing to right side of machine.

9.16 PLATFORM REMOVAL/INSTALLATION

9.16.1 Platform Removal

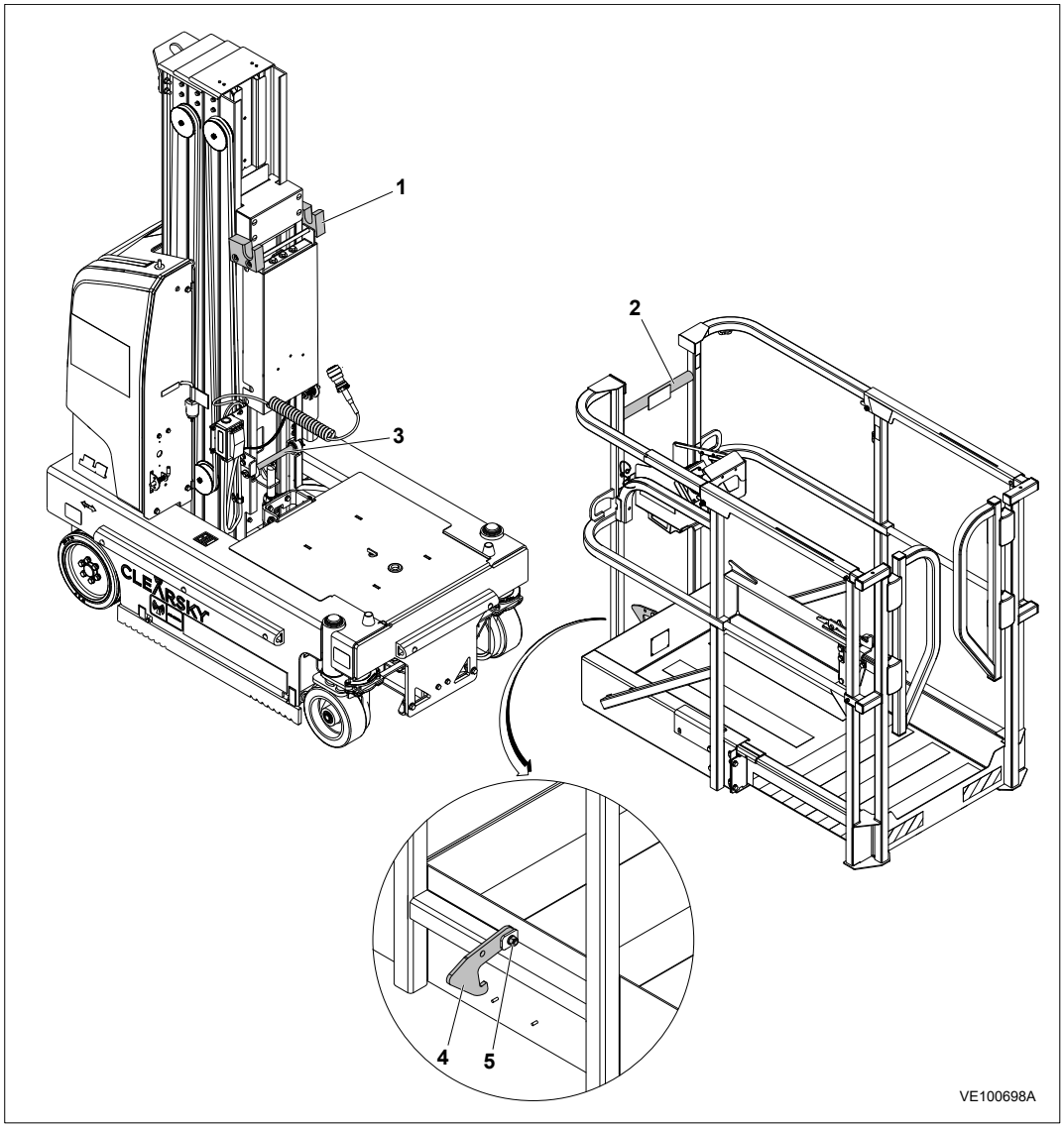


Figure 99. Platform Removal/Installation

1. Cradle Block	3. Spacer Tube	5. Lock Nut
2. Platform Rod	4. Platform Catch Plate	

⚠ CAUTION

Never work under an elevated platform. Platform must be fully lowered on the base of the machine.

1. Park the machine on a firm level surface. Make sure that the mast is fully lowered.
2. Push in the power/emergency stop switch (down) to off, turn the key switch to the (center) OFF position.

3. Remove key and tag machine out of service.
4. Disconnect battery power from the machine.
5. Before removing the platform, make sure that the machine is on a flat horizontal surface.
6. Apply the parking brake to stop machine movement.
7. Make sure that cables of the platform control station do not tangle with the platform. Disconnect the connectors and route the cables out through the rods of platform to free the platform from any constraint when lifting.

Note: Cover the connectors of cables with protective shield to avoid damaging them and to avoid contact with foreign dust particles.

8. Attach the platform to an overhead crane with straps.
9. Loosen the lock nut (**5**) from the platform catch plate (**4**).
10. Detach the platform catch plate (**4**) from the spacer tube (**3**) of LSS.
11. Slowly lift the platform from machine with the help of crane. Manually hold the platform.
12. Move the platform away from the machine in horizontal direction and place the platform on a flat horizontal surface.

⚠ CAUTION

Do not shake the platform while lifting otherwise it will damage the machine parts.

9.16.2 Platform Installation

1. Attach the platform to an overhead crane with the help of straps.

Note: Make sure that the straps properly hold the platform while lifting.

2. Align the platform on the machine with the help of crane and manual support.

⚠ CAUTION

Do not damage machine parts and control station cables while setting platform on machine.

3. Set the platform on machine.
4. Make sure that platform rod (**2**) is properly set on cradle block (**1**) of the machine.
5. Attach the platform catch plate (**4**) to the spacer tube (**3**) of LSS and tighten the lock nut (5) to the platform catch plate (4).

Note: Make sure that platform catch plate (**4**) properly holds the spacer tube (**3**) of LSS.

6. Remove the attached straps of crane from the platform.
7. Remove the protective shield from the applicable connectors and route the cables to the platform and connect the connectors to the platform control station.
8. Reconnect battery power to the machine.
9. Remove the machine out of service tag and re-insert the key.

9.17 CLEARSKY® LED MOTION / AMBER BEACON (CS550) (IF EQUIPPED)

9.17.1 ClearSky® LED Motion / Amber Beacon (CS550) (if equipped)

Configuration requires Bluetooth enabled mobile device with ClearSky Smart Fleet application, internet connectivity and a JLG online express account.

Note: Mounting surface may be different from image shown in *Figure - ClearSky® LED Motion / Amber Beacon (CS550), page 249*.

Removal

1. Park machine on a firm level surface, level the machine.
2. Push in the power/emergency stop switch (down) to off, turn the key switch to the (center) OFF position.
3. Remove key and tag machine out of service.
4. Disconnect battery power from the machine.
5. Remove the nuts (**2**), lock washers (**3**) and washers (**4**) that attach the CS550 (**9**) with mounting surface (**5**).
6. Carefully pull the CS550 (**9**) out from the mounting surface (**5**) and disconnect the harness (**1**) from the CS550 (**9**).
7. Remove the CS550 (**9**).
8. Remove the gasket (**6**), anti-tamper plate (**7**) and gasket (**8**).

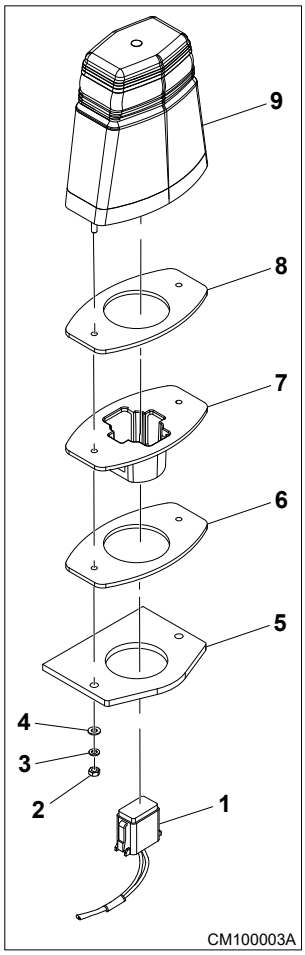


Figure 100. ClearSky® LED Motion / Amber Beacon (CS550)

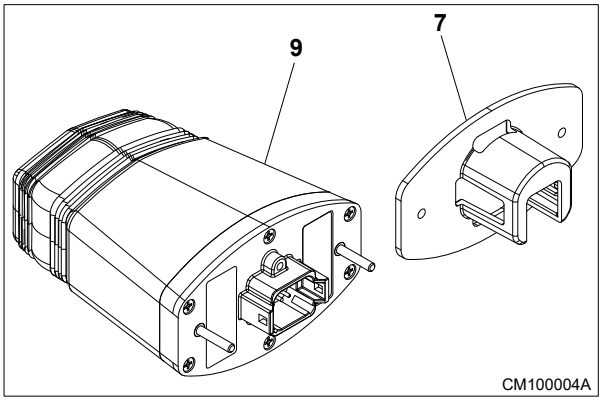


Figure 101. Anti-Tamper Plate Orientation

1. Harness	4. Washer	7. Anti-Tamper Plate
2. Nut	5. Mounting Surface	8. Gasket
3. Lock Washer	6. Gasket	9. CS550 (ClearSky Control Module)

Installation

1. Route the harness (**1**) through mounting surface (**5**), gasket (**6**), anti-tamper plate (**7**) and gasket (**8**), refer to *Figure - ClearSky® LED Motion / Amber Beacon (CS550), page 249*.

2. Connect the harness (**1**) to CS550 (**9**).

Note: Cover the vent hole on bottom of module with curved side of anti-tamper plate, refer to ***Figure – Anti-Tamper Plate Orientation, page 249***.

3. Properly place CS550 (**9**) on mounting surface (**5**).

Note: Apply Medium Strength Threadlocking compound on threaded mounting studs of CS550 (**9**) before installation of washers and nuts. Ensure threadlocking compound does not contact bottom of CS550 (**9**).

4. Install the washers (**4**), lock washers (**3**) and nuts (**2**) to fix the CS550 (**9**) on CS550 mounting studs. Torque the nuts (**2**) to 13 in. lbs. (1.4 Nm).
5. Connect battery power to the machine.
6. Remove the machine out of service tag and re-insert the key.
7. Start the machine and configure CS550 (**9**), refer to *Section - ClearSky (CS550) Configuration and Troubleshooting, page 83*.
8. Once configuration of CS550 (**9**) is successful, start the machine and verify proper operation of CS550 (**9**).

SECTION 10
DISASSEMBLY AND ASSEMBLY

10.1 DRIVE ASSEMBLY

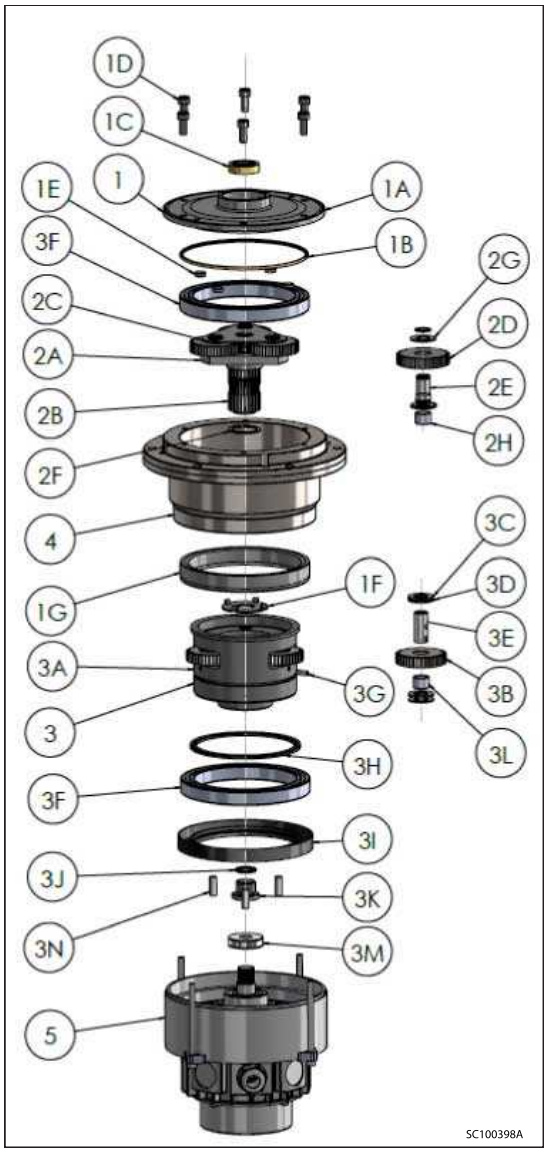


Figure 102. Drive Hub Components

1. End Cap Assembly	2. Primary carrier Sub-assembly	3. Spindle Carrier Assembly	3H. Retaining Ring
1A. End Cap	2A. Primary Carrier	3A. Spindle Carrier	3I. Lip Seal
1B. O-ring	2B. Sun Gear	3B. Secondary Planet Gear	3J. O-ring
1C. Lip Seal	2C. Support Plate	3C. Planet Gear Washer	3K. Flange Plug
1D. Bolt	2D. Primary Planet Gear	3D. Planet Gear Washer	3L. Slide Bearing
1E. Strong Magnet	2E. Planet Pin	3E. Planet Shaft	3M. Thrust Washer
1F. Thrust Washer	2F. Retaining Ring	3F. Ball Bearing	3N. Dowel Pin
1G. Ring Gear	2G. Slide Bearing	3G. Pin	4. Ring Gear
			5. Electric Motor

10.1.1 Torque Hub

NOTICE

The procedures within this section apply to all machines and torque hubs. Procedures that apply to specific machines and torque hubs will be so noted by proper serial numbers.

Note: These instructions will cover how to completely assemble and disassemble the Torque-Hub unit. However, if the unit is under warranty you should contact JLG Industries, Inc. for a replacement unit. The warranty will no longer be valid if the unit is disassembled by non-JLG personnel.

NOTICE

Torque hub units should always be roll and leak tested before disassembly and after assembly to make sure that the unit’s gears and sealants are working properly.

Note: Torque-Hub units should always be roll and leak tested before disassembly and after assembly to make sure that the unit's gears, bearings and seals are working properly. The following information briefly outlines what to look for when performing these tests.

⚠ WARNING

If the machine is on any incline, the wheels must be adequately blocked prior to manually disengaging the brakes. Failure to do so may result in injury or even death.

Note: The brake must be released before performing the roll test. This can be accomplished by connecting the brake release cable and depressing button. The brake can also be released by following the manual disengage procedures outlined in this section.

⚠ CAUTION

Return brake release cable before returning to normal operation.

Roll Test

The purpose of the roll test is to determine if the unit's gears are rotating freely and properly. You should be able to rotate the wheel or hub of the gearbox by hand. If you feel more drag in the gears only at certain points, then the gears are not rolling freely and should be examined for improper installation or defects. Some gear packages roll with more difficulty than others. Do not be concerned if the gears in your unit seem to roll hard as long as they roll with consistency.

Leak Test

The purpose of a leak test is to make sure the unit is air tight. You can tell if your unit has a leak if the pressure gauge reading on your leak checking fitting starts to fall after the unit has been pressurized and allowed to equalize. Leaks will most likely occur at the pipe plugs, the main seal or wherever O-rings are located.

⚠ WARNING

DO NOT use hand to check for leaks. Use a piece of cardboard or paper to search for leaks. Always wear gloves.

The exact location of a leak can usually be detected by brushing a soap and water solution around the main seal and where the O-rings or gaskets meet on the exterior of the unit, then checking for air bubbles. If a leak is detected in a seal, O-ring or gasket, the part must be replaced, and the unit rechecked. Leak test at **10 psi** for 20 minutes.

Note: Due to the small air volume inside this Torque-Hub, it will pressurize to 10 psi very quickly. If the pressure becomes excessive in the unit the seals will be destroyed.

Oil Check/Fill Procedure

The torque hub unit is shipped with EP85. It is designed to utilize the same oil throughout its service life. However, should it need to be checked/serviced use the following procedure.

In the event of servicing, fill the unit with EP85.

Note: The gearbox capacity is 10 oz of oil.

1. To check the oil level, rotate the wheel so that the plugs in the cover are at 12 o-clock and 3 o-clock.
2. Allow the oil to settle than slowly remove the plug at 3 o-clock.
3. If oil begins to come out the oil level is sufficient.
4. If no oil is noticed at the 3 o-clock plug remove both plugs.
5. Slowly add oil at the 12 o-clock plug location until oil begins to seep out at the 3 o-clock plug location.
6. Apply pipe dope or teflon tape to the cover plugs and reinstall into the cover.
7. Tighten to 6 ft. lbs. - 8 ft. lbs. (8.4 Nm to 11.2 Nm).

10.1.2 Primary Planet Carrier

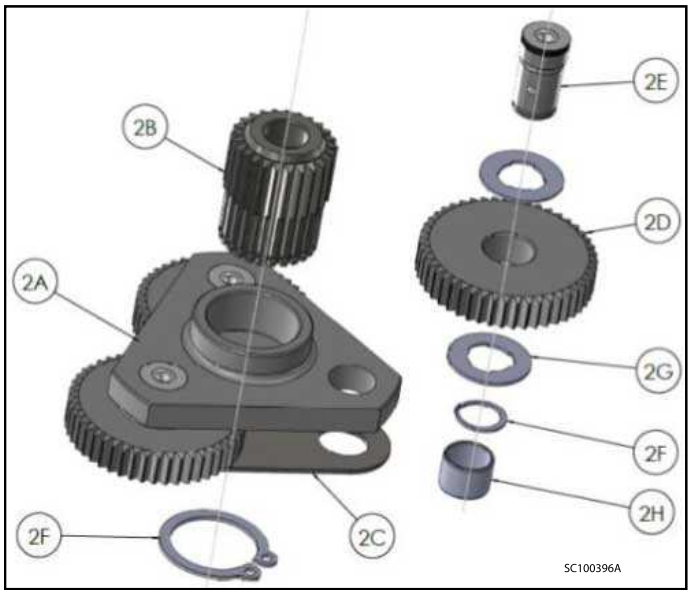


Figure 103. Primary Planet Carrier Disassembly

2A. Primary Carrier	2E. Planet Pin
2B. Sun Gear	2F. Retaining Ring
2C. Support Plate	2G. Planet Gear Washer
2D. Primary Planet Gear	2H. Slide Bearing

Disassembly

1. Rotate planet gears (2D) to check for abnormal noise or roughness in bearings (2H) or planet shafts (2E).
2. Take away three snap rings (2F) with pointed-nose pliers.
3. Press planet pins (2E) out of carrier (2A).
4. Inspect all planet gear (2D) for abnormal wear or damaged.
5. Remove planet gears (2D), thrust washers (2G), and the retaining ring (2C). The planets are a matched set, and all three should be replaced if damaged.
6. Sun gear (2B) was loose fit with the carrier.

Primary Planet Carrier Assembly

1. Install sliding bearings (2H) and thrust washers (2G) into planet gears (2D). Make sure that all bearings are seated around bore. Repeat this step for all three planet gears.
2. Install three roll pins (2E) into the specific carrier holes and go through the planet gears (2D).
3. Put the sun gear (2B) into the specific place.

10.1.3 Spindle Carrier

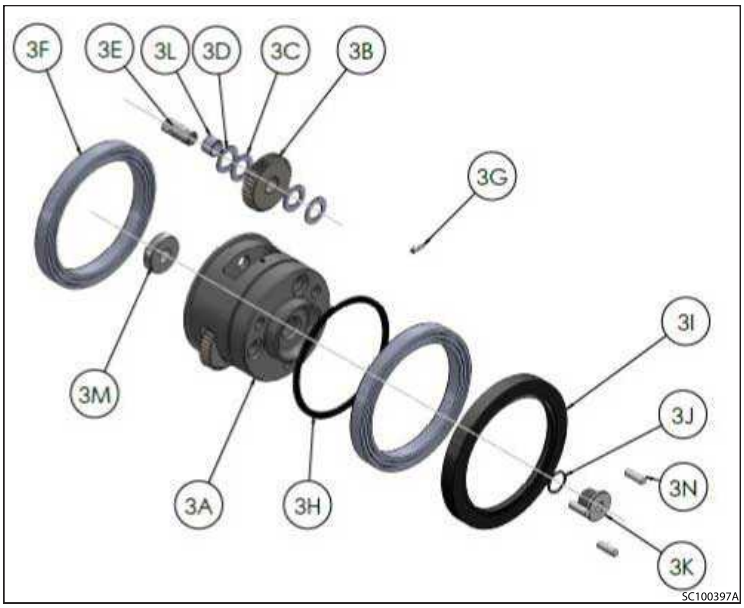


Figure 104. Spindle Carrier Disassembly

3A. Spindle Carrier	3F. Ball Bearing	3K. Flange Plug
3B. Secondary Planet Gear	3G. Pin	3L. Slide Bearing
3C. Planet Gear Washer	3H. Retaining Ring	3M. Thrust Washer
3D. Planet Gear Washer	3I. Lip Seal	3N. Dowel Pin
3E. Planet Shaft	3J. O-ring	

Disassembly

1. Remove the output seal (3I) and replace it after it damaged.
2. Take away the snap rings (3H) with pointed-nose pliers. Use the copper bar to press the carrier sub assembly out of the housing (from the seal direction).
3. Drive the roll pins (3G) out of the planet shafts (3E).
4. Press the planet pins (3E) out of the carrier (3A).
5. Replace bearings (3F) if damaged.
6. Take out the sun thrust washer (3M) and remove the three dowel pins (3N).

Assembly

1. Press the washer (3M) and pin (3G) in the Spindle carrier (3A) if required.
2. Press one of the bearings (3F) in spindle carrier (3A). Bearing (3F) should be tight in housing bore and flush against housing shoulder.
3. Press the sliding bearing (3L) inside of planet gear. Make sure that the sliding bearing are seated properly around the bore. Place a planet gear with washer on left and right end side into carrier.
4. Apply small amount of grease to bore of planet gear (3B). Repeat this step for all three planet gears.
5. Pull out dummy planet shaft. Install planet shaft (3E) by lightly tapping down through carrier holes and planet gear. Make sure planet shaft roll pin hole is aligned roll pin hole in carrier. Planet gear should rotate smoothly.

6. Then place the first carrier subassembly into the ring gear. Make sure the planet teeth engage with the ring gear teeth. Check all gear meshes for proper clearance. Insure outboard bearing inner cone (3F) seats fully against spindle shoulder. If outboard bearing is not seated fully, lightly tap bearing inner cone on inner hub until it seats properly.
7. Press other bearing (3F) in Spindle (3A) flange. Bearing should be tight in housing bore and flush against housing shoulder (3A).
8. Install the snap ring(3H) into groove of Spindle (3A). Extreme care should be taken to insure no damage to the seal spindle (3A) occurs.

10.2 PLATFORM CONTROL STATION

10.2.1 Control Components Overview

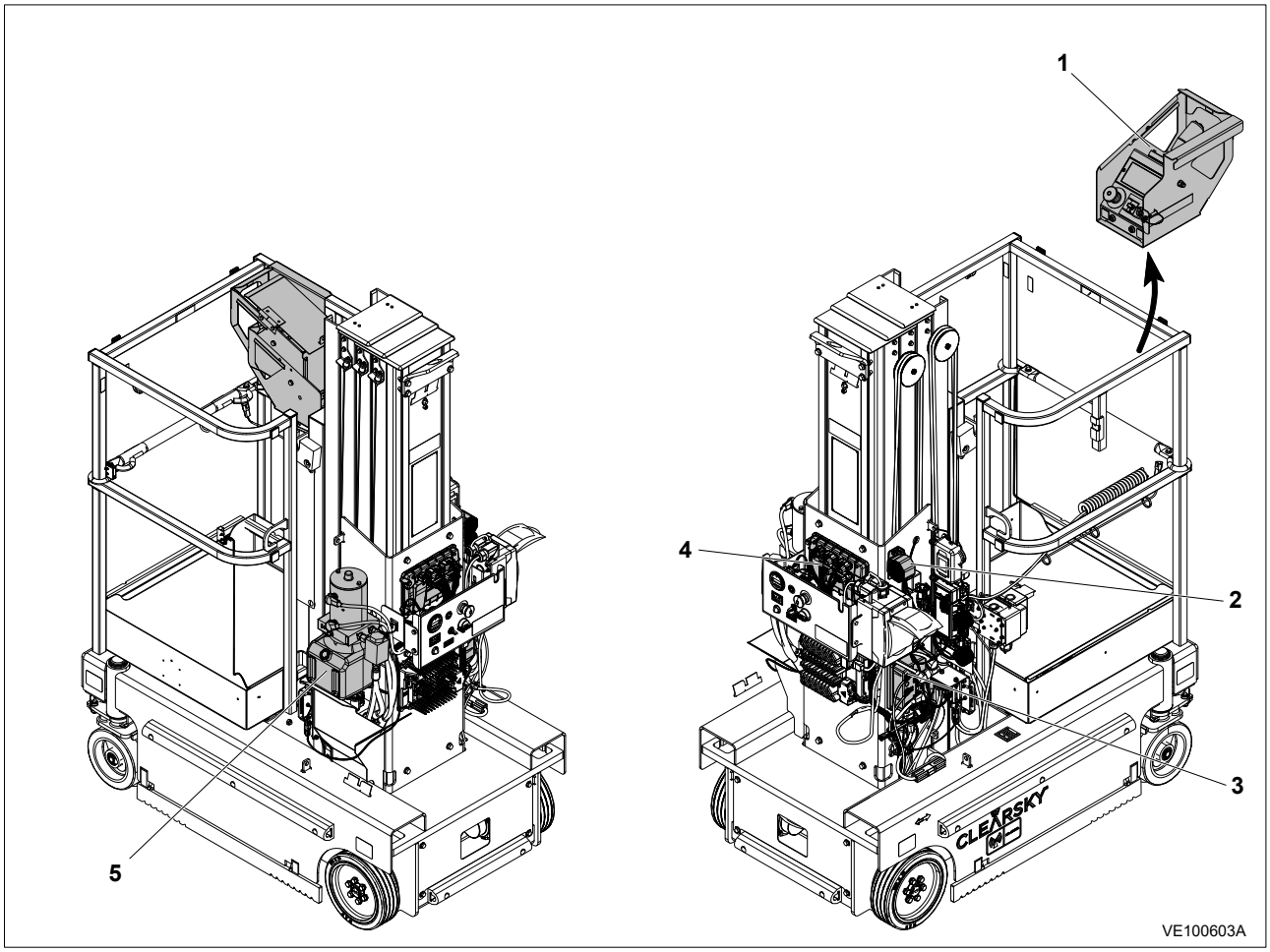


Figure 105. Control Components Location – MCL/MML/MSP

1. Platform Control Box	3. Batteries (4 – 6 V - Standard)	5. Pump/Motor/Tank Assembly
2. Alarm	4. Ground Control Module	

10.2.2 Disassembly

1. Place the platform control station assembly on a suitable work bench.

2. Remove the main body from the mount, by removing the long through bolt, cap-nut and washers (**1**) and the two rear edge bolts and washers (**2**) on the bottom of the assembly.

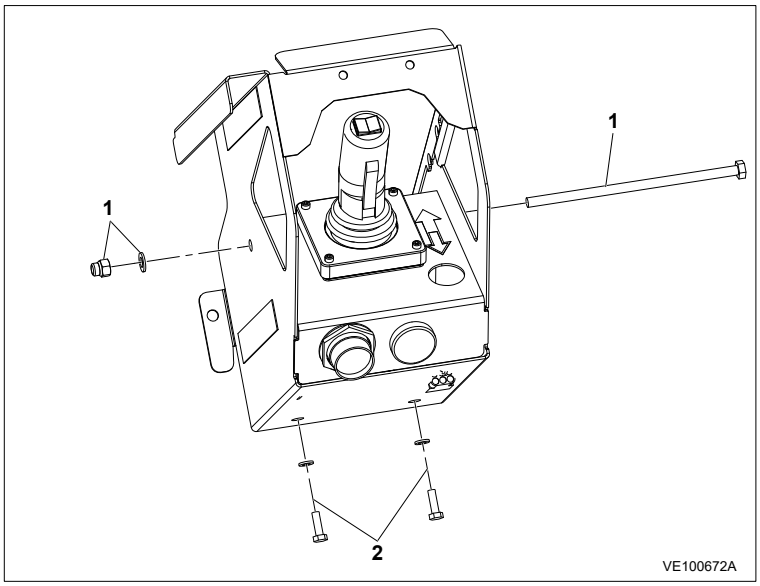


Figure 106. Platform Control Station Disassembly

1. Through Bolt, Cap-nut and Washers	2. Rear Edge Bolts and Washers

3. To install, reverse steps 1 and 2 above.

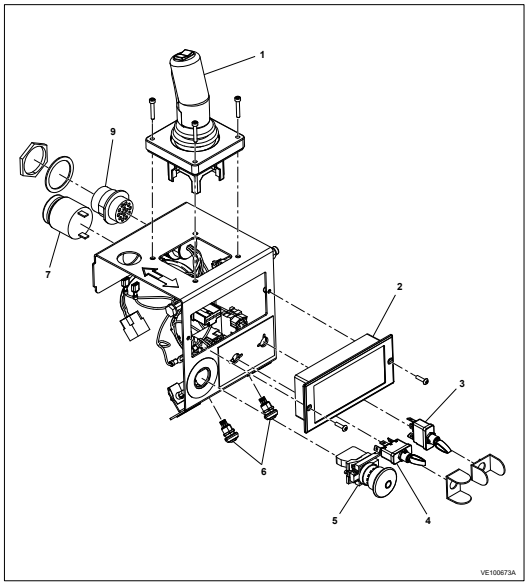


Figure 107. Platform Control Station Components - Internal

1. Drive, Lift and Steer Joystick Control	4. Lift/Drive Select Switch	7. Alarm
2. Platform control module	5. Emergency Stop Switch	8. Main Harness Connector
3. Speed Select Switch	6. Push Button Switch	9. Terminal

10.3 LIFT CYLINDER

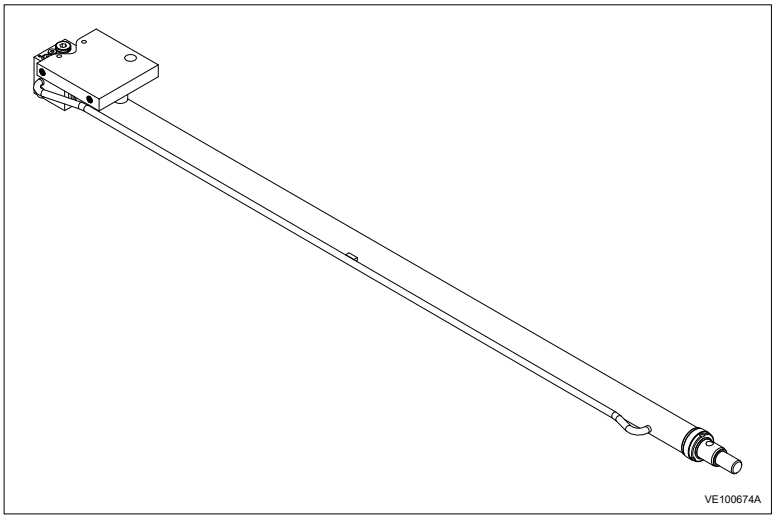


Figure 108. Lift Cylinder

Note: Service information is not available at the time of publication.

10.4 STEER CYLINDER

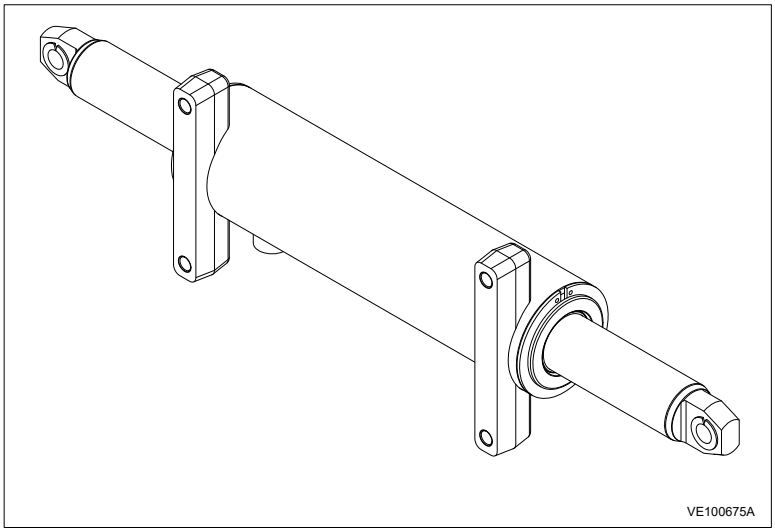


Figure 109. Steer Cylinder

Note: Service information is not available at the time of publication.

10.5 PUMP-MOTOR ASSEMBLY - SERVICE PROCEDURE

10.5.1 Hydraulic Pressure Settings and Adjustment

Adjust system pressure so that platform will raise with maximum rated capacity in platform.

The following pressure setting are factory recommended (initial) settings;

MODEL	VALVE	PRESSURE SETTING
E18MML, E18MCL, E18MSP	Main/Lift Relief	3000 Psi (209 Bar)
E18MCL	Steer Right	1120 Psi (77 Bar)
E18MCL	Steer Left	1120 Psi (77 Bar)

Turning adjustment screw clockwise increases system pressure, turning screw counterclockwise decreases system pressure.

Perform pressure adjustment with oil at normal operating temperature. If pressure is set when oil is cold, platform may not raise rated load after soil has warmed.

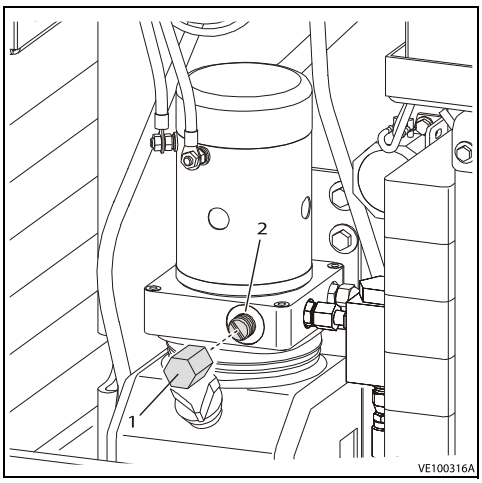


Figure 110. Hydraulic Pressure Adjustment Screw (Machine Rear Covers Removed)

1. Remove Adjust Screw Cap	2. Pressure Adjustment Screw

Note: Machine rear covers must be removed to access pump motor

10.5.2 Hydraulic Pressure Gauge Connection

⚠ CAUTION

Only open hydraulic system lines with the mast fully lowered to relieve pressure in the system. Carefully loosen required fittings, wear safety protection equipment when working with hydraulic systems.

Remove the hydraulic oil filter and install a t-fitting between the pump and the extend line to connect a hydraulic pressure gauge as shown below.

CHECK, and if necessary, ADJUST the hydraulic pressure to initial settings shown in table at the beginning of this section. Cycle the hydraulic system several times with the maximum load capacity in the platform, then recheck pressure setting. When pressure has stabilized continue to “After Filter Pressure Check” following.

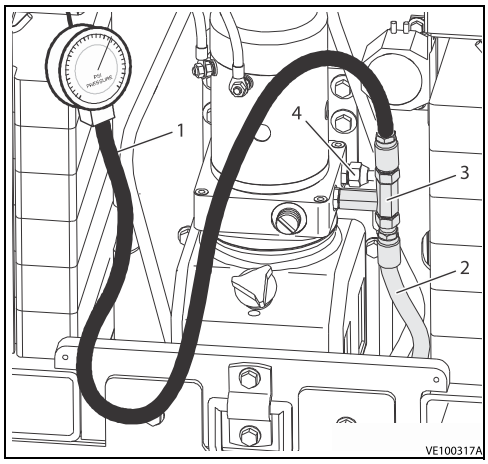


Figure 111. Typical Hydraulic Pressure Gauge Installation (Hydraulic Filter Removed)

1. Pressure Gauge Assembly	3. T- Fitting
2. Extend Line	4. Return Line

10.5.3 After Filter Pressure Check

Reinstall the hydraulic oil filter and install the t-fitting between the hydraulic filter and the extend line to the cylinder. Recheck the hydraulic pressure and compare with the previous readings when filter was removed. If a significant drop in pressure reading has occurred, replace the hydraulic filter and recheck the “after filter” pressure reading.

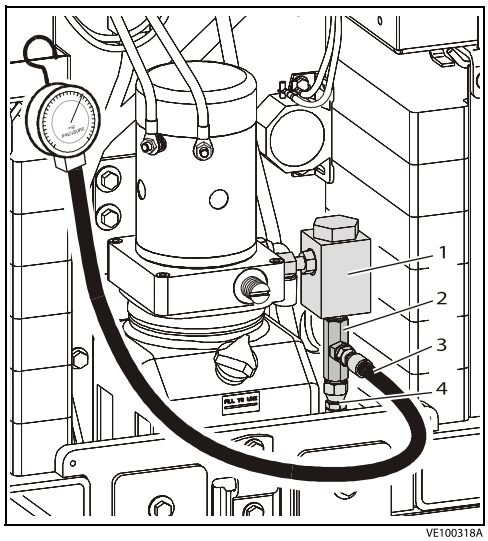


Figure 112. Typical Hydraulic Pressure Gauge Installation (After Hydraulic Filter)

1. Hydraulic Oil Filter	3. Pressure Gauge Assembly
2. T- Fitting	4. Extend Line

10.5.4 Pump/Motor/Tank Installation

NOTICE

Be certain the mast is fully lowered before removing any hydraulic lines from the pump unit. Wear protective gear when working around pressurized hydraulic lines. Remove connections carefully and cap all lines.

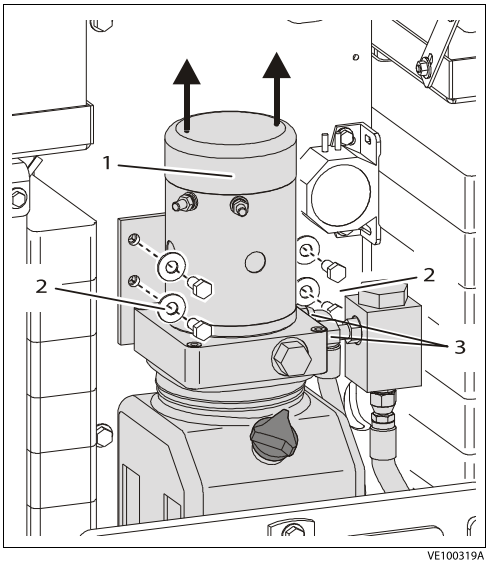


Figure 113. Pump/Motor/Tank Assembly Installation

1. Pump/Motor/Tank Assembly	2. Attach Screws/Washers	3. Detach and Cap Extend and Return Lines

10.5.5 General Assembly and Disassembly

The following is a complete disassembly/assembly of the E18MML, E18MCL, E18MSP machines pump/motor assembly. No internal parts to the hydraulic pump are serviced by JLG except for a pump installation seal kit. Also the only parts serviceable internal to the pump electric motor is the motor brush kit.

Note: During reassembly of the pump/motor assembly, apply a liberal coat of JLG recommended hydraulic fluid to all seals and O-rings.
Also keep all internal metal parts clean and coated with hydraulic fluid to prevent surface corrosion. JLG recommends replacing all seals and O-rings when disassembling and reassembling the pump/motor unit.

The motor and motor brushes can be serviced without removing the complete pump/motor unit. However components on the bottom end of the unit will require removal of the complete pump/motor unit. See Pump/Motor/Tank Installation instructions following.

10.5.6 Inline Hydraulic Filter Installation

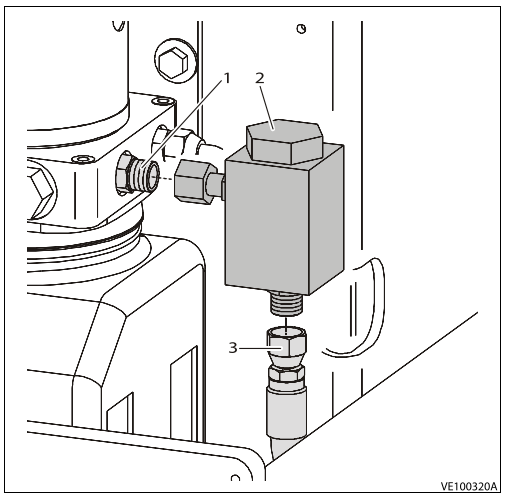


Figure 114. Pump/Motor/Tank Assembly Installation

1. Valve Body Extend Line Fitting	2. Inline Hydraulic Filter	3. Extend Line to Lift Cylinder

10.5.7 Fenner Brand Pump - Brush Replacement

Motor Cap/Motor Installation

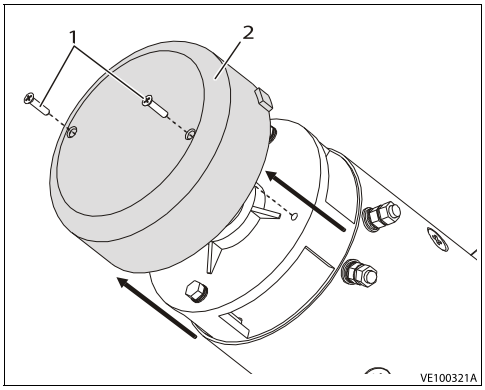


Figure 115. Motor Cap Installation

1. Cap Assembly Screws	2. Cap Assembly

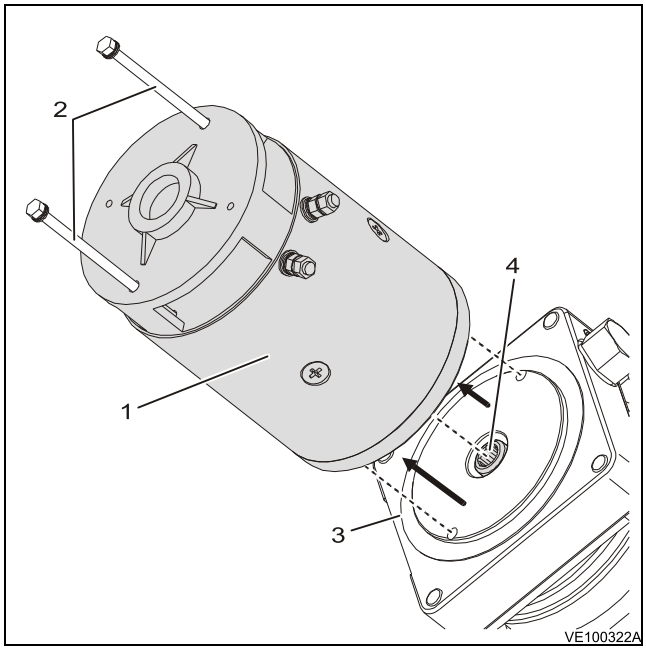


Figure 116. Motor Installation

1. Motor Assembly	3. Pump End Head
2. Motor Assembly Screws	4. Motor to Pump Coupler

Motor Brush Installation

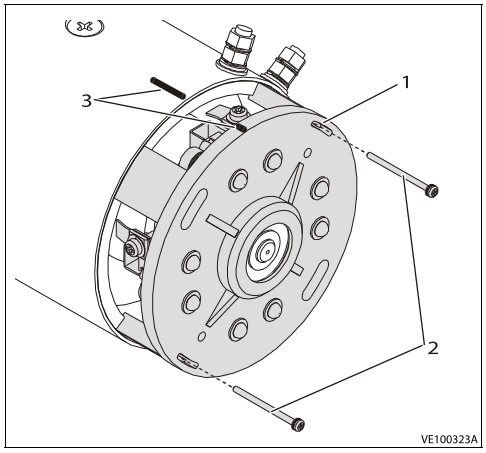


Figure 117. Brush Housing Installation

1. Brush Housing	2. Brush Housing Screws	3. Mark Front of Motor and Brush Housing for reference when reassembling.

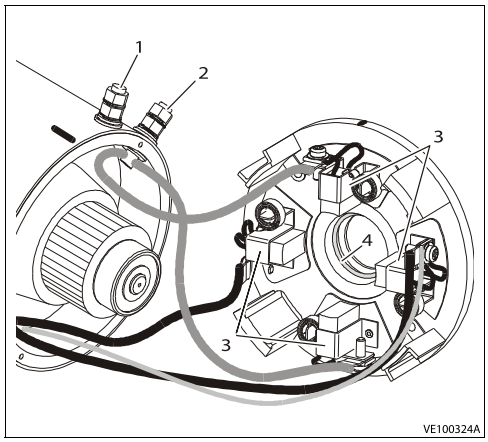


Figure 118. Brush Assembly Connections

1. Negative (–) Post	3. Brush Assemblies
2. Positive (+) Post	4. Spring Washer

Note: Length of wires to brush assemblies shown exaggerated for illustrative purposes.

Once brush housing has been removed, inspect the rotor commutator for excessive wear before installing a new brush set.

The rotor commutator surface when new, is approximately 1/8 in. (3 mm) in thickness.

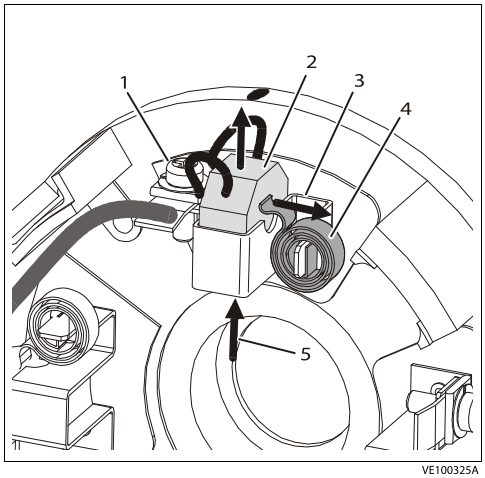


Figure 119. New Brush Installation

1. Brush Terminal Screw	3. Brush Holder	5. (See Installation Note Below)
2. Brush	4. Brush Spring	

Installation the same for all four (4) brush assemblies.

Note: Using a clean towel, push each brush (2) up into it's holder (3), slide the spring (4) over the side of the brush. This will hold each brush in place and allow them to clear the rotor commutator during reassembly. Clean the rotor commutator with a non-conductive electrical cleaner before assembling the brush housing to the motor housing.

Brush Housing Final Assembly Tips

It is easier to install the brush housing assembly by sliding the rotor assembly completely out of the other end of the motor housing, then attach the brush housing first. After the brush housing is installed look into the motor housing from the opposite end to check that the positive (+) post wires and static winding wires are positioned, not to block the holes for the motor mounting bolts, inside the motor housing.

After final assembly of the brush housing check that all brush terminal screws are tight and the brush springs are positioned properly before mounting the motor to the pump/motor end head.

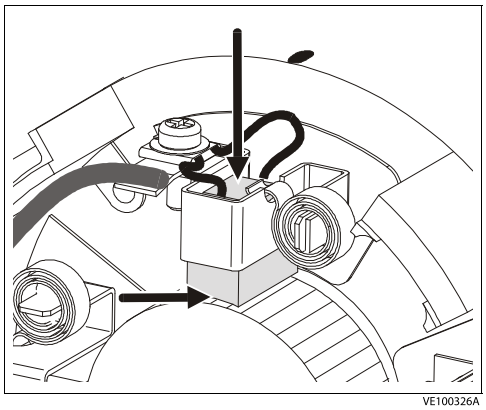


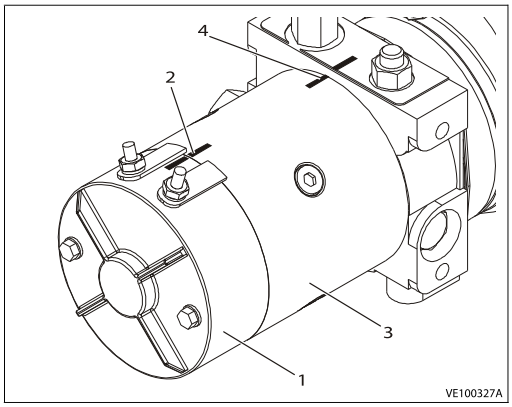
Figure 120. Brush Final Positioning

NOTICE

Once the rotor assembly is in place, remember to push each brush down until the brush face is in contact with the commutator on the rotor shaft and the brush spring is pushing down on top of the brush.

10.5.8 Monarch Brand Pump - Brush Replacement

Motor Assembly - Remove/Install - Reference Marks

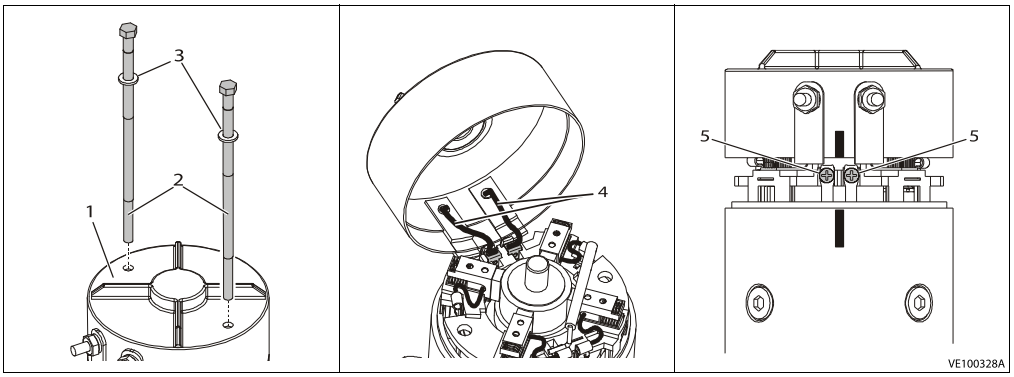


Pump Motor - Removal/Installation - Reference Marks

- For reference when reassembling, mark motor cover, housing and valve body position before disassembling.

1. Motor Top Cover	3. Motor Housing	5. Motor Valve Body
2. Cover/Housing Reference Mark.	4. Housing/Motor Valve Body Reference Mark	

Motor/Brush Cover - Remove/Install



1. Motor/Brush Cover (a)	3. Washers	5. Power Lead Clip Attach Screws
2. Cover Screws (b)	4. Power Leads to Lead Clips (Soldered)	

NOTICE

Remove the motor cover carefully, the (short) power leads inside the cover from the (+/–) posts are soldered to attach clips which are fastened to the brush carrier assembly with screws (item-5). Raise the cover straight up - remove the screws - then hinge the cover up (see center illustration) and pry the clips off of the brush carrier assembly to completely remove the motor cover.

Note: (a) Once cover screws are removed, you may need to tap lightly around the edge of the top cover to separate it from the motor housing. Read the important note above before attempting to remove the cover.
(b) These steel screws are threaded into the aluminum valve body, do not overtighten.

Brush Carrier Assembly - Remove/Install

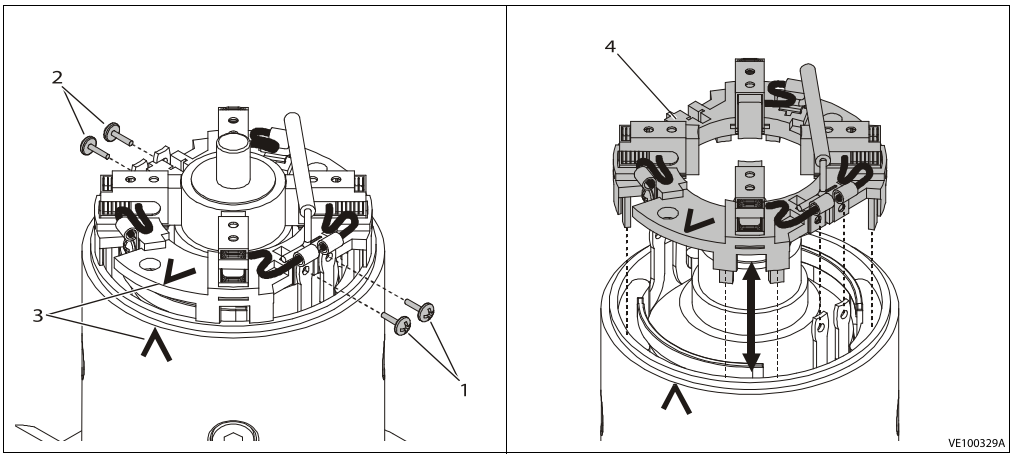


Figure 121. Brush Carrier Assembly - Remove/Install

1. Stator/Brush Carrier Screws (Pump Rear)	3. Mark Brush Carrier Position on Motor Housing
2. Stator/Brush Carrier Screws (Pump Front) (a)	4. Brush Carrier Assembly

Note: (a) Removed previously with motor cover disassembly (shown for reference only).

Brush Assembly - Remove/Install

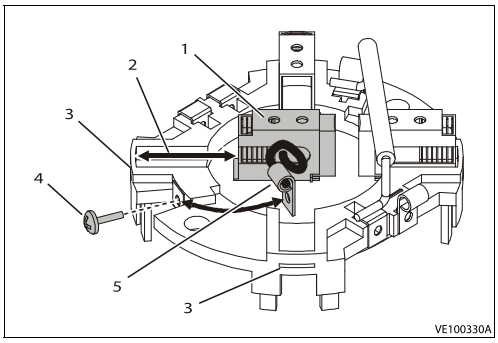


Figure 122. Brush Assembly - Remove/Install

1. Brush Assembly (a)	3. Brush Tab Slot	5. Brush Attach Terminal
2. Brush Carrier Socket	4. Brush Terminal Screw	

Note: (a) Slide brush assembly into socket until tab is in slot at rear of socket.

Tank Installation

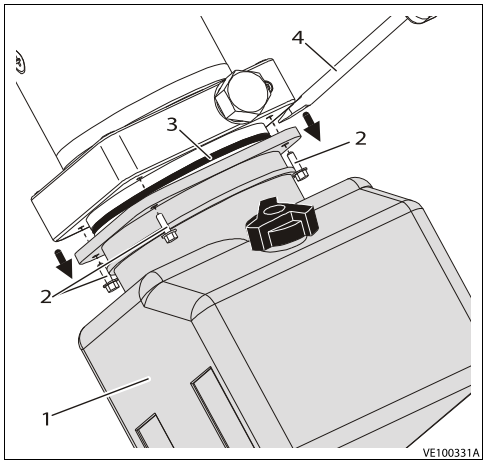


Figure 123. Tank Installation

1. Tank Assembly	3. O-Ring Seal
2. Tank Screws (4)	4. Use Screwdriver to pry tank away from pump head.

Filter Screen Installation

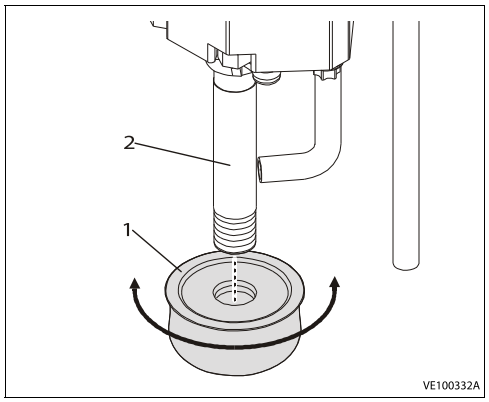


Figure 124. Filter Screen Installation

1. Filter Screen	2. Pump Pick-Up Tube

Pump Installation

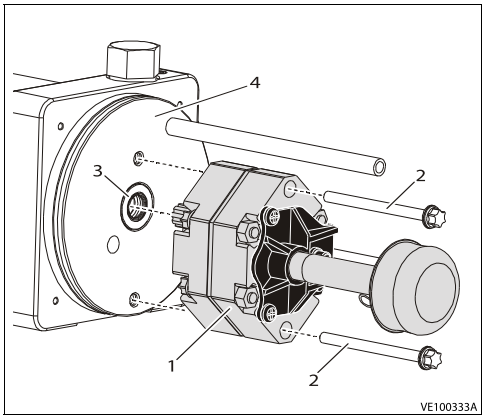


Figure 125. Pump Installation

1. Pump Assembly	3. Pump Shaft Seal
2. Pump Assembly Screws	4. Pump End Head

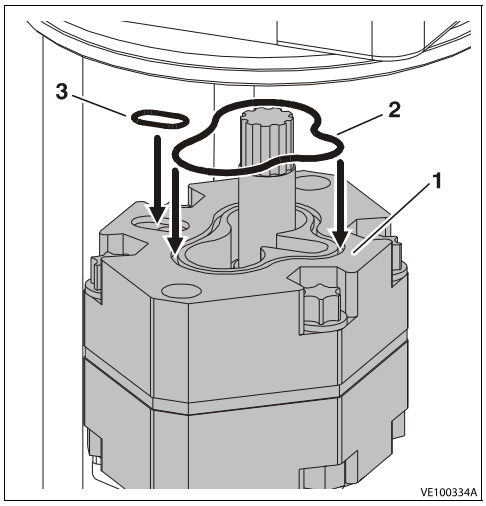


Figure 126. Pump O-Ring Installation

1. Pump Assembly	2. O-Ring Seal	3. O-Ring Seal

Pressure Adjust Valve Installation

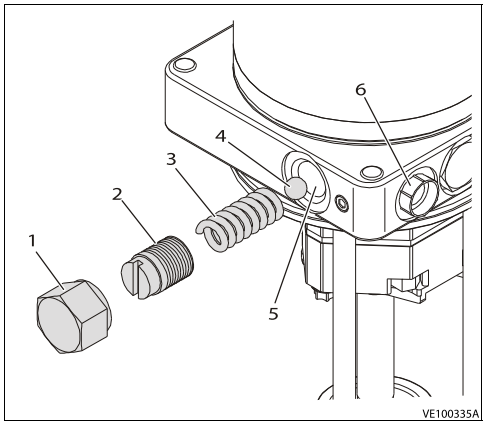


Figure 127. Pressure Adjust Valve Installation

1. Adjust Valve Cap	3. Valve Spring	5. Adjust Valve Port
2. Adjustment Screw	4. Valve Ball	6. Extend (Pressure) Port (Shown Plugged)

Note: Adjust pressure as per specifications of this service manual.

Pressure Check Valve Installation

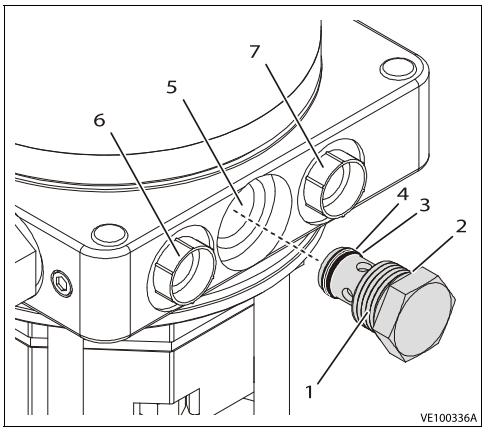


Figure 128. Pressure Check Valve Installation

1. Check Valve Assembly	4. Backing Ring	7. Return Port
2. O-Ring Seal	5. Check Valve Port	
3. O-Ring Seal	6. Extend (Pressure) Port	

Note: Extend (Pressure) and Return Ports Shown Plugged.

10.6 MAST ASSEMBLY AND DISASSEMBLY PROCEDURES

The MML/MCL/MSP lift mast sections are constructed of extruded aluminum, protected with an anodized surface finish. The mast sections are interlocked into each other when assembled, by internally mounted slide pads at the top and bottom of each mast section. These slide pads run up and down in slide pad channels on each side of the mast.

The MML/MCL/MSP model mast assembly contains a different number of mast sections as shown following;

Table 41. Mast Component Features

Model	No. of Mast Sections	Extend/Retract Device
MML/MCL/MSP	5	Chain

Assembly procedures for all mast sections is basically the same, carefully slide the mast sections together until mast ends are even. *(When sliding the mast sections together, be careful not to scratch the anodized surface)*. Assemble the hardware to the bottom of mast section first, slide this section out the top of previous section and assemble hardware to the top of mast. Always install slide pad shims with slide pads inserted into the slide pad channels, *(ends of mast sections even)*. Applying silicone spray onto the slide pads and slide pad channels before assembly will help mast sections slide easier after slide pads have been properly shimmed.

10.6.1 Mast Components Overview

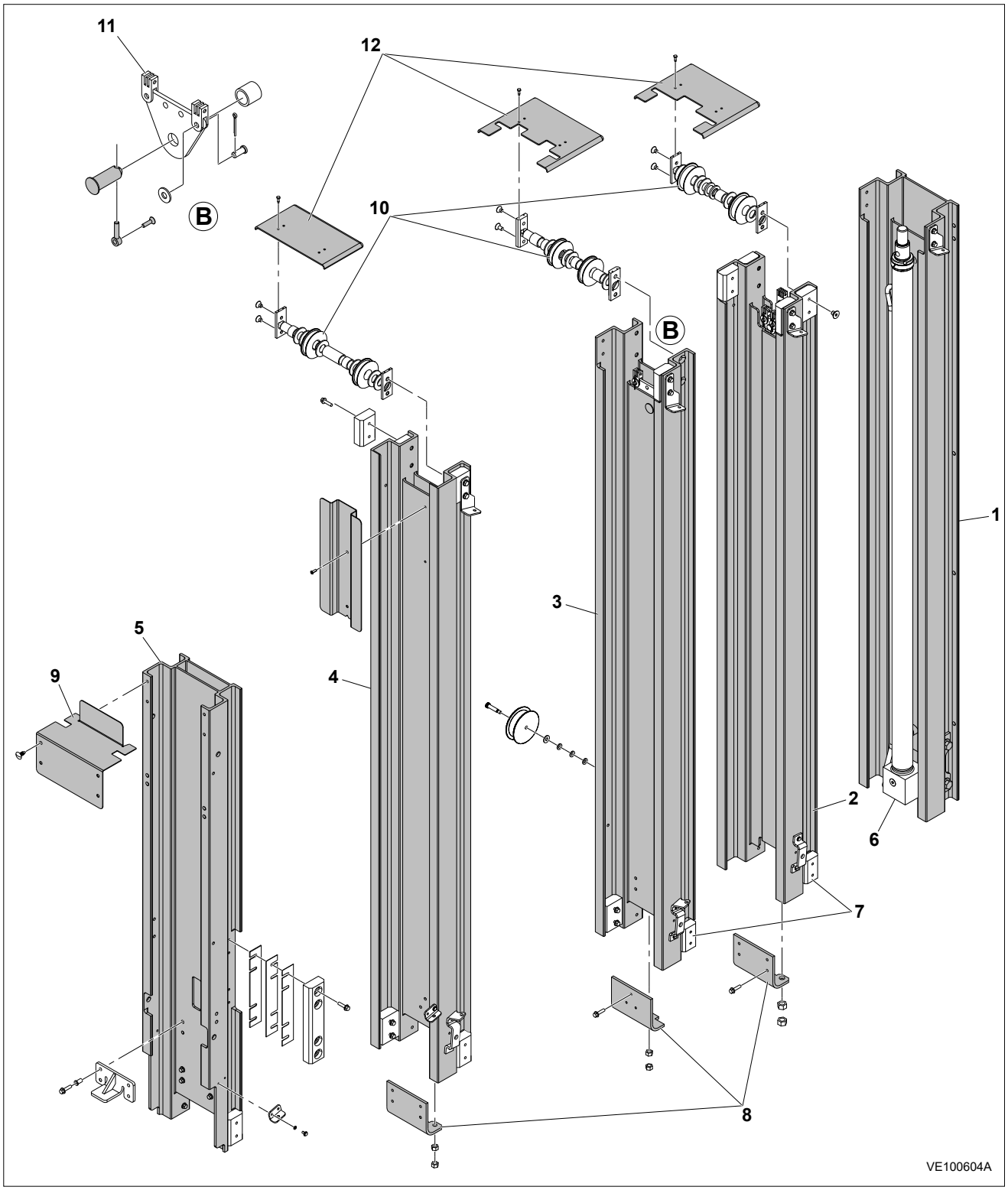


Figure 129. Mast Components – MML/MCL/MSP

1. Mast Section - 1	5. Mast Section - 5	9. Panel Head Cover
2. Mast Section - 2	6. Lift Cylinder	10. Sheave Assemblies
3. Mast Section - 3	7. Slide Pads	11. Chain/Equalizer - Plate Assemblies
4. Mast Section - 4	8. Bottom Bracket	12. Mast Covers

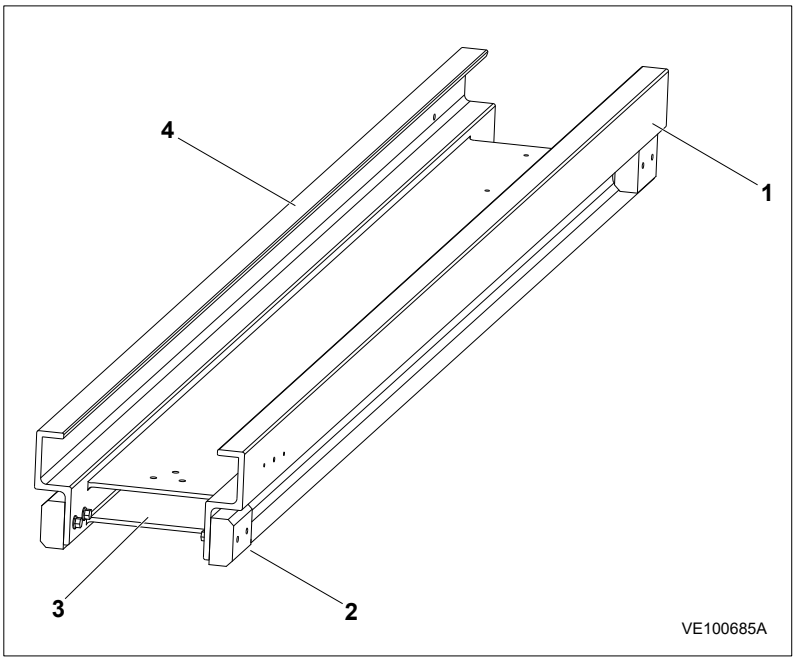


Figure 130. Mast Section - Assembly Reference

1. Top (Refers to top end of mast section where cover and sheave wheels attached)	3. Closed Rail (Refers to closed rail back mast section)
2. Bottom (Refers to bottom end of mast section which sets in machines base frame)	3. Open Rail (Refers to open rail front mast section)

10.6.2 Mast Disassembly Procedure - MML/MCL/MSP

1. After the mast assembly has been removed from the machine, lay the mast assembly down on a suitable work table with the platform mounting section on top, facing up.
2. Remove the sequencing cables and hardware from the sides of the mast assembly. Also remove the covers from the top of the mast assembly.

Mast Section-5 - Disassembly

3. Remove chain adjust nuts from threaded ends of chain attached to the chain anchor plate (lower) on BOTTOM end of mast section-5 (platform mounting section) . Push threaded ends of chain through anchor plate.
4. At the TOP of mast section-5, pull chains out and allow to hang loose. (Be certain floor surface is clean and free of any metal chips or debris which may stick to lubricated chains).

Note: When sliding mast sections apart, be careful not to scratch or score the anodized surface in the slide pad channels.

5. Carefully slide mast section-5 out the BOTTOM of mast section-4 rails. Disassemble slide pads, shims and chain anchor plate from mast section-5, if necessary.

Mast Section-4 -Disassembly

6. Remove chain adjust nuts from threaded ends of chains attached to the chain anchor plate (lower) on BOTTOM end of mast section-4. Push threaded ends of chains through anchor plate.
7. At TOP of mast section-4, pull chains out and allow to hang loose. (Be certain floor surface is clean and free of any metal chips or debris which may stick to lubricated chains).
8. Slide mast section-4 out the TOP of mast section-3 far enough to allow access to the chain sheave wheel assembly.
9. Remove countersunk-flathead screws securing chain sheave wheel assembly attach bars on both side rails at TOP of mast section-4 and remove sheave wheel assembly.

Note: When sliding mast sections apart, be careful not to scratch or score the anodized finish in the slide pad channels.

10. Carefully slide mast section-4 out BOTTOM of section-3. Remove slide pads, shims and cable anchor plate, if necessary.

Mast Section-3 - Disassembly

11. Remove chain adjust nuts from threaded ends of chain attached to the chain anchor plate on BOTTOM end of mast section-3. Push threaded ends of chain through the anchor plate.
12. At TOP of mast section-3, pull chains out and allow to hang loose, (be certain floor surface is clean and free of any metal chips or debris which may stick to lubricated chains).
13. Slide mast section-3 out TOP of mast section-2 far enough to allow access to the chain sheave wheel assembly.
14. Remove countersunk-flathead screws securing chain sheave wheel assembly attach bars on both side rails at TOP of mast section-3 and remove the sheave wheel assembly.
15. While mast section-3 is still extended from section-2 remove the pin attaching the chain anchor plate to the TOP of mast section-3. Remove chains.

Note: When sliding mast sections apart, be careful not to scratch or score the anodized finish in the slide pad channels.

16. Carefully slide mast section-3 out BOTTOM of section-2. Remove slide pads, and shims, if necessary.

Mast Section-2 - Disassembly

17. Slide mast section-2 out TOP of mast section-1 far enough to allow access to the chain assembly anchor block/sheave wheel assembly.
18. Remove countersunk-flathead screws securing chain anchor block/sheave wheel assembly attach bars on both side rails at TOP of mast section-2.
19. Slide the chain anchor block/sheave wheel assembly and hydraulic cylinder out the TOP of mast section-2 far enough to allow removal of the sheave wheel attach bars, sheave wheels and sheave pin from chain assembly anchor block.
20. Remove the setscrew holding the hydraulic cylinder rod onto the chain assembly anchor block. Lay chain assembly/ anchor block to side.
21. Remove the hydraulic cylinder through BOTTOM of mast section-2, be careful not to nick or score cylinder rod surface while removing.

Note: When sliding mast sections apart, be careful not to scratch or score the anodized finish in the slide pad channels.

22. Carefully slide mast section-2 out BOTTOM of section-1. Remove slide pads and shims, if necessary.

Mast Section-1 - Disassembly

23. Slide the TOP of remaining mast section-1 out over edge of work surface and remove the pins attaching the chain anchor block to mast section-1. Remove chain/anchor block assemblies from mast and lay aside.
24. Remove slide pads and shims from mast section-1.

Mast disassembly should now be complete.

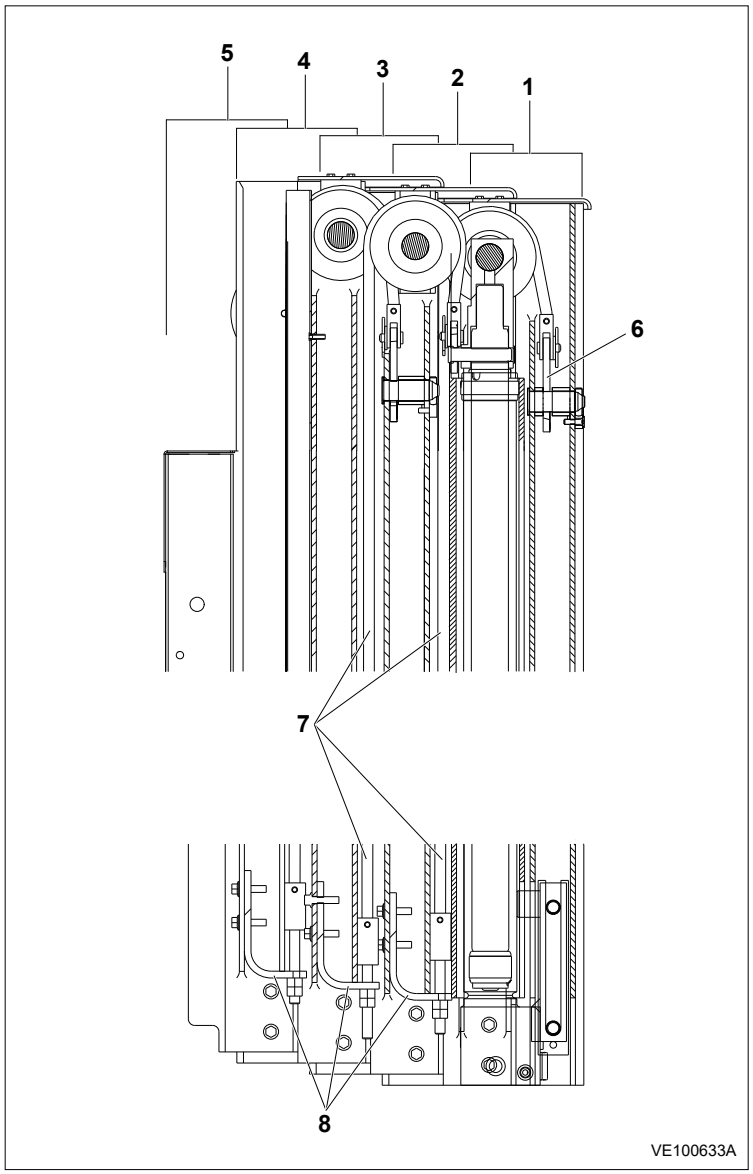


Figure 131. Mast Chain Routing Diagram. - MML/MCL/MSP

1. Mast Section 1	5. Mast Section 5
2. Mast Section 2	6. Anchored to Mast Section 1
3. Mast Section 3	7. Chain Assembly
4. Mast Section 4	8. Chain Anchor Brackets

10.6.3 Mast Assembly Procedure - MML/MCL/MSP

Mast Section 1 - Assembly

1. Place mast section-1, rail (open) side up on a clean, flat surface *(preferably a table or work bench capable of supporting the weight of the entire mast assembly)*. Slide mast out over end of work surface far enough to allow access to the chain anchor attach hole near the top of the mast.

2. Locate the two (2) single *(wide)* chain assemblies and attach to the large equalizer anchor plate *(if not already attached)*. Lay out the chain/anchor plate assembly with the anchor plate end towards top of the mast. *(Be certain floor surface is clean and free of any metal chips or debris which may stick to lubricated chains)*.

3. Insert the chain/anchor plate assembly end into the top of mast section-1 and secure using the large anchor plate attach pin, spacers, and pin keeper.

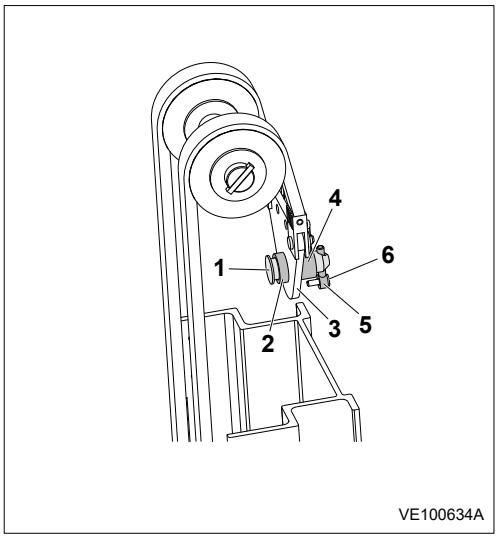


Figure 132. Chain/Anchor Plate Installation (Mast Section-1 - Shown Cut-Away)

1. Anchor Plate Pin	3. Chain/Anchor Plate Assy.	5. Pin Keeper
2. Short Spacer	4. Long Spacer	6. Keeper Screw (a)

Note: (a) Apply Medium Strength Threadlocking Compound to threads.

Mast Section 2 - Assembly

Note: When sliding mast sections together, be careful not to scratch or score the anodized finish in the slide pad channels.

4. Locate mast section-2, carefully slide mast section-2 closed rail into section-1 open rail. Slide sections together until ends are even.

5. Insert slide pads into the slide pad channels at bottom end of mast between section-1 and -2, *(one on each side of the mast)*, with beveled surface facing out towards section-1.

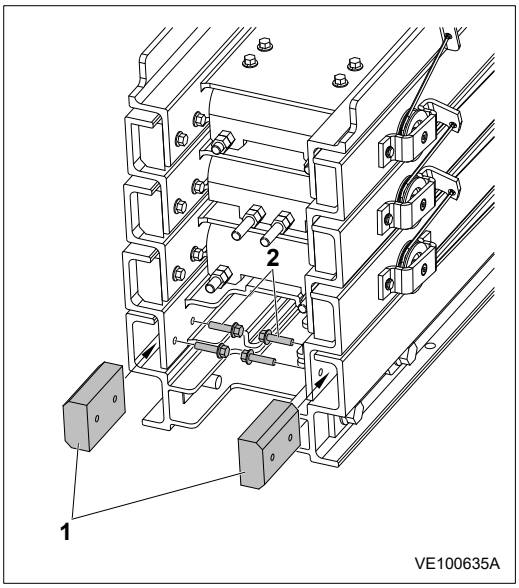


Figure 133. Mast Bottom End - Slide Pad Installation (Typical)

1. Slide Pads	2. Slide Pad Bolts

Note: (a) Apply Medium Strength Threadlocking Compound to threads.

6. Thread slide pad attaching bolts, (two (2) 1/4 in. - 20UNC x 1 in. long hex flange head bolt), through holes in mast section-2 inside rail, into the slide pad inserts. Thread in enough to hold pad in place.

7. Shim slide pads using the following steps:

Note: Always use the an even amount of shim material behind slide pads on both sides of the mast rails. This will keep mast sections centered in rail channels and prevent any distortion of the mast section.

   a. Start with a 0.036 in. thick shim and a 0.075 in. thick shim per side at each slide pad.

   b. Slide shims into place between slide pad and mast rail. Tighten the slide pad mounting bolts, be sure there are no air gaps between shims, shim and mast or shim and slide pad when tightened.

   c. Check mast section for side play. If play exists add 0.015 in. shims dividing the thickness equally between both sides of mast. Insert shims until the shims cannot be inserted halfway by hand with the mast pulled to the opposite side.

   d. When mast slide pads are shimmed properly, there should be no side to side movement of slide pad in rail channel. Mast sections should be snug in channels but still be able to slide in channel by hand.

8. Insert slide pads into the slide pad channels *(top of mast)* between section-1 and -2, *(one on each side of the mast)*, with beveled surface facing in towards section-2.

Note: Before fastening and shimming the slide pad on the top left side of the mast, install a sequence cable bracket against the mast under the flatwasher.

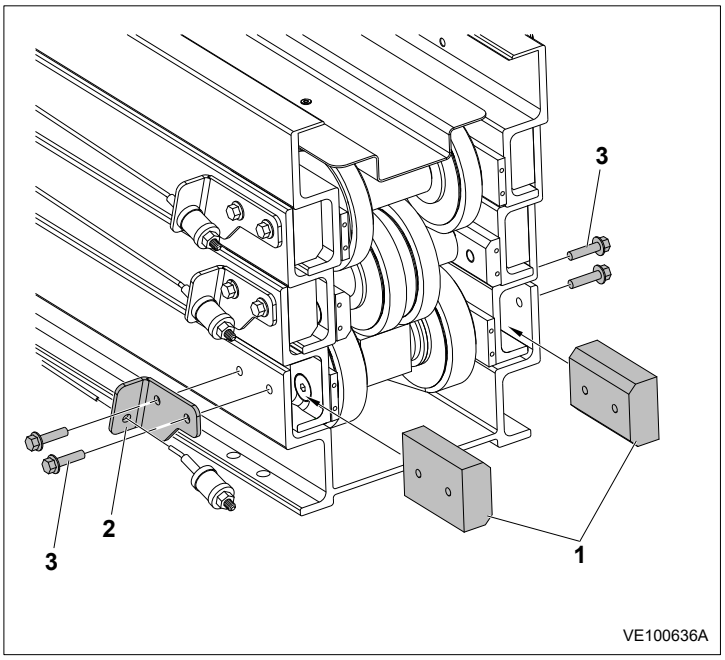


Figure 134. Mast Top End - Slide Pad Installation (Typical)

1. Slide Pads	3. Slide Pad Bolts
2. Sequence Cable Bracket	

Note: (a) Apply Medium Strength Threadlocking Compound to threads.

9. Thread slide pad attaching bolts, two (2) 1/4 in. - 20UNC x 1 in. long hex flange head bolts, through holes in mast section-1 outside rail *(top of mast)* and into the slide pad inserts. Thread in enough to hold pad in place.

10. Shim per instructions in step 7, Mast Section 2 - Assembly.

11. Lift cylinder installation into the bottom of Mast Section 1 and 2.

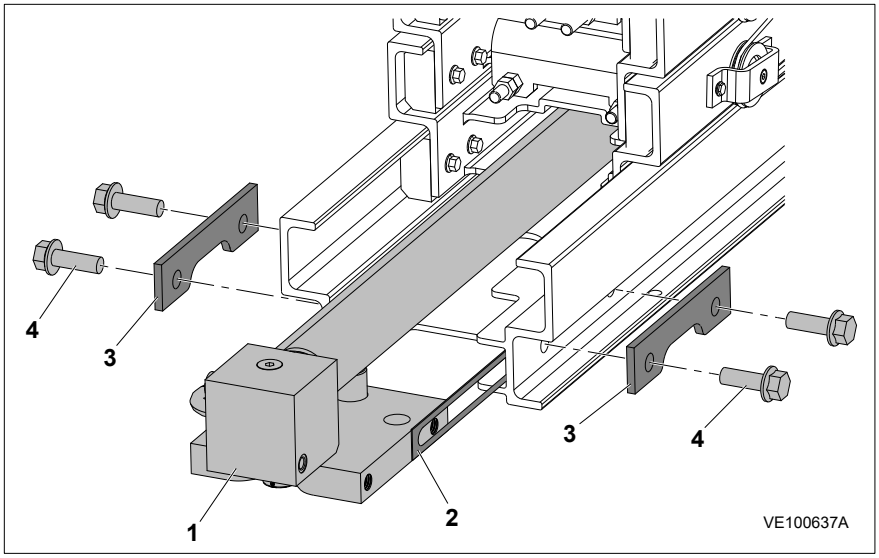


Figure 135. Lift Cylinder Mount Installation

1. Cylinder Mount	3. Cylinder Mounting Plate
2. Shim Stock	4. Mount Screws

Note: (a) Apply Medium Strength Threadlocking Compound to threads.

Note: The cylinder rod needs to be extended out of the cylinder approximately 12 in. (30 cm) before installation for later attachment of the upper chain anchor block to mast section-2. Remove any protective caps on the extend and return ports temporarily to allow rod extension. Catch any oil draining out of cylinder to avoid spillage onto work area. Be careful not to nick or scour rod surface when extending and during installation.

12. Slide the lift cylinder into the closed rail side of mast section-2 and the cylinder mount into mast section-1 closed rail, with the manual descent valve pointing down towards the back of the mast assembly.

13. Check the mount side to side clearance. Use mounting shims of equal thickness on each side to center the mount in the closed rail of section-1, if necessary.

14. Install the cylinder mounting plates 1 each side and secure the cylinder assembly to the mast using the cylinder mounting screws. Apply Medium Strength Threadlocking Compound to the screw threads before final tightening.

15. Slide mast section-2 out of mast section-1 approximately 8 in. (20 cm).

16. Assemble one of the narrow chains sets *(#466)* and to the small chain equalizer anchor plate using the pins, washers and cotter keys. Set aside.

17. Locate the chain anchor block and slide it onto the hydraulic cylinder rod end extending out the top of mast section-2.

18. Lay out the chain*(#466)*/anchor plate assembly with anchor plate end towards mast, *(be certain floor surface is clean and free of any metal chip or debris which may stick to lubricated chains or lay chains in a clean bucket)*.

19. Assemble the chain/anchor plate assembly and the chain anchor block to the cylinder rod end using the anchor plate/block attach pin and snap ring.

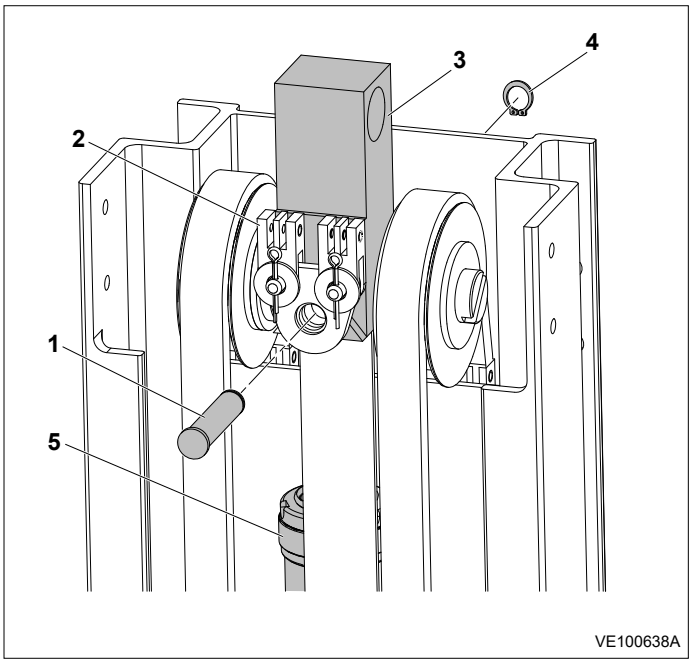


Figure 136. Install Chain/Anchor Block to Top of Lift Cylinder

1. Attach Pin	3. Chain/Anchor Block	5. Cylinder Rod (Extended)
2. Chain/Equalizer Assembly	4. Attach Pin - Snap Ring	

20. Assemble chain sheaves on chain assembly anchor block (attached to cylinder rod end) and attach to mast section-2 using following steps;
    a. Insert sheave pin through anchor block and cylinder rod on cylinder rod end.
    b. Load three 1 in. flat washers onto the sheave pin on each side of the anchor block.
    c. Place sheave wheels (for wide #444 chain) on sheave pin, one each side of anchor block.
    d. On the outside of each sheave wheel, place another 1 in. flatwasher, a roll pin *(into the slot in each end of the pin)*, and then place a sheave pin support bar *(rectangular plate with threaded holes on each side of pin bore hole)*.
    e. Slide the whole anchor block/cylinder assembly with sheave pin, wheels and pin support bars into top of mast section-2.
    f. Align the threaded holes in the attach bars on each side of the mast and attach to top of mast section-2 using two (2) 3/8 in. - 16UNC x 1/2 in. long socket head-countersunk- flathead capscrews each side. Coat threads with Medium strength Threadlocking Compound and tighten.

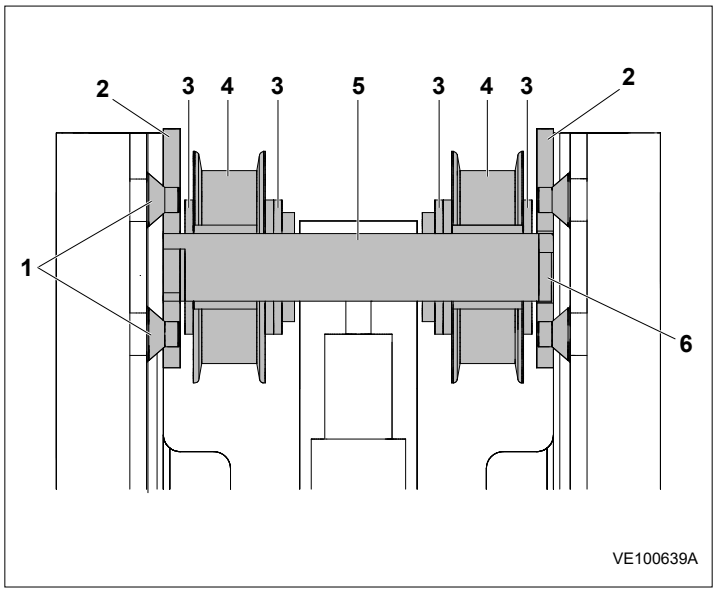


Figure 137. Mast Section 2 - Chain/Anchor Block (Sheave Wheel Assembly)

1. Support Bar Screws(a)	3. Washers	5. Sheave Pin
2. Sheave Pin Support Bars	4. Sheave Wheel Assy.	6. Square Keys

Note: (a) Apply Medium Strength Threadlocking Compound to threads.

21. Remove the cylinder mount cap - shoulder screws and apply Medium Strength Threadlocking Compound to the threads. Install the screws.
22. Tighten the center lift cylinder mount screw, this screw keeps the cylinder assembly from rotating in the mount.
23. Slide mast section-2 back into section-1 until top and bottom ends are even.

Mast Section 3 - Assembly

Note: When sliding mast sections together, be careful not to scratch or score the anodized finish in the slide pad channels.

24. Carefully slide mast section-3 into section-2 until ends are even.
25. Insert slide pads into the top end mast rails between section-2 and -3, (one on each side of the mast), with beveled surface facing inward towards section-3.

Note: Before fastening and shimming the slide pad on the top left side of the mast, install a sequence cable bracket against the mast under the flatwasher.

26. Thread slide pad attaching bolts, two (2) 1/4 in. - 20UNC x 3/8 in. long hex flange head bolts, through holes in outside rail, on top of mast section-2 and into the slide pad inserts. Thread in enough to hold pad in place.

27. Shim per instructions in step 7, Mast Section 2 - Assembly

28. Insert slide pads into the bottom end mast rails between section-2 and -3, *(one on each side of the mast)*, with beveled surface facing out towards section-2.

29. Thread slide pad attaching bolts, two (2) 1/4 in.- 20UNC x 1 in. long hex flange head bolts, through holes on inside rail, on bottom end of mast section-3 and into the slide pad inserts. Thread in enough to hold pad in place.

30. Shim per instructions in step 7, Mast Section 2 - Assembly.

31. Slide section-3 out the bottom of section-2 approximately one (1) foot.

32. Locate one (1) of the chain (bottom) anchor brackets (one with threaded holes horizontally aligned to outside of bracket). Attach using outer set of holes in bottom of mast section-3 with two (2) 1/4 in. - 20UNC x 1 in. long bolts.

33. Slide section-3 out the top of section-2 approximately one (1) foot.

34. Locate the remaining narrow chain set *(#466)* and attach them to the remaining triangular shaped anchor plate using the attach pins, flat washers and cotter keys.

35. Install the chain/anchor plate assembly into the top of mast section-3, using the remaining large pin and pin keeper. Allow to hang out the top of mast section-3 for later assembly.

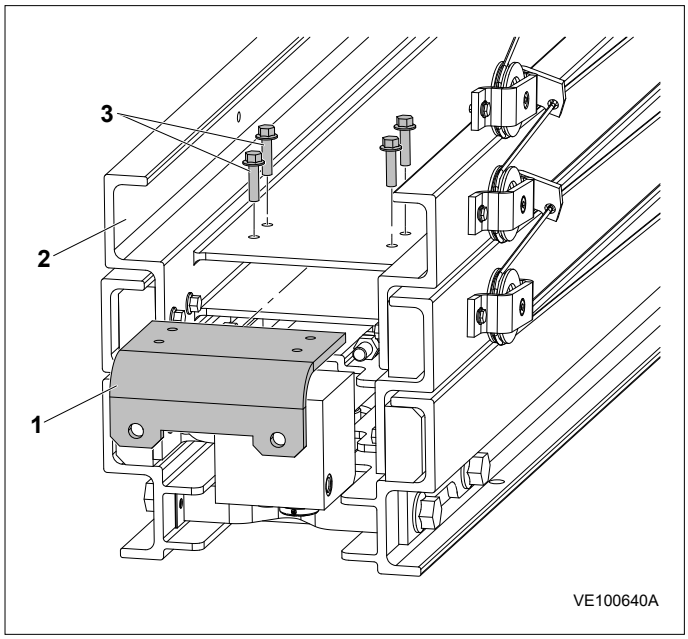


Figure 138. Mast Section 3 - Chain Anchor Bracket (Bottom of Mast)

1. Chain Anchor Bracket	2. Mast Section 3	3. Anchor Bolts

Note: (a) Apply Medium Strength Threadlocking Compound to threads.

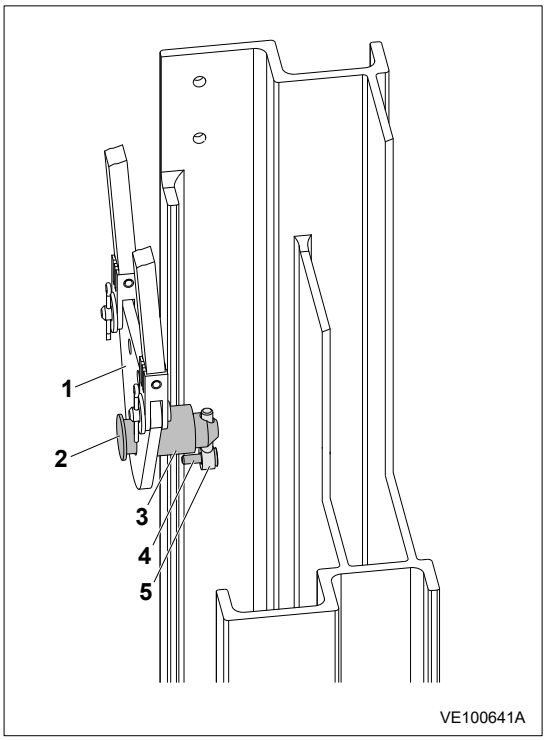


Figure 139. Mast Section 3 - Chain/Anchor Plate Installation (Mast Section-3 Shown Cut-away)

1. Chain/Anchor Plate Assy.	3. Spacer	5. Keeper Screw (a)
2. Anchor Pin	4. Pin Keeper	

Note: (a) Apply Medium Strength Threadlocking Compound to threads.

36. Insert the threaded the ends of chain assembly *(attached to top of mast section-1)*, into the opening between mast section-2 and mast section-3. Slide the threaded ends through the holes in chain anchor bracket attached at the bottom of mast section-3. Loosely thread two (2) 3/8 in. - 16UNC nuts onto stud threads on each chain and remove any slack in the chains. Chains will be adjusted later in assembly.

37. Assemble chain sheaves *(for narrow chain assembly)* to top of mast section-3 as follows;
    a. Place four (4) of the 1 in. flat washers onto one of the remaining sheave pins. Locate two (2) narrow chain sheave wheels and slide onto sheave pin on each side of the flat washers.
    b. Slide two (2) short spacer tubes onto sheave pin, one each end of sheave pin to outside of sheave wheels.
    c. Place two (2) sheave pin support bars, one each end of sheave pin onto outside of spacer tubes. Place a roll pin in the slots at each end of the sheave pins and align with the cutouts in the pin support bars.
    d. Holding complete sheave wheel assembly, slide assembly into top of mast section-3 and align threaded holes in sheave pin support bars with holes in mast rails.
    e. Attach to top of mast section-3 using two (2) 3/8 ft.- 16UNC x 1/2 in. long socket head-countersunk-flathead capscrews, each side. Coat threads with Medium strength Threadlocking Compound and tighten.

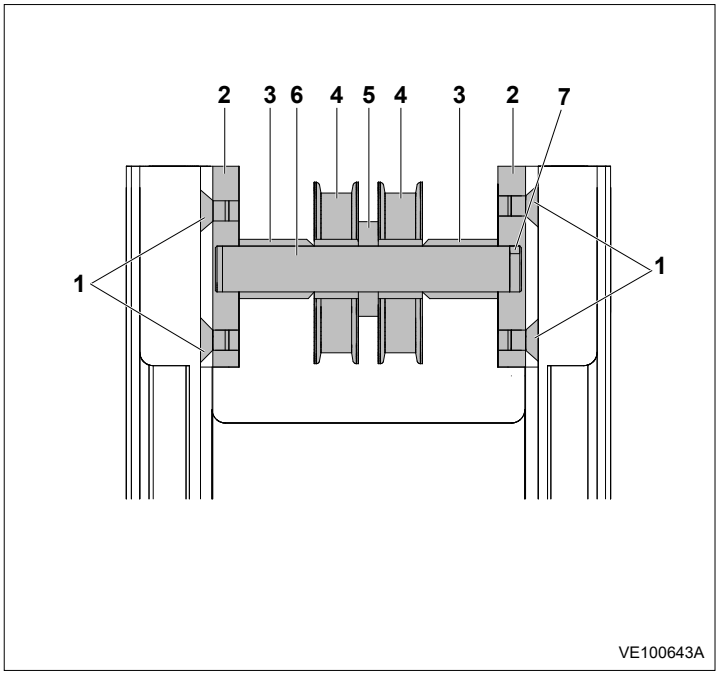


Figure 140. Mast Section 3 - Sheave Wheel Assembly

1. Support Bar Screws (a)	4. Sheave Wheel Assys.	7. Square Keys
2. Sheave Pin Support Bars	5. Washers	
3. Wide Spacers	6. Sheave Pin	

Note: (a) Apply Medium strength Threadlocking Compound to threads.

38. Slide mast section-3 back into section-2 until ends are even. Check to make sure chain assembly (wide chains) are seating properly in chain anchor block chain sheave wheels attached to mast section-2.

Mast Section 4 - Assembly

Note: When sliding mast sections together, be careful not to scratch or score the anodized finish in the slide pad channels.

39. Carefully slide mast section-4 into section-3 until ends are even.

40. Insert slide pads into the top end mast rails between section-2 and -3, *(one on each side of the mast)*, with beveled surface facing inward towards section-3.

Note: Before fastening and shimming the slide pad on the top left side of the mast, install a sequence cable bracket against the mast under the flatwasher.

41. Thread slide pad attaching bolts, two (2) 1/4 in. - 20UNC x 1 in. long hex flange head bolts, through holes in outside rail, on top of mast section-2 and into the slide pad inserts. Thread in enough to hold pad in place.

42. Shim per instructions in step 7, Mast Section 2 - Assembly.

43. Insert slide pads into the bottom end mast rails between section-2 and -3, *(one on each side of the mast)*, with beveled surface facing out towards section-2.

44. Thread slide pad attaching bolts, two (2) 1/4 in. - 20UNC x 1 in. long hex flange head bolts, through holes on inside rail, on bottom end of mast section-3 and into the slide pad inserts. Thread in enough to hold pad in place.

45. Shim per instructions in step 7, Mast Section 2 - Assembly.

46. Slide section-4 out the bottom of section-3 approximately one (1) foot.

47. Locate one (1) of the chain bottom anchor plates *(one with threaded holes horizontally aligned to center of bracket)*. Attach using holes in bottom of mast section-4 with four (4) 1/4 in. - 20UNC x 3/4 in. long bolts.

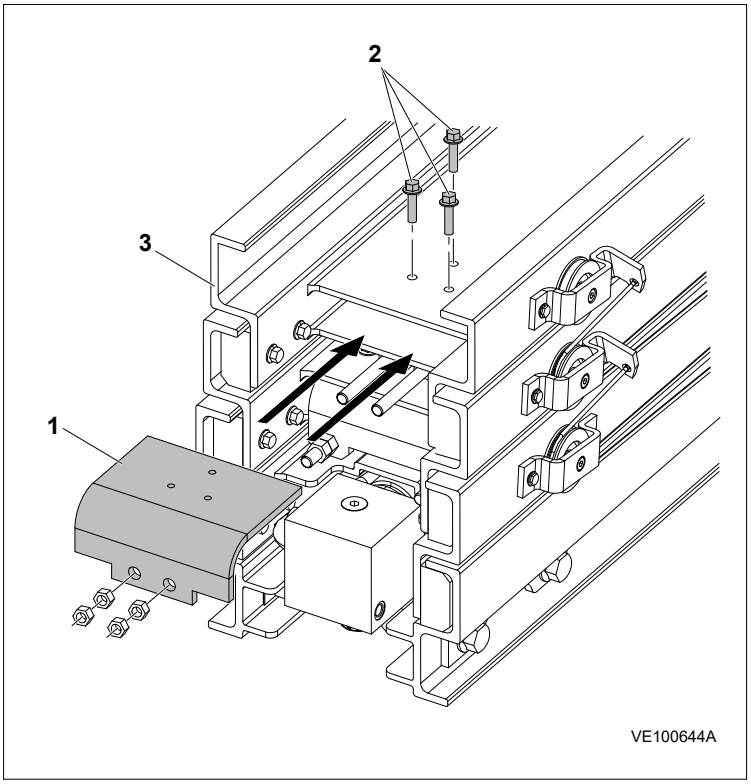


Figure 141. Mast Section 4 - Chain Anchor Bracket (Bottom of Mast)

1. Chain Anchor Bracket	3. Anchor Bolts
2. Mast Section 4	

Note: (a) Apply Medium strength Threadlocking Compound to threads.

48. Slide section-4 out the top of section-3 approximately one (1) foot.

49. Insert threaded ends of chain assembly *(attached to top of mast section-2)*, into the opening between mast section- 3 and mast section-4. Slide the threaded ends through the holes in bottom anchor plate attached to bottom of mast section-4. Loosely thread two (2) 3/8 in. - 16UNC nuts onto stud threads on each chain until all slack is taken out of chain. Chains will be adjusted later in assembly.

50. Assemble chain sheaves *(for narrow chain assembly)* to top of mast section-4 as follows;
    a. Locate the remaining sheave pin and slide the wide tube spacer onto the pin shaft.
    b. Place 1 in. flat washers onto the sheave pin on each side of the anchor block.
    c. Place two (2) of the narrow chain sheave wheels onto the sheave pin on each side of the wide spacer.
    d. Slide two (2) 1 in. flat washers onto each end of sheave pin to outside of sheave wheels.
    e. Place two (2) sheave pin support bars, one each end of sheave pin to outside of space tubes. Place a roll pin in the slots at each end of the sheave pins and align with the cutouts in the pin support bars.
    f. Holding complete sheave wheel assembly, slide assembly into top of mast section-4 and align threaded holes in sheave pin support bars with holes in mast rails.
    g. Attach to top of mast section-4 using two (2) 3/8 in.- 16UNC x 1/2 in. long socket head-countersunk-flathead capscrews, each side. Coat threads with Medium strength Threadlocking Compound and tighten.

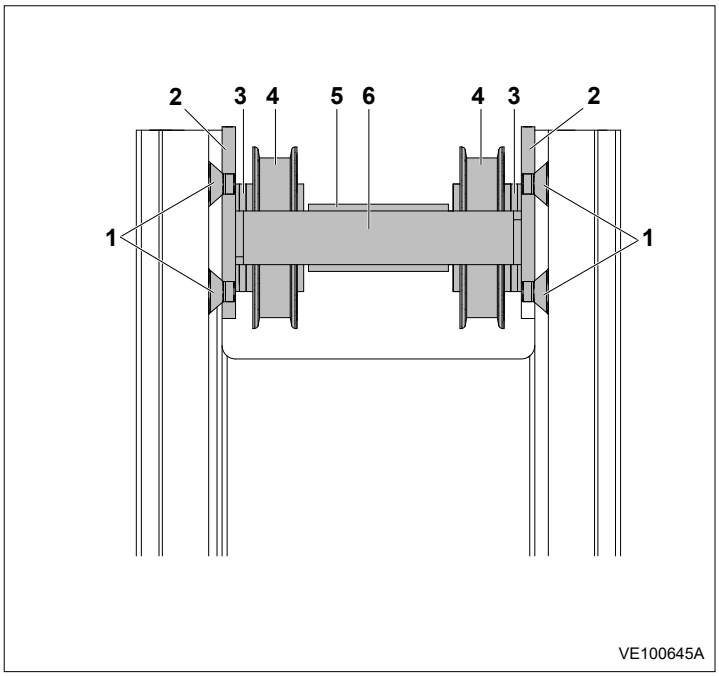


Figure 142. Mast Section 4 - Sheave Wheel Assembly

1. Support Bar Screws (a)	4. Sheave Wheel Assys.
2. Sheave Pin Support Bars	5. Wide Spacer
3. Washers	6. Sheave Pin

Note: (a) Apply Medium strength Threadlocking Compound to threads.

51. Carefully slide mast section-4 into section-3 until ends are even. Check to make sure chain assembly (narrow chains) are seating properly in chain anchor block chain sheave wheels attached to mast section-3.

Mast Section 5 - Assembly

52. Locate the remaining mast section-5 *(platform mounting - mast section)*. Lay mast section on a flat stable surface.

53. Attach the remaining chain bottom anchor plate *(one with threaded holes aligned at the outside of bracket)*. Attach through set of holes in bottom of mast section-5 with four (4) 1/4 in. - 20UNC x 3/4 in. long bolts.

Note: The platform mounting section slide pads, are assembled differently than the slide pads for the other mast sections. Mast section-5 slide pads may need to be assembled/disassembled several times in order to determine the correct shim stock required for proper fit.

54. Complete the following steps to determine shim stock thickness required for section-5;

Note: Always use the an even amount of shim material behind slide pads on both sides of the mast rails. This will keep mast sections centered in rail channels and prevent any distortion of the section.

a. Use two shim pieces per slide pad, a thick one and a thin one.

b. Start with a total thickness of approximately .035 in. and .075 in. thick shim stock.

c. Attach shim stock and slide pads to both sides of mast section-5 using five (5) 1/4 in.-20UNC x 1-1/4 in. long, hex flange head screws per side. (Assemble shim stock and slide pad to mast section rail with shim stock against rail and slide pad with beveled side out).

d. Carefully thread the slide pad mounting bolts through slide pads and shim stock into threads in mast section-5. Be certain there are no air gaps between shims, shim and mast or shim and slide pad when tightened.

Note: *Mast section-5 into section-4 fit should be very snug but still be able to be pushed together by hand. If too tight, remove section-5, disassemble slide pad and reduce thickness of shim stock.*

e. Begin sliding top of mast section-5 with closed rail down engaging the slide pads into slide pad channels at bottom of mast section-4's open rail. Continue to push section-5 into section-4 until BOTTOM ends of mast sections are even.

f. Check mast section for side play. If play exists use thicker shims dividing thickness equally between both sides of mast.

g. When mast slide pads are shimmed properly, there should be no side to side movement of slide pad in rail channel. Mast sections should be very snug in channels but still be able to slide in channel by hand.

55. Slide mast section-5 out even with top of section-4.

56. Insert threaded ends of chain assembly *(attached to top of mast section-3)*into the opening between mast section- 4 and mast section-5. Slide the threaded ends through the holes in bottom chain anchor plate located on bottom of mast section-5. Loosely thread two (2) 3/ 8 in. - 16UNC nuts onto stud threads on each chain. Chains will be adjusted later in assembly.

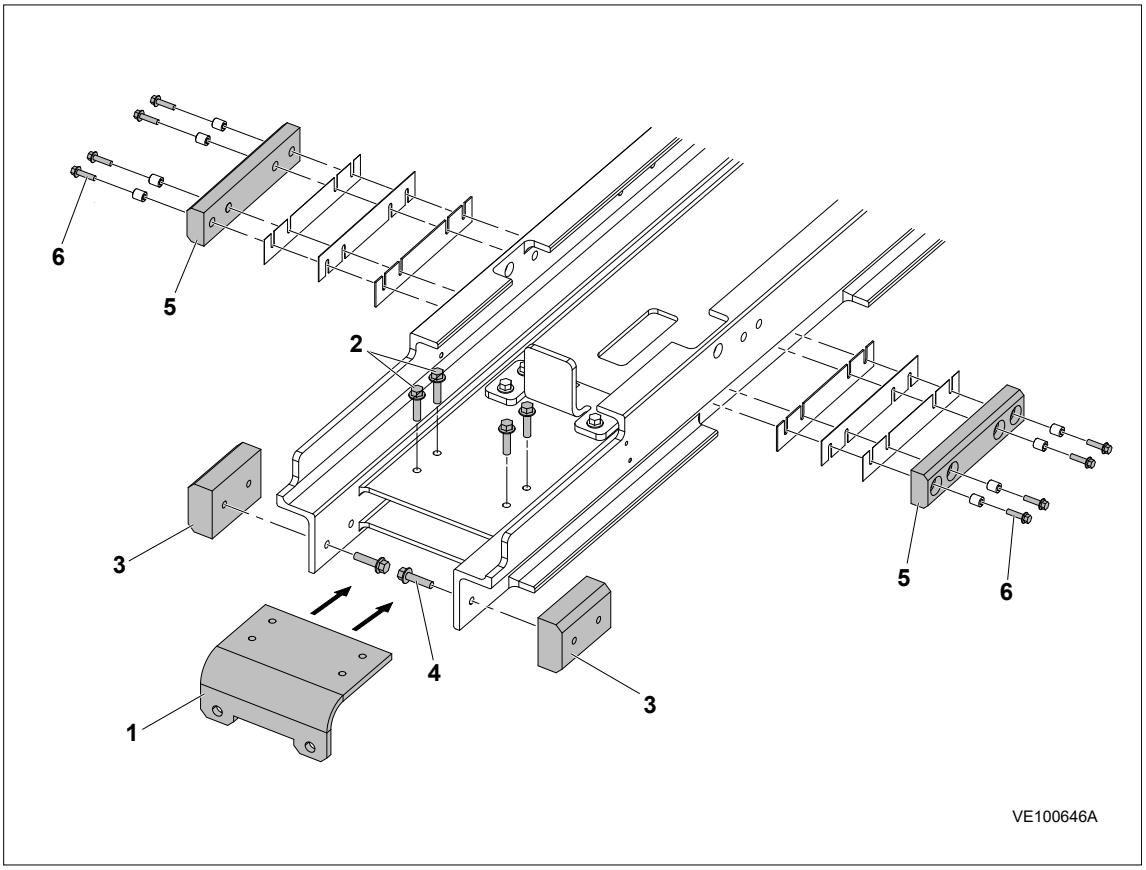


Figure 143. Mast Section 5 - Bottom End Components (Chain Anchor Bracket and Slide Pad Installation)

1. Chain Anchor Bracket	3. Slide Pad	5. Long Slide Pad
2. Anchor Bracket Bolts	4. Bolts	6. Slide Pad Bolts

Note: (a) Apply Medium strength Threadlocking Compound to threads.

57. Slide mast section-5 back into mast section-4 until bottom ends of masts are even. Check to make sure chain set attached to top of section-3 is seating properly in cable sheave wheels attached to top of mast section-4. *(Mast section-3 may need to be restrained to keep it's slide pads from pushing out the bottom of mast sections-2)*.

58. At bottom of mast assembly, thread all chain adjusting nuts on threaded ends until they are snug against the bottom anchor plates and all slack is removed from chains. Check that chains are seated in their sheave wheels at top of mast assembly.

59. Do not assemble the mini covers to the top of mast sections until the mast chains have been adjusted properly.

60. Attach the sequencing cables and hardware to the sides of the mast assembly.

61. Install the mast chain guard to the top mast section 5.
The mast assembly is now ready to install on the machines base frame.

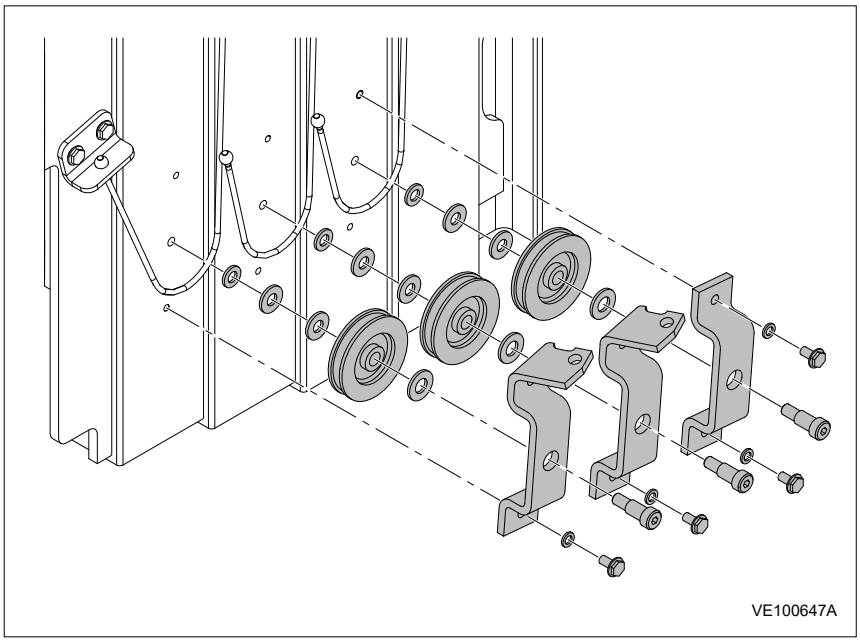


Figure 144. Sequence Cable Bracket Installation (Bottom End)

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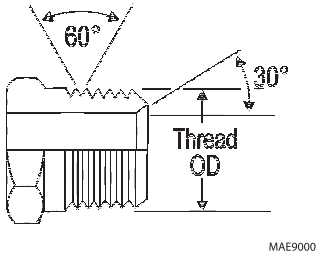
SECTION 11
TORQUE/CONNECTION INFORMATION

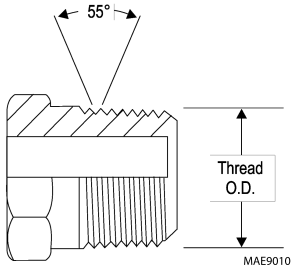
11.1 HYDRAULIC FITTINGS

11.1.1 Tapered Thread Types

NPTF = national tapered fuel (Dry Seal) per SAE J476/J512

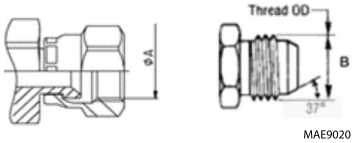


BSPT = British standard pipe tapered per ISO7-1

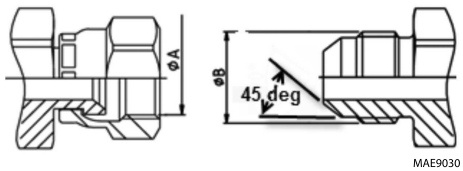


11.1.2 Straight Thread Types, Tube and Hose Connections

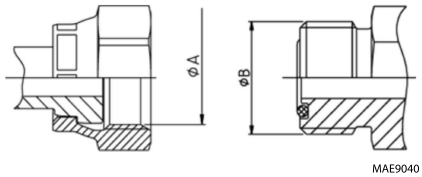
JIC = 37° flare per SAE J514



SAE = 45° flare per SAE J512

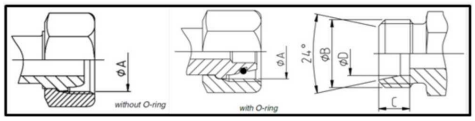


ORFS = o-ring face seal per SAE J1453

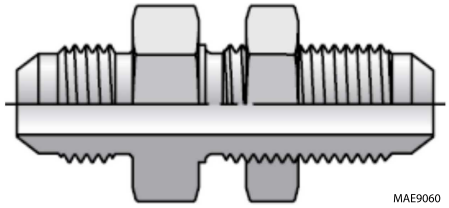


MBTL = metric flareless bite type fitting, pressure rating L(medium) per ISO 8434, DIN 2353

MBTS = metric flareless bite type fitting, pressure rating S (high) per ISO 8434, DIN 2353



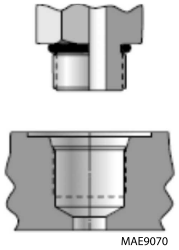
BH = bulkhead connection – JIC, ORFS, MBTL, or MBTS types



11.1.3 Straight Thread Types, Port Connections

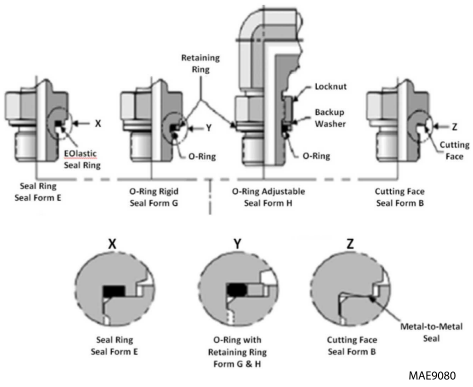
ORB = o-ring boss per SAE J1926, ISO 11926

MPP = metric pipe parallel o-ring boss per SAE J2244, ISO 6149, DIN 3852



MFF = metric flat face port per ISO 9974-1

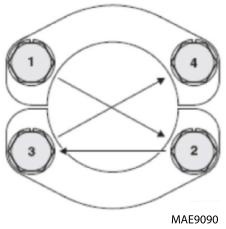
BSPP = British standard parallel pipe per ISO 1179-1, DIN 3852-2



11.1.4 Flange Connection Types

FL61 = code 61 flange per SAE J518, ISO 6162

FL62 = code 62 flange per SAE J518, ISO 6162



11.1.5 Tightening Methods

Torque = Application of a twisting force to the applicable connection by use of a precise measurement instrument (i. e. torque wrench).

Finger Tight = The point where the connector will no longer thread onto the mating part when tightened by hand or fingers. Finger Tight is relative to user strength and will have some variance. The average torque applied by this method is 3 ft-lbs [4 N-m]. Also referred to as 'Hand Tight.'

TFFT = Turns From Finger Tight; Application of a preload to a connection by first tightening the connection by hand (fingers) and applying an additional rotation counted by a defined number of turns by use of a tool.

FFWR = Flats from Wrench Resistance; Application of a pre-load to a connection by tightening to the point of initial wrench resistance and turning the nut a described number of ‘flats’. A ‘flat’ is one side of the hexagonal tube nut and equates to 1/6 of a turn. Also referred to as the ’Flats Method’.

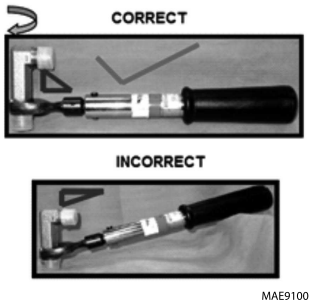
11.1.6 Assembly and Torque Specifications

Prior to selecting the appropriate torque from the tables within this section, it is necessary to properly identify the connector being installed. Refer to the Figures and Tables in this section.

11.1.7 General Tube Type Fitting Assembly Instructions

1. Take precautions to ensure that fittings and mating components are not damaged during storage, handling or assembly. Nicks and scratches in sealing surfaces can create a path for leaks which could lead to component contamination and/or failure.
2. When making a connection to tubing, compression or flare, inspect the tube in the area of the fitting attachment to ensure that the tube has not been damaged.
3. The assembly process is one of the leading causes for contamination in air and hydraulic systems. Contamination can prevent proper tightening of fittings and adapters from occurring.
   a. Avoid using dirty or oily rags when handling fittings.
   b. If fittings are disassembled, they should be cleaned and inspected for damage. Replace fittings as necessary before re-installing.
   c. Sealing compounds should be applied where specified; however, care should be taken not to introduce sealant into the system.
   d. Avoid applying sealant to the area of the threads where the sealant will be forced into the system. This is generally the first two threads of a fitting.
   e. Sealant should only be applied to the male threads.
   f. Straight thread fittings do not require sealants. O-rings or washers are provided for sealing.
   g. When replacing or installing an O-ring, care is to be taken while transferring the O-ring over the threads as it may become nicked or torn. When replacing an O-ring on a fitting, the use of a thread protector is recommended.
   h. When installing fittings with O-rings, lubrication shall be used to prevent scuffing or tearing of the O-ring. Refer to Section — O-ring Installation (Replacement) in this section.

4. Take care to identify the material of parts to apply the correct torque values.
   a. Verify the material designation in the table headings.
   b. If specifications are given only for steel fittings and components, the values for alternate materials shall be as follows:
      Aluminum and Brass- reduce steel values by 35%;
      Stainless Steel - Use the upper limit for steel.
5. To achieve the specified torque, the torque wrench is to be held perpendicular to the axis of rotation.



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6. Refer to the appropriate section in this manual for more specific instructions and procedures for each type of fitting connection.

11.1.8 Assembly Instructions for American Standard Pipe Thread Tapered Connections.

1. Inspect components to ensure male and female port threads are free of rust, splits, dirt, foreign matter, or burrs.
2. Apply a high temperature thread sealant with PTFE, to the male pipe threads if not already applied. Ensure the first 1 to 2 threads are uncovered to prevent system contamination.
3. Assemble connection hand tight.
4. Mark fittings, male and female.

NOTICE

Over tightening may cause deformation of the pipe fitting and damage to the joining fitting, flange or component may occur.

NOTICE

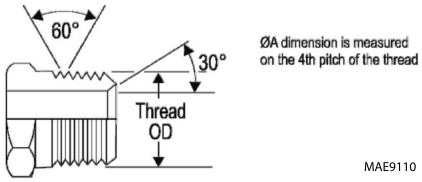
Never back off (loosen) pipe threaded connectors to achieve alignment. Meet the minimum required turns and use the last turn for alignment.

5. Rotate male fitting the number of turns per Table. refer to *Section — FFWR and TFFT Methods, page 355* for procedure requirements.

Note: TFFT values provided in below mentioned table are applicable for the following material configurations:

   a. Steel fittings with steel mating components.
   b. Steel fittings with aluminum or brass mating components.
   c. Aluminum or brass fittings with steel mating components.
   d. Aluminum or brass fittings with aluminum or brass mating components.

NPTF Pipe Thread



TYPE/FITTING IDENTIFICATION					Turns From Finger Tight (TFFT)**
Material	Dash Size	Thread Size	ØA*		
		(UNF)	(in)	(mm)	
STEEL, ALUMINUM, OR BRASS FITTINGS WITH STEEL, ALUMINUM, OR BRASS MATING COMPONENTS	2	1/8 - 27	0.40	10.24	2 to 3
	4	1/4 - 18	0.54	13.61	2 to 3
	6	3/8 - 18	0.67	17.05	2 to 3
	8	1/2 - 14	0.84	21.22	2 to 3
	12	3/4 - 14	1.05	26.56	2 to 3
	16	1 - 11 1/2	1.31	33.22	1.5 to 2.5
	20	1 1/4 - 11 1/2	1.65	41.98	1.5 to 2.5
	24	1 1/2 - 11 1/2	1.89	48.05	1.5 to 2.5
	32	2 - 11 1/2	2.37	60.09	1.5 to 2.5

Note: * ØA and ØB thread dimensions for reference only.
** Refer to ***Section — FFWR and TFFT Methods, page 355*** for FFWR procedure requirements.

11.1.9 Assembly Instructions for British Standard Pipe Thread Tapered Connections

1. Inspect components to ensure male and female port threads are free of rust, splits, dirt, foreign matter, or burrs.
2. Apply a high temperature thread sealant with PTFE, to the male pipe threads if not already applied. Ensure the first 1 to 2 threads are uncovered to prevent system contamination.
3. Assemble connection hand tight.
4. Mark fittings, male and female.

NOTICE

Over tightening may cause deformation of the pipe fitting and damage to the joining fitting, flange or component may occur.

NOTICE

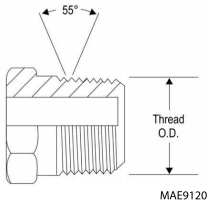
Never back off (loosen) pipe threaded connectors to achieve alignment. Meet the minimum required turns and use the last turn for alignment.

5. Rotate male fitting the number of turns as per below mention table.

Note: TFFT values provided in below table are applicable for the following material configurations:

a. Steel fittings with steel mating components.
b. Steel fittings with aluminum or brass mating components.
c. Aluminum or brass fittings with steel mating components.
d. Aluminum or brass fittings with aluminum or brass mating components.

BSPT Pipe Thread



TYPE/FITTING IDENTIFICATION					Turns From Finger Tight (TFFT)**
MATERIAL	Dash Size	Thread Size	ØA*		
		(BSPT)	(in)	(mm)	
STEEL, ALUMINUM, OR BRASS FITTINGS WITH STEEL, ALUMINUM, OR BRASS MATING COMPONENTS	2	1/8 - 28	0.38	9.73	2 to 3
	4	1/4 - 19	0.52	13.16	2 to 3
	6	3/8 - 19	0.66	16.66	2 to 3
	8	1/2 - 14	0.83	20.96	2 to 3
	12	3/4 - 14	1.04	26.44	2 to 3
	16	1 - 11	1.31	33.25	1.5 to 2.5
	20	1 1/4 - 11	1.65	41.91	1.5 to 2.5
	24	1 1/2 - 11	1.88	47.80	1.5 to 2.5
	32	2 - 11	2.35	59.61	1.5 to 2.5

Note: * ØA and ØB thread dimensions for reference only.
** Refer to *Section — FFWR and TFFT Methods, page 355* for FFWR procedure requirements.

11.1.10 Assembly Instructions for 37° (JIC) Flare Fittings

1. Inspect the flare for obvious visual squareness and concentricity issues with the tube OD. Ensure surface is smooth, free of rust, weld and brazing splatter, splits, dirt, foreign matter, or burrs. If necessary replace fitting or adapter.

NOTICE

DO NOT force a misaligned or short hose/tube into alignment. It puts undesirable strain onto the joint eventually leading to leakage.

2. Align tube to fitting and start threads by hand.

NOTICE

The torque method should NOT be used on lubricated or oily fittings. No lubrication or sealant is required. The lubrication would cause increased clamping force and cause fitting damage.

3. Torque assembly to value listed in below mentioned table while using the Double Wrench Method.

Note: Torque values provided in below table are segregated based on the material configuration of the connection.

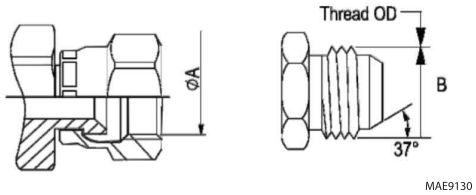
Aluminum/brass fittings or aluminum/brass mating components' indicate either the following material configurations:

a. Steel fittings with aluminum or brass mating components.

b. Aluminum or brass fittings with steel mating components.

c. Aluminum or brass fittings with aluminum or brass mating components.

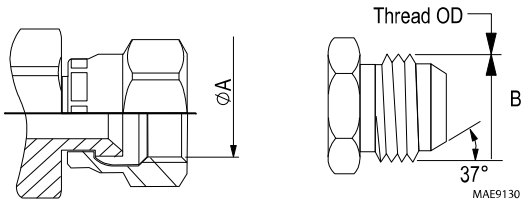
37° Flare (JIC) Thread - Steel



TYPE/FITTING IDENTIFICATION							Torque						Flats from Wrench Resistance (F.F.W.R)**
Material	Dash Size	Thread Size	ØA*		ØB*		[Ft-Lb]			[Nm]			
		(UNF)	(in)	(mm)	(in)	(mm)	Min	Nom	Max	Min	Nom	Max	
STEEL FITTINGS WITH STEEL MATING COMPONENTS; UN-LUBRICATED THREADS	2	5/16-24	0.28	7.00	0.31	7.75	6	7	7	8	9	10	–
	3	3/8-24	0.34	8.60	0.37	9.50	8	9	10	11	12	14	–
	4	7/16-20	0.39	10.00	0.44	11.10	13	14	14	18	19	19	1-1/2 to 1-3/4
	5	1/2-20	0.46	11.60	0.50	12.70	14	15	15	19	20	21	1 to 1-1/2
	6	9/16-18	0.51	13.00	0.56	14.30	22	23	24	30	31	33	1 to 1-1/2
	8	3/4-16	0.69	17.60	0.75	19.10	42	44	46	57	60	63	1-1/2 to 1-3/4
	10	7/8-14	0.81	20.50	0.87	22.20	60	63	66	81	85	89	1 to 1-1/2
	12	1 1/16-12	0.97	24.60	1.06	27.00	84	88	92	114	120	125	1 to 1-1/2
	14	1 3/16-12	1.11	28.30	1.19	30.10	100	105	110	136	142	149	1 to 1-1/2
	16	1 5/16-12	1.23	31.30	1.31	33.30	118	124	130	160	168	176	3/4 to 1
	20	1 5/8-12	1.54	39.20	1.63	41.30	168	176	185	228	239	251	3/4 to 1
	24	1 7/8-12	1.80	45.60	1.87	47.60	195	205	215	264	278	291	3/4 to 1
	32	2 1/2-12	2.42	61.50	2.50	63.50	265	278	292	359	377	395	3/4 to 1

Note: * ØA and ØB thread dimensions for reference only.
** Refer to *Section — FFWR and TFFT Methods, page 355* for FFWR procedure requirements.

37° Flare (JIC) Thread - Aluminum Brass



TYPE/FITTING IDENTIFICATION							Torque						Flats From Wrench Resistance (F.F. W.R)**
Material	Dash Size	Thread Size	ØA*		ØB*		[Ft-Lb]			[Nm]			
		(UNF)	(in)	(mm)	(in)	(mm)	Min	Nom	Max	Min	Nom	Max	
ALUMINUM/BRASS FITTINGS OR ALUMINUM/BRASS MATING COMPONENTS; UNLUBRICATED THREADS	2	5/16-24	0.28	7.00	0.31	7.75	4	4	5	5	6	7	–
	3	3/8-24	0.34	8.60	0.37	9.50	5	6	7	7	8	9	–
	4	7/16-20	0.39	10.00	0.44	11.10	8	9	9	11	12	13	1-1/2 to 1-3/4
	5	1/2-20	0.46	11.60	0.50	12.70	9	10	10	12	13	14	1 to 1-1/2
	6	9/16-18	0.51	13.00	0.56	14.30	14	15	16	19	20	21	1 to 1-1/2
	8	3/4-16	0.69	17.60	0.75	19.10	27	29	30	37	39	41	1-1/2 to 1-3/4
	10	7/8-14	0.81	20.50	0.87	22.20	39	41	43	53	56	58	1 to 1-1/2
	12	1 1/16-12	0.97	24.60	1.06	27.00	55	57	60	74	78	81	1 to 1-1/2
	14	1 3/16-12	1.11	28.30	1.19	30.10	65	68	72	88	93	97	1 to 1-1/2
	16	1 5/16-12	1.23	31.30	1.31	33.30	77	81	84	104	109	114	3/4 to 1
	20	1 5/8-12	1.54	39.20	1.63	41.30	109	115	120	148	155	163	3/4 to 1
	24	1 7/8-12	1.80	45.60	1.87	47.60	127	133	139	172	180	189	3/4 to 1
	32	2 1/2-12	2.42	61.50	2.50	63.50	172	181	189	234	245	257	3/4 to 1

Note: * ØA and ØB thread dimensions for reference only.
** Refer to ***Section — FFWR and TFFT Methods, page 355*** for FFWR procedure requirements.

11.1.11 Assembly Instructions for 45° SAE Flare Fittings

1. Inspect the flare for obvious visual squareness and concentricity issues with the tube OD. Ensure surface is smooth, free of rust, weld and brazing splatter, splits, dirt, foreign matter, or burrs. If necessary replace fitting or adapter.

NOTICE

DO NOT force a misaligned or short hose/tube into alignment. It puts undesirable strain onto the joint eventually leading to leakage.

2. Align tube to fitting.
3. Tighten fitting by hand until hand tight.

NOTICE

The torque method should NOT be used on lubricated or oily fittings. No lubrication or sealant is required. The lubrication would cause increased clamping force and cause fitting damage.

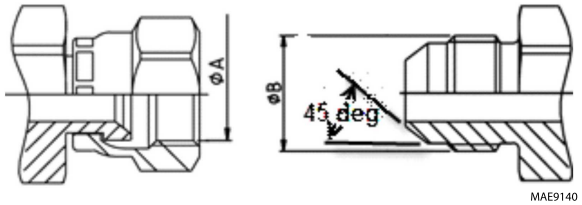
Torque fitting to value listed in below table while using the Double Wrench Method outlined in this section.

Note: Torque values provided in below table are segregated based on the material configuration of the connection.

‘Aluminum/brass fittings or aluminum/brass mating components’ indicate either the following material configurations:

1. Steel fittings with aluminum or brass mating components.
2. Aluminum or brass fittings with steel mating components.
3. Aluminum or brass fittings with aluminum or brass mating components.

45° Flare (SAE)



Steel

TYPE/FITTING IDENTIFICATION							TORQUE						Turns From Finger Tight (TFFT)**
Material	Dash Size	Thread Size	ØA*		ØB*		[Ft-Lb]			[Nm]			
		(UNF)	(in)	(mm)	(in)	(mm)	Min	Nom	Max	Min	Nom	Max	
STEEL FITTINGS WITH STEEL MATING COMPONENTS; UN-LUBRICATED THREADS	4	7/16-20	0.39	9.90	0.44	11.10	13	14	14	18	19	19	1/4 to 1/2
	6	5/8-18	0.56	14.30	0.63	15.90	22	23	24	30	31	33	1/4 to 1/2
	8	3/4-16	0.69	17.50	0.75	19.10	42	44	46	57	60	62	1/4 to 1/2
	10	7/8-14	0.81	20.60	0.87	22.20	60	63	66	81	85	89	1/4 to 1/2
	12	1 1/16-14	0.98	25.00	1.06	27.00	84	88	92	114	119	125	1/4 to 1/2

Note: * ØA and ØB thread dimensions for reference only

ALUMINUM BRASS

TYPE/FITTING IDENTIFICATION							TORQUE						Turns From Finger Tight (TFFT)**
Material	Dash Size	Thread Size	ØA*		ØB*		[Ft-Lb]			[Nm]			
		(UNF)	(in)	(mm)	(in)	(mm)	Min	Nom	Max	Min	Nom	Max	
ALUMINUM/ BRASS FITTINGS OR ALUMINUM/ BRASS MATING COMPONENTS; UN-LUBRICATED THREADS	4	7/16-20	0.39	9.90	0.44	11.10	8	9	9	11	12	12	1/4 to 1/2
	6	5/8-18	0.56	14.30	0.63	15.90	14	15	15	19	20	20	1/4 to 1/2
	8	3/4-16	0.69	17.50	0.75	19.10	27	29	30	37	39	41	1/4 to 1/2
	10	7/8-14	0.81	20.60	0.87	22.20	39	41	43	53	56	58	1/4 to 1/2
	12	1 1/16-14	0.98	25.00	1.06	27.00	55	58	61	75	79	83	1/4 to 1/2

Note: * ØA and ØB thread dimensions for reference only.

11.1.12 Assembly Instructions for O-Ring Face Seal (ORFS) Fittings

1. Ensure proper O-ring is installed. If O-ring is missing install per O-ring Installation (Replacement). Refer to *Section — O-ring Installation (Replacement), page 356* for procedure.
2. Ensure surface is smooth, free of rust, weld and brazing splatter, splits, dirt, foreign matter, or burrs. If necessary replace fitting or adapter.

NOTICE

Care to be taken when lubricating O-ring. Avoid adding oil to the threaded connection of the fitting. The lubrication would cause increased clamping force and cause fitting damage.

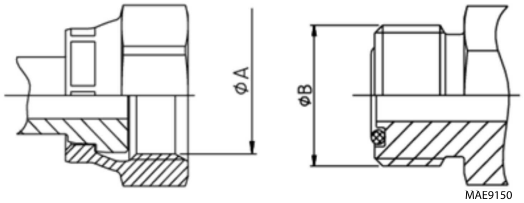
3. Pre-lubricate the O-ring with Hydraulic Oil.
4. Place the tube assembly against the fitting body so that the flat face comes in contact with the O-ring. Hand thread the nut onto the fitting body.
5. Torque nut to value listed in below mentioned table while using the Double Wrench Method. Refer to *Section — FFWR and TFFT Methods, page 355* for procedure if using the FFWR method.

Note: Torque values provided in below table are segregated based on the material configuration of the connection.

Aluminum/brass fittings or aluminum/brass mating components' indicate either the following material configurations:

a. Steel fittings with aluminum or brass mating components.
b. Aluminum or brass fittings with steel mating components.
c. Aluminum or brass fittings with aluminum or brass mating components.

O-ring Face Seal (ORFS)



TYPE/FITTING IDENTIFICATION							TORQUE							
Material	Dash Size	Thread Size	ØA*		ØB*		[Ft-Lb]			[Nm]			Tube Nuts	Swivel & Hose Ends
		(UNF)	(in)	(mm)	(in)	(mm)	Min	Nom	Max	Min	Nom	Max		
STEEL FITTINGS WITH STEEL MATING COMPONENTS; UN-LUBRICATED THREADS	4	9/16-18	0.51	13.00	0.56	14.20	18	19	20	25	26	27	1/4 to 1/2	1/2 to 3/4
	6	11/16-16	0.63	15.90	0.69	17.50	30	32	33	40	43	45	1/4 to 1/2	1/2 to 3/4
	8	13/16-16	0.75	19.10	0.81	20.60	40	42	44	55	57	60	1/4 to 1/2	1/2 to 3/4
	10	1-14	0.94	23.80	1.00	25.40	60	63	66	81	85	89	1/4 to 1/2	1/2 to 3/4
	12	1 3/16-12	1.11	28.20	1.19	30.10	85	90	94	115	122	127	1/4 to 1/2	1/2 to 3/4
	16	1 7/16-12	1.34	34.15	1.44	36.50	110	116	121	149	157	164	1/4 to 1/2	1/2 to 3/4
	20	1 11/16-12	1.59	40.50	1.69	42.90	150	158	165	203	214	224	1/4 to 1/2	1/2 to 3/4
	24	2-12	1.92	48.80	2.00	50.80	230	242	253	312	328	343	1/4 to 1/2	1/2 to 3/4
	32	2 1/2-12	2.43	61.67	2.50	63.50	375	394	413	508	534	560	1/4 to 1/2	1/2 to 3/4

Note: * ØA and ØB thread dimensions for reference only.

TYPE/FITTING IDENTIFICATION							TORQUE						FLATS FROM WRENCH RESISTANCE(F.F.W.R)**	
Material	Dash Size	Thread Size	ØA*		ØB*		[Ft-Lb]			[Nm]			Tube Nuts	Swivel & Hose Ends
		(UNF)	(in)	(mm)	(in)	(mm)	Min	Nom	Max	Min	Nom	Max		
ALUMINUM/ BRASS FITTINGS OR ALUMINUM/BRASS MATING COMPONENTS; UNLUBRICATED THREADS	4	9/16-18	0.51	13.00	0.56	14.20	12	13	13	16	18	18	1/4 to 1/2	1/2 to 3/4
	6	11/16-16	0.63	15.90	0.69	17.50	20	21	22	27	28	30	1/4 to 1/2	1/2 to 3/4
	8	13/16-16	0.75	19.10	0.81	20.60	26	28	29	35	38	39	1/4 to 1/2	1/2 to 3/4
	10	1-14	0.94	23.80	1.00	25.40	39	41	43	53	56	58	1/4 to 1/2	1/2 to 3/4
	12	1 3/16-12	1.11	28.20	1.19	30.10	55	58	61	75	79	83	1/4 to 1/2	1/2 to 3/4
	16	1 7/16-12	1.34	34.15	1.44	36.50	72	76	79	98	103	107	1/4 to 1/2	1/2 to 3/4
	20	1 11/16-12	1.59	40.50	1.69	42.90	98	103	108	133	140	146	1/4 to 1/2	1/2 to 3/4
	24	2-12	1.92	48.80	2.00	50.80	150	158	165	203	214	224	1/4 to 1/2	1/2 to 3/4
	32	2 1/2-12	2.43	61.67	2.50	63.50	244	257	269	331	348	365	1/4 to 1/2	1/2 to 3/4

Note: * ØA and ØB thread dimensions for reference only.

11.1.13 Assembly Instructions for DIN 24° Flare Bite Type Fittings (MBTL and MBTS)

NOTICE

A non-square tube end can cause improperly seated fittings and leakage.

6. Inspect the components to ensure free of contamination, external damage, rust, splits, dirt, foreign matter, or burrs. Ensure tube end is visibly square. If necessary replace fitting or tube.

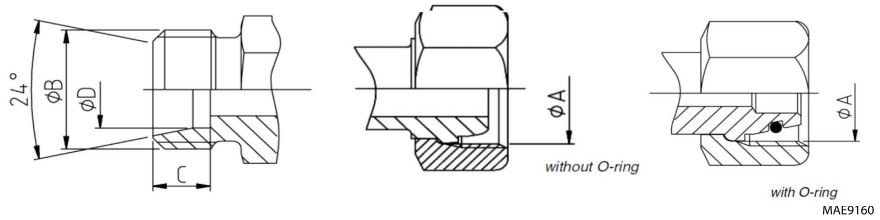
7. Lubricate thread and cone of fitting body or hardened pre-assembly tool, as well as the progressive ring and nut threads.

8. Slip nut and progressive ring over tube, assuring that they are in the proper orientation.

9. Push the tube end into the coupling body.

10. Slide collet into position and tighten until finger tight. Mark nut and tube in the finger-tight position. Tighten nut to the number of flats listed while using the Double Wrench Method. The tube must not turn with the nut.

DIN 24° CONE (MBTL and MBTS)



TYPE/FITTING IDENTIFICATION							DIN 24° CONE FLARELESS BITE FITTING (WITH OR WITHOUT O-RING)							
Material	Type	Tube O.D.	Thread M Size	ØA*	ØB*	C*	ØD*	Torque						Flats From Wrench Resistance (F.F. W.R)**
								[Ft-Lb]			[Nm]			
		(mm)	(Metric)	(mm)	(mm)	(mm)	(mm)	Min	Nom	Max	Min	Nom	Max	
STEEL FITTINGS WITH STEEL MATING COMPONENTS	DIN24° CONE FLARELESS BITE (MBTL) FITTING	6	M12 x 1.5	10.50	12.00	7.00	6.20	FFWR is the recommended method of fitting assembly. Torque values are application specific due to variability in the fitting supplier, coating, lubrication, and other physical characteristic of the connection. Consult Engineering on the generation of torque values for the particular application.						1.5 to 1.75
		8	M14 x 1.5	12.50	14.00	7.00	8.20							1.5 to 1.75
		10	M16 x 1.5	14.50	16.00	7.00	10.20							1.5 to 1.75
		12	M18 x 1.5	16.50	18.00	7.00	12.20							1.5 to 1.75
		15	M22 x 1.5	20.50	22.00	7.00	15.20							1.5 to 1.75
		18	M26 x 1.5	24.50	26.00	7.50	18.20							1.5 to 1.75
		22	M30 x 2	27.90	30.00	7.50	22.20							1.5 to 1.75
		28	M36 x 2	33.90	36.00	7.50	28.20							1.5 to 1.75
		35	M45 x 2	42.90	45.00	10.50	35.30							1.5 to 1.75
		42	M52 x 2	49.90	52.00	11.00	42.30							1.5 to 1.75

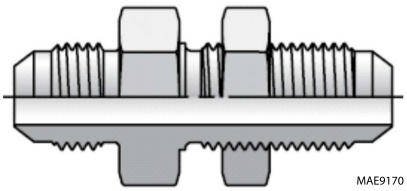
TYPE/FITTING IDENTIFICATION							DIN 24° CONE FLARELESS BITE FITTING (WITH OR WITHOUT O-RING)							
Material	Type	Tube O.D.	Thread M Size	ØA*	ØB*	C*	ØD*	Torque						Flats From Wrench Resistance (F.F. W.R)**
								[Ft-Lb]			[Nm]			
		(mm)	(Metric)	(mm)	(mm)	(mm)	(mm)	Min	Nom	Max	Min	Nom	Max	
STEEL FITTINGS WITH STEEL MATING COMPONENTS	DIN24° CONE FLARELESS BITE (MBTS) FITTING	6	M14 x 1.5	12.50	14.00	7.00	6.20	FFWR is the recommended method of fitting assembly. Torque values are application specific due to variability in the fitting supplier, coating, lubrication, and other physical characteristics of the connection. Consult Engineering on the generation of torque values for the particular application.						1.5 to 1.75
		8	M16 x 1.5	14.50	16.00	7.00	8.20							1.5 to 1.75
		10	M18 x 1.5	16.50	18.00	7.50	10.20							1.5 to 1.75
		12	M20 x 1.5	18.50	20.00	7.50	12.20							1.5 to 1.75
		14	M22 x 1.5	20.50	22.00	8.00	14.20							1.5 to 1.75
		16	M24 x 1.5	22.50	24.00	8.50	16.20							1.5 to 1.75
		20	M30 x 2	27.90	30.00	10.50	20.20							1.5 to 1.75
		25	M36 x 2	33.90	36.00	12.00	25.20							1.5 to 1.75
		30	M42 x 2	39.90	42.00	13.50	30.20							1.5 to 1.75
		38	M52 x 2	49.90	52.00	16.00	38.30							1.5 to 1.75

Note: * ØA, ØB, C, & ØD thread dimensions for reference only.
** Refer to *Section — FFWR and TFFT Methods, page 355* for FFWR procedure requirements.

11.1.14 Assembly Instructions for Bulkhead (BH) Fittings

1. Ensure threads and surface are free of rust, weld and brazing splatter, splits, burrs or other foreign material. If necessary replace fitting or adapter.
2. Remove the locknut from the bulkhead assembly.
3. Insert the bulkhead side of the fitting into the panel or bulkhead bracket opening.
4. Hand thread the locknut onto the bulkhead end of the fitting body.
5. Torque nut onto fitting while using the Double Wrench Method.

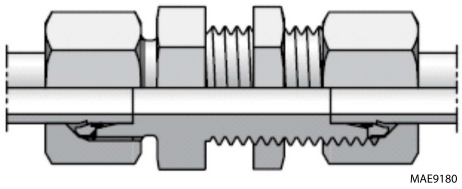
Bulkhead Fittings (BH) - INCH



TYPE/FITTING IDENTIFICATION				FASTENING JAM NUT FOR BULKHEAD CONNECTORS					
Material	Type	Dash Size	Thread Size	Torque					
				[Ft-Lb]			[Nm]		
			(UNF)	Min	Nom	Max	Min	Nom	Max
STEEL FITTINGS	O-RING FACE SEAL (ORFS) BULKHEAD FITTING	4	9/16-18	15	16	17	20	22	23
		6	11/16-16	25	27	28	34	37	38
		8	13/16-16	55	58	61	75	79	83
		10	1-14	85	90	94	115	122	127
		12	1 3/16-12	135	142	149	183	193	202
		14	1 5/16-12	170	179	187	230	243	254
		16	1 7/16-12	200	210	220	271	285	298
		20	1 11/16-12	245	258	270	332	350	366
		24	2-12	270	284	297	366	385	403

TYPE/FITTING IDENTIFICATION				FASTENING JAM NUT FOR BULKHEAD CONNECTORS					
Material	Type	Dash Size	Thread Size	Torque					
				[Ft-Lb]			[Nm]		
			(UNF)	Min	Nom	Max	Min	Nom	Max
STEEL FITTINGS	37° FLARE (JIC) BULKHEAD FITTING	3	3/8-24	8	9	9	11	12	12
		4	7/16-20	13	14	14	18	19	19
		5	1/2-20	20	21	22	27	28	30
		6	9/16-18	25	27	28	34	37	38
		8	3/4-16	50	53	55	68	72	75
		10	7/8-14	85	90	94	115	122	127
		12	1 1/16-12	135	142	149	183	193	202
		14	1 3/16-12	170	179	187	230	243	254
		16	1 5/16-12	200	210	220	271	285	298
		20	1 5/8-12	245	258	270	332	350	366
		24	1 7/8-12	270	284	297	366	385	403
		32	2 1/2-12	310	326	341	420	442	462

Bulkhead Fittings (BH) - METRIC



TYPE/FITTING IDENTIFICATION				FASTENING JAM NUT FOR BULKHEAD CONNECTORS					
Material	Type	Connecting Tube O.D.	Thread M Size	Torque					
				[Ft-Lb]			[Nm]		
		(mm)	(metric)	Min	Nom	Max	Min	Nom	Max
STEEL FITTINGS	DIN 24° CONE FLARELESS BITE (MBTL) BULKHEAD FITTING	6	M12 x 1.5	14	15	16	19	20	22
		8	M14 x 1.5	17	18	19	23	24	26
		10	M16 x 1.5	22	23	24	30	31	33
		12	M18 x 1.5	35	37	39	47	50	53
		15	M22 x 1.5	44	47	50	60	64	68
		18	M26 x 1.5	70	75	80	95	102	108
		22	M30 x 2	115	120	125	156	163	169
		28	M36 x 2	150	157	164	203	213	222
		35	M45 x 2	155	162	169	210	220	229
		42	M52 x 2	220	230	240	298	312	325

TYPE/FITTING IDENTIFICATION				FASTENING JAM NUT FOR BULKHEAD CONNECTORS					
Material	Type	Connecting Tube O.D.	Thread M Size	Torque					
				[Ft-Lb]			[Nm]		
		(mm)	(metric)	Min	Nom	Max	Min	Nom	Max
STEEL FITTINGS	DIN 24° CONE FLARELESS BITE (MBTS) BULKHEAD FITTING	6	M14 x 1.5	17	15	16	23	20	22
		8	M16 x 1.5	22	18	19	30	24	26
		10	M18 x 1.5	35	23	24	47	31	33
		12	M20 x 1.5	40	35	37	54	47	50
		14	M22 x 1.5	44	47	50	60	64	68
		16	M24 x 1.5	70	75	80	95	102	108
		20	M30 x 2	115	120	125	156	163	169
		25	M36 x 2	150	157	164	203	213	222
		30	M42 x 2	155	162	169	210	220	229
		38	M52 x 2	220	230	240	298	312	325

11.1.15 Assembly Instructions for O-Ring Boss (ORB) Fittings

1. Inspect components to ensure that male and female port threads are free of rust, splits, dirt, foreign matter, or burrs.
2. Ensure proper O-ring is installed. If O-ring is missing install per O-ring Installation (Replacement). Refer to *Section — O-ring Installation (Replacement), page 356* for procedure.

NOTICE

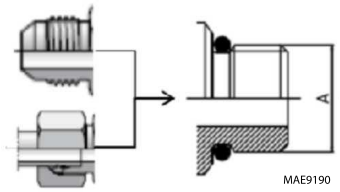
Care to be taken when lubricating O-ring. Avoid adding oil to the threaded connection of the fitting. The lubrication would cause increased clamping force and cause fitting damage.

3. Pre-lubricate the O-ring with Hydraulic Oil.
4. For Non-Adjustable and Plugs, thread the fitting by hand until contact.
5. For Adjustable fittings, refer to *Section — Adjustable Stud End Assembly, page 356* for proper assembly.
6. Torque the fitting or nut to value while using the Double Wrench Method
   a. The table headings identify the straight thread o-ring port and the type on the other side of the fitting. The torque will be applied to the straight thread o-ring port.
   b. Torque values are segregated based on the material configuration of the connection. ‘Aluminum/brass fittings or aluminum/brass mating components’ indicate either the following material configurations:

   - Steel fittings with aluminum or brass mating components.
   - Aluminum or brass fittings with steel mating components.
   - Aluminum or brass fittings with aluminum or brass mating components.

7. Inspect to ensure the O-ring is not pinched and the washer is seated flat on the counterbore of the port.

O-ring Boss (ORB) - Table 1 of 6

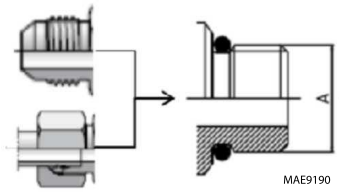


TYPE/FITTING IDENTIFICATION					HEX TYPE PLUGS & STUD ENDS WITH 37° (JIC) OR L SERIES DIN (MBTL) OPPOSITE END					
Material	Dash Size	Thread Size	ØA*		Torque					
					[Ft-Lb]			[Nm]		
		(UNF)	(in)	(mm)	Min	Nom	Max	Min	Nom	Max
STEEL FITTINGS WITH STEEL MATING COMPONENTS; UN-LUBRICATED THREADS	2	5/16-24	0.31	7.93	(85)	(90)	(94)	10	10	11
	3	3/8-24	0.37	9.52	(155)	(163)	(171)	18	18	19
	4	7/16-20	0.44	11.11	22	23	24	29	31	33
	5	1/2-20	0.50	12.70	23	25	26	32	34	35
	6	9/16-18	0.56	14.28	29	31	32	40	42	43
	8	3/4-16	0.75	19.10	52	55	57	70	75	77
	10	7/8-14	0.87	22.22	85	90	94	115	122	127
	12	11/16-12	1.06	27.00	135	142	149	185	193	202
	14	13/16-12	1.19	30.10	175	184	193	235	249	262
	16	15/16-12	1.31	33.30	200	210	220	270	285	298
	20	15/8-12	1.63	41.30	250	263	275	340	357	373
	24	17/8-12	1.87	47.60	305	321	336	415	435	456
	32	21/2-12	2.50	63.50	375	394	413	510	534	560

TYPE/FITTING IDENTIFICATION					HEX TYPE PLUGS & STUD ENDS WITH 37° (JIC) OR L SERIES DIN (MBTL) OPPOSITE END					
Material	Dash Size	Thread Size	ØA*		Torque					
					[Ft-Lb]			[Nm]		
		(UNF)	(in)	(mm)	Min	Nom	Max	Min	Nom	Max
ALUMINUM/BRASS FITTINGS OR ALUMINUM/BRASS MATING COMPONENTS; UN-LUBRICATED THREADS	2	5/16-24	0.31	7.93	(55)	(58)	(61)	6	7	7
	3	3/8-24	0.37	9.52	(101)	(106)	(111)	11	12	13
	4	7/16-20	0.44	11.11	14	15	16	19	20	22
	5	1/2-20	0.50	12.70	15	16	17	20	22	23
	6	9/16-18	0.56	14.28	19	20	21	26	27	28
	8	3/4-16	0.75	19.10	34	36	37	46	49	50
	10	7/8-14	0.87	22.22	55	58	61	75	79	83
	12	11/16-12	1.06	27.00	88	93	97	119	126	132
	14	13/16-12	1.19	30.10	114	120	126	155	163	171
	16	15/16-12	1.31	33.30	130	137	143	176	186	194
	20	15/8-12	1.63	41.30	163	171	179	221	232	243
	24	17/8-12	1.87	47.60	198	208	218	268	282	296
	32	21/2-12	2.50	63.50	244	256	268	331	347	363

Note: * ØA Thread OD dimension for reference only.
**Removal Torque for Zero Leak Gold® Hollow Hex Plugs is significantly higher than install torque, typically 1.5-3.5X install torque.

O-ring Boss (ORB) - Table 2 of 6

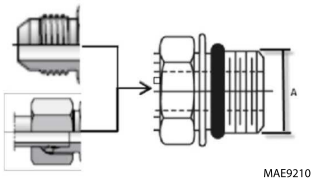


TYPE/FITTING IDENTIFICATION					STUD ENDS WITH (ORFS) OR S ERIES DIN (MBTS) OPPOSITE END					
Material	Dash Size	Thread Size	0A*		Torque					
					[Ft-Lb]			[Nm]		
		(UNF)	(in)	(mm)	Min	Nom	Max	Min	Nom	Max
STEEL FITTINGS WITH STEEL MATING COMPONENTS; UN-LUBRICATED THREADS	2	5/16-24	0.31	7.93	–	–	–	–	–	–
	3	3/8-24	0.37	9.52	–	–	–	–	–	–
	4	7/16-20	0.44	11.11	26	27	28	35	37	38
	5	1/2-20	0.50	12.70	30	32	33	40	43	45
	6	9/16-18	0.56	14.28	35	37	39	46	50	53
	8	3/4-16	0.75	19.10	60	63	66	80	85	89
	10	7/8-14	0.87	22.22	100	105	110	135	142	149
	12	1 1/16-12	1.06	27.00	135	142	149	185	193	202
	14	1 3/16-12	1.19	30.10	175	184	193	235	249	262
	16	1 5/16-12	1.31	33.30	200	210	220	270	285	298
	20	1 5/8-12	1.63	41.30	250	263	275	340	357	373
	24	1 7/8-12	1.87	47.60	305	321	336	415	435	456
	32	2 1/2-12	2.50	63.50	375	394	413	510	534	560

TYPE/FITTING IDENTIFICATION					STUD ENDS WITH (ORFS) OR S ERIES DIN (MBTS) OPPOSITE END					
Material	Dash Size	Thread Size	0A*		Torque					
					[Ft-Lb]			[Nm]		
		(UNF)	(in)	(mm)	Min	Nom	Max	Min	Nom	Max
ALUMINUM/BRASS FITTINGS OR ALUMINUM/BRASS MATING COMPONENTS; UN-LUBRICATED THREADS	2	5/16-24	0.31	7.93	–	–	–	–	–	–
	3	3/8-24	0.37	9.52	–	–	–	–	–	–
	4	7/16-20	0.44	11.11	17	18	18	23	24	24
	5	1/2-20	0.50	12.70	20	21	21	27	28	28
	6	9/16-18	0.56	14.28	23	24	24	31	33	33
	8	3/4-16	0.75	19.10	39	41	43	53	56	58
	10	7/8-14	0.87	22.22	65	69	72	88	94	98
	12	1 1/16-12	1.06	27.00	88	93	97	119	126	132
	14	1 3/16-12	1.19	30.10	114	120	126	155	163	171
	16	1 5/16-12	1.31	33.30	130	137	143	176	186	194
	20	1 5/8-12	1.63	41.30	163	171	179	221	232	243
	24	1 7/8-12	1.87	47.60	198	208	218	268	282	296
	32	2 1/2-12	2.50	63.50	244	256	268	331	347	363

Note: * ØA Thread OD dimension for reference only.
**Removal Torque for Zero Leak Gold® Hollow Hex Plugs is significantly higher than install torque, typically 1.5-3.5X install torque.

O-ring Boss (ORB) - Table 3 of 6

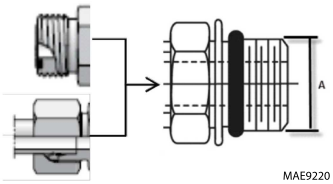


TYPE/FITTING IDENTIFICATION					ADJUSTABLE STUD END WITH 37° (JIC) OR L SERIES DIN (MBTL) OPPOSITE END					
Material	Dash Size	Thread Size	ØA*		Torque					
					[Ft-Lb]			[Nm]		
		(UNF)	(in)	(mm)	Min	Nom	Max	Min	Nom	Max
STEEL FITTINGS WITH STEEL MATING COMPONENTS; UN-LUBRICATED THREADS	2	5/16-24	0.31	7.93	(85)	(90)	(94)	10	10	11
	3	3/8-24	0.37	9.52	(155)	(163)	(171)	18	18	19
	4	7/16-20	0.44	11.11	22	23	24	29	31	33
	5	1/2-20	0.50	12.70	23	25	26	32	34	35
	6	9/16-18	0.56	14.28	29	31	32	40	42	43
	8	3/4-16	0.75	19.10	52	55	57	70	75	77
	10	7/8-14	0.87	22.22	85	90	94	115	122	127
	12	1 1/16-12	1.06	27.00	135	142	149	185	193	202
	14	1 3/16-12	1.19	30.10	175	184	193	235	249	262
	16	1 5/16-12	1.31	33.30	200	210	220	270	285	298
	20	1 5/8-12	1.63	41.30	250	263	275	340	357	373
	24	1 7/8-12	1.87	47.60	305	321	336	415	435	456
	32	2 1/2-12	2.50	63.50	375	394	413	510	534	560

TYPE/FITTING IDENTIFICATION					ADJUSTABLE STUD END WITH 37° (JIC) OR L SERIES DIN (MBTL) OPPOSITE END					
Material	Dash Size	Thread Size	ØA*		Torque					
					[Ft-Lb]			[Nm]		
		(UNF)	(in)	(mm)	Min	Nom	Max	Min	Nom	Max
ALUMINUM/BRASS FITTINGS OR ALUMINUM/BRASS MATING COMPONENTS; UN-LUBRICATED THREADS	2	5/16-24	0.31	7.93	(55)	(58)	(61)	6	7	7
	3	3/8-24	0.37	9.52	(101)	(106)	(111)	11	12	13
	4	7/16-20	0.44	11.11	14	15	16	19	20	22
	5	1/2-20	0.50	12.70	15	16	17	20	22	23
	6	9/16-18	0.56	14.28	19	20	21	26	27	28
	8	3/4-16	0.75	19.10	34	36	37	46	49	50
	10	7/8-14	0.87	22.22	55	58	61	75	79	83
	12	1 1/16-12	1.06	27.00	88	93	97	119	126	132
	14	1 3/16-12	1.19	30.10	114	120	126	155	163	171
	16	1 5/16-12	1.31	33.30	130	137	143	176	186	194
	20	1 5/8-12	1.63	41.30	163	171	179	221	232	243
	24	1 7/8-12	1.87	47.60	198	208	218	268	282	296
	32	2 1/2-12	2.50	63.50	244	256	268	331	347	363

Note: * ØA Thread OD dimension for reference only.
**Removal Torque for Zero Leak Gold® Hollow Hex Plugs is significantly higher than install torque, typically 1.5-3.5X install torque.

O-ring Boss (ORB) - Table 4 of 6



TYPE/FITTING IDENTIFICATION					ADJUSTABLE STUD END WITH (ORFS) OR S SERIES DIN (MBTS) OPPOSITE END					
Material	Dash Size	Thread Size	ØA*		Torque					
					[Ft-Lb]			[Nm]		
		(UNF)	(in)	(mm)	Min	Nom	Max	Min	Nom	Max
STEEL FITTINGS WITH STEEL MATING COMPONENTS; UN-LUBRICATED THREADS	2	5/16-24	0.31	7.93	–	–	-	–	–	–
	3	3/8-24	0.37	9.52	–	–	-	–	–	–
	4	7/16-20	0.44	11.11	15	16	17	20	22	23
	5	1/2-20	0.50	12.70	30	32	33	40	43	45
	6	9/16-18	0.56	14.28	35	37	39	46	50	53
	8	3/4-16	0.75	19.10	60	63	66	80	85	89
	10	7/8-14	0.87	22.22	100	105	110	135	142	149
	12	11/16-12	1.06	27.00	135	142	149	185	193	202
	14	13/16-12	1.19	30.10	175	184	193	235	249	262
	16	15/16-12	1.31	33.30	200	210	220	270	285	298
	20	15/8-12	1.63	41.30	250	263	275	340	357	373
	24	17/8-12	1.87	47.60	305	321	336	415	435	456
	32	21/2-12	2.50	63.50	375	394	413	510	534	560

TYPE/FITTING IDENTIFICATION					ADJUSTABLE STUD END WITH (ORFS) OR S SERIES DIN (MBTS) OPPOSITE END					
Material	Dash Size	Thread Size	ØA*		Torque					
					[Ft-Lb]			[Nm]		
		(UNF)	(in)	(mm)	Min	Nom	Max	Min	Nom	Max
ALUMINUM/BRASS FITTINGS OR ALUMINUM/BRASS MATING COMPONENTS; UN-LUBRICATED THREADS	2	5/16-24	0.31	7.93	–	–	–	–	–	–
	3	3/8-24	0.37	9.52	–	–	-	–	–	–
	4	7/16-20	0.44	11.11	10	11	11	14	15	15
	5	1/2-20	0.50	12.70	20	21	21	27	28	28
	6	9/16-18	0.56	14.28	23	24	24	31	33	33
	8	3/4-16	0.75	19.10	39	41	43	53	56	58
	10	7/8-14	0.87	22.22	65	69	72	88	94	98
	12	11/16-12	1.06	27.00	88	93	97	119	126	132
	14	13/16-12	1.19	30.10	114	120	126	155	163	171
	16	15/16-12	1.31	33.30	130	137	143	176	186	194
	20	15/8-12	1.63	41.30	163	171	179	221	232	243
	24	17/8-12	1.87	47.60	198	208	218	268	282	296
	32	21/2-12	2.50	63.50	244	256	268	331	347	363

Note: * ØA Thread OD dimension for reference only.
**Removal Torque for Zero Leak Gold® Hollow Hex Plugs is significantly higher than install torque, typically 1.5-3.5X install torque.

O-ring Boss (ORB) - Table 5 of 6

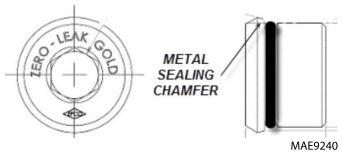
MAE9230

TYPE/FITTING IDENTIFICATION					HOLLOW HEX PLUGS					
Material	Dash Size	Thread Size	ØA*		Torque					
					[Ft-Lb]			[Nm]		
		(UNF)	(in)	(mm)	Min	Nom	Max	Min	Nom	Max
STEEL FITTINGS WITH STEEL MATING COMPONENTS; UN-LUBRICATED THREADS	2	5/16-24	0.31	7.93	(30)	(32)	(33)	3	4	4
	3	3/8-24	0.37	9.52	(55)	(58)	(61)	6	7	7
	4	7/16-20	0.44	11.11	10	11	11	14	15	15
	5	1/2-20	0.50	12.70	14	15	16	19	20	22
	6	9/16-18	0.56	14.28	34	36	38	46	49	52
	8	3/4-16	0.75	19.10	60	63	66	80	85	89
	10	7/8-14	0.87	22.22	100	105	110	135	142	149
	12	11/16-12	1.06	27.00	135	142	149	185	193	202
	14	13/16-12	1.19	30.10	175	184	193	235	249	262
	16	15/16-12	1.31	33.30	200	210	220	270	285	298
	20	15/8-12	1.63	41.30	250	263	275	340	357	373
	24	17/8-12	1.87	47.60	305	321	336	415	435	456
	32	21/2-12	2.50	63.50	375	394	413	510	534	560

TYPE/FITTING IDENTIFICATION					HOLLOW HEX PLUGS					
Material	Dash Size	Thread Size	ØA*		Torque					
					[Ft-Lb]			[Nm]		
		(UNF)	(in)	(mm)	Min	Nom	Max	Min	Nom	Max
ALUMINUM/BRASS FITTINGS OR ALUMINUM/BRASS MATING COMPONENTS; UN-LUBRICATED THREADS	2	5/16-24	0.31	7.93	(20)	(21)	(21)	2	2	2
	3	3/8-24	0.37	9.52	(36)	(38)	(40)	4	4	5
	4	7/16-20	0.44	11.11	6	7	7	8	9	9
	5	1/2-20	0.50	12.70	9	10	10	12	14	14
	6	9/16-18	0.56	14.28	22	24	25	30	33	34
	8	3/4-16	0.75	19.10	39	41	43	53	56	58
	10	7/8-14	0.87	22.22	65	69	72	88	94	98
	12	11/16-12	1.06	27.00	88	93	97	119	126	132
	14	13/16-12	1.19	30.10	114	120	126	155	163	171
	16	15/16-12	1.31	33.30	130	137	143	176	186	194
	20	15/8-12	1.63	41.30	163	171	179	221	232	243
	24	17/8-12	1.87	47.60	198	208	218	268	282	296
	32	21/2-12	2.50	63.50	244	256	268	331	347	363

Note: * ØA Thread OD dimension for reference only.
**Removal Torque for Zero Leak Gold® Hollow Hex Plugs is significantly higher than install torque, typically 1.5-3.5X install torque.

O-ring Boss (ORB) - Table 6 of 6



TYPE/FITTING IDENTIFICATION					ZERO LEAK GOLD® HOLLOW HEX PLUGS					
Material	Dash Size	Thread Size	ØA*		Torque					
					[Ft-Lb]			[Nm]		
		(UNF)	(in)	(mm)	Min	Nom	Max	Min	Nom	Max
STEEL FITTINGS WITH STEEL MATING COMPONENTS; UN-LUBRICATED THREADS	2	5/16-24	0.31	7.93	2	3	4	3	4	5
	3	3/8-24	0.37	9.52	3	4	5	4	5	7
	4	7/16-20	0.44	11.11	7	8	9	9	11	12
	5	1/2-20	0.50	12.70	9	10	11	12	14	15
	6	9/16-18	0.56	14.28	11	12	13	15	16	18
	8	3/4-16	0.75	19.10	28	30	32	38	41	43
	10	7/8-14	0.87	22.22	46	48	so	62	65	68
	12	11/16-12	1.06	27.00	51	54	57	69	73	77
	14	13/16-12	1.19	30.10	Fitting size greater than -12 not typically specified on Caterpillar applications. Consult specific service procedure if encountered.					
	16	15/16-12	1.31	33.30						
	20	15/8-12	1.63	41.30						
	24	17/8-12	1.87	47.60						
	32	21/2-12	2.50	63.50						

TYPE/FITTING IDENTIFICATION					ZERO LEAK GOLD 8 HOLLOW HEX PLUGS					
Material	Dash Size	Thread Size	ØA*		Torque					
					[Ft-Lb]			[Nm]		
		(UNF)	(in)	(mm)	Min	Nom	Max	Min	Nom	Max
ALUMINUM/BRASS FITTINGS OR ALUMINUM/BRASS MATING COMPONENTS; UN-LUBRICATED THREADS	2	5/16-24	0.31	7.93	2	3	4	3	4	5
	3	3/8-24	0.37	9.52	3	4	5	4	5	7
	4	7/16-20	0.44	11.11	7	8	9	9	11	12
	5	1/2-20	0.50	12.70	9	10	11	12	14	15
	6	9/16-18	0.56	14.28	11	12	13	15	16	18
	8	3/4-16	0.75	19.10	28	30	32	38	41	43
	10	7/8-14	0.87	22.22	46	48	so	62	65	68
	12	11/16-12	1.06	27.00	51	54	57	69	73	77
	14	13/16-12	1.19	30.10	Fitting size greater than -12 not typically specified on Caterpillar applications. Consult specific service procedure if encountered.					
	16	15/16-12	1.31	33.30						
	20	15/8-12	1.63	41.30						
	24	17/8-12	1.87	47.60						
	32	21/2-12	2.50	63.50						

Note: * ØA Thread OD dimension for reference only.
**Removal Torque for Zero Leak Gold® Hollow Hex Plugs is significantly higher than install torque, typically 1.5-3.5X install torque.

11.1.16 Assembly Instructions for Adjustable Port End Metric Fittings

1. Inspect components to ensure that male and female threads and surfaces are free of rust, splits, dirt, foreign matter, or burrs.
2. If O-ring is not pre-installed, install proper size, taking care not to damage it. Refer to *Section — O-ring Installation (Replacement), page 356* for instructions.

⚠ CAUTION

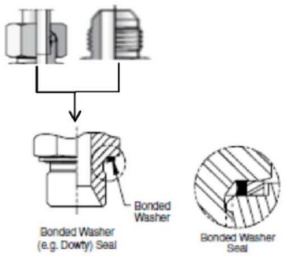
Care to be taken when lubricating O-ring. Avoid adding oil to the threaded connection of the fitting. The lubrication would cause increased clamping force and cause fitting damage.

3. Pre-lubricate the O-ring with Hydraulic Oil.
4. For Non-Adjustable Fittings and Plugs, thread the fitting by hand until contact.
5. For Adjustable fittings, refer to *Section — Adjustable Stud End Assembly, page 356* for proper assembly.
6. Torque the fitting or nut to value while using the Double Wrench Method.
   a. The table headings identify the Metric port and the type on the other side of the fitting. The torque will be applied to the Metric port.
   b. Torque values are segregated based on the material configuration of the connection. ‘Aluminum/brass fittings or aluminum/brass mating components’ indicate either the following material configurations:

   - Steel fittings with aluminum or brass mating components.
   - Aluminum or brass fittings with steel mating components.
   - Aluminum or brass fittings with aluminum or brass mating components.

7. Inspect to ensure the O-ring is not pinched and the washer is seated flat on the counterbore of the port.

Metric Flat Face Port (MFF) L Series - Table 1 of 3



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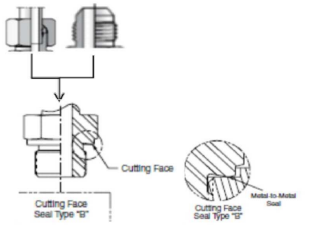
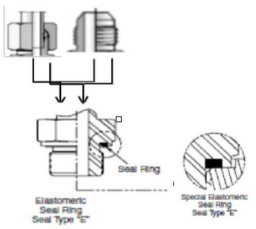


MAE9260

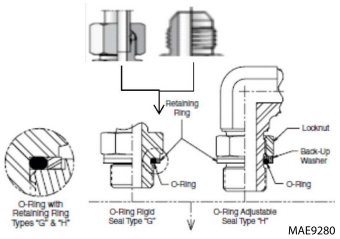
TYPE/FITTING IDENTIFICATION			FORM A (SEALING WASHER) STUD ENDS WITH 37° (JIC) or L SERIES DIN (MBTL) OPPOSITE END						FORM B (CUTTING FACE) STUD ENDS WITH 37° (JIC) OR L SERIES DIN (MBTL) OPPOSITE END					
Material	Thread M Size	Connecting Tube O.D	Torque						Torque					
			[Ft-Lb]			[Nm]			[Ft-Lb]			[Nm]		
	(metric)	(mm)	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max
ALUMINUM/ BRASS FITTINGS OR ALUMINUM/ BRASS MATING COMPONENTS; UN-LUBRICATED THREADS	M10x1	6	7	8	8	9	11	11	13	14	14	18	19	19
	M12x1.5	8	15	16	17	20	22	23	22	23	24	30	31	33
	M14x1.5	10	26	28	29	35	38	39	33	35	36	45	47	49
	M16x1.5	12	33	35	36	45	47	49	48	51	53	65	69	72
	M18x1.5	15	41	43	45	55	58	61	59	62	65	80	84	88
	M22x1.5	18	48	51	53	65	69	72	103	108	113	140	146	153
	M27x2	22	66	70	73	90	95	99	140	147	154	190	199	209
	M33x2	28	111	117	122	150	159	165	251	264	276	340	358	374
	M42x2	35	177	186	195	240	252	264	369	388	406	500	526	550
	M48x2	42	214	225	235	290	305	319	465	489	512	630	663	694

TYPE/FITTING IDENTIFICATION			FORM A (SEALING WASHER) STUD ENDS WITH 37° (JIC) or L SERIES DIN (MBTL) OPPOSITE END						FORM B (CUTTING FACE) STUD ENDS WITH 37° (JIC) OR L SERIES DIN (MBTL) OPPOSITE END					
Material	Thread M Size	Connecting Tube O.D	Torque						Torque					
			[Ft-Lb]			[Nm]			[Ft-Lb]			[Nm]		
	(metric)	(mm)	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max
ALUMINUM/ BRASS FITTINGS OR ALUMINUM/ BRASS MATING COMPONENTS; UN-LUBRICATED THREADS	M10x1	6	4	5	5	5	7	7	8	9	9	11	12	12
	M12x1.5	8	10	11	11	14	15	15	14	15	16	19	20	22
	M14x1.5	10	17	18	19	23	24	26	21	22	23	28	30	31
	M16x1.5	12	21	22	23	28	30	31	31	33	34	42	45	46
	M18x1.5	15	27	28	29	37	38	39	38	40	42	52	54	57
	M22x1.5	18	31	33	34	42	45	46	67	70	73	91	95	99
	M27x2	22	43	45	47	58	61	64	91	96	100	123	130	136
	M33x2	28	72	76	79	98	103	107	163	171	179	221	232	243
	M42x2	35	115	121	127	156	164	172	240	252	264	325	342	358
	M48x2	42	139	146	153	188	198	207	302	318	332	409	431	450

Metric Flat Face Port (MFF) L Series - Table 2 of 3



MAE9270

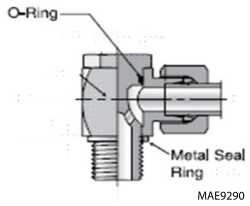


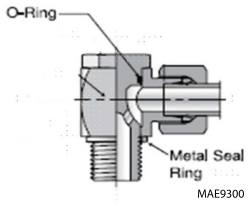
MAE9280

TYPE/FITTING IDENTIFICATION			FORM E (EOLASTIC SEALING RING) STUD ENDS WITH 37° (JIC) OR L SERIES DIN (MBTL) OPPOSITE END						FORM G/H (O-RING W/ RETAINING RING)STUD ENDS & ADJUSTABLE STUD ENDS WITH 37° (JIC) OR L SERIES DIN (MBTL)OPPOSITE END					
Material	Thread M Size	Connecting Tube O.D	Torque						Torque					
			[Ft-Lb]			[Nm]			[Ft-Lb]			[Nm]		
	(metric)	(mm)	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max
STEEL FITTINGS WITH STEEL MATING COMPONENTS; UN-LUBRICATED THREADS	M10x1	6	13	14	14	18	19	19	13	14	15	18	19	20
	M12x1.5	8	18	19	20	25	26	27	18	19	20	25	26	28
	M14x1.5	10	33	35	36	45	47	49	30	31	32	40	42	44
	M16x1.5	12	41	43	45	55	58	61	41	43	45	55	58	61
	M18x1.5	15	52	55	57	70	75	77	52	54	57	70	74	77
	M22x1.5	18	92	97	101	125	132	137	66	70	73	90	95	99
	M27x2	22	133	140	146	180	190	198	133	139	146	180	189	198
	M33x2	28	229	241	252	310	327	342	229	240	252	310	326	341
	M42x2	35	332	349	365	450	473	495	332	348	365	450	473	495
	M48x2	42	398	418	438	540	567	594	398	418	438	540	567	594

TYPE/FITTING IDENTIFICATION			FORM E (EOLASTIC SEALING RING) STUD ENDS WITH 37° (JIC) OR L SERIES DIN (MBTL) OPPOSITE END						FORM G/H (O-RING W/ RETAINING RING) STUD ENDS & ADJUSTABLE STUD ENDS WITH 37° (JIC) OR L SERIES DIN (MBTL)OPPOSITE END					
Material	Thread M Size	Connecting Tube O.D	Torque						Torque					
			[Ft-Lb]			[Nm]			[Ft-Lb]			[Nm]		
	(metric)	(mm)	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max
ALUMINUM/ BRASS FITTINGS OR ALUMINUM/ BRASS MATING COMPONENTS; UNLUBRICATED THREADS	M10x1	6	8	9	9	11	12	12	8	9	9	11	12	12
	M12x1.5	8	12	13	13	16	18	18	12	13	13	16	18	18
	M14x1.5	10	21	22	23	28	30	31	19	20	21	26	27	29
	M16x1.5	12	27	28	29	37	38	39	26	28	29	36	38	39
	M18x1.5	15	34	36	37	46	49	50	34	35	37	46	48	50
	M22x1.5	18	60	63	66	81	85	89	43	45	47	59	61	64
	M27x2	22	86	91	95	117	123	129	86	91	95	117	123	129
	M33x2	28	149	157	164	202	213	222	149	157	164	202	213	222
	M42x2	35	216	227	237	293	308	321	216	227	237	293	308	321
	M48x2	42	259	272	285	351	369	386	259	272	285	351	369	386

Metric Flat Face Port (MFF) L Series - Table 3 of 3

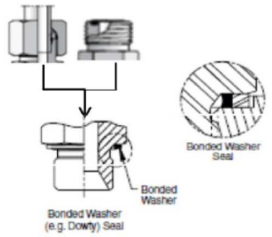




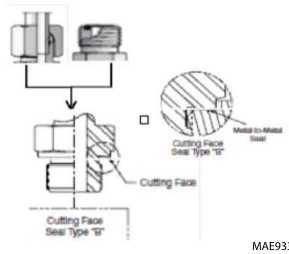
TYPE/FITTING IDENTIFICATION			BANJO FITTINGS WITH L SERIES DIN (MBTL) OPPOSITE END						HIGH PRESSURE BANJO FITTINGS WITH L SERIES DIN (MBTL) OPPOSITE END						FORM E (EOLASTIC SEALING RING) HOLLOW HEX PLUGS					
Material	Thread M Size	Connecting Tube O.D	Torque						Torque						Torque					
			[Ft-Lb]			[Nm]			[Ft-Lb]			[Nm]			[Ft-Lb]			[Nm]		
	(metric)	(mm)	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max
STEEL FITTINGS WITH STEEL MATING COMPONENTS; UNLUBRICATED THREADS	M10x1	6	13	14	14	18	19	19	13	14	14	18	19	19	9	10	10	12	14	14
	M12x1.5	8	26	28	29	35	38	39	33	35	36	45	47	49	18	19	20	25	26	27
	M14x1.5	10	37	39	41	50	53	56	41	43	45	55	58	61	26	28	29	35	38	39
	M16x1.5	12	44	46	48	60	62	65	59	62	65	80	84	88	41	43	45	55	58	61
	M18x1.5	15	59	62	65	80	84	88	74	78	81	100	10-6	110	48	51	53	65	69	72
	M22x1.5	18	89	94	98	1-20	12-7	13-3	1-03	108	113	140	14-6	153	66	70	73	90	95	99
	M27x2	22	96	101	1-06	1-30	13-7	14-4	2-36	248	260	320	33-6	353	100	1-05	110	1-35	14-2	1-49
	M33x2	28	–	–	–	–	–	–	2-66	280	293	360	38-0	397	166	1-75	183	2-25	23-7	2-48
	M42x2	35	–	–	–	–	–	–	3-98	418	438	540	56-7	594	266	2-80	293	3-60	38-0	3-97
	M48x2	42	–	–	–	–	–	–	5-16	542	568	700	73-5	770	266	2-80	293	3-60	38-0	3-97

TYPE/FITTING IDENTIFICATION			BANJO FITTINGS WITH L SERIES DIN (MBTL) OPPOSITE END						HIGH PRESSURE BANJO FITTINGS WITH L SERIES DIN (MBTL) OPPOSITE END						FORM E (EOLASTIC SEALING RING) HOLLOW HEX PLUGS					
Material	Thread M Size	Connecting Tube O.D	Torque						Torque						Torque					
			[Ft-Lb]			[Nm]			[Ft-Lb]			[Nm]			[Ft-Lb]			[Nm]		
	(metric)	(mm)	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max
ALUMINUM/ BRASS FITTINGS OR ALUMINUM/ BRASS MATING COMPONENTS; UNLUBRICATED THREADS	M10x1	6	8	9	9	11	12	12	8	9	9	11	12	12	6	7	7	8	9	9
	M12x1.5	8	17	18	19	23	24	26	21	22	23	28	30	31	12	13	13	16	18	18
	M14x1.5	10	24	26	27	33	35	37	27	28	29	37	38	39	17	18	19	23	24	26
	M16x1.5	12	29	30	31	39	41	42	38	40	42	52	54	57	27	28	29	37	38	39
	M18x1.5	15	38	40	42	52	54	57	48	51	53	65	69	72	31	33	34	42	45	46
	M22x1.5	18	58	61	64	79	83	87	67	70	73	91	95	99	43	45	47	58	61	64
	M27x2	22	62	66	69	84	89	94	1-53	161	169	207	218	229	65	69	72	88	94	98
	M33x2	28	–	–	–	–	–	–	1-73	182	190	235	247	258	108	1-14	119	1-46	155	1-61
	M42x2	35	–	–	–	–	–	–	2-59	272	285	351	369	386	173	1-82	190	2-35	247	2-58
	M48x2	42	–	–	–	–	–	–	3-35	352	369	454	477	500	173	1-82	190	2-35	247	2-58

Metric Flat Face Port (MFF) S Series - Table 1 of 3



MAE9320

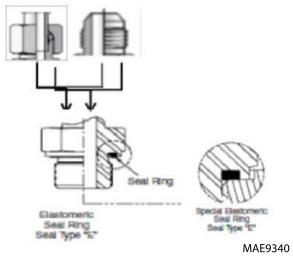


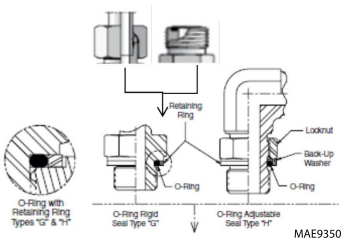
MAE9330

TYPE/FITTING IDENTIFICATION			FORM A (SEALING WASHER) STUD ENDS WITH (ORFS) OR S SERIES DIN (MBTS) OPPOSITE END						FORM B (CUTTING FACE) STUD ENDS WITH (ORFS) OR S SERIES DIN (MBTS) OPPOSITE END					
Material	ThreadM Size	Connecting Tube O.D.	Torque						Torque					
			[Ft-Lb]			[Nm]			[Ft-Lb]			[Nm]		
	(metric)	(mm)	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max	Min	No-m	Max
STEEL FITTINGS WITH STEEL MATING COMPONENTS; UN-LUBRICATED THREADS	M12x1.5	6	15	16	17	20	22	23	26	28	29	35	38	39
	M14x1.5	8	26	28	29	35	38	39	41	43	45	55	58	61
	M16x1.5	10	33	35	36	45	47	49	52	55	57	70	75	77
	M18x1.5	12	41	43	45	55	58	61	81	85	89	110	115	121
	M20x1.5	14	41	43	45	55	58	61	111	117	122	150	159	165
	M22x1.5	16	48	51	53	65	69	72	125	132	138	170	179	187
	M27x2	20	66	70	73	89	95	99	199	209	219	270	283	297
	M33x2	25	111	117	122	150	159	165	302	317	332	410	430	450
	M42x2	30	177	186	195	240	252	264	398	418	438	540	567	594
	M48x2	38	214	225	235	290	305	319	516	542	568	700	735	770

TYPE/FITTING IDENTIFICATION			FORM A (SEALING WASHER) STUD ENDS WITH (ORFS) OR S SERIES DIN (MBTS) OPPOSITE END						FORM B (CUTTING FACE) STUD ENDS WITH (ORFS) OR S SERIES DIN (MBTS) OPPOSITE END					
Material	ThreadM Size	Connecting Tube O.D.	Torque						Torque					
			[Ft-Lb]			[Nm]			[Ft-Lb]			[Nm]		
	(metric)	(mm)	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max
ALUMINUM/ BRASS FITTINGS OR ALUMINUM/ BRASS MATING COMPONENTS; UNLUBRICATED THREADS	M12x1.5	6	10	11	11	14	15	15	17	18	19	23	24	26
	M14x1.5	8	17	18	19	23	24	26	27	28	29	37	38	39
	M16x1.5	10	21	22	23	28	30	31	34	36	37	46	49	50
	M18x1.5	12	27	28	29	37	38	39	53	56	58	72	76	79
	M20x1.5	14	27	28	29	37	38	39	72	76	79	98	103	107
	M22x1.5	16	31	33	34	42	45	46	81	86	90	110	117	122
	M27x2	20	43	45	47	58	61	64	129	136	142	175	184	193
	M33x2	25	72	76	79	98	103	107	196	206	216	266	279	293
	M42x2	30	115	121	127	156	164	172	259	272	285	351	369	386
	M48x2	38	139	146	153	188	198	207	335	352	369	454	477	500

Metric Flat Face Port (MFF) S Series - Table 2 of 3

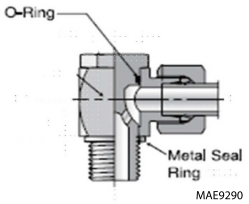


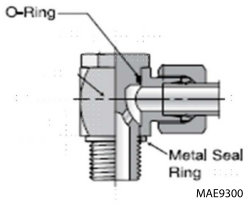


TYPE/FITTING IDENTIFICATION			FORM E (EOLASTIC SEALING RING) STUD ENDS AND HEX TYPE PLUGS WITH (ORFS) OR S SERIES DIN (MBTS) OPPOSITE END						FORM G/H (O-RING W/ RETAINING RING)STUD ENDS & ADJUSTABLE STUD ENDS WITH (ORFS) OR S SERIES DIN (MBTS)OPPOSITE END					
Material	ThreadM Size	Connecting Tube O.D.	Torque						Torque					
			[Ft-Lb]			[Nm]			[Ft-Lb]			[Nm]		
	(metric)	(mm)	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max
STEEL FITTINGS WITH STEEL MATING COMPONENTS; UNLUBRICATED THREADS	M10x1	6	26	28	29	35	38	39	26	28	29	35	38	39
	M12x1.5	8	33	35	36	45	47	49	41	43	45	55	58	61
	M14x1.5	10	52	55	57	70	75	77	52	55	57	70	75	77
	M16x1.5	12	66	70	73	90	95	99	66	70	73	90	95	99
	M18x1.5	15	92	97	101	125	132	137	92	97	101	125	132	137
	M22x1.5	18	100	105	110	135	142	149	100	105	110	135	142	149
	M27x2	22	133	140	146	180	190	198	133	140	146	180	190	198
	M33x2	28	229	241	252	310	327	342	229	241	252	310	327	342
	M42x2	35	332	349	365	450	473	495	332	349	365	450	473	495
	M48x2	42	398	418	438	540	567	594	398	418	438	540	567	594

TYPE/FITTING IDENTIFICATION			FORM E (EOLASTIC SEALING RING) STUD ENDS AND HEX TYPE PLUGS WITH (ORFS) OR S SERIES DIN (MBTS) OPPOSITE END						FORM G/H (O-RING W/ RETAINING RING)STUD ENDS & ADJUSTABLE STUD ENDS WITH (ORFS) OR S SERIES DIN (MBTS)OPPOSITE END					
Material	Thread M Size	Con-necting Tube O.D.	Torque						Torque					
			[Ft-Lb]			[Nm]			[Ft-Lb]			[Nm]		
	(metric)	(mm)	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max
ALUMINUM/ BRASS FIT-TINGS OR ALUMINUM/ BRASS MAT-ING COMPO-NENTS; UN-LUBRICATED THREADS	M10x1	6	17	18	19	23	24	26	17	18	19	23	24	26
	M12x1.5	8	21	23	23	29	31	32	27	28	29	37	38	39
	M14x1.5	10	34	36	37	46	49	50	34	36	37	46	49	50
	M16x1.5	12	43	45	47	58	61	64	43	45	47	58	61	64
	M18x1.5	15	60	63	66	81	85	89	60	63	66	81	85	89
	M22x1.5	18	65	69	72	88	94	98	65	69	72	88	94	98
	M27x2	22	86	91	95	117	123	129	86	91	95	117	123	129
	M33x2	28	149	157	164	202	213	222	149	157	164	202	213	222
	M42x2	35	216	227	237	293	308	321	216	227	237	293	308	321
	M48x2	42	259	272	285	351	369	386	259	272	285	351	369	386

Metric Flat Face Port (MFF) S Series - Table 3 of 3





TYPE/FITTING IDENTIFICATION			BANJO FITTINGS WITH S SERIES DIN (MBTS) OPPOSITE END						HIGH PRESSURE BANJO FITTINGS WITH S SERIES DIN (MBTS) OPPOSITE END						FORM E (EOLASTIC SEALING RING) HOLLOW HEX PLUGS					
Material	Thread M Size	Con-nect-ing Tube O.D	Torque						Torque						Torque					
			[Ft-Lb]			[Nm]			[Ft-Lb]			[Nm]			[Ft-Lb]			[Nm]		
	(metric)	(mm)	Min	Nom	Ma-x	Min	No-m	M-ax	Min	No-m	Max	M-in	Nom	Max	Min	N-o-m	M-ax	Min	N-o-m	M-ax
STEEL FIT-TINGS WITH STEEL MAT-ING COM-PONENTS; UN-LUBRI-CATED THREADS	M10x1	6	26	28	29	35	38	39	33	35	36	45	47	49	–	–	–	–	–	–
	M12-x1.5	8	37	39	41	50	53	56	41	43	45	55	58	61	–	–	–	–	–	–
	M14-x1.5	10	44	46	48	60	62	65	59	62	65	80	84	88	–	–	–	–	–	–
	M16-x1.5	12	59	62	65	80	84	88	74	78	81	1-00	106	110	–	–	–	–	–	–
	M18-x1.5	15	81	85	89	110	115	1-21	92	97	101	1-25	132	137	59	62	65	80	84	88
	M22-x1.5	18	89	94	98	120	127	1-33	100	105	110	1-35	142	149	–	–	–	–	–	–
	M27x2	22	100	105	110	135	142	1-49	236	248	260	3-20	336	353	–	–	–	–	–	–
	M33x2	28	–	–	–	–	–	–	266	280	293	3-60	380	397	–	–	–	–	–	–
	M42x2	35	–	–	–	–	–	–	398	418	438	5-40	567	594	–	–	–	–	–	–
	M48x2	42	–	–	–	–	–	–	516	542	568	7-00	735	770	–	–	–	–	–	–

TYPE/FITTING IDENTIFICATION			BANJO FITTINGS WITH S SERIES DIN (MBTS) OPPOSITE END						HIGH PRESSURE BANJO FITTINGS WITH S SERIES DIN (MBTS) OPPOSITE END						FORM E (EOLASTIC SEALING RING) HOLLOW HEX PLUGS					
Material	Thread M Size	Connecting Tube O.D	Torque						Torque						Torque					
			[Ft-Lb]			[Nm]			[Ft-Lb]			[Nm]			[Ft-Lb]			[Nm]		
	(metric)	(mm)	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max
ALUMINUM/ BRASS FITTINGS OR ALUMINUM/ BRASS MATING COMPONENTS; UNLUBRICATED THREADS	M10x1	6	17	18	19	23	24	26	21	22	23	28	30	31	–	–	–	–	–	–
	M12-x1.5	8	24	26	27	33	35	37	27	28	29	37	38	39	–	–	–	–	–	–
	M14-x1.5	10	29	30	31	39	41	42	38	40	42	52	54	57	–	–	–	–	–	–
	M16-x1.5	12	38	40	42	52	54	57	48	51	53	65	69	72	–	–	–	–	–	–
	M18-x1.5	15	53	56	58	72	76	79	60	63	66	81	85	89	38	40	42	52	54	57
	M22-x1.5	18	58	61	64	79	83	87	65	69	72	88	94	98	–	–	–	–	–	–
	M27x2	22	65	69	72	88	94	98	153	161	169	207	218	229	–	–	–	–	–	–
	M33x2	28	–	–	–	–	–	–	173	182	190	235	247	258	–	–	–	–	–	–
	M42x2	35	–	–	–	–	–	–	259	272	285	351	369	386	–	–	–	–	–	–
	M48x2	42	–	–	–	–	–	–	335	352	369	454	477	500	–	–	–	–	–	–

11.1.17 Assembly Instructions for Metric ISO 6149 (MPP) Port Assembly Stud Ends

1. Inspect components to ensure that male and female threads and surfaces are free of rust, splits, dirt, foreign matter, or burrs.
2. If O-ring is not pre-installed, install proper size, taking care not to damage it. Refer to *Section — O-ring Installation (Replacement), page 356* for instructions.

NOTICE

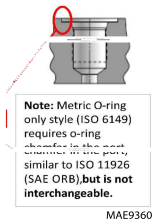
Care to be taken when lubricating O-ring. Avoid adding oil to the threaded connection of the fitting. The lubrication would cause increased clamping force and cause fitting damage.

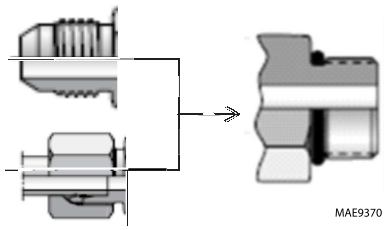
3. Pre-lubricate the O-ring with Hydraulic Oil.
4. For Non-Adjustable Fittings and Plugs, thread the fitting by hand until contact.
5. For Adjustable fittings, refer to *Section — Adjustable Stud End Assembly, page 356* for proper assembly.
6. Torque the fitting or nut to value while using the Double Wrench Method.
   a. The table headings identify the Metric port and the type on the other side of the fitting. The torque will be applied to the Metric port.
   b. Torque values are segregated based on the material configuration of the connection. ‘Aluminum/brass fittings or aluminum/brass mating components’ indicate either the following material configurations:

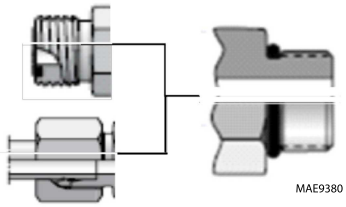
   - Steel fittings with aluminum or brass mating components.
   - Aluminum or brass fittings with steel mating components.
   - Aluminum or brass fittings with aluminum or brass mating components.

7. Inspect to ensure the O-ring is not pinched and the washer is seated flat on the counterbore of the port.

Metric Pipe Parallel O-Ring Boss (MPP)







TYPE/FITTING IDENTIFICATION			STUD ENDS WITH 37° (JIC) OR L SERIES DIN (MBTL) OPPOSITE END						STUD ENDS WITH (ORFS) OR S SERIES DIN (MBTS) OPPOSITE END					
Material	Thread M Size	Connecting Tube O.D.	Torque						Torque					
			[Ft-Lb]			[Nm]			[Ft-Lb]			[Nm]		
	(metric)	(mm)	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max
STEEL FITTINGS WITH STEEL MATING COMPONENTS; UN-LUBRICATED THREADS	M8 x 1	4	6	7	7	8	9	9	8	9	9	10	12	12
	M10 x 1	6	11	12	12	15	16	16	15	16	17	20	22	23
	M12 x 1.5	8	18	19	20	25	26	27	26	28	29	35	38	39
	M14 x 1.5	10	26	28	29	35	38	39	33	35	36	45	47	49
	M16 x 1.5	12	30	32	33	40	43	45	41	43	45	55	58	61
	M18 x 1.5	15	33	35	36	45	47	49	52	55	57	70	75	77
	M20 x 1.5	–	–	–	–	–	–	–	59	62	65	80	84	88
	M22 x 1.5	18	44	46	48	60	62	65	74	78	81	100	106	110
	M27 x 2	22	74	78	81	100	106	110	125	132	138	170	179	187
	M30 x 2	–	95	100	105	130	136	142	175	184	193	237	249	262
	M33 x 2	25	120	126	132	160	171	179	230	242	253	310	328	343
	M38 x 2	–	135	142	149	183	193	202	235	247	259	319	335	351
	M42 x 2	30	155	163	171	210	221	232	245	258	270	330	350	366
	M48 x 2	38	190	200	209	260	271	283	310	326	341	420	442	462
	M60 x 2	50	230	242	253	315	328	343	370	389	407	500	527	552

TYPE/FITTING IDENTIFICATION			STUD ENDS WITH 37° (JIC) OR L SERIES DIN (MBTL) OPPOSITE END						STUD ENDS WITH (ORFS) OR S SERIES DIN (MBTS) OPPOSITE END					
Material	Thread M Size	Connecting Tube O.D.	Torque						Torque					
			[Ft-Lb]			[Nm]			[Ft-Lb]			[Nm]		
	(metric)	(mm)	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max
ALUMINUM/ BRASS FITTINGS OR ALUMINUM/ BRASS MATING COMPONENTS; UNLUBRICATED THREADS	M8 x 1	4	4	5	5	5	7	7	5	6	6	7	8	8
	M10 x 1	6	7	8	8	9	11	11	10	11	11	14	15	15
	M12 x 1.5	8	12	13	13	16	18	18	17	18	19	23	24	26
	M14 x 1.5	10	17	18	19	23	24	26	21	22	23	28	30	31
	M16 x 1.5	12	20	21	21	27	28	28	27	28	29	37	38	39
	M18 x 1.5	15	21	22	23	28	30	31	34	36	37	46	49	50
	M20 x 1.5	–	–	–	–	–	–	–	30	40	42	41	54	57
	M22 x 1.5	18	29	30	31	39	41	42	48	51	53	65	69	72
	M27 x 2	22	48	51	53	65	69	72	81	86	90	110	117	122
	M30 x 2	–	62	65	68	84	88	92	114	120	125	155	163	169
	M33 x 2	25	78	82	86	106	111	117	150	157	164	203	213	222
	M38 x 2	–	88	93	97	119	126	132	153	161	168	207	218	228
	M42 x 2	30	101	106	111	137	144	150	159	168	176	216	228	239
	M48 x 2	38	124	130	136	168	176	184	202	212	222	274	287	301
	M60 x 2	50	150	157	164	203	213	222	241	253	265	327	343	359

11.1.18 Assembly instructions for Adjustable Port End (BSPP) Fittings

1. Inspect components to ensure that male and female threads and surfaces are free of rust, splits, dirt, foreign matter, or burrs.
2. If O-ring is not pre-installed, install proper size, taking care not to damage it. Refer to *Section — O-ring Installation (Replacement), page 356* for instructions.

NOTICE

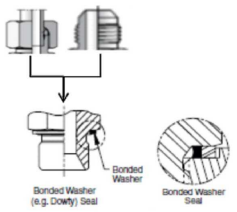
Care to be taken when lubricating O-ring. Avoid adding oil to the threaded connection of the fitting. The lubrication would cause increased clamping force and cause fitting damage.

3. Pre-lubricate the O-ring with Hydraulic Oil.
4. For Non-Adjustable Fittings and Plugs, thread the fitting by hand until contact.
5. For Adjustable fittings, refer to *Section — Adjustable Stud End Assembly, page 356* for proper assembly.
6. Torque the fitting or nut to value while using the Double Wrench Method.
   a. The table headings identify the BSPP port and the type on the other side of the fitting. The torque will be applied to the BSPP port.
   b. Torque values are segregated based on the material configuration of the connection. ‘Aluminum/brass fittings or aluminum/brass mating components’ indicate either the following material configurations:

   - Steel fittings with aluminum or brass mating components.
   - Aluminum or brass fittings with steel mating components.
   - Aluminum or brass fittings with aluminum or brass mating components.

7. Inspect to ensure the O-ring is not pinched and the washer is seated flat on the counterbore of the port.

British Standard Parallel Pipe Port (BSPP) - L Series - Table 1 of 3



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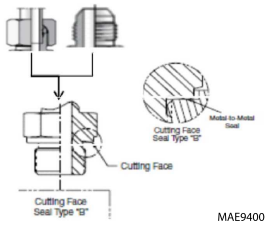


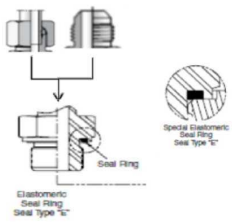
MAE9400

TYPE/FITTING IDENTIFICATION			FORM A**(SEALING WASHER) STUD ENDS WITH 37° (JIC) or L SERIES DIN (MBTL) OPPOSITE END						FORM B** (CUTTING FACE) STUD ENDS WITH 37° (JIC) OR L SERIES DIN (MBTL)OPPOSITE END					
Material	BSPP Thread GSize	Connecting Tube O.D.	Torque						Torque					
			[Ft-Lb]			[Nm]			[Ft-Lb]			[Nm]		
		(mm)	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max
STEEL FITTINGS WITH STEEL MATING COMPONENTS; UN-LUBRICATED THREADS	G1/8A	6	7	8	8	9	11	11	13	14	14	18	19	19
	G1/4A	8	26	28	29	35	38	39	26	28	29	35	38	39
	G1/4A	10	26	28	29	35	38	39	26	28	29	35	38	39
	G3/8A	12	33	35	36	45	47	49	52	55	57	70	75	77
	G1/2A	15	48	51	53	65	69	72	103	108	113	140	146	153
	G1/2A	18	48	51	53	65	69	72	74	78	81	100	106	110
	G3/4A	22	66	70	73	90	95	99	133	140	146	180	190	198
	G1A	28	111	117	122	150	159	165	243	255	267	330	346	362
	G1-1/4A	35	177	186	195	240	252	264	398	418	438	540	567	594
	G1-1/2A	42	214	225	235	290	305	319	465	489	512	630	663	694

TYPE/FITTING IDENTIFICATION			FORM A**(SEALING WASHER) STUD ENDS WITH 37° (JIC) or L SERIES DIN (MBTL) OPPOSITE END						FORM B** (CUTTING FACE) STUD ENDS WITH 37° (JIC) OR L SERIES DIN (MBTL)OPPOSITE END					
Material	BSPP Thread GSize	Connecting Tube O.D.	Torque						Torque					
			[Ft-Lb]			[Nm]			[Ft-Lb]			[Nm]		
		(mm)	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max
ALUMINUM/ BRASS FITTINGS OR ALUMINUM/ BRASS MATING COMPONENTS; UNLUBRICATED THREADS	G1/8A	6	4	5	5	5	7	7	8	9	9	11	12	12
	G1/4A	8	17	18	19	23	24	26	17	18	19	23	24	26
	G1/4A	10	17	18	19	23	24	26	17	18	19	23	24	26
	G3/8A	12	21	22	23	28	30	31	34	36	37	46	49	50
	G1/2A	15	31	33	34	42	45	46	67	70	73	91	95	99
	G1/2A	18	31	33	34	42	45	46	48	51	53	65	69	72
	G3/4A	22	42	45	47	57	61	64	86	91	95	117	123	129
	G1A	28	72	76	79	98	103	107	158	166	174	214	225	236
	G1-1/4A	35	115	121	127	156	164	172	259	272	285	351	369	386
	G1-1/2A	42	139	146	153	188	198	207	302	318	333	409	431	451

Note: ** Non typical for JLG Straight Male Stud Fittings, reference only.

British Standard Parallel Pipe Port (BSPP) - L Series - Table 2 of 3



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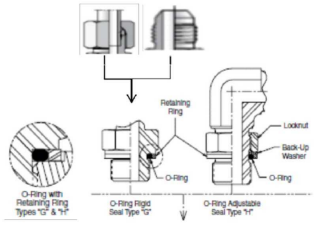

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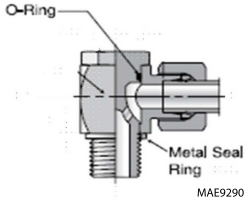
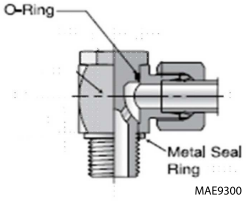
TYPE/FITTING IDENTIFICATION			FORM E*(EOLASTIC SEALING RING) STUD ENDS WITH 37° (JIC) ORL SERIES DIN (MBTL) OPPOSITE END						FORM G/H*** (0-RING W/ RETAINING RING) STUD ENDS & ADJUSTABLE STUD ENDS WITH 37° (JIC) ORL SERIES DIN (MBTL) OPPOSITE END					
Material	BSPP Thread GSize	Connecting Tube O.D.	Torque						Torque					
			[Ft-Lb]			[Nm]			[Ft-Lb]			[Nm]		
		(mm)	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max
STEEL FITTINGS WITH STEEL MATING COMPONENTS; UN-LUBRICATED THREADS	G1/8A	6	13	14	14	18	19	19	13	14	14	18	19	19
	G1/4A	8	26	28	29	35	38	39	26	28	29	35	38	39
	G1/4A	10	26	28	29	35	38	39	26	28	29	35	38	39
	G3/8A	12	52	55	57	70	75	77	52	55	57	70	75	77
	G1/2A	15	66	70	73	90	95	99	66	70	73	90	95	99
	G1/2A	18	66	70	73	90	95	99	66	70	73	90	95	99
	G3/4A	22	133	140	146	180	190	198	133	140	146	180	190	198
	G1A	28	229	241	252	310	327	342	229	241	252	310	327	342
	G1-1/4A	35	332	349	365	450	473	495	332	349	365	450	473	495
	G1-1/2A	42	398	418	438	540	567	594	398	418	438	540	567	594

TYPE/FITTING IDENTIFICATION			FORM E*(EOLASTIC SEALING RING) STUD ENDS WITH 37° (JIC) ORL SERIES DIN (MBTL) OPPOSITE END						FORM G/H*** (0-RING W/ RETAINING RING) STUD ENDS & ADJUSTABLE STUD ENDS WITH 37° (JIC) ORL SERIES DIN (MBTL) OPPOSITE END					
Material	BSPP Thread GSize	Connecting TubeO.D.	Torque						Torque					
			[Ft-Lb]			[Nm]			[Ft-Lb]			[Nm]		
		(mm)	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max
ALUMINUM/ BRASS FITTINGS OR ALUMINUM/ BRASS MATING COMPONENTS; UNLUBRICATED THREADS	G1/8A	6	8	9	9	11	12	12	8	9	9	11	12	12
	G1/4A	8	17	18	19	23	24	26	17	18	19	23	24	26
	G1/4A	10	17	18	19	23	24	26	17	18	19	23	24	26
	G3/8A	12	34	36	37	46	49	so	34	36	37	46	49	so
	G1/2A	15	43	45	47	58	61	64	43	45	47	58	61	64
	G1/2A	18	43	45	47	58	61	64	43	45	47	58	61	64
	G3/4A	22	86	91	95	117	123	129	86	91	95	117	123	129
	G1A	28	149	157	164	202	213	222	149	157	164	202	213	222
	G1-1/4A	35	216	227	237	293	308	321	216	227	237	293	308	321
	G1-1/2A	42	259	272	285	351	369	386	259	272	285	351	369	386

Note: ** Non typical for JLG Straight Male Stud Fittings, reference only.

British Standard Parallel Pipe Port (BSPP) L Series - Table 3 of 3

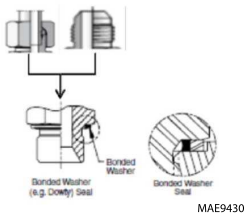


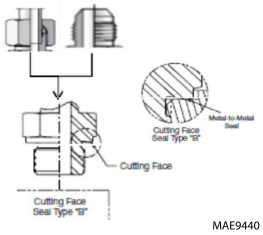


TYPE/FITTING IDENTIFICATION			BANJO FITTINGS WITH L SERIES DIN (MBTL) OPPOSITE END						HIGH PRESSURE BANJO FITTINGS WITH L SERIES DIN (MBTL) OPPOSITE END						FORM E (EOLASTIC SEALING RING) HOLLOW HEX PLUGS					
Material	BSPP Thread G Size	Connecting Tube O. D	Torque						Torque						Torque					
			[Ft-Lb]			[Nm]			[Ft-Lb]			[Nm]			[Ft-Lb]			[Nm]		
		(mm)	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max
STEEL FITTINGS WITH STEEL MATING COMPONENTS; UN-LUBRICATED THREADS	G 1/8A	6	13	14	14	18	19	19	13	14	14	18	19	19	10	11	11	13	15	15
	G 1/4A	8	30	32	33	40	43	45	33	35	36	45	47	49	22	23	24	30	31	33
	G 1/4A	10	30	32	33	40	43	45	33	35	36	45	47	49	22	23	24	30	31	33
	G 3/8A	12	48	51	53	65	69	72	52	55	57	70	75	77	44	46	48	60	62	65
	G 1/2A	15	66	70	73	90	95	99	89	94	98	120	127	133	59	62	65	80	84	88
	G 1/2A	18	66	70	73	90	95	99	89	94	98	120	127	133	59	62	65	80	84	88
	G 3/4A	22	92	97	101	125	132	137	170	179	187	230	243	254	103	108	113	140	146	153
	G 1A	28	–	–	–	–	–	–	236	248	260	320	336	353	148	156	163	200	212	221
	G 1-1/4A	35	–	–	–	–	–	–	398	418	438	540	567	594	295	313.5	332	400	425	450
	G 1-1/2A	42	–	–	–	–	–	–	516	542	568	700	735	770	332	349	365	450	473	495

TYPE/FITTING IDENTIFICATION			BANJO FITTINGS WITH L SERIES DIN (MBTL) OPPOSITE END						HIGH PRESSURE BANJO FITTINGS WITH L SERIES DIN (MBTL) OPPOSITE END						FORM E (EOLASTIC SEALING RING) HOLLOW HEX PLUGS					
Material	BSPP Thread G Size	Connecting Tube O.D	Torque						Torque						Torque					
			[Ft-Lb]			[Nm]			[Ft-Lb]			[Nm]			[Ft-Lb]			[Nm]		
		(mm)	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max
ALUMINUM/ BRASS FITTINGS OR ALUMINUM/ BRASS MATING COMPONENTS; UNLUBRICATED THREADS	G 1/8A	6	8	9	9	11	12	12	8	9	9	11	12	12	6	7	7	8	9	9
	G 1/4A	8	20	21	21	27	28	28	21	22	23	28	30	31	14	15	16	19	20	22
	G 1/4A	10	20	21	21	27	28	28	21	22	23	28	30	31	14	15	16	19	20	22
	G 3/8A	12	31	33	34	42	45	46	34	36	37	46	49	50	29	30	31	39	41	42
	G 1/2A	15	43	45	47	58	61	64	58	61	64	79	83	87	38	40	42	52	54	57
	G 1/2A	18	43	45	47	58	61	64	58	61	64	79	83	87	38	40	42	52	54	57
	G 3/4A	22	60	63	66	81	85	89	111	117	122	150	159	165	67	70	73	91	95	99
	G 1A	28	–	–	–	–	–	–	153	161	169	207	218	229	96	101	106	130	137	144
	G 1-1/4A	35	–	–	–	–	–	–	259	272	285	351	369	386	216	227	237	293	308	321
	G 1-1/2A	42	–	–	–	–	–	–	335	352	369	454	477	500	216	227	237	293	308	321

British Standard Parallel Pipe Port (BSPP) S Series - Table 1 of 3



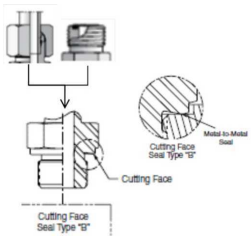


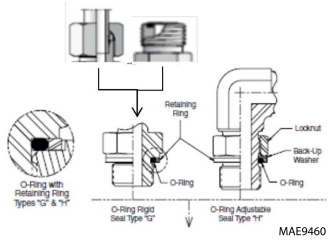
TYPE/FITTING IDENTIFICATION			FORM A** (SEALING WASHER) STUD ENDS WITH (ORFS) ORS SERIES DIN (MBTS) OPPOSITE END						FORM B** (CUTTING FACE) STUD ENDS WITH (ORFS) ORS SERIES DIN (MBTS) OPPOSITE END					
Material	BSPP Thread GSize	Connecting Tube O.D.	Torque						Torque					
			[Ft-Lb]			[Nm]			[Ft-Lb]			[Nm]		
		(mm)	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max
STEEL FITTINGS WITH STEEL MATING COMPONENTS; UNLUBRICATED THREADS	G1/4A	6	26	28	29	35	38	39	41	43	45	55	58	61
	G1/4A	8	26	28	29	35	38	39	41	43	45	55	58	61
	G3/8A	10	33	35	36	45	47	49	66	70	73	90	95	99
	G3/8A	12	33	35	36	45	47	49	66	70	73	90	95	99
	G1/2A	14	48	51	53	65	69	72	111	117	122	150	159	165
	G1/2A	16	48	51	53	65	69	72	96	101	106	130	137	144
	G3/4A	20	66	70	73	90	95	99	199	209	219	270	283	297
	G1A	25	111	117	122	150	159	165	251	264	276	340	358	374
	G1-1/4A	30	177	186	195	240	252	264	398	418	438	540	567	594
	G1-1/2A	38	214	225	235	290	305	319	516	542	568	700	735	770

TYPE/FITTING IDENTIFICATION			FORM A** (SEALING WASHER) STUD ENDS WITH (ORFS) ORS SERIES DIN (MBTS) OPPOSITE END						FORM B** (CUTTING FACE) STUD ENDS WITH (ORFS) ORS SERIES DIN (MBTS) OPPOSITE END					
Material	BSPP Thread GSize	Connecting Tube O.D.	Torque						Torque					
			[Ft-Lb]			[Nm]			[Ft-Lb]			[Nm]		
		(mm)	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max
ALUMINUM/ BRASS FITTINGS OR ALUMINUM/ BRASS MATING COMPONENTS; UNLUBRICATED THREADS	G1/4A	6	17	18	19	23	24	26	27	28	29	37	38	39
	G1/4A	8	17	18	19	23	24	26	27	28	29	37	38	39
	G3/8A	10	21	22	23	28	30	31	43	45	47	58	61	64
	G3/8A	12	21	22	23	28	30	31	43	45	47	58	61	64
	G1/2A	14	31	33	34	42	45	46	72	76	79	98	103	107
	G1/2A	16	31	33	34	42	45	46	62	66	69	84	89	94
	G3/4A	20	43	45	47	58	61	64	129	136	142	175	184	193
	G1A	25	72	76	79	98	103	107	163	171	179	221	232	243
	G1-1/4A	30	115	121	127	156	164	172	259	272	285	351	369	386
	G1-1/2A	38	139	146	153	188	198	207	335	352	369	454	477	500

Note: ** Non typical for JLG Straight Male Stud Fittings, reference only.

British Standard Parallel Pipe Port (BSPP) S Series - Table 2 of 3



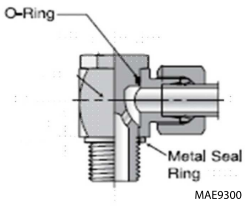


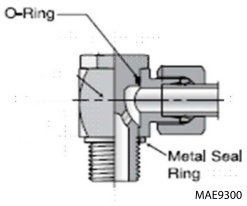
TYPE/FITTING IDENTIFICATION			FORM E* (EOLASTIC SEALING RING) STUD ENDS AND HEX TYPE PLUGS WITH (ORFS) or S SERIES DIN (MBTS) OPPOSITE END						FORM G/H*** (Q-RING W/ RETAINING RING) STUD ENDS & ADJUSTABLE STUD ENDS WITH (ORFS) ORS SERIES DIN (MBTS) OPPOSITE END					
Material	BSPP Thread G Size	Connecting Tube O.D.	Torque						Torque					
			[Ft-Lb]			[Nm]			[Ft-Lb]			[Nm]		
		(mm)	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max
STEEL FITTINGS WITH STEEL MATING COMPONENTS; UN-LUBRICATED THREADS	G 1/4A	6	41	43	45	55	58	61	26	28	29	35	38	39
	G 1/4A	8	41	43	45	55	58	61	26	28	29	35	38	39
	G 3/8A	10	59	62	65	80	84	88	52	55	57	70	75	77
	G 3/8A	12	59	62	65	80	84	88	52	55	57	70	75	77
	G 1/2A	14	85	90	94	115	122	127	66	70	73	90	95	99
	G 1/2A	16	85	90	94	115	122	127	66	70	73	90	95	99
	G 3/4A	20	133	140	146	180	190	198	133	140	146	180	190	198
	G 1A	25	229	241	252	310	327	342	229	241	252	310	327	342
	G 1-1/4A	30	332	349	365	450	473	495	332	349	365	450	473	495
	G 1-1/2A	38	398	418	438	540	567	594	398	418	438	540	567	594

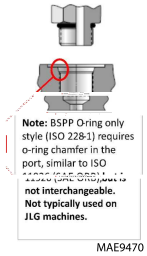
TYPE/FITTING IDENTIFICATION			FORM E* (EOLASTIC SEALING RING) STUD ENDS AND HEX TYPE PLUGS WITH (ORFS) or S SERIES DIN (MBTS) OPPOSITE END						FORM G/H*** (Q-RING W/ RETAINING RING) STUD ENDS & ADJUSTABLE STUD ENDS WITH (ORFS) ORS SERIES DIN (MBTS) OPPOSITE END					
Material	BSPP Thread G Size	Connecting Tube O.D.	Torque						Torque					
			[Ft-Lb]			[Nm]			[Ft-Lb]			[Nm]		
		(mm)	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max
ALUMINUM/ BRASS FITTINGS OR ALUMINUM/ BRASS MATING COMPONENTS; UNLUBRICATED THREADS	G1/4A	6	27	28	29	37	38	39	17	18	19	23	24	26
	G1/4A	8	27	28	29	37	38	39	17	18	19	23	24	26
	G3/8A	10	38	40	42	52	54	57	34	36	37	46	49	50
	G3/8A	12	38	40	42	52	54	57	34	36	37	46	49	50
	G1/2A	14	55	58	61	75	79	83	43	45	47	58	61	64
	G1/2A	16	55	58	61	75	79	83	43	45	47	58	61	64
	G3/4A	20	86	91	95	117	123	129	86	91	95	117	123	129
	G1A	25	149	157	164	202	213	222	149	157	164	202	213	222
	G1-1/4A	30	216	227	237	293	308	321	216	227	237	293	308	321
	G1-1/2A	38	259	272	285	351	369	386	259	272	285	351	369	386

Note: * Typical for JLG Straight Male Stud Fittings.
*** Typical for JLG Adjustable Fittings.

British Standard Parallel Pipe Port (BSPP) S Series - Table 3 of 3







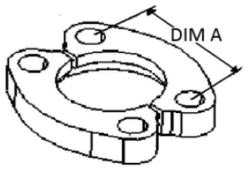
TYPE/FITTING IDENTIFICATION			BANJO FITTINGS WITH S SERIES DIN (MBTS) OPPOSITE END						HIGH PRESSURE BANJO FITTINGS WITH S SERIES DIN (MBTS) OPPOSITE END						JIS/BSPP O-RING ONLY					
Material	BSPP Thread G Size	Connecting Tube O.D.	Torque						Torque						Torque					
			[Ft-Lb]			[Nm]			[Ft-Lb]			[Nm]			[Ft-Lb]			[Nm]		
		(mm)	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max
STEEL FITTINGS WITH STEEL MATING COMPONENTS; UN-LUBRICATED THREADS	G 1/4A	6	30	32	33	40	43	45	33	35	36	45	47	49	Fitting type not typically specified on Caterpillar applications. Refer to the specific procedure in this Service Manual.					
	G 1/4A	8	30	32	33	40	43	45	33	35	36	45	47	49						
	G 3/8A	10	48	51	53	65	69	72	52	55	57	70	75	77						
	G 3/8A	12	48	51	53	65	69	72	52	55	57	70	75	77						
	G 1/2A	14	66	70	73	90	95	99	89	94	98	120	127	133						
	G 1/2A	16	66	70	73	90	95	99	89	94	98	120	127	133						
	G 3/4A	20	92	97	101	125	132	137	170	179	187	230	243	254						
	G 1A	25	–	–	–	–	–	–	236	248	260	320	336	353						
	G 1-1/4A	30	–	–	–	–	–	–	398	418	438	540	567	594						
	G 1-1/2A	38	–	–	–	–	–	–	516	542	568	700	735	770						

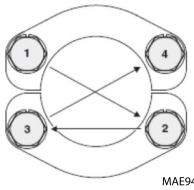
TYPE/FITTING IDENTIFICATION			BANJO FITTINGS WITH S SERIES DIN (MBTS) OPPOSITE END						HIGH PRESSURE BANJO FITTINGS WITH S SERIES DIN (MBTS) OPPOSITE END						JIS/BSPP O-RING ONLY					
Material	BSPP Thread G Size	Connecting Tube O. D.	Torque						Torque						Torque					
			[Ft-Lb]			[Nm]			[Ft-Lb]			[Nm]			[Ft-Lb]			[Nm]		
		(mm)	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max
ALUMINUM/ BRASS FITTINGS OR ALUMINUM/ BRASS MATING COMPONENTS; UNLUBRICATED THREADS	G 1/4A	6	20	21	21	27	28	28	22	22	23	30	30	31	Fitting type not typically specified on Caterpillar applications. Refer to the specific procedure in this Service Manual.					
	G 1/4A	8	20	21	21	27	28	28	22	22	23	30	30	31						
	G 3/8A	10	31	33	34	42	45	46	34	36	37	46	49	50						
	G 3/8A	12	31	33	34	42	45	46	34	36	37	46	49	50						
	G 1/2A	14	43	45	47	58	61	64	58	61	64	79	83	87						
	G 1/2A	16	43	45	47	58	61	64	58	61	64	79	83	87						
	G 3/4A	20	60	63	66	81	85	89	111	117	122	150	159	165						
	G 1A	25	–	–	–	–	–	–	153	161	169	207	218	229						
	G 1-1/4A	30	–	–	–	–	–	–	259	272	285	351	369	386						
	G 1-1/2A	38	–	–	–	–	–	–	335	352	368	454	477	499						

11.1.19 Assembly Instructions for Flange Connections: (FL61 and FL62)

1. Make sure sealing surfaces are free of rust, splits, scratches, dirt, foreign matter, or burrs.
2. Pre-lubricate the O-ring with Hydraulic Oil.
3. Position flange and clamp halves.
4. Place lock washers on bolt and bolt through clamp halves.
5. Tighten all bolts by hand.
6. Torque bolts in diagonal sequence in two or more increments to the torque listed.

Flange Code (FL61 and FL62) - Inch Fasteners





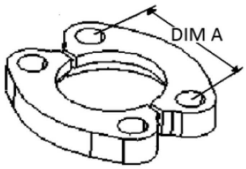
TYPE/FITTING IDENTIFICATION						STEEL 4-BOLT FLANGE SAE J518(INCH FASTENERS)													
Type	Inch Flange SAE Dash Size	Flange Size		A*		Bolt Thread Size	Fastener Torque for Flanges Equipped with GRADE 5 Screws						Fastener Torque for Flanges Equipped with GRADE 8 Screws					
							[Ft-Lb]			[Nm]			[Ft-Lb]			[Nm]		
		(in)	(mm)	(in)	(mm)	(UNF)	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max
CODE 61SPLIT FLANGE (FL61)	8	0.50	13	1.50	38.10	5/16-18	18	19	19	24	25	26	24	25	26	32	34	35
	12	0.75	19	1.88	47.75	3/8-16	32	33	35	43	45	47	44	46	49	60	63	66
	16	1.00	25	2.06	52.32	3/8-16	32	33	35	43	45	47	44	46	49	60	63	66
	20	1.25	32	2.31	58.67	7/16-14	52	54	57	70	74	77	68	71	75	92	97	101
	24	1.50	38	2.75	69.85	1/2-13	77	81	85	105	110	116	111	116	122	150	158	165
	32	2.00	51	3.06	77.72	1/2-13	77	81	85	105	110	116	111	116	122	150	158	165
	40	2.50	64	3.50	88.90	1/2-13	77	81	85	105	110	116	111	116	122	150	158	165
	48	3.00	76	4.19	106.43	5/8-11	155	163	170	210	221	231	218	228	239	295	310	325
	56	3.50	89	4.75	120.65	5/8-11	155	163	170	210	221	231	218	228	239	295	310	325
	64	4.00	102	5.13	130.30	5/8-11	155	163	170	210	221	231	218	228	239	295	310	325
	80	5.00	127	6.00	152.40	5/8-11	155	163	170	210	221	231	218	228	239	295	310	325

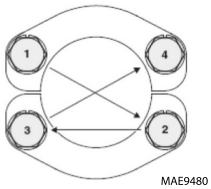
TYPE/FITTING IDENTIFICATION STEEL 4-BOLT FLANGE SAE J518(INCH FASTENERS)																		
Type	Inch Flange SAE Dash Size	Flange Size		A*		Bolt Thread Size	Fastener Torque for Flanges Equipped with GRADE 5 Screws						Fastener Torque for Flanges Equipped with GRADE 8 Screws					
							[Ft-Lb]			[Nm]			[Ft-Lb]			[Nm]		
		(in)	(mm)	(in)	(mm)	(UNF)	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max
CODE 62SPLIT FLANGE (FL62)	8	0.50	13	1.59	40.39	5/16-18	–	–	–	–	–	–	24	25	26	32	34	35
	12	0.75	19	2.00	50.80	3/8-16	–	–	–	–	–	–	44	46	49	60	63	66

TYPE/FITTING IDENTIFICATION STEEL 4-BOLT FLANGE SAE J518(INCH FASTENERS)																		
Type	Inch Flange SAE Dash Size	Flange Size		A*		Bolt Thread Size	Fastener Torque for Flanges Equipped with GRADE 5 Screws						Fastener Torque for Flanges Equipped with GRADE 8 Screws					
							[Ft-Lb]			[Nm]			[Ft-Lb]			[Nm]		
		(in)	(m-m)	(in)	(m-m)	(UNF)	Min	Nom	Max	Min	No-m	Max	Min	No-m	Max	Min	No-m	Max
	16	1.00	25	2.25	57.1-5	7/16-14	–	–	–	–	–	–	68	71	75	92	97	101
	20	1.25	32	2.62	66.5-5	1/2-13	–	–	–	–	–	–	111	116	122	150	158	165
	20	1.25	32	2.62	66.5-5	–	–	–	–	–	–	–	–	–	–	–	–	–
	24	1.50	38	3.12	79.2-5	5/8-11	–	–	–	–	–	–	218	228	239	295	310	325
	32	2.00	51	3.81	96.7-7	3/4-10	–	–	–	–	–	–	332	348	365	450	473	495

Note: * A dimension for reference only.

Flange Code (FL61 and FL62) - Metric Fasteners





TYPE/FITTING IDENTIFICATION						STEEL 4-BOLT FLANGE SAE J518 (INCH FASTENERS)													
Type	Inch Flange SAE Dash Size	Flange Size		A*		Bolt Thread Size	Fastener Torque for Flanges Equipped with CLASS 8.8 Screws						Fastener Torque for Flanges Equipped with CLASS 10.9 Screws					
							[Ft-Lb]			[Nm]			[Ft-Lb]			[Nm]		
		(in)	(m-m)	(in)	(mm)	(Metric)	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max
CODE 61 SPLIT FLANGE (FL61)	8	0.50	13	1.50	38.10	M8 x 1.25	18	19	19	24	25	26	18	19	19	24	25	26
	12	0.75	19	1.88	47.75	M10 x 1.5	37	39	41	50	53	55	37	39	41	50	53	55
	16	1.00	25	2.06	52.32	M10 x 1.5	37	39	41	50	53	55	37	39	41	50	53	55
	20	1.25	32	2.31	58.67	M10 x 1.5	37	39	41	50	53	55	37	39	41	50	53	55
	24	1.50	38	2.75	69.85	M12 x 1.75	68	71	75	92	97	101	68	71	75	92	97	101
	32	2.00	51	3.06	77.72	M12 x 1.75	68	71	75	92	97	101	68	71	75	92	97	101
	40	2.50	64	3.50	88.90	M12 x 1.75	68	71	75	92	97	101	68	71	75	92	97	101
	48	3.00	76	4.19	106.-43	M16 x 2	155	163	170	210	221	231	155	163	170	210	221	231
	56	3.50	89	4.75	120.-65	M16 x 2	155	163	170	210	221	231	155	163	170	210	221	231
	64	4.00	102	5.13	130.-30	M16 x 2	155	163	170	210	221	231	155	163	170	210	221	231
	80	5.00	127	6.00	152.-40	M16 x 2	155	163	170	210	221	231	155	163	170	210	221	231

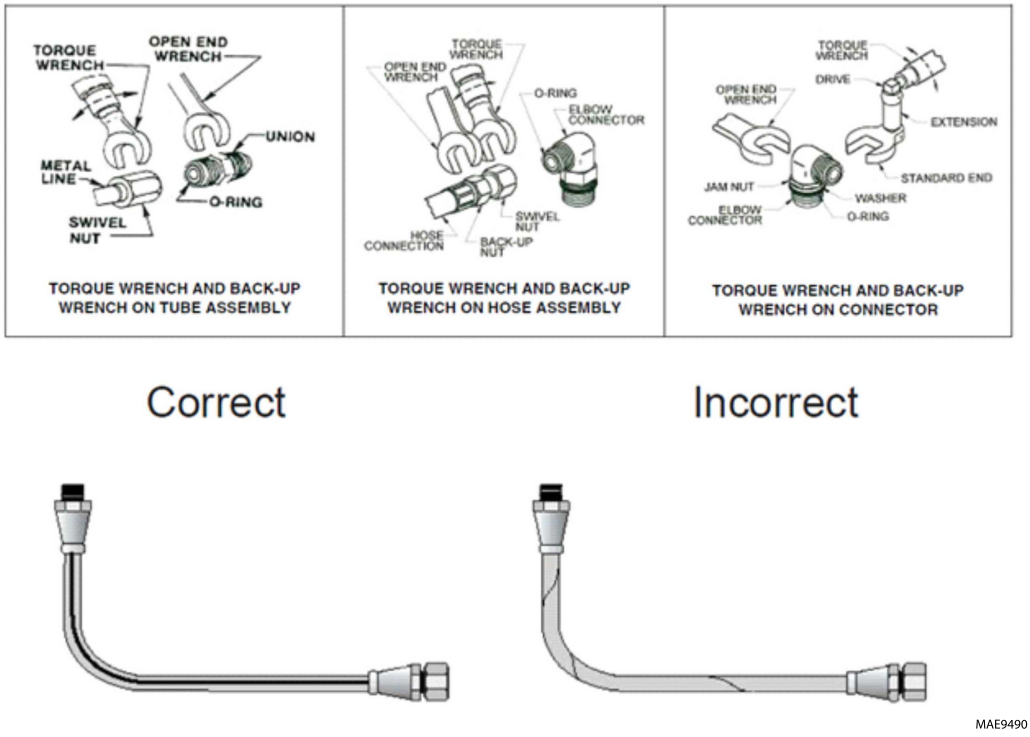
TYPE/FITTING IDENTIFICATION						STEEL 4-BOLT FLANGE SAE J518 (INCH FASTENERS)													
Type	Inch Flange SAE Dash Size	Flange Size		A*		Bolt Thread Size	Fastener Torque for Flanges Equipped with CLASS 8.8 Screws						Fastener Torque for Flanges Equipped with CLASS 10.9 Screws					
							[Ft-Lb]			[Nm]			[Ft-Lb]			[Nm]		
		(in)	(m-m)	(in)	(mm)	(Metric)	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max
CODE 62 SPLIT FLANGE (FL62)	8	0.50	13	1.59	40.39	M8 x 1.25	–	–	–	–	–	–	24	25	26	32	34	35
	12	0.75	19	2.00	50.80	M10 x 1.5	–	–	–	–	–	–	52	54	57	70	74	77
	16	1.00	25	2.25	57.15	M12 x 1.75	–	–	–	–	–	–	96	101	105	130	137	143
	20	1.25	32	2.62	66.55	M12 x 1.75	–	–	–	–	–	–	96	101	105	130	137	143

TYPE/FITTING IDENTIFICATION						STEEL 4-BOLT FLANGE SAE J518 (INCH FASTENERS)													
Type	Inch Flange SAE Dash Size	Flange Size		A*		Bolt Thread Size	Fastener Torque for Flanges Equipped with CLASS 8.8 Screws						Fastener Torque for Flanges Equipped with CLASS 10.9 Screws					
							[Ft-Lb]			[Nm]			[Ft-Lb]			[Nm]		
		(in)	(mm)	(in)	(mm)	(Metric)	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max
	20	1.25	32	2.62	66.55	M14 x 2	–	–	–	–	–	–	133	139	146	180	189	198
	24	1.50	38	3.12	79.25	M16 x 2	–	–	–	–	–	–	218	228	239	295	310	325
	32	2.00	51	3.81	96.77	M20 x 2.5	–	–	–	–	–	–	406	426	446	550	578	605

Note: * A dimension for reference only.

11.1.20 Double Wrench Method

To prevent undesired hose or connector rotation, two wrenches must be used; one torque wrench and one backup wrench. If two wrenches are not used, inadvertent component rotation may occur which absorbs torque and causes improper joint load and leads to leaks. For hose connections, the ‘layline’ printed on the hose is a good indicator of proper hose installation. A twisted lay-line usually indicates the hose is twisted.

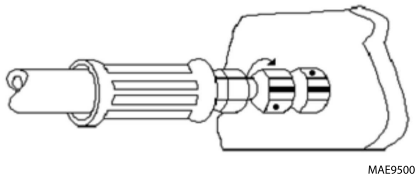


Double Wrench Method to Prevent Hose Twist

11.1.21 FFWR and TFFT Methods

1. FFWR (Flats from Wrench Resistance Method)
   a. Tighten the swivel nut to the mating fitting until no lateral movement of the swivel nut can be detected; finger tight condition.
   b. Mark a dot on one of the swivel hex nut flats and another dot in line on the connecting tube adapter.
   c. Use the double wrench method per Appendix A, turn the swivel nut to tighten. The nut is to be rotated clockwise the number of hex flats.
   d. After the connection has been properly tightened, mark a straight line across the connecting parts, not covering the dots, to indicate the connection has been properly tightened.

FFWR Method



2. TFFT (Turns from Finger Tight Method)
    a. Tighten the swivel nut to the mating fitting until no lateral movement of the swivel nut can be detected; finger tight condition.
    b. Mark a dot on one of the swivel hex nut flats and another dot in line on the connecting tube adapter.
    c. Use the double wrench method, turn the swivel nut to tighten. The nut is to be rotated clockwise the number of turns as defined by the applicable Table in Section 0.
    d. After the connection has been properly tightened, mark a straight line across the connecting parts, not covering the dots, to indicate the connection has been properly tightened.

11.1.22 Adjustable Stud End Assembly

For Adjustable Stud End Connections; the following assembly steps are to be performed:

e. Lubricate the o-ring with a light coat of hydraulic oil.

f. Position #1 – The o-ring should be located in the groove adjacent to the face of the back-up washer. The washer and o-ring should be positioned at the extreme top end of the groove as shown.

g. Position #2 – Position the locknut to just touch the backup washer as shown. The locknut in this position will eliminate potential back up washer.

11.1.23 O-ring Installation (Replacement)

Care must be taken when installing O-rings over threads during replacement or installation. O-rings could become nicked or torn. A damaged O-ring could lead to leakage problems.

1. Inspect O-ring for tears or nicks. If any are found replace O-ring.
2. Ensure proper O-ring to be installed. Many O-rings look the same but are of different material, different hardness, or are slightly different diameters or widths.
3. Use a thread protector when replacing O-rings on fittings.
4. In ORB; ensure O-ring is properly seated in groove. On straight threads, ensure O-ring is seated all the way past the threads prior to installation.
5. Inspect O-ring for any visible nicks or tears. Replace if found.

11.2 TORQUE CHARTS

11.2.1 SAE Fastener Torque Chart

Values for Zinc Yellow Chromate Fasteners (Ref 4150707)												
SAE GRADE 5 BOLTS & GRADE 2 NUTS												
Size	TPI	Bolt Dia	Tensile Stress Area	Clamp Load	Torque (Dry)		Torque Lubricated		Torque (Loctite® 242™ or 271™ orVibra-TITE™111 or 140)		Torque (Loctite® 262™or Vibra-TITE™ 131)	
		In	Sq In	LB	IN-LB	[N.m]	IN-LB	[N.m]	IN-LB	[N.m]	IN-LB	[N.m]
4	40	0.1120	0.00604	380	8	0.9	6	0.7				
	48	0.1120	0.00661	420	9	1.0	7	0.8				
6	32	0.1380	0.00909	580	16	1.8	12	1.4				
	40	0.1380	0.01015	610	18	2.0	13	1.5				
8	32	0.1640	0.01400	900	30	3.4	22	2.5				
	36	0.1640	0.01474	940	31	3.5	23	2.6				
10	24	0.1900	0.01750	1120	43	4.8	32	3.5				
	32	0.1900	0.02000	1285	49	5.5	36	4				
1/4	20	0.2500	0.0318	2020	96	10.8	75	9	105	12		
	28	0.2500	0.0364	2320	120	13.5	86	10	135	15		

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Values for Zinc Yellow Chromate Fasteners (Ref 4150707)												
SAE GRADE 5 BOLTS & GRADE 2 NUTS												
Size	TPI	Bolt Dia	Tensile Stress Area	Clamp Load	Torque (Dry)		Torque Lubricated		Torque (Loctite® 242™ or 271™ orVibra-TITE™111 or 140)		Torque (Loctite® 262™or Vibra-TITE™ 131)	
		In	Sq In	LB	FT-LB	[N.m]	FT-LB	[N.m]	FT-LB	[N.m]	FT-LB	[N.m]
5/16	18	0.3125	0.0524	3340	17	23	13	18	19	26	16	22
	24	0.3125	0.0580	3700	19	26	14	19	21	29	17	23
3/8	16	0.3750	0.0775	4940	30	41	23	31	35	48	28	38
	24	0.3750	0.0878	5600	35	47	25	34	40	54	32	43
7/16	14	0.4375	0.1063	6800	50	68	35	47	55	75	45	61
	20	0.4375	0.1187	7550	55	75	40	54	60	82	50	68
1/2	13	0.5000	0.1419	9050	75	102	55	75	85	116	68	92
	20	0.5000	0.1599	10700	90	122	65	88	100	136	80	108
9/16	12	0.5625	0.1820	11600	110	149	80	108	120	163	98	133
	18	0.5625	0.2030	12950	120	163	90	122	135	184	109	148
5/8	11	0.6250	0.2260	14400	150	203	110	149	165	224	135	183

Values for Zinc Yellow Chromate Fasteners (Ref 4150707)												
SAE GRADE 5 BOLTS & GRADE 2 NUTS												
Size	TPI	Bolt Dia	Tensile Stress Area	Clamp Load	Torque (Dry)		Torque Lubricated		Torque (Loctite® 242™ or 271™ orVibra-TITE™111 or 140)		Torque (Loctite® 262™or Vibra-TITE™ 131)	
	18	0.6250	0.2560	16300	170	230	130	176	190	258	153	207
3/4	10	0.7500	0.3340	21300	260	353	200	271	285	388	240	325
	16	0.7500	0.3730	23800	300	407	220	298	330	449	268	363
7/8	9	0.8750	0.4620	29400	430	583	320	434	475	646	386	523
	14	0.8750	0.5090	32400	470	637	350	475	520	707	425	576
1	8	1.0000	0.6060	38600	640	868	480	651	675	918	579	785
	12	1.0000	0.6630	42200	700	949	530	719	735	1000	633	858
1 1/8	7	1.1250	0.7630	42300	800	1085	600	813	840	1142	714	968
	12	1.1250	0.8560	47500	880	1193	660	895	925	1258	802	1087
1 1/4	7	1.2500	0.9690	53800	1120	1518	840	1139	1175	1598	1009	1368
	12	1.2500	1.0730	59600	1240	1681	920	1247	1300	1768	1118	1516
1 3/8	6	1.3750	1.1550	64100	1460	1979	1100	1491	1525	2074	1322	1792
	12	1.3750	1.3150	73000	1680	2278	1260	1708	1750	2380	1506	2042
1 1/2	6	1.5000	1.4050	78000	1940	2630	1460	1979	2025	2754	1755	2379
	12	1.5000	1.5800	87700	2200	2983	1640	2224	2300	3128	1974	2676

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NOTES:
1. THESE TORQUE VALUES DO NOT APPLY TO CADMIUM PLATED FASTENERS
2. ALL TORQUE VALUES ARE STATIC TORQUE MEASURED PER STANDARD AUDIT METHODS TOLERANCE = ±10%
3. *ASSEMBLY USES HARDENED WASHER

SAE Fastener Torque Chart (Continued)

Values for Zinc Yellow Chromate Fasteners (Ref 4150707)										
SAE GRADE 8 (HEX HD) BOLTS & GRADE 8 NUTS*										
Size	TPI	Bolt Dia	Tensile Stress Area	Clamp Load	Torque (Dry or Loctite®263) K= 0.20		Torque (Loctite® 242™ or 271™ or Vibra- TITE™ 111 or 140) K= 0.18		Torque (Loctite® 262™ or Vibra-TITE™ 131) K= 0.15	
		In	Sq In	LB	IN-LB	[N.m]	IN-LB	[N.m]	IN-LB	[N.m]
4	40	0.1120	0.00604							
	48	0.1120	0.00661							
6	32	0.1380	0.00909							
	40	0.1380	0.01015							
8	32	0.1640	0.01400							
	36	0.1640	0.01474	1320	43	5				
10	24	0.1900	0.01750	1580	60	7				
	32	0.1900	0.02000	1800	68	8				
1/4	20	0.2500	0.0318	2860	143	16	129	15		
	28	0.2500	0.0364	3280	164	19	148	17		

5000059K

Values for Zinc Yellow Chromate Fasteners (Ref 4150707)										
SAE GRADE 8 (HEX HD) BOLTS & GRADE 8 NUTS*										
Size	TPI	Bolt Dia	Tensile Stress Area	Clamp Load	Torque (Dry or Loctite®263) K= 0.20		Torque (Loctite® 242™ or 271™ or Vibra- TITE™ 111 or 140) K= 0.18		Torque (Loctite® 262™ or Vibra-TITE™ 131) K= 0.15	
		In	Sq In	LB	FT-LB	[N.m]	FT-LB	[N.m]	FT-LB	[N.m]
5/16	18	0.3125	0.0524	4720	25	35	20	25	20	25
	24	0.3125	0.0580	5220	25	35	25	35	20	25
3/8	16	0.3750	0.0775	7000	45	60	40	55	35	50
	24	0.3750	0.0878	7900	50	70	45	60	35	50
7/16	14	0.4375	0.1063	9550	70	95	65	90	50	70
	20	0.4375	0.1187	10700	80	110	70	95	60	80
1/2	13	0.5000	0.1419	12750	105	145	95	130	80	110
	20	0.5000	0.1599	14400	120	165	110	150	90	120
9/16	12	0.5625	0.1820	16400	155	210	140	190	115	155
	18	0.5625	0.2030	18250	170	230	155	210	130	175
5/8	11	0.6250	0.2260	20350	210	285	190	260	160	220
	18	0.6250	0.2560	23000	240	325	215	290	180	245
3/4	10	0.7500	0.3340	30100	375	510	340	460	280	380

Values for Zinc Yellow Chromate Fasteners (Ref 4150707)										
SAE GRADE 8 (HEX HD) BOLTS & GRADE 8 NUTS*										
Size	TPI	Bolt Dia	Tensile Stress Area	Clamp Load	Torque (Dry or Loctite®263) K= 0.20		Torque (Loctite® 242™ or 271™ or Vibra- TITE™ 111 or 140) K= 0.18		Torque (Loctite® 262™ or Vibra-TITE™ 131) K= 0.15	
	16	0.7500	0.3730	33600	420	570	380	515	315	430
7/8	9	0.8750	0.4620	41600	605	825	545	740	455	620
	14	0.8750	0.5090	45800	670	910	600	815	500	680
1	8	1.0000	0.6060	51500	860	1170	770	1045	645	875
	12	1.0000	0.6630	59700	995	1355	895	1215	745	1015
1 1/8	7	1.1250	0.7630	68700	1290	1755	1160	1580	965	1310
	12	1.1250	0.8560	77000	1445	1965	1300	1770	1085	1475
1 1/4	7	1.2500	0.9690	87200	1815	2470	1635	2225	1365	1855
	12	1.2500	1.0730	96600	2015	2740	1810	2460	1510	2055
1 3/8	6	1.3750	1.1550	104000	2385	3245	2145	2915	1785	2430
	12	1.3750	1.3150	118100	2705	3680	2435	3310	2030	2760
1 1/2	6	1.5000	1.4050	126500	3165	4305	2845	3870	2370	3225
	12	1.5000	1.5800	142200	3555	4835	3200	4350	2665	3625

5000059K

NOTES:
1. THESE TORQUE VALUES DO NOT APPLY TO CADMIUM PLATED FASTENERS
2. ALL TORQUE VALUES ARE STATIC TORQUE MEASURED PER STANDARD AUDIT METHODS TOLERANCE = ±10%
3. *ASSEMBLY USES HARDENED WASHER

SAE Fastener Torque Chart (Continued)

Values for Magni Coating Fasteners (Ref 4150701)										
SAE GRADE 5 BOLTS & GRADE 2 NUTS										
Size	TPI	Bolt Dia	Tensile Stress Area	Clamp Load	Torque (Dry) K=0.17		Torque (Loctite® 242™ or 271™ or-Vibra-TITE™111 or 140) K= 0.16		Torque (Loctite® 262™ or Vibra-TITE™ 131) K=0.15	
		In	Sq In	LB	IN-LB	[N.m]	IN-LB	[N.m]	IN-LB	[N.m]
4	40	0.1120	0.00604	380	7	0.8				
	48	0.1120	0.00661	420	8	0.9				
6	32	0.1380	0.00909	580	14	1.5				
	40	0.1380	0.01015	610	14	1.6				
8	32	0.1640	0.01400	900	25	2.8				
	36	0.1640	0.01474	940	26	2.9				
10	24	0.1900	0.01750	1120	36	4.1				
	32	0.1900	0.02000	1285	42	4.7				
1/4	20	0.2500	0.0318	2020	86	9.7	80	9		
	28	0.2500	0.0364	2320	99	11.1	95	11		

5000059K

Values for Magni Coating Fasteners (Ref 4150701)										
SAE GRADE 5 BOLTS & GRADE 2 NUTS										
Size	TPI	Bolt Dia	Tensile Stress Area	Clamp Load	Torque (Dry) K=0.17		Torque (Loctite® 242™ or 271™ or-Vibra-TITE™111 or 140) K= 0.16		Torque (Loctite® 262™ or Vibra-TITE™ 131) K=0.15	
		In	Sq In	LB	FT-LB	[N.m]	FT-LB	[N.m]	FT-LB	[N.m]
5/16	18	0.3125	0.0524	3340	15	20	14	19	15	20
	24	0.3125	0.0580	3700	15	20	15	21	15	20
3/8	16	0.3750	0.0775	4940	25	35	25	34	25	34
	24	0.3750	0.0878	5600	30	40	28	38	25	34
7/16	14	0.4375	0.1063	6800	40	55	40	54	35	48
	20	0.4375	0.1187	7550	45	60	44	60	40	54
1/2	13	0.5000	0.1419	9050	65	90	60	82	55	75
	20	0.5000	0.1599	10700	75	100	71	97	65	88
9/16	12	0.5625	0.1820	11600	90	120	87	118	80	109
	18	0.5625	0.2030	12950	105	145	97	132	90	122
5/8	11	0.6250	0.2260	14400	130	175	120	163	115	156
	18	0.6250	0.2560	16300	145	195	136	185	125	170
3/4	10	0.7500	0.3340	21300	225	305	213	290	200	272
	16	0.7500	0.3730	23800	255	345	238	324	225	306

Values for Magni Coating Fasteners (Ref 4150701)										
SAE GRADE 5 BOLTS & GRADE 2 NUTS										
Size	TPI	Bolt Dia	Tensile Stress Area	Clamp Load	Torque (Dry) K=0.17		Torque (Loctite® 242™ or 271™ or-Vibra-TITE™111 or 140) K= 0.16		Torque (Loctite® 262™ or Vibra-TITE™ 131) K=0.15	
7/8	9	0.8750	0.4620	29400	365	495	343	466	320	435
	14	0.8750	0.5090	32400	400	545	378	514	355	483
1	8	1.0000	0.6060	38600	545	740	515	700	480	653
	12	1.0000	0.6630	42200	600	815	563	765	530	721
11/8	7	1.1250	0.7630	42300	675	920	635	863	595	809
	12	1.1250	0.8560	47500	755	1025	713	969	670	911
11/4	7	1.2500	0.9690	53800	955	1300	897	1219	840	1142
	12	1.2500	1.0730	59600	1055	1435	993	1351	930	1265
13/8	6	1.3750	1.1550	64100	1250	1700	1175	1598	1100	1496
	12	1.3750	1.3150	73000	1420	1930	1338	1820	1255	1707
11/2	6	1.5000	1.4050	78000	1660	2260	1560	2122	1465	1992
	12	1.5000	1.5800	87700	1865	2535	1754	2385	1645	2237

5000059K

NOTE-S:
1. THESE TORQUE VALUES DO NOT APPLY TO CADMIUM PLATED FASTENERS
2. ALL TORQUE VALUES ARE STATIC TORQUE MEASURED PER STANDARD AUDIT METHODS TOLERANCE = ±10%
3. *ASSEMBLY USES HARDENED WASHER

SAE Fastener Torque Chart (Continued)

Values for Magni Coating Fasteners (Ref 4150701)										
SAE GRADE 8 (HEX HD) BOLTS & GRADE 8 NUTS*										
Size	TPI	Bolt Dia	Tensile Stress Area	Clamp Load	Torque (Dry or Loctite® 263) K= 0.17		Torque (Loctite® 242™ or 271™ or-Vibra-TITE™111or140) K= 0.16		Torque (Loctite® 262™ or Vi-bra-TITE™ 131) K=0.15	
		In	Sq In	LB	IN-LB	[N.m]	IN-LB	[N.m]	IN-LB	[N.m]
4	40	0.1120	0.00604							
	48	0.1120	0.00661							
6	32	0.1380	0.00909							
	40	0.1380	0.01015							
8	32	0.1640	0.01400							
	36	0.1640	0.01474	1320	37	4				
10	24	0.1900	0.01750	1580	51	6				
	32	0.1900	0.02000	1800	58	7				
1/4	20	0.2500	0.0318	2860	122	14	114	13		
	28	0.2500	0.0364	3280	139	16	131	15		

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Values for Magni Coating Fasteners (Ref 4150701)										
SAE GRADE 8 (HEX HD) BOLTS & GRADE 8 NUTS*										
Size	TPI	Bolt Dia	Tensile Stress Area	Clamp Load	Torque (Dry or Loctite® 263) K= 0.17		Torque (Loctite® 242™ or 271™ or-Vibra-TITE™111or140) K= 0.16		Torque (Loctite® 262™ or Vi-bra-TITE™ 131) K=0.15	
		In	Sq In	LB	FT-LB	[N.m]	FT-LB	[N.m]	FT-LB	[N.m]
5/16	18	0.3125	0.0524	4720	20	25	20	25	20	25
	24	0.3125	0.0580	5220	25	35	20	25	20	25
3/8	16	0.3750	0.0775	7000	35	50	35	50	35	50
	24	0.3750	0.0878	7900	40	55	40	55	35	50
7/16	14	0.4375	0.1063	9550	60	80	55	75	50	70
	20	0.4375	0.1187	10700	65	90	60	80	60	80
1/2	13	0.5000	0.1419	12750	90	120	85	115	80	110
	20	0.5000	0.1599	14400	100	135	95	130	90	120
9/16	12	0.5625	0.1820	16400	130	175	125	170	115	155
	18	0.5625	0.2030	18250	145	195	135	185	130	175
5/8	11	0.6250	0.2260	20350	180	245	170	230	160	220
	18	0.6250	0.2560	23000	205	280	190	260	180	245
3/4	10	0.7500	0.3340	30100	320	435	300	410	280	380

Values for Magni Coating Fasteners (Ref 4150701)										
SAE GRADE 8 (HEX HD) BOLTS & GRADE 8 NUTS*										
Size	TPI	Bolt Dia	Tensile Stress Area	Clamp Load	Torque (Dry or Loctite® 263) K= 0.17		Torque (Loctite® 242™ or 271™ or-Vibra-TITE™111or140) K= 0.16		Torque (Loctite® 262™ or Vi-bra-TITE™ 131) K=0.15	
	16	0.7500	0.3730	33600	355	485	335	455	315	430
7/8	9	0.8750	0.4620	41600	515	700	485	660	455	620
	14	0.8750	0.5090	45800	570	775	535	730	500	680
1	8	1.0000	0.6060	51500	730	995	685	930	645	875
	12	1.0000	0.6630	59700	845	1150	795	1080	745	1015
11/8	7	1.1250	0.7630	68700	1095	1490	1030	1400	965	1310
	12	1.1250	0.8560	77000	1225	1665	1155	1570	1085	1475
11/4	7	1.2500	0.9690	87200	1545	2100	1455	1980	1365	1855
	12	1.2500	1.0730	96600	1710	2325	1610	2190	1510	2055
13/8	6	1.3750	1.1550	104000	2025	2755	1905	2590	1785	2430
	12	1.3750	1.3150	118100	2300	3130	2165	2945	2030	2760
11/2	6	1.5000	1.4050	126500	2690	3660	2530	3440	2370	3225
	12	1.5000	1.5800	142200	3020	4105	2845	3870	2665	3625

5000059K

NOTE-S:
1. THESE TORQUE VALUES DO NOT APPLY TO CADMIUM PLATED FASTENERS
2. ALL TORQUE VALUES ARE STATIC TORQUE MEASURED PER STANDARD AUDIT METHODS TOLERANCE = ±10%
3. *ASSEMBLY USES HARDENED WASHER

SAE Fastener Torque Chart (Continued)

Values for Magni Coating Fasteners (Ref 4150701)										
SOCKET HEAD CAPSCREWS										
Size	TPI	Bolt Dia	Tensile Stress Area	Clamp Load See *Note 4*	Torque (Dry) K=0.17		Torque (Loctite® 242™ or 271™ or-Vibra-TITE™ 111 or 140) or Precoat® 85 K=0.16		Torque (Loctite® 262™or Vibra-TITE™ 131) K=0.15	
		In	Sq In	LB	IN-LB	[N.m]	IN-LB	[N.m]	IN-LB	[N.m]
4	40	0.1120	0.00604							
	48	0.1120	0.00661							
6	32	0.1380	0.00909							
	40	0.1380	0.01015							
8	32	0.1640	0.01400							
	36	0.1640	0.01474							
10	24	0.1900	0.01750							
	32	0.1900	0.02000							
1/4	20	0.2500	0.0318	2860	122	14	114	13		
	28	0.2500	0.0364	3280	139	16	131	15		

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Values for Magni Coating Fasteners (Ref 4150701)										
SOCKET HEAD CAPSCREWS										
Size	TPI	Bolt Dia	Tensile Stress Area	Clamp Load See *Note 4*	Torque (Dry) K=0.17		Torque (Loctite® 242™ or 271™ or-Vibra-TITE™ 111 or 140) or Precoat® 85 K=0.16		Torque (Loctite® 262™or Vibra-TITE™ 131) K=0.15	
		In	Sq In	LB	FT-LB	[N.m]	FT-LB	[N.m]	FT-LB	[N.m]
5/16	18	0.3125	0.0524	4720	20	25	20	25	20	25
	24	0.3125	0.0580	5220	25	35	20	25	20	25
3/8	16	0.3750	0.0775	7000	35	50	35	50	35	50
	24	0.3750	0.0878	7900	40	55	40	55	35	50
7/16	14	0.4375	0.1063	9550	60	80	55	75	50	70
	20	0.4375	0.1187	10700	65	90	60	80	60	80
1/2	13	0.5000	0.1419	12750	90	120	85	115	80	110
	20	0.5000	0.1599	14400	100	135	95	130	90	120
9/16	12	0.5625	0.1820	16400	130	175	125	170	115	155
	18	0.5625	0.2030	18250	145	195	135	185	130	175
5/8	11	0.6250	0.2260	20350	180	245	170	230	160	220
	18	0.6250	0.2560	23000	205	280	190	260	180	245
3/4	10	0.7500	0.3340	30100	320	435	300	415	280	380
	16	0.7500	0.3730	33600	355	485	335	455	315	430

Values for Magni Coating Fasteners (Ref 4150701)										
SOCKET HEAD CAPSCREWS										
Size	TPI	Bolt Dia	Tensile Stress Area	Clamp Load See *Note 4*	Torque (Dry) K=0.17		Torque (Loctite® 242™ or 271™ or-Vibra-TITE™ 111 or 140) or Precoat® 85 K=0.16		Torque (Loctite® 262™or Vibra-TITE™ 131) K=0.15	
7/8	9	0.8750	0.4620	41600	515	700	485	660	455	620
	14	0.8750	0.5090	45800	570	775	535	730	500	680
1	8	1.0000	0.6060	51500	730	995	685	930	645	875
	12	1.0000	0.6630	59700	845	1150	795	1080	745	1015
11/8	7	1.1250	0.7630	68700	1095	1490	1030	1400	965	1310
	12	1.1250	0.8560	77000	1225	1665	1155	1570	1085	1475
11/4	7	1.2500	0.9690	87200	1545	2100	1455	1980	1365	1855
	12	1.2500	1.0730	96600	1710	2325	1610	2190	1510	2055
13/8	6	1.3750	1.1550	104000	2025	2755	1905	2590	1785	2430
	12	1.3750	1.3150	118100	2300	3130	2165	2945	2030	2760
11/2	6	1.5000	1.4050	126500	2690	3660	2530	3440	2370	3225
	12	1.5000	1.5800	142200	3020	4105	2845	3870	2665	3625

5000059K

NOTE-S:

1. THESE TORQUE VALUES DO NOT APPLY TO CADMIUM PLATED FASTENERS
2. ALL TORQUE VALUES ARE STATIC TORQUE MEASURED PER STANDARD AUDIT METHODS TOLERANCE = ±10%
3. *ASSEMBLY USES HARDENED WASHER
4. CLAMP LOAD LISTED FOR SHCS IS SAME AS GRADE 8 OR CLASS 10.9 AND DOES NOT REPRESENT FULL STRENGTH CAPABILITY OF SHCS. IF HIGHER LOAD IS REQUIRED, ADDITIONAL TESTING IS REQUIRED.

SAE Fastener Torque Chart (Continued)

Values for Zinc Yellow Chromate Fasteners (Ref 4150707)*										
SOCKET HEAD CAPSCREWS										
Size	TPI	Bolt Dia	Tensile Stress Area	Clamp Load See *Note 4*	Torque (Dry) K=0.17		Torque (Loctite® 242™ or 271™ or-Vibra-TITE™ 111 or 140) or Precoat® 85 K=0.16		Torque (Loctite® 262™ or Vibra-TITE™ 131) K=0.15	
		In	Sq In	LB	IN-LB	[N.m]	IN-LB	[N.m]	IN-LB	[N.m]
4	40	0.1120	0.00604							
	48	0.1120	0.00661							
6	32	0.1380	0.00909							
	40	0.1380	0.01015							
8	32	0.1640	0.01400							
	36	0.1640	0.01474							
10	24	0.1900	0.01750							
	32	0.1900	0.02000							
1/4	20	0.2500	0.0318	2860	122	14	114	13		
	28	0.2500	0.0364	3280	139	16	131	15		

5000059K

Values for Zinc Yellow Chromate Fasteners (Ref 4150707)*										
SOCKET HEAD CAPSCREWS										
Size	TPI	Bolt Dia	Tensile Stress Area	Clamp Load See *Note 4*	Torque (Dry) K=0.17		Torque (Loctite® 242™ or 271™ orVibra-TITE™ 111 or 140) or Precoat® 85 K=0.16		Torque (Loctite® 262™ or Vibra-TITE™ 131) K=0.15	
		In	Sq In	LB	FT-LB	[N.m]	FT-LB	[N.m]	FT-LB	[N.m]
5/16	18	0.3125	0.0524	4720	20	25	20	25	20	25
	24	0.3125	0.0580	5220	25	35	20	25	20	25
3/8	16	0.3750	0.0775	7000	35	50	35	50	35	50
	24	0.3750	0.0878	7900	40	55	40	55	35	50
7/16	14	0.4375	0.1063	9550	60	80	55	75	50	70
	20	0.4375	0.1187	10700	65	90	60	80	60	80
1/2	13	0.5000	0.1419	12750	90	120	85	115	80	110
	20	0.5000	0.1599	14400	100	135	95	130	90	120
9/16	12	0.5625	0.1820	16400	130	175	125	170	115	155
	18	0.5625	0.2030	18250	145	195	135	185	130	175
5/8	11	0.6250	0.2260	20350	180	245	170	230	160	220
	18	0.6250	0.2560	23000	205	280	190	260	180	245
3/4	10	0.7500	0.3340	30100	320	435	300	415	280	380
	16	0.7500	0.3730	33600	355	485	335	455	315	430

Values for Zinc Yellow Chromate Fasteners (Ref 4150707)*										
SOCKET HEAD CAPSCREWS										
Size	TPI	Bolt Dia	Tensile Stress Area	Clamp Load See *Note 4*	Torque (Dry) K=0.17		Torque (Loctite® 242™ or 271™ orVibra-TITE™ 111 or 140) or Precoat® 85 K=0.16		Torque (Loctite® 262™ or Vibra-TITE™ 131) K=0.15	
7/8	9	0.8750	0.4620	41600	515	700	485	660	455	620
	14	0.8750	0.5090	45800	570	775	535	730	500	680
1	8	1.0000	0.6060	51500	730	995	685	930	645	875
	12	1.0000	0.6630	59700	845	1150	795	1080	745	1015
11/8	7	1.1250	0.7630	68700	1095	1490	1030	1400	965	1310
	12	1.1250	0.8560	77000	1225	1665	1155	1570	1085	1475
11/4	7	1.2500	0.9690	87200	1545	2100	1455	1980	1365	1855
	12	1.2500	1.0730	96600	1710	2325	1610	2190	1510	2055
13/8	6	1.3750	1.1550	104000	2025	2755	1905	2590	1785	2430
	12	1.3750	1.3150	118100	2300	3130	2165	2945	2030	2760
11/2	6	1.5000	1.4050	126500	2690	3660	2530	3440	2370	3225
	12	1.5000	1.5800	142200	3020	4105	2845	3870	2665	3625

5000059K

NOTE-S:

1. THESE TORQUE VALUES DO NOT APPLY TO CADMIUM PLATED FASTENERS
2. ALL TORQUE VALUES ARE STATIC TORQUE MEASURED PER STANDARD AUDIT METHODS TOLERANCE = ±10%
3. *ASSEMBLY USES HARDENED WASHER
4. CLAMP LOAD LISTED FOR SHCS IS SAME AS GRADE 8 OR CLASS 10.9 AND DOES NOT REPRESENT FULL STRENGTH CAPABILITY OF SHCS. IF HIGHER LOAD IS REQUIRED, ADDITIONAL TESTING IS REQUIRED.

11.2.2 Metric Fastener Torque Chart

Values for Zinc Yellow Chromate Fasteners (Ref 4150707)*							
CLASS 8.8 METRIC (HEX/SOCKET HEAD) BOLTS CLASS 8 METRIC NUTS							
Size	Pitch	Tensile Stress Area	Clamp Load See *Note 4*	Torque (Dry or Loctite® 263™)	Torque (Lube)	Torque (Loctite® 262™ or Vibra-TITE™ 131)	Torque (Loctite® 242™ or 271™ or Vibra-TITE™ 111 or 140)
		Sq mm	KN	[N.m]		[N.m]	[N.m]
3	0.5	5.03	2.19	1.3	1.0	1.2	1.4
3.5	0.6	6.78	2.95	2.1	1.6	1.9	2.3
4	0.7	8.78	3.82	3.1	2.3	2.8	3.4
5	0.8	14.20	6.18	6.2	4.6	5.6	6.8
6	1	20.10	8.74	11	7.9	9.4	12
7	1	28.90	12.6	18	13	16	19
8	1.25	36.60	15.9	26	19	23	28
10	1.5	58.00	25.2	50	38	45	55
12	1.75	84.30	36.7	88	66	79	97
14	2	115	50.0	140	105	126	154
16	2	157	68.3	219	164	197	241
18	2.5	192	83.5	301	226	271	331
20	2.5	245	106.5	426	320	383	469
22	2.5	303	132.0	581	436	523	639
24	3	353	153.5	737	553	663	811
27	3	459	199.5	1080	810	970	1130
30	3.5	561	244.0	1460	1100	1320	1530
33	3.5	694	302.0	1990	1490	1790	2090
36	4	817	355.5	2560	1920	2300	2690
42	4.5	1120	487.0	4090	3070	3680	4290

5000059K

NOTES:

1. THESE TORQUE VALUES DO NOT APPLY TO CADMIUM PLATED FASTENERS
2. ALL TORQUE VALUES ARE STATIC TORQUE MEASURED PER STANDARD AUDIT METHODS TOLERANCE = ±10%
3. *ASSEMBLY USES HARDENED WASHER
4. CLAMP LOAD LISTED FOR SHCS IS SAME AS GRADE 8 OR CLASS 10.9 AND DOES NOT REPRESENT FULL STRENGTH CAPABILITY OF SHCS. IF HIGHER LOAD IS REQUIRED, ADDITIONAL TESTING IS REQUIRED.

Metric Fastener Torque Chart (Continued)

Values for Zinc Yellow Chromate Fasteners (Ref 4150707)*						
CLASS 10.9 METRIC (HEX HEAD) BOLTS, CLASS 10 METRIC NUTS CLASS 12.9 SOCKET HEAD CAPSCREWS M3 - M5*						
Size	Pitch	Tensile Stress Area	Clamp Load See *Note 4*	Torque (Dry or Loctite® 263™) K=0.20	Torque (Lube or Loctite® 242™ or 271™ orVibra-TITE™ 111 or 140) K=0.18	Torque (Loctite® 262™or Vibra-TITE™ 131) K=0.15
		Sq mm	KN	[N.m]	[N.m]	[N.m]
3	0.5	5.03	3.13			
3.5	0.6	6.78	4.22			
4	0.7	8.78	5.47			
5	0.8	14.20	8.85			
6	1	20.10	12.5			
7	1	28.90	18.0	25	23	19
8	1.25	36.60	22.8	37	33	27
10	1.5	58.00	36.1	70	65	55
12	1.75	84.30	52.5	125	115	95
14	2	115	71.6	200	180	150
16	2	157	97.8	315	280	235
18	2.5	192	119.5	430	385	325
20	2.5	245	152.5	610	550	460
22	2.5	303	189.0	830	750	625
24	3	353	222.0	1065	960	800
27	3	459	286.0	1545	1390	1160
30	3.5	561	349.5	2095	1885	1575
33	3.5	694	432.5	2855	2570	2140
36	4	817	509.0	3665	3300	2750
42	4.5	1120	698.0	5865	5275	4395

5000059K

NOTES:

1. THESE TORQUE VALUES DO NOT APPLY TO CADMIUM PLATED FASTENERS
2. ALL TORQUE VALUES ARE STATIC TORQUE MEASURED PER STANDARD AUDIT METHODS TOLERANCE = ±10%
3. *ASSEMBLY USES HARDENED WASHER
4. CLAMP LOAD LISTED FOR SHCS IS SAME AS GRADE 8 OR CLASS 10.9 AND DOES NOT REPRESENT FULL STRENGTH CAPABILITY OF SHCS. IF HIGHER LOAD IS REQUIRED, ADDITIONAL TESTING IS REQUIRED.

Metric Fastener Torque Chart (Continued)

Values for Magni Coated Fasteners (Ref 4150701)*						
CLASS 8.8 METRIC (HEX/SOCKET HEAD) BOLTS CLASS 8 METRIC NUTS						
Size	Pitch	Tensile Stress Area	Clamp Load See *Note 4*	Torque (Dry or Loctite® 263™) K=0.17	Torque (Lube or Loctite® 242™or 271™ or Vibra-TITE™ 111 or 140) K=0.16	Torque (Loctite® 262™ orVibra-TITE™ 131) K=0.15
		Sq mm	KN	[N.m]	[N.m]	[N.m]
3	0.5	5.03	2.19	1.1	1.1	1.0
3.5	0.6	6.78	2.95	1.8	1.7	1.5
4	0.7	8.78	3.82	2.6	2.4	2.3
5	0.8	14.20	6.18	5.3	4.9	4.6
6	1	20.10	8.74	9	8.4	7.9
7	1	28.90	12.6	15	14	13
8	1.25	36.60	15.9	22	20	19
10	1.5	58.00	25.2	43	40	38
12	1.75	84.30	36.7	75	70	66
14	2	115	50.0	119	110	105
16	2	157	68.3	186	175	165
18	2.5	192	83.5	256	240	225
20	2.5	245	106.5	362	340	320
22	2.5	303	132.0	494	465	435
24	3	353	153.5	627	590	555
27	3	459	199.5	916	860	810
30	3.5	561	244.0	1245	1170	1100
33	3.5	694	302.0	1694	1595	1495
36	4	817	355.5	2176	2050	1920
42	4.5	1120	487.0	3477	3275	3070

5000059K

NOTE-S:

1. THESE TORQUE VALUES DO NOT APPLY TO CADMIUM PLATED FASTENERS
2. ALL TORQUE VALUES ARE STATIC TORQUE MEASURED PER STANDARD AUDIT METHODS TOLERANCE = ±10%
3. *ASSEMBLY USES HARDENED WASHER
4. CLAMP LOAD LISTED FOR SHCS IS SAME AS GRADE 8 OR CLASS 10.9 AND DOES NOT REPRESENT FULL STRENGTH CAPABILITY OF SHCS. IF HIGHER LOAD IS REQUIRED, ADDITIONAL TESTING IS REQUIRED.

Metric Fastener Torque Chart (Continued)

Values for Magni Coated Fasteners (Ref 4150701)*						
CLASS 10.9 METRIC (HEX HEAD) BOLTS CLASS 10 METRIC NUTS, CLASS 12.9 SOCKET HEAD CAPSCREWS M6 AND ABOVE*						
Size	Pitch	Tensile Stress Area	Clamp Load See *Note 4*	Torque (Dry or Loctite® 263™) K=0.17	Torque (Lube or Loctite® 242™ or 271™ orVibra-TITE™ 111 or 140) K=0.18	Torque (Loctite® 262™or Vibra-TITE™ 131) K=0.15
		Sq mm	KN	[N.m]	[N.m]	[N.m]
3	0.5	5.03	3.13			
3.5	0.6	6.78	4.22			
4	0.7	8.78	5.47			
5	0.8	14.20	8.85			
6	1	20.10	12.5	13	12	11
7	1	28.90	18.0	21	20	19
8	1.25	36.60	22.8	31	29	27
10	1.5	58.00	36.1	61	58	55
12	1.75	84.30	52.5	105	100	95
14	2	115	71.6	170	160	150
16	2	157	97.8	265	250	235
18	2.5	192	119.5	365	345	325
20	2.5	245	152.5	520	490	460
22	2.5	303	189.0	705	665	625
24	3	353	222.0	905	850	800
27	3	459	286.0	1315	1235	1160
30	3.5	561	349.5	1780	1680	1575
33	3.5	694	432.5	2425	2285	2140
36	4	817	509.0	3115	2930	2750
42	4.5	1120	698.0	4985	4690	4395

5000059K

NOTES:

1. THESE TORQUE VALUES DO NOT APPLY TO CADMIUM PLATED FASTENERS
2. ALL TORQUE VALUES ARE STATIC TORQUE MEASURED PER STANDARD AUDIT METHODS TOLERANCE = ±10%
3. *ASSEMBLY USES HARDENED WASHER
4. CLAMP LOAD LISTED FOR SHCS IS SAME AS GRADE 8 OR CLASS 10.9 AND DOES NOT REPRESENT FULL STRENGTH CAPABILITY OF SHCS. IF HIGHER LOAD IS REQUIRED, ADDITIONAL TESTING IS REQUIRED.

SECTION 12
SCHEMATICS

12.1 HYDRAULIC SCHEMATIC

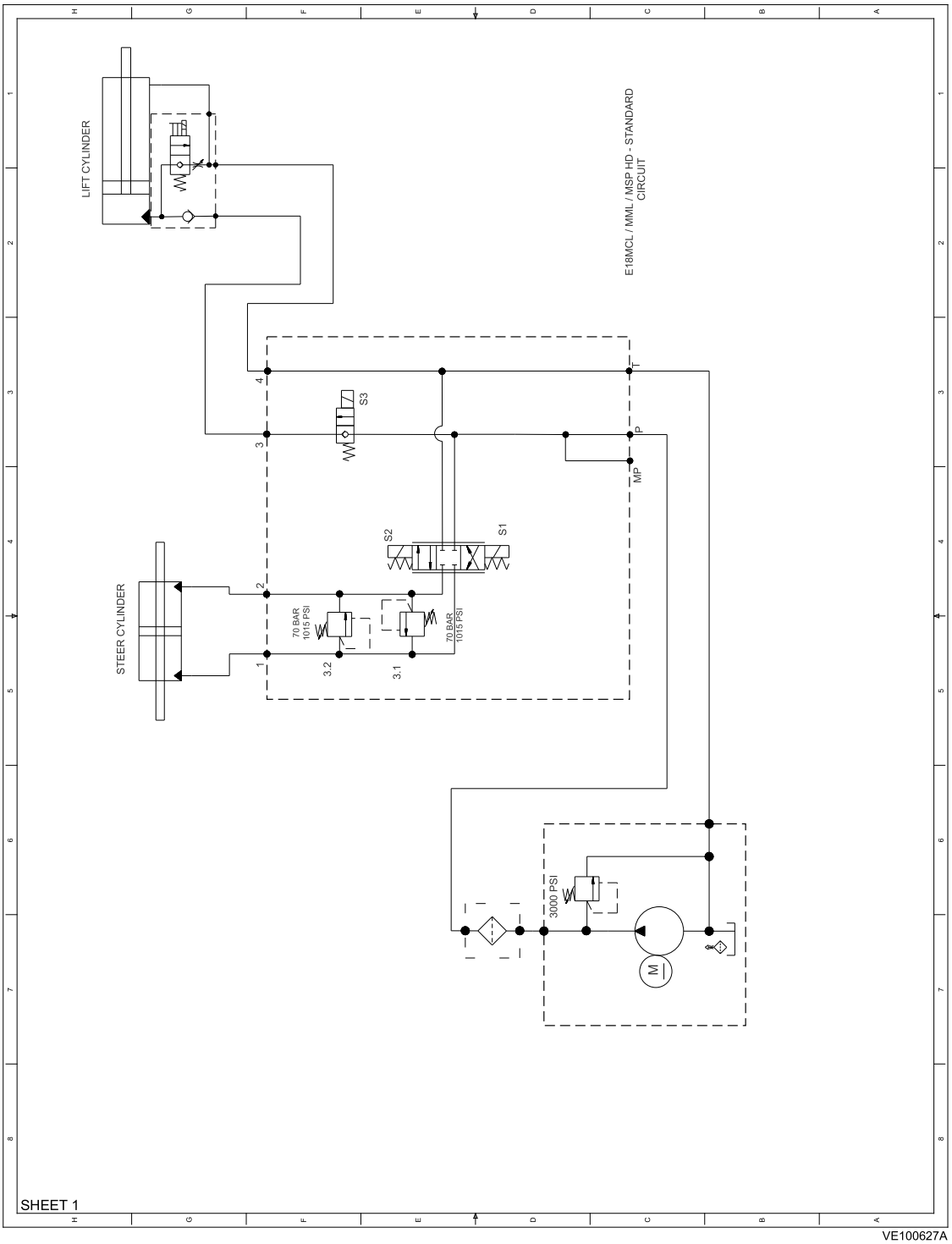


Figure 145. Hydraulic Schematic – Sheet 1 of 2

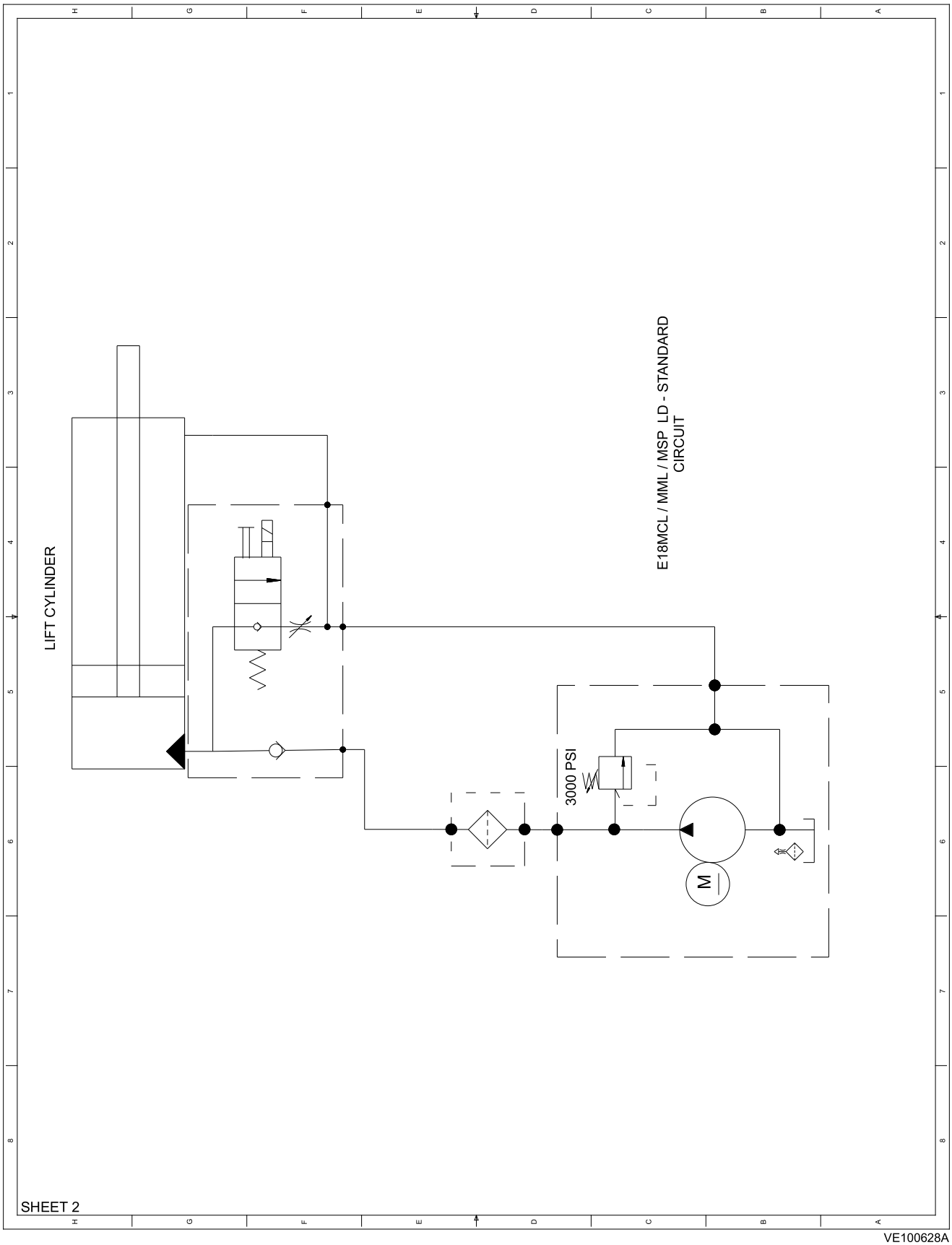


Figure 146. Hydraulic Schematic – Sheet 2 of 2

12.2 ELECTRICAL SCHEMATIC

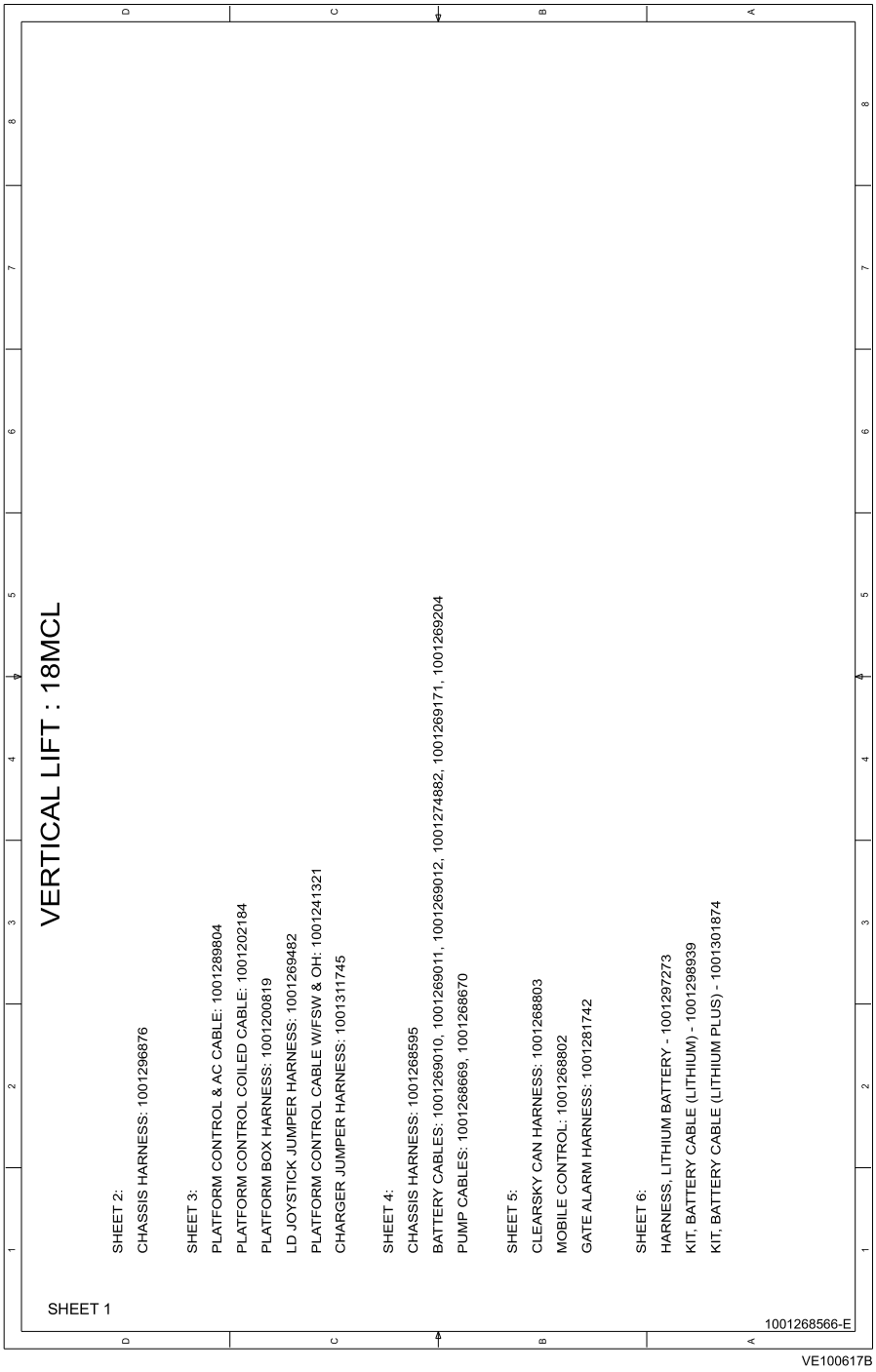


Figure 147. Electrical Schematic - Sheet 1 of 6

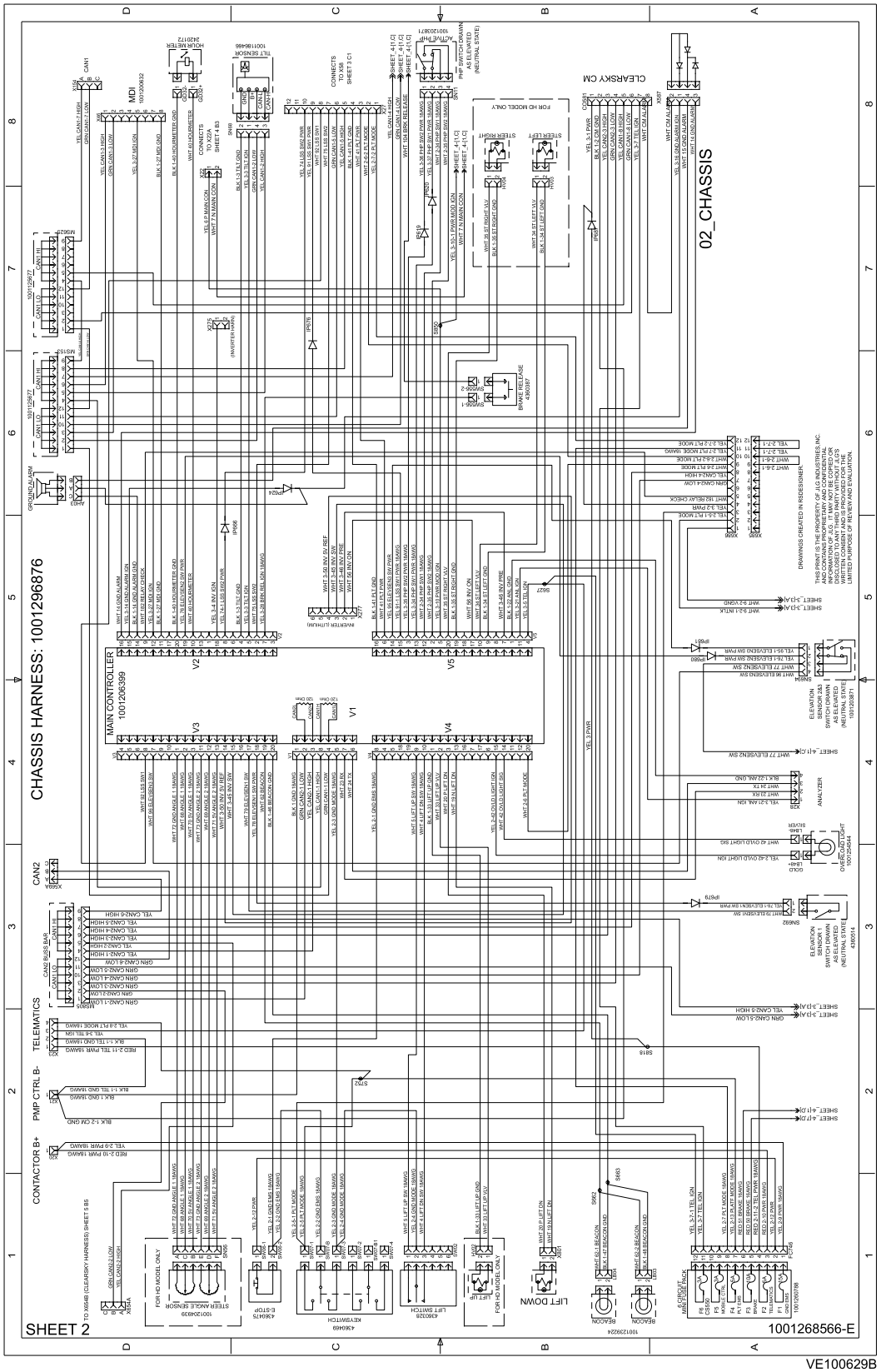


Figure 148. Electrical Schematic - Sheet 2 of 6

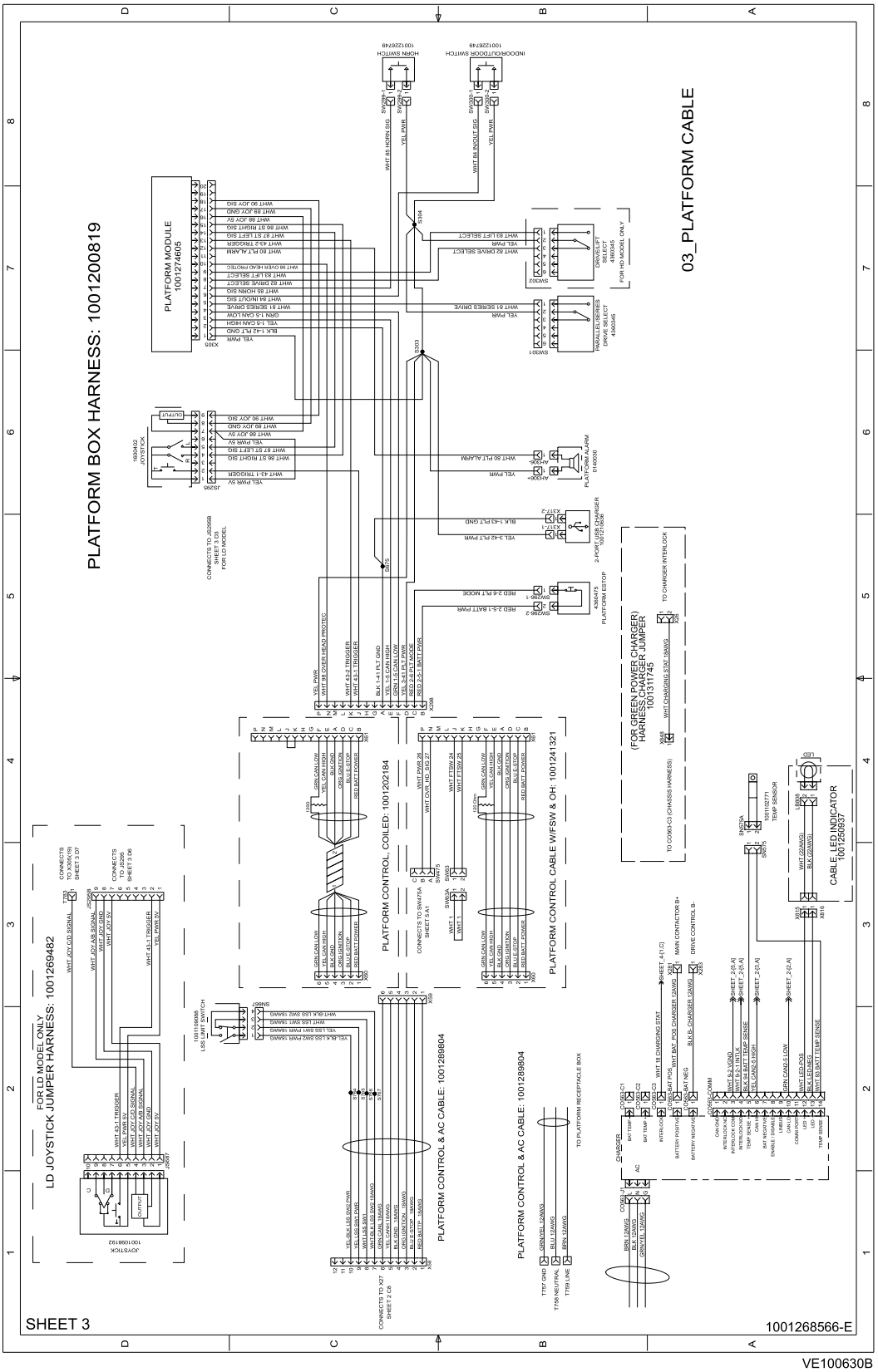


Figure 149. Electrical Schematic - Sheet 3 of 6

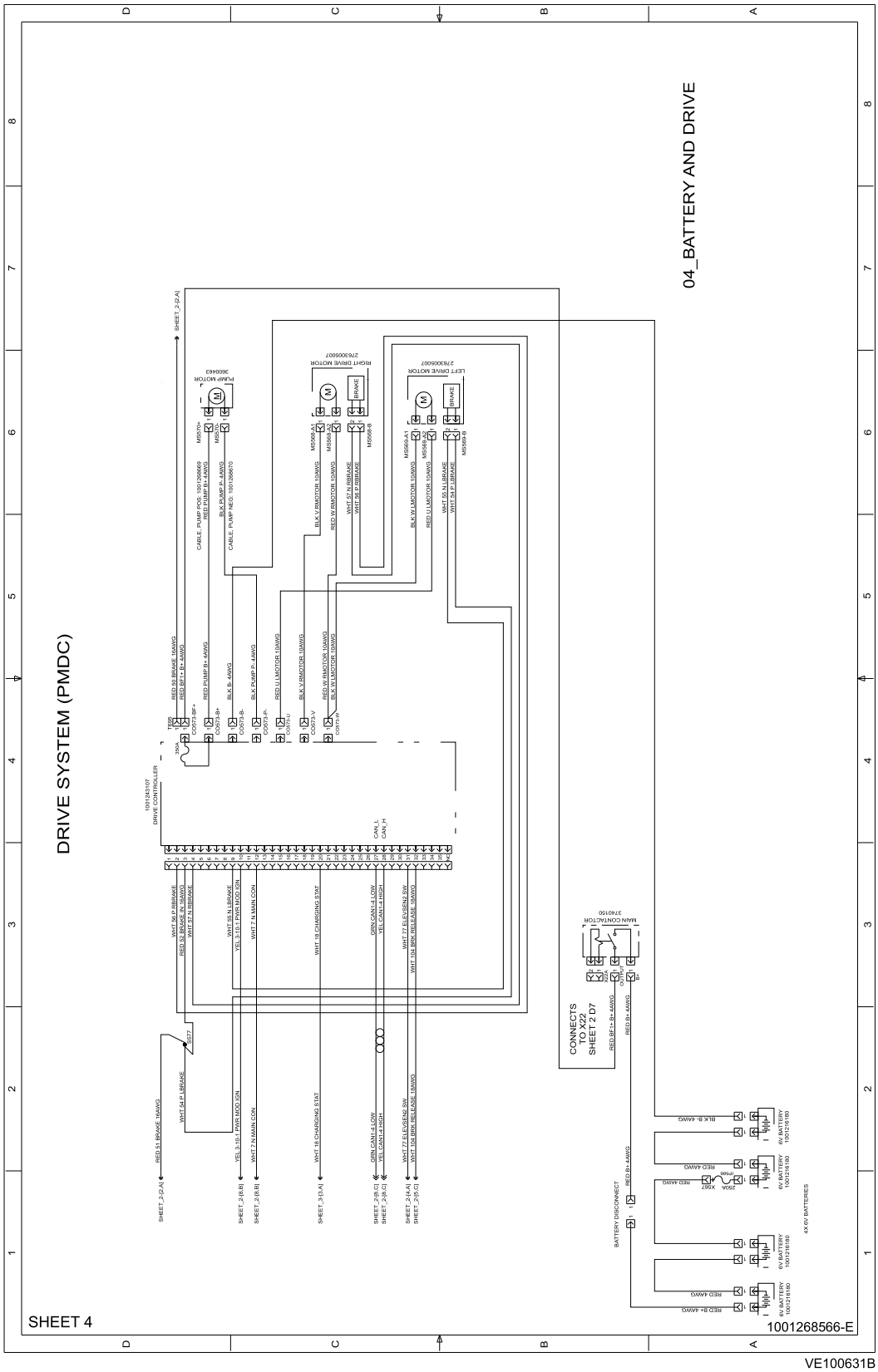
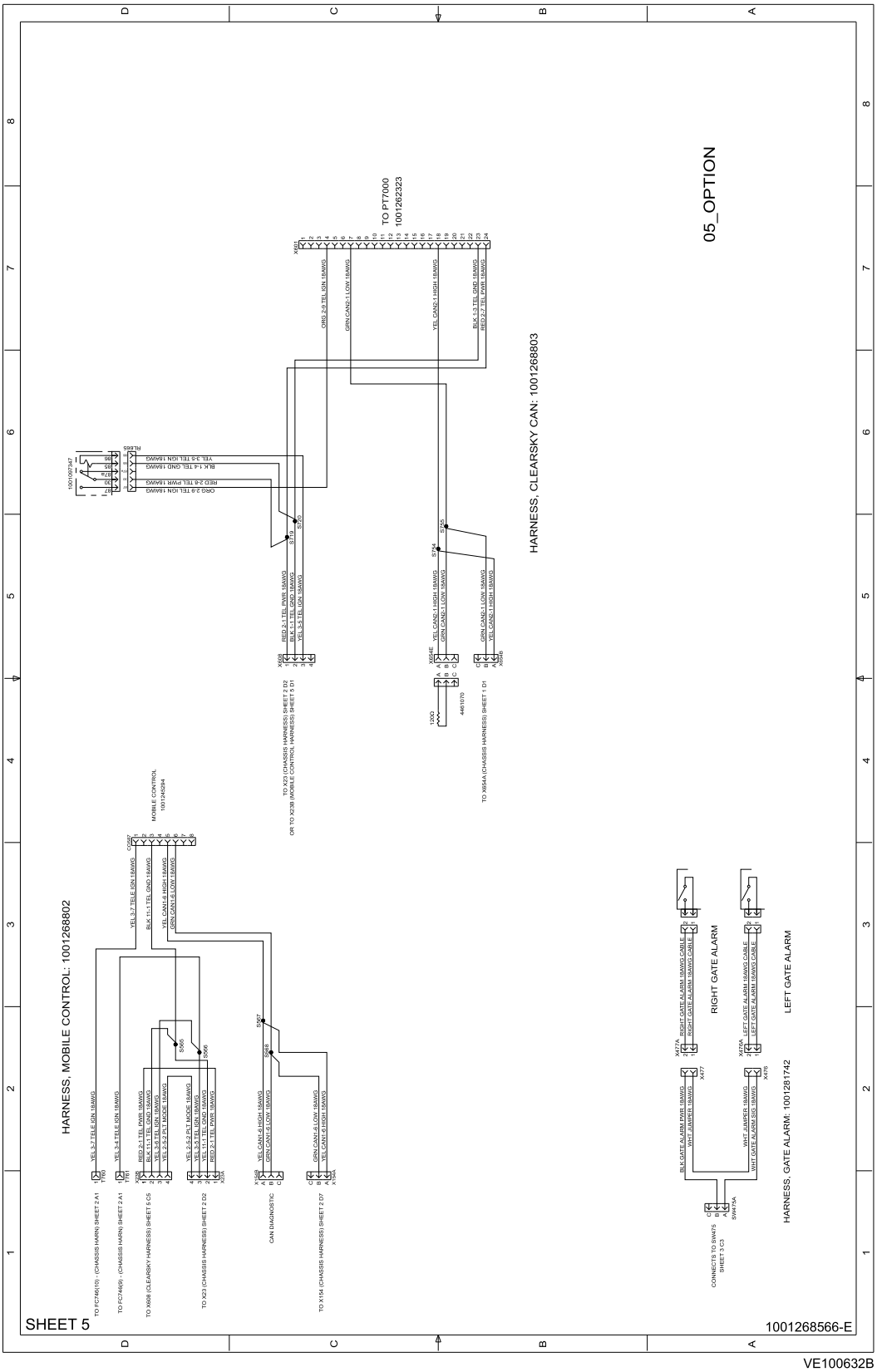


Figure 150. Electrical Schematic - Sheet 4 of 6



VE100632B

Figure 151. Electrical Schematic - Sheet 5 of 6

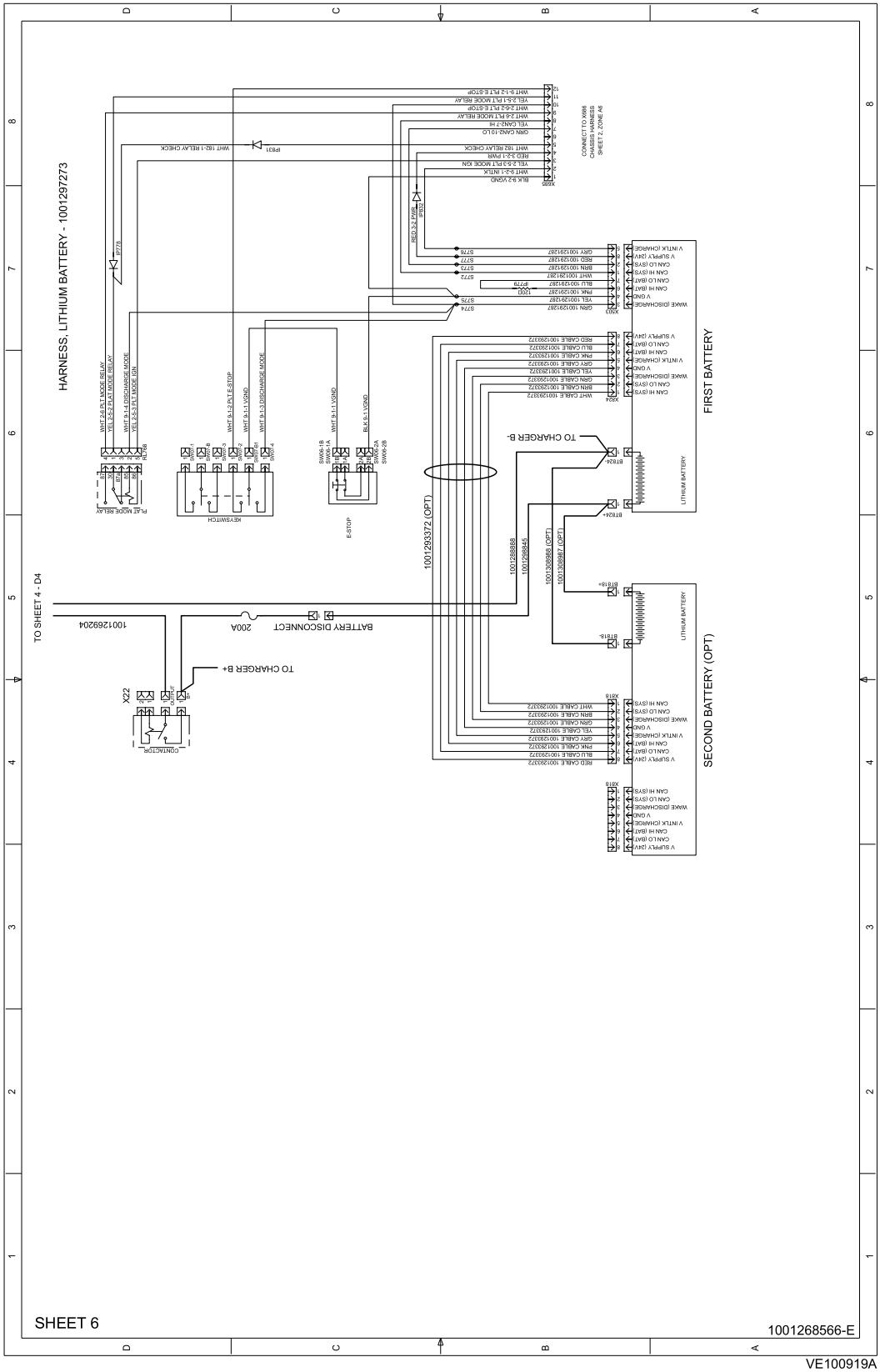


Figure 152. Electrical Schematic - Sheet 6 of 6

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